Inflation and the Purchasing Power Parity in South Africa

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This paper seeks to ascertain whether current inflation differentials can explain the differences between contemporaneous and previous exchange rate levels for South Africa and each of five of her trading partners in the developed world: the US, the UK, France, Germany and Japan. With the help of the absolute version of the Power Parity Theory (PPP) theory, the nominal exchange rate and national price levels are treated as integrated processes that will allow for trade between a pair of countries to make the exchange rate a stationary variable. After performing Ordinary Least Squares Regression tests, unit root tests are conducted on the various price and exchange rate variables. Next, using the Johansen Cointegration method, the paper investigates whether there is an underlying long-term relationship between the price differentials and the exchange rate for South Africa and each of these five developed countries (DCs). These various tests yield results that are generally mixed to somewhat unfavorable to the PPP Theory.

INTRODUCTION

This paper applies two of the more recent techniques in econometrics, unit root and cointegration, to one of the oldest and certainly unresolved issues in economic theory, namely the Purchasing Power Parity theory. The PPP derives its policy importance from the fact that if there were to be a real depreciation of a nation's currency away from its underlying equilibrium level this would precipitate countervailing trade flows that would ultimately lead the real exchange rate back to the previous equilibrium level, (Peter C Lui 1998). Further, deviations of the real exchange rate away from equilibrium could quantify the degree of currency misalignment (Edwards 1999, Machlup1973), and signal the necessary policy intervention as well as the level of aggressiveness by the monetary authorities in executing such a policy.

It must be noted that extensive research on the PPP over the last 30 years on this subject appears to have approached a number of consensus points: that the PPP works best in the long run; that there is no assurance of precisely a value of negative and a positive 1 on the lagged coefficients of domestic and foreign price levels respectively in a regression equation where the dependent variable is the nominal exchange rate; and that the PPP has greater explanatory power in the context of shocks of a monetary nature, usually in high inflation situations (Taylor 1988).

As South Africa is one of a handful of less developed countries that have for reasonably extended period of time kept its currency (the RAND) as a convertible unit (see Gunnar Jonsson 2001) a full examination of the effects of price differentials on the exchange rate should be revealing.

First a few observations are in order regarding South Africa’s recent economic performance. Table 1 compares the inflation experience of all six countries involved in this paper. Over the relevant study (1971 to 2012), South Africa had an inflation rate that was more than double that of all of the DCs, except for the UK where the margin was 9.61% to 6.04% over the UK. Also over every five-year period, South Africa's inflation rate exceeded that of every other developed country with the exception of the UK, 1971 to 1975 and 1976 to 1980, and Japan 1971 to 1975.

As did the rest of the world, South Africa suffered a severe decline in real GDP during the 2007 to 2009 financial crisis, but experienced a rapid return to growth, up to 4% by the end of the first quarter of 2011. Since then economic growth has relented, with unemployment remaining very high, in a range of 23 to 26% over the last four years, (see Moody's Analytics 2013). While South Africa traditionally sported a Merchandise Trade surplus over most of the 1971 to 2005 period, a growing Current Account deficit opened up over the last dozen years, with the Current Account deficit going from just under 1.3% of GDP in 2000 to about 2.5% in 2005, and reaching an estimated 4.3% in 2012,(see Bloomberg News). Finally, we note that the data used in this study are quarterly from 1972-2010, and are obtained from the IMF Monthly Financial Statistics. The nominal exchange rate used is a bilateral exchange rate between South Africa and each of the DCs, and is measured as the number of South African Rands that commands a single unit of the foreign currency.

TABLE 1
THE AVERAGE ANNUAL INFLATION RATE

Year	US	UK	France	Germany	Japan	South Africa
1971-1975	6.79%	13.16%	8.84%	6.13%	11.57%	9.40%
1976-1980	8.94%	14.47%	10.51%	4.04%	6.66%	12.04%
1981-1985	5.52%	7.24%	9.67%	3.87%	2.77%	14.01%
1986-1990	3.97%	4.76%	3.05%	1.37%	1.34%	15.34%
1991-1995	3.13%	3.80%	2.23%	3.60%	1.37%	11.33%
1996-2000	2.48%	1.60%	1.21%	1.26%	0.32%	6.68%
2001-2005	2.55%	1.45%	1.91%	1.53%	-0.45%	4.48%
2006-2012	2.35%	3.00%	1.67%	1.75%	-0.10%	5.94%
1971-2012	4.40%	6.04%	4.75%	2.90%	2.89%	9.61%

Note: Author's Calculations based on data published at http://www.inflation.eu.

