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EVALUATING PURCHASING POWER PARITY IN HYPERINFLATION AND LOW INFLATION COUNTRIES A CASE OF STRUCTURAL BREAKS

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Abstract

The theory of purchasing power parity has continually been evaluated over the years using different approaches that could be in favour of the theory. Some studies have obtained data from low-inflation and high-inflation countries to test for the theory. In this study, ADF and KPSS tests are employed, testing for unit root of 5 countries' effective exchange rate, in which they are split into hyperinflation and low inflation countries. Other tests such as the Bai-Perron test are employed to test for structural breaks over time. In contrast to previous studies that used the CPI and WPI, this study finds that PPP is not valid in both hyperinflation and low inflation countries. This therefore infers that PPP is not suitable for exchange rate determination in these economies.

Keywords: PPP, KPSS, ADF, Effective Exchange Rates, Inflation, Structural Breaks.

INTRODUCTION

"The willingness to pay a certain amount for foreign money must ultimately and essentially be due to the fact that this money possesses a purchasing power against goods and services in that country; on the other hand, when so much of our money is offered, we are actually offering purchasing power parity against goods and services in our own country. Our valuation of a foreign currency in terms of our own currency depends on the relative purchasing power of both currencies in their various countries" (Cassel 1922 in Taylor and Taylor 2004, pp.135)". The theory of purchasing power parity was first examined by David Ricardo; however, Gustav Cassel made the theory popular in 1918 when he termed it the purchasing power parity theory. Cassel who studied international trade explain that purchasing power parity doctrine suggests

that identical goods from different countries should sell at same price when converted to one currency. The theory was made popular during the World War I, evaluating the purchasing power of currencies between different countries. Although theoretical framework supports that purchasing power parity holds, most empirical work have proven otherwise. PPP hypothesis demonstrates that domestic and foreign price ratios are equivalent when converted to the same currency. Balassa (1964) explains the two versions of purchasing power parity namely the Absolute PPP doctrine and the Relative PPP doctrine. He states that Absolute PPP doctrine is based on the price ratio of consumer goods for any pair of countries and it is approximated to the exchange rate equilibrium while on Relative PPP doctrine, he states that when the exchange equilibrium prevails, changes in prices would show shifts in exchange rate. Some studies have failed to reject null hypothesis and also suggest that there may be deviations in the short run causing PPP not to hold and the tendency for mean reversion in exchange rate, but this may not be the case in the long run as exchange rate meets at equilibrium. Past studies also infer that testing for the validity of PPP using bilateral exchange rate may not favour the theory. Tests such as the Augmented Dickey-Fuller test has been used to test for unit root but has been criticised owing to the fact that it often fails to reject null hypothesis. The KPSS test which has recently been introduced is used alongside with the ADF test by some researchers and is sometimes able to reject null hypothesis. Further studies suggest that structural changes in the economy have effects on purchasing power between countries. Testing for structural changes, the Chow test and recently introduced Bai-Perron tests are used. However, there is limitation in the use of the chow test due to need that break dates are specified before the test is done, although, it still often times provides accurate results.

Furthermore, due to the lack of consensus on the validity of PPP theory, this study attempts to further test the conflicting conclusion. In this paper, the theory is evaluated using the Effective Exchange Rate and Consumer Price Index (CPI) and Wholesale Price Index (WPI). This paper aims at verifying if PPP holds in Argentina, Australia, Canada, Japan and USA with USA being a low inflation country, therefore is the home country; also, testing for PPP in a high inflation country, Argentina is used as the home country with Canada, Australia and Japan as its trading partners. Although, some studies have argued that estimating the wholesale price index rather than the consumer price index shows more evidence in favour of PPP. To verify the authenticity of this argument, this paper will be evaluating PPP using the wholesale price index as well. In addition, there is no clear possibility that PPP may hold using the WPI. Although, WPI may have more weight than CPI, still, it should be noted that WPI is based on specific type of goods in specified regions; this makes the possibility that using WPI may favour some countries than others, in other words, it may not favour PPP.

The paper is structured as follows: Chapter 2 reviews the literature behind the purchasing power parity doctrine and the law of one price as a core aspect of PPP. Chapter 3 describes the data collected and the methodology used. Chapter 4 presents and explains empirical results based on tests carried out. Chapter 5 summarises the main findings and offers a conclusion.

LITERATURE REVIEW

Continuous and extensive research has been carried out on purchasing power parity in the short-run, medium-run and long-run. Purchasing Power Parity (PPP) theory is based on traded goods only and it is another concept of the Law of One Price (LOOP); the PPP theory states that the price of goods in Country A must be the same price of goods in Country B when converted to the same exchange rate, where both goods are identical. The relationship between economic sine qua non and exchange rate behaviour has been a controversial issue in international finance, showing various empirical puzzles such as the purchasing power parity (Chen and Rogoff2002).

Abuaf and Jorion (1990) and Yin-Wong andKon (1993) explain that the purchasing power parity (PPP) doctrine is a fundamental basis of exchange rate determination. Farooq (2006) asserts that PPP doctrine implies an even restriction on domestic and foreign prices in a long-nominal exchange rate equation; in which he further argues that these restrictions are enacted by real exchange rate definition. According to Yin-Wong and Kon (1994) “PPP theory suggest that currencies are valued for the goods they can purchase and, in arbitrage equilibrium, the exchange rate between two countries’ currencies should equal the ratio of their price levels, of which a testable implication is that real exchange rate should display mean reversion, at least in the long-run”. In Frenkel (1981) view, there is contention behind the usefulness of the purchasing power theory; owing to the fact that there is no specified mechanism by which the exchange rate and prices are linked neither does it specify the conditions in which the PPP theory is satisfied.

“The idea that purchasing power parity may hold because international goods arbitrage is related to the so-called L aw of One Price, which holds that the price of an internationally traded good should be the same anywhere in the world once the price is expressed in the same currency, since people could make a riskless profit by shipping the goods from locations where the price is low to locations where the price is high (arbitraging) Taylor and Taylor (2004)”. According to Rogoff (1996), the variants of PPP are Law of One Price, Relative PPP and Absolute PPP and the Indices of measuring Absolute PPP; he emphasises that the issue of arbitrage in relation to LOOP was put in place, that is, the idea that if goods market arbitrage leads to an extensive parity in prices across a large scope of individual goods which is the law

of one price, then there should also be a relationship in aggregate price levels. Research carried out using the 'Big Mac' hamburgers as an illustration is to explain the Law of One Price. The Law of One Price theory states that the price of a given commodity or product should be the same price when changed to different currency between countries. However, this is not often the case. Using the Big Mac prices in 10 countries, Table 1 shows the prices of MacDonald burger in the 10 different countries; Switzerland has the highest price of burger selling at $7.14 while Hong Kong has the least price of burger which sells at $2.32.

TABLE 1 Relative Prices of Big Mac across some Counties

Country	Prices of Big Mac (in dollars)
Australia	4.47
Canada	5.01
China	2.74
Denmark	5.18
Euro Area	4.96
Germany	4.98
Hong Kong	2.32
Japan	2.97
Switzerland	7.14
United States	4.62

Source: The Economist, June, 2014.

