Uncovered Interest Parity, Purchasing Power Parity and the Fisher effect: Evidence from South Africa

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Abstract

This paper tests the validity of the Uncovered Interest Parity (UIP), the International Fisher Effect (IFE), and the Purchasing Power Parity (PPP) hypothesis in the context of South Africa using data of monthly periodicity from 1999 to 2014. We employ ordinary least squares regression, cointegration, causality, and impulse response functions for the empirical analyses. The results from the impulse response functions provide evidence for the rejection of the UIP, IFE and PPP for South Africa. Contrary to the UIP hypotheses, we show that in the event of shocks to the South African economy due to nominal interest rate increases, the rand will generally appreciate by approximately 2% against the euro. Moreover, an external shock due to increase in nominal interest rate in the euro-area leads initially to a transient 0.02% appreciation of the rand before it depreciates again by approximately 0.5% in the short run. Generally, we infer from the results that an increase in South Africa's interest rates prompts more capital inflows from foreign investors, leading to currency appreciation. Another implication from the results is that movements in the rand are influenced primarily by

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investor's actions in pursuit of higher yields, withdrawing funds when interest rate falls and conversely supplying more capital when interest rates increase. These results imply that the exchange rate market may still be inefficient, justifying more government intervention to eliminate inefficiencies. These interventions could include implementing mild capital controls to avoid excessive outflows during periods of economic slumps.

Keywords: South Africa, fisher effect, interest rate parity, exchange rate, capital flows.
JEL Classification: C5, C32, F3

1 – Introduction

One of the most widely researched empirical topics in the area of finance over the past few years has been the efficiency or, more accurately, the seeming inefficiency of the foreign exchange forward market. Specifically, a mammoth of surveys and studies have considered the supposed failure of the forward exchange rate to hold as unbiased predictor of future changes in spot rates, particularly in flexible exchange rate regimes. One crucial factor determining the exchange rate is the uncovered interest rate parity (UIP) condition. The UIP theory emphasizes the efficiency of the forward market, indicating that a country's currency is expected to depreciate against a foreign currency when the domestic interest rate rises higher than that of the foreign country. Uncovered interest rate parity (UIP) suggests that the interest rate differential between domestic and foreign country equals the expected change in the exchange rate. The differential in interest rate between the two countries will, on average, be similar to the *ex post* exchange rate movement. If the uncovered interest rate parity condition holds, the interest rate differential becomes an unbiased predictor of the *ex post* movement in the spot exchange rate. As an example, suppose the differential between one-year rand and dollar interest rates is 6 percent with the rand being higher, rational investors, who are deemed risk neutral, will then expect the rand to depreciate by 6 percent over the one year duration. This would cause the returns on the rand dollar to equalize. If instead the rand fails to adjust as expected, arbitrage opportunities would be created. Accordingly, the interest rate differential would be reflected by the forward rate.

A number of studies over the previous decades have attempted to investigate the validity of the uncovered interest rate parity in advanced world financial markets. The majority of these studies have mainly focused on economies with well-developed forward capital markets in foreign exchange rates, considering that data in those countries is much more readily available. It has been argued that the level of informational efficiency of these mature capital markets is superior to those which are less established, thereby making the interest parity hypothesis more plausible and occasions to make economic profits from the Uncovered Interest Parity (UIP) arbitrage unlikely (Adrangi, 2011). Additionally, frictions in the financial market, including the political and regulatory hurdles among developed markets has diminished over the recent period. This has further reduced opportunities for arbitrage in those foreign currency market establishments.

By testing the relevance and validity of the uncovered interest parity hypothesis in emerging markets like South Africa, the study will help to bridge the existing gap in the UIP literature concerning African economies. Because South Africa is considered an emerging economy, the UIP study will inform a determination of whether the movement in the actual exchange rate between two economies could equate to that which was implied by the interest rate differential in the past. The prevailing applied significance of this issue is that many big hedge funds now operating in the financial markets of emerging countries have sought to take advantage of mispricing market through different currencies (Cao *et al.*, 2015). This is despite the risky nature of earning economic profits in that manner and the unfavorable peculiar position in which the action of hedge fund managers has often left countries like South Africa.

The fundamental conjecture forming the crux of the UIP theory relates to the notion that capital markets are efficient and that prices reflect thoroughly all available information to all participants in the market (Stigler, 1957; Malkiel and Fama, 1970; Malkiel, 2005; Narayan *et al.,* 2015). Therefore, no profitable opportunities will be possible in the market. This suggests that exchange rates adjust swiftly to new information emerging in the market. In addition, market participants do not only have rational expectations but are also assumed to be dominated by investors who are risk neutral. Supposing that the assumptions are genuine and the UIP condition holds, the expected return realized from holding domestic currency as opposed to holding a foreign currency is offset by the opportunity cost associated with holding funds in the domestic currency against the foreign currency (Foy, 2005). Consequently no investor(s) can gain attractive arbitrage opportunities arising from currency with high yield because such a currency will be anticipated to depreciate against the other currency in the market. The depreciation will be equivalent to the amount approximately equal to the differential in interest rate between the domestic and foreign country. Empirical tests of the UIP theory often fail to accord with the facts.

A number of reasons have been advanced to explain the failure of UIP. Amongst these are expectations, risk neutrality and the presence of a time-varying risk premia (see Chinn & Meredith, 2005). In this study, an attempt is made to analyze evidence of the UIP relation using data from South Africa as the base country, United States, India, Eurozone, Japan, and China. Compared to developed economies, South Africa, just like other emerging markets (EMs), is often characterized by higher nominal interest rate and higher inflation (Alper *et.al*, 2009). Differences with respect to economic conditions may also have a direct impact on the relationship between nominal interest rate differences and the exchange rate depreciation (Chinn, 2006). Therefore, it is interesting to test the UIP in the context of an emerging market such as South Africa. More importantly, the need for this study is spurred by the fact that the UIP condition has implications for the efficiency of the foreign exchange market, an area of academic and professional research that is at its infancy. For example, the failure of the UIP presents opportunity for international investors to make profit. In the event that South Africa's currency does not appreciate following a decline in interest rates below those prevailing in the US, investors can earn a risk-free return by moving funds from South Africa in favour of holding American securities. This process may result in excessive capital outflows which may result in unfavourable outcome for the country, thereby affecting economic growth negatively.

According to data collected by the World Bank, the South Africa capital account balance declined from $31 in 2010 to $25 in 2013, despite efforts by the Federal Reserve Bank (FRB) to reduce interest rate during this period. Mohamed & Finnoff (2004) found that capital flight as a percentage of GDP was on average 6.6 percent between 1980 and 2000. Excessive capital flight may lead to significant currency and financial crisis. The 2008 Global Financial Crisis which also affected South Africa implies the vulnerability of the country to foreign financial contagion. For a country with an integrated and relatively open capital market such as South Africa, failure of the UIP, the related PPP and the International Fisher Effect hypothesis to hold, could lead to high capital outflows. This may necessitate a need for capital controls by the monetary authorities, though other dynamic peculiarities may hinder such measures.

The Uncovered Interest Parity Test, PPP and International Fisher Effect hypotheses are crucial because of their implications for the efficiency of the foreign exchange market. Market inefficiency implies that arbitrage opportunity is possible whereby investors can earn additional returns by borrowing from low interest rate country and invest in high interest rate country to earn proceeds. On the other hand, in order to affirm the Law of one Price, it is important to ascertain whether past increases in domestic prices have often been accompanied by commensurate depreciation of the domestic currency. Deviation from the PPP has direct implication on the efficiency of the markets. The International Fisher Effect posits that countries with higher interest rate generally tend to have higher inflation. While this case is generally accepted as valid, it is important to statistically test the significance of the hypothesis. Inter alia, the study attempts to answer the following questions: does uncovered interest parity, purchasing power parity and the International Fisher Effect hold for South Africa? What are the implications of the findings on the foreign exchange/capital markets? What is the relationship between UIP, PPP and IFE and movements in South Africa's capital account, and finally, what can policy makers glean from these relationships?

The remaining sections of the paper are organized as follows: Section 2 handles the literature review; Section 3 deals with data and methodology; and Sections 4 and 5 present empirical analysis and conclusion, respectively.

2 - Literature review

Extant literature on UIP has found that countries with relatively high interest rates tend to experience currency appreciation. These findings have made the UIP hypothesis testing an empirical failure for many studies. Part of the existing literature does not find adequate evidence in support of the UIP hypothesis. Part of the challenge in testing the UIP hypothesis stems from the difficulty associated with testing it directly, thereby relying heavily on rational expectations theories and unbiased hypothesis argument. Studying the UIP, PPP and Fisher Effect for emerging markets has often been approached with more highlighted caution. Alper *et al.,* (2009) notes that unlike developed markets, emerging markets are characterized by poor macroeconomic fundamentals, unstable economic conditions, weak financial markets, and need for greater institutional reforms. Consequently, these inherent differences between emerging and developed markets have implications on the UIP empirical tests. The peculiarity of emerging capital markets may violate some fundamental assumptions typically advanced when studying UIP, PPP and the International Fisher Effect in developed markets. These assumptions may include perfect substitutability of assets and negligible transactional costs. Surprisingly, despite the peculiarities already pointed and the expectation that UIP results from emerging markets was supposed to be more unfavourable when using the same methodology as the one typically applied for developed markets, the results are nonetheless less unfavourable (Alper et al., 2009).

In the empirical literature, various attempts have been made to test international parity hypotheses, such as the uncovered interest rate parity (UIP) and Purchasing Power Parity (PPP), both of which play a fundamental role in exchange rate and currency determination (MacDonald & Taylor, 1990). These parity hypotheses are usually considered as either arbitrage relations, which in the case of UIP is assumed to hold constantly, or sometimes just as long-run equilibrium relations, such as PPP. With regard to PPP, for most of the existing literature, there have been two competing views whereby on one side researchers argue that real exchange rates series are non-stationary (Roll, 1979; Adler & Lehmann, 1983; MacDonald, 1985). On the other side, as more investigations intensified, studies found that the real exchange rate exhibited stationary patterns and therefore free from unit root (Huizinga, 1987; Dornbusch, 1989; Whitt, 1992). Testing for the PPP using co-integration methodology advanced by Engle & Granger (1987), Taylor (1988) argues that the PPP fails to hold in the long run. However, contrary to Taylor (1988), a plethora of studies relied on the Johansen (1991) co-integration methodology to test the PPP and found that the parity condition holds in the long run (Kugler & Lenz, 1993; MacDonald & Marsh, 1994; Fisher & Park, 1991). Assuming that investors are risk neutral and market participants have rational expectations, studies based on the uncovered interest parity condition have typically favoured the rejection of the UIP (Cumby & Obstfeld, 1981; Davidson, 1985; Taylor, 1987).This failure of the PPP and UIP condition to hold suggest markets are inefficient and irrational (MacDonald & Taylor, 1992).

