

# Purchasing Power Parity: Some empirical evidence on Lesotho

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## Abstract

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*This paper investigates the validity of purchasing power parity (PPP) hypothesis under fixed exchange rate regime. First, the time series characteristics of real exchange rate are investigated using ADF unit root tests. The real exchange rate is found to be a random walk, a revelation that does not lend support to the validity of the PPP doctrine. Finally, cointegration-error-correction technique (a relatively more reliable procedure) is used to examine the issue of PPP. A major advantage of this procedure is that the coefficients ( $\beta$ 's) are estimated in an unconstrained fashion and the tests for validity or otherwise of the restrictions come last. Using this methodology, we are able to find evidence in favour of the PPP hypothesis.*

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## Introduction

The Purchasing Power Parity (PPP) hypothesis is the hypothesis that exchange rates between currencies are determined in the long run by the amount of goods and services that each can buy. The basic idea is that in the absence of trade impediments, if the price of tradable goods were lower in one country than another, traders could gain by buying goods in the cheaper country and selling in the dearer. Consequently, relative price levels determine the equilibrium exchange rate. The first person to treat PPP as a practical empirical theory is Cassel (1921, 1922). PPP has several applications. First, the purchasing power of a given income in one country can be compared with the purchasing power of the income of any other country by simply measuring incomes in a common currency. For instance, if one country's income is ten times larger than the other (measured in the same currency at the actual exchange rate), then the country's command over goods and services is ten times larger. However, if PPP does not hold such comparisons may lead to systematic errors (incomes of less developed countries are understated when actual exchange rates are employed in the comparisons). Second, it serves as a benchmark by which to gauge the level of exchange rate; that is, it facilitates meaningful discussions of overvaluation or undervaluation of currencies. Governments, financial institutions and international organisations routinely calculate and report the real exchange rate series. Such series depict exchange rate-adjusted price relatives for a country relative to its trading partner. Assuming that movements in equilibrium relative prices are negligible, changes in real exchange rates translate into changes in competitiveness. Thus they are used to gauge changes in the country's competitiveness. Finally, PPP serves as a

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prediction model for exchange rates. In open economy macroeconomics the relative efficacy of monetary policy depends on the validity of PPP. For instance, if PPP holds monetary expansion has no real effects. Monetary policy can only be effective if wages and prices are not fully flexible (PPP does not hold). An important channel in this case is the real depreciation of the exchange rate (The New Palgrave Dictionary of Economics, 1987).

There are, basically, two forms of the traditional (classical) version of the PPP, namely, the absolute and the relative. As a theory of exchange rate determination, the absolute PPP (strong form) relies on the international multi-good version of the "law of one price". From the perspective of absolute PPP, the exchange rate adjusts to equalise the prices of national baskets of goods and services between two countries because of market forces driven by arbitrage. The "law of one price" from which absolute PPP is derived states that in the absence of any trade frictions (such as transport costs, tariffs, taxes, information costs etc) competitive arbitrage makes the same good to sell for the same price (when expressed in a common currency) across countries. The law of one price can be defined algebraically as follows:

$$P_j = EP_j^* \text{ or } E = \frac{P_j}{P_j^*}$$

where  $P_j$ ,  $P_j^*$  and  $E$  are, respectively, domestic currency price of commodity  $j$ , foreign currency price of commodity  $j$  and the exchange rate. This serves as a basis for absolute PPP. As an illustration, consider the following:

$$P = \sum_{j=1}^n \theta_j P_j \text{ and } P^* = \sum_{j=1}^n \theta_j^* P_j^*$$

where  $P$ ,  $P^*$  and  $\theta_j$  and  $\theta_j^*$  are, respectively, domestic price level, foreign price level and weights of commodity  $j$  in the baskets. Assuming that  $\theta_j = \theta_j^*$  and that the law of one price holds for all commodities, then  $E = \frac{P}{P^*}$ .

This gives us the absolute PPP whose prediction is that the exchange rate will adjust to equalize price levels. Absolute PPP assumes that the nominal exchange rate that is adjusted for differences in national price levels (real

exchange rate,  $\varepsilon$ ) is constant, that is  $\varepsilon = \frac{EP^*}{P} = 1$ . This, therefore, implies

that the price of a common market basket of goods in the two countries (measured in a common currency) will be the same. The underlying assumption is that arbitrage is instantaneous and costless regardless of monetary and real disturbances in the economy. It is noteworthy that for

$E = \frac{P}{P^*}$  to make sense, both foreign and domestic prices should include the same goods with identical weights