This difference in the price of same good in different countries may lead to the question as to why there is price difference among countries. Rogoff (1996) however explains that non-traded inputs may not be the main reason for differences in prices, Value Added Tax (VAT) may also contribute to violation of LOOP; he further demonstrates his arguments by giving an example, that is, in the United States and Canada, ketchup for hamburger is free but in Italy and Holland, it costs extra cents. The presence of transaction costs, transportation costs, taxes, tariffs, non-tariff barriers and other commission costs would encourage a violation of LOOP says Taylor and Taylor (2004). Also, the difference in the relative productivity and the relative size of the public sector further contributes to the violation (Pakkio and Pollard 2003).

Rogoff (1996) explain that another way of measuring PPP is to employ the Absolute PPP which requires that sums are taken over a Consumer Price Index (CPI); knowing that the sum of price of goods in home country is the same as the sum of price of goods in another country. There is however acquisition as to which consumer price index, if it is home or foreign, and the problem associated with trying to implement absolute purchasing power parity, is the little or no available data used in measuring it. Relative PPP on the other hand requires only that

the growth rate in the exchange rate equipoise the discrepancy between the growth rate in home and foreign price levels. Explaining the versions of PPP which may not hold using aggregate price levels with reference to monetary shocks, Frenkel (1981) states that the relationship between exchange rate and to price levels and exchange rate to inflationary differentials are likely to hold if the internal relative prices are stable when there are monetary shocks; although if the relative prices change then PPP may not be valid.

Previous research carried out on PPP shows that there is failure to reject PPP which means PPP does not hold but may only hold in the long run. Many empirical studies show that deviations of PPP in the short-run and validity in the long-run PPP, (Yin-Wong and Kon, 1993). Frankel (1980, 1990 in Taylor and Taylor 2004:143) argues that not rejecting the null hypothesis does not mean the researcher should accept the null hypothesis. Rogoff (1996) states that the reason for failure to reject null hypothesis of real exchange rates is due to lack power in tests. Abuaf and Jorion (1990) are also of the opinion that the negative results obtained in previous empirical research reflect the poor power of the tests rather than evidence against PPP. Aside expanding the range of years in order to reject unit root (random walk), expanding the range of countries can also enhance the power of unit root tests Rogoff (1996). As recommended by Yin-Wong and Kon (1993), the decision on what index to use to test for long run PPP is between Wholesale Price Index (WPI) which is also called Producer Price Index (PPI) and Consumer Price Index (CPI). Testing that PPP may hold in the long-run, Abuaf and Jorion (1990), Yin-Wong and Kon (1993), Farooq (2006) suggests that WPI tend to yield more favourable test results to the long-run PPP considering that WPI has more weight on tradable than CPI. Abuaf and Jorion (1990) and Farooq (2006) went further to test for PPP using exchange rate, WPI and CPI came to the conclusion that PPP might hold in the long-run. Galliot (1970) using wholesale price and exchange rate found evidence for PPP in international trade. However, Officer (1980) explains that findings that employ the use of WPI tend to favour the PPP theory, although, there are usually loopholes in this findings; considering the WPI is heavily weighted with traded goods and may provide bias results. Taylor and Taylor (2004) who also lay claims that PPP may hold in the long run, in the sense that there is significant mean reversion in real exchange rate; explaining that there may be factors encroaching on the equilibrium real exchange over time. However, some researchers do not agree with this result. Bahmani-Oskooee et al (2009) using the ADF and KSS tests to evaluate biasness in productivity as the cause of breakdown in PPP, found evidence for this, especially when the KSS is used. They also propose that test for stationairty in the real effective exchange rate will tend to reject PPP; and in the case of non-stationarity, there is deviation from its equilibrium.

Testing for purchasing power parity, Frankel and Rose (1995) used the panel and cross-sectional data and found that there is deviation from PPP and a half-life of approximately four years. They further suggest that using time-series approach may not derive such results; therefore, it is recommended to use the cross-sectional approach. In the light of price level and exchange rate, Frenkel (1981) lays argument on the modern approach to PPP analysis; he infers that the main point on the analysis of exchange rate insinuates that there is an underlying dissimilarity between the features of exchange rate and a nation's price level. Corbae and Oularis (1988) used the cointergration method to test if absolute PPP holds; their theory was that if PPP holds, then real exchange rate would be said to be stationary. However, they were unable to reject null hypothesis implying PPP does not hold. However, Kim (1990) who also employed the cointegration approach to test for PPP, using CPI, WPI and bilateral exchange rate concluded that PPP holds. The researcher asserts that there is a linear relationship between nominal exchange rate and relative exchange rate. Glen (1992) in an attempt to test for PPP examined the real exchange rate in short, medium and long run, with reference to the ex-ante PPP theory used monthly and annual data of the post-Bretton Wood era. He explains that ex-ante PPP theory implies that real exchange rate is a martingale and neither absolute nor relative PPP; while testing for autocorrelation in real exchange rate, Glen finds out that the martingale hypothesis is rejected and there is evidence in favour of mean-reversion and long-run PPP. Officer (1980) in his test using effective exchange rate and price ratios finds that deviation from PPP follow a normal distribution and cannot be rejected, and that this deviation from PPP can be explained using structural changes in economies.

Although most studies make use of price index and exchange rates from industrialized countries, Bahmani-Oskooee (1993) and Arize (2011) are among the few researchers that tested for PPP in Less Developed Countries LDCs. However, it is a known fact that developing countries have a notable distinction with developed countries Arize (2011). Bahmani-Oskooee (1993) used the effective exchange rate of LDCs in cointegration method. He argues that the cointegration method implies that some non-stationary variable may drift apart in the short run but may intersect at equilibrium in the long run. From his test, he concluded that PPP does not successfully hold in both high-inflation and low-inflation countries LDCs. Arize (2011) on the other hand concluded that PPP holds. He tested for PPP using the KPSS and KSS techniques based on a monthly data and further suggested that the use of real effective exchange rate ensures the problems concerning the possibility of numeraire currency are avoided. The researcher's conclusion was based on the test carried out that stationarity of real effective exchange rate is over 80% which implies that PPP is valid in the long run. The result by Arize (2011) indicates that real exchange rate is generally mean reverting for LDCs.

Further examination of exchange rate and prices and it influence of purchasing power parity, the problem of structural change in the economy may cause an invalid PPP theory. Julia et al (1996) and Sabate et al (2013) examined the presence of structural breaks. Julia et al (1996) tested for cointegration in the presence of structural breaks and explains that structural break has little effect on the size of the cointegration tests studied, although, the break has an effect on the cointegration test when the procedure generating the data does not have a common factor. In Sabate et al (2013) examination where they tested for structural breaks and PPP, they show that if unit root is rejected, then real exchange rate will retrogress to PPP and this will further allow the application of cointegration tests in order to pinpoint long run equilibrium between nominal exchange rate and price index.

Correspondingly, with emphasis on monetary models, Dornsbusch (1980) suggest that the poor performance of PPP leads to an invalid theory in determining exchange rate; however, Hakkio (1982) argues against this, stating that PPP is the building block of monetary models in exchange rate determination. Hakkio (1982) finds that deviations from PPP are obstinate and valid; he also shows that estimation of the monetary model of exchange rate determination is expected to allow deviations from short run PPP.