Closely related with the UIP and PPP is the Fisher Effect which states that worldwide real interest rates are made equal across boarders through arbitrage. In this process, the level of real interest rate is determined by the demand and supply of funds whereby investors chase investment opportunities in countries where real interest rates are higher. Interest rate differentials between two integrated capital markets can be attributed to factors such as psychological barriers, political risk, (Solnik & Roulet, 2000), legal constraints, transaction costs, and currency risks (Taylor, 1998). However, in the absence of capital market imperfections and free capital mobility, interest rate differentials between markets are eliminated. Equilibrium in capital markets is therefore characterized by a state where the differential in nominal interest rate is approximately equal to the differential in expected inflation between the domestic and foreign country (Demirag & Goddard, 1994). Essentially, the international Fisher Effect states that differences in observed nominal interest rate between countries are owed to differences in inflation.

Despite the theoretical appeal, the Fisher Effect has yielded conflicting econometric evidence. Shapiro (1998) conducted a study for 22 countries by comparing their nominal interest rate and concluded that generally, countries with higher inflation rates tend to have higher interest rates. Aliber and Stickney (1975) observed for both developed and developing countries that the International Fisher Effect holds in the long run but no sufficient evidence was found to prove that it also holds in the short-run. More support in favour of the International Fisher Effect was further provided by Kane & Rosenthal (1982) for the period 1974-1979 who examined the Eurocurrency market and concluded that the International Fisher Effect is fulfilled in the long run.

Robinson & Wartburton (1980) were amongst the first group of researchers to dispute the empirical validity of the International Fisher Effect by arguing that the appreciation of the currency with lower nominal interest rates in relation to the currency with the higher nominal interest rate would in the medium run, erode any possibility of earning higher interest returns. Using the residual-based co-integration test methodology by Engle & Granger (1987), Mishkin (1992) argued that in the presence of a common stochastic trend on interest rate and inflation, the International Fischer Effect may hold. However, Gonzalo (1994) showed that the Engle-Granger test as applied by Mishkin is not sufficiently robust in detecting stochastic trends and argued that the most suitable approach would be the maximum likelihood method. Yuhn (1996) found that while there was no significant evidence in support of the Fisher Effect in the United Kingdom and Canada, the findings revealed that results for Germany confirmed the validity of the International Fisher Effect. Moreover, similar to Aliber & Stickey (1975), Yuhn (1996) found that the Fisher Effect is more powerful in the long period horizon but weak during periods of policy regime changes. Coppock & Poitras (2000) found that the Fisher Effect does not hold because interest rates do not fully adjust to inflation.

The overwhelming evidence against the UIP, PPP and the International Fisher Effect may be attributed to errors as a result of overlooking the linkages between an asset and goods markets (Johansen & Juselius, 1992). Employing the Johansen & Juselius (1992) co-integration framework that allows for interactions in the determination of interest rates, prices and exchange rates and different horizon dynamics, Caporale *et al.*, (2001) find evidence in support of the UIP and PPP.

While there has been extensive research done on the UIP in many regions around the world, the focus on emerging African economies like South Africa has been scarce and limited. The availability of credible data sources has contributed to limitations associated with conducting quantitative research on the African continent. As the African economies begin to modernize their institutions, the challenge pertaining to data availability and accessibility is gradually diminishing. Crucial investigation on the UIP for South Africa was conducted by Lacerda *et al.*, (2010), who in an attempt to circumvent modelling which previously ignored shifts in policy regimes and the concomitant distortions on the PPP and UIP relations, constructed a vector error correction model (VECM) which is based on a Markov-switching vector. This model incorporates shifts in exchange rate and monetary regimes in which the UIP and PPP is tested as a joint long-run relationship in the presence of shifts in both the political and economic regimes. Their standard linear VECM results reveal weak evidence in favour of the UIP and PPP, despite some residual indications that the functional form is inappropriate. However, the constructed Markov-switching VECM gives compelling evidence in support of the PPP and UIP, as well as, an improved distribution of the residuals.[1]

3 – Methodology

3.1 The uncovered interest rate parity (UIP)

With free capital mobility and capital markets which are assumed to be perfect, the relationship of the change in exchange rate and interest rate differential between the domestic (SA) and foreign country (e.g. U.S.) is defined below:

$$\mathrm{r_t - r_t{}^* = f_t - e_t} \qquad (1)$$

where r_t is the domestic (SA) interest rate, $r_t{}^*$ is the foreign interest rate, f_t is the forward rate and e_t is the domestic spot exchange rate. However, testing the UIP comes with a number of challenges because according to Isard (1996), expectations regarding the future exchange rates are not directly observable. Therefore, the current forward rate is assumed to equal the expected exchange rate $E(e_{t+1})$ as well as a forecast error term. The above relation assumes that investors are risk neutral. Factoring in expectations about future exchange rate, we have:

$$r_t - r_t^* = E(e_{t+1}) - e_t \quad (2)$$

Assuming the UIP hypothesis holds, capital moves freely across borders and investors are indifferent between investing in South African or U.S. assets because returns between the two countries is the same. Capital market imperfections under a flexible exchange rate regime lead to interest rate differences between the two countries. The simplest version of the uncovered interest parity condition is stated as:

$$r_{t+n} - r_{t+n}^* = [E(F_{t+n}) - e_t]/e_t \quad (3)$$

where, r_{t+n} and r_{t+n}^* are the domestic and foreign nominal interest rates respectively. F_{t+n} is the *n-horizon* forward rate.

Under the Uncovered Interest Rate Parity (UIP) condition, there are no arbitrage opportunities as the domestic interest rate (r_t) and foreign interest rate (r_t^*) equals the spread in the exchange rate yield. When investors are risk neutral, the UIP condition is simplified as:

$$\Delta e^e_{t,t+k} = (r_{t,k} - r_{t,k}^*) \quad (4)$$

$\Delta e^e_{t,t+k}$ represents the expected percentage change in the spot exchange rate, *t*, denotes the spot exchange rate period and *k* is the future exchange rate period, (r_t) and (r_t^*) defines domestic (South African) and foreign (US) interest rate respectively. Equation (4) assumes that there are no arbitrage opportunities between South Africa and the US, implying the change in the exchange rate and the interest rate differential are in equilibrium. This implies that investors cannot earn extra return by moving funds between countries. When investors are risk averse, equation (4) becomes:

$$\Delta e^e_{t,t+k} = (r_{t,k} - r_{t,k}^*) + \delta_{t,t+k} \quad (5)$$

Where $\delta_{t,t+k}$ represents the risk premium required by risk averse investors who expect to be compensated for the risk of holding securities. The caveat of equation (5) is that the expected exchange rate cannot be observed. Engel

(1996) attempted to circumvent this caveat by formulating that the market movement at period *t+k*, with information efficiently utilized at time *t*, can be determined as:

$$e_{t,t+k} = e^{e}{}_{t,t+k} + \mu_{t,t+k} \qquad (6)$$

The term $e^{e}{}_{t,t+k}$ denotes the expected future exchange rate under the assumption of rational expectation. $\mu_{t,t+k}$ defines the white-noise stochastic process which is not correlated with the exchange rate spread at period *t*. From equation (5) and (6), we get:

$$\Delta e_{t,t+k} = (r_{t,k} - r_{t,k}{}^{*}) + \delta_{t,t+k} + \Delta\mu_{t,t+k} \qquad (7)$$

Assuming that the terms $\delta_{t,t+k}$ and $\mu_{t,t+k}$ are statistically independent of the interest rate differential, equation (7) can be re-written in a testable form of the Uncovered Interest Parity (UIP) hypothesis (see Chin and Meredith, 2005):

$$\Delta e_{t,t+k} = \alpha + \beta(r_{t,k} - r_{t,k}{}^{*}) + \varepsilon_{t,t+k} \qquad (8)$$

The term $\varepsilon_{t,t+k}$ represents the white noise and assuming rational expectations in exchange markets and risk-neutrality amongst investors, α should equal zero to reflect the absence of a constant risk premium and β should be equal to one to capture a complete depreciating relation as posited according to the UIP. The UIP requires that as the interest-rate differential widens, the exchange rate should equally adjust through depreciation. For instance, if the foreign currency (say dollar) is two percent higher than the rand, the dollar is expected to depreciate by two percent after the two year period. Interest rate parity reinforces the balance between exchange rates and preventing arbitrage opportunities. The absence of the balance between the two currencies implies that both the foreign and domestic investors would not prefer to hold lower interest rate bonds. It must be noted that prior to estimating equation 8, unit root test ought to be executed to avoid obtaining spurious results.

3.2 The purchasing power parity (PPP)

As outlined in Section 2, purchasing power parity (PPP) is one of the most crucial theoretical notions in international finance. Purchasing power parity describes the quantity of baskets of goods and services that can be bought as defined by a representative bundle of goods. The absolute version of the PPP compares the absolute price level between two countries against the level of the exchange rate in the respective countries. The PPP relation is defined below:

$$(e_{t+1} - e_t)/e_t = (\pi^d - \pi^f)/(1 + \pi^f) \quad (9)$$

Where π^d and π^f represents domestic and foreign inflation rate respectively. Equation (9) implies that the exchange rate should be such that the domestic and foreign prices are equal. The relative PPP postulates that the differences in inflation between countries (domestic and foreign), is captured by changes in the exchange rate, implying for instance that if inflation in South Africa is higher than in the United States by a particular percentage, the US dollar must appreciate by the percentage by which South Africa's inflation exceed that of the US. The linear relation of the relative PPP is shown below:

$$\Delta e_t = \emptyset + \rho(\pi^d - \pi^f) + \varepsilon \quad (10)$$

3.3 The International Fisher effect

The International Fisher Effect hypothesis is a generalized relative version of the PPP positing that the possibility of arbitrage opportunities will ensure that real interest rates are equalized across economies. If real interest rates are equal between two countries, the observed differences in nominal interest rates are owed to differences in expected inflation. Equalization of real interest rates across countries requires perfect markets with free capital mobility (Taylor, 1988). In equilibrium, the differential in expected inflation rate is equal to the nominal interest rate differential (Demirag & Goddard, 1994). This relation is represented in equation (11) in which $r_{d,t}$ and $r_{f,t}$ are the domestic and foreign interest rate respectively; $E(\pi^d)$ and $E(\pi^f)$ denote the domestic and foreign country expected inflation rate.

$$\frac{(1+r_{d,t})}{(1+r_{f,t})} = \frac{(1+E(\pi^d))}{(1+E(\pi^f))} \quad (11)$$

Combining equation (9) and (11) yields the International Fisher relation:

$$\frac{((e_{t+1}-e_t)}{e_t}=\frac{(1+r_{d,t})}{(1+r_{f,t})} \quad (12)$$

The international Fisher Effect captured in equation (12) states that worldwide real interest rates are made equal across boarders through arbitrage. In this process, the level of real interest rate is determined by the demand and supply of funds whereby investors chase investment opportunities in countries where real interest rates are higher. Interest rate differences between two integrated capital markets can be attributed to factors such as psychological barriers, political risk, and inflation (Solnik & Roulet, 2000), legal constraints, transaction costs, and currency risks (Taylor, 1988). However, in the absence of capital market imperfections and free capital mobility, interest rate differentials between markets are eliminated.