It is noteworthy, however, that due to trade frictions, absolute PPP does not hold in real life situations. The trade impediments include transport costs, tariffs and quotas. Therefore, it would be unrealistic to expect the price, even of perfectly homogeneous commodities, to be equalized. Information costs and other impediments to trade act against the strict spatial equalization of price. Dornbusch, (1987) argues that the impediments to trade coupled with imperfect competition promote spatial price differentiation and this further limits strong PPP. Consequently, a weaker version of PPP (relative PPP) restates the theory in terms of changes in

relative price levels and exchange rate:  $E = \alpha \frac{P}{P^*}$ , where  $\alpha$  is a constant that reflects the given trade frictions. The presence of these obstacles, therefore, implies that an increase in the home price level, relative to the rest of the world, would lead to equi-proportionate depreciation of the home currency:  $\Delta E = \Delta \left( \frac{P}{P^*} \right)$  or  $\Delta e = \Delta p - \Delta p^*$  in logarithms. This is a weaker

version of PPP whose basic prediction is that the exchange rate adjusts to offset inflation differentials between two countries over time. This weaker version of PPP can explain a significant portion of the exchange rate movements between two countries, especially, in a situation whereby the main source of the shock affecting the exchange rate is monetary rather than real (Lafrance and Schembri, 2002). This shift from the use of absolute PPP to relative PPP (as a way of circumventing the qualifications arising from transport costs or obstacles to trade) leads to a use of PPP in terms of specific price indices like consumer price index (CPI), wholesale price index (WPI) or GDP deflators. The major difference between the two concepts is that absolute PPP can only be tested with price levels (not price indices). The use of these price indices, however, goes beyond the law of one price because the shares of various goods in the different national indices are not necessarily the same. Moreover, the goods that are used in calculations of respective indices may not be perfectly identical, especially, in respect of non-tradables. Under the circumstances, therefore, PPP only holds in the weak form, provided the shocks affecting the exchange rate are monetary in nature, that is, conditions of the homogeneity postulate are satisfied.<sup>1</sup> It is noteworthy that if these conditions are not met or if the disruptions originate from the real sector, then the use of PPP as a theory of exchange rate determination would be a "misleading pretentious doctrine" (Samuelson, 1964).

Although there is a vast amount of literature, both theoretical and empirical, on PPP, there has not been any credible attempt to investigate, empirically, the validity or otherwise of PPP under fixed exchange rates as in Lesotho. This paper is a modest attempt to fill the gap.

### PPP under fixed exchange rate, perfect capital mobility and free movement of goods and services

Theoretically, PPP should hold under fixed exchange rate, perfect capital mobility and free movement of goods and services. In particular, the price level should be the same among the trading partners in the long run because nominal exchange rate adjusts to eliminate inflation differentials between two countries overtime. The implication, therefore, is that the real exchange

rate is constant:  $\varepsilon = \frac{EP^*}{P} = 1$ . In logarithms we have:

$$\varepsilon = e + p^* - p = 0, \quad 1(a)$$

so that

$$e = p - p^* \quad 1(b)$$

Since there are fixed factors that cause divergence between the  $p$  and  $p^*$ , then a constant term can be introduced in 1(b) to capture such effects. Introduction of a constant in 1(b) restates the PPP in its weak form (relative PPP):

$$e = \beta + p - p^*, \quad 1(c)$$

Where  $\beta$  is a constant that reflects the given trade frictions. Obviously, the relative PPP encompasses the absolute PPP, because the latter is a special case of the former; that is, the absolute PPP is obtainable from the relative PPP if  $\beta = 0$ . However, Maeso-Fernandez(1998) points out that the main difference between the two is that the absolute PPP can only be tested with price levels, not price indices.

In respect of pegged exchange rate regime, equation 1(c) implies that:

$$e = \beta + p - p^* = 0 \quad 2(a)$$

and this yields:

$$p^* = \beta + p \quad 2(b)$$

In common with Maeso and Fernandez (1998), we can, therefore, write relative PPP as:

$$p_t = \beta_0 + \beta_1 p_t^* + \mu_t, \quad \mu_t = A(L)\lambda_t \quad 2(c)$$

where  $A(L)$  is a lag operator and  $\lambda_t$  is a white noise process. The error term  $\mu_t$  has been added to allow for deviations in the relative PPP. Relative PPP varies according to the nature of  $A(L)$ . If  $\mu_t$ 's are serially uncorrelated and  $A(L)$  has zero degree, then any disturbances have transitory effects. If deviations are persistent while relative PPP holds as a long run relationship,  $A(L)$  has a degree greater than zero and its roots lie outside the unit circle, there is mean reversion (stationarity). However, if relative PPP does not hold even in the long-run,  $A(L)$  has roots either inside or on the unit circle, the  $\mu_t$  is a nonstationary process.