METHODOLOGY

Data Description

The primary source of this data is Macrobond, which is a research platform that provides millions of financial instruments' in Excel format, ensuring flexibility when downloading data. It is a one time period quarterly data ranging from 1983 to 2013 in which the test is carried out using Eviews. The data obtained however is concerned with hyperinflation and low inflation countries. USA is the low inflation country which is the local currency with its trading partners as Australia, Canada and Japan. Argentina which is the hyperinflation country is the local currency with its trading partners as Australia, Canada and Japan.

The variables used are the effective nominal and real exchange rate, consumer price index (CPI) and wholesale price index. However, there were some problems encountered while obtaining these data. Some of the data were provided in monthly frequency so had to be converted to a quarterly data. Also, in the case of Argentina, the data provided for WPI could not be used as some year's data were unavailable and after been logged, the initially provided data became insignificant due to the negative signs. This led to an inability to run test using the Argentina WPI.

Analytical Tools

In order to investigate the validity of purchasing power parity doctrine, the empirical tests used include the Augmented Dickey-Fuller (ADF) test, Kwaistkowski-Philips-Schmidt-Shin (KPSS) test, confidence interval test, OLS recursive estimation, CUSUM of squares test, Chow test and Bai-Perron test. These tests are briefly explained below:

Augmented Dickey-Fuller (ADF) test:

The Dickey-Fuller test which was developed by D. Dickey and W. Fuller in 1979 is to test for unit root in autoregressive models. The simple model is given as:

$y_t = \rho y_{t-1} + u_t$ t = 1,2,3…. (1)

where u_t is the error term with an independent normal random variable with zero and variance; iid (0, σ_u^2), y_0 = 0, ρ is the parameter, y_t converges (as $t \rightarrow \infty$) to a stationarity time series if $|\rho| < 1$. If $|\rho| = 1$, then the time series is stationary and if $|\rho| > 1$, then the time series is not stationary and its variance grows exponentially as t increases (Dickey and Fuller, 1979). EwaSyczewska explains the Dickey-Fuller test where he shows the null hypothesis model which is shown as:

$\Delta y_t = \varphi y_{t-1} + u_t$ *t = 1,2,…* (2)

considering that the null hypothesis;

H_0: $\varphi = 1 \rightarrow y_t \sim I(1)$

H_1: $\varphi < 1 \rightarrow y_t \sim I(0)$

However, the ADF test has mainly been criticized for its low power against the alternative hypothesis, that the series is stationary. This has led to the introduction of the KPSS test which is used alongside with the ADF test to test for stationarity and unit root.

Kwaistkowski-Philips-Schmidt-Shin (KPSS) test:

The KPSS test which was developed by Kwaistkowski et al in 1992 has recently become widely used to test for stationarity. Although, the test is used alongside the ADF unit root test or the Philips-Perron unit root tests. The simple model is given as:

$y_t = \xi_t + r_t + \varepsilon_t$ (3)

Where β_t is a random walk which is given as:

$r_t = r_{t-1} + u_t$ (4)

where y_t, t = 1,2,3…,T, ε_t and u_t are the iid (0, σ_u^2). The initial value r_0 is treated as fixed and serves the roles of an intercept. The stationarity hypothesis is $\sigma_u^2 = 0$. Assuming that ε_t is stationary under the null hypothesis, y_t is trend stationary. That is, when $\xi_t = 0$, the null hypothesis means that y_t is stationary around r_0. If $\xi_t \neq 0$, then this means that the null

hypothesis y_t is stationary around the linear trend (Kwiatkowski et al, 1992). Ewa explains that if the variance σ_u^2 is greater than zero, then $y_t$is non-stationary in the presence of unit root.

Kwiatkowski et al (1992) and Ewa further shows that the model given in equation (4) implies that;

$$\Delta y_t = \xi + u_t + \Delta\varepsilon_t = \xi + w_t$$

wherew_t is defined as:

$w_t = u_t + \Delta y_t$

which is the error in expression for Δy_t (kwaitkowski et al, 1992) also demonstrates that if $u_t$and $\varepsilon_t$are iid and mutually independent, w_t has a non-zero one-period autocorrelation, with all other autocorrelations equal to zero, and can be expressed as an autoregressive process AR(1) : w_t = v_t + Θu_{t-1}. Therefore, the KPSS model is then expressed as:

$y_t = \xi + \beta y_{t-1} + w_t$,

$w_t = u_t + \Theta u_{t-1}$, β = 1

The above model suggests that the relationship between ADF and KPSS given β = 1.

OLS Recursive Estimation:

Farooq (2006) suggests that the PPP theory implies that the real exchange rate (R) revolves around a constant equilibrium level, ψ, over time. He formalized this into the equation shown below:

$R_t = \psi + \sum_{i=1}^{n} \beta\,(R_{t-1} - \psi) + \varepsilon_t$ (5)

ε_t is the error term which is iid (0, σ_u^2). The value of $\sum_{i=1}^{n} \beta$ (which can be denoted as δ) should be less than 1 for R to converge towards ψ after a shock. If δ is equal to 1, then R follows a random walk. Farooq (2006) went further to formulate the equation in the ADF framework by giving:

$\Delta R_t = \alpha - (1 - \delta)R_{t-1} + \sum_{i=1}^{n} \beta\,\Delta R_{t-1} + \varepsilon_t$ (6)

where the hypothesis of the model is:

H_0: δ = 1

H_1: δ < 1

CUSUM Square Test:

The CUSUM square test is used to test for structural break in the economy which may cause a shift. Greene in his book gives the model as:

$V_t = Y_t - \alpha_{t-1} + \beta_{t-1} X_t$ (7)

where α_{t-1} and β_{t-1} denote the OLS estimates based on the first t-1 observations. Assuming σ_{st}^2 denotes the variance of the recursive residuals and $w_t = \frac{vt}{\sigma st}$ and under the null hypothesis of no structural change $w_t \sim N(0, \sigma^2)$. If the distribution of w_t changes over time, then there is a structural change. CUSUM test is based on the cumulative sum of w_t, and if the test statistics are outside the confidence bound, then, the null hypothesis is rejected.

Chow Test:

This test was introduced by Gregory Chow in 1960 for the purpose of testing for structural break. The model is shown as:

$y_t = a + bx_t + \varepsilon$ (8)

where the coefficients are assumed to change at $t = t_1$, and are split into two groups; y_1 and x_1, y_2 and x_2. The associated coefficients are $B_1 = a_1, b_1$ and $B_2 = a_2, b_2$. The null hypothesis is then given as $H_0: B_1 = B_2$.

In addition, the Chow test has an important limitation which is the break date which is made a priori (Hansen, 2001). For this reason, researchers recommend the use of the Bai-Perron test along with the chow test in order to test for accurate and correct results.

