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An investigation into the validity of the intra-continental and intercontinental casselian hypothesis (PPP) and uncovered interest rate parity (UIP) in southern African development community (SADC) countries A long run structural modelling approach

Fidelia M. Gandiya

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AN INVESTIGATION INTO THE VALIDITY OF THE INTRA-CONTINENTAL AND INTERCONTINENTAL CASSELLIAN HYPOTHESIS (PPP) AND UNCOVERED INTEREST RATE PARITY (UIP) IN SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC) COUNTRIES: A LONG RUN STRUCTURAL MODELLING APPROACH.

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This THESIS is presented to satisfy the requirements for the Award of, Master of Business (Finance) degree at Edith Cowan University.

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Date: 20th August 2002

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DEDICATION

With Love, to Enock, Zoe, Tino and Fari. For a lot of nerve-steadying and hand-holding as the going got rough and the deadline loomed.
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ABSTRACT

The current high exchange rate volatility in the face of globalization, underpinned by growing trade and financial and commodity markets liberalization has attracted the resurgence of considerable interest from both financial economists and policy makers, into the validity of international parity relationships. Using multivariate cointegration framework and long run structural modeling, this paper investigates the evidence in support of two of the parity relationships that underpin either implicitly or explicitly much of international macroeconomics. The first is the purchasing power parity (PPP) hypothesis or the theorem that there exists an invariable long-run equilibrium real exchange rate. The second is the uncovered interest rate parity (UIP) theorem, a hypothesis, which implies that yields of domestic and foreign financial assets (real interest rates) can differ only by the expected change in the price of foreign exchange.

These tests are conducted on 8 of the 14 SADC economies using South Africa and United States as numeraires for the post- Bretton era; for the intra-continental and the intercontinental approaches respectively. All tests generally suggest that regardless of the approach used, there is significant evidence supporting cointegration, when the PPP is tested in its simple form and when the joint PPP and UIP hypothesis is tested. Except for a few countries, results are less favorable when the simple UIP is tested.

We are therefore able to conclude that the simple PPP and joint PPP and UIP variables are cointegrated or that they do move together in the long-run for most countries indicating that the propositions are valid. However, most of the estimated cointegrating vectors rejected the restrictions of symmetry and proportionality implied by the PPP and UIP theories. With the simple UIP our conclusion is that support is sample dependent as the UIP generally holds only for those countries with very strong economic ties and whose currencies are pegged one to one.
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SUMMARY

The PPP theorem used on its own or in conjunction with the UIP hypothesis is one of the basic ingredients of policy-makers' 'conventional wisdom' in the determination of their exchange rate policies. The relationship between the PPP used together with the UIP suggests that in the long run a country's real exchange rate will be given by the combination of a constant and real interest rate differential. Whereas, the purchasing power parity (PPP) hypothesis posits that there is an underlying tendency for movements in the nominal exchange rate to offset inflation differentials with a country's trading partners, such that, there exists a constant long-run equilibrium real exchange rate. The uncovered interest parity (UIP) hypothesis postulates that the expected change in the spot exchange rate is always equal to the interest rate differential between two countries. The practical implications of the PPP doctrine are diverse, ranging from the significance level of the exchange rate used in policy inference to inter-country comparisons of living standards. Empirically, the UIP alone or in conjunction with the PPP is usually used as an exchange rate forecasting and macroeconomic modeling tool. Combining these two theorems, the paper investigates the validity of the PPP and UIP in Southern Africa. Sadly despite the theoretical and intuitive appeal of both the PPP and UIP propositions empirical evidence for the two (either separately or collectively) has been a divisive issue, a factor, which often raises skepticism about their merits.

The analysis is conducted within the context of cointegration and it employs the Full Information Maximum Likelihood Multivariate Cointegration methodology developed by Johansen (1988, 1991) and Johansen and Juselius (1990, 1991), to investigate the empirical validity of the propositions under study. Also, since in a multivariate framework such as the one given by the combined PPP and UIP model, a vector error correction model may contain multiple cointegrating vectors, the long run structural modeling approach suggested by Pesaran and Shin (1997) is used. The technique imposes independent theory restrictions on the coefficients of the accepted cointegrating vectors based on long-run economic theory, in order to reach conclusions a propos the validity of the propositions under study.
The results are obtained using the individual country approach (not panel) for 8 SADC\(^1\) bilateral exchange rates against the South African rand (intra-continental approach) and, the US dollar (intercontinental approach) with monthly information of varying samples from the post Bretton Woods era\(^2\). The analysis uses multivariate cointegration theory and long run structural modeling to examine the existence of cointegration between the nominal exchange rate and either the price or interest rate differentials. Although recently panel approaches have proven to be superior in raising the power of econometric tests, the country specific approach, which highlights the cross country heterogeneity was preferred because the hypothesis under examination was the validity of the PPP and UIP, not in SADC but, in each SADC economy under investigation.

The findings vary from country to country but generally there is little evidence to support the UIP in its simple form in SADC. Support for the PPP is more favorable as indicated by the finding of cointegration between the PPP variables. Interestingly enough is the fact that this is true regardless of whether we use the intra-continental or intercontinental approach except, for a few countries with strong economic ties. This finding contradicts the evidence from other recent tests that the PPP holds better for countries within the same continent. However it does support previous empirical findings that there are greater chances for finding PPP cointegration for high inflation countries. One is therefore bound to conclude that finding empirical evidence of the PPP relationships may still be heavily sample dependant, in terms of length of sample period or choice of countries as well as, methodology dependent.

The results of the combined PPP and UIP relationship also provides evidence that there exists a cointegration relationship or a stationary long run relationship between the price and interest rate differentials. However we find several incidences of significant

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1 SADC = Southern Africa Development Community and is made up of the 14 Southern African countries (please see map on page xv). Therefore the term SADC and Southern Africa will be used synonymously.

2 The term intra-continental approach in this research means that both the foreign and domestic countries are within the same continent (Africa) and is synonymous with cross-national and so the words will be used interchangeably. Whereas the term intercontinental approach refers to the situation where the foreign country is outside the continent (in this case the US).
cointegrating vectors that reject the theory symmetry and proportionality condition restrictions

The conclusions are that except for a few exceptions where there are very strong trade links between the countries, generally the evidence of cointegration between exchange rates and interest and price differentials is invariant to the choice of numeraire currency. That is, the choice of foreign country does not seem to matter, whether it is intra-continental or intercontinental. Also except for a few countries where there are very strong links between the domestic country and the foreign country, the propositions' symmetry and proportionality conditions are rejected.
CHAPTER I
PROLOGUE

One of the most remarkable developments in recent years has been the increasing integration of the global village via the proliferation of global trade, investment flows and communication linkages in a world of rapid technological advancement. This phenomenon is normally termed globalization. In tandem with this rapid change has been the growing volatility of currency flows and exchange rate fluctuations. Needless to say as the IMF (1984) pointed out foreign exchange rate fluctuations tend to induce macroeconomic phenomena that are undesirable by affecting other macroeconomic variables. These other macroeconomic variables are the stability of domestic interest rates, the level of inflation and the level of unemployment as well as, wealth, constraints on government policy and protectionism. To this end exchange rate forecasting and management has become invaluable for long term strategic planning by governments and multinational corporations. Hence the question of what exactly, in terms of economic fundamentals determines the value of a country's exchange rate remains an important issue not only in open economy macroeconomics, but also in international finance and economics.

However the matter remains unsettled despite the fact that considerable ink has been and continues to be spilled over the issue. Whilst there are many possible answers, this paper will concentrate on two major international parity models that, are most commonly employed as building blocks in virtually all contemporary macroeconomic exchange rate models and, they are the purchasing power parity (PPP) and the real or uncovered interest parity theorem (UIP). In its simplest sense the theory of PPP suggests the presence of a long-run equilibrium relationship between national price levels, such that internationally traded identical goods should sell for the same effective price when converted into the same currency. Defined this way, the PPP provides a specific concept for the nominal exchange rate, namely, the PPP exchange rate. This is defined as the rate that equalizes the prices of a similar basket of goods in two different countries. The UIP on the other hand asserts that nominal interest rates (in a riskless environment) are determined by world interest rates plus the expected change in spot exchange rates, thus implying the equalization of real interest rates between countries- the real interest parity (RIP) theorem.
These two international economics theorems have been subjected to extensive empirical testing and there still is burgeoning empirical literature documenting the two concepts and yet the debate regarding their empirical validity, although now heading well into extra time, remains controversial. With the PPP debate, the sense of a conundrum is only furthered by the realization that for the most part, studies have been run on essentially the same econometric models and data, deriving different conclusions from slight changes in sample periods and length of samples, countries included in the sample, frequency of data, pooling and panel techniques, stationarity tests and the like (Taylor, 2000).

A flavor of the PPP tests can be obtained from Krugman (1978), Frankel (1981), Dornbusch (1988), Hakkio (1984), Lothian and Taylor (1996), Rogoff (1996), MacDonald (1997), Geppert (1997), Engel et al (1996), Ramirez (1999) and Taylor (2000), Chortareas and Driver (2001). Though there seems to be no broad agreement at hand, as to the PPP empirical validity (i.e. the symmetry and proportionality conditions do not hold exactly for any pair of countries over time), there is some degree of consensus on a couple of basic facts. First, because the adjustment of bilateral exchange rates to domestic and relevant foreign price levels is not instantaneous as required by the theory, it is not out of the ordinary to observe short-run deviations from the PPP. For this reason, the PPP theory does not explain the behavior of exchange rates in the short run (see Frankel 1981 for a classic example, Adler and Lehmann (1983) and Krugman (1978)). This conclusion is in line with Froot and Rogoff’s (1994, p. 2) observation that,

“...the advent of floating exchange rates made it obvious—that PPP is not a short run relationship; price levels movements do not begin to offset exchange rate swings on a monthly or even annual basis”.

Secondly, using both regression and cointegration, generally studies using long range annual time series data sets, found persuasive evidence of mean reversion or a cointegration relationship between nominal exchange rates and relative price ratios. Real exchange rates tend towards the purchasing power parity in the very long run, with consensus estimates, suggesting a very slow rate of conversion of a 3-5 year half-life. One caveat though to the long horizon time series approach, is that apart from the potentially serious structural changes between each exchange regime, the long time series encompass periods in which nominal exchange rate regimes shifted from floating to fixed and back again (Frankel and Rose, 1996; Lothian 1997). As shown in Mussa (1986), real exchange
rates tend to be much less volatile under fixed exchange rates than they do under floating exchange rates. Also, the basket used to construct the price indices is likely to be very different at the beginning and end of the sample. The empirical implication of amalgamating data from different periods on test results therefore remains unclear and for this reason some authors including the author of this paper, preferred not to use data from different regimes. In addition, this long-horizon approach is also susceptible to specific sample selection bias, referred to as the survivorship bias (Froot and Rogoff, 1995) in that due to data availability, long horizon studies of the PPP primarily investigate industrial countries.

Thirdly, in post 1973 - the period of floating exchange rates - using high frequency monthly data—most tests generally found poor performance of the PPP, the existence of unit root in real exchange rates, or no cointegration between exchange rates and the price ratios and therefore failed to reject the random walk hypothesis. However, for the same period studies using panel data found evidence against the random walk real exchange rate hypothesis. Such tests involve testing the hypothesis that each individual series is I (1), against the alternative that all the series taken as a panel are stationary. This evidence supports the conclusion by Bethelomy and Sorderling (1999) that using a panel data set combining cross sectional and time series information leads to substantially better econometric results. It also confirms the argument by Li (1997) and Frankel and Rose (1996) and many others that the ability to find evidence of the PPP depends crucially on the total variation, which might come either from time series dimension or the cross-sectional dimension in the data used.

Fourth, some studies like Krugman (1978) found evidence suggesting that there is more to exchange rates than the PPP. This conclusion leads to the missing variable problem in the theory’s specification. Finally in many PPP tests reported in empirical literature, there is a clear pattern of greater support for the PPP under episodes of high inflation. A classical example is the German hyperinflationary experience documented in Frankel 1978 and Madhavi and Zhou (1996).

With the real interest parity theorem, commonly known as the uncovered interest rate parity (UIP), results also remain mixed. Bollerslev (2000) noted that the UIP is one of the

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2 High frequency data here refers to monthly and quarterly data as opposed to annual data.
most unresolved paradoxes in international finance. So unconvincing has been the empirical verification of the UIP hypothesis that the general view of the economics profession weighs more in favor of the empirical failure of the UIP in predicting exchange rate movements. In fact, most research in the area point to the conclusion that the UIP is at best a poor or even a perverse predictor of exchange rate movements. For this reason, Guy Meredith (2000) concluded that this resounding unanimity on the failure of the predictive power of the interest rate differential is virtually unique in the empirical literature in economics. Also, using the Engle and Granger cointegration method, Meese and Rogoff (1988) and Edison and Pauls (1993) among others failed to establish a clear long run relationship in their analyses. However, Edison and Melick (1997) and MacDonald (1997) using the Johansen method have reported somewhat stronger UIP evidence. More support for the UIP was also reported by Meredith (2000), who using interest rates of longer maturity horizons found all coefficients on interest rate differentials not only having the correct sign, but almost very close to the predicted value of unity. Probably the strongest evidence in favor of establishing a clear long run relationship between exchange rates and interest rate differential was established by MacDonald and Nagayasu (2000) using panel cointegration methods.

Simply put one can surmise that the high regard that the PPP and UIP theorems are held in seem incongruous with the poor empirical support that they enjoy.

Motivation and Significance of Study

It is clear from the above discussion that although testing the PPP and UIP theorems has been prolific, the empirical validity of the PPP and UIP concepts as models of exchange rate movements remains very controversial and unclear. Despite evidence on these concepts not being conclusive, what is clear from the sheer extensiveness of published and unpublished work devoted to these theorems, is the indication in part that there is a reluctance to accept that the PPP and UIP do not hold, at least in the long run. In addition, the very fact that either one or both the two theorems continue to be employed by practitioners in their exchange rate models only attests to this apparent reluctance to accept that these theorems do not hold.

In light of this, the major motivation of this study is not only topicality, as evidenced by
the continued vast research and interest in the area. The motivation to study the Southern African economies also arises from the fact that while these theorems have been extensively studied, admittedly most research in this area has focused on industrialized countries, Latin America, Asia and/or other developing countries mostly outside Africa. In contrast empirical evidence for developing countries in Africa, least of all in Southern Africa is notably limited. At least three factors may account for this. First, limitations on quality and frequency of data may be a constraining factor. Second, developing countries tend to be prone to sudden crisis and marked gyrations in macroeconomic variables, often making it difficult to discern any type of cycle or economic regularity. Related to this are the frequent large policy shocks, which lead to time series noise evidenced by severe measurement problems (official and market exchange rates often differ by large margins). Thirdly, the economic insignificance of African states in the global economy could also help to explain the apparent lack of interest in carrying out much research into these economies.

Clearly economists like to use PPP as a frame of reference not just for industrial countries but for the rest of the world as well. Even more important is the fact that, in small open economies like those of SADC, the determination of exchange rates is of crucial importance to understanding the links between domestic and foreign economies. Therefore, given that very little attention by way of research on the PPP and UIP has been given to Sub-Saharan Africa and least of all Southern Africa, this paper builds on the existing literature by systematically documenting the stylized facts on the validity of these exchange rate theorems in the developing economies of SADC. This could prove useful for a number of reasons. To begin with, such an investigation could be valuable for analyzing whether similar empirical regularities are observed across countries with different macroeconomic policies and at different economic development levels. Most important of all as argued for instance by Agenor and Montiel (1996), these findings may have important policy implications.

In the case of SADC in particular where one of the major causes of its dire economic consequences has been overvalued national currencies and unstable monetary events, the existence of an empirically verifiable long-run exchange rate theory, may prove crucial in providing firm foundations on, which to develop exchange rate models that capture exchange rate movements over the economic life cycle and, for exchange rate management
purposes. The results may also provide an important theoretical basis in the designing of financial stabilization policies, in as far as these concepts play a major role in the choice between interest rates, inflation or exchange rate targeting in their monetary policies (Boyd and Smith, 1999). In addition the findings might prove invaluable in providing a basis for the designing of structural adjustment policy programs recommended by the, IMF and World Bank as they play their increasing role as supervisors of stabilization and adjustment in transitional economies.4 Last but not least, since the use of these exchange rate theories is of immense importance (due to their implications for setting prices and hedging) to multinational firms, it is very important to establish whether these theories of exchange rate determination are accurate or even applicable to SADC countries.

Another motivation for the study is based on Thomas (1973) who warns against an unqualified projection of results based on historical periods to the current situation. He suggests that the recent experience of foreign exchange markets is necessary to gauge the relevance of the PPP theory to improve its applicability to existing conditions. In particular the new era of, floating albeit managed exchange rates affords useful data for such empirical work. For the SADC countries, even though the current floating exchange rate system dates back to 1973, currency liberalization started in the 1980s and only gained momentum during the 1990s when most foreign exchange restrictions were relaxed. It therefore goes without saying that with the current thrust to economic reforms, underpinned by among other things the need to properly value Southern African states' currencies, there is an inevitable need to investigate the validity of the PPP and UIP in SADC countries in the 1980s-90s. It is hoped that, the empirical findings will be of interest to the respective countries' policy makers and their economic-advisers as these investigations will indicate macroeconomic policy implications the policy makers can work on to achieve financial stabilization and stable and properly valued exchange rates.

Purpose of Study and Research Questions

To this end, a key contribution of this study is to build on the existing literature by extending the scope of investigations into the empirical evidence of the joint PPP and UIP hypotheses in Southern Africa in several dimensions. Using the framework of multivariate

4 One of the reasons the IMF was created, was to assist in the elimination of foreign exchange restrictions, which hamper the growth of world trade (Article 1 of the IMF's Articles of Agreement—IMF 1993).
cointegrating equations suggested by Johansen and Juselius (1990, 1992) and Pesaran and Shin (1997)'s long run structural modeling methodology, the paper investigates the existence of a long run relationship between nominal bilateral exchange rates of the currencies of the SADC against, a set of factors consisting of measures of interest rates and price differentials, as assumed by the PPP and UIP relation, as well as the real price of oil. The investigations were conducted using two approaches, (i) the intra-continental or cross-national approach where South African is the foreign country and the intercontinental approach, where the US is the foreign country.

The questions to be answered are:

1) Does the simple PPP and UIP hold in SADC countries?

2) Does the PPP model of exchange rates, used in conjunction with the UIP and allowing for the effect of oil prices hold for the SADC countries? In other words, how important is the price ratio variable as a theory of the determination of exchange rates, when compared to the interest rate differentials variable? This will be examined in two contexts: (i) the intra-continental approach and (ii) the intercontinental approach with the aim of answering question (3),

3) Is evidence of finding support for the PPP dependent upon the choice of numeraire currency? In other words does the PPP and UIP hold better for countries within the same continent or not

4) Are the speeds of gravitation towards PPP and UIP different or the same for the different SADC countries? The measuring of speed of convergence is critical especially where the strong form PPP is rejected.

Methodology

First an analysis of the order of integration of the variables is established using unit root tests as has become the standard procedure in most empirical studies applying time-series techniques. Secondly the order of the vector autoregression (VAR) is also established and finally the simultaneous model, which analyses data in a full system of equations as used by Johansen and Juselius (1990, 1992) is adopted for this analysis. The novelty of the

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5 The term simple PPP or UIP in the context of this study refers to the hypotheses, in their originally postulated forms i.e., not the joint study of the two.

6 The formulator of the modern PPP, Cassel (1922), believed that the disturbances to PPP would be extinguished after one year and the currencies revert to PPP.
model is that it allows for possible interactions in the determination of prices, interest rates and exchange rates, thus avoiding the single-equation bias (for full discussion see Johansen and Juselius, 1992). For the intra-continental analysis variance decompositions, persistence profiles and impulse response functions were also used to gauge the exogeneity of each variable and to measure the time profile of the effect of shocking one or all variables in the system respectively.

Although the use of the panel data approach has shown more power in predicting the validity of the PPP and UIP in most recent empirical literature, it was deemed necessary for the purposes of this study to preclude this approach for the following reasons. Firstly, because cross-country differences between the sample countries are substantial, this cross-sectional heterogeneity was taken into account and the countries considered individually for the empirical modeling of exchange rate dynamics. Secondly, as the hypothesis under investigation is not testing the validity of the Casselian theorem and the uncovered interest parity in general, but to test whether their empirical validity applies to each individual SADC country, the country by country approach was considered ideal. This is in line with the conclusion by Frankel and Rose (1996) and Maddala and Wu (1999), that assuming all sample countries have an identical PPP regression coefficient is too restrictive due to the considerable diversities of the macro-economic policies (particularly foreign exchange policies), which exist in each country and different traded and non-traded goods.

Also, since the empirical literature is of the opinion that the selection of a standard foreign country is useful in testing the PPP a lot of consideration was put into the issue. As stated by Officer (1976), if a unique standard country is to be used in the computation of PPPs for a broad group of countries then the usual choice of the US seems appropriate. However for individual country analysis, the optimal standard country would be the one with which the former country's trade and payments links are strongest. Davutyan and Pippenger (1990) produce evidence that PPP holds better for countries within the continent than for countries on separate continents. Using the same argument some studies have found that the PPP holds better for European countries than for the US (see, for example, Edison, et al (1997), Jorion and Sweeney (1996) and Papell (1997)). This seems to be caused by the fact that the geographical proximity of European countries facilitate greater goods arbitrage, making it more likely for the PPP to occur. South Africa was therefore chosen as the foreign country

7 Strong form PPP in this study refers to the PPP hypothesis in its symmetry and proportionality
for the cross-national approach not only because of its geographical proximity but also due to the fact that, all SADC member states have some trade links with it albeit to different extents. The US was deemed the favorite foreign country for the intercontinental or cross-continental approach.

Summary

The findings are that, cointegration tests for both the simple PPP and the joint PPP and UIP indicate some evidence of cointegration thus confirming the validity of weak form PPP and joint PPP and UIP hypotheses in the SADC. This positive result could be attributed to high inflation, which is a common characteristic of the sample countries during the sample period. However using long-run structural modeling, generally the estimated cointegrating vectors violate the symmetry and proportionality conditions implied by the PPP and UIP theories. The choice of foreign country does not seem to matter, as the results are similar both for the intra-continental and the intercontinental approaches with very few exceptions. We also observed that a common conclusion to this research is that the SADC exchange rates contain sizable mean reverting components but the mean reversion rate vary between countries and also between the PPP and UIP. Gravitation back to long-run equilibrium definitely does not occur overnight and deviation from parity is by and large persistent.

The rest of the thesis is structured as follows; Chapter 2 gives a detailed analysis to Sub-Saharan Africa’s economic trends over the past three decades. The Chapter also gives an introduction of SADC and outlines the specifics of each member country’s, economic standing. The Chapter concludes by isolating the unique economic characteristics of the sample countries relevant for the analysis. Chapter 3 outlines the literature review and gives the theoretical background of the PPP and UIP doctrines, marking out their empirical origins and the subsequent criticisms as well as problems underlying their testing and implementation. Following this, the model and methodology is presented in Chapter 4. Data and results are analyzed in Chapter 5. Chapter 6 outlines the limitations of the study

restrictions \( \{\text{i.e., } p \rightarrow p^* = I-I-I-1\} \)

\(^8\) Where there is cointegration at the 95% critical level we conclude that the weak form version of the theory holds even though the theory restrictions of symmetry and proportionality are subsequently rejected. The strong form theory validity is where the theory restrictions of symmetry and proportionality are accepted.

\(^9\) Southern Africa falls under Sub-Saharan Africa and this background chapter is intended to give the reader a better understanding of the structural characteristics of the region under study.
and recommendations for further research. The last Chapter concludes with an epilogue. An Appendix, containing data sources, data figures and detailed data analysis tables is also provided. The Appendix also contains a detailed description of the organizational structure of SADC. A reference list and notes are at the end.
CHAPTER 2
BACKGROUND

Any study of the SADC countries would not be complete without a brief overview of the overall African economic trends. The overview is also intended to provide the reader with a better understanding of the structural characteristics of the African economies.

2.1 A General Overview of the African Economic Trends in Sub-Saharan Africa

Southern African countries fall under Sub-Saharan Africa (SSA) and like all economies of SSA, the region is not only being left behind in the tide of globalization but has been arguably overturned by it much to the detriment of its economies. Stein (1999) even goes further and argues that globalization has failed to transform the structure of African economies and might have actually exacerbated some of its structural weaknesses and economic dislocation. It must be however noted at the onset that although they share common characteristics sub-Saharan African countries have great diversities, and as such it is accordingly difficult to draw general conclusions about the region’s economic performance as a whole. Broad generalizations will however be attempted.

By virtually any economic or social indicator SSA countries perform less well than any other developing region outside Africa. Its economic performance over the last three decades can be best described as disappointing as most of the region’s states failed to break away from the path of low or negative per capita income growth. With the lowest average GDP per capita output growth rate in the world of US$308, SSA has in many ways found itself retreating economically while other developing areas of the world, *vis a vis* East Asia, South Asia and Latin America, are developing strongly. Although performance slightly improved from 1995 primarily due to new commitment by many countries to sound macro-economic policies and more open and better managed economies, growth remain fragile. Factors underlying Africa’s parlous economic conditions and macro-instability can be broadly categorized as external and or internal, all of which have militated against sub-Saharan Africa’s fuller engagement in the international economy.

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10 Globalization in the context of this study means, the increasing integration of world economies through a combination of capital, information and technology and trade flows.
Major external factors contributing to most of Africa's economic pathologies include the vicissitudes of international commodity prices coupled with adverse movements in terms of trade, historical structures, massive shifts and huge declines in foreign aid and/or investment (financial flows). Internal factors are mostly sui generis to developing countries. They include poor soils, widely fluctuating and harsh climates, poor human and physical infrastructure, rapid urbanization and population growth, poor health delivery systems worsened by the upsurge of the HIV/AIDS pandemic, environmental degradation, ineffective and inefficient governments and, inappropriate public policies all topped up with persistent political turmoil and frequent transformation of political regimes. Unfortunately African governments have very limited control over many of these factors particularly the external ones.

2.1.1 External Factors of Economic Decline

Trade and Regional Co-operation:

The pillars of Africa's relationship with the western industrialized countries are, trade, aid and investment. Decline in all three has inevitably added to the continent’s poor economic performance over the last two decades, with the most serious of the external factors being the worsening terms of trade characterized by waning traditional exports both in terms of price and quantities, alongside ever increasing imports also both in price and value. Processing which would provide employment opportunities to African economies is discouraged by import policies (i.e. tariffs and non-tariff barriers to trade) of western industrialized countries. These forms of protectionism, for example strict inspection requirements on food imports also play a major and often negative role in Africa’s export performance. Additionally the relative decline in terms of trade in Africa is also directly related to the shifting nature of global production. Due to advances in biotechnology and material sciences, industry in western countries is increasingly turning to synthetic substitutes for primary products such as beet sugar for cane sugar. On the demand side fiber optics or microwaves are replacing copper wires in telecommunications, putting downward pressure on prices and curtailing imports from Africa.

Moreover, trade among African countries is low as most states produce similar products
for export, generally primary agricultural products and mineral commodities. As most value added is carried out in western industrialized countries (WIC) there is little African demand for these products. In fact, African countries themselves often discourage trade by their strongly inward oriented import substitution development strategies, including, over-valued exchange rates and protectionist trade policies. Their transport infrastructure is geared for export to Western Europe, Japan and North America making a mockery of the saying that charity begins at home. In Southern Africa for example, only 4% of the export trade of the 14 member countries of SADC were transacted between SADC markets in 1998. The result is that Africa has been missing the large expansion of international trade. Figures from the ARD of March- April 1998 show that, Africa’s share of global trade has fallen from around 3% in the 1950s to 1% in 1995.

In an attempt to improve their trade performance and to develop overall regional economic cooperation, there have been several attempts to form free trade areas or customs unions. Several of these have failed and have since been abandoned, such as the colonial imposed Federation of Rhodesia and Nyasaland (Zimbabwe Zambia and Malawi) or the East African Community incorporating Kenya, Tanzania and Uganda. Only the South African Customs Union (SACU) founded in 1969 and comprising of Botswana, South Africa, Lesotho, Namibia and Swaziland has stood the test of time and as such is the longest standing and successful regional organization.

Two other groupings commanding good prospects for success and respect are the Southern Africa Development Community (SADC) and the Economic Community of West African States (ECOWAS). ECOWAS has as its eventual goal the removal of barriers to trade, employment and movement between its 16 member states as well as the rationalization of currencies and financial payments among its members. However, owing to the political and economic disparities between its members, it is likely to be decades before any of the above objectives are fully met.

SADC was established initially as Southern African Development Co-ordination Conference (SADCC) to provide a counter, during the era of apartheid, to South Africa’s economic hegemony over the region. SADC did not initially seek an economic association or customs union, but rather to function as a sub regional planning center to rationalize

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development planning. Its reconstitution in 1982 to SADC placed binding obligations on member countries with the aim of promoting economic integration towards a fully developed economic market. This regional integration, it is hoped, will help the member countries to overcome the disadvantage of their relatively small economic size and enhance their ability to trade globally.

Foreign debt, aid and investment:

Three of the most obvious manifestations of external difficulties are the high level of foreign debt, moribund levels of international aid and the difficulty of attracting foreign investment. Africa’s debt has long passed sustainable debt ratios and its structure remains a major impediment to the continent’s recovery. In the whole region of SSA, total external debt as a percentage of exports rose from 91% in 1980 to 270% in 1995, whilst debt relative to GDP also increased from 30.6% of GDP in 1980 to 74.1% in 1995. Of the 36 most severely indebted low-income countries listed by the World Bank in 1996, 28 were from SSA. To date, without foreign debt relief and with the continued capital flight, some countries are paying much more than their exports bring in resulting in too frequent budget deficits.

Africa’s ability to service its debts has been impaired by rising world interest rates (commercial debt often uses floating interest rates) and severe falls in foreign exchange earnings coupled with ever declining annual levels in net foreign financial flows (including concessionary economic assistance) from the mid 1980s. For example in 1993, SSA attracted only $8.00 per capita in foreign capital flows against almost $200.00 per capita in Latin America. Also, much of the assistance particularly from IMF is short term and must be paid back even before structural adjustment is complete, such that in 1996 alone, Africa paid US$2.5 billion more in debt servicing than it received in long term loans and credits.

The major reasons for the dearth of foreign investment have been that the sub-Saharan Africa region has yet to broaden its investment base beyond energy and mining, which remain the prime attractions to foreign investors. While investors are, attracted by the region’s vast raw materials and low wage economies, they are fearful of high risk due to internal political volatility and the uncertainty surrounding obtaining enforcement of
contracts and low returns on capital. These considerations combined with the deteriorating human and physical infrastructure have virtually extinguished overall investor confidence leaving just a minute participation of Africa in flows of foreign direct investment (FDI). According to UNCTAD, Africa's share of developing countries' FDI has fallen from 11% in 1986-90 period to 5% during the 1991-96 and falling to a mere 3.8% in 1997. In the period 1991-95 the total going to Africa was only 2% of the world's total FDI (44% of it went to Nigeria alone). In comparison in 1996 Malaysia and Poland received more than the total of the entire continent. For sub-Saharan Africa this understates the paucity of participation.

Overall the poor export performances coupled with the problems of decline in foreign debt, aid and investments discussed above, have resulted in large deficits in most countries' current balance of payment accounts.

### 2.1.2 Internal Factors of Economic Decline

Having discussed the external problems, the internal economic problems in the view of many analysts far outweigh the external factors. Indeed the World Bank (WB) 1989 study on Sub-Saharan Africa's quest for sustainable growth suggested that, "underlying the litany of Africa's problems is a crisis of governance."

**Government, Social factors and Environment:**

Internationally, social and political stability is generally associated with higher economic growth rates. Unfortunately more than half of the African states have been caught up in civil wars, uprisings, mass migrations and famine. Ethnic conflicts and civil wars have continued in 2000 in Sudan, Liberia, Somalia, the democratic Republic of Congo and Angola to name a few. In addition to damaging economic prospects in the region, armed conflicts and instability has resulted in very low average GDP per capita. According to the World Bank between 1965 and 1985 the more unstable countries averaged annual GDP per capita.

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12 Statistics were extracted from Africa South of the Sahara 1999; Economic trends in Africa South of the Sahara, 1999.
13 For comparison with previous periods, according to the ECA Economic Report, FDI and bilateral credits to Sub-Saharan Africa fell from 5% in the 1970s to 3.5% in the 1990s.
capita output growth rate of 0.5% while the region’s most stable countries achieved an average growth rate of 1.4% over the same period.

In addition some governments even stable ones have been suspicious and hostile towards the business community be it foreign or domestic and have also become bloated, greedy and corrupt. This animosity has in some instances proved to be counter productive and a major impediment to foreign investment and economic growth. The quest for better governance remains critical especially in the area of economic management.

The region’s population growth has doubled since the 1960s and at the current growth rate it is again expected to double by 2020. Unfortunately most African governments until relatively recently did not view rapid population growth and environmental degradation (characterized by over cultivation and overgrazing) as matters of concern. Only in the last decade of the 20th century has a succession of countries realized that, their resources cannot service the ever-increasing population growth and so have begun programs on family planning and environmental protection.

Rapid urbanization also caused stress in many African economies and with it came rampant unemployment and underemployment as job opportunities failed to keep pace with the growth of labor force. To compound the problem, African states face significant problems in the provision of health services and education. This is made worse by the fact that several countries continue to spend more on military requirements than on health and education. The dramatic upsurge in HIV infections coupled with the rise in the incidence of tuberculosis also continue to exacerbate budgetary pressures on individual governments’ ability to provide adequate health care and education. The United Nations has estimated HIV to have, infected 24.5 million or 8.6 percent of the adult population of sub-Saharan Africa by the end of 1999. Given the size of the pandemic and its adverse impact on life expectancy, savings, growth, labor productivity and human welfare and the social fabric in several Central, Southern and East African states, it is reasonable to expect that AIDS will curtail GDP growth in several countries well into the 21st century.

Related to problems of inadequate education facilities and opportunities is the fact that participation in the era of information technology (IT) is contingent upon basic technological literacy. Without education vital elements of participation in the IT
revolution continue to lack seriously. Primary school enrollment rates continue to plummet from 69% for female children and 91% for male children in 1980 to 64% and 77% respectively by 1993 (World Bank; 1996). The decline in education is due to a variety of factors including pulling out children to support family income strategies in the informal sector after layoffs in the formal sector; the introduction of school fees in education and, the cutback in the 1980s on spending in education by many African governments partly in response to IMF credit and deficit targets. Also, the lack of hope in the formal economy for educated graduates has created demonstration effect due to paucity of jobs (Stein, 1999).

To cap it all, Africa’s institutions of research and development and higher learning have seriously eroded in recent years with irregular payments of staff salaries and, poor and inadequate staffing and funding, which remain very tiny by world standards. One can therefore argue that if Africa is to foster growth, then more investment and additional focus on human capital is needed, especially through shifting the structure of public spending in favor of primary education, health care and other social services.

Physical Infrastructure and the Structure of the Economies

For most countries in the region except South Africa, physical infrastructure has generally deteriorated since the countries achieved their independence due to neglect and funding crises. Serious infrastructure deficiencies in essential services such as transportation (roads, railways and ports), communications and power generation, remain a major feature in most economies in the region. The situation is particularly worse in the rural areas. Millions of US dollars worth of investment in transportation will be required if Africa is to take advantage of any improvement in agricultural output performances. Better allocation of public funds as well as opening these sectors to private investment, with appropriate supporting policies to foster competition, would improve infrastructure and at the same time reduce the public budgetary burden.

Although African industry marginally expanded during the past generation from about 25% of the continent’s GDP in 1965 to 30% in 1987, contribution to GDP is still lower than the least developed countries’ average.

The structure of sub-Saharan Africa’s economies has not changed drastically since the time of independence, as African goals of rapid industrialization have not materialized. We
argue that globalization has failed to transform the structure of African economies and might even have actually exacerbated some of its structural weaknesses. Manufacturing, which advanced rapidly in the 1960s has slowed to about the same average as the gross domestic product (GDP) growth and by the early 1990s manufacturing represented only 11% of the region's economic productivity (against 9% in 1965). In 1995 its contribution to global manufacturing was a mere 0.3%.

The Sub-Saharan Africa region experienced overall rates of inflation of 37.2% in 1993, 60.7% in 1994 and 43.4% in 1995. Many African countries' currencies appreciated in exchange rate terms during the mid 1970s because while inflation raised domestic prices, local currencies were not devalued to compensate. As a result most currencies became overvalued, such that their purchasing power was stronger for goods from abroad than at home leading to increased demand for imports. At the same time, their exports have become increasingly uncompetitive in price as their currencies became overvalued and the foreign "hard" currencies were in short supply. This drove African governments to limit or ration foreign exchange. This move triggered "parallel" or "black markets" for foreign currencies. Foreign exchange overvaluation was thus a result of inflation which, in turn was generated at least in part by escalations of government deficits itself a product of poor monetary and fiscal policies. To raise more revenue, African governments increased export and import tariffs and this led to declines in trade. As trade declines, so does government revenue thus exacerbating year on year budget deficits. If not corrected, overall production and exports are hurt by an overvalued currency, which inhibits economic diversification and resilience to future economic shocks.

**Agriculture and Famine**

Indisputably the leading factor behind the drastic declines in African economies has been the general neglect of agriculture. Agriculture alone accounts for about a third of the GDP for the continent as a whole, two thirds of employment and 40% of export value. As suggested by the WB, "if agriculture is in trouble, Africa is in trouble", and agriculture has been in trouble for the past three decades. On average agricultural growth was slower during the period 1970-1990 (then it rose by 1.4% annually, about half the rate of the population growth) than in the 1960s when it advanced at the rate of 2.7%. The impact is that several African states in the region are suffering from food deficits and the under
Many African countries continue to suffer from either chronic food insecurity because there is not enough food locally or because they cannot afford enough food, or from transitory food insecurity due to fluctuations in prices and production levels caused by natural climatic difficulties including droughts and floods and civil wars. Sadly, several millions suffer from hunger or are at the immediate risk of famine especially in rural areas. Grain, meat and overall calorie consumption are well below the required minimums and Africa remains the only continent in the world that has not reached a life expectancy of 60 years. To make matters worse producers are often bound by prices fixed by their governments and at times these “producer” prices fail to cover input costs, forcing farmers to reduce production for sale and reverting to subsistence agriculture. Low levels of technology and bottlenecks like poor roads for transporting produce also have a negative impact on agricultural production.

Parastatal Organizations

Central to the understanding of direct state involvement in many African economies is the role of parastatal organizations. The establishment of these state-owned organizations rose out of the governments’ justifiable concerns that the private sector could not or would not help in improving the living conditions for the poorest citizens. Generally most analysts consider these public enterprises to have failed at least in terms of the economic efficiency criteria. Consistent and at times uncalled for government intervention in their day to day running, mismanagement and corruption are some of the often cited causes for the failure of the predominantly monopolistic parastatal bodies. Appropriately designed and regulated divestiture should improve efficiency, reduce strains on the public budget, eliminate political interference in decision making and provide incentives for foreign investment, more innovation and dynamism.

2.1.3 Pressures for Economic Policy Reform and Adjustment

Pressures from international organisations

Due to their poor economic performance and their growing economic malaise, the African
countries have been coming under increasing pressure from a variety of sources to liberalize their public economic policies. During the 1970s to the 1990s most direct pressure came from the IMF, which stressed the importance of macroeconomic stability as a precondition for growth and poverty reduction crippling most countries in the region. It insisted on a condition for its support sometimes termed “structural adjustment”, usually in the areas of exchange rates (i.e. devaluation) agriculture, infrastructure and institutional reform in the public sector as well as reduction in government spending, before a new loan agreement could be signed. By 1997, 35 African countries had launched Structural Adjustment Programs. Additional pressures came from the WB and USAID all, which joined the IMF in playing an increasing role as the supervisors of stabilization and adjustment in transitional economies. To date, in essence, African governments have little choice but to agree to the terms and conditions of the IMF and Word Bank if they are to receive any concessional assistance and debt relief.

From the perspective of the World Bank and IMF, the cause of Africa’s economic melancholy was directly the result of policies pursued by the governments of Africa since independence and particularly from the 1970s. The important policies as cited in H. Stein 1999 are:

1) Overvalued exchange rates which encouraged imports at the expense of exports which in turn caused imbalances in the current account
2) The neglect of agriculture through low production prices and government controlled marketing boards, reflecting broader policy of an urban bias.
3) Over investment in import substitution relative to domestic demand and to the export industries that are needed to generate rising foreign exchange.
4) Over extension of public ownership relative to their economic justification and existing management capacity, leading to inefficiently run public enterprises while displacing the private sector.
5) Overspending on government, usually to support bloated bureaucracies leading to exorbitant budget deficits.
6) Financing of government deficits and public companies through money supply creation or seigniorage leading to inflationary pressure.
7) Artificially low interest rates leading to the discouraging of savings while encouraging investment in capital intensive production at the expense of more
suitable labor intensive operations. Shortage of savings ultimately lowered investment levels.

8) Price controls on products leading to disincentives to produce, shortages and rampant corruption.

9) Foreign exchange controls with central allocation of foreign exchange also leading to corruption, bureaucratic obstacles and usage, which was of little benefit to the country.

10) Excessive and often misguided use of trade tariffs and other forms of protection leading to a paucity of competition and inefficient production.

The prescribed treatment or model of adjustment follows from the above diagnosed causes and, specifically the 1981 WB study proposed four major and basic policy changes it felt were critical and they are:

(i) Exchange Rate Policies; Correction of the overvalued foreign exchange rates through currency devaluation and shifting the currency allocation procedures away from centralized control. At the sectoral level, lower exchange rates will make local funds available for export oriented agriculture and industry thereby providing incentives to produce in this area, which in turn increases the supply of foreign exchange. Devaluation also penalizes companies heavily dependent on imported inputs, thus encouraging a greater conservation of foreign exchange. Liberalizing foreign exchange will reduce corruption, punish inefficient industries and benefit viable ones, which are export oriented and, encourage the inflow of foreign investment by removing bureaucratic obstacles and the security of an exit option.

(ii) Price Policies; This is also termed the “getting prices right” doctrine of adjustment. It allows for pricing policies conducive to the free operation of supply and demand by, removing of all forms of price controls, elimination of subsidies and disbanding all methods of state sponsored inter-firm allocation as well as improvement of price incentives for exports and agriculture. Improving agriculture is in Africa at the heart of adjustment. It provides raw materials to industry, vital foreign exchange when exported and important demand linkages to the rest of the economy. Also raising the terms of trade in agriculture is the best way to improve income distribution and reduce poverty since the majority of the poorest
population is engaged in agricultural production.

(iii) Commercial Policies; The protection of industry in a more uniform and less direct way to avoid distortions in the economy by allowing competition from imports to act as an incentive to lower costs and raise quality and quantity of production. Quotas and other protectionism should be replaced by tariffs so that the market can be used as a basis of adjustment.

(iv) Financial and Institutional policies through reduction of direct government controls; This falls into two parts,

(a) Financial policies entail a tight control of monetary aggregates and government deficit spending through the operation of an independent central bank. Public debt will no longer be covered by high-powered credits from central banks but through the auctioning of treasury bills to the public. As part of financial policies, the exchange rate levels should be a reflection of the relative price levels between countries (purchasing power parity). In a world of floating exchanges, little or no inflation will generate exchange rate stability, which will provide a climate more propitious for encouraging foreign investment in industry. Similarly price liberalization will reduce informal sector activities and in turn generate, a potentially larger tax base and tax revenues making it easier to contain budget deficits (supply side argument).

(b) Institutional policies focus on reform of the public sector. Inefficient state enterprises should be closed down, sold to the private sector or systematically restructured. Operating decisions should be developed away from political influences and managers should be subject to clear financial and economic performance criteria. Profits should be a reliable indicator of efficiency in the public sector. Public policy towards private sector and investment activity should be made transparent and should transcend price and foreign exchange alignments. Private property rights need to be established and enforced through the expansion of an autonomous judiciary system. Finally the informal sector should be encouraged to shift into formal production.
Though these grandiose remedies sound very attractive both in theory and maybe in practice in industrialized macro-stable economies, to Sub-Saharan Africa, they have proven to be more of a “shock therapy” approach to financial liberalization. They are also problematic and have ineluctably contributed to financial chaos in some countries (Nigeria is a good example). McKinnon cited in Stein (1999) argues that much of the financial disarray has arisen, because the proponents of liberalization have not followed an optimal sequence of liberalization, including macro-stability before financial deregulation. In particular, he suggests the sequence should be inflation control, followed by interest rate liberalization, privatization and commercialization, unification of foreign exchange rates, trade liberalization and lastly opening up economies to capital flows.

It is also crucial to ensure institutional homology, such that the rate of transformation or adjustment in the different components of the system are internally consistent and well suited to servicing the needs of the real sector of the economy.

Pressure from within

In addition to IMF and World Bank other pressures also originated and grew internally, as more people became increasingly dissatisfied with their declining living standards and the poor economic performances of their countries. As a result, during the early 1990s several countries, most notably the following SADC member countries, Mauritius, Malawi, Kenya, Tanzania, Uganda and Zimbabwe removed restrictions on external capital transactions. This effectively closed the gap between official rates and “parallel” or “black market” rates. South Africa removed its two-tier exchange rate system in 1995 and Angola, Zambia, Sierra Leone and Ethiopia have also unified their foreign exchange systems making foreign trade and investment less cumbersome.

Recognizing their poor past performances and also as part of their structural adjustment programs, African governments are currently scaling down their involvement in parastatal organizations by commercializing their operations, providing them with greater operating autonomy or privatizing them completely. In addition to privatizing state-owned organizations, many African governments are actively seeking and encouraging participation of the private sector both domestic and foreign. However, by the mid 1990s less than one fifth of sub-Saharan Africa’s state-owned enterprises had been sold, very few
of which were operating in such key sectors as electricity, telecommunications transport and mining.

The region has also, as a result of adopting progressive economic policies, experienced a dramatic growth in stock exchanges and in 1996 new houses had opened in Zambia, Malawi, Uganda, Seychelles, Sudan, Swaziland and Tanzania (mostly SADC countries)

2.1. Current Economic Outlook

Economic reforms for those very few countries that followed reform prescriptions well have in general led to some improved economic performance especially since the second half of the 1980s. However growth remains fragile, standards of living are still very low and poverty is widespread as some sectors have experienced sharp declines. Accordingly, the 1994 WB report on 29 sub-Saharan countries, which took reform adjustment strategies in the 1980s and early 1990s, concluded that in the broadest sense no African country has yet firmly established a sound macro-economic policy. In fact only six countries out of the 29 namely Ghana, Tanzania, The Gambia, Burkina Faso, Nigeria and Zimbabwe, which also made the most improvement in macro economic policies between 1981-1991, performed comparatively well in economic terms. From this result it is clear that the extent and depth of the impoverishment of African peoples are such that, as most would agree, market forces alone and the grandiose IMF/World Bank structural adjustment prescriptions, have so far failed to improve the quality of life of millions of Africans.

It is also clear that for African governments to implement their plans for economic liberalization encompassing generally higher agricultural producer prices, revised and realistic foreign exchange rates and publicly unpopular policy reform measures, they require increased outside support. Sadly unlike other countries like Thailand, Indonesia, South Korea, Brazil and Russia, where the IMF continue to intervene with multi-million dollar bailouts, in Africa such economic assistance to the region from IMF, OECD and other major multilateral donors was and continues to be dependent upon the pursuance of sound economic reform. Although the UN and United Nations Center for Trade and Development (UNCTAD) in conjunction with the Organization of African Unity (OAU) continue to launch programs mainly financed by the WB to assist Africa’s economic development their efforts are not adequate.
2.1.5 Summary

One can conclude that overall the performance by sub-Saharan economics over the past three decades has been depressing. However despite the dismal economic performances by most of its states, Africa is still a resilient continent in other areas. It has notably withstood drastic changes during the past three centuries especially within the last three decades of the 20th century. It has moved from colonial domination to independence in less than two generations. Recent history elsewhere, particularly in Asia suggests that the unacceptable economic deterioration of the past thirty years can be reversed. As sub-Saharan Africa moves into the 21st century its governments must, realize that, while most economic problems were inherited, responsibility must be taken for problems that are soluble. So rather than being hostile to foreign entrepreneurs and investors in the form of harsh regulatory controls, most African governments are actively seeking foreign based involvement. By 2000 most governments were presenting the appearance of reform and acknowledging the parallel between political pluralism and economic development. This combination of liberalized economic policies together with more political openness could signal the beginning of sub-Saharan Africa's transformation towards economic recovery and sustained long term development.