Alternatively, we can define PPP by taking first differences in the exchange rate equation (as in Frenkel, 1978) to obtain:

$$\Delta e = \Delta p - \Delta p^* \quad 3$$

Equation (3) says that changes in exchange rate equal the difference in changes in the price level of two countries. This weaker version of PPP helps to circumvent the methodological problems of measurements and other problems caused by trade frictions. Under fixed exchange rate regime, equation (3) implies that:

$$\Delta e = \Delta p - \Delta p^* = 0, \quad 4(a)$$

which implies that:

$$\Delta p = \Delta p^* \quad 4(b)$$

Under a fixed exchange rate, therefore, relative PPP implies convergence in inflation rates between two countries.

The first differences version (equation 3) can, also, be used provided a correct specification is adopted. As pointed out by Maeso-Fernandez (1998), adding an error term to equation 3 above may pose problems depending on the nature of the error term. For instance, if the error term is white noise, then the real exchange follows a random walk; that is, any deviations from the relative PPP will not be corrected even in the long run. Consequently, they suggest specifying equation 3 in an error correction form:  $\Delta p = \beta_0 + \beta_1 \Delta p^* + \beta_2 (p - p^*) + v$ .

### Empirical literature on PPP

A substantial amount of empirical literature does not seem to lend support to PPP (see, for instance, Khoon and Mithani, 2000; MacDonald, 1993; Christev and Noorbakhsh, 2000; Conejo and Shields, 1993; Li, 1999 etc). Moreover, Khoon and Mithani (2000) cite about seventeen empirical studies on five south East Asian countries that fail to lend support to the PPP theory.

In most instances the failure of PPP theory is attributed to its underlying assumptions that, by and large, appear to be unrealistic. For instance, the theory assumes away the presence of transportation costs, trade barriers and non-tradables. Some studies blame the failure of PPP on certain macroeconomic variables such as technology, government spending (non-tradables) and productivity growth differentials (Balassa, 1964; Samuelson, 1964; Rogoff, 1996). These macroeconomic variables are said to change equilibrium relative prices between tradable and non-tradable goods and, therefore, bring about changes in exchange rate and deviation from PPP (Khoon and Mithani, 2000). Consequently, Khoon and Mithani (2000) consider current account balance and government expenditure to be the mystifying variables whose examination could explain deviation from PPP in most studies.

### **The Southern African Common Monetary Area (CMA) and its implications for a choice of exchange rate regime by the members.**

Currently, four countries form the CMA, they are: Lesotho, Namibia, South Africa and Swaziland. Under the arrangement, Swaziland is the only country that has an option to vary the exchange rate between her currency (lilangeni) and the South African rand. However, Swaziland has, to date, decided to maintain parity between lelangini and South African rand. Moreover, the South African rand is not legal tender in Swaziland. In respect of the other two countries, the option of independent exchange rate policy is not yet available. Moreover, they run a dual currency system whereby both the South African rand and their respective currencies circulate in parallel. Although there are bilateral agreements between each of the smaller countries and South Africa, there is one common exchange rate regime. They have all opted for a fixed exchange rate regime between rand and their respective national currencies. Moreover, there is free capital mobility within CMA. It is noteworthy, also, that all the members of CMA together with Botswana are members of an important trade arrangement, Southern African Customs Union (SACU).

SACU allows, among others, free movement of goods among member states and imposition of common tariffs and other trade restrictions on goods imported from outside SACU. The fact that there is a free movement of goods within SACU and that the smaller members of CMA (Lesotho, Namibia and Swaziland) peg their respective national currencies at par with the South African rand, implies that the price level in these countries should, by all laws of probability, mimic the South African price level.<sup>2</sup> It is in this sense that the study on PPP or inflation rate becomes important.