Bai-Perron Test:

The Bai-Perron test which has recently been developed by Bai J. and Perron P. in 2003 is used to test for multiple structural breaks. Explaining that the problems of multiple structural changes is not a lot but has an increasing attention. Considering a multiple linear regression, they show the following model:

$y_t = x_t'\beta + z_t' + u_t \quad t = T_{j-1} + 1,\ldots,T_j$ (9)

for j = 1,…, m+1, y_t is the dependent variable at time t; x_t (p × 1) and z_t (q × 1) are vectors of covariates and β and δ_j (j = 1,..,m + 1) are the corresponding vectors of the coefficients; u_t is the error term at time t. The break points ($T_1,\ldots,T_m$) are treated as unknown. The unknown regression coefficients together with the break points are estimated when observations at time T are available. Furthermore, when p = 0, the pure structural change model is obtained, where all the coefficients are subject to change and the breaks in the variance are permitted so long the occur at the same dates as the breaks in the parameters of the regression (Bai and Perron, 2003).

As earlier stated, consumer prices and wholesale prices and effective nominal and real exchange rate were estimated using the above tests. Testing for real exchange rate between USA, Canada, Australia and Japan, to give an understanding of the variable used in the next

chapter, the variable is explained in the models below. The variables were logged due to the high values obtained in order to allow for an accurate comparison between countries

q_t =*logr* - logp_t+ logp_{t1}+ logp_{t2}+ logp_{t3} (10)

where q_t is the real exchange rate between US, Canada, Australia and Japan, logr is the log of effective real exchange rate of U.S dollar, logp_t is the log of U.S CPI, logp_{t1} is the log of Australia CPI, log$p_{t2}$is the log of Canada CPI and logp_{t3} is the log of Japan CPI. Further testing for validity in PPP theory, the effective nominal exchange rate is used. The model is given as:

logn c diffn(11)

However, before estimating this model, the variable for diffn is generated. This is shown below:

diffn= logp_t- logp_{t1}- logp_{t2}- logp_{t3} (12)

wherelogn is the log of effective nominal exchange rate and diffn is the difference of all countries' consumer prices. Additionally, testing for cointegration, the model used is given as:

u_t = *logn* – (logp_t- logp_{t1}- logp_{t2}- logp_{t3})

knowing that logn is the effective nominal exchange rate, which is differenced from the consumer prices. Using the wholesale prices and effective exchange rate to evaluate the purchasing power parity theory, the equation is:

v_t = $logr$ - $logw_t$ + $logw_{t1}$ + $logw_{t2}$ + $logw_{t3}$ (13)

wherev_t is the real exchange rate between US, Canada, Australia and Japan, logr is the log of effective real exchange rate of U.S dollar, $logw_t$ is the log of U.S WPI, $logw_{t1}$ is the log of Australia WPI, $logw_{t2}$is the log of Canada WPI and $logw_{t3}$ is the log of Japan WPI. Estimating the nominal exchange rate, the model estimated is given as:

$logn\ c\ diffm$ (14)

knowing that:

$diffm = logw_t$- $logw_{t1}$ - $logw_{t2}$ - $logw_{t3}$ (15)

where$diffm$ is the difference of all four countries' wholesale prices, $logn$ is the effective nominal exchange rate. For the cointegration test, the wholesale prices and effective nominal exchange rate for USA against the three countries is differenced. This is shown below:

w_t = $logn$ – ($logw_t$- $logw_{t1}$ - $logw_{t2}$ -$logw_{t3}$) (16)

The model used to estimate the OLS recursive estimation, chow test, CUSUSM test and Bai-Perron test is shown below:

qt c logr (17)

whereq_t is the real exchange rate equals the estimation of U.S dollar and consumer prices, c is the constant and log_r is the log of effective exchange rate of USA.

In addition, the variable used to test the purchasing power relationship between Argentina and its trading partners is specified below;

$R_t = logargr - logargpt + logp_{t1} + logp_{t2} + logp_{t3}$ (18)

where R_t is the real exchange rate between the four countries, $logargr$ is the log of Argentina effective real exchange rate which is differenced from the sum of all four countries' consumer prices, namely Argentina, Australia, Canada and Japan. For nominal exchange rate, the model is specified below:

$logargn\ c\ diffp$ (19)

considering that:

$diffp = logargpt - \log p_{t1} - \log p_{t2} - \log p_{t3}$ (20)

given that $diffp$ is the difference of all consumer prices, $logargn$ is the log of Argentina peso effective nominal exchange rate and c is the constant. The cointegration model is seen below:

$y_t = logargn - (logargpt - \log p_{t1} - \log p_{t2} - \log p_{t3})$ (21)

EMPIRICAL RESULTS

This chapter explains the empirical results which are divided into four sections. The first section involves the use of effective exchange rate and consumer price index (CPI) of USA and its trading partners, the second section involves the use of effective exchange rate and wholesale price index (WPI) of USA and its trading partners, the third section is the effective exchange rate and consumer price index (CPI) of Argentina and its trading partner and the last section shows the structural break tests carried out on both hyperinflation country_Argetina and low inflation country_USA. Note that the same test procedure is used in the first 3 sections and so the results may not be explained in detail is section 2 and 3. The variables used are explained below.

- QT – real exchange rate of USA, Australia, Canada and Japan. It contains the real effective exchange rate of USA and the consumer price index of all four countries.
- DIFFN – the difference of USA, Australia, Canada and Japan consumer price index.
- LOGN – the effective nominal exchange rate of USA
- UT – difference of effective nominal exchange rate, and all four countries' consumer price index.
- VT – real exchange rate of all four countries. It contains the real effective exchange rate of USA and the wholesale price index of all four countries.
- DIFFM – the difference of all four countries' wholesale price index.

- WT – difference of effective nominal exchange rate and all four countries' wholesale price index.
- RT – real exchange rate of Argentina, Australia, Canada and Japan which is computed using effective real exchange rate, and CPI of all four countries.
- DIFFP – the difference of Argentina, Australia, Canada and Japan.
- LORGARN - Argentina effective nominal exchange rate.
- YT – difference of Argentina effective nominal exchange rate and CPI of all four trading partners.

These tests carried out is set to prove that PPP does not hold among these trading partners due to failure to reject null hypothesis.

Section 1

Graph 1 plots for stationarity and unit root test based on the real effective exchange rate. The graph indicates a positive intercept of approximately 13.1; however, the variable is non-stationary and has no trends. The graph further indicates there is an upward movement in the variable implying that from year 1983 to 2013, there was no shock to cause a mean reversion in the variable. Furthermore, Table 2 reports the outcome of both the ADF and KPSS tests in testing for unit root and stationarity. The KPSS test indicates that the test for null hypothesis; noting that the test statistics is higher than the critical values; the test result shows that the variable is non-stationary in null hypothesis test. Also, the null hypothesis cannot be rejected based on the ADF unit root test; where the statistic is less than all levels of significance, and with a probability almost 1, which implies that PPP does not hold. Further test is carried out based on the effective nominal exchange rate as seen in Table 3.