The paper is organized as follows. The next section lays out the traditional empirical formulation of the PPP Hypothesis, to be followed by a brief description of the two techniques (the cointegration and unit root tests) that will be featured as the primary empirical framework for this study. The next three sections present the empirical results from the Ordinary Least Squares (OLS) regression analysis of the PPP, the Non-Stationary and the Cointegration tests. This section is followed by a brief conclusion.

FORMULATING THE PURCHASING POWER PARITY THEORY

The exchange-rate between two currencies that equates the purchasing power in two countries in the face of likely divergent national price levels is the purchasing power parity rate. If we measure the nominal exchange rate as the number of domestic currency units that commands a single unit of the foreign currency, this can be expressed as:

EQUATION 1

$$S_{it} = \beta_i(P_{it} - P^*_{it}) + \mu_t$$

Where: S_{it} is the nominal exchange rate
P_{it} is the domestic price level
P_{it}^{*} is the foreign price level.

To make Equation 1 more amenable to empirical testing and to the traditional interpretation of the coefficients, it is converted to the following log linear expression:

EQUATION 2

$$S_{it} = \beta_0 + \beta_1 P_t + \beta_1 P_t^{*} + \mu_t$$

Note that this is the absolute version of the PPP accompanied by either the symmetry or the proportionality condition.[1] A milder version (the Relative PPP) merely requires that a nominal exchange rate adjustment provide a percentage match for any relative price adjustment. This formulation implies that deviations from parity (such as excessive inflation in one country) create potentially profitable arbitrage opportunities which when exploited would result in an automatic adjustment of the nominal exchange rate change that would restore the purchasing power to its previous level. It also implies that for a country with a flexible exchange rate system, the exchange rate becomes an endogenous variable.

THE UNIT ROOT AND COINTEGRATION TESTS

The unit root technique begins from a first order regression equation where Y the dependent variable is expressed as:

EQUATION 3

$$Y_T = \rho Y_{t-1} + \delta X_t + E_t$$

Where X_t represents regressors such as a constant or a time trend, ρ and δ represent the parameters and E_t the white noise.

Equation 3 is said to have a unit root and is thus stationary if the value of the coefficient ρ is estimated to be 1 in a simple Dickey-Fuller test. Also higher order series lag correlation can be incorporated into this formulation by adding lagged differential terms of the dependent variable Y. This results in the standard Augmented Dickey Fuller (ADF) test construct that is used in this paper, and is represented below as follows:

EQUATION 4

$$\Delta Y_t = \alpha Y_{t-1} + \beta_1 \Delta Y_{t-2} + \cdots + \beta_t \Delta Y_{t-p} + \delta X_t + V_t$$

Engle and Granger postulated that if each of two variables X and Y possesses a unit root then the residual from a regression of Y and X can be written out as:

EQUATION 5

$$u_t = Y_t - \beta_0 - \beta_1 X_t$$

Once a unit root test confirms that u_t is itself stationary i.e. I(0), without stochastic trends, it can be concluded that Y and X are cointegrated with the implication of the existence of a long-term relationship between them.

TABLE 2
ORDINARY LEAST SQUARE (OLS) RESULTS

Country	CPISA	CPISA(-1)	CPIDC	CPIDC(-1)	R- square	DW
USA	-1.59 (-32.09)		1.63 (14.15)		0.99	0.29
	-3.19 (-3.07)	1.51 (1.50)	-1.61 (-1.08)	3.43 (2.27)	0.99	0.40
UK	-1.19 (-26.62)		0.36 (4.88)		0.98	0.22
	-3.86 (-2.82)	2.60 (1.95)	1.23 (1.07)	-0.76 (-0.66)	0.98	0.28
France	-1.09 (-25.31)		0.36 (4.02)		0.97	0.17
	-2.86 (-2.02)	1.85 (1.34)	11.93 (5.69)	-11.62 (-5.50)	0.98	0.33
GERMANY	-3.07 (-8.20)		7.03 (5.24)		0.84	0.28
	-7.11 (-3.65)	3.96 (2.12)	11.86 (2.74)	-4.63 (-1.06)	0.84	0.42
JAPAN	-0.80 (-33.24)		0.94 (10.72)		0.94	0.20
	-1.21 (-0.87)	0.39 (0.29)	-1.51 (-1.06)	2.46 (1.76)	0.94	0.22