The rationale and consequences of fixed exchange rate can best be explained by the “impossible trilogy”. According to the “impossible trilogy”

a government can choose a maximum of two out of the following options: independent monetary policy; fixed exchange rate; and absence of capital controls. The basic notion is that a country that chooses a fixed exchange rate forgoes an independent monetary policy unless it imposes capital controls (restrictions on capital flows). This can best be understood by considering the case of uncovered interest rate parity (UIP) that is based on arbitrage relationship. In the absence of capital controls, investors reallocate funds to a country where the highest expected return is offered. UIP, therefore, implies that interest rate differentials equal expected exchange depreciation. But expected devaluation is zero under fixed exchange rate, therefore, interest rates should be the same between countries with fixed exchange rates. A basic idea here is that countries cannot run independent monetary policies. This is exactly what the "impossible trilogy" says (a government cannot operate both a fixed exchange rate and an independent monetary policy). It is noteworthy, however, that it is possible to have both a fixed exchange rate and an independent monetary policy if capital controls are in place. For instance, with perfect capital mobility and fixed exchange rate, a country that unilaterally cuts its interest rate would experience substantial capital outflow. This exerts pressure on the currency and threatens the exchange rate target. Imposition of capital controls, however, limits the outflow; therefore, the government can have both an exchange rate target and an independent monetary policy. This is one of the serious shortcomings of CMA. The option of capital controls is not available to member states. According to the "impossible trilogy", therefore, the cost of a fixed exchange rate is the inability to choose a monetary policy that suits a country's unique circumstances. Economic theory fails to establish an unambiguous relationship between exchange rate regime and macroeconomic targets (inflation, growth etc). Similarly, empirical studies find unclear link between the exchange rate regime and macroeconomic performance. Nevertheless, there is an indication that exchange rate peg leads to lower inflation, but also to slower productivity growth.

Fixed exchange rate is likely to lower inflation because it induces greater policy discipline and, also, instils greater confidence in the currency. A peg provides a highly visible commitment and, therefore, increases the political costs of loose monetary and fiscal policies. With a credible peg the willingness to hold domestic currency is enhanced. Therefore, inflationary consequences of a given expansion in money supply are reduced (Ghosh et al.1997).

Although economic theory has relatively little to say about the effect of the nominal exchange rate regime on the growth of output, there is an indication that fixed exchange rates foster investment by reducing policy uncertainties and lowering real interest rates. Empirical evidence seems to suggest that pegged regimes have higher investment while floating regimes have faster productivity growth (Ghosh et al. 1999).

### Testing for PPP

Since data on the domestic and foreign price levels are not readily available empirical studies focusing on the PPP hypothesis, by and large, use price indices as proxies for these variables. This practice is problematic for the following reasons: first, the domestic and foreign price indices are not based on the same basket of goods. Second, the commonly used price indices (CPI, WPI, GDP deflator), by and large, encompass tradable and non-tradable goods and services. Under the circumstances, therefore, the observed divergence between  $p$  and  $p^*$  cannot be regarded as a violation of the PPP doctrine because international arbitrage applies only in the case of tradable goods. Finally, price indices are expressed in relation to a base period (base year = 100). As a result it becomes impossible to tell whether or not the PPP was valid in the base year (Alves *et al.*, 2001).

To circumvent the first and the second problems highlighted above, together with the presence of trade frictions, some authors recommend the use of equation 1(c) (a less restricted form). This allows for trade frictions (such as transportation costs and tariff and non-tariff restrictions) and imperfections in the price indices (Alves *et al.*, 2001).

In respect of the third problem, one can either assume validity of the absolute PPP in the base year or focus on the relative PPP (Rogoff, 1996). Relative PPP is likely to hold even if the absolute PPP fails, especially, if the causes of the failure in the absolute PPP remain fairly stable overtime (Alve *et al.*, 2001)<sup>3</sup>.

Since the relative structure of tradables and non-tradable goods and services are likely to change overtime, Frenkel (1981) suggests that instead of testing for cointegration between the exchange rate, domestic and foreign prices, one can consider checking whether or not the two price levels cointegrate. If the two price levels (expressed in terms of the same currency) have some kind of a stable long run link, then the PPP doctrine is supported.

The issues of whether or not PPP holds in the long run can be framed in terms of the time series characteristics of real exchange rate. Specifically, if the real exchange rate is non-stationary, then PPP does not hold in the long run (DeLoach, 1997). Non-stationarity in the real exchange rate can be caused, among others, by the presence of menu costs (Mussa, 1982; Obstfeld and Rogoff, 1984) and non-traded goods.

In the presence of menu costs, changes in nominal exchange rates do not induce immediate proportional changes in relative prices across countries. Moreover, relative prices need not necessarily change in proportion to the changes in nominal exchange rates. Non-tradable goods, on the other hand lead to a breakdown of the commodity arbitrage condition that is necessary for PPP to hold (DeLoach, 1997). As a result PPP can be expected to hold for traded goods only. The basic notion is that the real exchange rate depends on the relative prices of traded goods relative to non-



traded goods in the two trading countries. If the real exchange rate is co-integrated with the relative prices of non-tradable and tradable goods in the two countries, then PPP may be said to hold for tradables.