Graph 1 QT

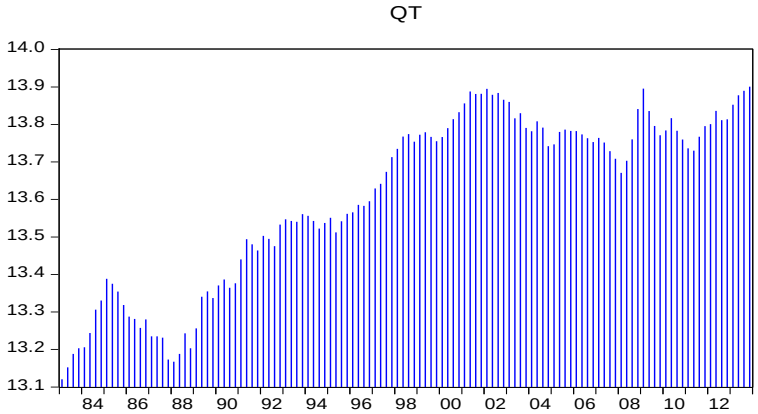


Table 2 Unit Root and Stationarity Test

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: QT has a unit root Exogenous: Constant, Linear Trend			
		T- Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.126899	0.5254
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: QT is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.250889
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Table 3 Test using Effective Nominal Exchange Rate

Variable	Coefficient	Probability
C	-3.607734	0.0000
DIFFN	-0.872779	0.0000
R-Squared		0.770762
F-statistic		410.1985
Probability (F-stat)		0.000000
Durbin-Watson Statistic		0.055712

Table 3 shows test of PPP employing nominal exchange rate. R^2 0.77 which implies that the total variability of the dependent variable is only explained by 77%. F-statistics indicates that the variables are statistically significant with a p-value of 0.00. Durbin-Watson statistics been 0.05 leads to some doubts on the model which means the model suffers from positive serial correlation. On the table, diffn is indicated to be negative, -0.87 which is far from 1. This result therefore implies that PPP is not valid. Further estimation is carried out to verify the authenticity of the above tests already done. Graph 2 tests for cointegration between effective nominal exchange rate and the difference of CPI. The graphs show that the models are non-stationary

but there may be long run behaviour, which makes inference possible that PPP may hold in the long run.

Graph 2 DIFFN & LOGN

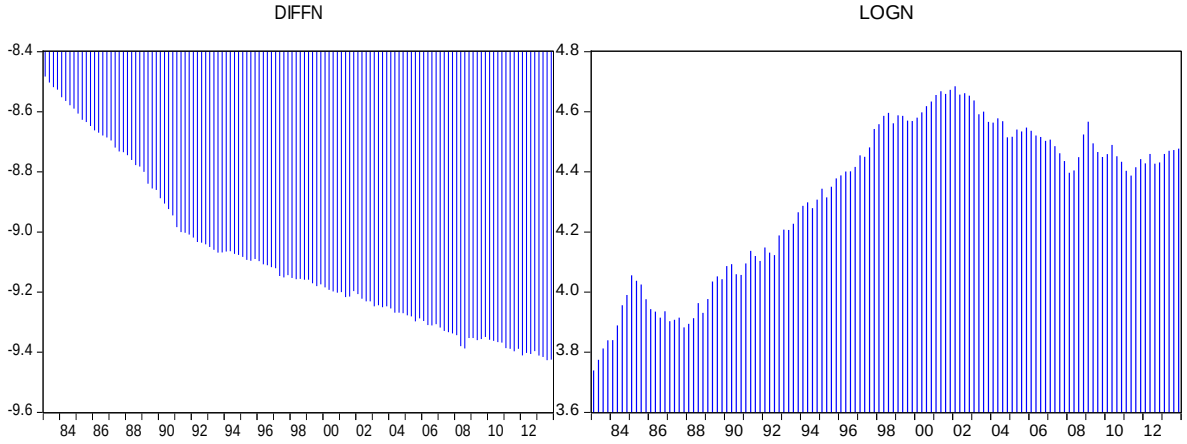


Table 4 Unit Root Test for LOGN and DIFFN

I. **Augmented Dickey –Fuller Unit Root Test**

LOGN:

Null Hypothesis: LOGN has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.172782	0.9111
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: LOGN is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.302929
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Table 4....

II. **Augmented Dickey –Fuller Unit Root Test**

DIFFN:

Null Hypothesis: DIFFN has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.09569	0.5427
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: DIFFN is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.3018
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Drawing a conclusion from the cointegration test, residual series is generated and tested for stationarity and unit root and null hypothesis is not rejected, indicating that PPP does not hold. This is shown in Graph 3 and Table 5. The results report again, that null hypothesis is not rejected and there is also no stationarity in null hypothesis test which corresponds with the test above that PPP does not hold but may hold in the long run.

Graph 3 UT

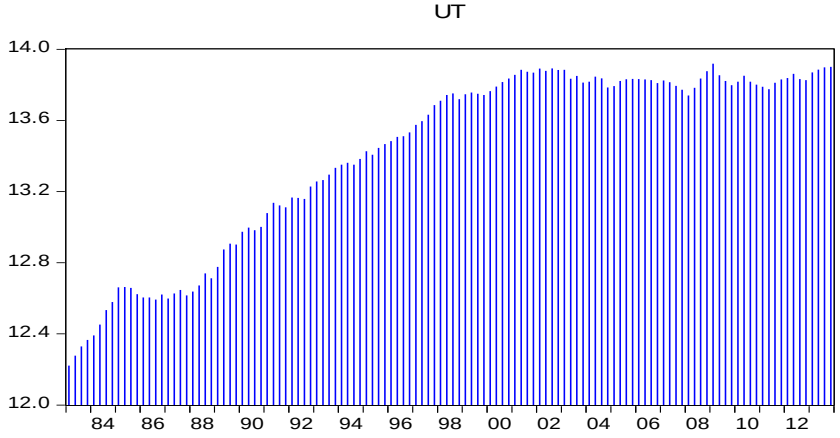


Table 5 Unit Root and Stationarity Test UT

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: UT has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.218992	0.9017
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

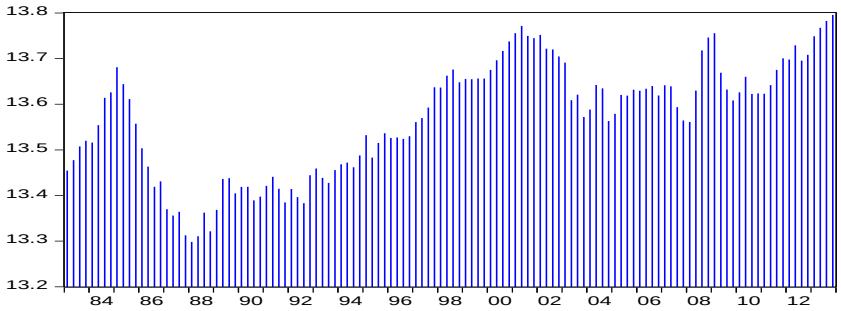
Null Hypothesis: UT is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.334381
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

These tests carried out further implies that since there is inability to reject null hypothesis of non-stationarity, then a conclusion is reached that PPP does not hold between the four countries.

Section 2

This section as earlier stated employs the use of WPI to test for PPP validity. The procedure follows the same test procedure as the first section. Graph 4 shows a more inconsistent behaviour in real exchange rate. As seen, between year 1987 and 1989, there was a downward movement in exchange rate, although, between 1998 and 2002, exchange rate moved upwards, therefore, there is no trend it the movement.

Graph 4 VT



The graph shows a positive intercept beginning from 13.45, and there is also no shock of mean reversion in the variable. The tests for stationarity and unit root test in table 6 infer that the null hypothesis is non-stationary and is not rejected. The test in table 6 further shows that PPP does not hold since null hypothesis cannot be rejected.