Undoubtedly, continued productivity gains and sustainable economic growth performance can only come through the implementation of a successful macroeconomic adjustment policy underpinned by structural changes, which includes allocation of state factors to more productive activities, diversification and opening up of the economy. As an example, Lucas (1993) cited in Berthelemy and Soderling (1999), argued that the creation of "Asian Miracles" relied on structural changes leading to the production of increasingly sophisticated product mixes. Structural changes are however not likely to occur in the absence of significant investment and capital accumulation. It is in this area that Africa needs foreign assistance in the form of sustained aid flows, inasmuch as local savings capacity will be insufficient to support the necessary human and physical capital accumulation in the short term.

A joint report issued by the World Resources Institute and the International Institute for Environment and Development succinctly states that, "Sub-Saharan Africa poses the greatest challenge to world development efforts to the end of the 20th century and beyond."
Africa’s path ahead remains difficult and uncertain but not without hope. Vital questions are posed by the extent to which, the region is truly committed to genuine reform and whether it can finally break the cycle of poverty, macro-instability and political instability in which it has been trapped for the past 3 decades. In addition, will sub-Saharan Africa continue to be marginalized in the globalization process or can it find ways to better integrate into the global economic village. Can the very recent and positive signs of economic growth be sustained?\(^\text{14}\)

2.2 Southern African Development Community (SADC)

2.2.1 Introduction

The Declaration and Treaty establishing the SADC, which replaced the Southern African Development Coordination Conference (SADCC)\(^\text{15}\) was signed by the then existing ten member countries at the Summit of Heads of State Government on 17 July 1992 in Windhoek, Namibia. By September 1993 all the member states had ratified the treaty and it came into effect on 5 October of the same year. SADC’s stated aims are economic harmonization and to achieve this end, the economic community is dedicated to the ideals of free trade, free movement of people, a single currency, democracy and respect for human rights. An understanding of the PPP and UIP in the region will therefore, undoubtedly provide some input into that process.

The current fourteen member states are Angola, Botswana, and Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

2.2.2 Review of the SADC

Given the organization, its aims and sound macro economic fundamentals (please refer to SADC Appendix page.), the SADC has indeed great potential to become one of the most prosperous and dynamic economically viable and vibrant political blocs in Africa as well

\(^{14}\) Sustainable development in this context is as defined by Robertson (1999), as the economic enhancement that meet the needs of the present generation without compromising the ability of future generations to meet their needs.

\(^{15}\) SADDC the predecessor to SADC was established in 1979 to harmonize development plans and reduce the region’s economic dependence on South Africa.
as a key player in the world’s economic arena. With a population of about 190 million and a combined gross domestic product (GDP) of $176 billion, the region has the prerequisites for economic growth and remains one of the largest unexploited markets in the world. It is richly endowed with abundant energy resources, huge diversified mineral deposits and an agricultural sector that in most of its member states could expand considerably. It has sufficient human resources that can be trained, a reasonably good infrastructure, a significant tourism business and, an embryonic industrial sector that given the right conditions could be a driving force in the development process. However, this potential is in sharp contrast to the actual situation of escalating violence, hostile legal regimes, corruption, economic crisis, hunger and poverty\(^{16}\), declining life expectancy caused in main by the AIDS pandemic\(^{17}\), distorted economic structures and adverse regulations, declining resource inflows and a huge debt burden and credit risk.

It is estimated that the SADC region’s huge external debt at the end of 2000 amounted to US$79 billion. Because of this, six of the SADC member states now belong to the category of highly indebted low-income countries. The reasons for the colossal debt burden of Southern Africa are many, varying from corruption of military and civilian leaders to drought, failed projects (many directed by western technology) and the fact that Southern Africa is not getting a “fair share” of the world’s investment. The major historical reason for debt is however destabilization by apartheid, which drove most of the SADC countries to resort to borrowing as a means of finance their own security. This coupled with hard currency constraints, are major stumbling blocks for national and regional development, as SADC has had to rely heavily on foreign donors.

Related to the above, another factor contributing to the sluggish performance of the SADC economies remain the marked reduction in resource flows as evidenced by a decline in both FDI and developmental assistance to Southern Africa’s low credit worthiness. Apart from the high levels of indebtedness other factors believed to have contributed to the low levels of credit worthiness are high political risk, weak economic growth and export

\(^{16}\) Poverty in this context is described as a multidimensional phenomena reflected in poor social indicators such as illiteracy, unemployment, underemployment, declining life expectancy and unsatisfactory access to basic services and infrastructure needed to sustain basic human capacities. Poverty can also be categorized into, (i) income poverty (i.e. lack of income to buy basic food requirements and non-food needs; often called extreme poverty and overall poverty respectively) and (ii) human poverty (lack of human capabilities such as education, clean water sanitation and energy).

\(^{17}\) Available statistics show that as high as 1 in every 5 is infected with aids. In 4 countries the rate is over 400 people in every 1000.
performance, large structural fiscal deficits, erratic monetary and exchange rate policies and weaknesses in financial systems. The enhancement of the volume and productivity of investment is vital in bringing about accelerated economic growth, but both foreign direct investment and official development assistance have been falling while domestic savings are at a level, which cannot support the investment expenditure needed to give fresh impetus to growth.

Another previously mentioned drawback is the protectionist tendencies of developed countries. These unfair trade practices of developed countries deprive Southern Africa and other developing countries of potential export revenues. The World Bank President in his statement at the annual meeting of the Bank in Prague 2000 hinted that, 'the protectionist measures and subsidies in industrialized countries cost developing countries US$40 billion a year in lost export earnings, more than they receive in official developmental aid'. Linked to the above is the issue of member countries' inward oriented import substitution development strategies and burdensome regulations all, which discourage regional trade thus thwarting trade its rightful role as the engine of economic growth. Evidence from other regional integrations have shown that other things being equal, regions in which the nations have much trade with each other and relatively little trade with the rest of the world and have structures of production that complement each other, are much more likely to gain from regional economic integration. Unfortunately in SADC, as in most third world countries the opposite situation exists where the lion's share of external trade is with the rest of the western industrialized countries and only a very small portion goes to the region.

Furthermore, the strength of the SADC as a region is weakened by the fact that production structures in individual economies do not complement each other and as such investment opportunities have yet to be created. This lack of a cohesive economic agenda by the SADC for regional economic integration has meant that individual economies of most member states are not internationally viable and competitive. As a result they are not in a position to enjoy the required economies of scale and to effectively deal with constraints to international economic competitiveness. These constraints include uncompetitive industries, small markets, inadequate infrastructure, underdeveloped financial and capital markets and, lack of modern technology and skilled manpower. As such, significant benefit to its individual member countries is yet to be realized.
All the weaknesses discussed above tend to undermine the fundamnetals upon which the organization was originally established. One is therefore bound to question whether the organization’s continued existence is warranted considering the fact that its original *raison d’etre*, which was to isolate South Africa is now gone. Is the organization now not just a neo-colonial hinterland of South Africa? However this debate although interesting is beyond the scope of this thesis.

However, on a more positive note the recent implementation effected in Windhoek on September 1, 2000, of the fourteen-member SADC trade agreement, although it falls short of establishing completely a free trade area (FTA) throughout the region, is a giant step towards trade liberalization and the achievement of SADC’s ultimate goal of regional economic development. The trade agreement, is a follow up to the SADC Trade Protocol of August 1996 which seeks to establish an FTA and it entails the immediate elimination of tariffs for what is termed, Category A goods. Members, especially South Africa, offered to reduce their tariffs under this agreement and they were all expected to enforce the reciprocal tariff reductions by March 1, 2001. This is well in line with the agreement that SADC members categorized as developed, specifically South Africa and other participants in the Southern African Customs Union (SACU) will front-load the bulk of the tariff reductions. While the schedule will be slower for developing countries, which include Zimbabwe, Seychelles and Mauritius, and even more slow-paced for the least developed countries, namely Malawi, Tanzania, Mozambique, DRC, Angola and Zambia.

Also worth noting is the fact that, against all the odds discussed above, the SADC region has scored a few pluses in terms of overall economic growth since 1991 with an average annual growth rate of 3% at the regional level. Some member states such as Botswana, Mauritius and Mozambique have recorded average annual growth rates above 5 percent, while the majority recorded average annual growth rates below 4% as reflected in the Table 1 overleaf.

Last but not least is the fact that gradually the SADC is beginning to coordinate its activities and acting together as one region in many international forums as demonstrated by the SADC Pavilion at the *Expo 2000* in Hanover Germany. Such efforts are intended to strengthen the region’s international economic competitive advantage.
2.3 Individual Member Country’s Economic Characteristics

Although all could potentially benefit significantly from regional integration and cooperation, there are vast disparities in the levels of development between the 14 SADC member countries. There are also some systematic differences in the structural characteristics across the countries as revealed in the following discussion.

2.3.1 Angola: Prior to its independence in 1975, Angola enjoyed a high output economy with a rapidly expanding manufacturing sector, near self sufficiency in agriculture with crop surpluses for export and, abundant natural resources such as petroleum and iron ore. With the petroleum sector continuing to prosper, Angola is the second largest oil exporter in sub-Saharan Africa and oil receipts account for the great bulk of merchandise exports and of government revenue and slightly more than half of the GDP. However, the country has had to endure many decades of internal conflicts before and after independence, to the extent that the economic activity in almost all the non-oil sectors are operating at a fraction of pre-independence levels.

To address this a program of radical economic reform was announced in 1991 as part of the government’s commitment to move away from economic policies based on Marxist-
Leninist ideology adopted at independence to a market economy. Although, the program liberalized most aspects of the economy and saw the massive devaluation of the kwanza national currency, it failed mainly because of the ballooning budgetary deficit triggered by unplanned military spending. A second attempt at reform saw the introduction of a new reformed program named, ‘Nova Vida’ (New Life) in conjunction with the IMF and it resulted in the reduction of inflation.

Despite all this effort at reform social conditions continue to be adversely affected by the armed hostilities, which exerts strong pressures on public finances leading to worsening current account deficits. In particular, the resumption and intensification of the civil war since 1998 led to a slow down in GDP from 3.2% in 1998 to 2.7% in 1999. Inflation has accelerated to triple digits and was 438% for the twelve months ending May 2000.

In addition, the financial market is still not well developed and the monetary policy was accommodating until trade and foreign exchange rate policy and financial systems were liberalized in May 1999 and the kwanza was allowed to freely float. Although there are still some exchange rate restrictions, action is being taken to strengthen public finances, reform public administration and improve transparency in a bid to control government operations and continue with tax reforms.

2.3.2 Botswana: The country has been among the world’s best performing developing economies with an average annual growth rate of 7%. This per capita output growth of more than 7% a year has allowed Botswana to develop from one of the world’s poorest countries at its independence in 1966 to an “upper middle income” country today (under the World Bank’s definitions)\(^\text{18}\), with per capita income well above the sub-Saharan Africa average. The back-bone of Botswana’s economy are diamonds, which remain the country’s strongest foreign currency earner (88% of earnings) and accounts for more than 45% of the total government revenue. Factors contributing to this long-run success include prudent monetary and fiscal policies, the efficient exploitation of mineral resources and the use of those resources to boost investment in infrastructure and social services, such as

\(^\text{18}\) The World Bank defines (World Bank 1989), (a) Low Income countries as those with per capita GNP of US $480 or less in 1987. (b) Middle Income countries as those with a per capita GNP of US$480 < $6,000 in 1987 and (c) High Income Countries as those with a GNP per capita in excess of $6000. Usually low income and medium income countries are referred conveniently to as developing countries. Since the per capita GNP naturally occur over time, the income classification criteria have
health and education, and a stable political environment attributable to a democratically elected government.

2.3.3 Democratic Republic of Congo (DRC): Since 1990 the DRC has experienced an extraordinary period of high inflation among the longest on record, from 56% in 1989 to 10,000% in 1994 before falling to 370% in 1995 and rising again to 657% in 1996. Roots of hyperinflation were essentially political and the collapse of the traditional form of government, under the administration of Mobutu, which was accompanied by an explosion in government spending and dwindling revenue collections.

During 1991 and 1992, opposition forces derailed the gradual liberalization process led by the president, and by 1993 DRC (then Zaire)'s political system had all but disintegrated. A measure of control over monetary policy was restored in 1995 but in late 1996 political conditions further deteriorated and inflationary pressures reemerged. Hope was somewhat restored by the coming into power of L Kabila in 1998, but it was short lived as war resumed in the same year plunging the nation into a deeper economic and political quagmire.

The urgent challenges the country is facing in order to recover economically are an immediate solution to the prolonged political stalemate, an abrupt and complete halt to currency issuing and an immediate address to the fiscal policy in form of structural reforms. The coming to power of J. Kabila in 2000 is expected to bring some peace to the war torn nation and hopefully some economic recovery. However positive recovery signs are likely to take a while to emerge.

2.3.4 Lesotho: Although economically Lesotho is one of the least developed countries with its resources having been listed as "people, water and scenery", until the late 1990s economic performance in Lesotho was favorable due to prudent fiscal management. In 1995, the World Bank measured Lesotho's GNP at an average of $720 per head. The country's GDP increased in real terms and averaged 6% in the decade ending 1997. Performance began to deteriorate in 1998, leading to a 4% decline in GDP for the fiscal year 1998/99. This turn-around in economic performance was caused by political disturbances after the 1998 elections, fiscal pressures, decline in foreign direct investment been adjusted upwards periodically by the WB. As such, with the adjustments in criteria, the country
and a slow down in the manufacturing industry. GDP however, picked up and grew by 2.5% during the 1999/2000 fiscal year.

Although the country does not have an independent monetary policy, inflation has remained low because the nation’s currency, loti (plural maloti) is fixed one to one with the South African rand. Given the limitations of the monetary policy, fiscal prudence is crucial to sustain economic growth. With growth in mind, as from 2000 into the early 21st century, the country is focusing on growth oriented policies as well as fiscal restraint, tax policy and administration reforms, privatization, financial sector reform, bank restructuring and institution strengthening.

2.3.5 Malawi: Malawi’s growth performance in the 1990s was modest, thanks to some structural reforms in the form of liberalizing agricultural production and external trade. Real per capita GDP grew an average of less than 0.5% per annum from 1989-1999. This was an improvement on Malawi’s performance in the 1980s when per capita GDP declined after having grown at an average of 2.2% per year between 1969 and 1979. However, the high and variable rates of domestic inflation experienced in Malawi during the past two decades caused by a monetary policy which accommodated fiscal pressures, coupled with incomplete programs in structural reforms, have been the major obstacles to the achievement of satisfactory growth rates.

The exchange rate throughout the 1990s was that of formal and/or informal management and therefore the currency experienced episodes of sizeable depreciation episodes in 1994, 1998 and 2000. However as from May 2000 the Central Bank established a fully flexible and market-determined exchange rate system. The financial sector, nonetheless continue to provide very limited support for the private sector development. In addition, infrastructure remains in a precarious condition. The task ahead therefore, is to build more on the achievements made so far by ensuring steadfast application of policies for macroeconomic stabilization and structural reform.

2.3.6 Mauritius: Unlike most countries in SADC, Mauritius has enjoyed good rates of economic growth over the past two decades and, it is classified by the World Bank as an “upper middle income economy”. Tourism, light industry (including textiles) and sugar,
dominates the backbone of Mauritius' economy. Despite its relatively favorable economic performance in recent years, Mauritius faces a number of uncertainties. Among them is rapid population growth, which could lead to overcrowding and environmental damage, and an infrastructure showing need for heavy investment in projects such as roads, telecommunications and public utilities. However, prospects for growth remain high well into the 21st century, mainly because of the textile and tourism industry.

2.3.7 Mozambique: Mozambique's post independence economy suffered the damaging effects of guerilla war, drought, floods, famine, the displacement of population and severe scarcity of skilled workers and foreign exchange, compounded by a large visible trade deficit. As a result, the country is heavily reliant on foreign credits. Signs of economic recovery began to emerge at the end of the 1980s, only to decline due to the 1992-93 drought and to rise again after 1993. In 1995 according to estimates by the World Bank, GNP per head measured by 1993-95 prices was $80.00.

The country has made considerable progress since 1995 in dismantling the state-owned economy and adopting outward-looking and market-oriented economic policies. Structural reforms focused on the shift toward market determination of prices, with the liberalization of the exchange rate and interest rates and elimination of virtually all price controls and trade. Exchange liberalization also saw the removal of non-tariff barriers and exchange controls, a lowering of average import tariffs and elimination of most export taxes. Fiscal reforms included civil service reform, simplification and restructuring of the tax system and improved public expenditure management, while raising the actual delivery of health and education in real terms. Private sector development has been fostered by reducing administrative barriers to trade and investment, legal and judicial reform to increase economic security and, financial sector reform to develop money markets and indirect instruments of monetary policy.

2.3.8 Namibia: With a GDP per capita of more than US$2 000, Namibia is relatively prosperous in the Southern African context and is classified as a 'lower middle income economy' (World Bank definitions). However the figure disguises an extreme inequality in income distribution, with the average income of the white minority significantly higher than that of the mass of the black population. Having experienced deep economic recession in the early 1980s, due to war, drought and low world prices, the
economy has been recovering since the mid 1980s. The economy however remains highly extractive and poorly integrated with about 90% of the goods it produces being exported and 90% of goods used in the country, including ½ of the food being imported. Overall, Namibia's economic growth rate continues to advance with future economic prospects primarily due to its abundant mineral reserves and rich fisheries.

2.3.9 Seychelles: Over the ten years ended 1997, the Seychelles grew by an average annual rate of 6% and inflation averaged less than 2% a year. However, real GDP growth slowed in 1998 and 1999 while inflation rose sharply ending at above 10% at the end of 1999 for the first time since the early 1980s. Despite growth in the manufacturing and construction sectors, declining tourist arrivals and tourism earnings, the heightened shortage of foreign exchange and the devastating effects of the global weather phenomena El nino and La nina, were the main factors accountable for the slowdown in overall output during the 1998-99 period.

The slump in economic activity led to large fiscal deficits evidenced by substantial external arrears due to foreign exchange shortages and deteriorating external competitiveness. In response and mindful of the acute foreign exchange shortages emanating mainly from the rigid exchange rate policy, the country introduced (in 1998), a series of elaborate trade and exchange restrictions aimed at limiting imports of goods and services. These restrictions have so far proved ineffective in stemming the foreign exchange crisis. To brace itself for economic recovery and to improve its external competitiveness, the Seychelles needs to work on liberalizing its trade and exchange policies, reduce its balance of payment deficit and implement structural reforms.

2.3.10 South Africa: The country has the largest economy in the region and is classified as an, 'upper middle income economy' using World Bank definitions. The vagaries of climate mean, South Africa remains a relatively poor crop raising country in most branches of farming. However, its greatest wealth lies in substantial and diverse mineral deposits including diamonds and gold. Fisheries also contribute to the economy's wealth. Exports remain the major source of growth causing the country to record an overall surplus in the current account. Unlike most of its SADC and African counterparts, South Africa's manufacturing industry is the largest sector of the national economy, measured in terms of contribution to GDP.
The country undoubtedly achieved remarkable economic development in the 1960s with one of the highest economic growth rates in the world during that decade. The fruits of that development were however unevenly distributed because of apartheid. Growth during the 1970s was lower but picked up again in 1980 due to the boom in world economic prices especially gold. The weakening price of gold and generally unfavorable commodity prices on the international markets, plus the damaging effects of political instability and sanctions, and severe drought and low overall investment caused an economic recession in the late 1980s and the early 1990s.

Following the election of the new government in 1994 the country has been following a market oriented approach to economic development that has been characterized by the extensive pursuit of prudent fiscal and monetary policies, substantial progress in trade liberalization and the maintenance of a healthy and robust financial system. This approach helped South Africa to withstand contagion from the Asian financial markets turbulence of 1997-98, with relatively little economic dislocation. Since then the country has regained its momentum and experienced a modest export-led economic recovery, fueled by the expansion in world output and improvements in external competitiveness.

Progress in strengthening public finances has been impressive and as a result the overall deficit of national government has been reduced as a percent of GDP since 1992/93. At the same time, fiscal expenditures have been reprioritized toward the social sectors (education, health and welfare) and strong improvements have been made in the efficiency of tax administration. Due to sound monetary policy inflation has fallen considerably during the 1990s from 18% in 1991 to 8% in 1999. However the AIDS pandemic and the escalation of criminal activity remain major challenges to the government. Looking ahead, South Africa needs to build on the progress made so far towards macroeconomic stability by implementing faster structural reforms, particularly in the labor market and privatization areas. The fight against AIDS and crime also poses a major challenge.

2.3.11 Swaziland: Swaziland, the smallest state in mainland Africa after Gambia, is a "lower middle income country" according to World Bank definitions, with a per capita.
Despite its relative diversification and wealth, Swaziland has not escaped the extremes of income distribution familiar elsewhere in Africa\(^\text{19}\)

Over the past three decades, from 1972 to 1997 the country experienced growth and the GDP grew at an annual rate of just under 6% with manufacturing contributing the largest share of GDP. In 1998 growth declined and inflation rose because of the depreciation of the South African rand against which the Swazi currency, the lilangeni (plural emalangeni) is pegged. Unemployment increased as private sector employment declined. Although unemployment remained high and the country’s government moved into deficit, by 1999 economic activity had picked up.

In 2001 the receipts from the South African Customs Union (SACU), the major source of government revenue, are expected to taper off at the same time when the country is facing high incidence of HIV/AIDS infection. The country’s immediate challenge is therefore to offset the effect of the tapering SACU receipts by safeguarding fiscal sustainability, without unduly adversely affecting the level of existing public services and at the same time, permit much needed expansion in outlays of health and education. This calls for reforms to expand the tax base in order to boost government revenue coffers.

In addition, there is the need to accelerate the pace of reforms, in particular reform relating to land tenure arrangements, restructuring and privatization of additional public enterprises, maintain adequate investment levels and improve the skills base in order to, help sustain broad based economic expansion.

2.3.12 Tanzania: Tanzania remains one of the poorest countries in the world and economically the country performed dismally from independence in 1961 until the mid-1980s. The almost two decades of severe economic decline brought the country to a condition of economic collapse with a near static average annual growth of 0.8%.

However in the 1980s the government driven in main by the desire to obtain continued aid from international donors, abandoned the Marxist-Leninist economic ideologies and

\(^{19}\) It is interesting to note that the general trend in Africa is that even for those countries doing well, the distribution of wealth is very uneven. This was well noted by the former Managing Director of IMF in his last statement at the UNCTAD conference in Bangkok in 2000 where he said, “It is not enough to increase the size of the cake; the way it is shared is deeply relevant to the dynamism of development and to reducing poverty.”
adopted a more pragmatic approach to economic planning and began a decisive shift away from government control and ownership of the economy. By 1995, the exchange and trade system and the financial system had been liberalized, price controls had been eliminated, and a major privatization program had begun. Macroeconomic performance during 1996-1999 was generally good and, based on the strong fiscal policies the efficient cash budgetary management helped to contain public expenditure. Substantial progress was made with structural reforms, including major tax reforms, a comprehensive framework for monetary management and fiscal sector development. Civil service reform led to rationalization, retrenchment and the initiation of pay reform. The petroleum sector was fully liberalized and subsidies eliminated. The government has focused and continues to increase its efforts to improve its governance record and to develop sectoral anticorruption plans.

2.3.13 Zambia: Its economy expanded rapidly during the 1960s and early 1970s owing to high levels of the international price of copper. The failure by the Kaunda government to develop other sectors of the economy, coupled with the reduction in the international price of copper since the 1970s, resulted in severe economic decline characterized by critical foreign exchange shortages, lack of skilled manpower, poor infrastructure and high debt service obligations. After the coming of the Chiluba administration, Zambia adopted a three-year structural adjustment program in 1992 in agreement with IMF and World Bank. It liberalized its foreign exchange rate policy in the same year and since then the economy has been recovering though at a sluggish rate. The government is also reducing the public sector workforce partly by retrenchment and containing public sector wage rates in a bid to ensure a sound and efficient civil service so as to increase public investment and social programs.

Despite the efforts to liberalize like Zimbabwe and Tanzania, the country continue to experience double-digit inflation due to increases in the money supply, currency depreciation and food shortages among others. The country therefore still remains a long way from economic independence.

2.3.14 Zimbabwe: Since independence in 1980, economic growth has been uneven due to climatic reasons as well as changes in economic policy. In 1991 Zimbabwe launched an

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20 Kenneth Kaunda was the first president of Independent Zambia.
economic reform program which was instrumental in liberalizing the economy and addressing structural impediments to growth. In 1994 exchange control regulations were substantially relaxed and a market determined exchange rate was formally adopted although the Reserve Bank of Zimbabwe (RBZ) continued to intervene whenever the exchange rate fell out of the specified band. As a result during the early 1990s the country experienced growth and performed well economically due to the benefits of structural adjustments coupled with sound economic policies and political stability.

However the economy has been deteriorating since 1997 as its recent experience has shown how quickly governance problems, monetary policies and fiscal profligacy can get out of control with macroeconomic stability and investor confidence being undermined as a result. Over the three years from 1997-1999 the country suffered economic recession and there was a decline in per capita income, deterioration in social conditions as a result of Zimbabwe’s loose macroeconomic policies especially in the fiscal area, the rapid spread of the HIV/AIDS pandemic and poor governance. Economic activity and unemployment faltered especially in the manufacturing, mining, tourism and agricultural sectors as they were, buffeted by erratic law enforcement and acute foreign exchange shortages. As a result GDP contracted by more than 5% resulting in a cumulative decline in per capita income of 12% over the three-year period. This and the weakened balance of payments from 1997 coupled with the crisis in the emerging markets sparked sharp depreciation of the currency. Dissatisfaction with the sharp devaluation and its effects on domestic prices led the authorities to fix the exchange rate from January 1999 to July 2000.

Economic crisis deepened in 2000 fueled by continued deterioration in the fiscal position kindled by severe fiscal imbalances, erosion of competitiveness, fuel shortages, high interest rates and an overvalued currency. Political tensions related to the February 2000 constitutional referendum and the June parliamentary election and, escalating tension and uncertainty related to the significant change in the government’s stance on the land reform program deepened this. The lack of transparency in its fast track “land reform program”, is having spill over effects on international investor confidence in other countries of Southern Africa, leading to adverse economic contagion in the form of capital flight and curtailed access to foreign financing; much to the exasperation of some SADC members. Zimbabwe needs to be mindful of these increasing negative externalities on neighboring countries.

21 Fredrick Chiluba is the reigning Zambian President.
With mayhem reigning in Zimbabwe, the country's economy is currently under siege, characterized by constrained growth in all sectors, a burgeoning budget deficit evidenced by depletion of usable foreign reserves and the emergence of external payment arrears, escalating inflation, a weak monetary policy and a slow pace of selling off loss making state firms.

Probably, the 2001, Zimbabwean situation was best described by professor A. Hawkins, who in his line of thinking noted that, although the manifestations of Zimbabwe's crisis are economic, the nation's problem was rooted in skewed social and political policies. He stated that, "The country's deepening economic difficulties are explained by a combination of weak institutional capacity and administration on one hand and the subordination of sustained economic progress to short term political goals". 22

Urgent corrective measures in the form of improved governance, a credible adjustment program anchored by a return to a sustainable fiscal path supported by prudent monetary and wage policies, and a restoration of external competitiveness need to be taken. One can conclude that Zimbabwe faces a difficult and complex set of economic, political, social and other challenges. They include, the stabilizing of the macroeconomic environment, restoring investor confidence, fighting against HIV/AIDS, which continues to assume dramatic proportions23 and reducing unemployment. Success in restoring economic stability also hinges on rebuilding of confidence through speedy return to rule of law and the implementation of an orderly land reform program that could garner domestic and international support. The major downside risk in the outlook stems from the possibility of continued political tension and uncertainties ahead of the March 2002 presidential election, which would prolong the economic drift and create enormous social hardship (IMF Staff Report for 2000 Consultation with Zimbabwe, November 2000).

2.3.15 Summary Comment

Although the above analyses do show how diverse the 14 member SADC states' economic statuses are there are some common characteristics. In general, like all other typical African economies all SADC countries (with the exception of probably South Africa and

23 The International Labor action against HIV/AIDS on Southern Africa (Geneva 2000), projected that in Zimbabwe alone, the labor force will be 17.5% lower by 2015 than in a non-AIDS scenario.
Botswana) get the bulk of their export revenues from a narrow group of primary commodities, import mainly capital goods and intermediate outputs and faces persistent trade deficits. They also allocate a significant fraction of their export revenues to meet their short-term debt obligations. To recover economically and sustain economic growth most SADC member states need to undertake a speedy and steadfast application of policies for macroeconomic stabilization and structural reform. This will call for market discipline that entails strict and sustained adherence to macroeconomic targets including properly valued currencies and favorable trading policies, determined application of systems for monitoring and controlling public spending, effective use of foreign aid and debt relief in productive investments, improved governance and resistance to vested interests.

2.4 Key characteristics of Sample Countries

The 14 countries, which fall under SADC, also constitute Southern Africa and these two terms will be used synonymously. The dire economic circumstances of Southern African countries in the midst of globalizing forces and its economic structures have already been extensively covered in sections 2.1 and 2.2.7. This section seeks to isolate a number of economic features specific to the countries in the sample during the sample period that are relevant to the analysis in this study. Although these countries belong to one economic integration the countries in the sample were also chosen on the basis of several other considerations.

Due to data availability and data quality problems six of the SADC member states were deliberately excluded from the sample. Thereby addressing the criticism that the whole study has limited validity because of data inaccuracies and contamination. These historically crisis prone, countries are the Democratic Republic of Congo, Angola, Mozambique, Malawi, Seychelles and Lesotho.24 The eight remaining countries used in the sample can be reasonably argued to be a good representation of the SADC region. Their economies range from the ‘poor’ countries namely Tanzania, Zambia and Zimbabwe to ‘lower middle income’ economies represented by Namibia and Swaziland and lastly ‘upper middle income’ economies represented by Botswana, Mauritius and South Africa.

24 As can be ascertained from the individual country analysis given in Section 2.6, these countries because of internal conflicts do not have sufficient and or consistent data even though some of the countries are now stable and progressing well economically.
The eight remaining countries though different in terms of economic governance and development share a number of common characteristics. Firstly all the countries generally suffer from substantial economic turmoil albeit to different extents and they also share a common feature of tolerating sustained episodes of moderate to high inflation during the period under study. High inflation in Southern Africa, as in most emerging market countries, is mainly caused by: (a) the need for governments to finance persistent fiscal deficits through seigniorage and (b) the time inconsistency of economic policies. Caution must be given that using data from such countries could lead to difficulties associated with data interpretation as the PPP is likely to hold because high inflation tends to bias the symmetry and proportionality test towards acceptance (Rogoff, 1996). Frankel (1978) also found evidence supporting PPP using high inflation data, which according to Rogoff

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According to the World Economic Outlook (May 2001) governments (more so of developing countries) have financed persistent fiscal deficits by issuing money since time immemorial. At the root of seigniorage, is the government’s unwillingness or incapacity to avoid persistent deficits or to resort to other sources of financing to make up for the shortfall. Governments also favor seigniorage because compared to other forms of revenue it tends to be easier to collect and enforce and does not require the approval of the legislative body, which can be lengthy and politically difficult. As such, incentives to use seigniorage is lower in countries where collection of other forms of other revenue mainly in form of formal taxes is more efficient and borrowing is cheaper due to more developed capital markets. Seigniorage also tends to be lower in countries where, public tolerance for inflation is lower (itself a function of institutional and historical factors) and where the governments capacity to enhance the use of high-powered money (the tax base of seigniorage) is limited.

While the seigniorage theory emphasizes the behavior of the fiscal authority, the time inconsistency theory focuses on the behavior of the monetary authority. The theory highlights the inflationary bias to monetary policy as stemming from not being able to credibly commit to low inflation. Usually the perception that output can be raised in the short run by expansionary monetary policies may induce the central bank to run a looser monetary policy than is, consistent with low inflation. This is particularly likely if the Central Bank is not independent from the rest of government and where political considerations, such as, electoral cycles may influence policy. By the same token, the time inconsistency theory also helps explain why, Reserve Banks may adopt an accommodative policy stance once inflation is triggered by other factors such as adverse supply or oil price shocks.

It is evident from this brief discussion that, the complexities of unsustainable and persistent high inflation can be addressed by among other things, institutional reforms like, central Bank independence, and structural reforms such as greater openness to trade.
(1996) is not surprising given the overwhelming predominance of price movements denominated by monetary shocks in such environments.

In addition, Froot and Rogoff (1995) observed that real exchange rates are prone to instability for developing countries because rapid income growth or inflation often induces drastic changes in the relative price structure between tradables and non-tradables. Similarly, Madhavi and Zhou (1996) reported results favoring the PPP in some high-inflation developing countries. Finally, Liu (1992) using data for nine Latin American countries tested the weaker version of the PPP theory and found support for the hypothesis that because of the high inflation rates the exchange rates for these countries versus the US dollar are influenced by, the relative price level.25

Secondly, all countries in the sample have relatively small economies by global standards and thus exercise very limited influence on world prices of oil and traded goods, international interest rates and exchange rates. Moreover, all the countries in the sample are heavily dependent on oil imports and hence an increase in oil prices is expected to result in the depreciation of the countries' currencies. For this reason, the model used in this study considered foreign variables vis a vis interest rates, oil prices and foreign prices as being weakly exogenous for the cross continental approach. It is also important to mention that Zimbabwe was subject to oil sanctions during the very early part of the sample,27 as was South Africa for the first decade of the sample. Botswana and Swaziland may have felt spill over effects. Namibia did not join the sample until 1991 but until then was a de facto South African province. In short apart from the economies being too small to affect world oil prices, the world oil prices did not rule much over the sample period. Rather there was what could be termed a sanctions-busting premium which may have been high or low or variable depending on the volumes of each country’s strategic reserves, oil from coal production etc. For this the methodology used employed long-run structural modeling to test for the importance of including the oil price variable in the sample.

Thirdly, although trade restrictions and exchange and capital controls, which in the long run discourage foreign direct investment and undermine overall sustainable economic

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24 Liu tests the weaker version of the PPP theory, i.e., \( e_t = a_0 + a_1 p_t + a_2 p_t^* \) with \( a_1 \) negative and \( a_2 \) positive (but not necessarily unit in magnitude).

27 The sample varies for each country but the full sample is from January 1979 to May 2001.
growth and competitiveness were lowered in the 1990s; they are still prevalent in Southern Africa and generally higher than in other regions. In addition, even though most of the sample countries floated their currencies in the 1990s (some have since returned to a managed float again) the operations of the central banks and capital markets are still subject to frequent government intervention as the monetary policies are set to accommodate fiscal policies. Because of this either, (i) their financial markets are not complete and are not integrated to the international financial system. For example there are no organized markets for stocks or bonds or there are no mutual funds or the banks are few and only offer limited number of products. Or, (ii) financial markets and financial intermediation are not fully developed and do not function as efficiently as in large industrial countries and hence their monetary transmission mechanism is surrounded by uncertainty (Worrell, 2000). Additionally, capital flows and information asymmetries limit the interest responses of the financial markets and make it difficult to interpret market signals. Financial systems in most of the sample countries are also characterized by wide spreads between deposit and loan interest rates because interest rates are sticky or fixed by the Central Banks.

These factors impinge on Southern Africa's ability to trade freely with the rest of the world and hence tend to reduce its share of world trade and capital flows and investment, whilst at the same time raising the domestic price of imports. Better financial systems and terms of trade in the form of lower duties and simplification of tariff structures will benefit SADC more especially in terms of external competitiveness. This characteristic, which hinders international arbitrage on both the goods and financial markets, could have a significant impact on the results.

Fourthly all the countries excluding Botswana, South Africa and Mauritius have relatively large trade deficits. Their volume of international trade on average accounts for more than half of their aggregate output and their export revenues are highly unstable due to recurrent and sharp fluctuations in prices of primary commodities. Most of the sample countries are also heavily indebted due to large imports of capital goods and intermediate inputs and as such, a significant fraction of their export revenues are used to meet their debt service

28 However, Mussa et al (2000) argue that for small economies, the costs of the fully developed financial institutions and the technical expertise required for a well developed independent monetary policy (i.e., under a flexible exchange rate regime), can be too high relative to the potential benefits of exchange rate flexibility.
obligations. This makes the SADC countries extremely vulnerable to changes in world interest rates. Related to this the characteristics of the economies’ industrial structures make them highly vulnerable to trade shocks: they have relatively smaller industry and service sectors compared to the agricultural sector.

Last but not least, the sample countries excluding Botswana and South Africa are to a large extent characterized by limited domestic savings. While foreign investment can play a valuable role in stimulating economies’ capital markets, the growth and stability of these markets will require the development of a health base of domestic investors. Pension reform and the promotion of mutual funds could encourage domestic investment in fledging stock markets.

2.5 The sample Countries Exchange rate regimes during the sample period

For the purposes of understanding the results of the statistical tests, it is necessary to give a summary of the exchange rate regimes that were ruling during the sample period in each of the SADC countries. This is considered important as the cointegration tests results are likely to be affected by the exchange rate arrangements. Tables 2 and three summarises the exchange rate regimes prevalent prior to 1991 and those as of December 1999, respectively.
Table 2:

<table>
<thead>
<tr>
<th>Exchange Rate Regime</th>
<th>Countries</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NS/CBA</td>
<td>Democratic Republic of Congo, Namibia</td>
<td></td>
</tr>
<tr>
<td>FP</td>
<td>Angola, Botswana, Lesotho, Malawi, Mauritius, Seychelles, Swaziland, Tanzania, Zimbabwe</td>
<td></td>
</tr>
<tr>
<td>HB</td>
<td>NIL</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>NIL</td>
<td></td>
</tr>
<tr>
<td>MF</td>
<td>Mozambique, South Africa, Zambia</td>
<td></td>
</tr>
<tr>
<td>IF</td>
<td>NIL</td>
<td></td>
</tr>
</tbody>
</table>

Source: IMF

KEY:
NS = Arrangements with no separate legal tender
CBA = Currency board
FP = Other conventional fixed pegs
HB = Pegged rate in horizontal band
CP = Crawling peg
MF = Managed float with no pre-announced exchange rate path
IF = Independently floating

While the all other countries had a unified exchange rate throughout the sample period irrespective of the exchange rate regime they adopted, South Africa moved to and from a unified exchange rate to a dual exchange rate system from 1979 to 1995. Theoretically the dual exchange rate system must have imposed a shock to any existing interest rate relativities on the date of the policy changes. For this reason the data for South Africa was tested, once for the whole sample and secondly from 1995 when the rate was finally unified and allowed to float freely.
Table 3:

SADC Countries Grouped by Exchange Rate Arrangement
(as of December 31, 1999)

<table>
<thead>
<tr>
<th>Exchange Rate Regime</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS/CBA</td>
<td>NIL</td>
</tr>
<tr>
<td>FP</td>
<td>Botswana, Lesotho, Namibia, Seychelles, Swaziland, Zimbabwe</td>
</tr>
<tr>
<td>HB</td>
<td>NIL</td>
</tr>
<tr>
<td>CP</td>
<td>NIL</td>
</tr>
<tr>
<td>MF</td>
<td>Malawi,</td>
</tr>
<tr>
<td>IF</td>
<td>Angola, Democratic Republic of Congo, Mauritius, Mozambique, South Africa, Tanzania, Zambia</td>
</tr>
</tbody>
</table>

Source: IMF, Annual report 2000

KEY:
NS = Arrangements with no separate legal tender
CBA = Currency board
FP = Other conventional fixed pegs
HB = Pegged rate in horizontal band
CP = Crawling peg
MF = Managed float with no pre-announced exchange rate path
IF = Independently floating

South Africa and the Dual exchange rate system

The dual exchange rate system played a vital role in protecting the current account from large capital outflows due to episodes of political risk. On January 24, 1979, the commercial rand’s link with the US dollar was freed and allowed to float ushering in the dual exchange rate regime. On February 7 1983 the financial rand was abolished only to be re-introduced in, September 1985 due to increased political turmoil.

The dual exchange rate system consisted of a ‘commercial rate’ and a ‘financial rate’. The financial rand traded at market-determined prices often at a substantial discount to the commercial rand. In general the financial rand applied to portfolio investments or approved direct investment by non-residents, while the commercial rand applied to current account foreign trade dealings as well as foreign loans and credits.

29 He institutional features of the dual exchange rate system were largely the result of political influences. These included links with the British financial system, political and economic events resulting in shocks to the South African economy and the recommendations of the De Kock Commission.
The financial rand therefore served as the principal exchange control on non-resident equity capital flows with the purpose of insulating the South African market for current account transactions from the volatility in the flow of non resident equity (capital account transactions). For this reason, Dornbusch and Kuenzier (1993, p.120) concluded that,

"In a dual rate system the commercial rate remains stable, whereas the free rate reflects the instability of portfolio holders’ expectations, and hence capital flows".

After the first democratic elections in the country, the removal of sanctions and the stabilization of South Africa’s economy, the dual exchange rate was unified on March 15, 1995 and has been freely floating against foreign currencies since.
CHAPTER 3
THEORETICAL UNDERPINNINGS AND REVIEW OF LITERATURE

International macroeconomics makes use of a set of parity conditions. Whilst empirical evidence supporting these conditions has often been ambiguous, they are convenient because they combine analytical tractability with theoretical desirability (Chortareas and Driver, 2001). In view of the mixed nature of the empirical evidence this paper investigates the validity of the PPP and UIP in Southern Africa. Although empirical literature on these two proposals is vast, it still is necessary to set out the theoretical background before the empirical analysis is done.

3.1 The PPP Theory

The first of these parity conditions is the purchasing power parity (PPP). The origins of the PPP theory dates back to Spanish scholars of the 16th century although, intellectual origins of the doctrine are credited to Wheatley and Ricardo’s work in the 19th century.30 However the term PPP originated from Gustav Cassel (1918, page 413) who rekindled interest in the theory in the 1920s, although as quoted by Officer (1976) the PPP theory had been presented earlier using the term “theoretical rate of exchange” in 1916. The debate over, the PPP was resumed by Samuelson in 1964 but it only intensified after the collapse of the Breton Woods system and the introduction of the flexible exchange rates in the early 70s.31

The PPP theory of exchange rates looks at the relationship between a country’s foreign exchange rate and its price level as well as the relationship between the changes in those variables. It suggests that the exchange rate between two countries must be proportional to the ratio of the price levels between the two countries. The PPP hypothesis is closely associated with an international version of the law of one price (LOOP), which states that abstracting from transport costs, in equilibrium, the price of identical commodities should be the same everywhere in the world when expressed in common currency units, as free trade causes prices in the various countries to converge. The LOOP holding for any good \( i \) we get:

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30 The origins of the PPP are analyzed in detail by Officer 1976
31 A comprehensive review of previous research in this area can be found in Donbusch (1987) and Officer (1976).
where $p_i^t$ stands for the domestic price of good $t$, $E_i$ denotes the home currency price of a unity of foreign currency or the exchange rate and $p_i^t$ denotes foreign price with an asterisk denoting a foreign magnitude. The key to why PPP is an attractive theory and a condition for (1) to hold is what is known as arbitrage in the international commodities market. Thus, if for some reason the left-hand side of (1) falls out of equilibrium and is larger than the right-hand side, it would be profitable to ship the good from the foreign country to the domestic country thereby pushing the domestic currency of the foreign good up and the domestic price of the good down, until equilibrium between the two prices is restored. The underlying PPP assumption of course, being that internationally produced goods are perfect substitutes for domestic goods.

Needless to say the LOOP as concluded by Rogoff (1996) holds only in the breach because not only are commodities with the same name not the same everywhere, but there are several factors which drive a wedge between their prices. He gives the interesting example of the McDonald’s “Big Mac”, which is priced differently in different countries. The “Big Mac’s” pricing disparities are due to the fact that, not only is it not possible to trade/arbitrage (i.e., transport and sell the final form product to other countries) the final product or some of its inputs and components, but the way the Big Mac is bundled is different between countries and so are profit margins charged and taxes included in the basic prices. More reasons that cause the PPP to deviate such as differences in taste and technology and others will be discussed later under the theory criticism section.

By adding the prices of a basket of common goods in each country and giving each price the same weight in the sum, we obtain a condition of what is termed absolute purchasing power parity.

$$E_i = P_i / P_i^*$$  \hspace{1cm} (2)

where, $P_i = \sum_{t=1}^{n} \alpha_i p_i^t$, $P_i^* = \sum_{t=1}^{n} \alpha_i p_i^*$ and $\alpha$ represent a weight. A rise in the domestic price level triggered by, say, an increase in interest rates or by a monetary expansion, should result in an equi-proportionate depreciation of the exchange rate. The PPP hypothesis like
all economic theories is expected to hold only in the long run, and for it to hold the real exchange rate should be stationary and not governed by permanent shocks. Obviously the restrictions of the PPP theory are clear. For example even if for simplicity sake it was possible to construct prices in the manner suggested by condition (2), the existence of transportation costs and other multifarious impediments to trade will affect the arbitrage process and prevent condition (1) or (2) from holding exactly. However, as stated by McDonald (1995), if such factors are assumed constant over time and depending on the efficient functioning of the goods market, then either condition (1) or (2) would be expected to hold up to a constant factor A giving us:

**\( E_t = A \left( \frac{p_t}{p_t^*} \right) \) \( \text{(2.1)} \)**

where, if the arbitrary constant term, \( A = 1 \) we have the absolute version of the PPP, and if \( A \neq 1 \) but is a constant, we obtain a weaker version of the PPP hypothesis, which is usually labeled the relative purchasing power parity. With relative PPP the PPP theory is weakened to symmetry rather than proportionality. Expressed in logs we get:

**\( e_t = a + p_t - p_t^* \) \( \text{(3)} \)**

for the absolute PPP where, the lowercase letters now indicate that the variable has been transformed using the natural logarithm operator. Upon expressing the terms in equation (3) in changes we obtain the relative PPP hypothesis:

**\( \Delta e_t = \Delta p_t - \Delta p_t^* \) \( \text{(4)} \)**

which states that an \( \alpha \% \) change in relative price level will have an \( \alpha \% \) change on the nominal exchange rate, i.e. the percentage exchange rate depreciation is equal to the difference between domestic and foreign inflation.

Allowing for the possibility of short run deviations from the fundamental PPP, the long run relationship between the PPP variables is given by:

**\( p_t - p_t^* - e_t = \epsilon_u \) \( \text{(5)} \)**

where \( \epsilon_u \) is a stationary zero/constant mean random variable, otherwise the mean value of the exchange rate will depend in some way on \( t \). In other words, \( \epsilon_u \) should not exhibit random walk behavior. If it does, then there will be no tendency of for \( p_t \) and \( p_t^* \) and \( e_t \) to move together in the long run. If the absolute PPP holds then \( \epsilon_u = 0 \) and symmetry between the domestic and foreign countries implies that the coefficients of \( p_t \) and \( p_t^* \) in equation (5) are of the same magnitude, while proportionality between the exchange rate and prices
implies that the values of these coefficients are \((1, -1)\), respectively.

In testing the PPP, recent work has concentrated on the application of cointegration methods to an equation such as \((6)\):

\[
e_t = \beta + \alpha_0 p_t + \alpha_1 p_t' + \varphi_t
\]

\((6)\)

If \(e_t\), \(p_t\), and \(p_t'\) are integrated of order one \(-1\) then weak form PPP (MacDonald, 1999) exists if the residual term from an estimated version of \((6)\) is stationary \(- I (0)\). Strong form PPP exists if in addition to the weak form holding, symmetry and proportionality is also satisfied: \(\alpha_0 = 1\) and \(\alpha_1 = -1\). According to Patel (1990) the distinction between weak and strong form (or relative and absolute) PPP is seen important because the existence of transportation costs and different price weights across countries means that there are no hypotheses regarding the specific values of \(\alpha_0\) and \(\alpha_1\), except that they are positive and negative.

### 3.1.1 Empirical Applications

The PPP is important in that because of its simplicity and intuitive appeal, it has many empirical applications and they are as follows:

(i) It can be used to convert data from denomination in one currency to another and as such the PPP plays a central role in the theory of trade.

(ii) It can be used by governments, especially of newly independent states as a guide in setting up appropriate exchange rate policies (Kim 1990).

(iii) As a theory of exchange rate, the PPP equation is used widely in almost all models of theoretical exchange rate determination and exchange rate behavior. It can be used to forecast floating exchange rates as well as measuring the amount of disequilibrium of a floating exchange rate from its long-term equilibrium (assumed to be the PPP) caused by speculation. The PPP can equally be used to measure the disequilibrium of a pegged exchange rate. The PPP in this case becomes a relevant prediction model of exchange rates and a criterion for assessing the over or under valuation of a currency, especially in smaller open economies and those experiencing large differences between domestic and foreign inflation (Fraser et al 1991). A currency can be undervalued if speculators exaggerate their mistrust of it. So the deviation of a floating exchange rate from the PPP can be taken as a measure of the amount of speculative activity in the foreign exchange market.
(iv) As cited by Officer (1976), it can be used as a computational device, for example, De Vries (1968) used relative price parity to calculate the depreciation and or appreciation of currencies of 64 countries compared to the US dollar.