According to the co-integration literature, PPP holds if  $p^*$  and  $p$  are individually non-stationary but co-integrated, that is, even though they may individually be non-stationary linear combination of the two is stationary. Alternatively, we can test for a long-run PPP by investigating whether or not the real exchange rate follows a random walk. If the real exchange rate is a random walk, then there will be no tendency for the price levels to converge even in the long run. First, we consider the following truncated version of ADF auto-regression (for  $p^*$ ,  $p$  and the real exchange rate)<sup>4</sup>:

$$\Delta y_t = (\rho - 1)y_{t-1} + \sum_{i=1}^k \sigma_i \Delta y_{t-i} + \mu_t \quad 5$$

The null hypothesis to be tested is:  $H_0 : \rho = 1$  against the alternative that  $H_1 : \rho < 1$ .

Finally, we use cointegration-error-correction technique to investigate the validity or otherwise of PPP between Lesotho and South African. The real exchange rate is defined as in equation 2(c) above.

Our study uses measured prices as opposed to price levels. These measured prices (CPI's) may contain significant non-tradable elements and their construction may differ from one country to another. Therefore, it is not likely that they will have equi-proportionate effect on the exchange rate. Although transaction and trade restrictions may be insignificant, these measured prices are likely to deviate from the true price measures due to measurement errors. In that eventuality, therefore, it may be inappropriate to impose restrictions with respect to the coefficients,  $\beta$ 's in equation 2(c). Testing for stationarity of real exchange rate implies restricting  $\beta_1$  in 2(c) to be 1, which may be unrealistic given the argument above. However, using cointegration-error-correction technique helps to circumvent this problem. A major advantage of this procedure is that the  $\beta$ 's are estimated in an unconstrained fashion and the test for validity or otherwise of the relevant restrictions comes last. In a nutshell, this methodology allows one to test these restrictions without imposing them a priori. In this paper we focus mainly on proportionality condition derived from absolute PPP proposition. Under fixed exchange rate regime, proportionality condition implies that  $-\beta_1 = 1$  in equation (2c). It is noteworthy, however, that in respect of the weak-form PPP, the requirement is that there be cointegration between exchange rate and relative prices. This does not place any restrictions on the cointegrating vector. The weak-form PPP in the present study refers to a situation where there is cointegration between  $P$  and  $P^*$  in (2c) above.

In common with Johansen (1988) and Johansen and Juselius (1990), we consider the following vector auto-regression model:

$$X_t = \Theta_1 X_{t-1} + \dots + \Theta_k X_{t-k} + \varepsilon_t, \quad (t = 1, \dots, T), \quad 6$$

for given initial values of  $X_{k+1}, \dots, X_0$  and  $\varepsilon_t \sim IN(0, \Lambda)$ .

Since time series is generally a non-stationary process,  $I(1)$ ; then, VAR systems like (6) above are normally expressed in first differences form. But unless co-integration is taken into account, differencing leads to loss of information in the data. Thus the process,  $X_t$  in (6) above can be rewritten in error correction form as follows:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \varepsilon_t \quad 7$$

where  $\Delta = 1-L$  ( $L$  = lag operator),  $\Gamma_i = -(I - \Theta_1 - \dots - \Theta_i)$ , ( $i = 1, \dots, k-1$ ), and  $\Pi$  is a coefficient matrix defined as  $\Pi = -(I - \Theta_1 - \dots - \Theta_k)$ .

$\Pi$  contains information about long run relationships between the variables in the data vector. The last, but one term in (7) above is in levels therefore retains information on the long run relationship. It is worth noting that (7) excludes constant and seasonal dummies. These should be included especially when dealing with quarterly data, thus (7) becomes:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu_t + \sigma D_t + \varepsilon_t \quad 8$$

Where  $\mu$  is constant and  $D$ 's are centred seasonal dummies that sum to zero over a full year. To test the hypothesis that there is at most  $r$  co-integration vectors,  $H_0: \text{rank}(\Pi) \leq r$ , the procedure uses two likelihood ratio test statistics, namely trace statistic and maximal eigen value statistic. It is noteworthy that the two tests may lead to contradicting conclusions, especially, in a case where dummy-type variables are included as they may affect the underlying distribution of the test statistic differently depending on the number of dummies included. In that eventuality, Maddala and Kim (1998) suggest that a decision be based on the trace test because it is more robust to skewness and excess kurtosis in the residuals than the maximal eigen value test. Moreover, the trace test is found to be more robust to normality than the other test.