The International Fisher relation regression model discussed below is similar to that of Sundqvist (2002). When a market is efficient, the exchange rate makes an immediate adjustment to reflect the new information on which all rational market participants make their decisions (Cheung *et al.*, 2005). Given a certain set of information, φ_t at time t, the expected future spot exchange rate can be represented as:

$$E(e_{t+1},\varphi_t) \quad (13)$$

Given all the available information at time t, on average, the expected future spot rate is approximately equal to the future spot rate (Hansen & Hodrick, 1980):

$$e_{t+1}=E(e_{t+1},\varphi_t) \quad (14)$$

In order to capture the difference between the actual future spot rate realized and the expected future spot rate, an error term ϑ_{t+1} is added to equation (14). The assumption that all market participants are rational implies that the error term is not correlated with the available information at time *t.*

$$e_{t+1}=E(e_{t+1},\varphi_t)+\vartheta_{t+1} \quad (15)$$

The International Fisher Effect regression model to be estimated takes the form below:

$$(e_{t+1}-e_t)/e_t=\alpha+\gamma((r^d-r^f)/(1+r^f))+\vartheta_{t+1} \quad (16)$$

The coefficient α captures the value by which the exchange rate changes when the nominal interest rate differential is equal to zero. The null hypothesis for the International Fisher is that $\alpha = 0$ and $\gamma = 1$. Just like the UIP and PPP regression models discussed above, equation (16) coefficients will be estimated using Ordinary Least Squares.

3.4 Data and descriptive statistics

The study uses the ZAR/USD, ZAR/YEN, ZAR/YUAN, ZAR/RUPEE and ZAR/EURO spot exchange rates and discounted (nominal) interest rates for both South Africa as the domestic country and the U.S, Japan, China, India and the Euro area respectively. To incorporate the Purchasing Power Parity (PPP) and the International Fischer effect, we also use consumer price inflation (CPI) data from these countries, as well as the real interest rate. The data frequency is monthly and covers the period 1999-2014. The data used are obtained from the websites of the Federal Reserve Bank of St. Louis and individual country national or central banks.

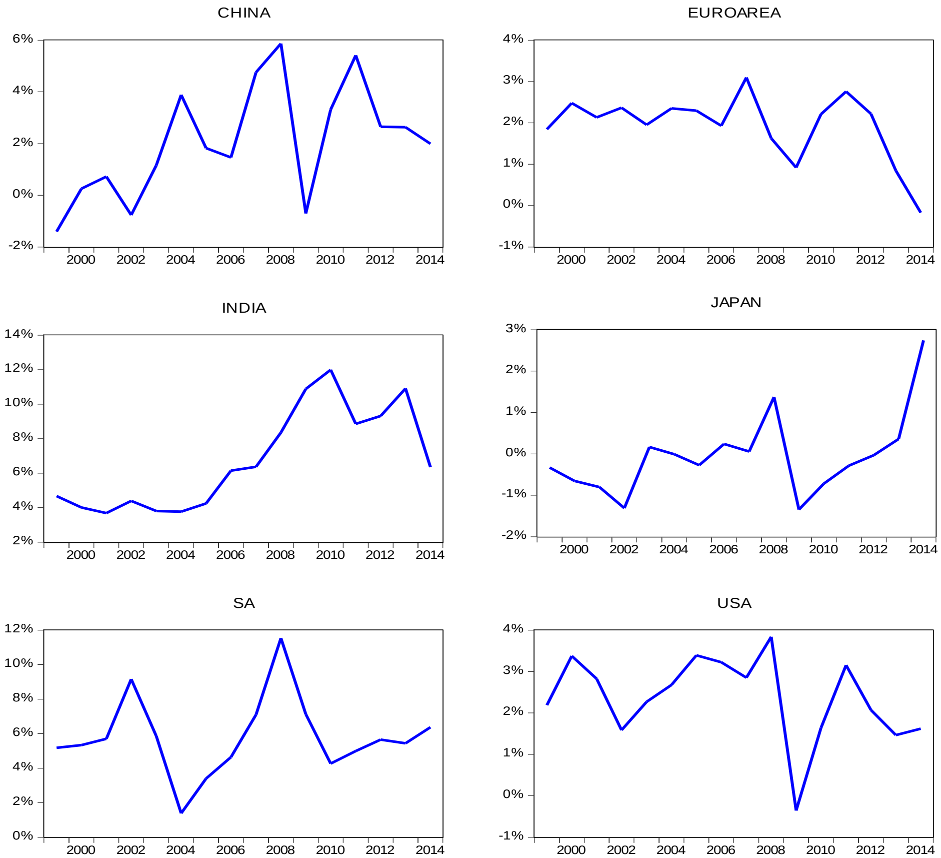
Table 1 depicts summary statistics for the nominal interest rates, real interest rates and inflation for the sampled countries. Of these countries, South Africa has the highest average nominal and real interest rates (9% and 3% respectively) while Japan has the lowest real and nominal interest rates. Contrary to inflation trends in developed economies, the relatively high inflation environment in South Africa necessitates commensurate high interest rates by monetary authorities. In his work on the long run relationship between inflation and interest rates, Mishkin (1992) finds that a 1% increase in the rate of inflation leads to a 1.34% increase in the nominal interest rate. The highest nominal interest rate period for South Africa was 1999 when the interest rate reached 19%, coinciding with inflation rate of approximately 6%. South Africa recorded its highest inflation rate for the period under review in 2008 as the globe slumped into a financial meltdown emanating from developed countries. The Inflation trend across the selected countries for the period under review is depicted in the Figure 1.

Table 1: Descriptive statistics-1999-2014

Monthly nominal interest Rates (%)						
	South Africa	**United States**	**Japan**	**India**	**Euro-Area**	**China**
Mean	0.09	0.03	0.00	0.07	0.03	0.03
Median	0.08	0.02	0.00	0.06	0.03	0.03
Maximum	0.19	0.06	0.01	0.10	0.06	0.05
Minimum	0.05	0.01	0.00	0.06	0.00	0.03
Std. Dev.	0.03	0.02	0.00	0.01	0.02	0.00
Skewness	0.59	0.61	0.83	0.91	-0.06	1.31
Jarque-Bera	13.07*	23.79*	22.29*	31.59*	9.50*	122.15*
Monthly real interest rates (%)						
Mean	0.03	0.00	0.00	0.00	0.01	0.01
Median	0.02	-0.00	0.00	0.00	0.01	0.01
Maximum	0.13	0.03	0.01	0.04	0.03	0.07
Minimum	0.01	-0.02	-0.01	-0.06	-0.06	-0.02
Std. Dev.	0.02	0.01	0.00	0.03	0.01	0.02
Skewness	0.70	0.26	-0.13	-0.52	0.02	0.15
Kurtosis	3.19	1.98	2.63	2.17	2.15	2.44
Jarque-Bera	15.49*	9.86*	1.592786	13.35*	5.44*	3.02*
Monthly inflation rates (%)						
Mean	0.06	0.02	0.01	0.06	0.02	0.02
Median	0.05	0.02	0.06	0.06	0.02	0.02
Maximum	0.11	0.04	0.12	0.12	0.03	0.06
Minimum	0.01	-0.07	0.03	0.03	0.02	-0.02
Std. Dev.	0.02	0.01	0.02	0.02	0.06	0.02
Skewness	0.69	-1.01	0.47	0.47	-0.77	0.16
Jarque-Bera	19.56*	39.73*	19.41*	19.41*	18.95*	6.77*