(v) Finally as noted by Vachris and Thomas (1999), the PPP can also be used to examine the structure of expenditures across countries.

3.1.2 Possible Causes of Departure from PPP

Although proponents of the PPP theory are understood to be those who believe that expressions (2) and (4) hold; it is clear from the writings of the father of the PPP theory Cassel that his concept has limitations. As the disturbances in prices do not instantly transmit to the exchange rate, cognizance must be taken when working with or interpreting results from testing the PPP. Cassel acknowledged the following limitations as an integral part of his theory and for these reasons, the floating exchange rate may, in the short run, diverge from the PPP-defined value.\footnote{For details see Officer 1976.}

1) While the theory assumes no trade barriers, it has since been recognized that if trade restrictions in the form of quotas and tariffs are more severe in one direction than the other, for example, if the country’s imports are more restricted than its exports, then the exchange rate value of the country’s currency may be overvalued, that is, it may exceed the PPP value.

2) Over speculation in the foreign exchange market may be against a country’s currency and therefore reduce its exchange rate value below the PPP.

3) Anticipation of greater inflation in the domestic country than abroad, may reduce the foreign exchange value of its currency below the PPP.

4) Changes in relative prices in a country are an indicator of real cyclical economic changes compared to a base period and so involve a divergence between relative PPP and the exchange rate.

5) Long term capital flows volatility resulting from changing perceptions of interest rates can move the exchange rate away from the PPP, for instance, a net long-term capital outflow may depress a country’s currency below the PPP.

6) Institutional intervention in foreign exchange markets, for example, the government through its monetary policies can intervene in the foreign exchange market, bidding up the price of foreign exchange above the PPP by demanding a
certain amount of foreign currency irrespective of price. This can result in a managed float where exchange rates can be artificially held away from their fundamental economic or PPP values.

Given these limitations it is clear from the writings of Cassel and other prominent proponents of the PPP hypothesis, that the interesting question is not whether the PPP holds exactly in the long-run both in its symmetry and proportionality conditions, but rather how far do exchange rates deviate from the price ratio and how much time does it take for arbitrage to correct these deviations from PPP? In other words, using a time-series expression, in the Casselian view, the PPP should be mean reverting. However, it has been empirically observed that deviations from the PPP are remarkably persistent, much more than can be explained by the cited limitations alone.

3.1.3 Criticisms of the PPP Theory

Although simple in theory and intuitively appealing, the criticisms of the PPP follow directly from its limitations and they have created considerable challenges and even problems for testing the PPP theory empirically. They are detailed below.

1) Index Number Problems

As MacDonald (1995) points out, if one could construct price series consisting of prices of homogenous internationally traded goods, then testing the PPP would be relatively clean and straightforward. However, it would be vanity even to pretend that this happens because, in practice governments do not construct intertemporal price indices for internationally standardized baskets of goods. Actual price indices used to test the PPP are calculated from only a sample of commodities rather than all commodities in the economy. Obviously, the very diverse expenditure patterns in each country due to differences in climate, tastes, packaging, regulations and the like, determines the items selected for inclusion into this representative basket. This raises the issue of how practical the PPP theory is in a more complex realistic case as it follows that any computed price parity is an imperfect representation of the true theoretical parity. Closely related to the above is the difficulty that even if the entire population of commodities is used to calculate the index in each country, the value of parity will vary with the base period of the index as well as, the
weighting pattern of the price measures. So even if price measures refer to traded goods alone and there is costless international arbitrage of these goods (no trade restrictions, foreign exchange market intervention, transport costs and other imperfections in the arbitrage process); different weighting schemes for the countries’ price levels (indices) will in general lead to different parities, none of which can be expected to be the true parity—namely the current nominal exchange rate in this case—which equalizes all commodity prices internationally.

The only solution according to Stein (1973, page 143) cited by Officer (1976) is that, “in principle; the calculation of PPP on the basis of absolute interpretation requires taking a common basket of goods with a standard system of weighting for the individual countries.” Yeager (1958, page 517), takes the same position in stronger terms by stating that, “the “absolute” or “positive” approach to index calculation, ideally envisages that, the pricing in local currency in each of the two countries of a standard assortment of goods and services be the same and yet be duly representative of the economic life in each.” As this dual requirement is impossible due to different consumption and production patterns between countries, Yeager rejects the absolute PPP as non-operational, a view not shared by many.

In addition, even in the same country and more so with time series data, the index problems are exacerbated as the basket used to construct the price indices is likely to be very different at the beginning and end of the sample, raising the question of how to handle introduction of new goods and, shifting consumption weights. Also, when using long horizon, time series data for one country, one faces the problem of amalgamating data from very different exchange rate regimes, a factor, which may affect the statistical properties of the real exchange rates. This maybe viewed as the temporal analogue to the spatial problem that arise in comparing price indices at a particular point in time (MacDonald, 1999).

In recognition of the problems with using government price indices when making purchasing power parity comparisons, since the early 1950s, there have been attempts to construct indices or acceptable measures of absolute PPP (Rogoff, 1996). Milton Gilbert and Irving Kravis (1954), for example developed price level measures for common baskets of goods across the U.S., U.K., France Germany and Italy. In more recent years as cited by
Rogoff (1996), the endeavor to develop absolute PPP measures has culminated in the influential research of Robert Summers and Alan Heston (1991), who together with colleagues have constructed estimates covering a much broader range of years and countries termed, International Comparison Program data. But again this data is gathered infrequently, country coverage is limited and much of the data is often filled in by a mélange of extrapolation, period averages and other approximations. So the solution to index problems as a hindrance to testing PPP empirically remains to be found.

2) Absolute Parity

Officer (1976) states that under this category criticism falls into 2 categories, (a) those that suggest a reduced accuracy with, which the short run equilibrium exchange rate approaches the PPP and (b), those that deny the basic premise of the PPP hypothesis, namely that freely floating exchange rates tend to PPP.

2.1 Although in what is rather characteristic of economics, the theory of PPP is timeless in the sense that the passage of time is not accorded an essential role in the theory. The existence of information disparities, tariffs and non-tariff barriers, and transport costs as expected, allow for considerable deviations from (absolute) PPP in the short-run. The amount of this deviation varies directly with the severity of the imperfections because these forces frustrate the commodity arbitrage mechanism by making it unprofitable to arbitrage away potentially profitable trading opportunities. According to Taylor (2000), these fixed and variable trading costs or risk aversion can under certain scenarios lead to what he terms a, "band of inaction" in which no arbitrage occurs despite a nonzero price gap. This neutral band can also arise simply because it takes time for information on arbitrage opportunities to become available and for economic agents to react to price differences. Only when prices move apart sufficiently will arbitrage occur and reversion, begin. With the exception of information disparities, these factors are likely to persist even indefinitely. While some like Scammel (1961), argue that the very existence of these imperfections involves a breakdown in the PPP theory,

33 A number of studies have indicated that transportation costs represent a statistically significant explanation for PPP deviations (MacDonald, 1999) Also, the existence of other factors such as uncertainty of the permanence of shock and so-called sunk costs of the activity of arbitrage may widen the bands over and above the width associated with simple trade restrictions ((Krugman, 1989).
others (e.g. Ellsworth, 1950; cited in Taylor, 1976) see moderate levels of tariffs as only reducing the accuracy of the theory especially in the short-run, but not destroying it outright.

In particular, when trade restrictions take the form of sufficiently high and comprehensive tariff walls, quotas or exchange controls, a freely floating or any maintained exchange rate may bear virtually no relationship to the PPP because the price responsiveness of imports and exports is greatly reduced. PPP becomes all the more inapplicable if controls are extended to the domestic sector in the form of price and wage controls, rationing of consumer goods and industry allocation of raw materials and primary factors of production. Under these conditions, the buying power of a country’s currency is but poorly reflected in the market prices.

2.2 Depending on their magnitude and persistence in one direction, the existence of non-current account items like long-term and short-term capital movements are a well-known limitation of the PPP theory.

2.3 Before cointegration theory the issue of causation was a major criticism of the PPP theory in that it views the exchange rate changes as determined variables and the price levels as causal variables. However in circumstances where we have short-term real exchange rate changes, it is possible for chains of causation to run from exchange rates to prices. As R. MacDonald (1995) concluded, this reverse causation and joint endogeneity of exchange rates and prices is especially likely to be a feature of actual data from the recent floating period. Related to this is the fact that the operation of fixed exchange rates also suggest that the causation implied in the PPP theory is reversed with the domestic price level adjusting to the fixed exchange rate and largely to exogeneous foreign price levels.

2.4 The concept of arbitrage though it seems to be OK for goods that can be traded internationally, is complicated by the presence of non-traded commodities. On a practical level, the price indices used in testing the PPP must be constructed from prices of traded goods. However, the truth of the matter is that both the Consumer price index (CPI) and the wholesale price index (WPI) incorporate prices of non-traded goods, and therefore it is unlikely that their use in an empirical test would
produce the symmetry and proportionality implied by conditions (2) and (4). The wholesale price index seems the most appropriate (although it also consists of some non-traded goods), because it contains a relatively large traded goods element and is therefore often chosen. Moreover the wholesale price index is more likely to produce the symmetry and proportionality implied by conditions (2) and (4). An alternative view however, is that if one takes the exchange rate as a relative price of national monies where currency is held as an asset, which when necessary like all other forms of wealth can be converted into purchasing power over tradable and non-tradable goods, then the consumer price index, which consists of both traded and non-traded goods may be deemed more appropriate.

It is interesting to note at this stage that even if there are substantial non-traded elements in the price series employed in an empirical test, relative PPP may still hold if the overall prices are homogeneous of degree one in monetary impulses (MacDonald, 1995). This so-called homogeneity postulate suggests that an increase in the money supply should leave equilibrium relative prices unchanged and should increase all prices by the same amount.

2.5 The issue of pricing to market also frustrates the international arbitrage process in that for some tradable goods (especially by international producers with monopoly power) arbitrage across national frontiers is difficult. Examples are automobiles and many types of electronic goods. To the extent that their goods cannot be arbitrated, these producers often exploit the price leverage available from monopoly power to price discriminate across different export destinations such that their prices are market specific and therefore sticky. The difficulty in international arbitrage can also arise due to differing national standards (e.g., left-hand drive cars are not popular in Southern Africa).

3) Relative Parity

The calculation of relative PPP requires a base year in which ideally the exchange rate should be in long-run equilibrium. However, unless the base year exchange rate was freely floating there is no guarantee that it was even in short term equilibrium, hence its use will result in a relative price parity which perpetuates this disequilibrium. The difficulty of
finding a "normal" or equilibrium base period exchange rate often caused by policy shortcomings and external constrains, is viewed so overwhelming that the relative PPP theory becomes virtually unusable; an extreme position taken by Bunting (1939) and Bacha and Taylor (1971) as cited in Officer (1976).

Moreover, structural economic conditions may have changed in some manner since the base year period. Conditions include circumstances determining international capital flows, unilateral transfers and investment income. Also changes in tastes, technology, factor supplies and market forms may occur. The implication of this to relative PPP is that for the theory to work, the base period should be as close as possible to the current period in order to minimize the scope of structural changes. A prescription which might be flawed if the chosen base period conflicts with the requirement of selecting a base year in which the exchange rate is at or close to long term equilibrium. However when the base period is properly chosen, Officer (1976), concludes that the relative PPP has greater advantages over the absolute PPP.

3.1.4 Residual Validity of the PPP

When all the limitations and criticisms of the PPP are taken into consideration, Rogoff (1996) evaluating the LOOP concluded that,

"Overall, it is hard to read the empirical evidence without concluding that outside a fairly small range of various homogenous goods, short-run international arbitrage, has only a limited effect on equating international goods market prices".

He added that with the PPP warm and fuzzy feelings about the theory should never be a substitute for hard evidence.

However, in spite of all criticisms directed against it, its mixed support and the fact that like any theory the PPP theory is flawed, (that is, it cannot make exact predictions and results are subject to a random error), the PPP has been and continues to be extensively used as a basis for estimating equilibrium exchange rates. No wonder, some authors contend that the PPP does provide a strong basis for exchange rate determination with useful policy implications. In fact the words of, Ellsworth (1950 page 600) that, "the purchasing power parity has almost irresistible attractions in spite of its many pitfalls" (italics added and cited in Officer, 1976), remain valid to this day. This popularity of the
PPP is mainly attributed to its relatively simple and intuitive appeals. Its basic variables are minimal, that is, domestic and foreign prices and the exchange rate between two countries. Furthermore, the ability of the theory to allow for adjustments and extensions, that is, including other variables further contributes to its versatility.

3.2 The Uncovered Interest Parity Theorem

The second parity condition is the uncovered interest rate parity (UIP) doctrine, which has been invoked to explain the determination of interest rates usually in association with the unbiased market efficiency hypothesis.\(^{34}\) It entails the uncovered arbitrage of nominal interest rates and links real interest rates differentials to exchange rates.

In the capital market, the UIP hypothesis is a monetary model, which states that in the long run the equality between the nominal interest rates differential and the expected inflation differential between two countries follows from the interest rate parity. In other words, the interest rate differential between two currencies is the conditional expected value of the rate of depreciation of the high interest rate currency relative to the low interest rate currency. That is, assuming efficient markets in which the bonds of different countries are perfect substitutes, long-run international investment flows (or unlimited arbitrage on the capital market) ensures that, real interest rates are equal across countries.\(^{35}\) Defined this way, the UIP asserts that nominal interest rates are determined by world interest rates plus the expected change in the spot exchange rates. The exchange rate in this case is viewed as moving to equilibrate the international demand for stocks of assets rather than the international demand for flows of goods as under the PPP view. Thus we get a positive relationship between the exchange rate and nominal interest differential. The UIP is represented by:

$$ E_i \Delta e_{t+k} = e_{t+k}^r - r^*_t $$

where, $ E_i \Delta e_{t+k} = e_{t+k} $, $ e_{t+k} $ is the log of nominal exchange rate (home currency price of foreign currency) for country $ i $ at period $ t $ for $ k $ periods ahead ($ i = 1, \ldots, N $ and $ t = $

\(^{34}\) The UIP is equivalent to the expectations hypothesis in the foreign exchange market, as discussed by Fisher (1930) and Keynes (1930).

\(^{35}\) This investment argument is not necessary however, nor if used does it preclude the possibility of different real interest rates in the short run, since even the most perfectly classical of economies have fixed capital stocks that earn non-zero profits in the short run.
I. is the nominal long run, short term interest rate at period for periods ahead and an asterisk denotes a foreign variable, $\Delta$ is the first difference operator and $E_t(\cdot_{t+k})$ implies the expected value of $\cdot$ for time $t+k$ formed at time $t$ using all relevant information or the expected rate of depreciation or appreciation of country $i$'s currency.

For condition (7) to hold it implicitly assumes no uncertainty as in a perfect foresight economy, i.e., the term structures of the interest rate differential and the forward discount rate contain no risk premium.

Equation (7) can be rearranged into an equilibrium condition for, real exchange rates as:

$$e_t = e_{t+k} - \left( k_{r_t} - r_{r_t}^* \right)$$

where $e_t$ is the systematic or long-run component of the real exchange rate and is driven by real fundamental factors such as government spending, productivity differences across countries, net foreign assets accumulation and terms of trade effects (MacDonald, 1999).

3.2.1 UIP Limitations

Although, the UIP model is typically justified, most of its limitations emanate from the very assumptions upon which it is built. To begin with, the assumption of perfect markets, which entails investors' rational expectations, risk neutrality, free capital mobility and the absence of transaction costs like, taxes on capital transfers, is always cited as a potential limitation of the UIP hypothesis. Linked to this is the fact that invariably, the ability to arbitrage is restricted due to risk aversion by rational investors and speculative effects. Also as noted by Piggot (1993, p. 29),

"The belief that real interest rates should converge internationally is based on the presumption that returns to capital will ultimately be equalized and that the PPP determines nominal exchange rates—conditions that are likely to hold, if at all only in the very long-run."

For this reason the UIP is expected to hold only in the long run if it holds. Another reason for explaining the empirical failure of the UIP might be due to the very omission of the variable capturing the risk premium in the empirical model specification used because in reality there is always the time varying risk premium. Therefore if these variables, which

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36 Although it is straightforward to include a no-risk premium assumption in (7) it turns out from empirical tests, that including a risk premium typically has no significant impact on the results (MacDonald, 1999).
capture the risk premium are correlated with interest rates the estimated coefficients would be pulled away from those implied in the UIP.

3.2.2 Problems with Testing the UIP

Because the question arises as to what determines the expectations about future exchange rates, testing for UIP directly either in real or nominal form is complicated by the fact that it is difficult to obtain information on expected exchange rates (either nominal or real). This point might also explain the doctrine’s alarming empirical failure. For example, Meese and Rogoff (1988) examine the relationship between real exchange rates and real interest rates of major industrialized economies under the flexible regime and their findings demonstrate that interest rate differentials are not significantly better than the random walk hypothesis. They fail to find cointegration between exchange rates and real interest rate differentials suggesting a lack of a real long-run relationship between the two. Indeed, some researchers have concluded that the empirical failure of the UIP helps sustain the notion that, central banks (relying on the behavior of dealers and participants in the exchange markets) are able to set, real interest rates that are lower (or higher) than those ruling on average in the rest of the world. One strategy therefore has been to combine the PPP and UIP (as in this study) with the hope of finding some empirical support for the UIP.

3.2.3 Significance of UIP

1. As McCallum (1996, p. 191) cited by Lavoie (2000) recognizes, the UIP is, “a constituent of virtually all contemporary exchange rate models, from small scale theoretical systems... to large scale econometric systems constructed and tended by teams of researchers employed by organizations such as the IMF”. This is true despite the general empirical failure of the UIP. Moreover, neoclassical authors still rely on it because they say a more attractive relationship is yet to be found. In this context therefore, exchange rate movements/fluctuations can be explained by shifts in interest rates differentials if the UIP holds.

2. The UIP exchange rate theory is of immense importance to multinational firms due to its implications for, hedging against international financial risk.
3.3 Country Specific versus Panel Approach to Testing PPP and UIP

To search for more support for parity reversion in real exchange rates, a growing body of literature has turned to panel data methods and away from country by country analysis. These panel approach studies adopt a cross-section approach and combine it with time series information, which contrasts with the individual country approach highlighting the cross-country heterogeneity. As a result many have indeed found support for the PPP (Engel et al; 1977, Frankel and Ross; 1996, Wei and Parsely; 1995 and Wu 1996) and for UIP (MacDonald and Nagayasu 2000) and for PPP and UIP (Chortareas and Driver, 2001). Unlike long run horizon studies, which extend the sample period, panel studies advocate for increasing the sample size by, pooling data across many currencies in order to amplify statistical power and therefore lead to substantially better econometric results. The, use of panel data therefore avoid the long-horizon data problems, which arise from structural breaks. However as noted by Maddala, it is not clear whether the structural changes dilemma is more of a setback than cross sectional heterogeneity, a common problem with the use of panel data. Also as Papell 1997 observes, the panel results can be sensitive to the panel size and country grouping. In the case of Southern Africa, even though the countries belong to one economic block, they are not yet integrated economically and as such results could be very sensitive if the panel approach was used.

O'Connel (1998) further points at the possible bias in panel tests due to cross sectional dependence. Moreover, because panel unit root tests examine the null hypothesis of a unit root for all pooled currencies, rejection of the null does not therefore necessarily imply that the currencies being pooled all contain no unit root. The rejections may reflect the parity reverting behavior of a possibly small sub-grouping of currencies only. Indeed for all intents and purposes as Taylor and Sono (1998) illustrate, the joint non-stationarity of a group of real exchange rates may be rejected when only one of the series is mean reverting.

Using a similar line of argument, Maddala (2001) notes that the decision whether or not to use panel data unit roots tests in PPP depends on the hypothesis of interest. For example, one maybe interested (as in this study) in testing whether the hypothesis of PPP holds for the Zimbabwe dollar against the U.S dollar. In this case what is of relevance are only data on the Zimbabwe dollar exchange rate. As such it is irrelevant to be told that we reject the long run validity of the PPP for the Zimbabwe dollar/the US dollar, but if we throw in a
number of other Southern African countries and use panel data unit root tests, we do not reject the PPP validity for the ZD/US exchange rate. On the other hand, one maybe interested not in the validity for any particular exchange rate but as a general PPP hypothesis for a set of exchange rates. In this case as argued by Li (1997), estimating the PPP regression country by country would invariably lead to noisy and often nonsensical estimates because of excessive data variability. Therefore, the use of panel data to get improved estimates for the autoregression parameter in the equation of each of the grouped exchange rates would be deemed important and appropriate.

So although under some plausible assumptions the panel approach may be very helpful and powerful as well as theoretically appealing, the use of panel data is of limited empirical value especially if the hypothesis of interest is on country by country approach (O’Connel, 1998; Kim and Maddala, 1996). In addition, presupposing that all countries have the same PPP or UIP regression coefficient can be too restrictive especially where each country in the group of countries have diverse macro-economic policies as well as different traded and non-traded goods. Assuming that the speed of adjustment is the same for a number of exchange rates as recent literature has typically done, may also not only be questionable and misleading but untenable and so may the assumption of homoskedasticity across real exchange rates. For this reason this study considered the country by country analysis as superior, as the results are intended to benefit national monetary authorities and economic leaders.
CHAPTER 4
THE ANALYTICAL FRAMEWORK/MODEL AND METHODOLOGY

This chapter sets out the data description, the methodology and a review of the cointegrating vector autoregressions (VARS) including a discussion of how the intercepts and trends are specified in the models used. The chapter also expatiates, the statistical structures, bringing out the relationship between the various representations of the vectorial processes. The various representations are useful for different purposes like, identifying the Granger causal chain and its strength in addition to, indicating the time profile of shocks to either the individual variables or the whole system.

4.1 Data Source and Description

Based on the six variables defined below, the study applies a multivariate empirical equation to examine the relationship between price and interest rate differentials for 8 SADC countries over varying sample periods from January 1979 to May 2001:

The countries considered are Botswana, Mauritius, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. In each case the nominal exchange rates are monthly closing bilateral and measured against the South African rand and the US dollar.

The model relates nominal exchange rates to price differential variables while allowing for the effect of other relevant factors like the interest rate differential and changes in world oil prices. The model thus enables the testing for both UIP as well as the absolute PPP relations based on the significance of the relevant coefficients in the cointegrating relations. The real price of oil was included in the model because it has been identified as a major source of shock to the flexible-price equilibrium values of real exchange rates (Throop 1993, cited by Zhou and Madhavi, 1996). An increase in the real price of oil causes deterioration in the trade balance or, a reduction in aggregate demand of an oil importing country. As a result, the value of the country’s currency is expected to depreciate to restore equilibrium in the goods market ceteris paribus. However to the extent that the country is less dependent on oil imports relative to its trading partners its currency vis-à-vis the currency of its trading partners, is expected actually to appreciate. Long run structural modeling is used to test the validity of including the oil price variable.
All data is monthly. The majority of the time series available for most of the data used in the study cover the sample period from January 1979 to May 2001, though a number of them are limited by data availability and have somewhat shorter sample periods. The shortest time series available (Mauritius) ranges from January 1997 to May 2001 (see appendix for detailed information of the data samples). All data was obtained from Global Financial Data Company, California, USA and the data set include:

- The logarithm of the effective nominal exchange rate (defined as units of domestic currency per US dollar or South African rand \((e_i)\) such that an increase represents a depreciation of the home currency). As the original data was all expressed in US dollar/local currency, the exchange rate against the South African rand was calculated by dividing the US dollar/South Africa rand exchange rate against each individual country’s currency exchange rate.

- The logarithm of the domestic price levels i.e., consumer price index (CPI) denoted by \(p_t\).

- The logarithm of foreign (i.e., US or South Africa) price levels, (CPI) denoted by \(p_t^*\).

- The logarithm of the oil price index \((p_o)\)

- The logarithm of domestic interest rate \((r_t = \ln\left(1 + \frac{R_t}{100}\right))\) where \(R_t\) is the three months treasury-bill (TB) rate. For Botswana, Tanzania and Swaziland the deposit rate was used instead.

- Logarithm of foreign interest rate \(r_t^* = \ln\left(1 + \frac{R_t^*}{100}\right)\) where \(R_t^*\) is the US of South Africa’s three months treasury-bill rate.

Data was assumed to be consistent for analysis purposes. This assumption was made based on the reliability of the data source. However, because of the South African dual exchange rate system during part of the sample period, South Africa’s exchange rate data from Financial Data Company was checked against data from the Reserve Bank of South Africa.

\[^{37}\text{Although on theoretical grounds, price series for tradable goods might be preferable, the observed price variables used are given by the consumer price index series. The empirical motivation for the use of CPI series is that, they are similarly defined at least in most of the countries, they are easily well understood and official measurements of price inflation are usually calculated from this index.}\]
The differences in values were very negligible and so were disregarded as negligible for analysis purposes.

As the seasonal effects were considered to be only marginally significant and also given the limited sample size available it was thought best to leave out seasonal effects. The data therefore did not include any seasonal dummies. Related to this is the question of structural breaks. Whereas other studies have included dummies to capture structural breaks, in this paper we focused only on the exchange rate, prices and interest rates and did not consider the possibility of structural breaks mainly because the sample is fairly short. Extensions to include, structural breaks dummies in the vectorial processes used in this study are therefore beyond the scope of the current study. Cognizance though was taken of the fact that when there are structural breaks, the various unit root test statistics are biased towards non-rejecting the null of a unit root.

Based on these six variables, cointegration analysis was carried out using the following empirical models for the vectorial process:

**Intra-continental/Cross-national Approach**

$$x_t = [e_t, p_t, r_t^*, r_t^* + p_o]$$

All variables are treated as endogenous $I(1)$ and conditioned on the changes in world oil prices, which is $I(0)$

**Intercontinental Approach**

$$y_t = [e_t, p_t, r_t]$$

$$x_t = [p_t, r_t^*, p_o]$$

Where, $z_t = (y_t, x_t)$ and $z_t^* = (t, p_t, e_t, r_t^*, p_t^*, p_o)$

The variables $x_t$ are treated as weakly endogenous $I(1)$ and $t$ stands for the time trend.

The above vector(s), contain two long-run relationships—one relating to exchange rate and relative prices, PPP, and the other an interrelationship among interest rates and exchange
rates, UIP. A detailed discussion of the statistical models for the two approaches will be given later.

4.2 Econometric Methodology

4.2.1 Cointegration technique

The analysis applies VAR techniques to the Southern African exchange rates, interest rates and price differentials. Cointegration was used because it has been empirically proven that it can provide an important framework within which a closer link between theory and econometric applications could be fostered and therefore can capture the economic notion of a long run economic relation. Cointegration techniques are also imminent when modeling the behavior of data series that display stochastic trends as it counters the ordinary least squares (OLS) method's problem of spurious regressions. According to Engle and Granger (1987, 1988), if two variables are found to be cointegrated, then the possibility of no causation in the Granger sense (not structural sense) is ruled out and causality must exist at least in one direction, either unidirectional or bi-directional.

This study employs cointegration analysis based on the technique pioneered by Engle and Granger (1987) and extended by Johansen (1988, 1991) and Johansen and Juselius (1990, 1992) and many others. It is a full information Maximum Likelihood Estimation method and it allows the estimation of both long and short-run relationships without having to difference the data. In testing for the presence of these relationships among the variables included in the data set, the Johansen and Juselius procedure is employed. Although the Johansen modus operandi is well known a brief outline of the methodology is given here to shed some light on how the procedure was applied in this paper.

The Johansen and Juselius (JJ) tests of cointegration are conducted through say, a \( \rho^{th} \) order \( n \)-dimensional vector of I (1) time series variables \( X_t \) with an autoregressive representation, which in its error correction form can be mathematically expressed in the following form:

\[
\Delta X_t = \delta + \sum_{i=1}^{\rho} \Gamma_i \Delta X_{t-i} + \Pi \Delta X_{t-\rho} + \Psi D + \epsilon_t
\]

(9)

where, \( X_t \) is an \( n \times 1 \) vector of I (1) or stochastic variables integrated of same order, \( \Gamma \), \( \Psi \) and \( \Pi \) represent \( n \times n \) coefficient matrices of short and long run effects/ adjustments to
the changes of the process, respectively, \( \Delta \) is the difference operator, \( \rho \) denotes the longest lag length so the VAR is the \( \rho \)th order, \( \delta \) is a constant or drift and \( \varepsilon \sim \text{Niid}(\theta, \Sigma) \), is a vector of white noise errors. \( D_t \) is a vector of non-stochastic variables designed to capture the time trend \( t \) and centered seasonal dummy variables should they be needed, as well as other intervention dummies, which will depend upon the particular circumstances of an empirical application. Centered seasonal dummies, sum to zero over twelve consecutive months by construction and are necessary to account for short run effects, which would otherwise violate the Gaussian assumption. In our cointegration tests the lag length \( \rho \) in the above model has been chosen on the basis of the Akaike Information Criterion (AIC). Model (9) will be used as a benchmark model within which all the subsequent hypotheses are tested, since in the unrestricted form it corresponds to the \( I(0) \) model. All higher models used in this research are nested in this model.

Important to this study, the variable \( \Pi \) embodies information on the long-run relationships between variables comprising the data set. As such it is the rank \( (r) \) of \( \Pi \) which indicate the number of cointegrating vectors. Johansen (1991) shows that if \( Z_t \sim I(1) \), (as is in this study) the following restrictions on model (9) have to be satisfied. If, \( \Pi \) has a zero rank, then no stationary linear combination can be identified and the variables in \( X_t \) are non cointegrated meaning that they can wander arbitrarily far from each other.\(^{38}\) However, if \( \Pi \) has the reduced rank \( r \), where \( 0 < r < n - 1 \), then \( \Pi \) can be decomposed into two \( n \times r \) matrices \( \alpha \) and \( \beta \) such that \( \Pi = \alpha \beta \). The matrix \( \beta \) consists of reduced rank \( r \) linearly-independent stationary combinations or cointegrating vectors (long-run relations), while \( \alpha \) can be interpreted as a matrix of vector error correction parameters or short run adjustments (also known as feedback coefficients) to the cointegrating relationships, \( \beta \). In such a case some of the elements of \( \alpha \) must be non-zero, that is, there must be Granger causality involving the levels of the variables in the system to keep the elements of \( X_t \) from diverging boundlessly. Thus not only can the existence of an equilibrium relationship determined; but also the relative speed of adjustment of each cointegrating vector to

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38 Lack of cointegration implies no long-run equilibrium among the variables. It is important to note that the term equilibrium means different things between economic theorists and econometricians. To economic theorists the term equilibrium refers to an equality, between desired and actual transactions. Whereas, the econometric use of the term makes reference to any long-run relationship among stationary variables. This means that, cointegration does not require that the long-run relationship (i.e., equilibrium), be generated by market forces.
disequilibrium shocks. The elements of \( \beta \) are estimated using the, full information maximum likelihood approach.

The beauty of the JJ multivariate cointegration technique is that it makes use of the information incorporated in the dynamic structure of the model, whilst at the same time it estimates the entire space of the long run relationships among a set of variables, without imposing any normalization on the dependent variable \( a \textit{ priori} \). In this case the joint analysis of the PPP and UIP using the JJ multivariate cointegrating allows for possible interactions between the goods and capital market. It must be stressed however, that a cointegrating vector is not unique.

4.2.2 Long-run Structural Modeling (LRSM)

In a multivariate context, such as the one given by the combined PPP and UIP model, a vector error correction model subject to deficient rank restrictions on the long-run multiplier matrix, \( \Pi \), may contain multiple cointegrating vectors termed \( \textit{cointegration rank} \). In such a case, the individual cointegrating vectors are under-identified in the absence of sufficient linear restrictions on each of the vectors and as such lack any meaningful economic interpretation. It is because of this that the VAR has been criticized as being devoid of any economic content. Thus in order to avoid this indeterminacy, we need to impose appropriate \( a \textit{ priori} \) just/exact identifying restrictions and/or over-identifying restrictions preferably obtained from the long-run equilibrium properties of a suitable underlying economic theory. Restrictions can either be coefficient restrictions or symmetry restrictions or both. For example, one can impose homogeneity and/or zero restrictions in order to identify the structural model from an estimated VAR. Long-run structural modeling endeavors to achieve this end by estimating theoretically meaningful long-run relationships through testing both just identifying and over-identified restrictions on the cointegrating vectors based on theories (in this case the PPP and UIP theories). In other words, LRSM provides a practical approach to discriminate between the vectors by incorporating long-run structural relationships suggested by theory in an otherwise unrestricted VAR model (Garrett et al, 1999).

In a simple case where \( r = 1 \), typically the one restriction needed to identify the cointegrating relation can be viewed as a ‘normalizing’ restriction, which could be applied
to the coefficient of any of the integrated variables which enter the cointegrating relation (by fixing its coefficient to unity) without changing the likelihood function. However in the more general case where \( r > 1 \), the number of such ‘normalizing’ restrictions must be at least equal to \( r \) linear independent restrictions on each of the cointegrating vectors, which needs to be supplemented with further \( r^2 - r \) a priori restrictions. The log-likelihood ratio statistic to test over identifying restrictions is asymptotically distributed as a chi-squared \( (\chi^2) \) variate with degrees of freedom equal to the number of over-identifying restrictions \( (v) \), namely \( n - r^2 > 0 \). A large value of \( \chi^2 \) on \( (v) \) indicates that over-identifying restrictions are not consistent with data. Estimation of the model subject to all the (exact and over-identifying) restrictions, thus enables a test of the validity of the over-identifying restrictions and hence of the economic theory, to be carried out. The long-run structural modeling approach described in Pesaran and Shin (1997) and Pesaran, Shin and R Smith (1998), was used in this study to test just and over-identifying restrictions. 39

4.2.3 Vector Error Correction Modeling (VECM) and Exogeneity

A practical feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from long run equilibrium. After all, if the system is to return to equilibrium, the movement of at least some of the variables must respond to the magnitude of the disequilibrium. Thus, having identified the vector either exactly identified or over-identified, a natural step to examine the short-term dynamics influenced by temporary deviations from a long run relationship (or PPP as in our case) would be to formulate a relationship called Vector Error Correction Modeling (VECM). VECM seeks to uncover the propagation mechanism underlying the behavior of the dynamics under consideration or to indicate the direction of the Granger (temporal) causality. VECM is also known as the Granger representation theorem. 40

39 According to Pesaran and Pesaran (1997), this test of over-identifying restrictions on the cointegrating relations, pre-assumes that the variables, \( X_t = (y_t, x_t) \), are I (1), and the number of cointegrating relations, \( r \), is correctly chosen.

40 The Granger Representation theorem states that, for any set of I (1) variables, error correction and cointegration are equivalent representations. In a cointegrated system, \( z_t \) does not Granger cause \( y_t \) if lagged values \( \Delta z_t \), does not enter the \( \Delta y \) equation and if \( y_t \) does not respond to deviations from the long-run equilibrium.
Engle and Granger (1987) established that in the presence of cointegration, i.e., once a number of variables (say, \( x \) and \( y \)) are found to be cointegrated there always exists a corresponding representation of data known as error correction form, which represents the dynamics of the series. More formally, if \( x \) and \( y \) are both integrated of order 1, and they are cointegrated so that \( Z_t = x_t - A y_t \) is \( I(0) \), then Engle and Granger (1987) showed that it must be the case that the following error correction mechanism is correct:

\[
\Delta x_t = a_1 z_{t-1} + \beta_1 \text{lagged}(\Delta x_t, \Delta y_t) + \epsilon_{1t} \\
\Delta y_t = a_2 z_{t-1} + \beta_2 \text{lagged}(\Delta x_t, \Delta y_t) + \epsilon_{2t}
\]  

(10.1)  

(10.2)

where, at least one of \( a_1 \) or \( a_2 \) is nonzero and \( \epsilon_{1t} \) and \( \epsilon_{2t} \) are white noise errors.

This error correction representation implies that changes in the dependent variable are a function of the level of disequilibria in the cointegration relationship (captured by the error correction term), as well as changes in other explanatory variable(s). This way, the error correction term, captures the dynamics of the system whilst incorporating the equilibrium suggested by economic theory (Dolado et al 1990). Equally, through the error correction mechanism, a proportion of the disequilibrium from one period is corrected in the next (Caesar 1090). In this case we exploit the idea that there may exist co-movements between the exchange rate, price levels and interest rate differentials, and the possibilities that they will trend together in the long-run stable equilibrium. If the VECM test results display signs of serial correlation and heteroskedasticity they are corrected using the Newey-West test.

Cointegration and error correction modeling is applied in this analysis because it holds several intuitive implications. When the variables are cointegrated, then in the short-run, deviations from the long run equilibrium will feed back on the changes in the dependent variable in order to force the movements towards the long-run equilibrium. If the dependent variable (say the change in the nominal exchange rate as is in this case) is driven directly by this long-run equilibrium error, then it is responding to this feedback. If not, it is responding only to short-term shocks to the stochastic environment. The Granger causality or the endogeneity of the dependent variable can be evidenced through the statistical significance of the \( t \)-test of the lagged error correction term and/or the \( F \)-test.
applied to the joint significance of the sum of the lags of each explanatory variable. In other words, the $F$-tests of the differenced explanatory variables, give us an indication of the short term causal effects, whereas the validity of the long-run relationship is implied through the significance of the $t$-test(s) of the lagged error correction term(s), which contain the long term information since it is derived from the long-run cointegrating relationship(s).

The coefficient of the lagged error correction term however, has the interpretation of speed of adjustment parameters and represents the proportion by which the long-run disequilibrium in the dependent variable is being corrected in the short period. The larger the error correction term the greater the response of that variable to the previous period’s deviation from the long-run equilibrium. On the other extreme, non-significant values of any of the lagged error correction terms imply that the variable(s) in question are unresponsive to the last period’s equilibrium error. Such an extreme scenario affects the implied long-run relationship and may be a violation of the underlying theory. On the other hand, the non-significance of any of the differenced variables, which reflects only the short-term relationship does not involve any theory violations, because theory especially economic, typically offers very little information on short term relationships (Thomas, 1993).

VECM therefore plays the simultaneous role of indicating the direction of Granger causality or the endogeneity of dependent variables as well as allowing us to distinguish between long term and short –term dynamics of variables in the cointegrating system. Thus a known novelty of error correction techniques can be illustrated in testing various economic issues which are especially elusive with respect to the causal direction. For example, Masih and Masih (1995a, 1997 and 1998) have used a multivariate formulation of VECM techniques on several mainstream macroeconomic analyses in order to test for the causal chains implied by major paradigms in international macroeconomic theory.

4.2.4 Intra-Continental/Cross-national Approach (South Africa as foreign country)

In the intra-continental approach, all variables were treated as endogenous except the growth in oil price, which was assumed exogenously determined in the system of equations and so the other variables are conditioned on the changes in oil prices. The
following, equation in error correction (VECM) form is used also assuming unrestricted intercepts and no time trends and, using VAR (2):

\[ \Delta X_t = \Gamma_1 \Delta X_{t-1} - \Pi X_{t-2} + C_0 + \psi_0 \Delta p_o + \psi_1 \Delta p_{o-1} + \varepsilon_t \]  

(11)

where, \( X_t = \{p_t, e_t, p_t^*, r_t, r_t^*\} \), \( p_o \) is the logarithm of the world oil price at time \( t \), \( C_0 \) is a vector of intercepts and, \( t = 1, \ldots, T \).

If the PPP and UIP hold, then theory predicts that we expect to find 2 cointegrating relationships among the variables \( p_t, p_t^*, e_t, r_t \), and \( r_t^* \) corresponding to the PPP and UIP respectively. For the cointegration rank \( r = 2 \), the cointegrating vectors will be,

\( (1, -1, -1, 0, 0) \) and \( (0, 0, 0, 1, -1) \).

Because the PPP relationship does not involve interest rates and the UIP does not involve PPP variables, the two relationships are distinguishable with \( r = 2 \) as the necessary condition for identification. Therefore, with \( r = 2 \) as a necessary condition for identification, there should be a 2-1 + 1 restriction on each vector. Where there are 4 restrictions on the first vector comprising of 2 exclusions and 2 equality restrictions and 4 restrictions on the second vector comprising 3 exclusions and 1 equality restriction and hence each vector is over-identified.

4.2.5 The Intercontinental Approach (US as the foreign country).

Unlike the intra-continental approach where domestic and foreign prices are all assumed to be endogenously determined, such a symmetric treatment of domestic and foreign variables does not seem necessary in small open economies like those of SADC, where it is highly unlikely that changes in domestic variables have a significant impact on the long run evolution of foreign (world) prices or interest rates. Therefore, under the intercontinental approach we adopt Pesaran and Smith (1999)'s argument that in the context of small open economies, it can be plausible to a priori assume that some of the 1 (1) variables in the cointegrating vector autoregressive model (VAR) are long forcing, in the sense that in the long run they are not caused by other variables in the model. Whilst these long forcing variables are indeed determined by economic processes, they are not
influenced by domestic variables and therefore can be viewed as being determined outside the system and are conditioned in explaining the remaining variables.

According to Pesaran and Smith (1999), the imposition of such exogeneity restrictions is likely to result in substantial reductions in the number of freely estimated parameters. Exclusion restrictions on exogenous variables can also aid identification to the coefficient matrix of the current endogenous (in this case domestic) variables. In their line of thought, the a priori restrictions that certain variables do not appear in particular domestic equations may be much more plausible, than a priori restrictions that structural shocks are orthogonal, an argument adopted in this study. This however, as Pesaran and Smith (1999) were quick to point out, does not rule out contemporaneous or short term interactions between the weakly exogenous I (1) variables and the endogenous I (1) variables, a fact that might change their asymptotic distributions to some unknown extent.

In the case of SADC, where most of the countries in the sample are poor, small and moderately open economies heavily dependent on oil imports, the important shocks to the world prices and interest rates are not only exogenous but observable because, it can be fairly easy to measure their impact on the economy. In Southern Africa, the price of oil is therefore a natural exogenous variable. Similarly, the foreign prices and foreign interest rates are also treated as exogenous. Therefore for the intercontinental approach the two foreign variables and oil prices are treated as weakly exogenous I (1), and are thus ‘long forcing variables’\(^4\). This treatment of the oil price variable is a slight change from earlier analyses in other studies (see Johansen and Juselius, 1992 and, Pesaran and Smith 1996) where changes in the log of oil prices and its lagged values were treated as strictly exogenous I (0) variables in the cointegrating VAR model. This approach taken in previous literature and adopted in the intra-continental approach excludes the possibility that there exist cointegrating relationships, which involve the oil prices. However, according to Garrett et al (2001) and Pesaran and Smith (2000), the appropriate method of

\(^4\) The concept of long forcing is fully discussed in Granger and Lin (1995) and Pesaran, Shin and Smith (2000) and is weaker than the concept of Granger non-causality, in the sense that it allows for lagged changes in the endogenous variables to influence foreign prices, foreign interest rates and oil prices, although it still rules out shocks to the endogenous variables to have any long-run impacts on foreign interests and prices and, oil prices. It must also be noted that, the exogenous treatment of foreign prices, foreign interests and oil prices could involve loss of efficiency in estimation if they are in fact not long forcing.
allowing for oil price effects is to include an integrated version of the \( I(0) \) variables in the underlying cointegrating VAR, which in the context of this application implies adding the log of oil price to the list of \( I(1) \) exogenous variables, and then testing the validity of excluding the level of oil prices, from the cointegration relations. If the restriction is rejected, then it is imposed. The following system of equations in error correction form was tested using varying observations

\[
\Delta y_t = C_{0y} + C_1 t + \Lambda \Delta x_t + \sum_{i=1}^{p-1} \Gamma_y \Delta x_{t-i} + \Pi_y x_{t-1} + \epsilon_t
\]

(12.1)

\[
\Delta x_t = a_{0x} + \sum_{i=1}^{p-1} \Gamma_x \Delta x_{t-i} + v_x
\]

(12.2)

where,

\[ C_i = (-\Pi_i') \]

- \( z_t = (y_t, x_t) \), which is \( = (p_t, e_t, r_t, r_t^*, p_t, po) \)
- \( y_t = (p_t, e_t, r_t) \) or the vector of jointly determined (endogenous) \( I(1) \) variables
- \( x_t = (r_t^*, p_t^*, po) \) or vector of structurally exogenous \( I(1) \) variables, which are long forcing.
- There is no vector of exogenous/deterministic \( I(0) \) variables.
- The disturbance vectors \( \epsilon_t \) and \( \nu_t \) satisfy the following assumptions:

\[
\mu_t = \begin{pmatrix} \epsilon_t \\ \nu_t \end{pmatrix} - iid(0, \Sigma)
\]

(12.3)

where \( \Sigma \) is a symmetric positive-definite matrix

The intercept and trend coefficients \( C_{0y} \) and \( C_1y \) are \( 3 \times 1 \) vectors; \( \Pi y \) is the long-run multiplier matrix of order \( (3, 6) \) and \( \Gamma_y, \Gamma_2y, ..., \Gamma_{p-1}y \) are \( (3, 6) \) coefficient

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\(^{42}\) Equation (11.2) contains the restriction that \( \Pi = 0 \), which implies that the elements of the vector process \( \{x_t\}_{t=1}^\infty \) are not cointegrated among themselves. Moreover the information available from the differenced VAR (\( p - 1 \)) model (11.2) for \( \{v_t\}_{t=1}^\infty \) is redundant for efficient conditional estimation and inference concerning the long-run parameters \( \Pi_x \) as well as deterministic and short run parameters \( c_0, c_1, \lambda \) and \( \Psi \) of (11.1).
matrices capturing the short-run dynamic effects, whilst $\Lambda$ is a 3 x 3 short run coefficient matrix.

The VECM in (11.1) differs in a number of important respects from the usual VAR formulation for VECM (see (9)) analyzed inter alia by Johansen (1991). Firstly, (11.1) allows for a subsystem approach in which the $m_x$ vector of random foreign variables $x_t$ is the forcing variables or common ‘stochastic trends’ in the sense that the error correction terms do not enter in the sub-system for $x_t$ (given by (11.2). Therefore cointegration analysis applied using the inter-continental approach, allows for contemporaneous and short-term feed backs from $y_t$ to $x_t$ but requires that no such feedbacks are possible in the long run. The weakly exogenous $I(1)$ variables (foreign prices and foreign interests and oil prices as in this case) $x_t$, are the ‘long-run forcing’ variables of the system. Secondly, the cointegration analysis critically depends on whether the underlying VECM contains intercepts and or time trends, and whether the coefficient intercepts, $C_{0_y}$ and the time trends, $C_{1_y}$, are restricted. As in Pesaran (1997), this study assumed that, intercepts are unrestricted and the time trends are restricted and hence the level of $y_t$ will exhibit no linear deterministic trends for all values of the cointegrating rank, $r = \text{Rank (}\Pi_{y')}.^43$ Therefore, $C_0 \neq 0$ and $C_1 = \{-\Pi_{y'}\}$. The VECM combining the two systems of equations (11.1) and (11.2), is represented by:

$$\Delta z_t = C_0 + \left(-\Pi_{y'}\right) + \Lambda \Delta x_t + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \Pi_t z_{t-i} + \mu_t \quad \text{(12.4)}$$

For $i = 1, 2, \ldots, n$, where

$$z_t = \begin{pmatrix} y_t \\ x_t \end{pmatrix}, \quad \mu_t = \begin{pmatrix} \epsilon_t \\ \nu_t \end{pmatrix}, \quad C_0 = \begin{pmatrix} a_{0y} \\ 0 \end{pmatrix}, \quad C_1 = \begin{pmatrix} \Pi_{y'} \\ 0 \end{pmatrix}, \quad \Pi = \begin{pmatrix} \Pi_{y} \\ 0 \end{pmatrix}, \quad \Gamma = \begin{pmatrix} \Gamma_y \\ \Gamma_x \end{pmatrix}$$

This equation with the option of restricted trends was used for the analysis. A constant was also included to capture the linear trends, which were observed in price level variables when the data was plotted.

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43 This assumption of unrestricted intercepts and restricted time trends, is referred to as case IV in Pesaran, Shin and Smith (2000).
The cointegration rank hypothesis stated in the context of (11.5) is

\[ H_r : \text{Rank}[\Pi_y] = r \quad r = 0, \ldots, n \]

where \( \Pi_y = \alpha, \beta \)

If the PPP and UIP holds, economic theory suggests the existence of two long run relations defined as, \( p_t - e_t - p_t' \) and \( r_t - r_t' \) respectively. We therefore expect to get, \( r = 2 \) cointegrating relationships and the vectors will be:

\((1, -1, -1, 0, 0)\) and \((0, 0, 0, 1, -1)\)

4.2.6 Generalized Variance Decomposition Analysis and Relative Causality

Since unrestricted VARS are over-parameterized they are not particularly useful for short-term forecasts. However understanding the properties of the forecast errors is exceedingly helpful in uncovering inter relationships among variables in the system. Inference from using VECMs, in the way of \( F \)- and \( t \)-tests as explained in (4.2.4) may be interpreted as within sample causality tests. They indicate only the Granger causality of the dependent variable within the sample period, but they neither provide an indication of the dynamic properties of the system, nor allow us to gauge the relative strength of the Granger causal chain beyond the sample period. Variance Decomposition Tests are an extension of the VECM as they allow out of sample testing of the Granger exogeneity or endogeneity of the dependent variable. In addition, VDCs provides a measure of the extent to which a variable is exogenous in comparison to other variables in the system.