## Data and Results

Annual data on CPI's, covering the period 1977 to 2000, are obtained from International Financial Statistics Books (IFS) and Central Bank of Lesotho Quarterly Review Reports. Quarterly series were generated through interpolation. The CPI is a base-weighted index that is designed to measure changes in the price level of an average basket of commodities in an economy (Khoon and Mithani, 2000). The choice of a price index is of critical importance because the interpretation of real exchange rate differs

depending on the price index used in its calculation. For instance, using WPI, price index biased towards traded goods, implies looking at the PPP as an arbitrage condition; that is, paying a special attention to trade balance. However, using CPI (a more general price index) means considering the real exchange rate as the price of an asset (Maeso-Fernandez, 1998). It is argued that PPP holds better for WPI pairs than CPI pairs because CPI excludes exported goods and, therefore, is weighted more towards non- traded goods than WPI (Zhou, 1997).

**Unit root test results**

Tables 1, A1, A2 and A4<sup>5</sup> report the unit root test results using ADF procedure. The results are reported for two different model specifications. First, constant only; and second, constant plus trend. The lag length chosen in each case is that which whitens the residual. The results show that CPI's are integrated of order 2, they need to be differenced twice to reach stationarity. It is often a case that ADF tests are used more for motivational purposes than as definitive statements because they are notorious of low power and size distortions, especially, in small samples (MacDonald, 1993). We note, in particular, in Table 1 that the CPI based real exchange rate is non-stationary for the case of absolute PPP and nearly stationary for the relative PPP. As highlighted above, non-stationarity of real exchange rate implies that PPP does not hold. On the basis of these tests, therefore, one would argue that the empirical evidence does not lend support to the validity of the classical PPP in its strongest form in Lesotho, a revelation that is in keeping with the findings of most studies as indicated above. There is, however, a shaky support for the weak form of the PPP doctrine. On the basis of this, we proceed to a relatively reliable procedure (cointegration and error correction technique) for testing validity of the PPP hypothesis.

**Table 1: Unit Root Test Results For Real Exchange Rate**

Variable	Test Statistic		
	Constant	Constant + Trend lag	
$\epsilon$ (absolute)	-1.697	-1.68	9
$\epsilon$ (relative)	-3.488*	-3.44	8

For the  $\epsilon$ , absolute, the MacKinnon (1991) values for the sample size 90 and 12 variables including trend are: 5% = 3.46; 1% = -4.062, while for 11 variables (excluding trend) they are: 5% = -2.894 and 1% = -3.504. For  $\epsilon$ , relative, the mackinnon (1991) values for the sample size 90 and 11 variables (including trend) are: 5% = -3.46; 1% = -4.062, while for 10 variables (excluding trend) they are 5% = -2.894 and 1% = -3.504.

## Cointegration Results

Since both LCPI and SACPI appear to be  $I(2)$  and the Johansen methodology used in this study can only handle  $I(1)$  and  $I(0)$  variables, then the first differences of the variables are used in the analyses.

Table 2 below reports the results of cointegration tests. Both the maximal eigen value and trace statistics complement each other. We note, in particular that there is one cointegrating vector since the hypothesis of  $r = 0$  is rejected while the hypothesis that  $r = 1$  is easily accepted. Table 3(a) below reports the long run solutions, where  $\beta_1$  is shown to take the value 0.8719. The issue of whether or not this coefficient is statistically different from one (1) is dealt with in the next section.

### Testing for linear hypotheses on cointegrating relations

Table 3(b) below provides test results on linear restrictions (PPP tests). We, first, impose restrictions on  $A$  and, finally, on  $B$ . As noted earlier,  $A$  represents the speed of adjustment to dis-equilibrium, while  $B$  is matrix of long run coefficients.

The restrictions imposed on  $A$  are that the  $\alpha_{ij}^*$ s are not different from zero. Specifically, we test for weak exogeneity of all the variables. Testing for weak exogeneity in the system as a whole requires the test of the hypothesis that  $H: \alpha_{ij} = 0$ , for  $j = 1, \dots, r$ , that is, row  $i$  contains zeros only. The test is conducted by imposing row restrictions on  $A$  to yield a new restricted model, then a likelihood ratio test involving the restricted and unrestricted models is used to ascertain whether or not the restrictions are valid. If  $\alpha_{ij} = 0$ , then row  $i$  contains zeros, implying that the particular cointegration vector  $j$  does not enter into the short run equation determining the associated variable. In that eventuality, the variable in question is referred to as weakly exogenous. Our test results reveal that SACPI is weakly exogenous.