Table 6 Unit Root and Stationarity Test for VT

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: VT has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.451268	0.3517
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

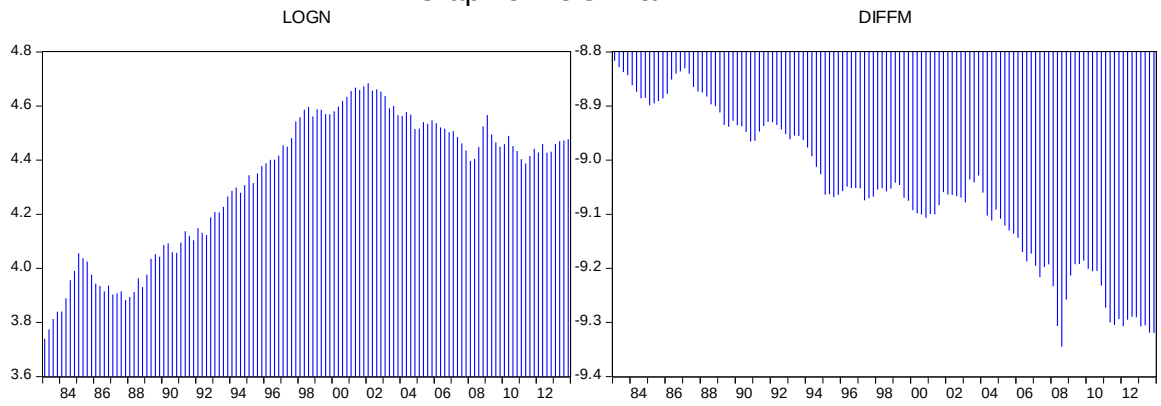
Null Hypothesis: VT is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.105107
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Using the nominal exchange rate, table 7 has an R^2 0.55, this proposes that the total variability of the dependent variable is only explained by 55%. F-statistics indicates that there is no reversion and has a p-value of 0.00. Durbin-Watson statistics suffers from positive serial correlation of been 0.04 leads to some doubts on the model which means the model suffers from positive serial correlation.

Table 7 Test using Effective Nominal Exchange Rate

Variable	Coefficient	Probability
C	-8.190032	0.0000
DIFFM	-1.382361	0.0000
R-Squared		0.558134
F-statistic		154.1019
Probability (F-stat)		0.000000
Durbin-Watson Statistic		0.046525

Graph 5 LOGN & DIFFM



From the cointegration test, logn moves in and upward and downward behaviour, although diffm on the other hand moves in a downward behaviour. Diffm from table 8 shows a probability of 0.00 and a test statistic of -4.03; however there is also no cointegration between these variable and null hypothesis cannot be rejected implying PPP is invalid.

Table 8 Unit Root Test for LOGN and DIFFM

LOGN:

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: LOGN has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.172782	0.9111
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Table 8....

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: LOGN is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.302929
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

DIFFM:

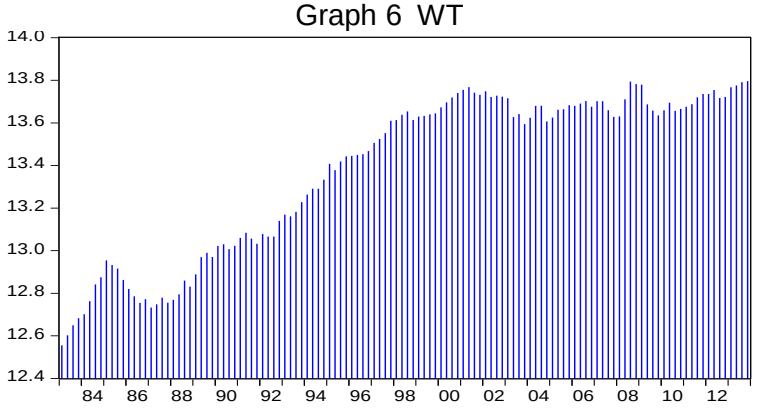
Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: DIFFM has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.039652	0.0099
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: DIFFM is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.094185
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Graph 6 WT



Inability to reject null hypothesis from table 9 results leads to a conclusion that PPP does not hold.

Table 9 Unit Root and Stationarity Test for WT

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: WT has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.539929	0.8104
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

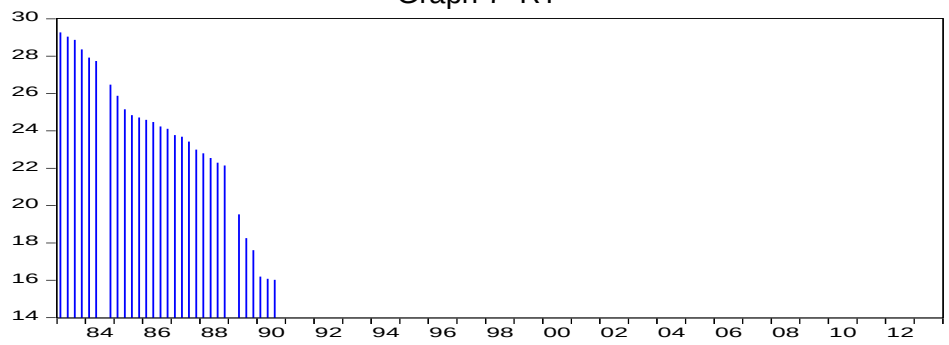
Null Hypothesis: WT is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.293312
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Although, wholesale price index has been argued by some researchers to be in favour of PPP, this paper proves otherwise. There is failure to reject null hypothesis, therefore, suggesting that PPP truly does not hold between these countries.

Section 3

This section shows empirical test carried out with Argentina being the home country.

Graph 7 RT



The above table shows an intriguing movement in real exchange rate. An upward movement is consistent on 1983 but it decreases over the years and from 1991, there is sign of either and upward or downward movement in real exchange rate.

It can therefore be speculated that due to the pegged Argentina Peso with U.S dollar between 1991 and 2002, the real exchange rate movement became highly inconsistent. It should be noted that the pegged currency was done in order to eliminate hyperinflation and enhance economic growth in Argentina.

Table 10 Unit Root and Stationarity Test for RT

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: RT has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.060954	0.9946
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: RT is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.12012
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

The unit root and stationarity tests carried out in table 11 infer that null hypothesis is non-stationary; therefore, null hypothesis cannot be rejected; this infers that PPP theory is invalid. Moving further, using the effective nominal exchange rate, there is evidence of positive serial correlation. Given the F-statistic and probability, it shows that the variables are significant but this does not guarantee that PPP holds.

Table 11 Test using Effective Nominal Exchange Rate

Variable	Coefficient	Probability
C	-3.922432	0.0000
DIFFP	-0.009726	0.0000
R-Squared		0.026154
F-statistic		0.725110
Probability (F-stat)		0.401962
Durbin-Watson Statistic		0.525623

Graph 8 shows that the variable are not cointegratedand from table 12, null hypothesis is not rejected, therefore suggesting that PPP is invalid between Argentina and its trading partners.