Results of forecast error variance decompositions, also termed out-of-sample causality tests, indicate that by partitioning the variance of the forecast error of a certain variable into proportions attributable to shocks in each variable in the system including its own, we are able to gauge the relative causality of the variables initially identified as being endogenous or exogenous via the vector error correction model. In more simple terms, the forecast error variance decomposition tells us the proportion of the change or movements in the value of a sequence (or the variable) in a given period due to its own shocks versus shocks to other variables. If \( \sigma^2 \) shocks explain none of the forecast error variance of \( (y_t) \)
at all forecast horizons, we can say that the \( y_t \) sequence is exogenous. This is in line with Sims (1982) findings, that a variable that is optimally forecast from its own lagged values will have all its forecast error accounted for by its own disturbances and hence, it is exogenous. In applied research, it is typical for a variable to explain most of its forecast error variances at short horizons and smaller proportions at longer horizons.

As results based on standard or orthogonalised VDCs have been empirically found to be generally sensitive to the lag length used and to the ordering of variables, to circumvent the problem, this study applies the generalized VDCs advanced and applied in Lee and Pesaran (1993).

4.2.7 Generalized Impulse Response Functions and Persistent Profiles

Finally having estimated the structural cointegrating VAR model, we use it in the examination of the economy’s short-run dynamic properties of our model. To achieve this an analysis of generalized impulse response functions (GIRF) and persistence profiles (PF) are conducted in an attempt to examine the effect of shocks in causing deviations from long-run equilibrium and to gauge the speed with which, the PPP and UIP for the economies under study converge back to equilibrium after a variable specific or system wide shocks. The information from VDCs can be equivalently represented by the graphs of the impulse response functions (IRFs). As stated by Pesaran and Shin (1994), focusing on the long run only as is often done when testing for cointegration has the danger of making empirical research irrelevant or at best rather of limited use for policy analysis. Pesaran and Shin (1994) cite Keynes (1923, p. 80) who put it in the following way:

"But this long run is a misleading guide to current affairs. In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is long past the ocean is flat again."

It is therefore imperative that the analysis of cointegration is accompanied by some estimates of the speed with which the economy or markets under consideration return to their equilibrium states once shocked. That is of-course assuming that the equilibrium exists as is in this case. Such analysis is particularly valuable where two or more cointegrating relations characterizing equilibrium have been identified. One of the best
methods to establish the speed of convergence is to apply the impulse response approach, originally due to Sims (1980) to estimate the time profile of the effect of "particular" or variable specific shocks on all the model's endogenous variables or on the cointegrating relations. While shocks on individual variables in a cointegrating VAR model do not dissipate but persist forever, the effect of shocks on the cointegrating relations is bound to dissipate. There are two types of impulse response functions, orthogonalized and generalized. As previous studies have invariably shown, because of the dependence of the orthogonal method on the ordering of variables in the system, this method produces highly disparate if not nonsensical results when the ordering of variables is changed, therefore the generalized approach was used in this application.

The second method to gauge the speed with which deviations from long-run relations in the model are eliminated is to apply persistence profiles as proposed in Pesaran and Shin (1994). In direct contrast to impulse response functions, which focuses on the impact of variable-specific shocks, persistence profiles are best used to map out the dynamic response path of "system wide shocks" or composite shock on the cointegrating relations. In simple economic terms, persistence profiles are used to estimate the speed with which the economy or markets under consideration return to their equilibrium states. The profiles are constructed so that they take the value of unity on the impact of the shock and tend to zero as the time horizon tends to infinity assuming that the long-run relationship is in fact cointegrating. Persistence profiles of near integrated or I (1) time series variables are transitory and eventually converge to zero as the economy returns to its steady trend, but they can be substantially different from zero for protracted periods.
CHAPTER 5
EMPIRICAL FINDINGS

This chapter outlines the results and implications of empirical tests on the data. Due to the number of countries investigated and huge volumes of results generated, most computer test results are commented on but not reported in this paper. However the results are available on request from the author.

5.1 Unit Root Tests and Order of VAR

In order to apply cointegration techniques to this data series, it was first necessary to determine the dimensions of the VAR. This entailed deciding the number of $k$ integrated variables to be jointly modeled in the VAR, determining which variables should be included as $I(1)$ endogenous (jointly determined and explained in the model) and, determining whether or not to include any exogenous (determined outside the model) or $I(0)$ variables in the model. It was also necessary to determine whether or not to include an intercept or time trend in the VAR analysis, as well as establishing the lag length of the variables or the order of VAR.

Firstly, consideration of purpose, judgment, economic theory guidance and previous empirical research was used to inform the choice and number of variables jointly modeled as well as the functional form. True, other factors such as economic fundamentals like real output levels, level of government spending, net foreign assets accumulation and cumulated current account balances were initially considered for inclusion into the VAR. However, apart from the fact that results from previous work along these lines have been mixed, when the lack of transparency and accuracy in the data from most of the sample countries was considered, it was deemed prudent to drop out these variables. Including more variables whilst using monthly data was also not favored because as a practical matter the more variables are added, the quicker the degrees of freedom are eroded. Moreover, including other variables to capture the fundamental factors would have made it difficult to impose linear PPP and UIP theory restrictions to the cointegrating vectors at the long-run structural modeling stage.

As stated by Pesaran and Smith, cited in McAleer and Oxley (1999), the immense benefit
of using economic theory to impose structure on the VAR is that in addition to substantially reducing the dimensionality of the estimation problem, it also increases the efficiency of the estimates and the power of the tests. Therefore given the importance of system properties, the theory has to be used to impose some structure on the system rather than to impose ad hoc restrictions on individual (dynamic) coefficients.

The second step was data analysis. In order to embody the long-run relations (in this case the PPP and UIP) within a suitable macroeconometric model, it is important that the variables used in the empirical analysis can be reasonably be argued to be I(1). To ascertain this investigations were undertaken to, establish the stationarity or order of integration of the variables of the empirical model under consideration and, to determine whether the series are I(1) in nature. All variables used namely, exchange rates, price indices and interest rates and world oil prices are, time series data, and it is an established fact that most time series data is non-stationary in level form. This was also observed when the data was plotted on graphs for all variables except the Namibia/South Africa and Swaziland/South Africa exchange rates, which were found to be stationary in level form (see appendix data figures). The interest rates were found to have a general upward trend but are mean reverting. To establish and confirm this, the data was tested for a unit root or nonstationarity using Augmented Dickey-Fuller (ADF) and the Phillips Perron (PP) (1988) unit root tests procedures. Both these tests are conducted on the null hypothesis that there is nonstationarity or one unit root in the variable under question. Despite it not being very powerful in finite samples, the ADF and PP tests were especially favored because they have good power characteristics as compared to other unit root tests in literature.

In determining the order of integration each of the two tests discussed above was performed with a constant and with and without a trend variable. For either standard ADF tests or PP tests, the choice of lag length \( k \) may affect the test results, hence this study follows the procedure suggested by Campbell and Perron (1991) where you start with an upper bound, \( k_{\text{max}} \), on \( k \). If the last lag is significant, choose \( k = k_{\text{max}} \), and if not, reduce \( k \) by one until the last lag becomes significant. A summary report of the ADF and PP results computed over varying observations for the different countries and, for the period ranging from 1979M1 to 2001M5, for the levels and 1st differences of all variables are presented in Appendix Table 1. Several points are worth noting in relation to these results. First, with few exceptions the results show that the null of non-stationarity is accepted for the
following variables in level form but not for the Namibia/South Africa and Swaziland/South Africa exchange rates variables. The null of non-stationarity is however rejected in the first difference form for the ADF test and the PP test for the rest of the variables that are non-stationary in level form, indicating that, most of the tested variables are first difference stationary or an I (1) process. The evidence that the variables are described by an, I(1) process are strong based on the consistent results of the two tests.

So, combining parsimony, these unit root tests and the a priori knowledge that, all the six variables, like most time series data are generally considered to be integrated of order of one, the null hypothesis of nonstationarity (in 1st difference) was accepted for all variables under consideration, except the Namibia/South Africa and Swaziland/South Africa exchange rate variables. Further investigations established that these two exchange rates are stationary in level form because the two currencies are pegged against each other around one to one basis. Therefore the PPP was not tested for intra-continental approach for Namibin and Swaziland because their exchange rates were found to be I (0). Accordingly, the rest of the analysis proceeded under the assumption that the time series relevant for our cointegration test are all integrated of same order I (1), which of course is a necessary condition for time series to be cointegrated. This finding is also consistent with other studies focusing on the post Bretton Woods period where it is clear that exchange rates interest rates and price level variables are characterized by a non stationary process.

The only intervention dummy variable, which was included in the model, was the growth in the world oil prices and only for the intra-continental approach. No other deterministic dummies were included because they were considered insignificant given the short sample size used.

Subsequently, based on the observation that the plot of the data over the period under study indicated no upward trend in difference form for all variables except SA/Namibia and SA/Swaziland exchange rates, and the a priori knowledge which suggests that interest rates tend to be mean reverting in the long run, the VAR was estimated without a deterministic trend for the intra-continental approach. However no a priori restrictions on intercepts were assumed and the VAR was estimated with unrestricted intercepts to account for the constant in the equation. For the intercontinental approach, we assumed unrestricted constants and restricted trends. Over-identifying restrictions were then used to
test the validity of including a trend that is, testing the co-trending hypothesis that the trend coefficients in the cointegrating relations are equal to zero.

Finally, before cointegration tests were conducted on the data for each country, the order of the vector autoregression was selected in order to determine the number of lags of the variables to be included in the cointegration model. Due to their voluminous amount the test results of the VAR selection are not included in this paper, but are available upon request from the author. In line with the common empirical practice, the order of VAR \( k \) was chosen using the Akaike Information Criterion or Schwartz Bayesian Information Criterion subject to, the lag length choice passing the Lagrange- Multiplier test for the absence of serial correlation. For most of the countries, consideration of the Akaike Information Criterion generally suggested an optimal VAR order of two while the Schwartz Bayesian Information Criterion generally suggested VAR order 1. Subsequent analysis of the residuals of the individual equations in the VAR for serial correlation for all variables, concluded that a VAR of two was a reasonable choice, with a few exceptions (Country- specific VAR order selection results are reported later under the respective country's cointegration results as some countries used higher VAR orders). Moreover the selection of VAR (2) was considered prudent on the grounds that the consequences of over-estimation of the order of VAR is less damaging than under-estimating it especially where the sample is reasonably large (see Kilian (1997)).

The cointegration tests are based on the procedure suggested by Johansen (1988) and Johansen and Juselius (1990, 1991) already discussed above. For each country the number of cointegrating vectors is sequentially determined using the Maximum eigenvalue statistic (\( \lambda_{\text{max}} \)) and the trace statistic (\( \lambda_{\text{trace}} \)), as well as the Akaike information criterion (AIC), the Hannan-Quinn Criterion (HQC) and the Schwarz Bayesian Criterion (SBC).

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44 The Johansen and Juselius procedure offers two likelihood ratio statistics that test for cointegrating vectors and they both follow non-standard distributions. Firstly in the case of maximum eigenvalue test, if based on the value of the statistic the null of \( r = 0 \) can be rejected, then the explicit alternative null hypothesis that there is at most one cointegrating vector \( (r \leq 1) \) is tested and so on. Secondly, in an \( n \)-variable case \( 0 \leq r \leq n - 1 \), Johansen (1988) also proposes another likelihood ratio test known as the 'trace' test for determining the number of cointegrating relationships. The trace statistic tests the hypothesis that there are at most \( r \) distinct cointegrating vectors.
5.2 Estimation and Testing of Models

Given the non-stationarity of all variables for the countries considered, the vector of interest rates, exchange rates and prices is viewed as a system of possibly cointegrated variables (Engle and Granger, 1987). As such the number of cointegrating relationships between them was estimated. The Johansen maximum likelihood procedure (1992) was used to estimate the number of cointegrating vectors and to derive a likelihood ratio test for the null hypothesis that there are a given number of these relationships. As the specific country approach was used to investigate the propositions under study because findings are intended to benefit national policy makers, the results are reported on a country-by-country basis. Conclusions that the PPP and UIP variables move together in the long run for each country were drawn where at least one cointegrating vector was found at the conventional 95% significance level. Long-run structural modeling (LRSM) was then used to determine the validity of the two propositions in their symmetry and proportionality conditions.

Of these two tests, however, the maximum eigenvalue test is expected to provide more accurate results than the trace statistic (JJ, 1990). However as argued by Juselius (1995), the results of the trace and maximum eigenvalue test statistics of the I (1) variables analysis, i.e. from the estimation of the model without allowing for I (2) trends, must be interpreted with caution for two reasons. First, the conditioning on intervention dummies and/or weakly exogenous variables is likely to change the asymptotic distributions to some (unknown) extend. Second, the asymptotic critical values may not be very close approximations in small samples. Also these two tests do not impose the symmetry and proportionality restrictions. The statistical package used in the cointegration analysis is Microfit 4.0 (Pesaran and Pesaran, 1997). The asymptotic distributions for both the trace and maximum eigenvalue statistics are tabulated and presented in Johansen and Juselius (1990) and Osterwald-Leman (1992).
5.2.1 BOTSWANA

• Botswana Simple PPP and UIP

Intra-Continental Approach

Using the AIC and SBC selection criteria, the tests for order of VAR selects 2 and 3 as order of VAR for the PPP and UIP respectively. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equations suggest that autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP using selected order of VAR are presented in Appendix Table 2.

PPP

The vectorial process used to test the PPP hypothesis is defined by;

\[
\Delta X_t = \delta + \sum_{i=1}^{s-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-\rho} + \epsilon_t
\]  

(13)

where \( X_t = (p_1, e_1, p_2, \ldots) \), \( \Gamma \) and \( \Pi \) represent short and long-run coefficients and \( \delta \) is a constant.

Both the Maximum eigenvalue (\( \lambda_{max} \)) and the Trace statistics (\( \lambda_{trace} \)) suggest \( r = 2 \). The hypothesis \( r = 0 \) is rejected against \( r = 1 \), and the hypothesis \( r = 1 \) is rejected against \( r = 2 \) but the hypothesis that \( r = 2 \) cannot be rejected against \( r = 3 \) etc. However, according to the PPP theory we only expect one cointegration relationship and so the finding of more than one cointegrating vector tends to complicate the interpretation of results, as it may not be possible to identify the structural relationship. However since there is cointegration we conclude that the simple weak form PPP does seem to hold because the variables do move

---

\(^{45}\) The equation tested for PPP is defined by the system \( X_t = (p_t, e_t, p_t^*) \) where \( p \) is the domestic price, \( e \) is the exchange rate and \( p^* \) is the foreign price. Equation (13) was used for all countries' simple PPP tests throughout the analyses.
together in the long run\textsuperscript{46}. To reach definite conclusions on the validity of the theory we impose the theory restrictions. Assuming $r = 1$ in line with the PPP theory under proportionality and symmetry, the coefficients of the cointegrating vector $\beta$ should satisfy $\beta_{PPP} = p - e - p^* = 1 - 1 - 1$, when the coefficient on the domestic price has been normalized to one. But, first we impose the exact identifying restriction $p = 1$ to the cointegrating vector $\beta = (LBCPI (p), LBSAR (e), LSACPI (p^*))$, yields the following exactly identified estimates:

\[
\beta = \begin{pmatrix}
1.000 \\
2.7432 \\
-0.1170
\end{pmatrix}
\]

where the log likelihood function (LL) subject to just-identifying restrictions = 2675.9.\textsuperscript{47}

The vector does not support the PPP theory because only the foreign price coefficient has the right sign. Next we imposed over-identifying restrictions based on the strict PPP theory restrictions where, $\beta_{PPP} = (p - e - p^*) = (1 - 1 - 1)$. These were also rejected as the log likelihood ratio (LR) statistic for testing these restrictions was computed to be 39.82, which is way higher than the 95% critical value of the chi-squared distribution with two degrees of freedom. The symmetry and proportionality restrictions are thus rejected at the conventional 95% significance level.\textsuperscript{48}

\textbf{UIP}

For the UIP the system of equations used in the analysis, is represented by the following vectorial process:

\[
\Delta X_t = \delta + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-p} + \varepsilon_t \tag{13}
\]

\textsuperscript{46} The term weak form validity (PPP or UIP), is used where the variables are cointegrated but the theory restrictions are rejected, whereas, strong form validity is where there is cointegration and the economic theory restrictions are accepted.

\textsuperscript{47} The LL is the maximized value of the log-likelihood function for the just-identified case. All computations reported in this chapter are carried out using Microfit 4.0. (See Pesaran and Pesaran (1997))

\textsuperscript{48} Under proportionality and symmetry, the coefficients of the cointegrating vector $\beta$ should satisfy $\beta = (1-1-1)$ when the coefficient on the domestic price has been normalized to one. In contrast to the trace and maximum eigenvalue tests, rejection of the null for the tests of these restrictions is evidence against the strong form or PPP theory in its symmetry and proportionality conditions.
where \( X_t = (r_t, r_t^*)^{49} \), \( \Gamma \) and \( \Pi \) represent short and long-run coefficients and \( \delta \) is a constant.

The simple UIP is rejected at the conventional 95% critical level, as there is no cointegration between domestic interest (LBDR) rates and foreign interest rates (LSATB).\(^{50}\)

**Intercontinental Approach**

For the tests for order of VAR both the AIC and SBC selects 2 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP using order of VAR = 2 are presented in Appendix Table 3.

**PPP**

For the PPP using model (13), both the Maximum eigenvalue (\( \lambda_{\max} \)) and the Trace statistics (\( \lambda_{trace} \)) suggests one cointegrating vector, \( r = 1 \) at the five percent level. The hypothesis \( r = 0 \) is rejected against \( r = 1 \), but the hypothesis that \( r = 1 \) cannot be rejected against \( r = 2 \). This result is in line with the PPP hypothesis, which posits that there should be only one cointegrating relationship between the PPP variables namely, \( (p - e - p^* = l-1-I) \) hence, we conclude that the intercontinental PPP variables move together in the long run. However without imposing the PPP theory restrictions it is accordingly difficult to draw definite conclusions on whether the PPP proposition hold in its proportionality and symmetry conditions so we apply restrictions to this statistical vector based on economic theory. Assuming \( r = 1 \), which is also in line with the PPP theory, we present the estimates of the cointegrating coefficients normalized on the coefficient of the domestic price (LBCPI (p)) = 1). The estimated results of cointegrating vector, \( \beta = \langle LBCPI (p), LBER (e), LUSCPI(p^*) \rangle \) are:

---

\(^{49}\)The equation tested for PPP is defined by the system \( X_t = (r_t, r_t^*) \) where \( r \) is the domestic interest rate and \( r^* \) is the foreign price. Equation (13) was used for all countries’ simple PPP tests throughout the analyses.

\(^{50}\)There is however one cointegration relation at the 90% significance level. But to limit the scope of this study further analysis was only carried out where there was cointegration at the 95% significance level. Overall conclusions will also be drawn based on the 95% significance level.
\[
\beta = \begin{pmatrix}
1.000 & -0.1599 & -2.9001 \\
0.1253 & (none) & (0.3313)
\end{pmatrix}
\]
where LL = 2786.5

The vector supports the PPP theory as both domestic exchange rate and foreign price have negative coefficients, but not in its symmetry and proportionality conditions. The imposed symmetry and proportionality over-identifying restrictions, based on the strict PPP restrictions represented by \( \beta_{PPP} = (p - e - p^*) = (1 - 1 - 1) \) were subsequently rejected. The log likelihood ratio statistic (LR) for testing these restrictions was computed to be 26.23, which is way higher than the critical value of the chi-squared distribution with two degrees of freedom. The simple PPP therefore holds but not under the symmetry and proportionality restrictions.

UIP
Using model (13), the UIP between Botswana and the US is rejected, as there is no cointegration between Botswana deposit rates and US interest rates at the 95% significance level.

- Botswana Joint PPP and UIP

Intra-continental Approach
We use model (11) defined earlier, where, \( X_t = [p_t, e_t, p_t^*, r_t, r_t^*] \) and \( p_{oil} \) is the logarithm of the world oil price at time \( t \), \( C_t \) is a vector of intercepts and, \( t = 1, ..., T \).

PPP
Using the optimal VAR order of 2, both the \( \lambda_{max} \) and the \( \lambda_{race} \) suggest \( r = 1 \), at 95% critical value. The hypothesis of no cointegration (namely \( r = 0 \)) is rejected against null hypothesis that there exists one cointegrating relation (namely \( r = 1 \)) but the hypothesis that \( r = 1 \) cannot be rejected against \( r = 2 \) at the 95% significance level. The Akaike information criterion (AIC) and the Hannan-Quinn Criterion (HQC) also unanimously selects \( r = 2 \), while the Schwarz Bayesian Criterion (SBC) suggest \( r = 1 \). Considering these statistical results there is some ambiguity in choosing the number of cointegrating relationships among the six I (1) variables. However the long-run economic theory posits that, based on arbitrage in the commodity and capital markets, we should expect two
cointegrating relations (i.e., \( r = 2 \)): the PPP arbitrage condition;

\[ p_t - e_t - p_t^* \sim I(0) \]

and the interest rate arbitrage relation (which is the long-run implication of the uncovered interest parity hypothesis);

\[ r_t - r_t^* \sim I(0) \]

Also according to Pesaran and Smith (1999) any empirical analysis involves balancing, consideration of purpose (the relevance of the model and its intended use), theory (consistency with prior knowledge), and statistical adequacy (itself a function of fit and parsimony). They further demonstrate that, in case of choosing the number of cointegration relations, this balancing act can be particularly difficult because not only are there usually a large number of choices required to establish a specification but also because statistical criteria may not be very informative about these choices. Using this line of argument, in this application it was deemed proper and in conformity with economic theory to set \( r = 2 \) for the purposes of further analysis.

Using Long-run structural modeling (Pesaran and Shin, 1997) we first obtain estimates of the cointegrating coefficients (together with their asymptotic standard errors) normalized on the following exact (theory) identifying restrictions:

\[ H_E: \begin{bmatrix} \beta_{11} = 1, \beta_{13} = 0 \\ \beta_{21} = 0, \beta_{23} = 1 \end{bmatrix} \]

where we have denoted the two cointegrating vectors associated with the coefficients of \( X_t = \begin{bmatrix} p_t, e_t, r_t, P_t^* \end{bmatrix} \) by, \( \beta_1 = ( \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15} ) \), \( \beta_2 = ( \beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25} ) \) representing the PPP and UIP respectively. The test yield the following estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>( p )</th>
<th>( e )</th>
<th>( r )</th>
<th>( P^* )</th>
<th>( r^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_1 )</td>
<td>1</td>
<td>-0.5841 (1.8854)</td>
<td>0</td>
<td>-0.8301 (0.4159)</td>
<td>0.2491 (0.7182)</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0</td>
<td>2.1816 (3.0934)</td>
<td>1</td>
<td>0.4920 (0.6858)</td>
<td>-0.8718 (1.2199)</td>
</tr>
</tbody>
</table>

with the maximized value of the log-likelihood function being 4737.4 (LL = 4737.4) and, where asymptotic standard errors are given in brackets.\(^{51}\)

\(^{51}\) For details of computational algorithms see Pesaran and Pesaran (1997, Section 19.8)
The first vector represents the PPP condition and the exchange rate (LBPSAR (e)) and foreign price (LSACPI (p)) have the expected signs although not equal to unity. Vector 2 stands for the UIP condition, and the foreign interest rate (LSATB(r^*)) has the right sign. However, since the above exact-identifying restrictions do not impose any testable restrictions on the cointegrating VAR, over-identifying restrictions based on the two long run theories under study, were imposed on the cointegrating vectors (CVs) in order to test their validity.

In addition to the exact-identifying restrictions (HE), the over-identifying restrictions based on the PPP theorem where \( p_t - e_t - p_t^* \sim I (0) \equiv 1 - 1 - 1 \), namely \( \beta_{12} = \beta_{14} = -1 \), and \( \beta_{15} = 0 \), produced the following estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>( p )</th>
<th>( e )</th>
<th>( r )</th>
<th>( P^r )</th>
<th>( r^r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_1 )</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0</td>
<td>2.3835</td>
<td>1</td>
<td>0.5704</td>
<td>-0.7821</td>
</tr>
</tbody>
</table>

\( L \ell = 4731.7 \)

The log likelihood ratio (LR) statistic for testing the three over-identifying restrictions is computed to be 11.34 \( \sim 2(4737.4 - 4731.7) \), which is significantly above the 0.05 critical value of the chi-squared distribution (\( \chi_2^2 \)) with 3 degrees of freedom, suggesting that the theory restrictions are rejected at 95% significance level. Modified versions of the PPP with either the domestic interest rate (LBDR (r)) or foreign interest rate (LSATB (e)) unrestricted were also tested but were all rejected at the 95% critical level as the LR statistic obtained were all above the critical chi-squared distribution with 2 degrees of freedom.\(^{52}\)

Next, taking \( HE \) as the exact identifying restrictions, we provide tests for the UIP theory restrictions, where \( r - r^* = I - I \), namely \( \beta_{22} = \beta_{24} = 0 \) and \( \beta_{25} = -1 \), we obtained these results:

\(^{52}\) According to Garrat et al (2001, Section 5.1) tests for over-identifying restrictions are invariant to the choice of the exact identifying restrictions.
\[
\beta_{\text{UIP}} = \begin{pmatrix}
\beta_1 \\
\beta_2
\end{pmatrix}
\begin{pmatrix}
1 & 3.8834 & 0.6332 & 0.4325 \\
0 & 0 & 1 & 0
\end{pmatrix}
\begin{pmatrix}
(7.5371) & (1.7058) & (3.2352) \\
-1
\end{pmatrix}
\]

\[\text{LL} = 4729.4\]

The LR statistic of 16.06, obtained for testing the imposed UIP over-identifying restrictions is above the 0.05 critical value of the chi-squared distribution with 3 degrees of freedom. The UIP theory restrictions are therefore rejected. The exchange rate (LBPSAR (e)) and foreign price (LSACPI (p')) in vector one representing the PPP also have the wrong signs.

Subsequently the hypothesis testing for the over-identifying restrictions on the joint PPP and UIP were tested and also rejected at 95% significance level. The LR obtained was 50.38, which is way above the critical value of the Chi-squared distribution with 6 degrees of freedom at the 95 percent level. However, since these over-identified cointegrating vectors namely \(\beta_1 = (\beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15} = -1, -1, 0, 0)\) and \(\beta_2 = (\beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25} = 0, 0, 0, 1, -1)\), are consistent with the PPP and UIP theory restrictions, we adopted them for use in analyzing the short run dynamic properties of the model.

**The Vector Error Correction Model**

Having identified the vectors, a natural step is to examine the short-term dynamics influenced by temporary deviations from the long-run relationship, is to formulate a vector error correction modeling relationship. VECM also known as, Granger representation theorem seeks to indicate the direction of Granger causality. The error correction coefficient represents the proportion by which the long-run disequilibrium in the dependent variable is corrected in the short period. Results for vector error correction modeling are presented in Table 2 below.

The error correction term for the domestic price equation (LBCPI (p)) associated with the first cointegrating vector representing the PPP has the correct sign and passes the diagnostic tests for serial correlation and heteroscedasticity. It is however very small, indicating a very slow gravitation back to equilibrium once shocked. Theory predicts that the error correction term must be significantly different from zero and the larger the
equation’s error correction coefficient (in absolute value), the faster the variable’s return to its equilibrium once shocked. The result, also indicate that domestic prices are relatively endogenous and partly bears the brunt of short-run adjustment to restore long-term equilibrium after any shock to the system.

Table 4:

Botswana: Reduced Form Estimates of Error Correction Coefficients and Diagnostic Statistics-Intra-Continental Approach.

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$R^2$</th>
<th>$\chi_{SC}^2(12)$</th>
<th>$\chi_{FF}^2(1)$</th>
<th>$\chi_{LR}(2)$</th>
<th>$\chi_{HA}(1)^{33}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALBCP(p)</td>
<td>-0.021</td>
<td>-0.009</td>
<td>0.090</td>
<td>16.74</td>
<td>0.26</td>
<td>1148.6</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.010)</td>
<td></td>
<td>[0.159]</td>
<td>[0.610]</td>
<td>[0.000]</td>
<td>[0.898]</td>
</tr>
<tr>
<td>ALBPSAR(e)</td>
<td>0.025</td>
<td>0.013</td>
<td>0.081</td>
<td>18.57</td>
<td>2.15</td>
<td>1321.1</td>
<td>0.155</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.037)</td>
<td></td>
<td>[0.099]</td>
<td>[0.142]</td>
<td>[0.000]</td>
<td>[0.693]</td>
</tr>
<tr>
<td>ALSACPI(p*)</td>
<td>0.005</td>
<td>-0.015</td>
<td>0.184</td>
<td>37.25</td>
<td>7.29</td>
<td>85.54</td>
<td>12.60</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.009)</td>
<td></td>
<td>[0.000]</td>
<td>[0.007]</td>
<td>[0.000]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>ALBDR(r)</td>
<td>-0.008</td>
<td>-0.023</td>
<td>0.147</td>
<td>16.37</td>
<td>6.65</td>
<td>2125.2</td>
<td>44.14</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.009)</td>
<td></td>
<td>[0.175]</td>
<td>[0.010]</td>
<td>[0.000]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>ALSATB(r*)</td>
<td>0.000</td>
<td>0.014</td>
<td>0.155</td>
<td>30.16</td>
<td>0.24</td>
<td>148.51</td>
<td>50.17</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.006)</td>
<td></td>
<td>[0.000]</td>
<td>[0.621]</td>
<td>[0.000]</td>
<td>[0.000]</td>
</tr>
</tbody>
</table>

Notes: The results are estimated by OLS based on cointegrating VAR (2) using the equation:

$$\Delta x_t = \delta + \Gamma_1 \Delta x_{t-1} + \alpha_1 \beta_1 x_{t-1} + \alpha_2 \beta_2 x_{t-1} + \epsilon_t,$$

where $\beta_1 = \xi_t$ which are I (0) and $\alpha_1$ and $\alpha_2$ are five dimensional matrices of adjustment or feedback coefficients and the two error correction terms are given by;

$$\xi_{1,t+1} = p_t - e_t - p_t^*,$$
$$\xi_{2,t+1} = r_t - r_t^*.$$

The figures in (.) are estimated asymptotic standard errors whereas those in [.] are the corresponding $\rho$-values. The bold faced estimates denote significance at 0.05 level. The diagnostic tests are chi-squared statistics for the following; $\chi_{SC}^2(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi_{FF}^2(1)$ is Ramsey’s RESET test statistic, $\chi_{LR}^2(2)$ is the Jarque-Bera statistic for testing the null of Gaussian errors, and $\chi_{HA}^2(1)$ is the statistic for testing the null of no heteroskedasticity. The number in (.) indicates the degrees of freedom.

$^{33}$ Full estimation of results are available on request from the author.
Although they have the highest $R^2$, error correction equations for both domestic (LBDR ($r_t$)) and foreign interest rates (LSATB ($r^*_t$)) equations pass only the functional form test and fail all other tests. Their error correction terms associated with the two cointegrating vectors are significant indicating that interest rates are relatively endogenous and do respond to correct short-run deviations from equilibrium, albeit at a crawling pace. The exchange rate equation (LBPSAR ($e_t$)) passes the serial correlation and heteroskedasticity tests, but both error correction terms are insignificant indicating no response to restore back equilibrium once shocked. The exchange rate is therefore exogenous and causality moves from the exchange rates. In terms of the $R^2$, the foreign price equation (LSACPI ($p^*_t$)) performs best, explaining 0.28 of the price variation over the sample period. However, the equation fails all diagnostic tests, and all the error correction terms are insignificant.

Only diagnostic tests of the domestic price and exchange rate are satisfactory as far as tests for the residual serial correlation, heteroskedasticity and functional form are concerned. The diagnostic tests show that the assumption of normally distributed errors is rejected in all the error correction equations.

**Forecast Error Variance Decompositions**

A sample of the VDC results generated for all the variables LBPCPI ($p_t$), LSACPI ($p^*_t$), LBPSAR ($e_t$), LBDR ($r_t$) and LSATB ($r^*_t$) with unrestricted intercepts and no trends are included in Table 3. Variance decompositions allow for out of sample testing of Granger exogeneity or endogeneity of the dependant variable and also provide a measure of the extent to which a variable is exogenous in comparison with other variables in the system. They achieve this end by providing a literal breakdown of the change in the value of the variable in a given period arising from changes in the same variable in addition to changes in other variables in previous periods.

The exchange rate (LBPSAR ($e_t$)) seems to be the most exogenous variable closely followed by foreign interest rate (LSATB ($r_t$)). This is inferred as the greater part (93% for exchange rate and 92% for foreign interest) of its shock/variance is being explained by its own innovations compared to own shocks contributing to explaining the rest of the variables. Foreign prices (LSACPI ($p^*_t$)) are also relatively exogenous with 70 percent of its
forecast error accounted for by its own disturbances. On the other hand the domestic price (LBCPI \( p_j \)) and the domestic interest (LBDR \( r \)) variables are relatively endogenous with their own shocks explaining 0.48 and 0.64 of their variances over the forecast horizon respectively. These results seem to indicate the strength of the Granger causal chain than the VECM results. Caution must be given though that VDC results give only relative indicators.

Table 5:

Botswana: Variance Decomposition Results

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LBCPI ( p )</th>
<th>LBPSAR ( \phi )</th>
<th>LBDR ( r )</th>
<th>LSACPI ( \phi )</th>
<th>LSATB ( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.50</td>
<td>0.12</td>
<td>0.20</td>
<td>0.21</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>0.56</td>
<td>0.17</td>
<td>0.05</td>
<td>0.11</td>
<td>0.01</td>
</tr>
<tr>
<td>20</td>
<td>0.21</td>
<td>0.21</td>
<td>0.05</td>
<td>0.15</td>
<td>0.01</td>
</tr>
<tr>
<td>30</td>
<td>0.00</td>
<td>0.00</td>
<td>0.05</td>
<td>0.17</td>
<td>0.01</td>
</tr>
<tr>
<td>40</td>
<td>0.33</td>
<td>0.40</td>
<td>0.03</td>
<td>0.18</td>
<td>0.01</td>
</tr>
<tr>
<td>50</td>
<td>0.48</td>
<td>0.21</td>
<td>0.04</td>
<td>0.18</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LBCPI ( p )</th>
<th>LBPSAR ( \phi )</th>
<th>LBDR ( r )</th>
<th>LSACPI ( \phi )</th>
<th>LSATB ( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>0.02</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>30</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>40</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Notes: The bold faced amounts denote in percentage the variable's variance explained by own shocks over the forecast horizon.

Impulse Response Analysis

Impulse response analyses are useful in that they can be used to estimate the time profile of the effect of 'particular' shocks to the cointegrating relations. The generated generalized impulse response analysis of the individual equations and cointegrating vectors to one
standard shock in the domestic price \( (LBPCPI (p)) \) and exchange rate \( (LBPSAR (e)) \) equations are portrayed in Figure 1 below. The first 2 figures A and B show generalized impulse response paths on each variable to one standard error (SE) shock in the equations of the domestic price \( (LBPCPI (p)) \) and exchange rate \( (LBPSAR (e)) \) respectively. Effects of these shocks on the level of individual series seem to persist forever, reflecting their unit root properties. The results are the same for shocks to the equations for foreign price and domestic and foreign interest variables.

**Figure 1 A**

Generalized impulse response to a unit S.E. shock in the equation for LBPCPI

**Figure 1 C**

Generalized impulse response to a unit S.E. shock in the equation for LBPSAR

**Figure 1 B**

Generalized impulse response to a unit S.E. shock in the equation for LBPSAR

**Figure 1 D**

Generalized impulse response to a unit S.E. shock in the equation for LBPSAR

**Figure 1:** Botswana Generalized Impulse Responses to a unit domestic price and exchange rate shock to the individual series and to the cointegrating vectors.

**Notes:** The horizon is in months and CV1 and CV2 in figures C and D represent the 2 cointegrating relations PPP and UIP respectively.

The last two figures C and D show the effects on the two cointegrating vectors (long-run relations) to one standard error shock in the domestic price \( (LBPCPI (p)) \) and exchange rate \( (LBPSAR (e)) \) respectively. The effects of the shocks disappear eventually, but the
speed with which this occurs varies considerably across the different arbitrage conditions depending on the variable shocked. With LBPCPI ($p_i$) the shocks are slowly dissipated and the cointegrating vectors return to their equilibrium values in about 8 years for both the UIP and the PPP arbitrage conditions. However, when the exchange rate (LBPSAR ($e_i$)) is shocked the effect to the cointegrating vectors is different. Whereas the uncovered interest rate parity condition quickly adjusts to its long-run equilibrium in 2 years, the PPP relation returns to equilibrium after about 6 years (72 periods). Response paths for the two, arbitrage conditions also vary when other variables are shocked.

Persistence Profiles

Unlike impulse response functions, persistence profiles measure the time profile of the effect of a system-wide shock on the cointegrating relations. Persistence profiles also have the advantage that they are unique and do not require prior orthogonalization of the shocks. Figure 2 illustrates the persistence profiles.

**Persistence Profile of the effect of a system-wide shock to CV'(s)**

![Persistence Profile](image)

**Figure 2:** Botswana Persistence profiles

**Notes:** The variables in the VAR (2) model are $p_i$, $p_i^*$, $e_i$, $r_i$, and $r_i^*$. The graphs define the long-run relationships in the following manner, the first cointegrating relation CV1 is for the PPP and the second one CV2 is for the UIP. $\beta_{11} = (1, -1, -1, 0, 0)$ and $\beta_{21} = (0, 0, 0, 1, 1)$ are the PPP and UIP vectors respectively. The horizon is one month.
The point estimates in Figure 2 clearly show that the estimated persistence profiles of the PPP condition converge to zero fairly quickly while that of the UIP relation takes much longer. The Persistence profile of the PPP relation overshoots for barely two months then declines to zero moderately fast, totally converging to zero after three years. The convergence of PPP to equilibrium is in sharp contrast to that of the UIP, which takes five years to return to equilibrium.

**Intercontinental Approach**

For the tests for order of VAR both the AIC and SBC selects 2 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Using model (12) defined above, Appendix Table 5, presents cointegration rank statistics defined by the eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 0.05 and 0.10 significance levels reproduced using 2 as order of VAR. Both statistics reject the hypothesis that there is any cointegration relation between the six \( I(1) \) variables under investigation. Since these results are in conflict with the predicted confines of economic theory, that there should be two long run (cointegrating) relations namely the PPP and UIP relations defined as, \( p_t - e_t - p_t^* \) and \( r_t - r_t^* \), respectively, we reject the results of the statistical analysis. No further analysis was attempted because the variables do not move together in the long run (i.e., they are not cointegrated).

One can surmise therefore that the joint PPP and UIP between the US and Botswana does not hold using the data in the present application.

**Country summary and policy recommendations**

Comparing both results for the intra-continental and intercontinental approach, it is recommended that the financial planners in Botswana use South Africa as the foreign country rather than the US when modeling their exchange rate using combined PPP and UIP. This is hardly surprising considering that Botswana and South Africa belong to SACU and have stronger trade links than those between Botswana and the USA. In this application the joint intra-continental PPP and UIP does hold better than the intercontinental
one for which there is no cointegration, a conclusion in agreement with previous empirical studies because of strong trade links and lower transportation costs, a fact which fosters arbitrage in both the goods and capital markets. However when the simple PPP is adopted for exchange rate modeling it does not matter whether the foreign country is SA or USA and in both cases there is cointegration.

Another conclusion is that the simple UIP does not hold both in the cross-national and intercontinental approaches, a conclusion also in line with previous studies. As such there is no merit in using the simple UIP for Botswana exchange rate modeling. It is therefore important that, when the UIP is adopted for exchange rate determination, it be combined with the PPP.
5.2.2 MAURITIUS

- Simple PPP and UIP, and Joint PPP and UIP

Intra-continental and International Approaches

Results for cointegration tests both for the simple PPP and UIP as well as the combined model are contained in Appendix Tables 2 to 5. Using the trace and maximum eigenvalue selection criterions, not in one instance was there found to be any cointegration between the variables in either the cross-national or the intercontinental approach. As there was no cointegration at the conventional 95% significance level, no further analysis was attempted.

Country summary and policy recommendations

In the current application the validity of the PPP and UIP both in their simple form and as a joint model was rejected for the intra-continental approach as well as the intercontinental approach. However since the sample period used was very short (compared to that of other countries in the sample) due to data availability dictates, it is not prudent to globally reject the validity of the PPP and UIP in Mauritius outside the current sample. As empirical literature is of the opinion that both the PPP and UIP do not hold in the short run, it is possible that rejection could be attributable to sample period length and, it is therefore recommended that the theories be tested using a different or longer sample period before valid conclusions can be reached. This recommendation, is in line with Juselius (1995)'s reasoning that, failure to find cointegration rank might be due to the fact that the asymptotic critical values (i.e., the trace and maximum eigenvalue statistics) may not be very close approximations in small samples.
5.2.3 NAMIBIA

- Simple PPP and UIP

Intra-Continental Approach

PPP

The simple intra-continental PPP was not tested under this approach because the necessary cointegration requirement that all variables be I (0) was not satisfied (see section 5.1 and Appendix Table I). This is because the Namibian dollar and the South African rand are pegged on a one to one basis and so testing this approach was deemed irrelevant and trivial.

UIP

We use model (13) to test the validity of the simple UIP theory. Using VAR (2), both the maximum eigenvalue and the trace statistic suggest one cointegrating relation at the 95% significance level. In line with theory and setting \( r = 1 \) the estimates of the cointegration coefficients when the vector \( \beta = (r - r^*) \) is normalized on the domestic interest rate (LNTB \((r)\)) coefficient are:

\[
\beta_E = \begin{pmatrix}
  r \\
  1.000 \\
  \text{(none)} \\
  -0.1159 \\
  (0.0065)
\end{pmatrix}
\]

where \( LL = 684.81 \).

As these results lack any meaningful economic interpretation, we further impose the UIP over-identifying restrictions denoting \( \beta_{UIP} = (r - r^* = 1, -1) \). The log-likelihood ratio statistic yielded from these theory restrictions is 15.68, which is significant and exceeds the critical value of the chi-squared distribution with 1 degree of freedom. The theory restrictions are therefore rejected at the conventional 95% significance level indicating that, the cross-national simple UIP does not hold for Namibia in its symmetry and proportionality conditions. However the weak form UIP does hold because the variables move together indicating a long-run relationship.
Intercontinental Approach

For the tests for order of VAR we select 2. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP using order of VAR= 2 are presented in Appendix Table 3.

PPP

Using (13) for testing the PPP proposition, both the Maximum eigenvalue ($\lambda_{\text{max}}$) and the Trace statistics ($\lambda_{\text{trace}}$) suggest $r = 1$. This result is in line with the PPP hypothesis where we expect one cointegrating relation, so we conclude that the intercontinental PPP variables do move together in the long run. However to arrive at definite conclusions regarding the validity of the PPP proposition we apply LRSM to this statistical vector based on the PPP theory symmetry and proportionality restrictions. First, assuming $r = 1$ we present the estimates of the cointegrating coefficients normalized on the coefficient of the domestic price ($\text{LNCPI}_1$). The estimated results obtained using this just-identifying restriction to the cointegration vector denoted by $\beta = (\text{LNCPI}(p), \text{LNER}(e), \text{LUSCPI}(p^*))$ are:

$$
\beta_E = \begin{pmatrix}
p & e & p^* \\
1.000 & -0.1636 & -2.6663 \\
(none) & (0.1343) & (0.6028)
\end{pmatrix}
$$

where $LL = 1319.9$

The vector seems to support the PPP theory as both the domestic exchange rate and the foreign price coefficients have the right signs, but we cannot draw any structural conclusions without testing for the over-identifying theory restrictions. The imposed symmetry and proportionality over-identifying restrictions based on the strict PPP condition where, $\beta_{\text{PPP}} = (p - e - p^*) = (1 - 1 - 1)$ were rejected. The log likelihood ratio (LR) statistic for testing these restrictions was computed to be 24.4, which is higher than the critical value of the chi-square test with two degrees of freedom. Therefore simple PPP in Namibia's case using the current sample data does not hold under the symmetry and proportionality restrictions although the weak form PPP is valid because the variables are cointegrated.
UIP

Using model (13) to test the validity of the simple UIP theory and optimal VAR (2), both the maximum eigenvalue and the trace statistic suggest no cointegrating relation at the 95 percent significance level, indicating that the cross-continental simple UIP does hold in the Namibian case. See Appendix Table 3 for the cointegration results.

- Joint PPP and UIP

Intra-Continental Approach

The validity of the PPP using the intra-continental approach was not tested using data in this application because the Namibia/South Africa exchange rate contained no unit root in its level form or was \( I(0) \). Please see Appendix Table 1 for unit root tests results. Again the reason for the stationarity is because the two currencies are pegged one to one.

Intercontinental Approach

For the order of VAR we select 2. Appendix Table 5, presents Namibia's cointegration rank statistics defined by the eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 0.05 and 0.10 significance levels reproduced using VAR (2) estimated using model (12). Both the \( \lambda_{max} \) and \( \lambda_{trace} \) statistics accept the hypothesis that there is, at most one, cointegration relation between the six \( I(1) \) variables under investigation. Since these results are not in agreement with the predicted confines of economic theory that there should be two long-run (cointegrating) relations, namely the PPP and UIP relations defined as, \( p_t - e_t - p_t^* \) and \( r_t - r_t^* \) respectively; we set aside the results of the statistical analysis and adopt theory restrictions for further analysis. Consequently we proceed as if there are two cointegrating relations. We will however return to analyze the statistical results that \( r = I \) later.

We now examine the validity of the PPP and UIP hypothesis using the long-run structural modeling advanced in Pesaran and Shin (1997). The novel of this approach is that it enables us to test the validity of these hypotheses and to identify factors that could explain the reason(s) for their breakdown. The two cointegrating vectors associated with
$z^*_i = (p_i, e_i, r_i, p^*_i, r^*_i, p_{0i}, t)$ are denoted by \( \beta^*_i = (\beta_{0i1}, \beta_{11i}, \beta_{21i}, \beta_{31i}, \beta_{41i}, \beta_{51i}, \beta_{61i}) \) and \( \beta^*_i = (\beta_{01i}, \beta_{12i}, \beta_{22i}, \beta_{32i}, \beta_{42i}, \beta_{52i}, \beta_{62i}) \) respectively, viewing \( \beta^*_1 \) as explaining domestic prices and \( \beta^*_2 \) domestic interest rate. The first six elements are the coefficients of the \( I(1) \) variables and the last element (i.e., \( \beta_{6i}, i = 1, 2 \)) refers to the time trend. As exact identification of these vectors requires the imposition of two restrictions per vector, the following exactly identifying restrictions are chosen as constraints and do not impose any testable restrictions on the cointegrating VAR model:

$$H_E: \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & * & * \\ 0 & * & 1 & * & * & * & * \end{pmatrix}$$

Which produced the estimate

$$\beta_{*E} = \begin{pmatrix} p & e & r & p^* & r^* & p_{0} & t \\ 1 & -0.4299 & 0 & -1.4462 & -0.0621 & -0.0074 & -0.0082 \\ (0.4438) & (1.7571) & (0.5322) & (0.0624) & (0.0028) \end{pmatrix}$$

$$H_{co}: \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & * & 0 \\ 0 & * & 1 & * & * & * & 0 \end{pmatrix}$$

$$LL_E = 1185.7$$

where, \( LL_E (r = 2) \) is the maximized value of the log likelihood function for the justified case or subject to exactly identifying restrictions. Asymptotic errors are given in parentheses.

We then proceeded to test a number of hypotheses using the above just-identified model as a basic model and imposing over-identifying restrictions. First, since we do not expect these long-run relations to include a linear trend, we first test the co-trending hypothesis \( H_{co} \) namely that, \( \beta_{6i} = \beta_{62} = 0 \) and is represented by:
Under $H_{CO}$ the restrictions were collinear and there was no convergence. Hence the hypothesis that there are no linear trends in the cointegrating relations is rejected. Individual tests of $H_{CO}$ were then undertaken separately for each vector and they produced different results. Whereas the co- trending restrictions were accepted in the second vector standing for the UIP, they were rejected for the PPP or 1st vector. We term this hypothesis $H_{CO}$ for further analysis.