*Note: * indicates significance at 1 percent and non-normality of the series.*

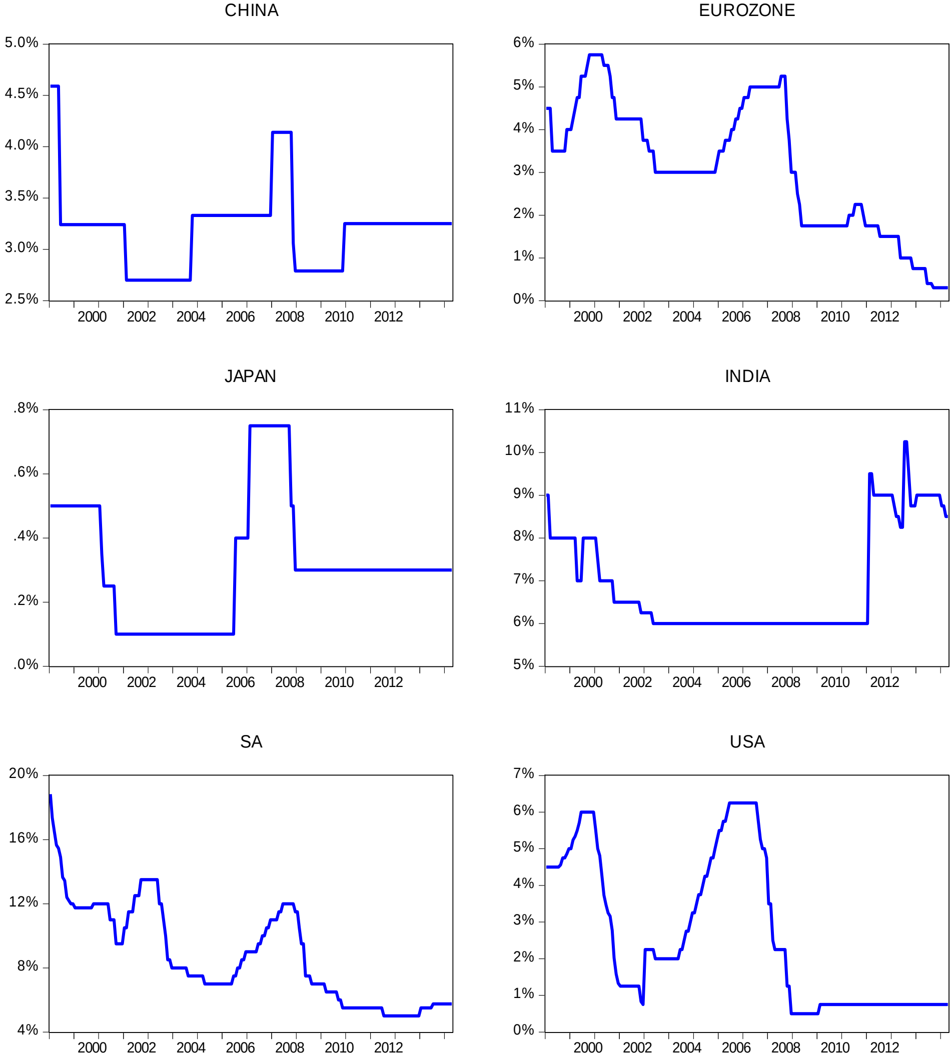
Figure 1: Monthly inflation rate-1999-2015



It is observed from Fig.1 that the scale of the financial distress of the Japanese economy beginning in the early 1990s was unprecedented amongst the developed world in the post War era, characterized by a deflationary spiral in which prices plummeted steadily (Cargill, 2001). As can be seen in Table 1, Japan's average inflation for the period is 1% while the average interest rate is 0%. The nominal interest rates in the U.S and Euro Area are also low, both averaging 3% for the period. Following the 2008 Great Recession and the European Sovereign debt crisis, the US Federal Reserve Bank and the European Central Bank have both embarked on a series of monetary stimulus efforts and interest rates cuts in an attempt to stimulate demand. Typical of most emerging countries, similar to South Africa (SA), India's average interest rates and inflation are also relatively high (7% and 6% respectively). China had average nominal interest rates similar to the U.S and Euro area average rates for the period (3%) while average inflation was moderate at 2%.

Historical nominal interest rates analyses (see Fig. 2) shows that starting in the mid-1970s; US interest rate generally increased significantly and reached a high of 14 percent in 1982. The relatively low interest rate environment of the early 1970s led inflation to rise and prompted the Federal Reserve Bank to hike interest rate sharply during the late 1970s and early 1980s (Cogley and Sargent, 2005). From 1983, US interest rates continued to decline and were at 1 percent in 2003. After rising from 1 percent to approximately 7 percent in 2007, the US interest rate began falling as a result of the 2008 Financial Crisis. The Federal Reserve Bank has since then kept interest rates at near zero. In the recent periods, US interest rates have declined significantly.

Figure 2: Historical nominal interest rates



The dynamics are not much different from India, China, Japan, and the Euro-area; which have reduced their interest rates in line with the global trend to stimulate economic growth. Japan enjoyed rapid economic growth, especially from mid-1960s through the 1970s. The rapid economic expansion was as a result of a large-consumption society, as technological progress stimulated the growth of manufacturing facilities, thereby increasing the sale of consumer durables (Koo, 2011). The resilience of the Japanese economy which was built in the 1960s shielded the country against effects of the two oil crises of the 1970s. However, the housing market bubble that began in the 1990s had tremendous negative impact on the general economy and led to a decade of weak growth and deflationary spiral (Ito & Mishkin, 2006). In an effort to restore economic growth, the Japanese Central Bank began aggressively reducing interest rates. From 1972 to 2014, interest rates in Japan averaged 3.04 percent and reached record low in 1999 (Koo, 2011).

Unlike South Africa, the US, India, Japan and the Euro-area, monetary policy in China has in recent years been conducted under difficult limitations, including a relatively underdeveloped financial system, fixed exchange rate regime and many institutional challenges (Goodfriend & Prasad, 2006). Interest rates in China have averaged 3.2% for 1999-2014 and were reduced significantly in 2002 and 2010. A desire to enhance trade led to liberalization efforts as authorities began a move towards a flexible exchange rate regime. These considerations have led the authorities to initiate a move towards a more flexible exchange rate regime. However, despite the intention to allow for greater flexibility, the Renminbi remain pegged to the dollar. The weak economic growth in the Euro-area, compounded more by the recent Greece severe debt crisis, has prompted the European Central Bank (ECB) to reduce interest rates. The bank began a series of aggressive interest rate cuts following the 2009-2010 Financial Crisis which saw most Euro member countries affected severely and sliding into recession (Martin & Phillippon, 2014). In India, interest rates have also tended to decline over the span.

Table 2: Exchange rate descriptive statistics- 1999-2014

Monthly exchange rates					
	ZAR_EURO	ZAR_RUPEE	ZAR_USD	ZAR_YEN	ZAR_YUAN
Mean	9.73	0.17	7.98	0.08	1.10
Median	9.63	0.16	7.57	0.07	1.05
Maximum	15.01	0.24	12.06	0.11	1.94
Minimum	6.20	0.13	5.73	0.05	0.69
Std. Dev.	2.29	0.02	1.60	0.02	0.32
Skewness	0.42	1.18	0.84	0.31	0.85
Kurtosis	2.39	4.60	2.65	1.70	2.86
Jarque-Bera	8.84*	66.37*	24.05*	16.96*	24.01*

*Notes: Note: * indicates significance at 1 percent and non-normality of the series.*
*South African Rand/Euro **(ZAR_EURO),** South African Rand/Rupee **(ZAR_RUPEE)**, South African Rand/USD **(ZAR_USD),** South African Rand/Yen (**ZAR_YEN),** South African Rand/Yuan (**ZAR_YUAN).***

Figure 2: Exchange rate movement: South Africn Rand against selected currencies (1999-2015)

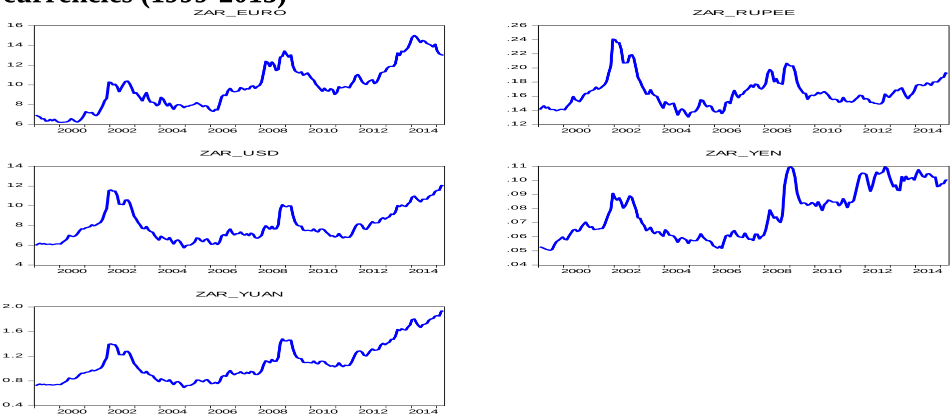


Table 2 provides summary statistics of the relationship between the rand and the selected currencies. The rand has averaged R9.70 against the Euro, R0.17 against the Rupee, R7.9 against the USD, R0.08 against the Japanese Yen, and R1.10 against the Renminbi. South Africa uses a free floating exchange rate determined by market forces. The spot and forward rate for the rand-dollar exchange rate is depicted in Fig. 3. The rand has depreciated steadily against the U.S. Dollar over the time horizon under review. The forward exchange rate movement closely mirrors the spot exchange rate trend. South Africa's rand has tended to depreciate against the selected countries' currencies in the study.

In Fig. 3, it is noted that the South African rand has weakened against the selected currencies to reflect a number of factors, among them the weak economic fundamentals and low investor sentiments, (Zouaoui *et.al,* 2011), lower yields compared to those in the US, compounded by several downgrades of the country's sovereign bond ratings by rating agencies (Block & Vaaler, 2004). Generally, the rand is seen to have depreciated against the selected currencies.

4 - Empirical analysis

4.1 Unit root test

Table 3 shows the Augmented Dickey Fuller (ADF) unit root tests results for the interest rate, interest rate differential between the domestic and foreign country (Panel A), and exchange rate (Panel B) series. Results in Panel A suggest that all the series of nominal domestic (South Africa) and foreign interest rate are differenced-stationary, despite mixed orders of integration at the levels.

Similar to Panel A, the evidence presented in Panel B shows that the hypothesis of unit roots in the exchange rates can be rejected at the first difference. The focus now turns to the analysis of the variables which enters directly in the UIP models outlined in the methodology. The interest rate differential $(r_{t,k} - r_{t,k}{}^{*})$ is tested for presence of unit root using the ADF procedure as the one followed above. The results which are presented in Table 4, shows that the interest rate differentials are first-differenced stationary. The dependent variable, expected percentage exchange rate, $(\Delta e_{t,t+k})$ is also tested for stationarity in similar fashion as the interest rate differential and the results which are presented in Table 5, shows a stationary process at the levels.

Therefore, the expected percentage exchange rate data will be used in level form in the model.