Graph 8 LOGARGN & DIFFP

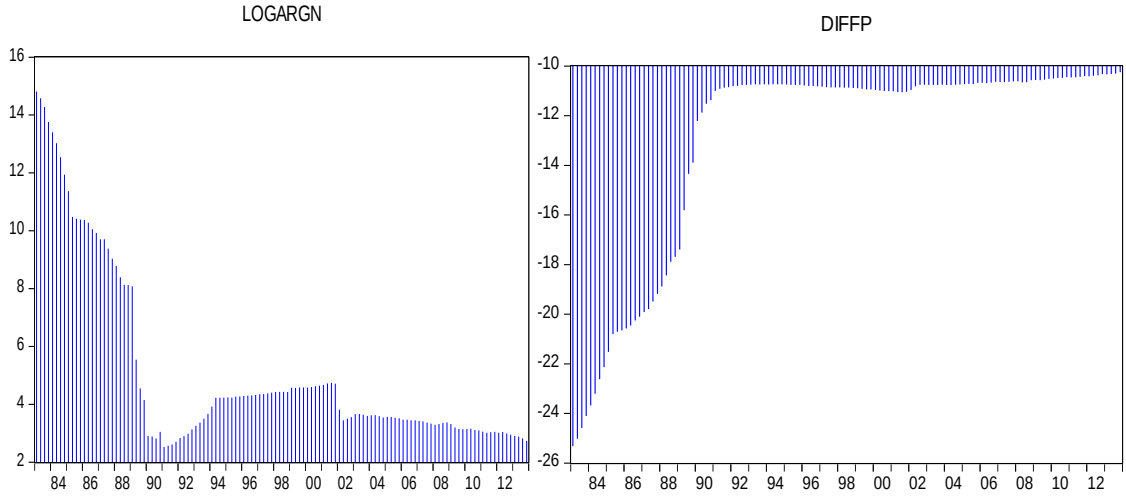


Table 12 LOGARGN:

Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: LOGARGN has a unit root Exogenous: Constant, Linear Trend		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.966563	0.146
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Table 12....

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: LOGARGN is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.223244
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

DIFFP:

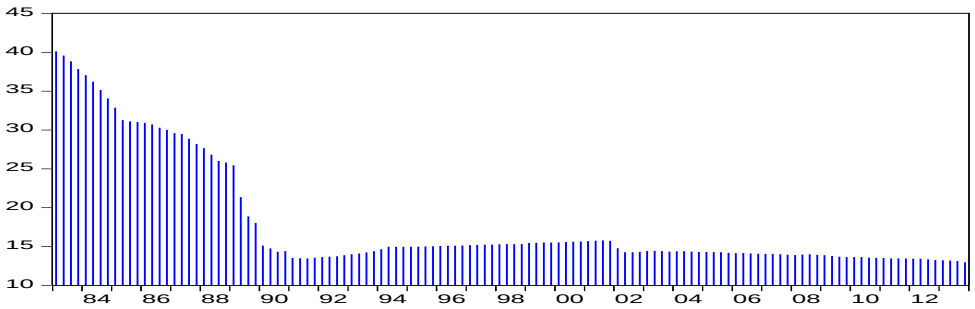
Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: DIFFP has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.666491	0.2524
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: DIFFP is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.279236
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Graph 9 YT



Graph 9 and table 13 therefore suggest that PPP is not valid owing to the fact that null hypothesis cannot be rejected.

Table 13 Augmented Dickey –Fuller Unit Root Test

Null Hypothesis: YT has a unit root Exogenous: Constant, Linear Trend			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.844449	0.1846
Test critical values:	1% level	-4.034997	
	5% level	-3.447072	
	10% level	-3.148578	

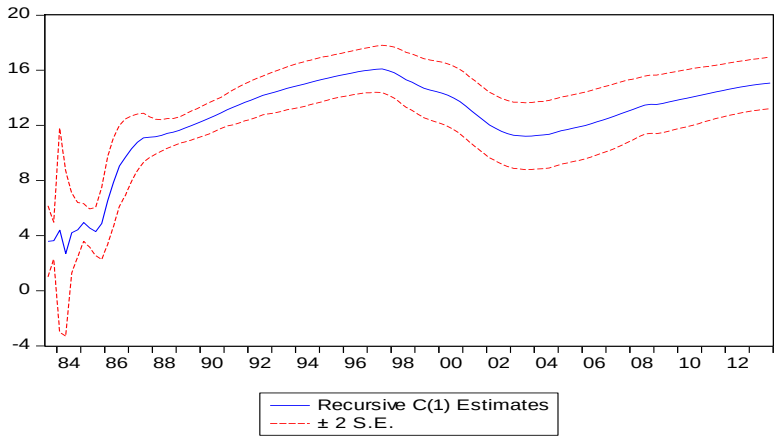
Kwiatkowski-Phillips-Schmidt-Shin Test

Null Hypothesis: YT is stationary Exogenous: Constant, Linear Trend		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.257155
Asymptotic critical values*:	1% level	0.216
	5% level	0.146
	10% level	0.119

Section 4

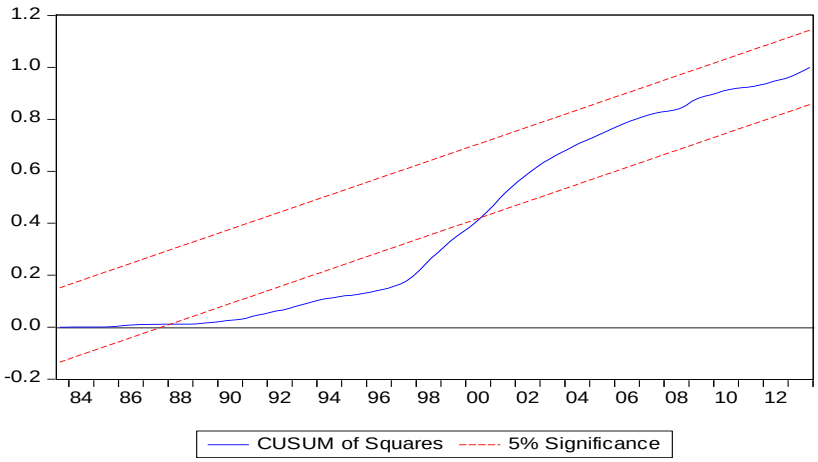
Further test is carried out on the USA and Argentina, testing for possible structural breaks over time. As seen in graph 10, there is no stability over the years. There is a major structural change in 1984 and 1985 and another structural change between 2002 to 2007.

Graph 10 Testing for possible structural breaks over time



The possibility of structural break, that is, an unexpected shift at a point in time may lead to some speculations. Graph 11 show that there is a structural break between 1990 and 1998, where the test statistics is outside the confidence interval with 5% significance which implies that the null hypothesis is rejected. Further test is carried out in Table 14 to verify the authenticity of the CUSUM of squares test.

Graph 11 Testing for possible structural breaks over time (a)



Testing for the break point using the chow test, the time of financial crisis is used in order to know if there was any structural break at a point in time and if this may have affected the international trade. Result from table 13 does not authorize the acceptance of null hypothesis; therefore, the null hypothesis is rejected, implying a structural break at that point in time.