Second the hypothesis implied by the PPP and UIP theories that the level of oil prices do not enter these long-run relationships denoted by $H_{PO}$ is tested and it yields:

\[
\begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 1 & -0.4101 & 0 & -1.4049 & -0.5851 & 0 & 0.0081 \\ 0 & -1.0114 & 1 & -1.1394 & -0.1862 & 0 & 0.0127 \end{pmatrix}
\]

\[
\beta_{PO} = \begin{pmatrix} 0.1716 \\ 0.7772 \\ 0.0278 \\ 0.0028 \end{pmatrix}
\]

\[
LL_{PO} = 1185.5
\]

The LR statistic associated with these 4 over-identifying restrictions is 0.34, and thus does not reject the $H_{PO}$ hypothesis at the 95% significance level. The joint $H_{CO} \cap H_{PO}$ produced the following results:

\[
\begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 1 & 0.4055 & 0 & -1.0177 & 0.5846 & 0 & 0.0088 \\ 0 & -0.8834 & 1 & 4.3711 & -0.1786 & 0 & 0 \end{pmatrix}
\]

\[
\beta_{CO,PO} = \begin{pmatrix} 0.1661 \\ 1.0832 \\ 0.0285 \\ 0.0021 \end{pmatrix}
\]

\[
LL_{CO,PO} = 1184.9
\]

The LR statistic obtained under these 3 over-identifying restrictions is 1.64, and thus do not reject the $H_{CO} \cap H_{PO}$ hypothesis at the 95% critical level. It can also be seen that the value of the trend in the first vector representing the PPP is almost insignificant.
Consequently, tests for the validity of the PPP and UIP propositions are tested given $H_{co} \cap H_{po}$ (only the second vector is co-trended)

Under the UIP hypothesis given $H_{co} \cap H_{po}$:

$$H_{UIP} \quad \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & 0 & * \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \end{pmatrix}$$

the estimate of which is:

$$\beta_{UIP} = \begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 1 & 0.5233 & 0 & -1.2801 & -0.0322 & 0 & 0.0095 \\ (0.1105) & (0.7979) & (0.1672) & (0.0024) \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \end{pmatrix}$$

$L_{UIP} = 1178.3$

The LR statistic obtained under these 6 over-identifying restrictions is 14.78, and thus rejects the UIP hypothesis (given $H_{co} \cap H_{po}$) at the conventional 95% significance level.

Similarly under the PPP hypothesis and $H_{co} \cap H_{po}$ (the PPP vector includes a trend)

$$H_{PPP} \quad \beta_* = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 & * \\ 0 & * & 1 & * & * & 0 & 0 \end{pmatrix}$$

The following estimate was produced.

$$\beta_{PPP} = \begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 1 & -1 & 0 & -1 & 0 & 0 & 0.0009 \\ (none) \\ 0 & -1.3496 & 1 & 6.0285 & -0.2066 & 0 & 0 \\ (1.0610) & (5.2085) & (0.1885) \end{pmatrix}$$
The LR statistic for testing the PPP hypothesis is 32.89, which is highly significant compared to the 0.05 critical value of the Chi-squared distribution with 6 degrees of freedom. Thus the hypothesis of the PPP (jointly with \( H_{o} \cap H_{p0} \)) is rejected at the conventional 95% percent significance level.

Several modifications to the PPP hypothesis (denoted by \( H_{ppp}^{*} \)) that allow for the effect of either domestic interest rate or foreign interest rate or both to be unrestricted were subsequently considered. They were all rejected, as the LR statistics obtained in each case were much higher than the critical value of Chi-squared distribution with \( x \) degrees of freedom.

Finally in our long-run structural modeling, taking the unmodified PPP and UIP (rejected) versions we estimated the cointegrating relations under the PPP and UIP over-identifying restrictions (jointly with \( H_{o} \cap H_{p0} \)):

\[
H_{UIP,PPP}: \beta_{PPP,UIP} = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 \end{pmatrix}
\]

which yields:

\[
\hat{\beta}_{PPP,UIP} = \begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 1 & -1 & 0 & -1 & 0 & 0 & 0.0050 \end{pmatrix} \quad LL = 1168.2
\]

The LR statistic of 35.09 is above the 0.05 critical value of the Chi-squared distribution with 9 degrees of freedom. Thus the joint PPP and UIP theory restrictions considered jointly with \( H_{o} \cap H_{p0} \) is rejected at the 95% significance level despite, there being a cointegration relationship between the variables.
The Vector Error Correction Model

Conditional on the above long-run estimates, we have the following expressions for the error correction terms:

\[ \hat{\beta}_1 z_{t-1} = p_{t-1} - e_{t-1} - p^*_{t-1} + 0.005t, \]

\[ \hat{\beta}_2 z_{t-1} = r_{t-1} - r^*_{t-1}, \]

where \( \hat{\beta}z_{t-1} = \xi \), which are I (0).

To check the resultant model’s statistical adequacy, the following VECM was estimated:

\[ \Delta y_t = c_0 - \alpha_1 y_{t-1} + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_2 \beta z_{t-1} + u_t, \]

where \( \alpha_{1y} \) and \( \alpha_{2y} \) are three dimensional vectors of adjustment (error correction) coefficients associated with the 2 cointegrating relations PPP and UIP respectively. The number of error correction equations in the present application is 3, corresponding to the jointly determined variables of the model namely domestic prices (LZNCPI \( p_t \)), exchange rate (LNER \( e_t \)) and domestic interest rates (LNTB \( r_t \)). The estimates of these adjustment coefficients together with a number of diagnostic test statistics) are presented in Table 4.

The equation for the change in domestic prices (LNCPI \( p_t \)) passes all the diagnostic tests, with the equation also explaining 0.16 of the price variation over the sample period. Its error correction term associated with the first cointegrating relation explaining long-run price movements has the correct sign and is significant but, it is very small indicating an equilibrating but very slow adjustment process for Namibia prices in response to changes in the domestic interest rate and the exchange rate. The change in the domestic interest rate (LNTB \( r_t \)) equation performs the best in terms of the \( R^2 \), explaining 18 percent of interest rate variation over the sample period and passing all diagnostic tests except the functional form tests. However, its error correction terms associated with both cointegrating relations are insignificant, suggesting no response to equilibrium for Namibia’s interest rates in response to the domestic prices and exchange rate movements. Lastly, the error correction
term of the exchange rate (LNER (e)) equation associated with the first cointegration vector representing the PPP that is fairly significant suggesting a slow but moderate response to restore long-run equilibrium once shocked.

The diagnostic statistics of the equations in Table 4 are generally satisfactory as far as the tests of the residual serial correlation, functional form and heteroskedasticity are concerned. However, it is clear from the diagnostic statistics that, the assumption of normally distributed errors is rejected. Generally speaking, therefore, diagnostic tests are satisfactory and the equations appear to capture the time series properties of these two macroeconomic aggregates in Namibia over the sample period.

Table 6:

<p>| Namibia: Reduced Form Estimates of Error Correction Coefficients and Diagnostic Statistics- Intercontinental Approach |</p>
<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_{11}$</th>
<th>$\alpha_{21}$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{FP}(1)$</th>
<th>$\chi^2_{N}(2)$</th>
<th>$\chi^2_{HE}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNCPI($p_t$)</td>
<td>-0.024 (0.006)</td>
<td>-0.003 (0.002)</td>
<td>0.169</td>
<td>19.14 [0.085]</td>
<td>0.069 [0.792]</td>
<td>0.777 [0.678]</td>
<td>4.92 [0.027]</td>
</tr>
<tr>
<td>LNER($e_t$)</td>
<td>0.055 (0.027)</td>
<td>0.005 (0.011)</td>
<td>0.115</td>
<td>9.34 [0.674]</td>
<td>5.78 [0.016]</td>
<td>31.48 [0.000]</td>
<td>1.64</td>
</tr>
<tr>
<td>NTB ($r_t$)</td>
<td>-0.007 (0.007)</td>
<td>-0.002 (0.002)</td>
<td>0.181</td>
<td>9.15 [0.690]</td>
<td>2.72 [0.099]</td>
<td>152.19 [0.000]</td>
<td>0.42 [0.518]</td>
</tr>
</tbody>
</table>

Notes: The ECM results are estimated by OLS based on cointegrating VAR (2). The two error correction terms are given by:

$$\xi_{1, t+1} = p_{t-1} - e_{t-1} - p_{i-1} + 0.005t,$$

$$\xi_{2, t+1} = r_{t-1} - r_{i-1}.$$

The figures in () are estimated asymptotic standard errors whereas those in [] are the corresponding $p$-values. The bold faced estimates, denotes statistical significance at 0.5 level. The diagnostic tests are Chi squared statistics for the following; $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{FP}(1)$ is Ramsey's RESET test statistic, $\chi^2_{N}(2)$ is the Jarque- Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HE}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in () indicates the degrees of freedom.
We now return to consider the estimation results under cointegration rank \( r = 1 \), which is what the statistical results suggested (see Appendix Table 5). For this scenario we express \( z^* = (p, e, r, p^*, r^*, p_o, t) \) by \( \beta^* = (\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7) \). Under the exact-identifying restriction normalized on domestic price (LNCPI \( \langle p \rangle \)) coefficient i.e., \( \beta_1 = 1 \), we obtained the following estimates:

\[
\beta^* = \begin{pmatrix}
1 & 0.4974 & 0.0358 & -1.5497 & 0.0721 & 0.01277 & -0.0087 \\
none & (0.1110) & (0.2119) & (0.8792) & (0.0227) & (0.02233) & (0.0026)
\end{pmatrix}
\]

\[ LL_E = 1178.0 \]

Imposing the restrictions implied by \( H_{po} \) that is \( \beta_6 = 0 \), yields:

\[
\beta_{po}^* = \begin{pmatrix}
1 & 0.5234 & -0.1121 & -1.2772 & 0.0794 & 0 & 0.0095 \\
none & (0.1106) & (0.1748) & (0.8000) & (0.0204) & 0 & (0.0024)
\end{pmatrix}
\]

\[ LL_{po} = 1177.8 \]

The LR statistic for these two restrictions is 0.30, which is below the 95 % critical value of the Chi-squared distribution with 2 degrees of freedom. These restrictions are therefore accepted. While imposing restrictions implied by \( H_{po} \) were accepted, those restrictions implied by the co-trending hypothesis (\( H_{oo} \)) were rejected. This result is similar to the one obtained when \( r = 2 \) and thus the co-trending hypothesis implied by the theories is rejected.

Further, imposing the restrictions that the coefficients of \( e \) and \( p^*_i \) are both equal to \(-1\), namely, \( \beta_2 = \beta_4 = -1 \), as indicated by the PPP hypothesis and setting the coefficients of \( r_t \) and \( r^*_t \) to zero (see below) are strongly rejected. The LR statistic obtained of 22.11 is significantly higher than the 95 % critical value of the chi-squared distribution with 5 degrees of freedom.

\[ H_{ppp} : \quad \beta^* = (1, -1, 0, -1, 0, 0, 0) \]

and it yields:
Consequently a number of modifications to the PPP hypothesis with either the domestic interest rate or the foreign or interest rate or both unrestricted were also rejected.

We also assumed that the single cointegrating relationship in fact represents the UIP hypothesis. Normalizing on the coefficient of \( r \), and estimating the cointegrating relation subject to UIP restrictions (jointly with \( H_{po} \)), namely \( \beta_3 = 1 \), \( \beta_4 = -1 \) and \( \beta_1 = \beta_2 = \beta_4 = \beta_6 = 0 \), and leaving \( \beta_7 \) unrestricted, we obtain:

\[
\hat{\beta}_{UIP} = \begin{pmatrix} 
0 & 0 & 1 & 0 & -1 & 0 & 0.0088 \\
0 & 0 & 1 & 0 & -1 & 0 & (0.0036)
\end{pmatrix}
\]

\( \text{LL}_{UIP} = 1162.9 \)

The LR statistic for testing these five (5) restrictions is equal to 30.15 and therefore strongly rejects the UIP hypothesis if \( r = 1 \). Several other modifications to the UIP hypothesis were attempted but were all strongly rejected.

These results are fairly close to those obtained assuming \( r = 2 \) above where the PPP and UIP theory restrictions of proportionality and symmetry were also rejected. Therefore as far as the tests for the PPP and UIP are concerned the main conclusion does not seem to be affected by assuming the cointegration rank to be \( r = 1 \) or \( r = 2 \).

**Country summary and policy recommendations**

One can surmise that, in the case of Namibia, it would seem that although the variables are cointegrated, the restrictions imposed by symmetry and proportionality conditions for both the PPP and UIP propositions, either when tested in their simple form or when tested together are rejected. Again we are drawn to the conclusions drawn by (Edison et al, 1997) that despite there being significant cointegrating vectors, the symmetry and proportionality conditions are rejected. But without there being any pattern in the coefficients of these
cointegrating vectors, it is accordingly frustrating to attempt to provide an economic theory that could account for the theories' proportionality and symmetry rejections.

However because the price and interest rate differentials and the exchange rates are cointegrated, Namibia can still apply these propositions in their exchange rate modeling.
5.2.4 SOUTH AFRICA

Because if the dual exchange rate regime which South Africa reverted to and from 1979 to 1995 the sample was broken into two parts. First we tested the sub-sample from 1995 to 2001 when the rand exchange rate was unified. We then tested the whole sample. Using the first scenario, we failed to establish any cointegration relationship both for the simple PPP and for the joint UIP and PPP. No further analysis was attempted using the sub-sample and the results were deemed not worth reporting. Only results obtained using the full sample are reported.

- Simple PPP and UIP

Intra-Continental Approach

This approach was not tested for South Africa because it was used as the foreign country for the approach

International Approach

For the order of VAR tests, both the AIC and SBC selects 2 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP and UIP using model (13) and order of VAR (2) together with their associated 90% and 95% critical values are reported in Appendix Table 3.

PPP

Both the maximum eigenvalue ($\lambda_{\text{max}}$) and the trace statistics ($\lambda_{\text{trace}}$) suggest $r = 2$. Although this result is at variance with the PPP hypothesis where we expect one cointegrating relation, because the three PPP variables are cointegrated, we conclude that the intercontinental PPP variables do move together in the long run and so the weak form simple PPP is valid. However, to arrive at definite conclusions on the theory's long-run validity, we apply LRSM to this statistical vector based on the PPP theorem. Assuming $r = I$, which is also in line with the PPP theory, we present the estimates of the cointegrating
coefficients normalized on the coefficient of the domestic price (LSACPI). The estimated results obtained after we impose this just identifying restriction to the vector for $\beta = [\text{LSACPI}(p), \text{LSAER}(e), \text{LUSCPI}(p^*)]$ are:

$$\beta_E = \begin{pmatrix} p & e & p^* \\ 1.000 & 0.1067 & -4.4413 \\ (\text{none}) & (0.1893) & (0.7964) \end{pmatrix}$$

where $LL = 2787.2$

The vector does not seem to support the PPP theory as the domestic exchange rate coefficient has the wrong sign, but we cannot draw any structural conclusions without testing for the over-identified theory restrictions. The imposed symmetry and proportionality over-identifying restrictions based on the PPP theory, where $(p - e - p^*) = (1 - 1 - 1)$ were strongly rejected, as the log likelihood ratio (LR) statistic for testing these restrictions was computed to be 42.51, which is way above the critical value of the chi-square test with two degrees of freedom. One can surmise that the simple PPP in the South African case using the current sample does not hold under the theory symmetry and proportionality restrictions.

**UIP**

Using model (13) and the selected VAR (2), the trace statistic suggests two cointegrating relationships between the two UIP variables (see Appendix Table 3 for results) while the maximum eigenvalue statistic suggests no cointegration relationship at the conventional 95% significance level. In line with theory we set $r = I$. Denoting the UIP vector, $\beta = (\text{LSATB}(r), \text{LUSTB}(r^*))$, the estimates of the cointegration coefficients normalized on the domestic interest rate coefficient are:

$$\beta_E = \begin{pmatrix} r & r^* \\ 1.000 & 3.2439 \\ (\text{none}) & (4.6401) \end{pmatrix}$$

where $LL = 2033.7$

As these results lack any meaningful economic interpretation, we further impose the theory over-identifying UIP theory restrictions denoted by $\beta_{UIP} = (r - r^* = 1 -1)$. The log-likelihood ratio statistic yielded from these theory restrictions is 2.60, which is insignificant and is below the critical value of the chi-squared distribution with 1 degree of freedom.
freedom. The theory restrictions are therefore accepted at the conventional 95% significance level indicating that, the international simple UIP does hold for South Africa.

- Joint PPP and UIP

**Intra-Continental Approach**

The validity of the PPP using the intra-continental approach was not tested using data in this application because South Africa was the numeraire country for this approach.

**Intercontinental Approach**

For the order of VAR we select 2. Using model (12) for testing the validity of the joint PPP and UIP hypothesis, Appendix Table 5, presents cointegration rank statistics defined by the maximum eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 90% and 95% significance levels, reproduced using VAR (2). Both statistics accept the hypothesis that there is, at most one, cointegration relation between the six \( I(1) \) variables under investigation. Since these statistical results are not in agreement with the predicted confines of economic theory that, there should be two long run (cointegrating) relations namely the PPP and UIP arbitrage conditions defined as, \( p_t - e_t - p_t^* \) and \( r_t - r_t^* \), respectively, we adopt theory restrictions for further analysis. Consequently we proceed as if there are two cointegrating relations.

We now examine the validity of the PPP and UIP hypothesis using the long-run structural modeling advanced in Pesaran and Shin (1997). The novelty of this approach is that, it enables us to test the validity of these hypotheses and to identify factors that could explain the reason(s) for their breakdown. The two cointegrating vectors associated with \( z_t^* = (p_t, e_t, r_t, p_t^*, r_t^*, \rho_{0, t}) \) are denoted by \( \beta_1^* = (\beta_{01}, \beta_{11}, \beta_{21}, \beta_{31}, \beta_{41}, \beta_{51}, \beta_{61}) \) and \( \beta_2^* = (\beta_{02}, \beta_{12}, \beta_{22}, \beta_{32}, \beta_{42}, \beta_{52}, \beta_{62}) \) respectively, viewing \( \beta_1^* \) as explaining domestic prices and \( \beta_2^* \) domestic interest rate. The first six elements are the coefficients of the \( I(1) \) variables and the last element (i.e., \( \beta_{6i}, i = 1, 2 \)) refers to the time trend. As exact identification of these vectors requires the imposition of two restrictions per vector, the following exactly identifying restrictions are chosen as constraints and do not impose any testable restrictions on the cointegrating VAR model:
\[
\begin{align*}
\beta_{61} &= 1; \beta_{21} = 0 \\
\beta_{62} &= 0; \beta_{22} = 1
\end{align*}
\]

represented by:

\[
H_E: \quad \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & * & * \\ 0 & * & 1 & * & * & * & * \end{pmatrix}
\]

Which produced the estimate:

\[
\beta_{s,E} = \begin{pmatrix} p & e & r & p^* & r^* & p_0 & t \\ 1 & 0.9956 & 0 & -0.7665 & -0.6608 & 0.2692 & -0.0174 \\ (0.6148) & (1.5350) & (2.4898) & (0.1366) & (0.0105) \\ 0 & -0.1569 & 1 & -1.3538 & -1.4469 & 0.03695 & -0.0056 \\ (0.3167) & 0.8461 & (1.1621) & (0.0638) & (0.0057) \end{pmatrix}
\]

\[
LL_E = 2591.2
\]

where, \( LL_E (r = 2) \) is the maximized value of the log likelihood function for the justified case or subject to exact-identifying restrictions. Asymptotic errors are given in parentheses.

We then proceeded to test a number of hypotheses using the above just-identified model as a basic model and imposing over-identifying restrictions. First, since we do not expect these long-run relations to include a linear trend, we first test the co-trending hypothesis \( H_{co} \), namely that, \( \beta_{61} = \beta_{62} = 0 \) and represented by:

\[
H_{co}: \quad \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & * & 0 \\ 0 & * & 1 & * & * & * & 0 \end{pmatrix}
\]

Under the \( H_{co} \) hypothesis the following estimates we obtained the LR statistic of 13.34, which is well above the 0.05 critical value of the chi-squared (\( \chi^2 \)) distribution with 2
degrees of freedom. Hence the hypothesis that there are no linear trends in the cointegrating relations is rejected.

Second the hypothesis implied by the PPP and UIP theories that the level of oil prices do not enter these long-run relationships denoted by $H_{po}$ is tested. The $H_{po}$ hypothesis restriction is rejected at 95 percent level because the LR statistic obtained was above the 0.05 critical value of the $\chi^2$ distribution, with 2 degrees of freedom. However the hypothesis that only the first cointegration vector representing the PPP does not include oil prices $H_{po}$ is accepted as the LR statistic obtained of 1.05 is lower than the 0.05 critical value of the $\chi^2$ distribution, with 1 degree of freedom. The joint testing of the $H_{po} \cap H_{po}$ hypotheses is also rejected at the 95% significance level as the LR statistic obtained, was above the 0.05 critical value of the $\chi^2$ distribution, with 3 degrees of freedom. We conclude that for South Africa, the joint PPP and UIP cointegration relation contains significant trend coefficients and that the oil price variable for the UIP vector enters the cointegrating relation with a significant coefficient.

Consequently, tests for the validity of the modified PPP and UIP propositions including a trend in both vectors and oil prices in the UIP vector only ($H_{po}$) were carried out.

Under the UIP hypothesis:

$$H_{UIP} \quad \beta_* = \begin{pmatrix} 1 & \ast & 0 & \ast & \ast & 0 & \ast \\ 0 & 0 & 1 & 0 & -1 & \ast & \ast \end{pmatrix}$$

the estimate of which is:

$$\beta_{UIP} = \begin{pmatrix} p & e & r & p^* & r^* & po & t \\ \ast & 0.9110 & 0 & -2.8406 & -1.2693 & 0 & -0.0108 \\ 0 & 0.4440 & 0.8920 & 2.1585 & (0.0043) \\ 0 & 0 & 1 & 0 & -1 & 0.1417 & 0.0004 \\ \ast & (0.0747) & (none) \end{pmatrix}$$
\[ LL_{\text{UIP}} = 2581.4 \]

Again the LR statistic of 19.67 is above the 0.05 critical value of the chi-squared distribution with 4 degrees of freedom. Therefore, the UIP hypothesis considered jointly with \( H_{poe} \), is rejected.

Similarly under the PPP hypothesis given \( H_{poe} \) and represented by:

\[ H_{\text{PPP}} \begin{pmatrix} \beta \end{pmatrix} = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 & 0 \end{pmatrix} \]

The following estimate was produced:

\[
\begin{pmatrix} p & e & r & p' & r' & p_0 & t \\ 1 & -1 & 0 & -1 & 0 & 0 & 0.0095 \\ 0 & 1.0891 & 1 & -1.4031 & -1.9173 & 0.2107 & -0.0106 \\ 0 & 0.6493 & 0.5520 & 1.6811 & 0.1152 & 0.0089 & \end{pmatrix}
\]

\[ LL_{\text{PPP}} = 2586.2 \]

The LR statistic for testing the PPP hypothesis is 10.12, which is significant when compared to the 0.05 critical value of the chi-squared distribution with 4 degrees of freedom (4 is the total number of over-identifying restrictions). Thus the hypothesis of the PPP (jointly with \( H_{poe} \)) is rejected at the 95 percent significance level.

Finally in our long-run structural modeling, taking the unmodified PPP and UIP rejected versions we estimated the cointegrating relations under the PPP and UIP over-identifying restrictions (jointly with \( H_{poe} \));

\[ H_{\text{UIP,PPP}} \begin{pmatrix} \beta \end{pmatrix}_{\text{UIP,PPP}} = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 & 0 \end{pmatrix} \]

which yields;
\[ \hat{\beta}_{PPP,UIP} = \begin{pmatrix} p & e & r & p^* & r^* & p_0 & t \\ 1 & -1 & 0 & -1 & 0 & 0 & 0.0048 \\ 0 & 0 & 1 & 0 & -1 & 1.3359 & 0.0043 \\ \text{(none)} & \text{(none)} & \end{pmatrix} \]

\[ LL_{PPP,UIP} = 2567.2 \]

The LR statistic of 48.02 is above the 0.05 critical value of chi-squared distribution with 7 degrees of freedom. Thus the joint PPP and UIP hypothesis restrictions, considered jointly with H_{po*} are rejected at the 95% significance level.

**The Vector Error Correction Model**

Conditional on the above long-run estimates, we have the following expressions for the error correction terms:

\[ \hat{\beta}_1 z_{t-1} = p_{t-1} - e_{t-1} - p_{t-1}^* + 0.0048 t, \]

\[ \hat{\beta}_2 z_{t-1} = r_{t-1} - r_{t-1}^* + 1.3359 p_0 + 0.43 t. \]

where \( \hat{\beta}_{z_{t-1}} = \xi_t \), which are I (0).

To check the resultant model's statistical adequacy, the following VECM was estimated:

\[ \Delta y_t = c_0 - \alpha_{y} \beta y_t + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_{y} \beta z_{t-1} + u_t, \]

\[ = c_0 - \alpha_{y} \beta y_t + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_{y} \beta z_{t-1} + a_{2y} \beta_2 z_{t-1} + u_t, \]

where \( \alpha_{y} \) and \( \alpha_{2y} \) are three dimensional vectors of adjustment (error correction) coefficients. The number of error correction equations in the present application is 3, corresponding to the jointly determined variables of the model namely domestic prices (LSACPI \((p_y)\)), exchange rate (LSAER \((e)\)) and domestic interest rates (LSATB \((r)\)). The estimates of these adjustment-coefficients together with a number of diagnostic test statistics are presented in Table 5 below.
Table 7:

South Africa: Estimates of Error Correction Coefficients and Diagnostic Statistics - Intercontinental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_{c1}$</th>
<th>$\alpha_{c2}$</th>
<th>$R^2$</th>
<th>$\chi_{SC}^2(12)$</th>
<th>$\chi^{2}_{EP}(1)$</th>
<th>$\chi^{2}_{J}(2)$</th>
<th>$\chi^{2}_{HE}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$LSACPI($p$)</td>
<td>-0.007</td>
<td>-0.000</td>
<td>0.289</td>
<td>16.99</td>
<td>6.40</td>
<td>125.59</td>
<td>13.34</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.000)</td>
<td></td>
<td>[0.150]</td>
<td>[0.011]</td>
<td>[0.000]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>$\Delta$LSAER($e$)</td>
<td>-0.005</td>
<td>0.005</td>
<td>0.038</td>
<td>25.25</td>
<td>0.30</td>
<td>871.44</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.006)</td>
<td></td>
<td>[0.014]</td>
<td>[0.579]</td>
<td>[0.00]</td>
<td>[0.414]</td>
</tr>
<tr>
<td>$\Delta$LSATB ($r$)</td>
<td>0.0020</td>
<td>-0.000</td>
<td>0.174</td>
<td>23.66</td>
<td>1.71</td>
<td>178.77</td>
<td>60.89</td>
</tr>
<tr>
<td></td>
<td>(0.0014)</td>
<td>(0.000)</td>
<td></td>
<td>[0.023]</td>
<td>[0.190]</td>
<td>[0.00]</td>
<td>[0.00]</td>
</tr>
</tbody>
</table>

Notes: The ECM results are estimated by OLS based on cointegrating VAR (2). The two error correction terms are given by:

$$\xi_{c1,t} = p_{t-1} - e_{t-1} - p^*_{t-1} + 0.0048t,$$

$$\xi_{c2,t} = r_{t-1} - r^*_{t-1} + 1.3359r_{o} + 0.43t.$$  

The figures in (,) are estimated asymptotic standard errors whereas those in [.] are the corresponding p-values. The bold faced estimates denote statistical significance at the 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi_{SC}^2(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi_{EP}^2(1)$ is Ramsey’s RESET test statistic, $\chi_{J}^2(2)$ is the Jarque- Bera statistic for testing the null of Gaussian errors, and $\chi_{HE}^2(1)$ is the statistic for testing the null of no heteroskedasticity. The number in (,) indicates the degrees of freedom.

The equation for the change in domestic prices (LSACPI ($p$)) passes the serial correlation and functional form diagnostic tests, with the equation also explaining 0.28 of the price variation over the sample period. Its error correction terms associated with the first cointegrating relation has the correct sign and is insignificant, but is tiny suggesting very slow response to restore long-term equilibrium once shocked. In terms of $R^2$ the equation for domestic interest rates (LSATB ($r$)) performs the best, explaining 18 percent of interest rate variation over the sample period and passing all diagnostic tests except the functional form tests. However, its error correction terms associated with the both cointegrating relations are also insignificant, suggesting no response to equilibrium for South Africa’s interest rates in response to the domestic prices and exchange rate.
movements. The error correction terms for the exchange rate equation (LSAER(eJ)) are also insignificant and fail all diagnostic tests except the functional form test denoting the exogeneity of exchange rates. These VECM results seem to indicate that shocks to the system tend to take very long to dissipate and for equilibrium to be restored.

Country summary and policy recommendations

For South Africa the results for the simple UIP are exciting and the use of UIP in their exchange rate modeling is recommended. Results for the joint UIP and PPP hypothesis are slightly different in that although the variables are cointegrated, the restrictions imposed by symmetry and proportionality conditions for both the PPP and UIP propositions are rejected. As observed for most of the sample countries, one is drawn to the conclusions drawn by (Edison et al, 1997) that despite, there being significant cointegrating vectors, the symmetry and proportionality conditions are rejected. But without there being any pattern in the coefficients of these cointegrating vectors, it is accordingly frustrating to attempt to provide an economic theory that could account for the theories’ proportionality and symmetry rejections.

Also worth pointing out is the observation that for South Africa, the joint PPP and UIP hypothesis enters cointegration with a significant trend and that the oil price variable for the UIP vector enters the cointegration relation with a significant coefficient. This attests to the effect that the oil price plays a significant factor in the South African economy, as the country is a major oil importer.
5.2.5 SWAZILAND

- Simple PPP and UIP

Intra-Continental Approach

PPP
The validity of the PPP using the intra-continental approach was not tested using data in this application, because the Swaziland/South Africa exchange rate was found to be $I (0)$ (see Appendix Table 1). As is the case for Namibia the reasons for the stationarity is because the currencies are pegged on a one to one basis.

UIP
With the simple UIP, using model (13) and optimal VAR (2), both the maximum eigenvalue and the trace statistic suggest one cointegrating relation at the 95 percent significance level. In line with theory and setting $r = I$ the estimates of the cointegration coefficients normalized on the domestic interest rate coefficient for the vector $\beta = (\text{LSWDR} (r), \text{LSATB} (r^*))$ are:

$$\beta = \begin{bmatrix} r & r^* \\ 1.000 & -0.8819 \\ \text{(none)} & \text{(0.0065)} \end{bmatrix}$$

where $LL = 2016.5$

As these results lack any meaningful economic interpretation if theory restrictions are not imposed, we further impose the UIP theory over-identifying restrictions namely $\beta_\text{UIP} = (r - r^* = 1 -1)$. The log-likelihood ratio test yielded from these theory restrictions is 0.34, which is insignificant and less than the critical value of the chi-squared distribution with 1 degree of freedom. The theory restrictions are therefore accepted at the conventional 95% significance level indicating that, the cross-national simple UIP does hold for Swaziland. As is the case with Namibia this result is expected because South Africa and Swaziland both belong to SACU, their currencies are pegged one to one and they have strong economic and financial ties.
Intercontinental Approach

For the tests for order of VAR both the AIC selects 2 for order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP using order of VAR (2) are presented in Appendix Table 3.

PPP

Using model (13), for the PPP both $\lambda_{\text{max}}$ and $\lambda_{\text{trace}}$ suggests $r = 1$. This result is in agreement with the PPP hypothesis where we expect one cointegrating relation hence we conclude that the intercontinental PPP variables move together in the long run. However to arrive at definite economic conclusions on the validity of the PPP, we apply LRSM to this statistical vector based on economic theory. Adopting the statistical result $r = 1$, which is also in line with the PPP theory, we present the estimates of the cointegrating coefficients normalized on the coefficient of the domestic price (LSWCP). The estimated results from this just identifying restriction to the vector for $\beta = \{(LSWCP(p), LSWER(e), LUSCPI(p^*))$ are:

$$
\beta_E = \begin{pmatrix} p & e & p^* \\ 1.000 & -0.2420 & -2.8342 \\ (\text{none}) & (0.0686) & (0.1987) \end{pmatrix} \quad \text{where LL = 2307.8}
$$

The vector does seem to be compatible with the PPP theory as both the domestic exchange rate and foreign price coefficients have the expected signs, but we cannot draw any structural conclusions without testing for the over-identified theory restrictions. The imposed symmetry and proportionality over-identifying restrictions based on the PPP theory where, $\beta_{PPP} = (p - e - p^*) = (1 - 1 - 1)$ were rejected because the log likelihood ratio (LR) for testing these restrictions was computed to be 38.38, which is way higher than the critical value of chi-square test with two degrees of freedom. The simple PPP in the Swaziland case using the current data sample therefore does not hold under the symmetry and proportionality restrictions even though the PPP variables are cointegrated.
UIP

Using the vectorial process (13), the UIP between Swaziland and the US is rejected, as there is no cointegration between Swaziland interest rates and the US treasury-bill rates.

- Joint PPP and UIP

Intra-continental Approach

The validity of the PPP using the intra-continental approach was not tested using data in this application because the Swaziland/South Africa exchange rate contained no unit root in its level form or was $I(0)$. It was therefore deemed trivial to run statistical tests using this approach.

Intercontinental Approach

For the tests for order of VAR both the AIC and SBC selects 2 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Using (12) we ran the cointegration tests for the joint PPP and UIP hypothesis. Appendix Table 5, presents Swaziland's cointegration rank statistics defined by the eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 0.05 and 0.10 significance levels reproduced using 2 as order of VAR. Both statistics accept the hypothesis that there is, at most one, cointegration relation between the six $I(1)$ variables under investigation. Since these results are not in agreement with the predicted confines of economic theory that there should be two long run (cointegrating) relations, namely the PPP and UIP relations defined as, $p_t - e_t - p_t^*$ and $r_t - r_t^*$ respectively; we set aside the results of the statistical analysis and adopt theory restrictions for further analysis. Consequently we proceed as if there are two cointegrating relations. We will however return to analyze the statistical results that $r = 1$ later.

We now examine the validity of the PPP and UIP hypothesis using the long-run structural modeling advanced in Pesaran and Shin (1997). The beauty of this approach is that it enables us to test the validity of these hypotheses as well as identify factors that might be responsible for their breakdown. The two cointegrating vectors associated with
$z_t^* = \begin{pmatrix} p_1, e_1, r_1, p_1^*, r_1^*, p_0, t \end{pmatrix}$ are denoted by $\beta_1^* = \begin{pmatrix} \beta_{01}, \beta_{11}, \beta_{21}, \beta_{31}, \beta_{41}, \beta_{51}, \beta_{61}^* \end{pmatrix}$ and $\beta_2^* = \begin{pmatrix} \beta_{02}, \beta_{12}, \beta_{22}, \beta_{32}, \beta_{42}, \beta_{52}, \beta_{62}^* \end{pmatrix}$ respectively, viewing $\beta_1^*$ as explaining domestic prices and $\beta_2^*$ domestic interest rate. The first six elements are the coefficients of the I(1) variables and the last element (i.e., $\beta_{6i}$, $i = 1, 2$) refers to the time trend. As exact identification of these vectors requires the impositions of two restrictions per vector, the following exactly identifying restrictions are chosen as constraints and do not impose any testable restrictions on the cointegrating VAR model:

$$H_0: \quad \beta^* = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Which produced the estimate:

$$\beta_{011}^* = \begin{pmatrix} \begin{pmatrix} p \\ e \\ r \\ p^* \\ r^* \\ p_0 \\ t \end{pmatrix} \\ \begin{pmatrix} 1 \\ -0.8876 \\ 0 \\ 0.7113 \\ 7.0311 \\ -0.1486 \\ -0.0034 \\ (0.6388) \\ (1.7140) \\ (5.2726) \\ (0.2215) \\ (0.0013) \\ 0 \\ 0.4177 \\ 1 \\ -1.2823 \\ -3.7461 \\ -0.1212 \\ -0.0001 \\ (0.3674) \\ (0.9767) \\ (3.0160) \\ (0.1258) \\ (0.0013) \end{pmatrix} \end{pmatrix}$$

$LLE = 2103.0$

where $LLE$ ( $r = 2$) is the maximized value of the log likelihood function for the justified case or subject to exactly identifying restrictions. Asymptotic errors are given in parentheses.

We then proceeded to test a number of hypotheses using the above just-identified model as a basic model and imposing over-identifying restrictions. First, since we do not expect these long-run relations to include a linear trend, we first test the co-trending hypothesis $H_{co}$, namely that, $\beta_{01} = \beta_{02} = 0$ and is represented by:

$$H_{co}: \quad \beta^* = \begin{pmatrix} \begin{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \\ 0 \end{pmatrix} \end{pmatrix}$$

Under $H_{co}$ the following estimates were obtained:
The log-likelihood ratio (LR) statistic for testing the two, over-identifying restrictions for co-trending is computed to be 4.35 \sim 2(2103.0 - 2100.8), which is below the 0.05 critical value of the chi-squared ($\chi^2$) distribution with 2 degrees of freedom. Hence the hypothesis that there are no linear trends in the cointegrating relations is not rejected although there was a linear trend in the underlying VAR model.

Second the hypothesis implied by the PPP and UIP theories that the level of, oil price do not enter these long-run relationships denoted by $H_{po}$ is tested. To conserve space, only the results of this hypothesis combined with the co-trending hypothesis, $H_{co} \cap H_{po}$ is reported and, it yields

$$
\begin{pmatrix}
p & e & r & p^* & r^* & p_{co} & t \\ 1 & -1.1256 & 0 & 0.2735 & 6.9739 & 0 & 0 \\
(0.44.2) & (1.3386) & (3.5757) &
\end{pmatrix}
$$

$LL_{co,po} = 2099.4$

The LR statistic associated with these 4 over-identifying restrictions is 7.11, and thus does not reject the $H_{co} \cap H_{po}$ hypothesis at the conventional 95 percent level. Individual tests of $H_{po}$ undertaken separately from $H_{co}$ also produced similar results. Consequently, tests for the validity of the PPP and UIP propositions are tested, given $H_{co} \cap H_{po}$.

Under the UIP hypothesis, given $H_{co} \cap H_{p}$ we have:
\[ H_{UIP} : \beta_s = \begin{pmatrix} 1 & * & 0 & * & * & 0 & 0 \\ 0 & 1 & 0 & * & -1 & 0 & 0 \end{pmatrix} \]

the estimate of which is:

\[
\beta_{UIP} = \begin{pmatrix} p & e & r & p^* & r^* & p_o & t \\ 1 & -0.9374 & 0 & -0.3219 & 6.3934 & 0 & 0 \\ (0.3453) & (1.0662) & (2.7703) & \end{pmatrix}
\]

\[ LL_{UIP} = 2095.9 \]

Again the LR statistic of 14.1 is equal to the 0.05 critical value of the chi-squared distribution with 7 degrees of freedom. Therefore, the UIP hypothesis considered jointly with \( H_{co} \cap H_{po} \), is marginally accepted.

Similarly under the PPP hypothesis and \( H_{co} \cap H_{po} \) represented by:

\[ H_{PPP} : \beta_s = \begin{pmatrix} 1 & * & -1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 1 & * & * & 0 & 0 & 0 \end{pmatrix} \]

The following estimate was produced:

\[
\beta_{PPP} = \begin{pmatrix} p & e & r & p^* & r^* & p_o & t \\ 1 & -1 & 0 & -1 & 0 & 0 & 0 \\ 0 & -0.1768 & 1 & -0.4293 & -0.6049 & 0 & 0 \\ (-0.0811) & (0.1333) & (NONE) \end{pmatrix}
\]

\[ LL_{PPP} = 2088.8 \]
The LR statistic for testing the PPP hypothesis is 28.24, which is highly significant compared to the 0.05 critical value of the chi-squared distribution with 7 degrees of freedom (7 is the total number of over-identifying restrictions). Thus the hypothesis of the PPP (jointly with \( H_{c0} \cap H_{p0} \)) is rejected at the 95% significance level.

We subsequently considered several modifications to the PPP hypothesis (denoted by \( H_{ppp*} \)) that allow for the effect of either domestic interest rate or foreign interest rate or both on the real exchange rate to be unrestricted respectively. The following are the restrictions and results:

i) unrestricted foreign interest:

\[
H_{ppp*} \quad \beta_* = \left( \begin{array}{cccccc}
1 & -1 & 0 & -1 & * & 0 \\
0 & * & 1 & * & * & 0 \\
\end{array} \right)
\]

which yields

\[
\beta_{*,ppp*} = \left( \begin{array}{ccccccc}
p & e & r & p^* & r^* & p_o & t \\
1 & -1 & 0 & -1 & 2.0928 & 0 & 0 \\
0 & 0.1743 & 1 & -0.4477 & -1.0119 & 0 & 0 \\
\end{array} \right)
\]

\( r_e = (2.9205) \)

\( r_{p*} = (0.08532) \)

\( r_{r^*} = (0.1419) \)

\( r_{p_o} = (0.2790) \)

\( \text{LL}_{ppp*} = 2089.2 \)

The LR statistic for testing \( H_{ppp*} \) with unrestricted foreign interest rate is 27.52, which is well above the 0.05 critical value of the \( \chi^2 \) with 6 degrees of freedom hence this modified PPP version is rejected. Modified PPP versions where the domestic interest rate and both the domestic and foreign interest rates are unrestricted are also rejected at the conventional 95% significance level.

Taking the unmodified PPP, but rejected version and the marginally accepted UIP we finally estimated the cointegrating relations under the PPP and UIP over-identifying restrictions (jointly with \( H_{c0} \cap H_{p0} \)), represented by:
The LR statistic of 34.74 is above the 0.05 critical value of the chi-squared distribution with 10 degrees of freedom. Thus the PPP and UIP hypothesis considered jointly with $H_{co}$ \cap $H_{po}$ is rejected at the 95% significance level. We however adopt these theory restrictions for the analysis of the short run dynamics of the model.

The Vector Error Correction Model

Conditional on the above long-run (rejected) theory restrictions, we have the following expressions for the error correction terms:

$$\hat{\beta}_1 z_{t-1} = r_{t-1} - e_{t-1} - p_{t-1},$$

$$\hat{\beta}_2 z_{t-1} = r_{t-1} - r_{t-1}^{*},$$

where $\hat{\beta}_1 z_{t-1} = \xi_t$, which are I (0).

To check the resultant model’s statistical adequacy the following VECM was estimated:

$$\Delta y_t = c_0 - \alpha_1 \beta y_t + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_1 \beta z_{t-1} + u_t$$

$$= c_0 - \alpha_1 \beta y_t + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_1 \beta z_{t-1} + \alpha_2 v y_{t-1} + u_t$$

where $\alpha_1$ and $\alpha_2$ are three dimensional vectors of adjustment (error correction) coefficients. The number of error correction equations in the present application is 3, corresponding to the jointly determined variables of the model namely domestic prices (LSWCP (p)), exchange rate (LSWER (e)) and domestic interest rates (LSWDR (r)).

The estimates of these adjustment coefficients together with a number of diagnostic test statistics are presented in Table 6, below.
Table 8: Estimates of Error Correction Coefficients and Diagnostic Statistics—Intercontinental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>$c_{1y}$</th>
<th>$c_{2y}$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{J}(1)$</th>
<th>$\chi^2_{H}(2)$</th>
<th>$\chi^2_{HR}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$LSWCPI($p_t$)</td>
<td>-0.124</td>
<td>-0.065</td>
<td>0.065</td>
<td>20.13</td>
<td>0.02</td>
<td>2893.8</td>
<td>4.76</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.058)</td>
<td></td>
<td>[0.065]</td>
<td>[0.888]</td>
<td>[0.000]</td>
<td>[0.029]</td>
</tr>
<tr>
<td>$\Delta$LSWER($e_t$)</td>
<td>0.048</td>
<td>0.184</td>
<td>0.042</td>
<td>28.74</td>
<td>1.96</td>
<td>744.31</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.085)</td>
<td></td>
<td>[0.004]</td>
<td>[0.161]</td>
<td>[0.000]</td>
<td>[0.245]</td>
</tr>
<tr>
<td>$\Delta$LSWDR($r_t$)</td>
<td>-0.005</td>
<td>-0.022</td>
<td>0.150</td>
<td>14.01</td>
<td>5.24</td>
<td>723.82</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.011)</td>
<td></td>
<td>[0.300]</td>
<td>[0.022]</td>
<td>[0.000]</td>
<td>[0.479]</td>
</tr>
</tbody>
</table>

Notes: The ECM results are estimated by OLS based on cointegrating VAR (2). The two error correction terms are given by:

$$\xi_{t+1} = p_{t+1} - e_{t+1} - p^*_{t+1},$$

$$\xi_{t+1} = r_{t+1} - r^*_{t+1}.$$  

The figures in (.) are estimated asymptotic standard errors whereas those in [.] are the corresponding p-values. The bold faced estimates denote statistical significance at the 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{J}(1)$ is Ramsey’s RESET test statistic, $\chi^2_{H}(2)$ is the Jarque-Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HR}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in (.) indicates the degrees of freedom.

The equation for the change in domestic price equation (LSWCPI ($p_t$)) passes the serial correlation and functional form diagnostic tests, but marginally fails the heteroskedasticity test and the normality test and only explains 0.06 of the price variation over the sample period. However, the error correction term associated with the first cointegrating relation explaining long-run price movements (or PPP), has the correct sign and is highly significant, suggesting a moderately high speed of convergence to equilibrium for Swaziland prices in response to the domestic interest rate and the exchange rate movements. Hence the domestic price variable is endogenous.

The change in the domestic interest rate equation (LSWDR ($r_t$)), performs the best explaining 0.15 of the price variation over the sample period and passing all diagnostic
tests except the normality test. However, the error correction term associated with the interest rate although it has the correct sign and is statistically insignificant is very small suggesting a crawling speed of convergence back to equilibrium once shocked. Both error correction coefficients for the exchange rate (LSWER (e)) equation associated with the two cointegrating relations are highly significant and moderately large suggesting a moderate speed for the equation to return to its equilibrium once it has been shocked. The larger the error correction coefficient (in absolute value) the faster is the system or economy’s return to its equilibrium, once shocked. The result also indicates that the exchange rate is relatively endogenous, that is, Granger causality moves from domestic prices to the exchange rate.

Generally, the diagnostic tests for all variables are satisfactory as far as tests for serial correlation, heteroskedasticity and functional form are concerned, but the assumption of normally distributed errors is rejected in all the error correction equations. The equation for the change in exchange rate (LSWER (e)) also suffers from serial correlation.

We now return to consider the estimation results under cointegration rank $r = 1$, which is what the statistical results suggested (see Appendix Table 5). For this scenario we express $z_t = (p_t, e_t, r_t, p_t^*, r_t^*, p_o t)$ by $\beta_* = (\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7)$. Under the exact-identifying normalization restriction domestic price (LSWCPI) is equal to one i.e., $\beta_1 = 1$, we obtained the following estimates:

$$
\beta_{eE} = \begin{pmatrix}
1 & -0.8293 & 0.1394 & 0.5325 & 6.5086 & -0.1317 & -0.0034 \\
(0.5917) & (1.3076) & (1.7773) & (5.2817) & (0.2053) & (0.0022)
\end{pmatrix}
$$

$$LL_{E} = 2092.5$$

Imposing the restrictions implied by $H_{co} \cap H_{po}$ yields:

$$
\beta_{co,po} = \begin{pmatrix}
1 & -1.1342 & 0.0436 & 0.3008 & -7.0458 & 0 & 0 \\
(0.5442) & (1.8431) & (1.6987) & (4.5951) & 0 & 0
\end{pmatrix}
$$

$$LL_{co,po} = 2090.8$$
The LR for these two restrictions is 3.44, which is below the 95 percent critical value of the chi-squared distribution with 2 degrees of freedom. These restrictions are therefore accepted. Further, imposing the restrictions that the coefficients of \( e \) and \( p^* \) namely, \( \beta_2 \) and \( \beta_4 \) are both equal to -1 and \( \beta_3 \) and \( \beta_5 \) are equal to zero, as indicated by the PPP hypothesis, are strongly rejected. So are modified PPP restrictions where in addition to the PPP over-identifying restrictions (combined with \( H_{00} \cap H_{po} \)) either the domestic interest rate or the foreign interest rate is unrestricted. Modifications where both domestic and foreign interest rates are unrestricted are also rejected at the conventional 95% significance level.