Table 3: ADF Test on nominal interest rate and exchange rate

Panel A: ADF Nominal Interest Rate												
Countries	Levels						First Differences					
	Intercept			Intercept & Trend			Intercept			Intercept & Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
South Africa (Home country)	-3.781	-2.712	-2.152	-3.290	-2.628	-2.799	-11.63	-3.673	-4.625	-11.724	-6.366	-4.566
United States	-0.835	-1.128	-1.453	-1.004	-1.374	-1.795	-10.243	-6.269	-4.827	-10.224	-6.272	-4.811
China	-3.934	-3.935	-3.94	-3.924	-3.921	-3.913	-13.034	-13.038	-13.039	-13.090	-13.098	-13.096
Euro Area	-0.104	-0.483	-0.836	-1.336	-1.686	-2.064	-11.045	-7.074	-7.076	-11.065	-7.084	-7.085
India	-2.078	-2.075	-2.074	-2.563	-2.564	-2.563	-13.314	-11.583	-11.585	-13.406	-11.665	-11.664
Japan	-1.707	-1.701	-1.703	-1.72	-1.7201	-1.720	-13.310	-13.310	-13.310	-13.293	-13.293	-13.293
Critical Values												
1%			-3.463			-4.005			-3.464			-4.006
5%			-2.876			-3.433			-2.876			-3.433
10%			-2.574			-3.140			-2.574			-3.140

Panel B: ADF exchange rate												
Countries	Levels						First Differences					
	Intercept			Intercept & Trend			Intercept			Intercept & Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
R/¥ (Yuan)	0.501	-0.364	-0.364	-0.661	-1.526	-1.524	-9.677	-9.677	-9.677	-9.713	-9.713	-9.713
R/$	-0.508	-1.365	-1.364	-0.941	-1.783	-1.785	-9.761	-9.761	-9.761	-9.776	-9.776	-9.776
R/¥ (Yen)	-1.354	-1.928	-1.926	-2.048	-2.913	-2.914	-9.870	-9.870	-9.870	-9.845	-9.845	-9.845
R/€	-0.935	-1.253	-1.253	-1.977	-2.442	-2.442	-11.214	-11.214	-11.214	-11.191	-11.191	-11.191
R /Rupee	-1.912	-2.554	-2.557	-1.917	-2.552	-2.557	-10.458	-10.458	-10.458	-10.424	-10.424	-10.424
Critical Values												
1%			-3.463			-4.006			-3.464			-4.006
5%			-2.876			-3.433			-2.876			-3.433
10%			-2.574			-3.140			-2.574			-3.140

Table 4: ADF on interest rate differential

ADF Interest rate differential												
Countries	**Levels**						**First Differences**					
	Intercept			**Intercept & Trend**			**Intercept**			**Intercept & Trend**		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
SA-CHN	-2.942	-2.943	-1.873	-2.718	-2.719	-2.658	-12.220	-6.970	-6.970	-12.263	-6.952	-6.953
SA-USA	-3.018	-2.339	-2.310	-2.407	-2.048	-2.310	-10.90	-6.21	-4.38	-10.96	-6.20	-4.32
SA-IND	-2.077	-2.077	-2.077	-2.561	-2.561	-2.561	-13.318	-11.587	-11.587	-13.409	-11.669	-11.669
SA-JAP	-3.730	-2.681	-2.143	-3.352	-2.682	-2.881	-11.705	-6.461	-4.744	-11.800	-6.463	-4.681
SA-EUR	-4.780	-4.785	-2.933	-3.814	-3.814	-2.713	-12.354	-7.243	-4.852	-12.600	-7.335	-4.934
Critical Values												
1%	-3.463			-4.005			-3.464			-4.006		
5%	-2.876			-3.433			-2.876			-3.433		
10%	-2.574			-3.140			-2.574			-3.140		

Table 5: ADF test on expected percentage exchange rate

ADF Percentage Exchange rate						
Countries	Levels					
	Intercept			Intercept & Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
SA-CHN	-9.762	-9.762	-9.762	-9.762	-9.762	-9.762
SA-USA	-9.891	-9.891	-9.891	-9.881	-9.881	-9.881
SA-IND	-10.624	-10.624	-10.624	-10.600	-10.600	-10.600
SA-JAP	-10.163	-10.163	-10.163	-10.142	-10.142	-10.142
SA-EUR	-11.011	-11.011	-11.011	-10.981	-10.981	-10.981
Critical Values						
1%			-3.464			-4.006
5%			-2.876			-3.433
10%			-2.574			-3.140

4.2 Co-integration test

Following from the unit root test, we apply the Johansen-Juselius (1992) cointegration test to examine the possibility of a long-run equilibrium relationship between ($r_{t,k} - r_{t,k}^*$) and ($\Delta e_{t,t+k}$). The results are presented in Table 6. We find at least one cointegrating equation in each pair, implying a long run relationship between ($r_{t,k} - r_{t,k}^*$) and ($\Delta e_{t,t+k}$). The assumption of no cointegration in the series can therefore be rejected. Thus, despite the possibility that the interest rate differential and the expected percentage exchange rate can diverge substantially in the short-run, they will obey a long-run equilibrium relationship.

Table 6: Test for co-integration

Included observations: 190 after adjustments.						
Trend assumption: Linear deterministic trend						
Lags interval (in first differences): 1 to 4						
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**	No. of Cointegrating eqn(s)
SA-CHN	None *	0.162	38.213	15.494	0.000	2
	At most 1 *	0.036	6.140	3.848	0.010	
SA-USA	None *	0.168	39.757	15.491	0.000	2
	At most 1 *	0.046	7.540	3.84	0.010	
SA-IND	None *	0.217	45.324	15.494	0.000	1
	At most 1 *	0.012	1.485	3.841	0.220	
SA-JAP	None *	0.222	51.572	15.492	0.000	2
	At most 1 *	0.034	5.565	3.844	0.020	
SA-EUR	None *	0.205	55.013	15.495	0.000	2
	At most 1 *	0.063	12.635	3.846	0.000	

4.3 Long run UIP

The co-integration results form a fundamental basis for examining the two series (interest rate differential and the expected percentage exchange rates) for each of the five UIP test cases using Ordinary Least Squares to yield unbiased non-spurious regression results. Table 7 provides the long-horizon OLS estimation results for the UIP model.

Table 7: UIP long horizon (1999-2014)

$$\Delta e_{t,t+k} = \alpha + \beta(r_{t,k} - r_{t,k}^{*}) + \varepsilon_{t,t+k}$$

Variable	Coefficient		Std. Error	t-Statistic	Prob.	R^2
$(r_{SA} - r_{CHN}^{*})$	β	0.125	0.089	1.403	0.162	0.010
	α	-0.011	0.005	-2.017**	0.045	
$(r_{SA} - r_{USA}^{*})$	β	0.144	0.094	1.524	0.128	0.011
	α	-0.011	0.006	-1.845*	0.066	
$(r_{SA} - r_{IND}^{*})$	β	-0.202	0.189	-1.067	0.287	0.005
	α	0.012	0.013	0.972	0.331	
$(r_{SA} - r_{JAP}^{*})$	β	-0.011	0.100	-0.118	0.905	0.000
	α	-0.001	0.008	-0.160	0.872	
$(r_{SA} - r_{EUR}^{*})$	β	0.282	0.118	2.372**	0.018	0.028
	α	-0.018	0.007	-2.598**	0.010	

***Notes**: ** and * indicates significance at 5% and 10% levels respectively.*

In their UIP tests, Chinn & Meredith (2001) found that the UIP holds only at long horizons. Therefore the analysis begins with testing for the UIP in the long horizon. Examining the results from the UIP tests as depicted in Table 7, for each of the five domestic-foreign cases, we get interesting results. Starting with the β coefficient, the *t*-statistics and probability values suggest that the hypothesized UIP relation is insignificant for four out of the five cases (SA-CHN, SA-USA, SA-IND and SA-JAP). Similar to the findings of Lily *et al*. (2011), the β coefficient for the SA-IND and SA-JAP has wrong signs, opposed to the expectation of a positive slope coefficient. The UIP results for the SA-EUR zone however, seems to suggest that the hypothesized UIP relation between the euro-area and South Africa exists. In other words, the results for the SA-EUR case support the UIP which emphasizes the efficiency of the forward market, indicating that a country's currency is expected to depreciate against a foreign currency when the domestic interest rate rises higher than that of the foreign country. This implies that South Africa's rand is expected to depreciate against the euro when South Africa's interest rate rises higher than those prevailing in the euro-area. However, the SA-EUR exception does not hold for the other cases. The R^2 values portrayed in the table are very low, especially for the first four cases (SA-CHN, SA-USA, SA-IND and SA-JAP), suggesting that the interest rate differential between South Africa and the respective countries in the study are poor predictors of movements in the exchange rate. The value of the R^2 shows some minor negligible improvement for the SA-EUR case (0.03), though still insufficient to consider the interest rate differential as a good variable in explaining the variation in expected percentage change in exchange rates. Having tested the UIP at long horizon, we now turn to consider how the results differ when testing the UIP in the short run.

4.4 Short run UIP

Table 8 shows the regression results from testing the UIP at short-term horizon: 12 months, 16 months and 19 months. As it can be seen, the 12 months results reflect a definitive failure of the UIP, with very small *t*-statistics, wrong signs and too large coefficients. The signs and magnitude of the parameters seems to improve as we move from 12 month horizon to the 19 months horizon. In the 16 months and 19 month short-term horizon, two cases are observed in support of the UIP, namely the SA-IND and SA-JAP. However, the reduced degree of freedom associated with conducting UIP for short term horizon presents a number of challenges and caution with which the interpretation of the findings must be rendered, which could lead to distorted regression results.

Table 8: UIP Short Horizon (2013-2014)

$\Delta e_{t,t+k} = \alpha + \beta(r_{t,k} - r_{t,k}^*) + \varepsilon_{t,t+k}$						
	12 Months		16 Months		19 Months	
	Β	t-Statistic	β	t-Statistic	Β	t-Statistic
$(r_{SA} - r_{CHN}^*)$	-5.075	-0.881	-0.392	-0.194	0.833	0.439
$(r_{SA} - r_{USA}^*)$	-2.853**	-0.560	-0.572	1.768	0.600	0.345
$(r_{SA} - r_{IND}^*)$	-0.300	-0.739	1.044	2.672**	3.322***	4.381***
$(r_{SA} - r_{JAP}^*)$	8.621	1.298	0.79	0.338	2.890**	1.139
$(r_{SA} - r_{EUR}^*)$	0.700	0.396	1.118	1.246	1.803	1.777

***Notes**: *** , ** and * indicates significance at 1%, 5% and 10% levels respectively.*

4.5 The Purchasing Power Parity (PPP) and the International Fisher effect

The focus now turns to the related hypothesis of testing the validity of the Purchasing Power Parity (PPP) and the international Fisher Effect. The International Fisher Effect predicts that the domestic currency will depreciate against that of a foreign trading partner as a result of an increase in the domestic real interest rates above those of the foreign counterpart. On the other hand, the PPP relates the changes between currencies of two countries over a period of time to changes in the price levels between the two countries (Dornbusch, 1985). The PPP and the International Fisher Effect are therefore in many aspects comparable with the UIP.