In respect of  $B$ , the relevant restrictions are on proportionality between domestic price (LCPI) and foreign price (SACPI); that is, we test the hypothesis that  $\beta_1 = -1$ . The validity or otherwise of the restrictions (in both cases) is ascertained through the use of likelihood ratio test involving the restricted and unrestricted models. All these restrictions could not be rejected, a revelation that seems to lend support to validity of PPP in Lesotho.

Table 2: The Results of Co-integration Analysis.

	$\lambda_{max}$		$\lambda_{trace}$	
Ho:rank=p	$-T \log(1 - \bar{\lambda}_{r+1})$	95%	$-T \sum_{i=r+1}^p \log(1 - \bar{\lambda}_i)$	95%
p = 0	35.44**	19.0	43.89**	25.3
p <= 1	8.449	12.2	8.449	12.2

Note: \*\* signifies rejection at 1% levels of significance. The lag length used is k = 3.

Table 3a: Long run solutions

	&4=0;	
DLCPI	DSACPI	Trend
1.000	0.8719	0.000

loglik = 897.882 unloglik = 899.09  
 LR-test, rank=1:  $\chi^2(1) = 2.4155 [0.1201]$

Table 3b: PPP Test

	&1=0; &2=-1*&3; &4=0;	
DLCPI	DSACPI	Trend
1.000	-1.000	0.000

loglik = 896.312 unloglik = 899.09  
 LR-test, rank=1:  $\chi^2(2) = 5.5568 [0.0621]$

**Error Correction Model**

Having determined the long run cointegrating relationships, the following parsimonious error correction model (ECM) was estimated:

$$\Delta X_t = \mu + \sigma D_t + \Gamma_1 \Delta X_{t-1} + \phi EC_{t-1} + \varepsilon_t \tag{9}$$

where  $X = (P_t, P_t^*)$  and the fourth term on the right hand side of (9) is the error correction term. The ECM is arrived at by explicitly including the cointegrating relation into the VAR. Thus, the ECM is a restricted VAR, restricted by imposing cointegrating relation. The cointegrating relation enters as an identity (lagged once). Removing the insignificant regressors and testing for validity of the reduction by F-test attained parsimony.

The modelling procedure adopted here is the Hendry's general to specific modelling technique discussed in Hendry and Doornik (1994). The

crucial steps of the econometric methodology are summarized as follows: first, use the Johansen approach to get the long run co-integration relation(s) between the variables in the system; second, estimate the short run *VAR* in error correction form to obtain a parsimonious representation; and finally, condition on weakly exogenous variable(s) to get a conditional parsimonious error correction model and then test to make sure the resulting restricted model parsimoniously encompasses the parsimonious error correction model. The results reported in Table 4 below are obtained from estimating the conditional parsimonious ECM. The equation is estimated using Full Information Maximum Likelihood (FIML) estimation method in PcGive/FIML. We note from Table 4 that the conditional parsimonious model encompasses the ECM as reflected by the LR-test for over-identifying restrictions, which does not reject. The parsimonious ECM was subjected to a battery of diagnostic tests. These include within equation residual serial correlation, heteroscedasticity and normality tests. The normality test could not be passed at 1% level of significance. The rest of the tests could not indicate any problems. The results for the diagnostic tests are reported on Table A4. We note from Table 4 that, though the coefficient of the South African price level (SACPI) bears a sign that is consistent with economic logic, it is statistically insignificant at 5 per cent level. Moreover, the coefficient is statistically different from one (1). While this may appear to be a puzzle given a common understanding that Lesotho price level is, entirely, determined by South African prices (both in the short run and long run), a possible explanation may be that Lesotho's CPI basket contains a higher proportion of non-tradables than tradables. Moreover, there could be other macroeconomic disturbances in the form of current account and government spending, for instance, that explain short run behaviour of prices better. It may be interesting, therefore, to examine the impact of such variables in a multivariate framework.

One other interesting aspect of the findings in this study is the feedback on the error correction term. The coefficient of the own error correction term bears a correct sign and it is highly statistically significant. This finding is consistent with the existence of cointegration among the variables. Since the error correction term represents the deviation from equilibrium, then, its coefficient should carry a negative sign implying that the dependent variable varies in the opposite direction of the error. This ensures that the system corrects the deviation from equilibrium. In particular, we note that price level adjusts by 108 percent each quarter towards previous period's equilibrium state. This is indicative of a very rapid response to any deviation from equilibrium.