We also assumed that the single cointegrating relationship in fact represents the UIP hypothesis. Normalizing on the coefficient of \( r \) and estimating the cointegrating relation subject to UIP restrictions (jointly with \( H_{00} \cap H_{po} \)), namely \( \beta_3 = 1 \) and \( \beta_1 = \beta_2 = \beta_4 = \beta_{77} = 0 \), we obtain:

\[
\hat{\beta}_{UIP} = \begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \end{pmatrix} \quad \text{LL}_{UIP} = 2078.2
\]

The LR statistic for testing these six (6) restrictions is equal to 28.78 and therefore strongly rejects the UIP hypothesis if \( r = 1 \). Further modifications of the UIP hypothesis were also tested but, were all rejected.

One can conclude that as far as tests of the PPP hypothesis are concerned, the main conclusion would seem unaffected regardless of whether one assumes the cointegration rank to be \( r = 1 \) or \( r = 2 \). With both \( r = 1 \) and \( r = 2 \), the modified versions of the PPP are all rejected. However with the UIP when \( r = 2 \) the UIP hypothesis, given \( H_{00} \cap H_{po} \) is marginally accepted and one can conclude that the UIP hypothesis appear to be compatible with the data when \( r = 2 \) and not where \( r = 1 \). This conclusion, agree with the results from the simple UIP tests where the theory restrictions are accepted.
Country Summary and Policy Recommendations

From the results obtained from this application, it is recommended that the fiscal planners for Swaziland, adopt either the simple intra-continental UIP in their exchange rate modeling, because in what is a rare phenomenon in the UIP empirical literature, the UIP proposition is valid for Swaziland, in its symmetry conditions. However, it must be pointed out that this result could be biased because of the Common Monetary Area (formerly Rand Monetary Area. The Common Monetary Area is made up of South Africa, Swaziland, Lesotho and Namibia all who use the rand as a legal tender. As such their interest rates are likely to move together.

Swaziland monetary authorities could also use the joint UIP and PPP model as the UIP also holds in the intercontinental case when the joint PPP and UIP are tested. The PPP however does not seem to hold in its proportionality and symmetry conditions using the current data sample as the theory restrictions are rejected. The variables however, do move together in the long run because they are cointegrated.
5.2.6 TANZANIA

- Simple PPP and UIP

Intra-Continental Approach

The tests for order of VAR, selects 2 for both the PPP and UIP. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. We use VAR order of 2 for the cointegration tests. Cointegration results for simple PPP using and UIP using selected order of VAR (2) are presented in Appendix Table 2.

PPP

Using (13) to test the PPP theory, the maximum eigenvalue ($\lambda_{max}$) trace statistics ($\lambda_{max}$) suggest $r = 2$ and the trace statistics suggests $r = 1$. However, according to the PPP theory we only expect one cointegration relationship and so this finding of more than one cointegrating vector tends to complicate the interpretation of results as it may not be possible to identify the structural relationship without carrying out further tests. Assuming $r = 1$ in line with the PPP theory, under proportionality and symmetry, the coefficients of the cointegrating vector representing the PPP should satisfy $\beta = (p - e - p^* = 1 - 1 - 1)$ when the coefficient on the domestic price has been normalized to one. Imposing the exact identifying restriction $p = 1$ to the vector $\beta = (\text{LT CPI} (p), \text{LT SSAR} (e), \text{LS ACPI} (p^*))$ yields:

$$\beta_E = \begin{pmatrix} p \\ e \\ p^* \end{pmatrix} = \begin{pmatrix} 1.000 \\ -3.6013 \\ -6.7592 \end{pmatrix}$$

$$\begin{pmatrix} (none) \\ (3.6829) \\ (5.5288) \end{pmatrix}$$

where the log likelihood function for the just identifying restrictions = 2675.9.

The result shows that, although the vector does support the PPP theory in the sense that both the foreign price coefficient and the exchange rate coefficients have the right sign, but the symmetry and proportionality conditions are not met. Over-identifying restrictions were then imposed based on the PPP theory namely, $\beta_{\text{PPP}} = (p - e - p^*) = (1 - 1 - 1)$. These
over-identifying restrictions were subsequently rejected as the log likelihood ratio (LR) for testing these restrictions was computed to be 8.34, which is higher than the critical value of the chi-square test with two degrees of freedom. The symmetry and proportionality restrictions are thus rejected at the conventional 95% significance level.

UIP

Using equation (13), all cointegration test statistics unanimously rejected the simple UIP indicating that, there is no long-run equilibrium relationship between domestic interest (LTDR(r)) rates and foreign interest rates (LSATB (r*)).

Intercontinental Approach

For the tests for order of VAR both the AIC and SBC select 3 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP and UIP basing our analysis on (13) and using order of VAR (3) are presented in Appendix Table 2.

PPP

For the PPP both the maximum eigenvalue (\( \lambda_{max} \)) and the trace statistics (\( \lambda_{trace} \)) suggest \( r = 2 \). This result is not in line with the PPP hypothesis where we expect one cointegrating relation. However since the three PPP variables are cointegrated, we conclude that the weak form intercontinental holds because the PPP variables do move together in the long-run. Consequently, in order to arrive at definite conclusions on the proposition's validity, we apply LRSM to this statistical vector based on economic theory. Assuming \( r = 1 \), which is also in line with the PPP theory, we present the estimates of the cointegrating coefficients normalized on the coefficient of the domestic price (LTCPI(p)). The results obtained from this just-identifying restriction to the PPP vector represented by, \( \beta = (\text{LTCPI}(p), \text{LTER}(e), \text{LUSCPI}(p^*)) \) are:

\[
\beta_E = \begin{pmatrix}
    p & e & p^* \\
    1.000 & 0.8963 & -2.9001 \\
    (\text{none}) & (1.7922) & (0.3313)
\end{pmatrix}
\]

where LL = 873.05
The vector does not seem to support the PPP theory as the domestic exchange rate coefficient has the wrong sign, but we cannot draw any structural conclusions on the validity of the proposition without testing for the over-identified theory restrictions. The imposed symmetry and proportionality over-identifying restrictions based on the PPP theory namely: \( \text{PPP} = (p - e - p^*) = (1 - 1 - 1) \) were accepted as the log likelihood ratio (LR) statistic for testing these restrictions was computed to be 2.59, which is below the critical value of the chi-square test with two degrees of freedom. The simple PPP in the Tanzanian case using the current sample therefore holds under the symmetry and proportionality restrictions.

**UIP**

The UIP between Tanzania and the US is rejected, as there is no cointegration between Tanzania and US interest rates.

- **Joint PPP and UIP**

**Intra-continental Approach**

For estimation purposes we base our analysis on model (11). Using the optimal VAR (2), both the maximum eigenvalue and trace statistics suggest \( r = 1 \) at the 95% critical value. The hypothesis of no cointegration (namely \( r = 0 \)) is rejected against null hypothesis that there exists one cointegrating relation (namely \( r = 1 \)) but the hypothesis that \( r = 1 \) cannot be rejected against \( r = 2 \) at the 95% significance level. The Akaike information criterion (AIC), and the Hannan-Quinn Criterion (HQC) also unanimously selects \( r = 3 \), while the Schwarz Bayesian Criterion (SBC) suggest \( r = 1 \). Considering these statistical results there is some ambiguity in choosing the number of cointegrating relationships among the five \( I(1) \) variables. However the long-run economic theory states that based on arbitrage in the commodity and capital markets, we should expect two cointegrating relations (i.e., \( r = 2 \)): the PPP relation

\[ p_t - e_t - p_t^* \sim I(0) \]

and the interest-rate arbitrage relation (which is the long-run implication of the uncovered interest parity hypothesis)

\[ r_t - r_t^* \sim I(0) \]
Also according to Pesaran and Smith (1999), any empirical analysis involves balancing, consideration of purpose (the relevance of the model and its intended use), theory, and statistical adequacy. They further demonstrate that, in the case of choosing the number of cointegration relations this balancing act can be particularly difficult, because not only are there usually a large number of choices required to establish a specification but, also because statistical criteria may not be very informative about these choices. Using this line of argument, in this application it was deemed proper and in conformity with economic theory to set \( r = 2 \) for the purposes of further analysis.

Using Long-run structural modeling (Pesaran and Shin, 1997) we first obtain estimates of the cointegrating coefficients (together with their asymptotic standard errors) normalized on the following identifying restrictions:

\[
\begin{align*}
\beta_{11} &= 1, \beta_{13} = 0 \\
\beta_{21} &= 0, \beta_{23} = 1
\end{align*}
\]

where we have denoted the two cointegrating vectors associated with coefficients of

\[
X_t = [p_t, e_t, r_t, \hat{p}_t, \hat{r}_t]
\]

by \( \beta_1 = (\beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}) \), \( \beta_2 = (\beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25}) \), yielding (asymptotic standard errors are in brackets):

<table>
<thead>
<tr>
<th>Vector</th>
<th>( p )</th>
<th>( e )</th>
<th>( r )</th>
<th>( \hat{p} )</th>
<th>( \hat{r} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_1 )</td>
<td>1</td>
<td>-1.8962</td>
<td>0</td>
<td>-4.9171 (1.0989)</td>
<td>-0.4467 (2.3262)</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0</td>
<td>-0.3346</td>
<td>1</td>
<td>7.3904 (5.0942)</td>
<td>2.8796 (10.670)</td>
</tr>
</tbody>
</table>

\( LL = 1053.9 \)

The first vector represents the PPP condition and the exchange rate (LTSSAR \((s)\)) and foreign price (LSACPI \((p)\)) have the right signs although not equal to unity. Vector 2 stands for the UIP condition, but the foreign interest rate (LSATB \((r)\)) has the wrong sign. However, since the above exactly identifying restrictions do not impose any testable restrictions on the cointegrating VAR, over-identifying restrictions based on the two long run theories under study, were imposed on the cointegrating vectors (CVs) in order to test their validity.
The over-identifying restrictions based on the PPP theorem, represented by, \( PPP = (p_t - e_t - p_t' \sim I(0) = 1 - 1 - 1) \) produced the following maximum likelihood estimates:

\[
\beta_{EPPP} =
\begin{array}{c|ccccc}
\hline
\text{Vector} & p & e & r & \tilde{P}' & r' \\
\hline
\beta_1 & 0 & -1 & 0 & -1 & 0 \\
\beta_2 & 1 & -4.7391 & 1 & -12.739 & 0.5881 \\
(2.0336) & (9.2313) & & (1.0797) & \\
\hline
\end{array}
\]

\( LL = 1051.9 \)

The log likelihood ratio (LR) for testing the three over-identifying restrictions is computed to be 4.00, which is well below the 0.05 critical value of the chi-square distribution with 3 degrees of freedom, suggesting that the theory restrictions are accepted at 95% significance level. So the Tanzania intra-continental PPP proposition is valid.

Using UIP theory restrictions namely \( \beta_{UIP} = (r - r' = I - I) \) we obtained:

\[
\beta_{UIP} =
\begin{array}{c|ccccc}
\hline
\text{Vector} & p & e & r & \tilde{P}' & r' \\
\hline
\beta_1 & 1 & -1.9698 & 0 & -3.5073 & 0.3037 \\
& & (0.5308) & & (0.4318) & (0.3525) \\
\beta_2 & 0 & 0 & 1 & 0 & -1 \\
\hline
\end{array}
\]

\( LL = 1048.5 \)

The LR statistic of 10.86, obtained for testing the imposed UIP over-identifying restrictions is above the 0.05 critical value of the chi-square distribution with 3 degrees of freedom. The UIP theory restrictions are therefore rejected. However, the exchange rate (LTSSAR \( e \)) and foreign price (LSACPI \( p' \)) in the first vector have the right signs.

Subsequently the hypothesis testing for the over-identifying restrictions on the joint PPP and UIP were tested and also rejected at the 95% significance level. The LR obtained was 28.59, which is above the chi-squared distribution critical value at 0.05 with 6 degrees of freedom. However since these cointegrating vectors \( (1, -1, -1, 0, 0) \) and \( (0, 0, 0, 1, -1) \) standing for the PPP and UIP respectively, are consistent with theory restrictions, they were adopted for use in analyzing the short run dynamic properties of the model and all further analysis.
The Vector Error Correction Model

Having identified the cointegrating vectors the next step is to estimate the VECM in order to identify the short run properties of the model. Results for vector error correction modeling are reported in Table 7 below.

The error correction terms from the change in domestic price (LTCPI (p)) all have the correct signs and pass the diagnostic tests for functional form and heteroskedasticity, but fails the autocorrelation test. Its correction coefficient associated with the first vector though very small is significant, indicating a very slow gravitation back to equilibrium for the equation once shocked. This result indicates that domestic prices are relatively endogenous and partly bears the brunt of short-run adjustment to restore long-term equilibrium after any shock to the system. The error correction terms for the domestic interest rate (LTDR (r)) equation have the correct signs but are insignificant indicating that domestic interest rates are exogenous and do not respond to correct short-run deviations from equilibrium. The error correction coefficients for the change in foreign interest (LSATB (r')) equation also have the correct signs and pass all diagnostic tests except the normality test. Its error correction associated with the second cointegrating condition, representing the UIP is very small but significant signifying very slow adjustment to restore equilibrium once shocked.

The error correction equation for, the exchange rate equation (LTSSAR (e)) passes all other diagnostic tests except the normality test but its error correction terms are very small, have the wrong signs and are insignificant implying the exogeneity of exchange rates. In terms of the $R^2$, the foreign price (LSACPI (p)) equation performs best, explaining 0.39 of the price variation over the sample period. Its error correction term associated with the first cointegrating vector representing the PPP, is also significant but very small suggesting very slow adjustment to restore back long-run equilibrium. This also indicates that domestic prices are to some small degree exogenous.
Tanzania: Estimates of Error Correction Coefficients and Diagnostic Statistics-Intra-continental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{FE}(1)$</th>
<th>$\chi^2_{HR}(2)$</th>
<th>$\chi^2_{LR}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta LT CPI(p_1)$</td>
<td>-0.051</td>
<td>-0.009</td>
<td>0.250</td>
<td>30.04</td>
<td>1.45</td>
<td>1037.0</td>
<td>2.96</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.010)</td>
<td></td>
<td>[0.003]</td>
<td>[0.228]</td>
<td>[0.000]</td>
<td>[0.085]</td>
</tr>
<tr>
<td>$\Delta LT SSSAR(a_1)$</td>
<td>-0.037</td>
<td>-0.013</td>
<td>0.033</td>
<td>6.98</td>
<td>0.11</td>
<td>22.96</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.015)</td>
<td></td>
<td>[0.859]</td>
<td>[0.734]</td>
<td>[0.000]</td>
<td>[0.641]</td>
</tr>
<tr>
<td>$\Delta LS AC p (p_2^*)$</td>
<td>-0.004</td>
<td>-0.001</td>
<td>0.392</td>
<td>15.88</td>
<td>2.08</td>
<td>16.71</td>
<td>10.12</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.001)</td>
<td></td>
<td>[0.197]</td>
<td>[0.149]</td>
<td>[0.000]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>$\Delta LT DR(r_1)$</td>
<td>-0.089</td>
<td>-0.056</td>
<td>0.093</td>
<td>14.76</td>
<td>8.95</td>
<td>186.70</td>
<td>11.15</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.032)</td>
<td></td>
<td>[0.255]</td>
<td>[0.003]</td>
<td>[0.000]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>$\Delta LS AT B(r_1^*)$</td>
<td>0.025</td>
<td>0.628</td>
<td>0.298</td>
<td>8.38</td>
<td>0.17</td>
<td>37.45</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.014)</td>
<td></td>
<td>[0.754]</td>
<td>[0.677]</td>
<td>[0.000]</td>
<td>[0.683]</td>
</tr>
</tbody>
</table>

Notes: The results are estimated by OLS based on cointegrating VAR (2) using the equation:

$$\Delta x_t = \delta + \Gamma_1 \Delta x_{t-1} \alpha_1 \beta_1 x_{t-1} + \alpha_2 \beta_2 x_{t-1} + \epsilon_t,$$

where $\Delta x_{t-1} = \xi_t$, which are I (0) and $\alpha_1$ and $\alpha_2$ are five dimensional matrices of adjustment or feedback coefficients and the two error correction terms are given by:

$$\xi_{1,t+1} = \rho - \rho^*,$$

$$\xi_{2,t+1} = r - r^*.$$

The figures in (.) are estimated asymptotic standard errors whereas those in [.] are the corresponding $p$-values. The bold faced estimates denote statistical significance at the 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{FE}(1)$ is Ramsey's RESET test statistic, $\chi^2_H(2)$ is the Jarque- Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HR}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in (.) indicates the degrees of freedom.

**Forecast Error Variance Decompositions**

Variance decompositions allow for out of sample testing of Granger exogeneity or endogeneity of the dependant variable and also provide a measure of the extent to which a
variable is exogenous in comparison with other variables in the system. They achieve this end by providing a literal breakdown of the change in the value of the variable in a given period arising from changes in the same variable in addition to changes in other variables in previous periods. A sample of the VDC results generated for all the variables namely, domestic price (LTCPI \((p_t)\)), exchange rates (LTSSAR \((e_t)\)), foreign price (LSACPI \((p_t')\)), domestic interest rates (LTDR \((r_t)\)) and foreign interest rates (LSATB \((r_t')\)) are included in Table 10 below.

Table 10: Tanzania Variance decomposition

<table>
<thead>
<tr>
<th>Horizon</th>
<th>LTCPI ((p))</th>
<th>LTSSAR ((e))</th>
<th>LSACPI ((p'))</th>
<th>LTDR ((r))</th>
<th>LSATB ((r'))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>10</td>
<td>0.59</td>
<td>0.10</td>
<td>0.00</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>20</td>
<td>0.59</td>
<td>0.34</td>
<td>0.00</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>30</td>
<td>0.35</td>
<td>0.53</td>
<td>0.00</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>40</td>
<td>0.23</td>
<td>0.66</td>
<td>0.01</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>50</td>
<td>0.17</td>
<td>0.70</td>
<td>0.01</td>
<td>0.04</td>
<td>0.02</td>
</tr>
</tbody>
</table>

The exchange rate (LTSSAR \((e)\)) seems to be the most exogenous variable. This is inferred as the greater part 85% of its variance is being explained by its own innovations compared to own shocks contributing to explaining the rest of the variables. On the other hand, the domestic price (LTCPI \((p)\)) appears to be the most endogenous with its own innovations only explaining 17% of its shock whilst its shocks explain 70% of the exchange rates.
variance over the forecast horizon. Also, the domestic (LTDR ($r$)) and foreign (LSATB ($r^*$)) interest rates and foreign prices (LSACPI ($p^*$)) are relatively endogenous with own shocks explaining 0.46, 0.57 and 0.53 of their variances over the forecast horizon respectively. These results seem to be reasonably compatible with VECM findings.

**Impulse Response Analysis**

Impulse response analyses are useful in that they can be used to estimate the time profile of the effect of “particular” shocks to the individual equations or to cointegrating relations. The generated generalized impulse response analysis of the individual equations and cointegrating vectors to one standard deviation shock in the domestic price (LTCPI ($p_1$)) and exchange rate (LTSSAR ($e$)) equations are portrayed in Figure 3 below.

**Figure 3 A**
Generalized Impulse Response(s) to one S.E. shock in the equation for LTCPI

**Figure 3 B**
Generalized Impulse Response(s) to one S.E. shock in the equation for LTSSAR

**Figure 3 C**
Generalized Impulse Response(s) to one S.E. shock in the equation for LTCPI

**Figure 3 D**
Generalized Impulse Response(s) to one S.E. shock in the equation for LTSSAR

Figure 3: Tanzania Generalized Impulse response

Notes: Horizon is in Months and CV1 and CV2 in figures (C) and (D) stands for the PPP and UIP vectors respectively.
The first 2 figures (A and B) show impulse response paths for each variable to one SE shock to the equations of the LTCPI ($p_t$) and LTSSAR ($e_t$) correspondingly. As is often the case in empirical literature, effects of these shocks to individual equations seem to persist forever reflecting their unit root properties. The results are the same for shocks to other variables. Figures (C and D) show impulse response of cointegrating vectors to one SE shocks also in the domestic price equation (LTCPI ($p_t$)) and the exchange rate (LTSSAR ($e_t$)) respectively. The results are more or less the same regardless of the variable shocked with the shocks taking very long to dissipate. Whereas the first cointegrating vector representing the PPP return to their equilibrium values in about 135 months (11 years), the shock to the second CV for the UIP seem to persist for longer. Our finding is in line with empirical literature and confirms the cointegration tests result.

**Persistence Profiles**

Unlike impulse response functions, persistence profiles measure the time profile of the effect of a system-wide shock on the cointegrating relations. Persistence profiles also have the advantage that they are unique and do not require prior orthogonalization of the shocks. Figure 4 illustrate the persistence profiles.

![Persistence Profile of the effect of a system-wide shock to CV(s)](image)

**Figure 4: Tanzania Persistence Profiles**

Notes: The variables in the VAR (2) model are $p_{t-1}, p_t^*, e_t, r_t$ and $r_t^*$. The first cointegrating relation CV1 is for the PPP and the second one CV2 is for the UIP and $\beta_1 = (1, -1, -1, 0, 0)$ and $\beta_2 = (0, 0, 0, 1, 1)$ are the PPP and UIP vectors respectively. Horizon is in months
Intercontinental Approach

For the tests for order of VAR both the AIC and SBC selects 1 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Appendix Table 5, presents cointegration rank statistics defined by the maximum eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 0.05 and 0.10 significance levels reproduced using VAR (1) and model (12).

Both the maximum eigenvalue and the trace statistic, suggest one cointegration relation between the six $I(1)$ variables under investigation. However, in line with the predicted confines of economic theory that there should be two long run (cointegrating) relations namely the PPP and UIP relations defined as $p_t - e_t - p_t^*$ and $r_t - r_t^*$ respectively, we assume $r = 2$ for all further analysis.

We now examine the validity of the PPP and UIP hypothesis using the long-run structural modeling advanced in Pesaran and Shin (1997). The novel of this approach is that it enables us to test the validity of these hypotheses and to identify factors that might be responsible for their breakdown. The two cointegrating vectors associated with $z_t = (p_t, e_t, r_t, p_t^*, r_t^*, p_{o_t}, t)$ are denoted by $\beta_1^* = (\beta_{01}, \beta_{11}, \beta_{21}, \beta_{31}, \beta_{41}, \beta_{51}, \beta_{61})$ and $\beta_2^* = (\beta_{02}, \beta_{12}, \beta_{22}, \beta_{32}, \beta_{42}, \beta_{52}, \beta_{62})$ respectively, viewing $\beta_1^*$ as explaining domestic prices and $\beta_2^*$ domestic interest rate. The first six elements are the coefficients of the $I(1)$ variables and the last element (i.e., $\beta_{6i}, i = 1, 2$) refers to the time trend. As exact identification of these vectors requires the impositions of two restrictions per vector, the following exactly identifying restrictions are chosen as constraints and do not impose any testable restrictions on the cointegrating VAR model:

$$H_E : \quad \beta_t = \begin{pmatrix} 1 & * & 0 & * & * & * & * \\ 0 & * & 1 & * & * & * & * \end{pmatrix}$$
Which produced the estimate:

\[
\beta_{eL} = \begin{pmatrix}
1 & 2.5589 & 0 & 31.6713 & -3.9422 & 0.05993 & -0.0801 \\
(4.8498) & (62.3299) & (26.2170) & (0.7764) & (0.13356) \\
0 & -0.6357 & 1 & 2.6839 & -5.1954 & -0.0010 & -0.0002 \\
(0.6569) & (8.3994) & (3.5288) & (0.1046) & (0.0180)
\end{pmatrix}
\]

\[LL_E = 734.57\]

where \(LL_E (r = 2)\) is the maximized value of the log likelihood function for the justified case or subject to exactly identifying restrictions. Asymptotic errors are given in parentheses.

We then proceeded to test a number of hypotheses using the above just-identified model as a basic model and imposing over-identifying restrictions. First, since we do not expect these long-run relations to include a linear trend, we first test the co-trending hypothesis \(H_0\), namely that, \(\beta_{e1} = \beta_{e2} = 0\) and represented by:

\[H_0: \beta_\star = \begin{pmatrix}
1 & * & 0 & * & * & * & 0 \\
0 & * & 1 & * & * & * & 0
\end{pmatrix}\]

Under the hypothesis \(H_0\) the restrictions were collinear and there was no convergence. Hence the hypothesis that there are no linear trends in the cointegrating relations is rejected. Individual tests of \(H_0\) were then undertaken separately for each vector and they produced different results. Whereas the co-trending restrictions were accepted in the second vector standing for the UIP, they were rejected for the PPP or 1\(^{st}\) vector. We term this hypothesis \(H_{0\star}\) (where only the UIP vector is co-trended) for further analysis and it yields:

\[
\hat{\beta}_{e0\star} = \begin{pmatrix}
1 & 2.6030 & 0 & 32.3523 & -3.9400 & 0.0537 & 0.0816 \\
(2.9565) & (17.8733) & (26.5352) & (0.5581) & (0.0345) \\
0 & -0.6418 & 1 & 2.5889 & -5.1957 & -0.009 & 0 \\
(0.3773) & (1.0267) & (3.5719) & (0.0724)
\end{pmatrix}
\]
The restrictions are accepted because the LR statistic computed for the one restriction was insignificant.

Second the hypothesis implied by the PPP and UIP theories that the level of oil prices do not enter these long-run relationships denoted by $H_{po}$ is tested and it yields:

$$\begin{bmatrix}
  p & e & r & p^* & r^* & po & t \\
  1 & 2.7867 & 0 & 35.4233 & -3.4353 & 0 & 0.0881 \\
   & (4.3852) & & (44.5935) & (27.28258) & (0.0980) & \\
  0 & -0.6732 & 1 & 2.0613 & -5.2801 & 0 & 0.0011 \\
   & (0.6014) & & (6.0844) & (3.7215) & (0.0134) & 
\end{bmatrix}$$

$$LL_{po} = 734.56$$

The LR statistic associated with these 2 over-identifying restrictions is 0.01, and thus does not reject the $H_{po}$ hypothesis at the conventional 95% significance level. The joint $H_{co^*} \cap H_{po}$ (where only the second vector is co-trended) produced the following results:

$$\begin{bmatrix}
  p & e & r & p^* & r^* & po & t \\
  1 & 2.5329 & 0 & 31.8833 & -2.8219 & 0 & 0.0802 \\
   & (2.8356) & & (12.3988) & (25.0698) & (0.0219) & \\
  0 & -0.6374 & 1 & 2.5604 & -5.3666 & 0 & 0 \\
   & (0.3780) & & (1.0046) & (3.4082) & & 
\end{bmatrix}$$

$$LL_{co^*,po} = 734.6$$

The LR statistic obtained under these 3 over-identifying restrictions is 0.01, and thus do not reject the $H_{co^*} \cap H_{po}$ hypothesis at 95% significance level. It can also be seen that the value of the trend in the first vector representing the PPP is almost insignificant. Consequently, tests for the validity of the PPP and UIP propositions are tested given $H_{co^*} \cap H_{po}$. 
Under the UIP hypothesis given $H_{o^0} \cap H_{p_0}$ represented by:

$$H_{\text{UIP}} \quad \beta_* = \begin{pmatrix} 1 & * & 0 & * & 0 & * \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \end{pmatrix}$$

the estimate of which is:

$$\beta_{\text{UIP}} = \begin{pmatrix} p & e & r & p^* & r^* & p_0 & t \end{pmatrix}$$

$$= \begin{pmatrix} 1 & -1.9418 & 0 & 50.2628 & -33.9501 & 0 & 0.0808 \\ 0.5753 & (13.2975) & (8.5744) & (0.0221) & 0 & 0 & 0 \end{pmatrix}$$

$LL_{\text{UIP}} = 727.08$

The LR statistic obtained under these 6 over-identifying restrictions was 14.98, and thus rejects the UIP hypothesis together with the hypothesis $H_{o^0} \cap H_{p_0}$ at the 95% critical level.

Similarly under the PPP hypothesis and $H_{o^0} \cap H_{p_0}$ (the PPP vector includes an unrestricted trend), and is represented by:

$$H_{\text{PPP}} \quad \beta_* = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 & * \\ 0 & * & 1 & * & * & 0 & 0 \end{pmatrix}$$

The estimate failed to converge, thus the hypothesis of the PPP (jointly with $H_{o^0} \cap H_{p_0}$) was rejected.

Several modifications to the PPP hypothesis (denoted by $H_{\text{PPP}}*$) that allow for the effect of either domestic interest rate or foreign interest rate or both on the real exchange rate to be unrestricted respectively were subsequently considered. They were all rejected, as the LR ratios obtained in each case were much higher than the critical value of chi-squared distribution with $x$ degrees of freedom.
Finally in our long-run structural modeling, taking the unmodified PPP and UIP versions, we estimated the cointegrating relations under the PPP and UIP over-identifying restrictions (jointly with $H_{co} \cap H_{P:0}$):

$$H_{UIP,PPP}: \beta_{PPP,UIP} = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 * \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \\ \end{pmatrix}$$

which yields:

$$\hat{\beta}_{PPP,UIP} = \begin{pmatrix} p & e & r & p^* & r^* & po & t \\ 1 & -1 & 0 & -1 & 0 & 0 & 0.0046 \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \\ \end{pmatrix}$$ $\text{LL}_{PPP,UIP} = 712.39$

The LR statistic of 44.34, well exceeds the 0.05 critical value of the chi-squared distribution with 9 degrees of freedom. Thus the PPP and UIP hypothesis considered jointly with $H_{co} \cap H_{P:0}$ is rejected at the 95% significance level.

The Vector Error Correction Model

Conditional on the above long-run (rejected) theory restrictions, we have the following expressions for the error correction terms:

$$\hat{\beta}_1 z_{t-1} = p_{t-1} - e_{t-1} - p^*_{t-1} + 0.0046t,$$

$$\hat{\beta}_2 z_{t-1} = r_{t-1} - r^*_{t-1},$$

where $\hat{\beta}_z_{t-1} = \xi$, which are I (0).

To check the resultant model’s statistical adequacy, the following VECM was estimated:

$$\Delta y_t = c_0 - \alpha_j \beta y_t + \Delta \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_1 \beta x_{t-1} + \alpha_2 \beta z_{t-1} + u_t$$

$$= c_0 - \alpha_j \beta y_t + \Delta \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_1 \beta x_{t-1} + \alpha_2 \beta z_{t-1} + u_t$$
where $\alpha_{1y}$ and $\alpha_{2y}$ are three dimensional vectors of adjustment (error correction) coefficients. The number of error correction equations in the present application is 3, corresponding to the jointly determined variables of the model namely domestic prices (LTCPI ($p_t$)), exchange rate (LTER ($e_t$)) and domestic interest rates (LTDR ($r_t$)). The estimates of these adjustment coefficients together with a number of diagnostic test statistics are presented in Table 9 below.

Table 11: Tanzania : Estimates of Error Correction Coefficients and Diagnostic Statistics - Intercontinental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_{1y}$</th>
<th>$\alpha_{2y}$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{FF}(1)$</th>
<th>$\chi^2_{J}(2)$</th>
<th>$\chi^2_{HE}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTCPI($p_t$)</td>
<td>-0.037</td>
<td>0.046</td>
<td>0.197</td>
<td>29.51</td>
<td>0.97</td>
<td>690.66</td>
<td>3.51</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.058)</td>
<td></td>
<td>[0.003]</td>
<td>[0.323]</td>
<td>[0.000]</td>
<td>[0.061]</td>
</tr>
<tr>
<td>ALTER($e_t$)</td>
<td>-0.036</td>
<td>-0.054</td>
<td>0.047</td>
<td>8.86</td>
<td>2.04</td>
<td>32.99</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.085)</td>
<td></td>
<td>[0.715]</td>
<td>[0.153]</td>
<td>[0.00]</td>
<td>[0.646]</td>
</tr>
<tr>
<td>ALTDR($r_t$)</td>
<td>-0.019</td>
<td>-0.053</td>
<td>0.099</td>
<td>9.53</td>
<td>18.64</td>
<td>147.15</td>
<td>18.49</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.022)</td>
<td></td>
<td>[0.657]</td>
<td>[0.000]</td>
<td>[0.00]</td>
<td>[0.00]</td>
</tr>
</tbody>
</table>

Notes: The ECM results are estimated by OLS based on cointegrating VAR (1). The two error correction terms are given by:

$$\xi_{t+1} = p_{t-1} - e_{t-1} - r_{t-1} + 0.0046t,$$

$$\xi_{t+1} = r_{t-1} - r_{t-1}^*.$$

The figures in ( ) are estimated asymptotic standard errors whereas those in [ ] are the corresponding $p$-values. The bold faced estimates denote statistical significance at the 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{FF}(1)$ is Ramsey's RESET test statistic, $\chi^2_{J}(2)$ is the Jarque-Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HE}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in ( ) indicates the degrees of freedom.

The equation for the change in domestic price (LTCPI ($p$)) passes the heteroskedasticity and functional form diagnostic tests, but fails the serial correlation and the normality tests. It explains 0.197 of the price variation over the sample period. Its error correction term, associated with the first cointegrating relation explaining long run price movements, has
the correct sign and is significant, indicating a marginal speed of convergence to equilibrium for Tanzania prices in response to the domestic interest rate and the exchange rate shocks. Hence prices are endogenous. The equation for the change in the domestic interest rate (LTDR (r)) performs the worst passing only the serial correlation diagnostic test and explaining a meager 0.09 of the price variation over the sample period. However, the error correction term associated with the second vector representing the UIP although small is statistically significant suggesting a crawling speed of convergence to equilibrium. The error correction term for the exchange rate (LTER(e)) associated with the PPP (or I$^{st}$) vector is small and has the wrong sign indicating that the exchange rate has a small but negative response to restore equilibrium.

Country summary and policy recommendations

Comparing both results for the intra-continental and intercontinental approach, it is recommended that the financial planners in Tanzania use America rather than South Africa when modeling their exchange rate using simple UIP because in this rare case, the proposition is valid in its symmetry and proportionality conditions. This finding although supported well by the statistical data is economically counter-intuitive especially when one considers that Tanzania’s economy is one of the poorest countries in the world. But then it could also be because their currency has been free floating since 1995. However when using the combine PPP and UIP model the intra-continental approach performs better because the PPP proposition is valid in its symmetry and proportionality theory restrictions.
5.2.7 ZAMBIA

- Simple PPP and UIP

Intra-Continental Approach

The tests for order of VAR select 2 as order of VAR for both the PPP and UIP. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP using selected order of VAR (2) and equation (13) are presented in Appendix Table 2.

PPP

For the PPP the maximum eigenvalue suggests \( r = 1 \) and the trace statistics suggests \( r = 2 \). According to the PPP theory we only expect one cointegration relationship and so the existence of more than one cointegrating vector tends to complicate the interpretation of results. Hence we adopt the maximum eigenvalue result, which is also suggested by the SBC criterion. Assuming \( r = 1 \), in line with the PPP theory, we present the estimates of the cointegrating coefficients normalized on the coefficient of the domestic price (LZACPI(\( p \))). The results of this just identifying restriction for the cointegrating vector denoted by \( \beta = (LZACPI(\( p \)), LZKSAR(e), LSACPI(\( p^* \))) \) are:

\[
\beta_e = \begin{pmatrix}
p & e & p^* \\
1.000 & -0.3506 & -0.8707 \\
(no) & (0.5880) & (2.7035)
\end{pmatrix}
\]

The Log likelihood statistic subject to the exact identifying restrictions is equal to 1200.8

The vector supports the PPP theory only in as far as both domestic exchange rate and foreign price have negative coefficients but does not enable us to test any theory and so we further impose PPP theory restrictions. Imposed over-identifying restrictions based on the strict PPP theory symmetry and proportionality conditions where, \( (p - e - p^*) = (1 - 1 - 1) \) were rejected as the LR statistic of 25.4 is higher than the chi-square test with two degrees
of freedom. The simple PPP therefore does not hold in its symmetry and proportionality conditions even though the variables are cointegrated.

**UIP**

With the simple UIP, using the VAR order of 2, the maximum eigenvalue suggests one cointegrating relation and so does the trace statistic at the 10 % critical level. In line with theory and setting \( r = 1 \) the estimates of the cointegration coefficients normalized on the domestic interest rates are for the cointegrating vector denoted by, \( \beta = (\text{LZATB}(r), \text{LSATB}(r^*)) \)

\[
\beta_c = \begin{pmatrix}
  r & r^* \\
  1.000 & 12.355 \\
  (\text{none}) & (17.198)
\end{pmatrix}
\]

where \( \text{LL} = 1034.3 \)

As these results lack any meaningful economic interpretation, we further impose the UIP theory over-identifying restrictions where \( (r - r^* = 1 - 1) \). The log-likelihood ratio test statistic from these theory restrictions is 1.81, which is insignificant and below the critical value of the chi-squared distribution with 1 degree of freedom. The theory restrictions are therefore accepted at the conventional 95% significance level. We conclude that the intra-continental simple UIP does hold in the Zambian case.

**Intercontinental Approach**

For the tests for order of VAR both the AIC and SBC selects 2 as order of VAR. Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP obtained using equation (13) and VAR (2) are presented in Appendix Table 2.

**PPP**

For the PPP both the maximum eigenvalue and the trace statistics suggests \( r = 0 \). The hypothesis that \( r = 0 \) cannot be rejected against \( r = 1 \) at 95% significance level. This result however conflicts with the PPP hypothesis where we expect one cointegrating relation and so we conclude that, the simple intercontinental PPP does not hold.
UIP

The UIP between Zambia and the US is also rejected, as there is no cointegration between Zambia's interest rates and US interest rates.

- Joint PPP and UIP

Intra-continental Approach

Using model (11) with unrestricted intercepts and no trends to test the joint PPP and UIP hypothesis and optimal VAR of order two, the maximum eigenvalue statistic suggests, \( r = 2 \) and the trace statistic suggests \( r = 4 \). The Schwarz Bayesian Criterion (SBC) suggests \( r = 1 \) and the Akaike Information Criterion (AIC) and the Hannan-Quinn Criterion (HQC) select \( r = 5 \). Considering these statistical results, the data in this application seems hopelessly uninformative on the choice of the number of cointegrating relationships among the five \( I(1) \) variables. Turning to the long-run economic theory based on arbitrage in the commodity and capital markets, we should expect two cointegrating relations (i.e., \( r = 2 \)): the PPP relation;

\[
p_t - e_t - p_t^* \sim I(0)
\]

and the interest-rate arbitrage condition (which is the long-run implication of the uncovered interest parity hypothesis);

\[
r_t - r_t^* \sim I(0)
\]

It therefore seems reasonable to set \( r = 2 \) for the purposes of further analysis.

Applying long-run structural modeling (Pesaran and Pesaran, 1997) we first obtain estimates of the cointegrating coefficients (together with their asymptotic standard errors) normalized on the following identifying restrictions:

\[
H_E = \begin{vmatrix}
\beta_{11} = 1, & \beta_{13} = 0 \\
\beta_{21} = 0, & \beta_{23} = 1
\end{vmatrix}
\]

where we have denoted the two cointegrating vectors associated with coefficients of \( X_i = [p_t, e_t, r_t, p_t^*, r_t^*] \) by, \( \beta_1 = (\beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}) \), \( \beta_2 = (\beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25}) \), yielding (asymptotic standard errors are in brackets):
\[ \beta_k = \begin{bmatrix} (\beta_1) \\ (\beta_2) \end{bmatrix} \]

\[
\begin{array}{l|cccc}
\text{Variable} & p & e & r & P^* \\
\hline
(\beta_1) & 1 & -2.1621 & 0 & 7.1434 \\
 & & (1.7396) & & (11.016) \\
(\beta_2) & 0 & -0.9243 & 1 & 5.0131 \\
 & & (0.8751) & & (5.5638) \\
\end{array}
\]

\[ LL = 2282.4 \]

The first vector represents the PPP condition and although the exchange rate (LZACP1) estimate has the right sign, the foreign price (LSACPI) estimate has the wrong sign and both are not of the expected magnitude of unity. Vector 2 stands for the UIP condition, and the foreign interest rate (LSATB) has the right sign but is not equal to the expected value of unity (1). However, since the above exactly identifying restrictions do not impose any testable restrictions on the cointegrating VAR, over-identifying restrictions based on the two long run theories under study were imposed on the cointegrating vectors (CVs) in order to test their validity.

The over-identifying restrictions based on the PPP theory, where \( \text{PPP} = (p_t - e_t - p_t^* \sim I (0) = 1 - 1 - 1) \) produced the following maximum likelihood estimates:

\[ \beta_{PPP} = \begin{bmatrix} (\beta_1) \\ (\beta_2) \end{bmatrix} \]

\[
\begin{array}{l|cccc}
\text{Variable} & p & e & r & P^* \\
\hline
(\beta_1) & 1 & -1 & 0 & -1 \\
 & & & & 0 \\
(\beta_2) & 0 & -0.0638 & 1 & -0.9935 \\
 & & (0.2321) & & (1.4164) \\
\end{array}
\]

\[ LL = 2273.6 \]

The log likelihood ratio (LR) statistic for testing the three over-identifying restrictions is computed to be 17.48, which is well above the 0.05 critical value of the chi-square distribution with 3 degrees of freedom, suggesting that the theory restrictions are rejected at the conventional 95% significance level. We also tested modified versions of the PPP with either the domestic interest rate (LBDR) or foreign interest rate (LSATB) unrestricted, but they were all rejected at the conventional 95% level as the LR statistics obtained were, above the critical value of the chi-squared distribution with 2 degrees of freedom.
Using UIP theory restrictions \((r - r^* = l - l)\) we obtained:

\[
\beta_{UIP} = \begin{bmatrix}
1 & -0.8096 \\
0 & 0
\end{bmatrix}
\]

\(\text{LL} = 2274.5\)

The LR statistic of 15.76, obtained for testing the imposed UIP over-identifying restrictions is above the conventional 0.05 critical value of the chi-square distribution with 3 degrees of freedom and so the theory restrictions are rejected. The UIP theory restrictions are therefore rejected. The exchange rate (LZKSAR) and foreign price (LSACPI) coefficients in vector one however, have the right signs but do not satisfy the PPP proportionality condition of unity one expects.

Subsequently the hypothesis testing for the over-identifying restrictions on the joint PPP and UIP were tested and also rejected at the 95% significance level. The LR obtained was 62.62, which is way above the chi-squared distribution critical value at 0.05 with 6 degrees of freedom. However since these cointegrating vectors \((1, -1, -1, 0, 0)\) and \((0, 0, 0, 1, -1)\) representing the PPP and UIP respectively, are consistent with theory restrictions, they were adopted for use in analyzing the short run dynamic properties of the model (V ECM) and for all further analyses.

**The Vector Error Correction Model**

Our next step was to formulate a vector error correction modeling relationship, which seeks to indicate the direction of Granger causality. The error correction coefficient represents the proportion by which the long-run disequilibrium in the dependent variable is corrected in the short period. Results for Zambia vector error correction modeling are presented in Table 10 below.
Table 12: Zambia: Estimates of Error Correction Coefficients and Diagnostic Statistics-Intra-Continental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_{1y}$</th>
<th>$\alpha_{2y}$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{FP}(1)$</th>
<th>$\chi^2_{N}(2)$</th>
<th>$\chi^2_{HE}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta LZACPI(p_1)$</td>
<td>-0.008</td>
<td>-0.004</td>
<td>0.368</td>
<td>20.24</td>
<td>0.24</td>
<td>837.75</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.012)</td>
<td></td>
<td>[0.063]</td>
<td>[0.624]</td>
<td>[0.00]</td>
<td>[0.133]</td>
</tr>
<tr>
<td>$\Delta LZKSAR(e_i)$</td>
<td>0.11</td>
<td>0.001</td>
<td>0.091</td>
<td>10.31</td>
<td>1.15</td>
<td>1625.2</td>
<td>38.73</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.053)</td>
<td></td>
<td>[0.589]</td>
<td>[0.283]</td>
<td>[0.00]</td>
<td>[0.00]</td>
</tr>
<tr>
<td>$\Delta LSA CPI(p_{1}^*)$</td>
<td>-0.002</td>
<td>-0.005</td>
<td>0.268</td>
<td>40.28</td>
<td>6.20</td>
<td>25.61</td>
<td>5.98</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
<td></td>
<td>[0.000]</td>
<td>[0.013]</td>
<td>[0.00]</td>
<td>[0.14]</td>
</tr>
<tr>
<td>$\Delta LZAMTB (r_t)$</td>
<td>-0.004</td>
<td>-0.043</td>
<td>0.319</td>
<td>19.81</td>
<td>5.75</td>
<td>1295.2</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.014)</td>
<td></td>
<td>[0.071]</td>
<td>[0.017]</td>
<td>[0.00]</td>
<td>[0.158]</td>
</tr>
<tr>
<td>$\Delta LSATB(r_{t}^*)$</td>
<td>-0.001</td>
<td>0.000</td>
<td>0.187</td>
<td>14.94</td>
<td>2.42</td>
<td>71.66</td>
<td>42.83</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
<td></td>
<td>[0.24]</td>
<td>[0.119]</td>
<td>[0.00]</td>
<td>[0.000]</td>
</tr>
</tbody>
</table>

Notes: The results are estimated by OLS based on cointegrating VAR (2) using the equation:

$$\Delta x_t = \delta + \Gamma_1 \Delta x_{t-1} + \alpha_1 \beta_1 x_{t-1} + \alpha_2 \beta_2 x_{t-1} + \epsilon_t$$

where $\beta x_{t-1} = \xi_t$, which are $I(0)$ and $\alpha_1$ and $\alpha_2$ are five dimensional matrices of adjustment or feedback coefficients and the two error correction terms are given by:

$$\xi_{1t+1} = p - e - p^*,$$

$$\xi_{2t+1} = r - r^*.$$

The figures in () are estimated asymptotic standard errors whereas those in [.] are the corresponding $p$-values. The bold faced estimates denote statistical significance at the 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{FP}(1)$ is Ramsey’s RESET test statistic, $\chi^2_{N}(2)$ is the Jarque- Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HE}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in () indicates the degrees of freedom.

The error correction terms from the domestic price equation (LZACPI (p)) performs best explaining 36% of the price variance over the sample period. Both error correction terms
have the correct sign and pass all the diagnostic tests except for normality. The error correction terms are however insignificant, indicating nil response to shocks. Theory predicts that the error correction term must be significantly different from zero and the larger the equation's error correction coefficient (in absolute value), the faster the variable's return to its equilibrium once shocked. The insignificance of the error correction terms is also an indication in part that domestic prices are exogenous.

The error correction term for the change in domestic interest rate equation (LZAMTB \( (r_d) \)) associated with the UIP cointegrating relation has a small but significant negative impact on current interest rate changes indicating a scanty gravitation back to equilibrium once shocked. Domestic interest rates are thus relatively endogenous. The error correction terms for the change in foreign interest rates equation (LSATB \( (r_s^*) \)) passes only the functional form and serial correlation tests and are insignificant indicating that, foreign interest rates are exogenous. The error correction coefficient for the exchange rate (LZKSAR \( (e_d) \)) associated with the PPP vector, is very significant although it fails the normality and heteroskedasticity diagnostic tests. The result indicates that Zambian exchange rates are endogenous and partly bears the brunt of short-run adjustment to restore long-term equilibrium after any shock to the system. Finally the error correction coefficients for the change in the foreign price equation (LSACPI \( (p_s^*) \)) associated with the two cointegrating vector, although very small are significant.

The results of these tests also give an indication of Granger causality in the model. There is causality from the price differentials to the exchange rate and from the foreign interest rates to domestic interest rates.

**Forecast Error Variance Decompositions**

Variance decompositions allow for out of sample testing of Granger exogeneity or endogeneity of the dependant variable. By telling us the proportion of the change in the value of a variable in a given period due to its own shocks versus shocks to other variables VDCs help provide a measure of the extent to which a variable is exogenous in comparison with other variables in the system. A sample of the VDC results generated for all the variables domestic prices (LZACPI \( (p_d) \)), foreign prices (LSACPI \( (p_s^*) \)), exchange rate
(LZKSAR \((e_j)\)), domestic interest rate (LZATB \((r_i)\)) and foreign interests (LSATB \((r^*_{j})\)), are included in Table 11 below.