Table 9 shows the OLS results of both the International Fisher Effect (Panel A) and the PPP (Panel B). Except for the SA-EUR case under the International Fisher Effect which seems to reflect a significant relationship between the real interest rate differential on the real foreign rate against the expected percentage change in exchange rate, the rest of the cases do not seem to display any evidence to suggest any statistically significant relationship between the interest rate differential, inflation and the changes in the domestic exchange rate. Nor does the value of the R^2 across all the International Fisher and PPP cases indicate any explanatory power of the interest rate differential or inflationary differences to explain variations in the expected percentage exchange rate. The findings from the UIP tests regarding the SA-EUR case which suggested that the UIP could hold between South Africa and the Euro-area is confirmed in the International Fisher Effect but not in the PPP results displayed in Panel B of Table 9.

In Table 9, evidence in support of the International Fisher Effect is found for the SA-EUR case, with significant values of both the slope and intercept coefficients. This finding is similar to the results in Table 7 which also suggest some evidence in support of the UIP for the case of SA-EUR. However, neither the PPP nor the International Fisher Effect holds for the other four cases, as the *t*-statistics yields insignificant results, as was found when testing for the validity of the UIP. The implication for the failure of the International Fisher Effect to hold is that a country with higher interest rates need not necessarily be matched by higher inflation. This also implies that an increase in inflation may not necessarily be accompanied by a depreciation of the currency.

4.6 Impulse responses

The evidence in favour of the UIP and the International Fisher hypothesis necessitates some more scrutiny on the response of the exchange rate to shocks in the economy due to nominal interest rates and inflation. In this section, we closely examine the dynamic reaction of the models to changes in external factors. An impulse response is used to investigate these reactions as function of time and other variables which are of interest in the dynamic models. The impulses are generated though vector autoregressive systems in which we attempt to establish linear interdependencies among the various time series utilized in the models.

Table 9: The International Fisher Effect & PPP

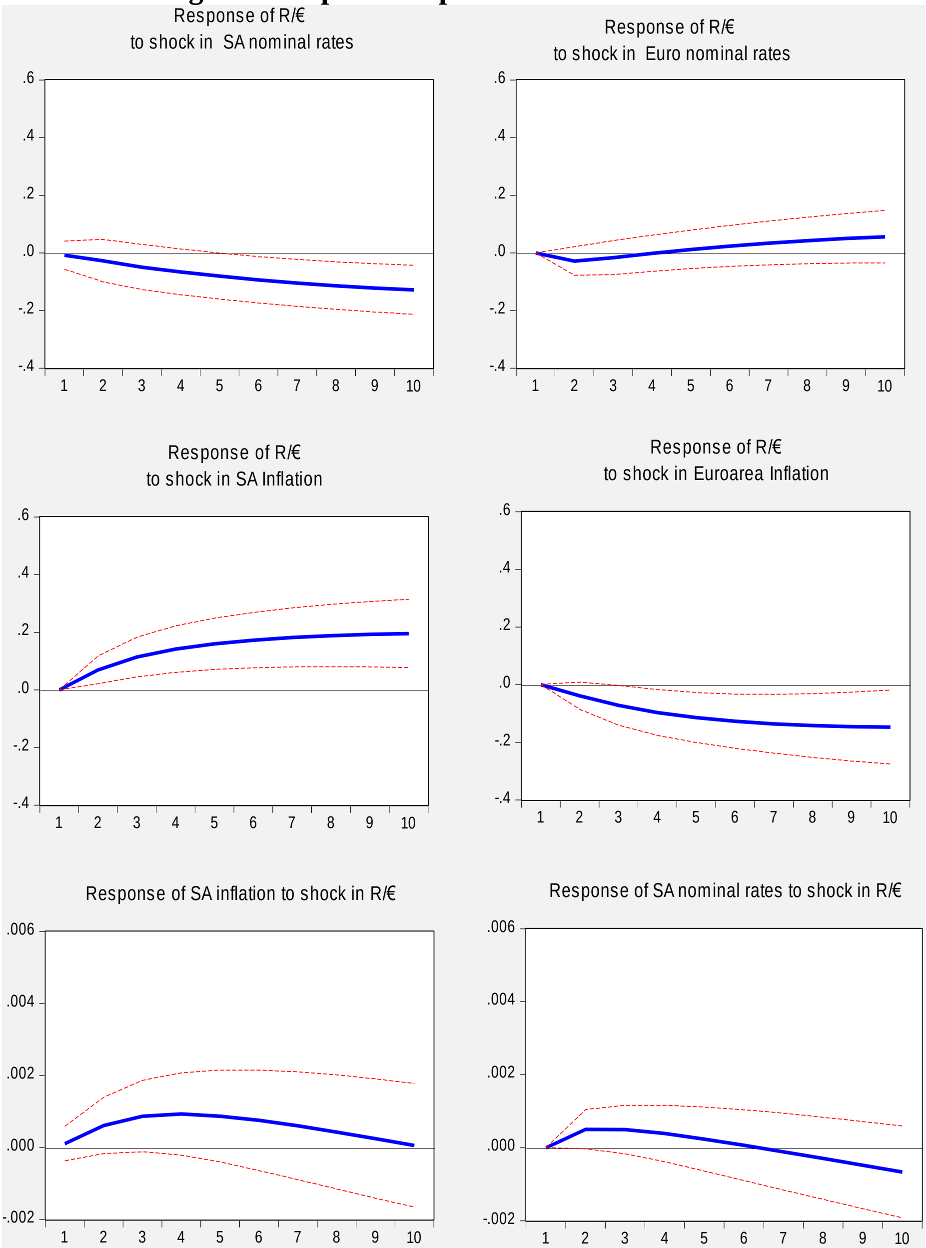
Panel A $(e_{t+1}-e_t)/e_t = \delta + \gamma((r^d - r^f)/(1+r^f)) + \vartheta_{t+1}$						
Variable	**Coefficient**		**Std. Error**	**t-Statistic**	**Prob.**	R^2
$(r^{SA}-r^{CHN})/(1+r^{CHN})$	γ	-0.066	0.115	-0.576	0.564	0.001
	δ	0.007	0.003	1.900*	0.058	
$(r^{SA}-r^{USA})/(1+r^{USA})$	γ	-0.117	0.123	-0.952	0.342	0.005
	δ	0.007	0.004	1.622	0.106	
$(r^{SA}-r^{IND})/(1+r^{IND})$	γ	-0.203	0.112	-1.799	0.073	0.017
	δ	0.008	0.004	1.873*	0.062	
$(r^{SA}-r^{JAP})/(1+r^{JAP})$	γ	-0.093	0.119	-0.783	0.434	0.003
	δ	0.007	0.004	1.576018	0.116	
$(r^{SA}-r^{EUR})/(1+r^{EUR})$	γ	-0.314	0.105	-2.988**	0.003	0.047
	δ	0.010	0.003	3.245***	0.001	
Panel B **PPP**						
$\Delta e_t = \emptyset + \rho(\pi^d - \pi^f) + \varepsilon$						
Variable	**Coefficient**		**Std. Error**	**t-Statistic**	**Prob.**	R^2
$(\pi^{SA}-\pi^{CHN})$	P	-0.069	0.093	-0.748245	0.455	0.003
	$\emptyset$	0.008	0.004	1.853529*	0.065	
$(\pi^{SA}-\pi^{USA})$	P	-0.053	0.111	-0.479	0.632	0.001
	$\emptyset$	0.005	0.004	1.229	0.220	
$(\pi^{SA}-\pi^{IND})$	P	-0.054	0.088	-0.613	0.540	0.002
	$\emptyset$	0.005	0.006	0.838	0.402	
$(\pi^{SA}-\pi^{JAP})$	P	0.145	0.142	1.023	0.307	0.005
	$\emptyset$	-0.004	0.009	-0.439	0.660	
$(\pi^{SA}-\pi^{EUR})$	P	0.118	0.107	1.096	0.274	0.006
	$\emptyset$	0.000	0.004	0.097	0.922	

Notes:**** , ** and * indicates significance at 1%, 5% and 10% levels respectively.*

The responses of inflation and nominal interest rate to shocks in the exchange rate are shown in Fig. 4. We observe that, in the event of shock in the economy due to nominal interest rate increase, the rand will appreciate by approximately 2% against the euro in the first period. An external shock due to increase in nominal interest rate in the euro-area leads initially to a transient 0.02% appreciation of the rand in the first period, before it depreciates against the euro by approximately 0.5%. However, this rather erratic path of response does not appear to be consistent with the UIP prediction, supporting the generally accepted proposition in the literature that the UIP in most cases fail to hold.

Following a domestic inflationary shock, the rand will adjust to the shock by depreciating against the euro by 1.8%, in line with the PPP and Fisher hypothesis (see Fig. 4). This behaviour could be attributed to a wide variety of factors. An increase in domestic inflation generally reduces the competitiveness of a country's currency in relation to that of the foreign trading partner. These findings are related with Mishkin's (1992) evidence in favour of the long-run Fisher Effect which showed how inflation has an effect on the exchange rate through the effects on interest rates, as they both have a common stochastic trend. The opposite happens when there are positive inflationary shocks in the euro-area, leading to a 1.9% appreciation in the rand, attributed to improving domestic competitiveness. A sudden exchange rate shock has an effect of increasing domestic inflation to 0.5% in the first period, before it eventually dampens to 0%.

Figure 3: Impulse Response Functions to shocks



4.7 Causality test: UIP, PPP and the International Fisher Effect

The next step involves looking at Granger Causality tests as initially proposed by Granger (1969) to examine whether there is a lead-lag effect between different series. For instance, the UIP hypothesis surmises that the interest rate differential between domestic and foreign country can be used to explain the expected percentage change in the exchange rate. The Granger Causality test therefore is interested in testing the validity of such hypothesis. Correlation is characterized by a tendency of variables to move together whether in positive or negative direction. In the case of UIP for instance, interest rate differential and expected percentage change in exchange rates appear to exhibit a correlated pattern in which the increase in the domestic interest rate occurs at the same time at which the exchange rate depreciates. However, it cannot necessarily be the case that the depreciation was caused by the increase in the domestic interest rate. The significance of the Granger test lies in separating relationships which are merely due to statistical correlation from those that are causal in nature. Thus, interest rate differential $(r_{t,k} - r_{t,k}{}^{*})$ can be considered to Granger-cause expected percentage in exchange rate, $\Delta e_{t,t+k}$ if it can be proved, usually through F-tests and probability values that the lagged values of $(r_{t,k} - r_{t,k}{}^{*})$ yields information in respect of future values of $\Delta e_{t,t+k}$ that is statistically significant. Table 10 provides such information, where column 1 shows the null hypothesis to be tested for each of the series. Column 2 and column 3 provide the F-tests and probability values respectively. Starting with the UIP examination for any causality in the series, the table displays the results for the PPP and the International Fisher Effect.