Note: The t-statistics are in brackets after the respective coefficient

EMPIRICAL RESULTS

OLS Regression

Table 2 presents the results of Equation 2, where the bilateral real exchange rate for South Africa with each of the five DCs is regressed against its domestic price level and that of the corresponding DC. For all five countries, the domestic price level carries the expected negative sign while the sign on the DC countries' price level is positive. Further, each of the 10 coefficients is shown to be statistically significant at the 1% level. While the proportionality condition of the absolute version of the PPP is not borne out, as none of these coefficients has a value of exactly 1(absolute value), only in the case of Germany do the coefficients noticeably diverge from absolute 1. Finally, it can be pointed out that in general the coefficient of determination (the adjusted R^2) is generally quite high, exceeding .97 in the US, UK and France.

When the regressions were run with both price levels and their lags, the results were mixed with the contemporaneous price levels retaining the expected sign, while the lagged variables alternated in sign without much of a pattern. Finally the quite low values of the reported Durbin Watson statistics imply the likely presence of Autocorrelation, while a comparison of the size of that latter statistic with the relatively high coefficient for determination (R^2) suggests the possibility that the estimated OLS regressions could be spurious. This raises the question of whether or not these variables do possess a unit root.

Unit Root Tests

The level and first difference stationary tests results are presented in Table 3 for all variables used in this paper, with the null hypothesis being the existence of a unit root. The Augmented Dickey Fuller construct as outlined above in Equation 4 is used together with an automatic lag length following the Schwartz Information Criterion. For this test we accept the null hypothesis of a unit root if the ADF statistic is either more positive or less negative than the reported critical value, and for the first difference test to reject the existence of multiple roots if the ADF statistic is less negative than the reported critical value.

TABLE 3
LEVEL AND FIRST DIFFERENCE STATIONARY TEST

	Level Test	First Difference Test
Variable	**ADF Statistics**	**ADF Statistic**
BXUS	-0.3176	-6.4389
BXUK	-0.6025	-5.1099
BXF	-0.6379	-11.4704
BXG	-0.1085	-5.8183
BXJ	-0.2914	-11.5387
DCPI	-2.585	-3.3436
CPIUS	-2.8936	-3.4132
CPIUK	-2.424	-3.1509
CPIF	-0.9705	-3.5589
CPIG	-0.4736	-6.6056
CPIJ	-3.7918	-4.2568

Note: For the BX variables, BXUS represents the Bilateral exchange rate between the US and South Africa; DCI is South Africa's domestic price level, while CPI is the US price level, etc.

Although there are minor variations in the individual country sample size, the ADF test critical values for both the level and first difference tests at the 1 percent and 5 percent levels are – 3.47 and – 2.88 respectively.

In general, the level test allows us to accept the null hypothesis of a unit root at the 1 percent level. However there are a few variables that would marginally cause us to reject this hypothesis namely Japan's price level (in the level test) and the UK's and South Africa's price level (in the first difference test). However we can reasonably conclude that the variables used in this study are non-singular, possessing one root. The weight of this evidence points to the possibility of a long-run underlying relationship between each bilateral exchange rate and the price levels. The logical next step is the execution of a cointegration test to further investigate the existence and nature of any such relationship.

Cointegration Results

Table 4 reports the results of the cointegration tests where the Johansen method was employed. The test is run using each of the five bilateral exchange rates, the country's domestic price level and the foreign price level as shown in Equation 2. The first column of this table provides the number of cointergrating relations as per the null hypothesis, with the number of reported cointergrating equations shown in the column after each statistic[4]. For the Trace Test, the 5 percent critical values for a null hypotheses of at most 0, 1 and 2 cointegrating vectors are 29.78, 15.49, and 3.84 respectively. The corresponding values for the Maximum Eigen Value test are 21.13, 14.26 and 3.84. All tests are run with an assumed linear deterministic trend.