Table 13:
Zambia: Forecast Error Variance Decompositions

Generalized Forecast Error variance decompositions for variable
LZACPI \((p)\) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZACPI ((\sigma^2))</th>
<th>LZKSAR ((\sigma^2))</th>
<th>LZATB ((\sigma^2))</th>
<th>LSACPI ((\sigma^2))</th>
<th>LSATB ((\sigma^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>0.59</td>
<td>0.03</td>
<td>0.01</td>
<td>0.59</td>
</tr>
<tr>
<td>10</td>
<td>0.92</td>
<td>0.60</td>
<td>0.02</td>
<td>0.01</td>
<td>0.60</td>
</tr>
<tr>
<td>20</td>
<td>0.93</td>
<td>0.62</td>
<td>0.06</td>
<td>0.01</td>
<td>0.62</td>
</tr>
<tr>
<td>30</td>
<td>0.93</td>
<td>0.65</td>
<td>0.09</td>
<td>0.01</td>
<td>0.65</td>
</tr>
<tr>
<td>40</td>
<td>0.92</td>
<td>0.68</td>
<td>0.09</td>
<td>0.01</td>
<td>0.68</td>
</tr>
<tr>
<td>50</td>
<td>0.92</td>
<td>0.71</td>
<td>0.04</td>
<td>0.01</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Generalized Forecast Error variance decompositions for variable
LSATB \((p)\) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZACPI ((\sigma^2))</th>
<th>LZKSAR ((\sigma^2))</th>
<th>LZATB ((\sigma^2))</th>
<th>LSACPI ((\sigma^2))</th>
<th>LSATB ((\sigma^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.16</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>10</td>
<td>0.12</td>
<td>0.06</td>
<td>0.02</td>
<td>0.02</td>
<td>0.06</td>
</tr>
<tr>
<td>20</td>
<td>0.12</td>
<td>0.06</td>
<td>0.02</td>
<td>0.02</td>
<td>0.06</td>
</tr>
<tr>
<td>30</td>
<td>0.12</td>
<td>0.06</td>
<td>0.02</td>
<td>0.02</td>
<td>0.06</td>
</tr>
<tr>
<td>40</td>
<td>0.11</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>50</td>
<td>0.11</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Generalized Forecast Error variance decompositions for variable
LZKSAR \((e_j)\) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZACPI ((\sigma^2))</th>
<th>LZKSAR ((\sigma^2))</th>
<th>LZATB ((\sigma^2))</th>
<th>LSACPI ((\sigma^2))</th>
<th>LSATB ((\sigma^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.22</td>
<td>0.33</td>
<td>0.09</td>
<td>0.01</td>
<td>0.33</td>
</tr>
<tr>
<td>10</td>
<td>0.44</td>
<td>0.76</td>
<td>0.17</td>
<td>0.01</td>
<td>0.76</td>
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<tr>
<td>20</td>
<td>0.52</td>
<td>0.88</td>
<td>0.25</td>
<td>0.01</td>
<td>0.88</td>
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<tr>
<td>30</td>
<td>0.56</td>
<td>0.98</td>
<td>0.06</td>
<td>0.01</td>
<td>0.98</td>
</tr>
<tr>
<td>40</td>
<td>0.61</td>
<td>1.08</td>
<td>0.06</td>
<td>0.01</td>
<td>1.08</td>
</tr>
<tr>
<td>50</td>
<td>0.63</td>
<td>1.17</td>
<td>0.04</td>
<td>0.01</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Generalized Forecast Error variance decompositions for variable
LSATB \((r^*_{j})\) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZACPI ((\sigma^2))</th>
<th>LZKSAR ((\sigma^2))</th>
<th>LZATB ((\sigma^2))</th>
<th>LSACPI ((\sigma^2))</th>
<th>LSATB ((\sigma^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>20</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>30</td>
<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>40</td>
<td>0.00</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>50</td>
<td>0.00</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Notes: The bold faced amounts denote in percentage the variable's variance explained by own shocks over the forecast horizon.

Unlike for other countries where the exchange rate seems to be the most exogenous variable, for Zambia, the exchange rate (LZKSAR \((e_j)\)) is relatively endogenous with its own shocks explaining 57% of its movements over the forecast horizon. The exchange rate appears to respond to shocks in the domestic prices with exchange rate shocks accounting for 63% of domestic price movements. The foreign price is also relatively endogenous with its own shocks explaining 48% of variance over the forecast horizon. On the other hand, the domestic price and the foreign interest rate variables appear to be the most
exogenous. This is inferred as the greater part (92%) of both the domestic price and foreign interest rate shock/variance is being explained by its own innovations compared to own shocks contributing to explaining the rest of the variables' variances. The domestic interest is also largely exogenous as well. These findings seem to be compatible with VECM results.

Impulse response functions

Impulse response analyses are useful in that they can be used to estimate the time profile of the effect of “particular” shocks to the variables or the cointegrating relations. The generated generalized impulse response analysis of the cointegrating vectors to shocks in the domestic price (LZACPI \((p_t)\)) and the exchange rate (LZKSAR \((e_t)\)) equations are portrayed in Figure 5 below.

Figure 5: Zambia Impulse Response

Notes: The Horizon is in months and CVs 1 and 2 in figures c and D stand for the PPP and UIP respectively
The first 2 Figures (A and B) show impulse response paths of the individual equations to one SE shock in the LZACPI \((p^*_t)\) and LZKSAR \((e_t)\) equations. Unlike for Zimbabwe and Botswana, effects of these shocks to individual equations do not persist forever. In fact they are dissipated between 2 to 3 years. The results are the same for shocks to equations for the other variables. This finding tends to contradict the unit root properties of the data. Figures C and D show impulse response of cointegrating vectors to shocks in the domestic price (LZACPI \((p_t)\)) and exchange rate (LZKSAR \((e_t)\)) respectively. The results slightly differ depending on the variable shocked. With domestic prices (LZACPI \((p_t)\)), the shocks are slowly dissipated and the cointegrating vectors return to their equilibrium values in about 6 to 7 years for both the UIP and the PPP. When the exchange rate (LZKSAR \((e_t)\)) is shocked, both the vector for the UIP relation and the PPP relation return to equilibrium after about 3 years (36 periods). Impulse response paths also vary when other variables are shocked.

**Persistence Profiles**

Figure 6 illustrates the persistence profiles for the two cointegrating vectors representing the PPP relation (CV1) and the UIP condition (CV2).

![Persistence Profile](image)

**Figure 6:** Zambia Persistence Profile

**NOTES:** The variables in the VAR (2) model are \(p_t, p^*_t, e_t, r_t, r^*_t\). The first cointegrating relation CV1 is for the PPP and the second one CV2 is for the UIP and \(\beta_{1*} = (1, -1, -1, 0, 0)\) and \(\beta_{2*} = (0, 0, 1, 1)\) are the PPP and UIP vectors respectively. The horizon is in months.
Unlike impulse response functions, persistence profiles measure the time profile of the effect of a system-wide shock on the cointegrating relations. Both, the estimated persistence profiles for the PPP and UIP return to their long-run equilibrium fairly quickly. Persistence profile of the PPP relation overshoots for barely a month then declines fairly rapidly, totally converging to zero within 12 months (1 year). This behavior is what the founder of the PPP hypothesis Cassel believed should be. Comparatively, the UIP persistence profiles overshoots for about 3 months before declining also fairly quickly back to zero or equilibrium within 24 months (2 years). Our finding is unique in that the PPP performs much better than empirical literature suggest, that is, half lives of four to five years for long-run equilibrium to be restored after shocks to the system.

**Intercontinental Approach**

Using the AIC and SBC we select VAR (2). Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application. Appendix Table 5 presents cointegration rank statistics defined by the maximum eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 0.05 and 0.10 significance levels reproduced using VAR (2) and model (12) with unrestricted intercepts and restricted trends. While the maximum eigenvalue statistic rejects the hypothesis that there are cointegration relations between the six $I(1)$ variables under investigation, the trace statistic suggests 2 cointegrating relationships at the 95% significance level. The trace statistics results are supported by the results of the HQC, which also select $r = 2$. These results are in conformity with the predicted confines of economic theory, that there should be two long run (cointegrating) relations namely the PPP and UIP relations defined as, $p_t - e_t - p_t^*$ and $r_t - r_t^*$, respectively. We therefore accept the results of the statistical analysis and set $r = 2$ for further analyses.

We now examine the validity of the PPP and UIP hypothesis using the long-run structural modeling advanced in Pesaran and Shin (1997). The novel of this approach is that it enables us to test the validity of these hypotheses and to identify factors that might be responsible for their breakdown. The two cointegrating vectors associated with $z_t = (p_t, e_t, r_t, p_t^*, r_t^*, p_{0,t})$ are denoted by $\beta_1^* = (\beta_{01}, \beta_{11}, \beta_{21}, \beta_{31}, \beta_{41}, \beta_{51}, \beta_{61})$ and $\beta_2^* = (\beta_{02}, \beta_{12}, \beta_{22}, \beta_{32}, \beta_{42}, \beta_{52}, \beta_{62})$ respectively, viewing $\beta_1^*$ as explaining domestic
prices (PPP) and \( \beta_2^* \) domestic interest rate (UIP). The first six elements are the coefficients of the \( I(1) \) variables and the last element (i.e., \( \beta_{61}, i=1,2 \)) refers to the time trend. As exact identification of these vectors requires the impositions of two restrictions per vector, the following exactly identifying restrictions are chosen as constraints and do not impose any testable restrictions on the cointegrating VAR model:

\[
H_E : \quad \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & * & * \\ 0 & * & 1 & * & * & * & * \end{pmatrix}
\]

Which produced the estimate:

\[
\beta_{56} = \begin{pmatrix} p & e & r & p^* & r^* & p_{0} & t \\ 1 & 1.3049 & 0 & -63.112 & 44.526 & -0.3190 & 0.0839 \\ (3.5799) & (91.960) & (83.430) & (1.0854) & (0.1271) \\ 0 & -0.9889 & 1 & -29.673 & 30.163 & -0.1460 & 0.0460 \\ (1.9262) & (49.477) & (44.886) & (0.5825) & (0.0684) \end{pmatrix}
\]

\[LL_E = 869.74\]

where \( LL_E \) (\( r = 2 \)) is the maximized value of the log likelihood function for the justified case or subject to exactly identifying restrictions. Asymptotic errors are given in parentheses.

We then proceeded to test a number of hypotheses using the above just-identified model as a basic model and imposing over-identifying restrictions. First, since we do not expect these long-run relations to include a linear trend, we first test the co-trending hypothesis \( H_{co} \), namely that, \( \beta_{61} = \beta_{62} = 0 \) and represented by:

\[
H_{co} : \quad \beta_* = \begin{pmatrix} 1 & * & 0 & * & * & * & 0 \\ 0 & * & 1 & * & * & * & 0 \end{pmatrix}
\]

Under \( H_{co} \) the following estimates were obtained:
\[
\beta_{co} = \begin{pmatrix}
1 & -2.3601 & 0 & 15.986 & -43.005 & 0.5803 & 0 \\
(1.8735) & (25.465) & (49.040) & (1.0271) \\
0 & -1.0358 & 1 & 13.931 & -18.212 & (0.3531) & 0 \\
(1.0542) & (14.330) & (27.599) & (0.5790)
\end{pmatrix}
\]

\[L_{L_{co}} = 867.46\]

The log-likelihood ratio (LR) statistic for testing the two over-identifying restrictions for co-trending is computed to be 4.57 \(\sim 2(869.74-867.46)\), which is below the 0.05 critical value of the chi-squared \((\chi^2)\) distribution with 2 degrees of freedom. Hence the hypothesis that there are no linear trends in the cointegrating relations is not rejected although there was a linear trend in the underlying VAR model.

Second, the hypothesis implied by the PPP and UIP theories that the level of oil prices do not enter these long-run relationships denoted by \(H_{po}\) is tested. To conserve space, only the results of this hypothesis combined with the co-trending hypothesis, \(H_{co} \cap H_{po}\), is reported and it yields:

\[
\beta_{co,po} = \begin{pmatrix}
1 & -2.0898 & 0 & 12.453 & -34.507 & 0 & 0 \\
(1.2919) & (17.722) & (32.3796) \\
0 & -0.8724 & 1 & 11.796 & -13.067 & 0 & 0 \\
(0.7192) & (9.8670) & (18.032)
\end{pmatrix}
\]

\[L_{L_{co,po}} = 867.03\]

The LR statistic associated with these 4 over-identifying restrictions is 5.43, and thus does not reject the \(H_{co} \cap H_{po}\) hypothesis at conventional the 95 % critical level. Individual tests of \(H_{po}\) undertaken separately from \(H_{co}\) also produced similar results. Consequently tests for the validity of the PPP and UIP propositions are tested given \(H_{co} \cap H_{po}\).
Under the UIP hypothesis given $H_{co} \cap H_{pco}$:

\[
H_{UIP} \quad \beta_{UIP} = \begin{pmatrix}
1 & * & 0 & * & * & 0 & 0 \\
0 & 0 & 1 & 0 & -1 & 0 & 0
\end{pmatrix}
\]

the estimate of which is:

\[
\beta_{UIP} = \begin{pmatrix}
p & e & r & p^* & r^* & po & t \\
1 & -0.5969 & 0 & -7.7581 & -10.2131 & 0 & 0 \\
\text{(none)} & \text{(none)} & \text{(none)} & \text{(4.5733)} & \\
0 & 0 & 1 & 0 & -1 & 0 & 0
\end{pmatrix}
\]

$LL_{UIP} = 855.83$

Again the LR statistic of 27.81 is well above the 0.05 critical value of the chi-squared distribution with 7 degrees of freedom. Therefore, the UIP hypothesis considered jointly with $H_{co} \cap H_{pco}$, is rejected.

Similarly under the PPP hypothesis and $H_{co} \cap H_{pco}$:

\[
H_{PPP} \quad \beta_{PPP} = \begin{pmatrix}
1 & * & 0 & -1 & 0 & 0 & 0 \\
0 & 1 & * & * & 0 & 0 & 0
\end{pmatrix}
\]

which produces the following estimate:

\[
\beta_{PPP} = \begin{pmatrix}
p & e & r & p^* & r^* & po & t \\
1 & -1 & 0 & -1 & 0 & 0 & 0 \\
0 & -0.4313 & 1 & 6.3561 & 0.9356 & 0 & 0 \\
(-0.1796) & (2.5801) & \text{(4.7339)} &
\end{pmatrix}
\]

$LL_{PPP} = 859.74$
The LR statistic for testing the PPP hypothesis is 20.01, which is significant compared to the 0.05 critical value of the chi-squared distribution with 7 degrees of freedom (7 is the total number of over-identifying restrictions). Thus the hypothesis of the PPP (jointly with $H_{co} \cap H_{po}$) is rejected at the 95% significance level.

We therefore consider several modifications to the PPP hypothesis (denoted by $H_{ppp^*}$) that allow for the effect of either domestic interest rate or foreign interest rate or both on the real exchange rate to be unrestricted respectively. The following are the restrictions and the results:

i) unrestricted foreign interest:

$$H_{ppp^*} \beta = \begin{pmatrix} 1 & -1 & 0 & -1 & * & 0 & 0 \\ 0 & * & 1 & * & * & 0 & 0 \end{pmatrix}$$

which yields:

$$\beta_{ppp^*} = \begin{pmatrix} p & e & r & p^* & r^* & p_0 & t \\ 1 & -1 & 0 & -1 & 0.5368 & 0 & 0 \\ 0 & -0.4317 & 1 & 6.3618 & 1.1393 & 0 & 0 \\ (0.1796) & (2.5797) & (5.1754) & 0 & 0 & 0 & 0 \end{pmatrix}$$

$LL_{ppp^*} = 859.74$

The LR statistic for testing $H_{ppp^*}$ with unrestricted foreign interest rate is 20.01, which is well above the 0.05 critical value of the $\chi^2$ with 6 degrees of freedom. So this modified PPP version is rejected. The modified PPP version with the unrestricted domestic interest and the that with unrestricted domestic and foreign interest were also rejected at the conventional 95% critical level.

Taking the unmodified versions of the PPP and UIP we finally estimated the cointegrating relations under the PPP and UIP over-identifying theory restrictions (jointly with $H_{co} \cap H_{po}$):
The LR statistic of 36.12 is above the 0.05 critical value of the chi-squared distribution with 10 degrees of freedom. Thus the PPP and UIP hypothesis considered jointly with \( H_{\infty} \cap H_{p0} \) is rejected at 95% level.

The Vector Error correction Model

Having tested the long-run relationships between the joint PPP and UIP, we move on to test the short-term dynamics of the system. Conditional on the above long-run estimates, which are the rejected theory estimates, we have the following expressions for the error correction terms:

\[
\hat{\beta}_1 z_{t-1} = p_{t-1} - e_{t-1} - p^*_t,
\]

\[
\hat{\beta}_2 z_{t-1} = r_{t-1} - r^*_t.
\]

where \( \hat{\beta}_1 z_{t-1} = \xi_t \), which are I(0).

To check the resultant model's statistical adequacy, the following VECM was estimated:

\[
\Delta y_t = c_0 - \alpha_y \beta y_t + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_z \beta z_{t-1} + u_t
\]

\[
= c_0 - \alpha_y \beta y_t + \Lambda \Delta x_t + \Psi_1 \Delta z_{t-1} + \alpha_z \beta z_{t-1} + \alpha_{z2} \beta z_{t-1} + u_t
\]

where \( \alpha_y \) and \( \alpha_{z2} \) are three-dimensional vectors of adjustment (error correction) coefficients. The number of error correction equations in the present application is 3, corresponding to the jointly determined variables of the model namely domestic prices (LZACPI \((p_i)\)), exchange rate (LZAER \((e_i)\)) and domestic interest rates (LZATB \((r_i)\)). The estimates of these adjustment coefficients together with a number of diagnostic tests are presented in Table 12 overleaf.
Table 14: Estimates of error correction coefficients and diagnostic statistics—Intercontinental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\alpha_\beta$</th>
<th>$\alpha_\gamma$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{IC}(1)$</th>
<th>$\chi^2_{IC}(2)$</th>
<th>$\chi^2_{HS}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta LZACPI(p)$</td>
<td>0.003</td>
<td>0.007</td>
<td>0.359</td>
<td>17.64</td>
<td>0.49</td>
<td>724.53</td>
<td>2.95</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.012)</td>
<td></td>
<td>[0.127]</td>
<td>[0.483]</td>
<td>[0.000]</td>
<td>[0.086]</td>
</tr>
<tr>
<td>$\Delta LZAER(e)$</td>
<td>0.13</td>
<td>-0.060</td>
<td>0.0992</td>
<td>9.95</td>
<td>0.61</td>
<td>3934.0</td>
<td>12.99</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.050)</td>
<td></td>
<td>[0.620]</td>
<td>[0.804]</td>
<td>[0.00]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>$\Delta LZATB(r)$</td>
<td>0.003</td>
<td>-0.041</td>
<td>0.332</td>
<td>20.47</td>
<td>7.56</td>
<td>1245.2</td>
<td>1.72</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.013)</td>
<td></td>
<td>[0.059]</td>
<td>[0.006]</td>
<td>[0.00]</td>
<td>[0.189]</td>
</tr>
</tbody>
</table>

Notes: The ECM results are estimated by OLS based on cointegrating VAR (2). The two error correction terms are given by:

$$\xi_{t+1} = p_{t-1} - e_{t-1} - p^*_{t-1}$$

$$\xi_{t+1} = r_{t-1} - r^*_{t-1}$$

The figures in (.) are estimated asymptotic standard errors whereas those in [.] are the corresponding p-values. The bold faced estimates denote significance at 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{IC}(1)$ is Ramsey’s RESET test statistic, $\chi^2_{HS}(2)$ is the Jarque–Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HS}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in (.) indicates the degrees of freedom.

The equation for, the domestic price ($LZACPI(p)$) passes the serial correlation, heteroskedasticity and functional form diagnostic tests but fails the normality test. It also performs best explaining almost 36% of the price variation over the sample period. However, its error correction terms associated with, the first cointegrating relation (or PPP) explaining long run price movements and, the second cointegration relation explaining the UIP condition are all insignificant and have the wrong signs, indicating non response to the last period’s equilibrium error and hence domestic prices are exogenous.

The domestic interest rate ($LZATB(r)$) equation also performs well passing autocorrelation and heteroskedasticity tests and explaining 0.33 of the price variation over the sample period. However, the error correction term associated with the second
cointegrating relation explaining domestic interest rate variation although it has the correct sign and is significant, it is statistically very small suggesting a crawling speed of convergence to equilibrium. It is the error correction term associated with exchange rate movements (LZAER(e)) in the PPP cointegrating relation, which is highly significant inferring 13% speed of convergence to restore long-run equilibrium. The exchange rate is therefore endogenous and bears the brunt of short-term adjustments. The finding is similar to the one obtained when using the intra-continental approach.

**Country summary and policy recommendations**

With the PPP it does not seem to matter which choice of numeraire currency is used to model Zambia’s exchange rate as there is cointegration in both cases for the simple PPP as well as the joint PPP and UIP. The theory restrictions of proportionality and symmetry are however rejected in both cases. The results of the simple intra-continental UIP are more exciting as the proposition holds in its symmetry conditions. As pointed out for the Tanzanian case, this result is economically counter-intuitive, but again it could be because the exchange rate was liberalized in 1992. It is therefore recommended that fiscal planners and their economic advisers adopt the simple intra-continental UIP to manage their exchange rate regimes. The intercontinental UIP is rejected and accordingly its use is not recommended.

Another interesting conclusion is that Zambia’s exchange rate is endogenous in that it moves to correct any disequilibrium in the joint long-run PPP and UIP.

5.2.8 ZIMBABWE

- **Zimbabwe Simple PPP and UIP**

**Intra-Continental Approach**

For the order of VAR tests, both the AIC and SBC unanimously selects VAR (1). Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that autocorrelation is not a problem in the present application.
Cointegration results for simple PPP using and UIP using model (13) are presented in Appendix Table 2.

**PPP**

Both the maximum eigenvalue and the trace statistics suggest \( r = 1 \). The hypothesis \( r = 0 \) is rejected against \( r = 1 \), but the hypothesis that \( r = 1 \) cannot be rejected against \( r = 2 \) etc. Assuming \( r = 1 \) which is also in line with the PPP theory, we present the estimates of the cointegrating coefficients normalized on the coefficient of the domestic price (LZIMCPI (\( p \))). The results of this just identifying restriction for the vector, \( \beta = (\text{LZIMCPI (} p \text{)}, \text{LZIDSAR (} e \text{), LSACPI (} p' \text{)}) \) are:

\[
\beta_{\delta} = \begin{pmatrix}
1.000 & e & p' \\
\text{(none)} & -1.7722 & -0.7488 \\
\end{pmatrix},
\]

where \( LL = 1994.2 \)

The vector supports the PPP theory, as both domestic exchange rate and foreign price have negative coefficients. Imposing over-identifying restrictions based on PPP theory we estimated, \( \beta_{\text{PPP}} = (p - e - p') = (1 - 1 - 1) \). The PPP symmetry and proportionality restrictions were rejected, as the log-likelihood ratio statistic obtained of 14.81 was above the chi-square test with highly significant. The simple PPP therefore holds but not in its symmetry and proportionality conditions.

**UIP**

We use model (13) to test the validity of Zimbabwe UIP. The simple UIP hypothesis was rejected, as there was no cointegration between domestic interest (ZIMTB (\( r \)) rates and foreign interest rates (LSATB (\( r' \))). The cointegrating results are also presented in Appendix Table 2.

**International Approach**

For this approach we used equation (13) with unrestricted intercepts and no trends. For the tests for order of VAR both the AIC and SBC selects VAR (2). Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggests that
autocorrelation is not a problem in the present application. Cointegration results for simple PPP using and UIP using order of VAR = 2 are presented in Appendix Table 3.

PPP
For the PPP both the maximum eigenvalue and the trace statistics suggest \( r = 2 \). The hypothesis \( r = 1 \) is rejected against \( r = 2 \), but the hypothesis that \( r = 2 \) cannot be rejected against \( r = 3 \). This result is in contradiction with the PPP hypothesis, which predicts that there should be only one cointegration relationship. Therefore in the absence of theory restrictions this result lacks meaningful economic interpretation. However the fact that the three variables are cointegrated means that causation in the Granger sense cannot be ruled out. Hence, we impose the PPP restrictions and test for the theory’s validity. First, normalizing the vector on the coefficient of the domestic price (\( \text{LZIMCPI} (p) \)), and denoting the vector by \( \beta = (\text{LZIMCPI}(p), \text{LZIDSAR}(e), \text{LUSCPI}(p)) \), we get:

\[
\beta_E = \begin{pmatrix}
1.000 & e & p^* \\
-0.8069 & -1.2656 & \text{(none)}
\end{pmatrix}
\]

where, \( \text{LL} = 2228.2 \)

The vector supports the PPP theory, as both domestic exchange rate and foreign price have negative coefficients of nearly equal to unity. Imposed over-identifying restrictions based on PPP theory where \( \beta_{PPP} = (p - e - p^*) = (1 - 1 - 1) \) were rejected at the 95% significance level, as the computed LR ratio statistic of 8.67 was significant compared to the chi-squared distribution with 2 degrees of freedom.

UIP
The UIP theory rejected, as there is no cointegration between Zimbabwe interest rates and US interest rates.

- **Joint PPP and UIP**

Intra-Continental Approach
Using VAR (2) and model (11) with unrestricted intercepts and no trend, both the maximum eigenvalue and the trace statistic suggest \( r = 1 \). The hypothesis of no cointegration (namely \( r = 0 \)) is rejected against null hypothesis that there exists one
cointegrating relation (namely \( r = 1 \)), but the hypothesis that \( r = 1 \) cannot be rejected against \( r = 2 \). The Schwarz Bayesian Criterion (SBC) and the Hannan-Quinn Criterion (HQC) also favor \( r = 1 \), but the same is not true of Akaike information criterion (AIC) which selects \( r = 2 \). Considering these statistical results there is some ambiguity in choosing the number of cointegrating relationships, although evidence weigh more in favor of one statistically significant cointegration relationship among the five \( I(1) \) variables. But even this conclusion is in conflict with the long-run economic theory which states that, based on arbitrage in the commodity and capital markets, we should expect two cointegrating relations (i.e., \( r = 2 \)), the PPP relation:

\[
p_t - e_t - p_t^* \sim I(0)
\]

and the interest-rate arbitrage relation (which is the long-run implication of the uncovered interest parity hypothesis):

\[
r_t - r_t^* \sim I(0)
\]

Using Pesaran and Smith (1999)'s line of argument stated above (see Botswana analysis above), in this application it was deemed proper to set \( r = 2 \) for the purposes of further analyses in line with PPP and UIP theorems.

Using Long-run structural modeling (Pesaran and Pesaran, 1997) we first obtain estimates of the cointegrating coefficients (together with their asymptotic standard errors) normalized on the following identifying restrictions:

\[
H_E = \begin{bmatrix} \beta_{11} = 1, \beta_{14} = 0 \\ \beta_{21} = 0, \beta_{24} = -1 \end{bmatrix}
\]

where we have denoted the two cointegrating vectors associated with coefficients of \( X_t = [p_t, e_t, r_t, p_t^*, r_t^*] \) by,

\[
\beta_1 = (\beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}), \quad \beta_2 = (\beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25}),
\]

yielding (asymptotic standard errors are in brackets):

<table>
<thead>
<tr>
<th>Vector</th>
<th>( p )</th>
<th>( e )</th>
<th>( r )</th>
<th>( p^* )</th>
<th>( r^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_1 )</td>
<td>1</td>
<td>-0.2598</td>
<td>0</td>
<td>-0.7823</td>
<td>-2.1844</td>
</tr>
<tr>
<td>&amp;</td>
<td>(1.3067)</td>
<td>(0.1965)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0</td>
<td>-0.8077</td>
<td>1</td>
<td>0.0026</td>
<td>0.2820</td>
</tr>
<tr>
<td>&amp;</td>
<td>(0.9525)</td>
<td>(0.1442)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( LL = 3771.4 \)
The first vector represents the PPP condition and the exchange rate (LZIMCPI) and foreign price (LSACPI) estimates have the right signs although not equal to the expected magnitude of unity. The second vector stands for the UIP condition, but the foreign interest rate (LSATB) has the wrong sign. However, since the above exactly identifying restrictions do not impose any testable restrictions on the cointegrating VAR, over-identifying restrictions based on the two long run theories under study were imposed on the cointegrating vectors in order to test their validity.

The over-identifying restrictions based on the PPP theory, namely \( \beta_{\text{PPP}} = (p, e, -p, e^{-1}) \), produced the following maximum likelihood estimates:

<table>
<thead>
<tr>
<th>Vector</th>
<th>( p )</th>
<th>( e )</th>
<th>( r )</th>
<th>( p' )</th>
<th>( r' )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_1 )</td>
<td>( 1 )</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0</td>
<td>-0.8729</td>
<td>1</td>
<td>0.0321</td>
<td>0.7488</td>
</tr>
</tbody>
</table>

\[ \text{LL} = 3765.3 \]

The log likelihood ratio (LR) statistic for testing the three over-identifying restrictions is computed to be 12.14, which is well above the 0.05 critical value of the chi-square distribution with 3 degrees of freedom, suggesting that the theory restrictions are rejected at conventional the 95% significance level.

Using UIP theory restrictions we obtained:

<table>
<thead>
<tr>
<th>Vector</th>
<th>( p )</th>
<th>( e )</th>
<th>( r )</th>
<th>( p' )</th>
<th>( r' )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_1 )</td>
<td>1</td>
<td>-1.5708</td>
<td>0</td>
<td>-0.7808</td>
<td>-0.1080</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

\[ \text{LL} = 3767.4 \]

The LR statistic of 8.02 obtained for testing the imposed UIP over-identifying restrictions is marginally above the 0.05 critical value of the chi-square distribution with 3 degrees of freedom. The UIP theory restrictions are therefore rejected. However the exchange rate
(LZIMTB) and foreign price (LSACPI) in vector one have the right signs, but are neither of the same magnitude nor equal to unity.

Subsequently the hypothesis testing for the over-identifying restrictions on the joint PPP and UIP were tested and also rejected at the 95% significance level. The LR obtained was 20.17, which is way above the chi-squared distribution critical value at 0.05 with 6 degrees of freedom. However since these two cointegrating vectors (1, -1, -1, 0, 0) and (0, 0, 0, 1, -1) representing the PPP and UIP respectively, are consistent with theory restrictions, they were adopted for use in analyzing the short run dynamic properties of the model and for all further analyses.

The Vector Error Correction Model

Vector error correction modeling seeks to indicate the direction of Granger causality. The error correction coefficient represents the proportion by which the long-run disequilibrium in the dependent variable is corrected in the short period. Results for vector error correction modeling are presented in table 1 overleaf.

The error correction terms from the domestic price (LZIMCPI (p)) all have the correct sign and pass the diagnostic tests for serial correlation and heteroscedasticity. They are however small, indicating a very slow gravitation to restore long-run equilibrium once shocked. Theory predicts that the error correction term must be significantly different from zero and the larger the equation’s error correction coefficient (in absolute value), the faster the variable’s return to its equilibrium once shocked. The results indicate that domestic prices are endogenous and partly bear the brunt of short-run adjustment to restore long-term equilibrium after any shock to the system.
Table 15:

Zimbabwe: Estimates of error correction coefficients and diagnostic statistics

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\xi_{p_{1}}$</th>
<th>$\xi_{p_{2}}$</th>
<th>$R^2$</th>
<th>$\chi^2_{SC}(12)$</th>
<th>$\chi^2_{FP}(1)$</th>
<th>$\chi^2_{N}(2)$</th>
<th>$\chi^2_{HE}(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$LZIMCPI($p_{d}$)</td>
<td>-0.036</td>
<td>-0.044</td>
<td>0.247</td>
<td>17.66</td>
<td>13.22</td>
<td>2849.5</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.017)</td>
<td></td>
<td>[0.126]</td>
<td>[0.00]</td>
<td>[0.00]</td>
<td>[0.376]</td>
</tr>
<tr>
<td>$\Delta$LZIDSAR($e$)</td>
<td>-0.018</td>
<td>0.008</td>
<td>0.047</td>
<td>14.98</td>
<td>26.51</td>
<td>285.59</td>
<td>30.21</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.062)</td>
<td></td>
<td>[0.242]</td>
<td>[0.00]</td>
<td>[0.00]</td>
<td>[0.00]</td>
</tr>
<tr>
<td>$\Delta$LSACPI($p_{t}^*$)</td>
<td>0.004</td>
<td>-0.011</td>
<td>0.281</td>
<td>11.12</td>
<td>6.00</td>
<td>223.42</td>
<td>7.67</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.005)</td>
<td></td>
<td>[0.518]</td>
<td>[0.014]</td>
<td>[0.00]</td>
<td>[0.006]</td>
</tr>
<tr>
<td>$\Delta$LZIMTB ($r_{d}$)</td>
<td>-0.007</td>
<td>-0.004</td>
<td>0.135</td>
<td>33.39</td>
<td>1.96</td>
<td>350.35</td>
<td>18.26</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.010)</td>
<td></td>
<td>[0.001]</td>
<td>[0.161]</td>
<td>[0.00]</td>
<td>[0.006]</td>
</tr>
<tr>
<td>$\Delta$LSATB($r_{t}^*$)</td>
<td>0.000</td>
<td>0.003</td>
<td>0.194</td>
<td>22.07</td>
<td>0.99</td>
<td>99.91</td>
<td>20.69</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.006)</td>
<td></td>
<td>[0.037]</td>
<td>[0.319]</td>
<td>[0.00]</td>
<td>[0.000]</td>
</tr>
</tbody>
</table>

Notes: The results are estimated by OLS based on cointegrating VAR (2) using the equation:

$$\Delta x_t = \delta + \Gamma_1 \Delta x_{t-1} + \alpha_1 \beta_1 x_{t-1} + \alpha_2 \beta_2 x_{t-1} + \epsilon_t$$

where $\beta_1 x_{t-1} = \xi_1$ which are I (0) and $\alpha_1$ and $\alpha_2$ are five dimensional matrices of adjustment or feedback coefficients and the two error correction terms are given by:

$$\xi_{1,t+1} = p - p^*$$

$$\xi_{2,t+1} = r - r^*$$

The figures in ( ) are estimated asymptotic standard errors whereas those in [ ] are the corresponding $p$ -values. The bold faced estimates denote significance at 0.05 level. The diagnostic tests are Chi squared statistics for the following: $\chi^2_{SC}(12)$ is the Lagrange multiplier statistic for testing the null of no serial correlation, $\chi^2_{FP}(1)$ is Ramsey’s RESET test statistic, $\chi^2_{N}(2)$ is the Jarque-Bera statistic for testing the null of Gaussian errors, and $\chi^2_{HE}(1)$ is the statistic for testing the null of no heteroskedasticity. The number in ( ) indicates the degrees of freedom.

Error correction coefficients for both domestic ($\Delta$LZIMTB ($r_{d}$)) and foreign interest rate ($\Delta$LSATB ($r_{t}^*$)) equations pass only the functional form test and fail all other tests. Their error correction terms except the one for the domestic interest rate equation representing the first vector, are also insignificant indicating that interest rates are exogenous. Both error correction terms for the exchange rate ($\Delta$LZIDSAR ($e$)) equation are also insignificant.
have the wrong signs and pass only the serial correlation test demonstrating that, exchange rates are relatively exogenous. The foreign price equation (LSACPI (p^*_i)) performs best, explaining 0.28 of the price variation over the sample period but the error correction terms are insignificant. In addition, its correction coefficients are significant but very small indicating scanty gravitation to restore equilibrium when shocked.

The results of these tests also give an indication of Granger causality in the model. There is causality from the exchange rate to the domestic prices. The domestic price is the most endogenous.

**Forecast Error Variance Decompositions**

Variance decompositions allow for out of sample testing of Granger exogeneity or endogeneity of the dependant variable and also provide a measure of the extent to which a variable is exogenous in comparison with other variables in the system. A sample of the VDCs, results generated for the variables LZIMCPI (p_i), LSACPI (p^*_i), LZIDSAR (e_i), LZIMTB (r_i) and LSATB (r^*_i) are included in Table 14 below.

The exchange rate seems to be the most exogenous variable. This is inferred as the greater part (92%) of its shocks is being explained by its own innovations at any forecast horizon, compared to own variance explained by shocks to the rest of the variables. The foreign interest and the domestic interest are also relatively exogenous. On the other hand, the domestic price and foreign prices are relatively endogenous with their own shocks explaining 0.96 and 0.92 of own variances over the longest forecast horizon respectively. These results seem to be compatible with VECM results. Caution must be given though that VDC results are only relative.
### Table 16:
Zimbabwe Variance Decomposition

#### Generalized Forecast Error variance decomposition for variable
LZIMCPI(p) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZIMCPI (p)</th>
<th>LZIDSAR (q)</th>
<th>LEACPI (p)</th>
<th>LZIMTB (p)</th>
<th>LSATB (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>10</td>
<td>0.66</td>
<td>0.43</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>20</td>
<td>0.58</td>
<td>0.32</td>
<td>0.04</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>40</td>
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<td>0.27</td>
<td>0.06</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>50</td>
<td>0.44</td>
<td>0.23</td>
<td>0.06</td>
<td>0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>

#### Generated Forecast Error variance decomposition for variable
LZIMCPI (p) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZIMCPI (p)</th>
<th>LZIDSAR (q)</th>
<th>LEACPI (p)</th>
<th>LZIMTB (p)</th>
<th>LSATB (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.01</td>
<td>1.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>10</td>
<td>0.00</td>
<td>0.07</td>
<td>0.75</td>
<td>0.03</td>
<td>0.29</td>
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<tr>
<td>20</td>
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<td>0.25</td>
<td>0.43</td>
<td>0.16</td>
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<tr>
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<td>0.53</td>
<td>0.48</td>
<td>0.32</td>
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</tr>
<tr>
<td>40</td>
<td>0.22</td>
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</tr>
<tr>
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<td>0.56</td>
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<td>0.06</td>
</tr>
</tbody>
</table>

#### Generalized Forecast Error variance decomposition for variable
LZIDSAR(e) with unrestricted intercepts and no trends.

<table>
<thead>
<tr>
<th>HORIZON</th>
<th>LZIDACPI (q)</th>
<th>LZIDAR (q)</th>
<th>LEACPI (q)</th>
<th>LZIMTB (q)</th>
<th>LSATB (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>0.00</td>
<td>0.04</td>
<td>0.03</td>
<td>0.53</td>
<td>0.00</td>
</tr>
<tr>
<td>20</td>
<td>0.01</td>
<td>0.10</td>
<td>0.02</td>
<td>0.87</td>
<td>0.00</td>
</tr>
<tr>
<td>30</td>
<td>0.02</td>
<td>0.15</td>
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</tr>
<tr>
<td>40</td>
<td>0.02</td>
<td>0.23</td>
<td>0.88</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>50</td>
<td>0.03</td>
<td>0.22</td>
<td>0.90</td>
<td>0.72</td>
<td>0.00</td>
</tr>
</tbody>
</table>

#### Notes: The bold faced amounts denote in percentage the variable’s variance explained by own shocks
over the forecast horizon

## Impulse Response Functions

Impulse response analyses can be used to estimate the time profile of the effect of “particular” shocks to either the cointegrating relations or the individual equations. The generated generalized impulse response analysis of both the individual equations and the cointegrating vectors to shocks in the LZIMCPI (p) and LZIDSAR (e) equations are portrayed in Figure 7 overleaf.
The first 2 figures A and B show impulse response paths on individual equations to one SE shock in the equations of the domestic price (LSACPI \( p_t \)) and exchange rate (LZIDSAR \( e_t \)). It is evident that effects of the shocks to individual equations seem to persist forever confirming the variables' unit root properties. The results are the same for shocks to other variables.

The last 2 figures C and D, show impulse response of cointegrating vectors to shocks in the LZIMCPI \( (p_t) \) and LZIDSAR \( (e_t) \) equations. Shocks in the domestic price (LZIMCPI \( p_t \)) are slowly dissipated and the cointegrating vectors return to their equilibrium values in about 3 years for the UIP and 5 years for the PPP (36 months and 60 months respectively). When the exchange rate (LZIDSAR \( e_t \)) is shocked, it takes a very long time for cointegrating very long to return to their equilibrium conditions.

Notes: Horizon is in Months and CV1 and CV2 in (C) and (D) stands for the PPP and UIP vectors respectively.
Persistence Profiles

Unlike impulse response functions, which are not unique, persistence profiles are unique and measure the time profile of the effect of a system-wide shock on the cointegrating relations. Because they are unique, persistence profiles also have the advantage that they do not require prior orthogonalization of the shocks. Figure 8 illustrates the persistence profiles. While the estimates of the PPP profiles converge to zero, that of the UIP seem to persist forever. Persistence profile of the PPP relation overshoots for barely a month then declines to zero very slowly, totally converging to zero after 6 years. Sluggish though it is, the convergence of PPP to equilibrium is in sharp contrast to that of the UIP, which appears to persist forever. This could explain why the cointegration tests for the combined PPP and UIP suggested one, instead of two cointegrating relations. In view of this finding it is not surprising to find that the validity of the UIP proposition has been generally rejected in the majority of previous empirical studies.

Figure 8: Zimbabwe Persistence Profiles

NOTES: The variables in the VAR (2) model are $p_t, p_t^*, e_t, r_t$ and $r_t^*$. The first cointegrating relation CV1 is for the PPP and the second one CV2 is for the UIP and $\beta_{11} = (1, -1, -1, 0, 0)$ and $\beta_{22} = (0, 0, 0, 1, 1)$ are the PPP and UIP vectors respectively. The horizon is in months.
Both the AIC and SBC selects optimal VAR (2). Diagnostic tests (LR test) for possible serial correlation in the residuals of the individual equation suggest that autocorrelation is not a problem in the present application. Appendix Table 5, presents Zimbabwe cointegration rank statistics defined by the eigenvalue and the trace statistic respectively, together with the corresponding asymptotic critical values at the 95 percent and 90 percent significance levels reproduced using VAR (2) and model (12).

Both statistics accept the hypothesis that there is, at most one, cointegration relation between the six I (1) variables under investigation. Since the results are not in agreement with the predicted confines of economic theory that there should be two long run (cointegrating) relations, namely the PPP and UIP relations defined as $p_t - e_t - p_t^*$ and $r_t - r_t^*$ respectively, we set aside the results of the statistical analysis and adopt theory restrictions for further analyses. Consequently, we proceed as if there are two cointegrating relations. We will however return to analyze the statistical results that $r = 1$ later.

We now examine the validity of the PPP and UIP hypothesis using the long-run structural modeling technique advanced in Pesaran and Shin (1999). The novel of this approach is that it enables us to test the validity of these hypotheses and to identify factors that might be responsible for their breakdown. The two cointegrating vectors associated with $z_i = (p_t, e_t, r_t, p_t^*, r_t^*, p_0, t)$ are denoted by $\beta_i = (\beta_{i1}, \beta_{i1}, \beta_{i2}, \beta_{i3}, \beta_{i4}, \beta_{i5}, \beta_{i6})$ and $\beta_i = (\beta_{i2}, \beta_{i3}, \beta_{i2}, \beta_{i32}, \beta_{i42}, \beta_{i52}, \beta_{i62})$ respectively, viewing $\beta_i^*$ as explaining domestic prices and $\beta_i^*$ domestic interest rate. The first six elements are the coefficients of the, I (1) variables and the last element (i.e., $\beta_{i6}, i = 1, 2$) refers to the time trend. As exact identification of these vectors requires the impositions of two restrictions per vector, the following exactly identifying restrictions are chosen as constraints and do not impose any testable restrictions on the cointegrating VAR model;

$$H_0: \beta_2 = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \begin{pmatrix} * & 0 & * & * & * & * & * \end{pmatrix}$$
Which produced the estimate:

$$
\beta_{e} = \begin{pmatrix}
1 & -0.7444 & 0 & 0.4487 & -1.1703 & -0.1207 & -0.0056 \\
(0.1005) & (0.5652) & (0.8853) & (0.0724) & (0.0030) \\
0 & -0.3199 & 1 & -0.7569 & 0.2884 & -0.0550 & 0.0056 \\
(0.1061) & (0.5761) & (0.8803) & (0.0610) & (0.0032)
\end{pmatrix}
$$

$LLE = 1880.0$

where $LLE (r = 2)$ is the maximized value of the log likelihood function for the justified case or subject to exact-identifying restrictions. Asymptotic errors are given in parentheses.

We then proceeded to test a number of hypotheses using the above just-identified model as a basic model and imposing over-identifying restrictions. First, since we do not expect these long-run relations to include a linear trend, we first test the co-trending hypothesis $H_{co}$, namely that, $\beta_0 = \beta_1 = 0$ and represented by:

$$H_{co}: \quad \beta_0 = \begin{pmatrix}
1 & * & 0 & * & * & * & 0 \\
0 & * & 1 & * & * & * & 0
\end{pmatrix}
$$

Under $H_{co}$ the following estimates were obtained:

$$\beta_{co} = \begin{pmatrix}
1 & -0.8988 & 0 & -0.4660 & -0.9260 & -0.0613 & 0 \\
(0.0617) & (0.2956) & (1.3562) & (0.0951) \\
0 & -0.1620 & 1 & -0.0869 & -0.1465 & (0.0949) & 0 \\
(0.0689) & (0.3417) & (1.5336) & (0.1094)
\end{pmatrix}
$$

$LL_{co} = 1878.5$
The log-likelihood ratio (LR) statistic for testing the two over-identifying restrictions for co-trending, is computed to be 2.98 ~ 2(1880.00-1878.50) which is below the 0.05 critical value of the chi-squared ($\chi^2$) distribution with 2 degrees of freedom. Hence the hypothesis that there are no linear trends in the cointegrating relations is not rejected although there was a linear trend in the underlying VAR model.

Second, the hypothesis implied by the PPP and UIP theories that the level of oil prices do not enter these long-run relationships denoted by $H_{po}$ is tested. To conserve space, only the results of this hypothesis combined with the co trending hypothesis, $H_{c0} \cap H_{po}$ is reported and it yields:

$$
\beta_{c0,po} = \begin{pmatrix}
1 & -0.9020 & 0 & -0.4997 & -1.4925 & 0 & 0 \\
0 & -0.1617 & 1 & -0.0126 & -1.0402 & 0 & 0 \\
\end{pmatrix}
$$

$$
\begin{pmatrix}
(0.5865) & (0.2733) & (1.1907) \\
(0.0861) & (0.4100) & (1.7340) \\
\end{pmatrix}
$$

$LL_{c0,po} = 1877.5$

The LR statistic associated with these 4 over-identifying restrictions is, 4.98, and thus does not reject the the $H_{c0} \cap H_{po}$ hypothesis at the 95 % critical level. Individual tests of $H_{po}$ undertaken seperately from $H_{c0}$ also produced similar results. Consequently tests for the validity of the PPP and UIP propositions are tested given $H_{c0} \cap H_{po}$.

Under the UIP hypothesis given $H_{c0} \cap H_{po}$:

$$
H_{UIP}: \quad \beta_* = \begin{pmatrix}
1 & * & 0 & * & * & 0 & 0 \\
0 & 0 & 1 & 0 & -1 & 0 & 0 \\
\end{pmatrix}
$$
the estimate of which is:

\[
\begin{pmatrix}
    p & e & r & p^* & r^* & p_0 & t \\
    1 & -0.9582 & 0 & -0.4990 & -1.5045 & 0 & 0 \\
    (0.0724) & (0.2597) & (1.1429) & & & & \\
    0 & 0 & 1 & 0 & -1 & 0 & 0 \\
\end{pmatrix}
\]

LL_{UIP} = 1874.3

Again the LR statistic of 11.35 is well below the 0.05 critical value of the chi-squared distribution with 7 degrees of freedom. Therefore, the UIP hypothesis considered jointly with \( H_{co} \cap H_{po} \), is not rejected.