The UIP tests for each of the five cases shows that the interest rate differential series between South Africa and China does not Granger cause movements in the expected percentage exchange rate. Instead, it is the exchange rate movement which seems to have causal effect on the interest rate differential. The results are the same for the SA-USA case which show that the interest rate differential does not cause changes in the rand/dollar exchange rate. The SA-IND and SA-JAP cases show that neither the interest rate differential nor the exchange rate has any causal effect on each other. The evidence in favour of the UIP for the SA-EUR case as displayed in Table 7 is confirmed in the Granger Causality test, as the information in Table 7 shows that the hypothesis positing that the series$(r_{t,k} - r_{t,k}{}^{*})$, can be used to predict movements in the rand/euro exchange rate cannot be rejected, with the F-test value of 2.97.

Most of the evidences from the PPP also show that with the exception of the SA-EUR case, the inflation rate differential series $\left(\pi^{d} - \pi^{f}\right)$ cannot be said to cause changes in the exchange rate. The null hypothesis of no causal relationship between the series in the International Fisher Effect model is seen across all tested cases.

Table 10: Granger Causality

Null Hypothesis:	**F-Statistic**	**Prob.**
UIP		
$(r_{SA} - r_{CHN}{}^{*})$does not Granger Cause Percentage change **R/¥ (Yuan)**	1.161	0.313
Percentage Change R/¥ (Yuan) does not Granger Cause $(r_{SA} - r_{CHN}{}^{*})$	4.864	0.01
$(r_{SA} - r_{USA}{}^{*})$ does not Granger Cause Percentage change **R/$**	2.704	0.080
Percentage change **R/$** does not Granger Cause $(r_{SA} - r_{USA}{}^{*})$	4.752	0.012
$(r_{SA} - r_{IND}{}^{*})$ does not Granger Cause Percentage change **R /₹**	1.992	0.143
Percentage change **R /₹** does not Granger Cause $(r_{SA} - r_{IND}{}^{*})$	0.114	0.905
$(r_{SA} - r_{JAP}{}^{*})$ does not Granger Cause Percentage change **R/¥ (Yen)**	0.284	0.768
Cause Percentage change **R/¥ (Yen)** does not Granger Cause $(r_{SA} - r_{JAP}{}^{*})$	1.154	0.323
$(r_{SA} - r_{EUR}{}^{*})$ does not Granger Cause Percentage change **R/€**	2.978	0.051
Percentage change **R/€** does not Granger Cause $(r_{SA} - r_{EUR}{}^{*})$	3.340	0.047
PPP		
$(\pi^{SA} - \pi^{CHN})$does not Granger Cause Percentage change **R/¥ (Yuan)**	2.336	0.106
Percentage change **R/¥ (Yuan)** does not Granger Cause $(\pi^{SA} - \pi^{CHN})$	6.525	0.000
$(\pi^{SA} - \pi^{USA})$ does not Granger Cause Percentage change **R/$**	3.070	0.056
Percentage change **R/$** does not Granger Cause $(\pi^{SA} - \pi^{USA})$	9.70	0.00
$(\pi^{SA} - \pi^{IND})$ does not Granger Cause Percentage change **R /₹**	0.106	0.90
Percentage change **R /₹** does not Granger Cause $(\pi^{SA} - \pi^{IND})$	0.73	0.485
$(\pi^{SA} - \pi^{JAP})$ does not Granger Cause Percentage change **R/¥ (Yen)**	1.873	0.163
Percentage change **R/¥ (Yen)** does not Granger Cause $(\pi^{SA} - \pi^{JAP})$	4.543	0.015
$(\pi^{SA} - \pi^{EUR})$ does not Granger Cause Percentage change **R/€**	6.995	0.001
Percentage change **R/€** does not Granger Cause$(\pi^{SA} - \pi^{EUR})$	3.805	0.023
International Fisher Effect		
SA-CHN Real Interest differential factor does not Granger Cause Percentage change **R/¥ (Yuan)**	0.853	0.432
Percentage change **R/¥ (Yuan)** does not Granger Cause SA-CHN Real Interest differential factor	1.212	0.307
SA-US Real Interest differential factor does not Granger Cause Percentage change **R/$**	0.723	0.498

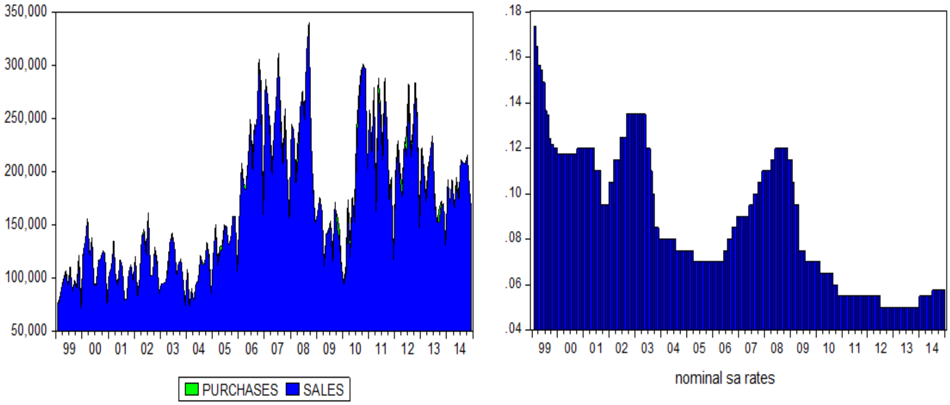
4.8 Why the UIP, PPP and International Fisher Effect?

The theoretical UIP hypothesis that an increase in domestic interest rate should be accompanied by a depreciation of the rand against that of the trading partner is violated for a number of reasons. The failure of these related three hypothesis is that the capital markets are inefficient, attributed mainly to adverse selection and moral hazard (Stiglitz & Weiss, 1981). Specifically, other factors closely associated with inefficient capital markets include the presence of transaction costs, taxes, differences in borrowing costs across countries and the existence of asymmetric information (Modigliani & Miller, 1958). When the borrowing costs are not the same, investors will always choose to borrow from low interest countries and this may prevent the UIP and International Fisher effect from being fulfilled.

However, the other reason concerns short-term investors chasing higher yields. Contrary to the UIP and the International Fisher Effect, an increase in interest rate differential as a result of an increase in domestic interest rates may cause the rand to appreciate. This phenomenon has been observed in the South African economy in which interest rates hikes in the United States has often led to capital flight out of the South African economy, resulting in currency depreciation. A decrease in returns due to a decrease in nominal interest rates following a monetary contraction action by the South African Reserve Bank, will lead to foreign investors seeking higher return on their holdings to sell the rand in exchange for a foreign currency whose return is higher. This action leads to an increase in the supply of rand, thereby causing a depreciation of the rand.

The scenario described above is depicted in Fig. 5 in which the plot on the left shows the volume of bonds purchases and sales by non-residents while the plot on the right shows the nominal interest rates over the time period under review. The figure shows that between 2003 and 2006 when interest rates were falling, the purchases of bonds by non-resident investors were also falling. The period 2006-2008 was marked by a sharp increase in interest rate, coinciding with a sharp increase in the purchases of bonds by non-residents. The period 2009-2010 was a repeat of the 2006-2008 cycles in which an interest rate fall was also followed by a decline in bond purchases. The movements in bond purchases which follow changes in nominal interest rate implies changes in the spot exchange rate which is not consistent with the UIP and the International Fisher relation. The forward market is therefore inefficient in predicting the expected exchange rate.

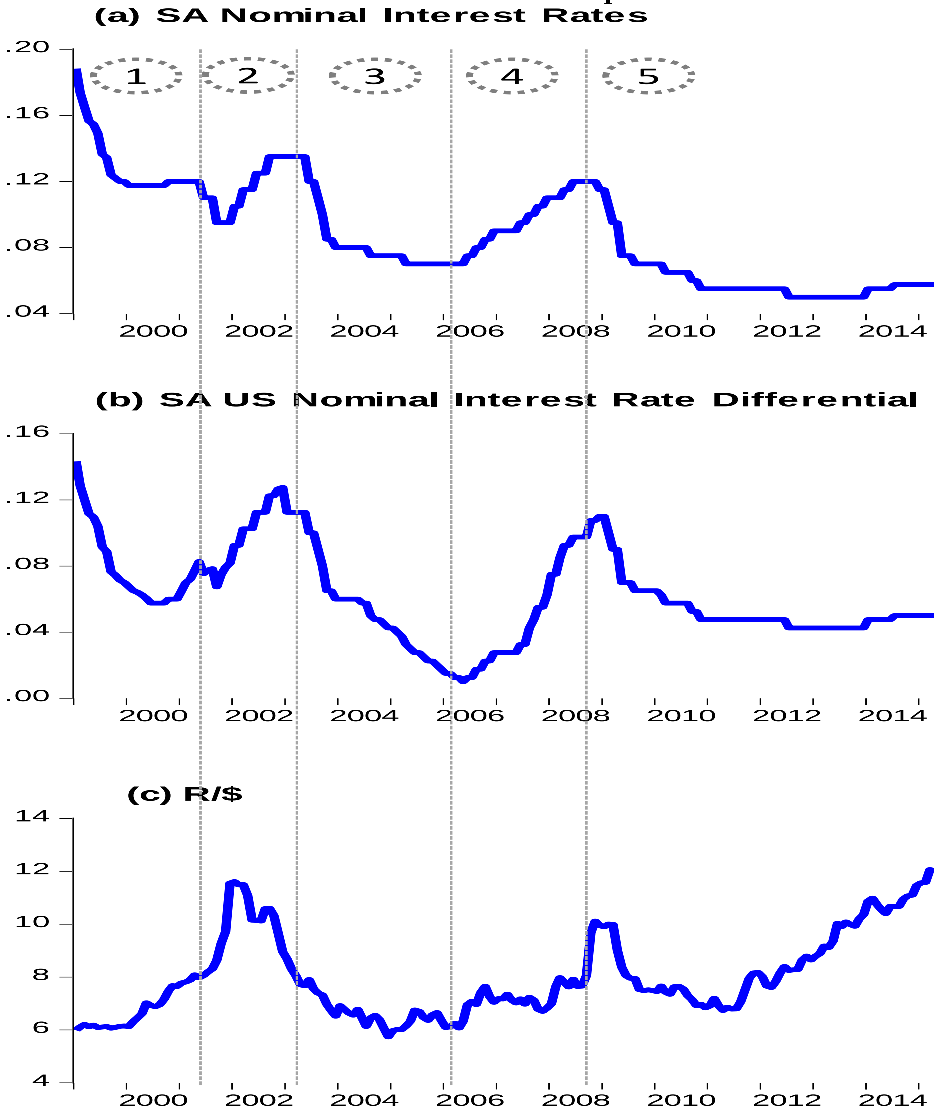
Figure 4: Bond purchases/sales by non-residents (Rm) and nominal interest rates



These results are supported by Taylor & Sarno (1997) who found that, other things equal, a reduction in US interest rates tended to increase capital inflows in developing countries. These findings were consistent with those of Calvo *et al.*, (1993) who showed that an increase in US interest rate could lead to a reversal of capital flows out of developing markets like South Africa, thus emphasizing the finding that interest rates are the most fundamental determinants of portfolio flows, especially bond flow dynamics in emerging markets. However, Taylor & Sarno (1997) also found that the impact of short-term interest rate on bond flow dynamics differs significantly across Latin American, Asian and African emerging markets, with the effect of interest rate changes on bond flows being stronger in Latin America than in most African economies.