Table 4: Estimating the model by FIML The present sample is: 1977 (2) to 2000 (4)

Equation 1 for DDLlcp<sub>i</sub>

Variable	Coefficient	Std. Error	t-value	t-prob	HCSE
ECM2_1	-1.0759	0.10682	-10.072	0.0000	0.14216
DDL <sub>sacpi</sub>	0.3340	0.17086	1.955	0.0537	0.20997
Constant	0.0157	0.0021273	7.364	0.0000	0.00291

$$\hat{\alpha} = 0.0133878$$

$$\text{loglik} = 411.29809 \quad \text{log}|\Omega| = -8.65891 \quad |\Omega| = 0.000173574 \quad T = 95$$

$$\text{LR test of over-identifying restrictions: } \text{Chi}^2(2) = 0.288053 [0.8659]$$

correlation of residuals

	DDL <sub>lcp<sub>i</sub></sub>
DDL <sub>lcp<sub>i</sub></sub>	1.000

## Conclusion

This paper has made an attempt to investigate the validity of PPP between Lesotho and South African. While investigation of time series properties of the real exchange rate fails to find evidence for PPP, a more reliable procedure (cointegration-error-correction technique) provides evidence in favour of PPP. Given the CMA arrangement the existence of cointegration between the two price measures implies that monetary shocks in South Africa will be transmitted to Lesotho's economy. For instance, monetary expansion in South Africa will lead to equi-proportional increases in prices in South Africa; and the impact will eventually find its way to Lesotho's economy. Moreover, the finding implies that monetary policy cannot be used to improve competitiveness between these countries.

Particularly noteworthy is the revelation that the South African price level does not seem to be a significant determinant of Lesotho's price level in the short run. It would be interesting, therefore, to investigate the factors that explain both the short run and long run behaviour of prices better. Such factors may include current account or trade balance and government spending.

## End notes

- 1 The homogeneity postulate states that a pure monetary shock that leaves all equilibrium relative prices unchanged will lead to equi-proportionate changes in money stock and all prices including the price of foreign exchange
- 2 Due to fixity of exchange rates, monetary policy expansion in South Africa is expected to bring a surge of inflation in these countries

- 3 Originates from Moosa and Bhatti (1997).
- 4 Note that real exchange rate equals the nominal exchange rate under the fixed exchange rate regime. The absolute and the relative PPP's are defined as  $e = p - p^*$  and  $\Delta e = \Delta p - \Delta p^*$ , respectively.
- 5 A1, A2 and A4 appear under the Appendix section.

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## Appendix

Table A1: Unit Root Test Results (Other variables in Levels)

Variable	Constant	Test Statistic	
		Constant + Trend	lag
LCPI	-3.508**	2.753	3
SACPI	-2.205	0.329	3

Note: \*\* and \*, respectively, signify the statistics that are significant at 1% and 5% levels of significance. The null hypothesis is the time series are  $I(1)$  against the alternative that they are  $I(0)$ .

Table A2: Unit Root Test Results (Other variables in First Differences)

Variable	Constant	Test Statistics	
		Constant + Trend	lag
LCPI	-1.838	-3.21	3
SACPI	-1.441	-2.522	2

Note: \*\* and \*, respectively, signify the statistics that are significant at 1% and 5% levels of significance. The null hypothesis is the time series are  $I(2)$  against the alternative that they are  $I(1)$ . The null hypothesis could not be rejected in the cases of LCPI and SACPI.

Table A3: Unit Root Test Results (LCPI and SACPI in Second Differences)

Variable	Constant	Test Statistic	
		Constant + Trend	lag
LCPI	-10.97**	-11**	2
SACPI	-13.28**	-13.3**	1

Note: \*\* and \*, respectively, signify the statistics that are significant at 1% and 5% levels of significance. The null hypothesis is that time series are  $I(3)$  against the alternative that they are  $I(2)$ .

Table A4: Diagnostic tests

DDLlpci:	Portmanteau 11 lags	=	16.328	
DDLlpci:	AR 1- 5F( 5, 85)	=	1.9985	[0.0870]
DDLlpci:	Normality $\chi^2(2)$	=	24.909	[0.0000]**
DDLlpci:	ARCH 4 F( 4, 82)	=	0.41559	[0.7969]
DDLlpci :	$\chi^2$ F( 8, 81)	=	1.1404	[0.3458]
Vector portmanteau 11 lags		=	14.152	
Vector AR 1-5 F( 5, 85)		=	1.9985	[0.0870]
Vector normality $\chi^2( 2)$		=	24.909	[0.0000]**
Vector $\chi^2$ F( 8, 81)		=	1.1404	[0.3458]
Vector $\chi_i \cdot \chi_j$ F(14, 75)		=	1.2721	[0.2450]



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