Table 14 Chow Breakpoint Test: 2007 (Significance level: 5%)

Null Hypothesis: No breaks at the specified breakpoint

F-Statistics	14.53814	Probability F (2, 120)	0.0000
Log likelihood	26.90384	Probability Chi-Square (2)	0.0000
Wald Statistics	29.07629	Probability Chi-Square (2)	0.0000

Since null hypothesis has been rejected which the P-value is not significant at 5% interval, a conclusion can be drawn that the structural break affected exchange rate and prices at that time, therefore, playing a role in purchasing power parity. Table 15 further shows evidence of multiple breakpoint and dates.

Table 15 Multiple Breakpoints (Bai-Perron) Test for Real Exchange Rate

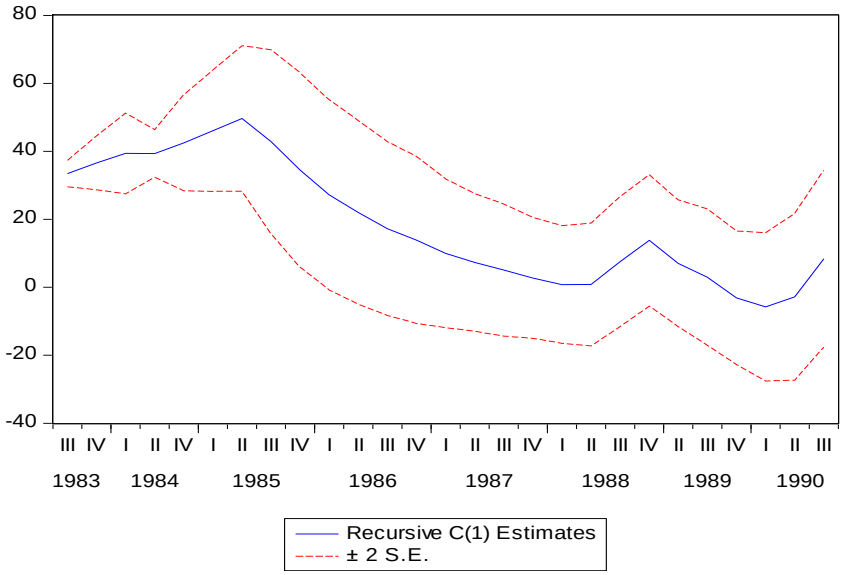
Tests	F-statistics	Critical Values	Break Dates
	5%		
i = 1	270.52	11.47	1997
i = 2	103.06	12.95	1990
i = 3	24.65	14.03	2001
i = 4	13.68	14.85	2008
i = 5	0.00	15.29	-

Notes: The trimming weight is 0.15, which is used to calculate the statistics. The maximum breakpoints are 5 and only 4 break points occurred.

As stated earlier that the structural break which occurred in 2007 due to financial crisis possibly had an effect on exchange rate and prices. Bai-Perron test proves this by showing break dates. The result shows that break dates that occurred were mainly in the 90's and 2000's. Having carried out tests based on USA being a low-inflation country, the same test of recursive OLS estimates and test for structural breaks is also carried out on Argentina being a high inflation country.

Graph 12 shows an incoherent movement in the case of Argentina and there is evidence of structural breaks over time ranging from 1985 to 1988 and again from mid-quarter of 1989 to 1990.

Graph 12 Incoherent movement



As stated earlier in the test carried out on Argentina, the presentation of test result may be due to its pegging with USA and also the poor economy as at that time. The graph 13 below implies that the test statistics is outside the confidence interval between years 1986 to 1990, meaning that null hypothesis is rejected, implying a structural break; this was the period of poor economy when Argentina peso had to be pegged to the U.S dollar.

Graph 13 CUSUM of Squares

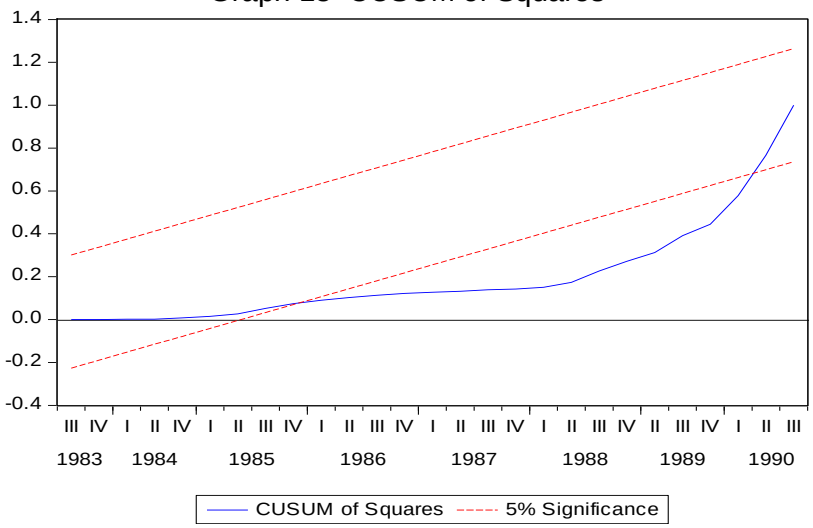


Table 16 shows the breakpoint test in 1990 in which the Argentina peso was pegged to the U.S dollar in order to reduce the national debt in Argentina. The result shows that there was indeed a structural break considering that null hypothesis is rejected.

Table 16 Chow Breakpoint Test: 1990

Null Hypothesis: No breaks at the specified breakpoint

F-Statistics	15.59553	Probability F (2, 120)	0.0000
Log likelihood	23.48657	Probability Chi-Square (2)	0.0000
Wald Statistics	31.19105	Probability Chi-Square (2)	0.0000

The test for possible structural breaks using the Bai-Perron tests shows the dates of structural breaks. Although it does not specify the break date has shown in the chow test, but it still reveals the structural changes from years before 1990.

Table 17 Multiple Breakpoints (Bai-Perron) Test for Real Exchange Rate.

Tests	F-statistics	Critical Values 5%	Break Dates
i = 1	31.79	11.47	1989
i = 2	44.16	12.95	1985
i = 3	11.77	14.03	1987
i = 4	3.78	14.85	-

Notes: The trimming weight is 0.15, which is used to calculate the statistics. The maximum breakpoints are 5 and only 4 break points occurred. The significance level is 5%.

CONCLUSION

The purchasing power parity doctrine has been exposed to different empirical research and conclusion on its validity. While some researchers argued that PPP does not hold, some argued that it does hold but in the long run, at the point where it meets equilibrium.

The results based on the tests carried out, using both CPI and WPI, gives evidence that PPP does not hold in both cases of high and low inflation countries. The economic state of the high inflation country_Argentina, showed evidence of hiccups in the results which insinuated that of a truth PPP does not hold. However, a final conclusion cannot be drawn that in the long run, PPP would hold in Argentina, and if it does, how long is the long run? This is a situation that further needs to be researched. It should be noted that limitations which includes collating the Argentina WPI data was encountered which lead to a loophole in estimating all necessary data and has further resulted to the recommendation for further study to be carried out.

Additionally, there is evidence of structural break at a point in time which suggests that exchange rate and prices would have been affected during this period. It can therefore be concluded that the PPP theory is invalid in the short run in both economic states which may be as a result of structural breaks over the time period.

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