TABLE 4
COINTEGRATION TEST

TRACE TEST										
CE	US	r	UK	r	FRANCE	r	GERMANY	r	JAPAN	r
0	35.44		38.83		35.9		18.94		48.39	
1	20.39		23.11		18.57		3.97		27.07	
2	6.85	3	9.27	3	6.76	3	0.14	0	11.41	3
MAX EIGENVALUE TEST										
CE	US	r	UK	r	FRANCE	r	GERMANY	r	JAPAN	r
0	15.05		15.73		17.33		14.97		21.32	
1	13.54		13.83		11.81		3.83		15.66	
2	6.85	0	9.27	0	6.76	0	0.14	0	11.41	3

Note: r denotes the number of cointegrating equations.
Note: the number at the bottom of the columns after the coefficients represent the actual number of cointegrating vectors found.

Up to this point the empirical evidence has clearly supported the relevance of the PPP hypothesis in determining South Africa's nominal exchange rate. The results however of the cointegration tests are decidedly mixed. For three of these DC's, the US, the UK, and France there is an open disagreement between the Trace and the Maximum Eigen Value versions of the test, with the former confirming the existence of three cointegration relations while the latter denies the existence of any such relation. As it is generally thought that the Maximum Eigen Value method carries the higher threshold of proof in the Johansen cointegration test, we will defer to it and conclude that for these three countries there is no fundamental underlying relationship between South Africa's exchange-rate with each of these countries and the corresponding national price levels.

For Germany both tests agree that no cointegration exists, but confirm that there are three cointegrating relations for Japan. These results are difficult to explain if one adheres to the PPP hypothesis. First, the greater explanatory power that might have been expected for the bilateral exchange rate with Britain, given South Africa’s longer period of trade relations with Britain, is not borne out by the results. Second, the clear-cut evidence of the PPP hypothesis in the case of South Africa's relations with Japan would seem to contradict earlier findings of the proof of the PPP in cases of countries with historically high inflation rates. After all Japan has enjoyed a lower average annual rate of inflation over the last four decades that each of the other four DCs, while South Africa has seen a higher average than all five DCs (please see http://www.inflation.eu). Thus the overall picture that emerges from these cointegration tests is at best, tepid support for the PPP hypothesis.

CONCLUSION

The goal of this paper was to examine the long run PPP using regression, unit root and cointegration tests on data depicting the relationship between South Africa and five developed countries with which it trades. While the proportionality condition of the absolute PPP is not supported, the OLS results do suggest that the bilateral exchange rate between South Africa and each of these DCs is impacted by both South Africa's and each DC’s price level with the appropriate sign found for each coefficient and with all coefficients being statistically significant. While the coefficient of determination is high in each case, the suggestion of autocorrelation by the low reading on the Durbin Watson statistic warrants an examination of the stationary nature of these variables. For the most part the ADF test confirms that these variables are non-stationary, leading us to the Johansen cointegration test. This test produced decidedly weak evidence in support of the PPP hypothesis, since for all countries except Japan, the bilateral exchange rate and the relative prices did not appear to be cointegrated.

Given that South Africa maintained a convertible currency for much of this period, and had inflation rates significantly above these five trading partners, these results have to be considered somewhat unfavorable to the PPP hypothesis. However, it must be noted that the significant apparatus of trade restrictions assembled against Apartheid was in place for more than half of the study period. Further studies can investigate this anomaly by breaking the data into two distinct periods to learn whether these trade sanctions impacted the relationship between prices and the nominal exchange rate.

These results do add to the collection of findings of a mixed relationship between these variables and point to the need for more research into the causes and consequences of a possible long term drift of relative prices away from the nominal exchange rate.

ENDNOTES

1. The symmetry and proportionality conditions are supposed measures of the accuracy of the empirical results from an **OLS** regression as provided by the coefficients on the domestic and foreign price variables β_1 and β_2. The symmetry condition requires that these be both equal and of opposite sign, while the proportionality condition (the more binding of the two) requires that β_1=1 and β_2 = -1.
2. It must be noted that for most LDCs there is a limited extent to which a central bank can influence the trading range of its currency if it operates a reasonably flexible exchange rate regime.
3. It must also be noted that while the quarterly data sample size averages about 155 for the other four DCs, for Germany there are only 72 observations.
4. In about two of the cases for the CPI, the lag length was fixed at 4 by the author.
5. Please see http://www.inflation.eu.

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