Similarly under the PPP hypothesis and \( H_{co} \cap H_{po} \):

\[
H_{ppp}: \quad \beta_s = \begin{pmatrix}
1 & -1 & 0 & -1 & 0 & 0 & 0 \\
0 & * & 1 & * & * & 0 & 0 \\
\end{pmatrix}
\]

The following estimate was produced:

\[
\begin{pmatrix}
p & e & r & p^* & r^* & p_0 & t \\
1 & -1 & 0 & -1 & 0 & 0 & 0 \\
0 & -0.1587 & 1 & 0.1125 & -1.1824 & 0 & 0 \\
(-0.0902) & (0.3152) & (1.6811) & & & & \\
\end{pmatrix}
\]

LL_{PPP} = 1867.5

The LR statistic for testing the PPP hypothesis is 25.09, which is insignificant compared to the 0.05 critical value of the chi-squared distribution with 7 degrees of freedom (7 is the total number of over-identifying restrictions). Thus the hypothesis of the PPP (jointly with \( H_{co} \cap H_{po} \)) is rejected even at the 99 percent critical level.
We therefore consider several modifications to the PPP hypothesis (denoted by \( H_{ppp}^{*} \)) that allow for the effect of either domestic interest rate or foreign interest rate or both on the real exchange rate to be unrestricted respectively. The following are the restrictions and results:

i) unrestricted foreign interest:

\[
H_{ppp}\beta^* = \begin{pmatrix} 1 & -1 & 0 & -1 & * & 0 & 0 \end{pmatrix}
\]

which yields:

\[
\hat{\beta}_{ppp}^* = \begin{pmatrix} 0 & -0.1359 & 1 & 0.2596 & 0.3032 & 0 & 0 \\
1 & -1 & 0 & -1 & -5.0703 & 0 & 0 \\
0 & 1 & 0.8587 & 0.3157 & 1.2943 & 0 & 0 \end{pmatrix}
\]

\[
LL_{ppp}^* = 1870.0
\]

The LR statistic for testing \( H_{ppp}^{*} \) with unrestricted foreign interest rate is 20.08 which is well above the 0.05 critical value of the \( \chi^2 \) with 6 degrees of freedom. So this modified PPP version is rejected.

ii) unrestricted domestic interest

\[
H_{ppp}\beta^* = \begin{pmatrix} 1 & -1 & * & -1 & 0 & 0 & 0 \end{pmatrix}
\]

which yields:

\[
\hat{\beta}_{ppp}^* = \begin{pmatrix} 0 & -0.2378 & 1 & 0.3744 & -2.2893 & 0 & 0 \\
1 & -1 & 1.3921 & -1 & 0 & 0 & 0 \\
0 & 1 & 0.1263 & 0.3744 & 3.1067 & 0 & 0 \end{pmatrix}
\]

\[
LL_{ppp}^* = 1869.5
\]
The LR statistic for testing $H_{PPP}$ with unrestricted foreign interest rate is 20.08 which is also above the 0.05 critical value of the $\chi^2$ with 6 degrees of freedom. So this second modified PPP version is also rejected.

iii) unrestricted domestic and foreign interest:

$$H_{PPP}, \beta = \begin{pmatrix} 1 & -1 & * & -1 & * & 0 & 0 \\ 0 & * & 1 & * & * & 0 & 0 \end{pmatrix}$$

Which produced the following estimates:

$$\hat{\beta}_{PPP} = \begin{pmatrix} 1 & -1 & 0.9987 & -1 & (-3.3360) & 0 & 0 \\ 0 & -0.2609 & 1 & 0.8028 & -0.2350 & 0 & 0 \\ (0.4773) & (0.2303) & (0.6252) & (3.2020) & & & \end{pmatrix}$$

$$LL_{PPP} = 1871.3$$

The log-likelihood ratio statistic for testing $H_{PPP}$ with unrestricted foreign and domestic interest rate is 17.44 which is well above the 0.05 critical value of the $\chi^2$ distribution with 5 degrees of freedom. So this third modified PPP version is also rejected.

Taking the unmodified PPP rejected version and the accepted UIP we finally estimated the cointegrating relations under the PPP and UIP over-identifying restrictions (jointly with $H_{co} \cap H_{po}$) represented by:

$$H_{UIP}, \beta_{PPP,UIP} = \begin{pmatrix} 1 & -1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \end{pmatrix}$$

The LR statistic of 21.32 is above the 0.05 critical value of the chi-squared distribution with 10 degrees of freedom. Thus the PPP and UIP hypothesis considered jointly with $H_{co} \cap H_{po}$ is rejected at the 95% critical level.

To confirm if with further restrictions to the joint PPP and UIP the joint hypotheses are accepted or not, several modified versions of the PPP allowing for the effects of domestic
or foreign interest rate variables and, UIP allowing for effects of domestic or foreign prices were tested. Results are not recorded here to save space but are available. Both modifications to the PPP either leaving the coefficient of foreign interest rate or domestic interest rate variable unrestricted [with the UIP over-identifying restrictions, \( r_t - r_t^* = (1 - 1) \) holding], were rejected as the LR values obtained were all above the 0.05 critical value of the chi-squared distribution with 9 degrees of freedom. However, modifications allowing for either the effects of the domestic prices or the foreign prices to the UIP relations (with the PPP over-identifying restrictions \( p_t - e_t - p_t^* = 1 - 1 - 1 \), holding) are accepted.

The hypothesis testing the over-identified PPP \( [p_t - e_t = p_t^* = (1 - 1 - 1)] \) and the UIP with unrestricted foreign price coefficient, \( H_{PPP, \text{UIP}^*} \) is

\[
H_{PPP, \text{UIP}^*} \quad \beta = \begin{pmatrix}
1 & -1 & 0 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & -1 & 0 & 0 & 0
\end{pmatrix}
\]

Estimates from the cointegrating relations of this over-identified PPP and modified UIP (jointly with \( H_e \cap H_{po} \)) are:

\[
\beta_{PPP, \text{UIP}^*} = \begin{pmatrix}
p & e & r & p^* & r^* & po & t \\
1 & -1 & 0 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & 1.2175 & -1 & 0 & 0
\end{pmatrix}
\]

\( LL_{PPP, \text{UIP}^*} = 1874.6 \)

The LR statistic is 10.86, which is well below the 95 percent critical value of the chi-squared distribution with 9 degrees of freedom. Hence we are unable to reject the joint over-identified PPP and modified UIP (allowing for the effects of foreign prices into the UIP equation) hypotheses.

\[54\] Similar results are obtained if instead of the foreign price the coefficient of the domestic price is left unrestricted. The LR statistic obtained here is 14.47.
Therefore given Zimbabwe data, it can be reasonably surmised that, although the restrictions on both modified versions of the PPP are rejected when the PPP was tested on its own, the PPP is accepted when jointly tested with a modified version of the UIP allowing for the effects of either the foreign or the domestic price effects into the cointegrating relations. Thus when modeling their exchange rates based on the PPP and UIP, Zimbabwe policy makers should employ these two theorems jointly.

**The Vector Error Correction Model**

Conditional on the above long-run estimates, we have the following expressions for the error correction terms:

\[
\hat{\beta}_1 z_{t-1} = p_{t-1} - e_{t-1} - p^*_t,
\]

\[
\hat{\beta}_2 z_{t-1} = r_{t-1} - r^*_t + 1.2175 p^*_t.
\]

where \( \hat{\beta}_{z_{t-1}} = \xi_t \) which are I (0).

To check the resultant model's statistical adequacy, the following VECM was estimated:

\[
\Delta y_t = c_0 - \alpha_{y} \beta_{y} + \Lambda \Delta x_t + \Psi_{y} \Delta z_{t-1} + \alpha_{y} \beta_{z_{t-1}} + u_t
\]

\[
= c_0 - \alpha_{y} \beta_{y} + \Lambda \Delta x_t + \Psi_{y} \Delta z_{t-1} + \alpha_{y} \beta_{z_{t-1}} + u_t
\]

where \( \alpha_{y} \) and \( \alpha_{z_{t-1}} \) are three dimensional vectors of adjustment (error correction) coefficients. The number of error correction equations in the present application is 3, corresponding to the jointly determined variables of the model namely domestic prices \((\text{ZIMCPI} (p_t))\), exchange rate \((\text{ZIMER} (e_t))\) and domestic interest rates \((\text{ZIMTB} (r_t))\). The estimates of these adjustment coefficients together with a number of diagnostic test statistics are presented in Table 15, below.

The equation for the change in domestic prices \((\text{LZIMCPI} (\Delta p_t))\) passes most of the diagnostic tests except the normality test, with the equation also performing best in explaining 0.26 of the price variation over the sample period. Its error correction term associated with the first cointegrating relation explaining long run price movements (or
PPP), has a significant but small negative impact on current prices, suggesting a very slow speed of convergence to equilibrium for Zimbabwe prices in response to the domestic interest rate and the exchange rate. Domestic prices are therefore relatively endogenous. The equation for change in domestic interest rates (LZIMTB(\(r\))) performs the worst failing all diagnostic tests, except the functional form tests. Its error correction terms are insignificant. The error correction terms associated with the exchange rate (LZIMER(\(e\))) are all very small also indicating slow response to long run equilibrium once shocked.

Table 17:
Zimbabwe: Reduced Form Estimates of Error Correction Coefficients and Diagnostic Statistics- Intercontinental Approach

<table>
<thead>
<tr>
<th>Equation</th>
<th>(\alpha_{dy})</th>
<th>(\alpha_{fy})</th>
<th>(R^2)</th>
<th>(\chi^2_{SC}(12))</th>
<th>(\chi^2_{FF}(1))</th>
<th>(\chi^2_{H}(2))</th>
<th>(\chi^2_{HE}(1))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta ZIMCPI(p))</td>
<td>-0.053 (0.009)</td>
<td>-0.032 (0.008)</td>
<td>0.257</td>
<td>17.43 (0.134)</td>
<td>3.47 (0.063)</td>
<td>2717.8 (0.00)</td>
<td>0.38 (0.536)</td>
</tr>
<tr>
<td>(\Delta ZIMER(e))</td>
<td>0.028 (0.028)</td>
<td>0.035 (0.024)</td>
<td>0.063</td>
<td>20.74 (0.054)</td>
<td>1.61 (0.205)</td>
<td>1144.2 (0.00)</td>
<td>18.58 (0.000)</td>
</tr>
<tr>
<td>(\Delta ZIMTB(r))</td>
<td>-0.013 (0.005)</td>
<td>-0.006 (0.005)</td>
<td>0.149</td>
<td>33.37 (0.001)</td>
<td>0.40 (0.525)</td>
<td>360.75 (0.00)</td>
<td>16.00 (0.00)</td>
</tr>
</tbody>
</table>

Notes: The ECM results are estimated by OLS based on cointegrating VAR (2). The two error correction terms are given by:

\[ \tilde{\varepsilon}_{1t+1} = p_{t+1} - e_{t-1} - p_{t-1}^* \]
\[ \tilde{\varepsilon}_{2,t+1} = r_{t-1} - r_{t-1}^* + 1.2175 p_{t-1}^* . \]

The figures in (.) are estimated asymptotic standard errors whereas those in [.] are the corresponding \(\rho\) -values. The bold faced estimates denotes significance at 0.05 level. The diagnostic tests are Chi squared statistics for the following: \(\chi^2_{SC}(12)\) is the Lagrange multiplier statistic for testing the null of no serial correlation, \(\chi^2_{FF}(1)\) is Ramsey's RESET test statistic, \(\chi^2_{H}(2)\) is the Jarque- Bera statistic for testing the null of Gaussian errors, and \(\chi^2_{HE}(1)\) is the statistic for testing the null of no heteroskedasticity. The number in (.) indicates the degrees of freedom.

We now return to consider the estimation results under cointegration rank \(r = 1\), which is what the statistical results suggested (see Appendix Table 5). For this scenario we express,
\( z^*_i = (p, e, r, p^*_i, r^*_i, p_o, t) \) by \( \beta_* = (\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7) \). Under the exact-identifying normalizing restriction domestic price \((LZIMCPI (p))\) is equal to one, i.e., \( \beta_1 = 1 \), we obtained the following estimates:

\[
\beta_* = \begin{pmatrix}
1 & -0.83407 & 0.2800 & 0.2367 & -1.0895 & -0.1361 & -0.1361 \\
(0.1808) & (0.5421) & (0.7209) & (1.0022) & (0.0793) & (0.0042)
\end{pmatrix}
\]

\( LL = 1875.2 \)

Imposing the restrictions implied by \( H_{co} \cap H_{po} \) yields:

\[
\beta_* = \begin{pmatrix}
1 & -0.9648 & 0.3878 & -0.5047 & -1.8959 & 0 & 0 \\
(0.735) & (0.4617) & (0.2628) & (1.0265) & 0 & 0
\end{pmatrix}
\]

\( LL = 1873.9 \)

The LR for these two restrictions is 2.42, which is below the 95 percent critical value of the chi-squared distribution with 2 degrees of freedom. These restrictions are therefore accepted. Further imposing the restrictions that the coefficients of \( e, p_i^* = -1 \), namely \( \beta_2 \) and \( \beta_4 = -1 \) as indicated by the PPP hypothesis are strongly rejected. Modified PPP restrictions where in addition to the PPP over-identifying restrictions (combined with \( H_{co} \cap H_{po} \)) either the domestic interest rate or the foreign interest rate is unrestricted were also rejected. However modifications with the following restrictions are accepted (both domestic and foreign interest rates are unrestricted):

\[
H_{ppp} : \quad \beta_* = \begin{pmatrix} 1 & -1 & * & -1 & * & 0 & 0 \end{pmatrix}
\]

and it yields:
Next we assumed that the single cointegrating relationship in fact represents the UIP hypothesis. Normalizing on the coefficient of \( r \) and estimating the cointegrating relation subject to UIP restrictions (jointly with \( H_{0o} \cap H_{po} \)), namely \( \beta_3 = 1 \) and \( \beta_1 = \beta_2 = \beta_4 = \beta_6 = \beta_{1r} = 0 \), we obtain:

\[
\hat{\beta}_{\text{UIP}} = (0 \ 0 \ 1 \ 0 \ -1 \ 0 \ 0) \quad \text{LL} = 1854.9
\]

The LR statistic for testing these six (6) restrictions is equal to 40.57 and therefore strongly rejects the UIP hypothesis if \( r = 1 \). Further modifications to the UIP were also rejected.

One can conclude that results will differ depending on whether one chooses \( r = 1 \) or \( r = 2 \). With \( r = 1 \), the modified version of the PPP where interest rate differentials are unrestricted appear to be compatible with the data.

**Country summary and policy recommendations**

As an overall conclusion on Zimbabwe cointegration findings, it does appear as though the simple PPP does hold regardless of whether the foreign country is within the continent or outside. However, it does not hold in its strict sense i.e., in its symmetry and proportionality conditions. The same is true for the joint PPP and UIP. However, when the joint UIP and PPP model is used several modifications must be made to either the PPP or UIP propositions (as already discussed above) in order to yield optimal results. The validity of the UIP proposition is rejected regardless of whether the foreign country is within or outside the continent.

5.2.9 **Summary/Findings**

Although in almost every case except for Mauritius, the weak form PPP and joint PPP and UIP propositions were found valid as evidenced by the support for cointegration, the
theory restrictions based on the symmetry and proportionality conditions were mostly rejected. Results for the simple UIP are less favorable as generally the hypothesis was rejected except for a few countries. This conclusion holds irrespective of whether the intra-continental or the intercontinental of approach was used. The choice of numeraire country when testing the PPP therefore generally does not seem to matter.

The resounding rejection of proportionality and symmetry conditions for the PPP and UIP in almost every country with significant cointegrating vectors, is in line with previous findings (see Cheung and Lai (1993b) using a different set of countries). This rejection of the theories' symmetry and proportionality restrictions could be attributed to the fact that the asymptotic critical values used are not suitable in small samples. A recommendation for further studies would be to use asymptotic critical values adjusted for small samples. Also as some authors for example Taylor (1988) have argued, although symmetry and proportionality may apply to the exchange rates and certain theoretical aggregate price series, they may not apply when measured aggregate price series are used because of measurement error and time series noise and, perhaps because of the effect of tariffs and transport costs. Taylor (2000) also concluded that the large deviations from the PPP (and we add the UIP), during the current floating exchange rates, are attributable to larger shocks to the real-exchange rate process in such episodes.

The results of the Johansen procedure therefore only provide a weak empirical support for the PPP and UIP where cointegration exists but does not assist us to draw conclusions based on theory restrictions. It is long-run structural modeling, which then helps us to draw structural conclusions on the validity of these international parity hypotheses in their symmetry and proportionality conditions.

Other interesting observations were made (only for the intra-continental approach) on the different dynamic properties of our model as well as the different speeds of convergence when the VECM, forecast error variance decompositions, impulse response functions and persistence profiles were examined. The results obtained were as different as the number of countries tested. Overall however, the VECM and variance decompositions results generally showed the exchange rate as the leading variable and thus relatively the most exogenous in the Granger sense. A notable exception was for Zambia where the exchange
rate actually adjusts to restore equilibrium and hence is relatively the most endogenous variable.

The generalized impulse response paths differed between the countries depending on the variable shocked but the general observation was that shocks to individual variables persist forever, a finding which confirms the unit roots tests results. Impulse response of cointegrating vectors to shocks to different variables however, are only temporary and eventually dissipate at different speeds for each of the cointegrating vectors representing the PPP and UIP, as well as for each country included in the sample.

Results for the persistence profiles, which provide information on the speed with which the different relations on the model are shocked, will return to their long-run equilibria indicated that shocks do not persist forever. However the time it takes for the system to return to equilibrium once shocked differed from country to country and was also different between the PPP and UIP vectors ranging from 1 year for Zambia’s PPP to more than 12 years for Zimbabwe UIP. The fact that Persistence Profiles for the PPP and UIP relationships converge to zero is in line with our conclusions based on formal statistical tests that that the PPP and UIP long-run relationships does contain cointegrating properties. These results are consistent with, those found in literature (see Garratt and et al (2001), Rogoff (1996) and Johansen and Juselius (1992)).

An interesting finding though is that some PPP half-lives reported here for Botswana and Tanzania are shorter than the 4-5 years reported in most empirical literature. However, the fact that most of the literature is on industrialized countries with much lower inflation rates could explain this difference. Finally the fact that persistence profiles show that effects of shocks do not persist forever, rules out the possibility that a contradictory monetary policy can permanently shift the interest rate differential or a country’s exchange rate for that matter, a phenomenon reported in Eichanbaum and Evans (1995), cited in Garratt et al (2001).

Overall, our general finding is that the PPP and the joint PPP and UIP propositions are valid for the SADC but only in their weak form as evidenced by cointegration. Shocks to these long-run relationships do not persist forever but neither do they dissipate
immediately. The validity if the UIP is not is not conclusive as the theorem holds in exceptional cases for those countries with strong economic ties.
Arguably the dictates of data availability were the most challenging limitation. Given these data limitations the whole empirical modeling was fraught with difficulties, which led to some unnecessary delays. Also, because of this, the empirical undertaking of robustness checks, by making use of different price indices and data frequencies and or different sample periods was impinged upon, and therefore could not done. Albeit all this did not compromise the resultant quality of the analysis. It also did not have adverse effects on achieving the intended research purpose, as the findings are quite informative.

There is however a need to carry out more research using a longer sample data series as well as different frequency data. It will be also interesting to use the panel approach as opposed to the country by country analysis and see if better econometric results can found especially in as far as ascertaining the validity of the symmetry and proportionality conditions for the two parity theorems in Southern Africa.

Another recommendation as mentioned in the above chapter is for further studies to use asymptotic critical values adjusted for small samples in an attempt to find out if the theories’ restrictions can be accepted.

We also recommend that further studies be carried out on the same countries using data which include a variable which follows a stationary process to capture short run variations in, transport costs, information disparities and the effects of tariffs and non-tariff barriers in the model specification for the PPP. For the UIP model specification, a variable, which follows the stationary process to capture risk premium associated with the effects of foreign exchange uncertainties on risk-averse agents, should be added.

Finally another recommended way to test the PPP and UIP will be to test it in a more complete model of macroeconomy incorporating feedbacks and interactions omitted in partial analyses like real money balances and foreign output. A good example is found in Garratt and et al (2001), where using UK data, they demonstrate that the novelty of such a long-run structural model has the advantage shared by all VAR models in that it is able to
capture complicated dynamic relationships in the data, while at the same time it incorporates theory-consistent long-run properties in a transparent manner.
CHAPTER 7
CONCLUSION

This paper investigates the validity of the PPP and UIP international parity theorems in Southern Africa either in their simple forms or jointly using data from eight SADC countries. Another objective was also to establish whether the speed of convergence back to equilibrium once the system is shocked, is the same for all countries. The investigation was carried out using the cross national and the intercontinental approaches respectively. It was also the aim of the thesis to establish whether when testing the validity of these theorems, the results are influenced by the choice of the foreign country.

The novelty of our research into the PPP and UIP also lies in the choice of the econometric model, which we used. Reported results use cointegration techniques advanced by Johansen (1988, 1991) and Johansen and Juselius (1990, 1992) to establish the number of cointegrating vectors. Since in a multivariate framework, such as the one given by the PPP and UIP models, a vector error correction model may contain multiple cointegrating vectors, a question arises as to whether one can associate all of them with the exchange rate models or otherwise which vector is identified with it and what is the interpretation given to the others. Thus following the long-run structural modeling analysis developed by Pesaran and Shin (1997), a technique, which incorporates long-run structural relationships in an otherwise unrestricted autoregressive model, we test the validity of the PPP and UIP theories in their symmetry and proportionality conditions by imposing theory restrictions on the coefficients of the accepted cointegrating vectors.

Subsequently, for the intra-continental approach the long-run model was then subjected to Granger causality, generalized error variance decompositions, generalized impulse response and persistence profile analysis, in the context of a vector error correction framework, with the view of finding more about the dynamic properties of these theories over the sample period in SADC countries.

Firstly with the simple PPP we found evidence of statistically significant cointegrating vectors among the data sets for all countries tested except Mauritius. This finding of cointegration suggests that the PPP variables move together in the long run thus attesting to the validity of what we termed the validity of a weak form PPP in the SADC; a pleasing
finding considering the wide usage of the theory in Southern Africa. However there are quite a number of perversely signed and statistically significant coefficients. Also for all those countries where there were found cointegrating vectors, the theory restrictions of symmetry and proportionality conditions were mostly rejected. With the simple UIP results were less favorable as cointegration was only found in three out of the 8 countries.

Secondly using the joint PPP and UIP model, the variables under investigation exhibited signs of cointegration except for Mauritius, indicating the existence of a long-term relationship. However theory restrictions were generally rejected except for a few countries. Therefore, this study like most studies using post-Bretton woods data sets fail to reject the null hypothesis of non-cointegration of prices interest rates and the exchange rates but the estimated cointegrating vectors typically violate the symmetry and proportionality implied by the PPP and UIP in most cases.

Thirdly, using the intra-continental approach, the common conclusions of this research is that the exchange rates contain sizable mean reverting components but that this mean reversion vary between countries but is generally quite slow as indicated by the error correction terms. Deviations from the PPP are persistent but in the end largely disappear as evidenced by the persistence profiles and impulse response analysis.

Forth, regarding the issue of whether the PPP and UIP hold better for countries within the continent than those across continents, we conclude that except for countries with very strong trade and economic links the choice of foreign country does not seem to matter.

Overall we surmise that when we compare our findings to those in empirical literature, our conclusions lean more towards those whose findings support the validity of the PPP. We however observe that empirical evidence on the PPP and the joint PPP and UIP appears to be sensitive to the data set used and the way in which the analysis is conducted.
DESCRIPTION OF DATA

The prices, interest rates and exchange rates data used in this paper are monthly, spanning from January 1979 to May 2000. All data used was obtained from Financial Data Company, in California, USA. For some countries, data either for interest rates series or for the consumer price index was not available for the whole sample period and so the sample periods for these countries, had to be reduced (see data table below). Sample periods varied for individual countries with Mauritius having the shortest sample period spanning from June 1996 to May 2001.

The nominal exchange rate is defined as the price of foreign currency (US dollar or South African rand) in terms of the home currency, so an increase in the nominal exchange rate implies depreciation. The exchange rate used is the end of month, ruling nominal exchange rate. Price series is Consumer Price Index (CPI). For interest rates, the 3 months Treasury Bill (TB) rate was used except for Botswana, Swaziland and Tanzania where the Deposit rate was used as a proxy for the TB rate.

Data table

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Data Sample</th>
</tr>
</thead>
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<tr>
<td>Botswana</td>
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</tr>
<tr>
<td>Mauritius</td>
<td>June 1996 – May 2001</td>
</tr>
<tr>
<td>Namibia</td>
<td>January 1991 – December 2000</td>
</tr>
<tr>
<td>South Africa</td>
<td>January 1979 – May 2001</td>
</tr>
<tr>
<td>Swaziland</td>
<td>January 1979 – December 2000</td>
</tr>
<tr>
<td>Tanzania</td>
<td>January 1993 – December 2000</td>
</tr>
<tr>
<td>Zambia</td>
<td>January 1985 – December 1999</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>January 1979 – December 1999</td>
</tr>
</tbody>
</table>
DATA PLOTS

Appendix Figure - 1

US AND OIL PRICE

Appendix Figure - 2

BOTSWANA
Appendix Figure -3

Mauritius

TIME

VALUE

MTB
MCPI
MER
MRSAR

Appendix Figure -4

Namibia

TIME

VALUE

NCPI
NTB
NER
NDSAR
### Appendix Table 1:

**UNIT ROOTS TESTS RESULTS**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level Form</th>
<th>First Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World Oil Price</strong> (Unit Root Lag = 6)</td>
<td>(-2.8727) (-3.4283) (-3.4279) (-2.8727) (-2.8724)</td>
<td>(-2.8727) (-2.8724)</td>
</tr>
</tbody>
</table>

| 1. United States (Unit Root Lag = 6) | (-2.8727) (-3.4283) (-3.4279) (-2.8727) (-2.8724) | (-2.8727) (-2.8724) |

| 2. Botswana (Unit Root Lag = 6) | (-2.8727) (-3.4283) (-3.4279) (-2.8727) (-2.8724) | (-2.8727) (-2.8724) |
| In BCPI | -1.9597 -0.4247 -2.5403 -1.0128 -6.1563 -13.7008 | **(I)** Log of Botswana Price index |
| In BDR | -2.5829 -2.4765 -2.4258 -2.3343 -5.9841 -20.0318 | **(I)** Log of Botswana Deposit Rate |
| In BER | -0.0753 -1.9565 -0.0453 -2.2458 -7.7790 -14.1280 | **(I)** Log of Botswana US Exchange Rate |

| 3. Mauritius (Unit Root Lag = 4) | (-2.9101) (-3.4849) (-3.9069) (-3.4881) (-2.9199) (-2.9777) | (-2.9109) (-2.9777) |
| In MCPI | -2.3835 -2.1884 -1.7908 -1.1792 -1.8964 -8.3147 | **(I)** Log of Mauritius Price index |
| In MTB | -1.8958 -1.9690 -1.9114 -1.9215 -3.2463 -8.6503 | **(I)** Log of Mauritius Treasury Bill Rate |
| In MER | -0.4755 -1.8178 -0.7409 -1.9725 -2.3711 -7.2969 | **(I)** Log of Mauritius/US Exchange Rate |
| In MRSAR | -0.4755 -1.8178 -1.9114 -1.9215 -2.3712 -8.6503 | **(I)** Log of Mauritius SA Exchange Rate |

| 4. Namibia (Unit Root Lag = 12) | (-2.8884) (-3.4519) (-3.8859) (-3.4478) (-2.8887) (-2.8889) | (-2.8887) (-2.8889) |
| In NCPI | -0.5511 -2.6058 -2.3537 -3.1920 -4.1338 -9.2649 | **(I)** Log of Namibia Price index |
| In NTB | -1.3569 -1.2569 -1.3352 -1.6836 -3.0840 -9.9612 | **(I)** Log of Treasury Bill Rate |
| In NER | 0.8179 -2.5932 -0.4084 -2.2585 -3.8087 -8.4024 | **(I)** Log of Namibia/US Exchange Rate |
| In NDSAR | -2.5833 -2.5150 -11.3225 -11.3020 -3.7720 -42.5113 | **(I)** Log of Namibia/SA Exchange Rate |

**Notes:**

1. All level form values are converted to their natural logarithms. @CPI (Consumer Price Index) is the log of relative prices; @TB (Treasury Bill Rate) or @DR (Deposit Rate) is the log of interest rates; @ER is the log of the nominal exchange rate against the US dollar and, @SAR is the log of the nominal exchange rate against the South African Rand. Where @ represents the Initials for each respective country.

2. The ADF and PP are for Augmented Dickey-Fuller and Phillips-Perron Tests, respectively. ADF and PP are for the model with a constant term but no time trend. ADF, and PP, are for the model with a constant term and intercept and a time trend. Statistics are computed using varying lag lengths (as indicated in bold italics for each country in the table) regressions. The 95% critical values for the statistics are in (), adjacent to the lag length.

3. No ADF, and PP, statistics are reported for the first differences because there is no significant time trend in the first differences of the variables.
### Appendix Table 1: Continued

#### UNIT ROOTS TEST RESULTS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistics</th>
<th>Conclusion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$ADF_c$, $ADF_f$, $PP_c$, $PP_f$</td>
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</tr>
<tr>
<td></td>
<td>$ADF_{c,1}$, $PP_{f,1}$</td>
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</tr>
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<td>Difference</td>
<td>I (0) OR I (1)</td>
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<tr>
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<td>Statistics</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Level</td>
<td>Form</td>
<td>Level</td>
</tr>
<tr>
<td>5. South Africa (Unit Root Lag = 6)</td>
<td>(-2.8727), (-3.4283), (-2.8724), (-2.8727), (-2.8727), (-2.8724)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In SACPI</td>
<td>-3.7558</td>
<td>1.6413</td>
<td>-5.6938</td>
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<tr>
<td>In SATB</td>
<td>-2.9226</td>
<td>-2.4248</td>
<td>-2.1362</td>
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<td>In SAER</td>
<td>-0.1880</td>
<td>-1.8201</td>
<td>-0.1445</td>
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<td>6. Swaziland (Unit Root Lag = 6)</td>
<td>(-2.8727), (-3.4283), (-2.8724), (-2.8727), (-2.8724)</td>
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<tr>
<td>In SWCPI</td>
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<tr>
<td>In SWTB</td>
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<td>In SLSAR</td>
<td>-5.4474</td>
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<td>7. Tanzania (Unit Root Lag = 6)</td>
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<td></td>
</tr>
<tr>
<td>In TCPI</td>
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<td>In TDR</td>
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<td>In TIR</td>
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<td>8. Zambia (Unit Root Lag = 6)</td>
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<td>-1.0208</td>
<td>1.0234</td>
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</table>

Notes:

1. All level form values are converted to their natural logarithms. @CPI (Consumer Price Index) is the log of relative prices; @TB (Treasury Bill Rate) or @DR (Deposit Rate) is the log of interest rate; @ER is the log of the nominal exchange rate against the US dollar and, @SAR is the log of the nominal exchange rate against the South African Rand, Where @ represents the initials for each respective country.

2. The ADF and PP are for Augmented Dickey-Fuller and Phillips-Perron tests, respectively. $ADF_c$ and $PP_c$ are for the model with a constant term but no time trend. $ADF_f$ and $PP_f$ are for the model with a constant term or intercept and a time trend. Statistics are computed using varying lag lengths (as indicated in bold italics for each country in the table) regressions. The 95% critical values for the statistics are in (.), adjacent to the lag length.

3. No $ADF_f$ and $PP_f$ statistics are reported for the first differences because there is no significant time trend in the first differences of the variables.
Appendix Table 2:
Johansen's Cointegration Rank Test Statistics for the Simple PPP and UIP Hypotheses applied to SADC Countries data over the period 1979 (m1) - 2001 (m5)

*INTRA-CONTINENTAL APPROACH*

<table>
<thead>
<tr>
<th>Country</th>
<th>Botswana</th>
<th>Mauritius</th>
<th>Namibia</th>
<th>South Africa</th>
<th>Swaziland</th>
<th>Tanzania</th>
<th>Zambia</th>
<th>Zimbabwe</th>
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<tr>
<td></td>
<td>95% Crit</td>
<td>90% Crit</td>
<td></td>
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<tr>
<td><strong>Testing for Simple PPP</strong></td>
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<tr>
<td>Maximum Eigen' Statistic</td>
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<td></td>
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</tr>
<tr>
<td>( H_0 )</td>
<td>( H_1 )</td>
<td>( r = 0 )</td>
<td>( r = 1 )</td>
<td>( r = 2 )</td>
<td>( r = 3 )</td>
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<tr>
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<td>( 73.19^* )</td>
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<td>( r = 2 )</td>
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<tr>
<td>Maximum Eigen' Statistic</td>
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<tr>
<td>( H_0 )</td>
<td>( H_1 )</td>
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<td>( r = 2 )</td>
<td>( r = 0 )</td>
<td>( r = 1 )</td>
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<td>( 3.85 )</td>
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<td>SBC Criterion</td>
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<td>( r = 0 )</td>
<td>( r = 1 )</td>
<td>( r = 0 )</td>
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<td>( 6.55^* )</td>
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<td>( r = 0 )</td>
<td>( r = 0 )</td>
<td>( 6.55^* )</td>
<td>( 3.85 )</td>
<td>( 3.58 )</td>
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</tbody>
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Notes: We used the following equation to test for cointegration:

\[
\Delta X_t = \delta + \sum_{i=1}^{r-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-i} + \varepsilon_t
\]

where \( X_t = (p_t, e_t, p_t^*) \) for the PPP and \( X_t = (r_t, r_t^*) \) for the UIP.

The sample periods for each country differ depending on data availability (see appendix figure one for details) and \( r \) is the hypothesised number of cointegrating vectors. These values are estimated using the underlying optimal VAR (p) model for each country (the VAR order used for individual countries are reported under each country test results analysis), with unrestricted intercepts and no trends. The 95% and 90% critical values are in bold-italics and * stands for significance at 95% level while ** indicate significance at 90% level.
Appendix Table 3:
Johansen's Cointegration Rank Test Statistics for the Simple PPP and UIP Hypotheses
applied to SADC Countries data over the period 1979 (m1) – 2001 (m5)

*INTERCONTINENTAL APPROACH*

<table>
<thead>
<tr>
<th>Country</th>
<th>Botswana</th>
<th>Mauritius</th>
<th>Namibia</th>
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<td>25.8*</td>
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</table>

| **Testings Simple UIP** |          |           |         |              |           |          |        |          |
| Maximum Eigen Statistic |          |           |         |              |           |          |        |          |
| $r = 0$ | $r = 1$ | 9.56 | 9.33 | 11.18 | 10.96 | 10.94 | 4.82 | 3.21 | 7.68 | 14.88 | 12.98 |
| $r <= 1$ | $r = 2$ | 7.1 | 2.78 | 2.72 | 8.09** | 8.43 | 1.26 | 1.84 | 2.71 | 8.07 | 6.5 |
| **Trace Statistic** |          |           |         |              |           |          |        |          |
| $r = 0$ | $r = 1$ | 16.67** | 12.11 | 13.9 | 19.05* | 17.37** | 6.09 | 5.06 | 10.39 | 17.86 | 15.75 |
| $r <= 1$ | $r >= 2$ | 7.1 | 2.7 | 2.7 | 8.09* | 6.43 | 1.26 | 1.85 | 2.71 | 8.07 | 6.5 |
| **AIC Criterion** |          |           |         |              |           |          |        |          |
| $r = 2$ | $r = 2$ | $r = 2$ | $r = 3$ | $r = 2$ | $r = 0$ | $r = 0$ | $r = 2$ |
| **SBC Criterion** |          |           |         |              |           |          |        |          |
| $r = 0$ | $r = 0$ | $r = 2$ | $r = 0$ | $r = 2$ | $r = 0$ | $r = 0$ | $r = 0$ |
| **HQC Criterion** |          |           |         |              |           |          |        |          |
| $r = 2$ | $r = 1$ | $r = 1$ | $r = 2$ | $r = 2$ | $r = 0$ | $r = 0$ | $r = 0$ |

Notes: We used the following equation to test for cointegration:

$$\Delta X_t = \delta + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-1} + \Pi X_{t-1} + \varepsilon_t$$

where $X_t = (p_t, e_t, p_t^*)$ for the PPP and $X_t = (r_t, r_t^*)$ for the UIP.

The specific number of observations for each country, differ depending on data availability (see appendix figure one for details) and $r$ is the hypothesised number of cointegrating vectors. These values are estimated using the underlying optimal VAR (p) model for each country (the VAR order used for individual countries are reported under each country test results analysis), with unrestricted intercepts and no trends. The 95% and 90% critical values are in
bold-italics and * stands for significance at 95% level while ** indicate significance at 90% level.
### Appendix Table 4:
Johansen's Cointegration Rank Test Statistics for the Joint PPP and UIP Hypothesis applied to SADC Countries data over the period 1979 (m1) – 2001 (m5)

**INTRA-CONTINENTAL APPROACH**

<table>
<thead>
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<th>Country</th>
<th>Botswana</th>
<th>Mauritius</th>
<th>Namibia</th>
<th>South Africa</th>
<th>Swaziland</th>
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</table>

**Notes:** We used the following equation to test for cointegration:

$$
\Delta X_t = \Gamma_1 \Delta X_{t-1} - \Pi X_{t-2} + C_0 + \psi_0 p_0 t + \psi_1 \Delta p_{t-1} + \epsilon_t
$$

where, $X_t = [p_t, r_t, p_t^*, r_t^*, r_t^**, \ldots]$, $p_0 t$ is the logarithm of the world oil price at time $t$, $C_0$ is a vector of intercepts and, $t = 1, \ldots, T$.

The specific number of observations for each country, differ depending on data availability (see appendix figure one for details) and $r$ is the hypothesised number of cointegrating vectors. These values are estimated using the underlying optimal VAR (2), with unrestricted intercepts and no trends in the five $I(1)$ variables. All variables are used in their natural logarithms. The change in oil price variable is treated as an $I(0)$ conditioning variable. The 95% and 90% critical values are in bold-italics and * stands for significance at 95% level while ** indicate significance at 90% level.
Appendix Table 5:
Johansen’s Cointegration Rank Test Statistics for the Joint PPP and UIP Hypotheses applied to SADC Countries data over the period 1979 (m1) – 2001 (mS)

*INTERCONTINENTAL APPROACH*

<table>
<thead>
<tr>
<th>Country</th>
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<th>Mauritius</th>
<th>Namibia</th>
<th>South Africa</th>
<th>Swaziland</th>
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<tr>
<td>$H_0$</td>
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<td>27.10**</td>
<td>26.34**</td>
<td>9.72</td>
<td>22.8</td>
<td>25.28</td>
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</table>

| Trace Statistic |          |           |         |              |           |          |        |          |          |          |
| $H_0$ | $r = 0$ | $r = 1$ | $r = 2$ | $r = 3$ | $r = 4$ | $r = 5$ | $r = 6$ | $r = 7$ | $r = 8$ | $r = 9$ | $r = 10$ |
| $H_1$ | 46.49 | 36.95 | 69.65* | 94.76* | 72.7* | 89.17* | 72.49* | 66.17* | 61.54 | 59.39 |
| $r < 1$ | 21.44 | 22.51 | 30.39 | 41.61* | 30.52 | 35.94 | 40.7* | 15.26 | 40.37 | 35.97 |

| AIC Criterion |          |           |         |              |           |          |        |          |          |          |
| $r = 0$ | $r = 1$ | $r = 2$ | $r = 3$ | $r = 4$ | $r = 5$ | $r = 6$ | $r = 7$ | $r = 8$ | $r = 9$ | $r = 10$ |
| $r = 2$ | 21.44 | 22.51 | 30.39 | 41.61* | 30.52 | 35.94 | 40.7* | 15.26 | 40.37 | 35.97 |

| SBC Criterion |          |           |         |              |           |          |        |          |          |          |
| $r = 0$ | $r = 1$ | $r = 2$ | $r = 3$ | $r = 4$ | $r = 5$ | $r = 6$ | $r = 7$ | $r = 8$ | $r = 9$ | $r = 10$ |

| HQC Criterion |          |           |         |              |           |          |        |          |          |          |
| $r = 0$ | $r = 1$ | $r = 2$ | $r = 3$ | $r = 4$ | $r = 5$ | $r = 6$ | $r = 7$ | $r = 8$ | $r = 9$ | $r = 10$ |

Notes: We used the following equation to test for cointegration:

$$\Delta z_t = C_0 + \left(-\sum_{j=1}^{p} \Pi_j \gamma_j \right) + \Lambda \Delta x_t + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \Pi_i z_{t-i} + \mu_t$$

where $z_t = (p, e, p^*, r, r^*, po)$

The specific number of observations for each country, differ depending on data availability (see appendix figure one for details) and $r$ is the hypothesized number of cointegrating vectors. These values are estimated using the underlying optimal VAR (2) model except for Tanzania where we used Var (1), with unrestricted intercepts and restricted trends. Testing for cointegration is between the six I (1) variables $[p, e, p^*, r, r^*, po]$ in their natural logarithms for the joint PPP and UIP model, and foreign prices, interest rates and oil prices are treated as weakly exogenous. The 95% and 90% critical values are in bold-italics and * stands for significance at 95% level while ** indicate significance at 90% level.
SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

THE ORGANISATION

1: History

Born out of the positive experiences of closer cooperation among governments and the peoples of Southern Africa, the first Southern African Development Coordination Conference (SADCC) was held in Arusha, Tanzania in July 1979. The organization was officially formed in Lusaka, Zambia on April 1 1980 following the adoption of the Lusaka declaration- Southern Africa: Towards Economic Liberation. Its aim was to harmonize development plans and reduce the region’s economic dependence on South Africa for rail links, air links, port facilities, imports of raw materials and manufactured goods and the supply of electric power. The conference, which was attended by delegations from Angola, Botswana, Mozambique, Tanzania and Zambia also brought together representatives from donor governments and international agencies; the group was later joined by Lesotho, Malawi, Swaziland, and Zimbabwe, and Namibia became a member in 1990.

In 1985 a SADCC report noted that since 1980 the region had become still more dependent on South Africa for its trade outlets and the 1986 summit meeting, although it recommended the adoption of economic sanctions against South Africa, it failed to establish a timetable for doing so.

By the late 1980s, it had become apparent to the SADCC policy makers that the existing de facto international organization needed a treaty or some legally binding instruments to replace the Memorandum of Understanding. So in January 1992 a meeting of SADCC council of Ministers approved proposals to transform the organization into a fully integrated economic community and on August 17, of the same year the Declaration and Treaty establishing the SADC (see above) was signed in Windhoek Namibia. The Treaty places binding obligations on member countries with the aim of promoting economic integration towards a fully developed common market. South Africa subsequently became a member of the SADC in August 1994 and so did Mauritius and Seycheles, thus strengthening the objective of regional cooperation and economic integration.
2: Objectives of the Treaty Establishing the SADC

The Treaty declares the following objectives:

i. Deeper and accelerated regional economic cooperation and integration on the basis of balance, equality and mutual benefit, providing for cross border investment and trade, and free movement of factors of production, goods and services across national boundaries;

ii. To achieve self-sustaining common economic development, evolve political and social values, systems and institutions, enhancing of enterprise competitiveness democracy and good governance, respect for the rule of law and human rights, popular participation and the alleviation of overall poverty;

iii. Promote and achieve strengthened complementarity between national and regional strategies and programs, regional solidarity, defend peace and security, support the socially disadvantaged and, improve the standard and quality of life in order for the people of Southern Africa to live and work in harmony; and

iv. Achieve sustainable utilization of natural resources and effective protection of the environment as well as, strengthen and consolidate the long-standing historical, social and cultural affinities and links among the people of the region.

To achieve these objectives SADC shall aim to:

- Harmonize political and socio-economic policies and plans for member states;
- Mobilize the people of the region and their institutions to take initiatives to develop economic, social and cultural ties across the region, and to participate fully in the accomplishment of the SADC's projects and programs;
- Create appropriate institutions and mechanisms for the mobilization of requisite resources for the implementation of programs and operations for SADC;
- Develop policies aimed at the progressive elimination of obstacles to free movement of capital and labour, goods and services, and of the peoples of the region generally among member States;
- Advance the development of human resources to eradicate human poverty;
- Promote the development, transfer and mastery of technology;
- Improve economic management and performance through regional cooperation;
• Support the co-ordination and harmonization of the international relations of member states; and
• Secure international understanding, cooperation and support, and mobilize the inflow of public and private resources into the region;
• Develop such other activities as member States may decide in furtherance of the objectives of SADC.

3: The Treaty

The Treaty is a legally binding and all-encampassing framework by which countries of the region shall coordinate, harmonise and rationalise their policies and strategies for sustainable development in all areas of human endeavor. The Treaty commits member States to fundamentals of, (a) sovereign equality of member States, (b) solidarity, peace and security, (c) human rights, democracy and rule of law, and (d) equity balance and mutual benefit. Member states are expected to demonstrate their commitment to act in accordance with these principles as set out in article four of the treaty.

Sanctions may be imposed on member states which,
• Persistently fail without good reason to fulfil obligations assumed under the treaty;
• Implement policies which, undermine the principles and objectives of SADC
• Are in arrears for more than one year in the payment of contributions to SADC for reasons other than those caused by vis major or other exceptional circumstances.

4: Organization, Institutions and Structures (as of 2000)

Over the years SADC has managed to establish institutions through which its business is conducted, from policy making to administration.

Summit of Heads of States or Government

The Summit is held annually and is attended by the Heads of State and Government or their representatives. It is the supreme policy making organ of the SADC and is responsible for the general direction and control of the functions of SADC, including the
achievement of its objectives, creation of commissions institutions and committees and the appointment of the Executive Secretary and his/her deputy.

Council of Ministers
It consists of representatives of SADC member countries at Ministerial level, usually responsible for their country’s economic planning and/or finance. The Council is responsible for overseeing the functioning and development of SADC and ensuring that policies are properly implemented. It also advises the Summit on matters of overall policy and approves strategies and work programs for the SADC. One of its major tasks is the definition of sectoral areas of cooperation and the allocation to member states of responsibility for coordinating sectoral activities. The Council meets at least once a year to review progress and operations for its subordinate institutions.

Sectoral Committees and Commissions
SADC has constituted Commissions and Sectoral committees to guide and coordinate cooperation and integration policies and programs in designated sectoral areas. The sectors are allocated to individual member states to coordinate and provide leadership. Sectoral activities are supervised by, Sectoral Committees of Ministers.

Sectoral Commissions may be established as and when necessary through a convention or other instruments approved by the Summit and ratified by the member states. Commissions are regional institutions supported by all member states whereas Sector Coordinating Units are part of national governments.

The current specialized sectoral coordinating offices are:

i) **FOOD AGRICULTURE AND NATURAL RESOURCES:** The sector’s principle objectives are regional food security, agricultural development and natural resources development. The sector covers seven sub-sectors namely:

- Agriculture and Natural Research and Training (based in Botswana)
- Inland Fisheries, Wild Life and Forestry (based in Malawi)
- Food Security, Agriculture and Natural Resources (based in Zimbabwe)
- Livestock production and Animal Disease Control (based in Botswana)
- Environment and Land Management (based in Lesotho)
• Marine Fisheries and Resources (based in Namibia)
• Southern African Center for Cooperation in Agricultural Research -SACCA (based in Botswana)

ii) ENERGY: (based in Angola): Areas of activity in the energy sector include joint petroleum exploration, training programs for the petroleum sector and studies for strategic fuel storage facilities, promotion for the use of coal, development of hydroelectric power and the co-ordination of SADC generation and transmission capacities and new and renewable sources of energy including pilot projects in solar energy, assessment of the environmental and socio-economic impact of wood-fuel scarcity and relevant education programs, and energy conservation.

iii) TRADE, INDUSTRY and MINING: The sector aims to facilitate regional economic integration by the creation of an enabling investment and trade environment in SADC countries, the establishment of a single regional market by progressively removing barriers to the movement of goods, services and people and, the promotion of cross-border investment and foreign investment in mining. The sub sectors are:
• Industry and Trade (Based in Tanzania)
• Mining (Based in Zambia)
• Employment and Labor (based in Zambia)

iv) HUMAN RESOURCES AND DEVELOPMENT: As SADC aims to provide the region with skilled manpower in the categories of high level managerial personnel, agricultural managers, high and medium level technicians, artisans and instructors, the sector aims to harmonize, strengthen and improve education policy and training systems.

v) CULTURE AND INFORMATION (based in Mozambique): The sector is expected to emphasize regional and socio-cultural development as part of the process of greater integration.

vi) TOURISM (based in Lesotho): Its objective is to promote tourism within the context of national and regional socio-economic development objectives.
SOUTHERN AFRICAN TRANSPORT AND COMMUNICATION COMMISSION (based in Mozambique): At SADC’s inception transport was seen as the core area to be developed on the grounds that without the establishment of an adequate regional transport and communications system, other areas of cooperation become impractical. The sector also seeks to identify measures to simplify procedures at border crossings throughout Southern Africa.

Standing Committee of Officials

A Permanent Secretary or an official of equivalent rank, usually from the Ministry of Economic Planning or Finance of each member state makes the standing committee. This institution is a technical advisory committee to the council and meets at least once a year.

National Contact Points

National contact points are located in the Ministry responsible for all SADC matters and act as a vital link between other agencies of government and SADC organs. Their duties include regular consultation with and briefing of relevant government institutions, the enterprise community and media on matters relating to SADC.

Sectoral Contact Points

All government Ministries with responsibilities for SADC sector(s) are Sectoral Contact Points and they work closely with the respective Sector Coordinating Units in the preparation of sectoral policies, strategies and formulation of product proposals and monitoring of projects.

Secretariat

The Secretariat is the Principal executive institution of the SADC and is responsible for strategic planning and management of programs of the SADC, the implementation of decisions of the Summit and the Council. Headed by the Executive Secretary, who is appointed by the Summit, it is also charged with the organization and management of
SADC meetings, its financial and general administration, as well as representation and promotion of the SADC.

**Tribunal**

The tribunal shall be constituted to ensure adherence to and ensure proper interpretation of the provisions of the SADC Treaty and subsidiary instruments and to adjudicate upon such disputes as may be referred to it. Decisions of the Tribunal are final and binding. The SADC tribunal has not yet been constituted.
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