In order to closely examine the relationship between the nominal interest rate and the exchange rate, Fig. 6 expands on the analysis ensuing from Fig. 5 to depict some interesting trends between the two variables. Panel (*a*) depicts South Africa's nominal interest rate trend, panel *(b*) shows the interest rate differential trend between South Africa and the United States, and the last panel (*c*) shows the rand/dollar exchange rate trend. Note that the interest rate differential has mirrored the pattern of the nominal interest rate differential, especially owing to the tendency of the South African Reserve Bank (SARB) to adjust rates in tandem with the monetary policy decision of

Figure 5: Nominal Interest rate, Interest rate differential and Rand/dollar relationship



the Federal Reserve Bank. Coincidentally, in order to stimulate domestic demand, both South Africa and the United States have cut rates aggressively following the 2008 financial crisis.

Figure 6 divides South Africa’s nominal interest rate trend from 1999-2015 into 5 phases. Period 1999-2000 marks the first phase characterized by interest rate decline. The second phase begins in 2001 with a moderate rise in interest rates until 2002. Interest rates began falling again from 2003 through 2005, denoted as the third phase. Period 2006-2007 represents the fourth phase in which SARB aggressively hiked interest rate to curb inflation (Rangasamy, 2009). The 2008 financial crisis prompted SARB to begin a series of interest rate cuts beginning late in 2008. The unprecedented reduction in interest rates was compounded by the Eurozone 2011-2013 sovereign debt crisis which resulted in a significant decline in global aggregate demand, marking the fifth phase in our study (2008-2015).

Turning to the analysis of these five phases, when interest rates were falling from 1999-2000, the South Africa rand depreciated from R6 per dollar to R8 per dollar, peaking at R12 per dollar in late 2000. The second phase (2001-2002) was associated with a general rise in interest rates, coinciding with a period of appreciation of the rand against the America dollar. The third phase (2003-2005) mimicked the first phase as interest rates began falling again. However, contrary to the first phase in which the fall in interest rate appeared to coincide with the rand depreciation, the rand does not spontaneously react to the decrease in interest rate until 2004 after which the transition towards depreciation begins. As the interest rate began rising sharply in efforts to curtail inflation by the monetary authority, the rand/dollar exchange rate became more volatile, though the rand generally depreciated. As the interest rates began falling in the fifth phase amid fears of recession, the rand was appreciating against the dollar until 2011, from which it reversed into a major depreciating trajectory.

The patterns observed above reveal that the periods of decline in South Africa’s interest rates are associated with periods of depreciation of the rand. Conversely, a general increase in South Africa’s interest rates tends to elicit an appreciation of the rand against the American dollar. This has been found to be the case for all the phases except the fourth phase in which the rand depreciated in spite of the increase in interest rates during 2006-2007. These results support the evidence in favour of the rejection of the UIP and to a broader extent, the rejection of the associated PPP and the International Fisher Effect. The relationship between the interest rate and the rand/dollar exchange rate seems plausible with the notion that investors tend to chase higher yields, leading to currency depreciation when the domestic interest rates fall.

The phenomenon outlined in the preceding paragraph explains the major part concerning the failure of the UIP to hold. In their work for emerging markets, Bosworth *et al.* (1999) acknowledge that in order to quell capital outflows, emerging markets may be forced to raise interest rates. The authors also indicate that portfolio flows are more sensitive to changes in interest rate than Foreign Direct Investment (FDI). While this paper does not delve into a detailed examination of the possible causes of the failure of the PPP, the existence of transportation costs and trade barriers and the lack of competition in the goods market are understood as reasons behind the failure of the PPP to hold (Aizenman, 1984, 1985; Rogers & Jenkins, 1995). The difference in taste between countries and non-tradable goods has also frequently been cited as reasons behind the failure of the PPP (Warnock, 1998).

5 – Conclusion

In this paper, the Uncovered Interest Parity (UIP), the International Fisher Effect (IFE) and the Purchasing Power Parity (PPP) hypothesis were tested in the context of South Africa as an emerging economy. Similar to Chinn & Meredith (2001), the Uncovered Interest Parity was tested at both long and short-term horizon to establish whether the claim advanced by some authors that the UIP holds only to the long run applies in emerging market context. We employed the Johansen co-integration test to determine whether any long term relationship existed between the dependent and independent variables during the sampled period. The co-integration result support the existence of long term relationship between the variables in question.

The study did not find any evidence in support of the UIP in the long-term horizon for all the cases except for the SA-EUR. The OLS results did not provide any strong support of the UIP in the short-term horizon, except for the case of SA-IND. Like many other extant studies, the UIP is therefore generally rejected. The results from the International Fisher Effect were also predominantly insignificant, though consistent with the UIP test, there seems to be some moderate evidence in support of the International Fisher Effect for the case of the SA-EUR. The PPP is also rejected for all the cases as the *t*-statistics all yield insignificant results. The R-squares for all the cases were found to be low, suggesting the exchange rate is instead explained by many other factors, not just the changes in nominal and real interest rates and the rate of inflation. Impulse response functions were used to determine the effect of shocks in interest rates and inflation on the exchange rate in a dynamic system. The results from the impulse response functions provide more evidence for the rejection of the UIP, IFE and PPP. Contrary to the UIP hypothesis, the impulse response functions showed that in the event of shock in the economy due to nominal interest rate increase, the rand will generally appreciate by approximately 2% against the foreign country currency in the first period. Moreover, an external shock due to increase in nominal interest rate in the euro-area leads initially to a transient 0.02% appreciation of the rand in the first period, before it depreciates against the euro by approximately 0.5%.

Granger causality tests results also showed that under the UIP tests for each of the five cases the interest rate differential series does not Granger cause movements in the expected percentage exchange rate. Instead, it is the exchange rate movement which seems to have causal effect on the interest rate differential. Most of the evidence from the PPP also showed that with the exception of the SA-EUR case, the inflation rate differential series could not cause changes in the exchange rate. The same results were found for the IFE case.

Plausibly, the failure of the PPP, UIP, and IFE could be due to the existence of transaction costs and taxes between countries. In addition, investors also tend to chase higher returns for their assets, a phenomenon recently seen across emerging markets including South Africa. Interest rates hikes in the trading partner countries have often led to capital flight out of South Africa, resulting in rand depreciation. A decrease in returns due to a decrease in nominal interest rates following a monetary contractionary action by the South African Reserve Bank, will lead to foreign investors seeking higher return on their holdings to sell the rand in exchange for a foreign currency whose return is higher. This action leads to an increase in the supply of rand, thereby causing a depreciation of the rand. Movements in purchases and sale/purchase of treasury bonds have also mirrored trends in interest rates as set by the Monetary Policy Committee.

By dividing South Africa’s interest rate trends into five phases between 1999 and 2015 and analyzing the movements in exchange rate following changes to interest rate and the interest rate differential, it was shown that the adjustment of the rand to changes in levels of interest rate is not consistent with UIP. This more pragmatic analysis suggests that an increase in South Africa’s interest rates prompts more capital inflows from foreign investors, leading to currency appreciation. The implication of these results is that the movements in the rand are influenced primarily by investor's actions in pursuit of higher yields -withdrawing funds when the interest rate fall and conversely supplying more capital when interest rates increases, leading the currency to appreciate. These results imply that capital markets may still be inefficient, justifying more government intervention to eliminate inefficiencies. These interventions could include implementing capital controls to avoid excessive outflows during periods of economic slumps. Future research in relation to the effectiveness of such capital controls should explore each of the different mechanisms to understand the extent to which each alternative would be most effective. A limitation of the models used in this paper is that they do not fully capture the dynamic trends in capital markets, especially as the markets become even more sophisticated. The OLS method also does not most accurately capture the time-varying risk premium required by investors, which could potentially affect the findings of the study.

Footnotes

1. *Since the 1970s, South Africa has had three interest rate regimes. The liquid asset ratio-based system characterized by quantity controls on credit and interest rate was typical and predominantly favoured through the 1970s until the 1980s (Aron & Muellbauer, 2007). The 1985 Commission Report by de Kock recommended reforms which led to a move towards cash-reserves based system enacted along with the controls on interest rate. By 1986, the second regime was in operation and focused more on monetary targets whose effectiveness was undermined by the liberalization of financial markets which had already commenced in the early 1980s (Fry, 1997). The interest rate trend was more volatile and the systems of the two regimes were less credible (Aron & Muellbauer, 2007). In an effort to enhance the transparency, predictability and credibility of monetary policy, the South African Reserve Bank transitioned into the third regime by adopting inflation targeting in 2000. Under this regime, interest rate is set and determined by the Monetary Policy Committee. Comparison between the three interest rate regimes reveals that South Africa's interest rates were relatively higher during the 1970s. However, at the end of 2000, interest rate began falling sharply from their historical level, reaching 7 percent in 2006. In the same year, interest rate trend reversed, rising moderately to 12 percent in 2008.*

However, the 2008-2009 Global Financial Crisis led to interest rate decline.

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