Did it matter? Monetary Policy Regime Change and Exchange Rate Dynamics in South Africa

Did it matter? Monetary Policy Regime Change and Exchange Rate Dynamics in South Africa

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Abstract

The paper provides empirical evidence of how a change in the monetary policy regime in South Africa has affected the anchorage of the exchange rate to fundamental determinants. Seeking to secure economic stabilization, South Africa has until 2000 devoted significant attention to stabilizing measures in the domestic foreign exchange market through a myriad of changes to its exchange rate regime and the macroeconomic landscape. In 2000, the country changed its monetary policy regime to inflation targeting. This new policy regime was expected to anchor market expectations to pricing the currency based on economic fundamentals, since it stabilizes interest rates by making them more predictable. However, the rand has sustained a long swing of decline in its exchange rate value that reversed in 2002 for a short while; resuming the swing in 2006.

The paper explores whether then the monetary policy regime change did matter for the rand's pricing? Drawing on the asset approach to exchange rate determination, it uses a systems approach that combines Johansen's (1995) multivariate cointegration technique with the long run structural modeling approach of Persaran, Shin, and Smith (2002) and finds that economic fundamentals indeed anchor the rand's long swing. However, the anchorage is regime dependent; the policy regime shift to inflation targeting appears to have significantly altered the role and importance of economic fundamentals in pricing the rand. The results lend empirical support to the ongoing debate – the bipolar hypothesis (Fischer, 2008, 2001; Frankel, 1999) – on the suitability of exchange rate regimes for middle-income countries with wide exposure to international capital such as South Africa. The message of this study is that policy regime change matters a lot for currency pricing.

[1] The World Bank, Country Office in Zambia, Lusaka. Email emtonga@worldbank.org . The findings, interpretations, and conclusions expressed in this paper are those of the author. They do not reflect the views of the World Bank Group and its affiliated organisations, or those of the Executive Directors of the World Bank Group or the governments they represent.

1 Introduction

South Africa has until 2000 devoted significant attention to stabilization measures in the domestic foreign exchange market, as a coping strategy to economic and political crises the country faced due to its policy of Apartheid. It has done this through a myriad of changes to the exchange rate regime. These have ranged from fixed exchange rates in the 1960s and 1970s, to experiments with floating rate regimes of various forms in the 1980s and 1990s (Van der Merwe, 1996). Stringent exchange control regulations and regular market interventions by the South African Reserve Bank (SARB) accompanied the changes to the exchange rate regime. However, mostly these measures were unsuccessful in stabilizing the foreign exchange market; exchange rate instabilities continued.

In 2000, the country changed the monetary policy regime to inflation targeting. Under this new policy regime, monetary policy aims at pre-announced inflation targets, with the interest rate as the instrument variable for achieving them. This has essentially stabilized interest rates by making them more predictable. Moreover, as implementation of the policy has required the authorities to abandoned pre-commitment to any exchange rate parity, particularly using exchange rate interventions, it has effectively made the exchange rate regime a free float. Since the inflation-targeting regime stabilizes interest rates, such a reduction in volatility of a key nominal variable should improve information processing by the market. To that extent, therefore, the regime switch to inflation targeting should anchor the market's expectations to pricing of the exchange rate based on economic fundamentals.

However, exchange rate instability has continued. Since the mid 1980s, exchange rates of the rand have sustained a long swing of depreciation that reversed in 2002 only for a short while, but resuming the swing in 2006, before another temporally reversal in 2009 (figure 1). Contrasting this fairly predictable movement, short run fluctuations in exchange rates are increasingly volatile and seemingly unpredictable, especially since the mid-1990s (figure 2). Indeed, variations in the exchange rate by as much as four percent in a single day or week are common.

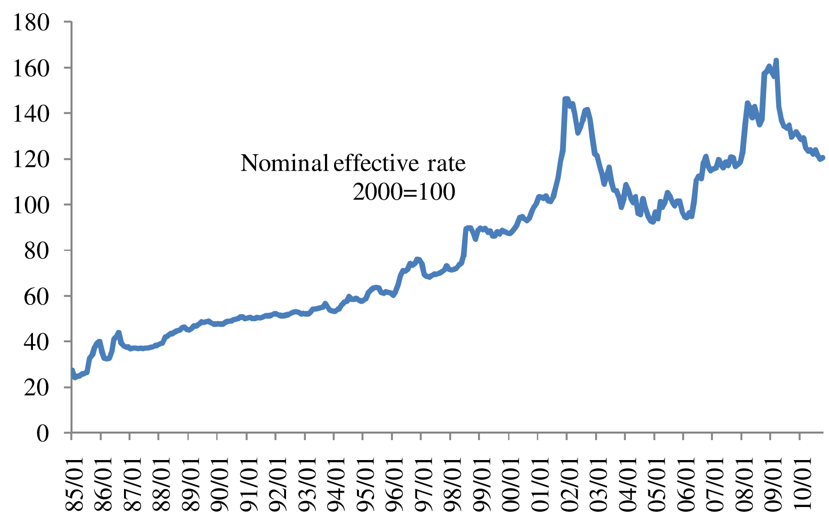
It is, therefore, of concern that the regime change to shift to inflation targeting has come a parallel rise in volatility of the exchange rate. Indeed, in 2001, out of worry over the overall impact of the economy of an unexpectedly large fall in the exchange rate of 40 percent over the relatively short period of six months, the government appointed the Myburg Commission of Inquiry (2002), which investigated the factors behind its rapid collapse. Although the commission failed to pinpoint responsible factors, its constitution highlights the level of concern that exchange rate volatility is continuing to attract from policy makers[2].

This paper asks what, if any, the rise in exchange rate volatility means about the effects of the monetary policy regime change on exchange rate dynamics. It

[2] Some of the factors cited were the strength of the US dollar over other major currencies and higher inflation in South Africa relative to that of its major trading partners. Others included negative sentiments against South Africa's financial markets due to contagion effects that arose from the Argentinean crisis, economic problems in neighbouring Zimbabwe, and a host of factors related to the performance of the economy (Myburg Commission, 2002).

probes this question by examining whether then the regime change to inflation targeting did matter for pricing of the currency in South Africa. Drawing on the asset approach to uncovering determinants of currency pricing, it does this by first establishing whether economic fundamentals map the long trends in the exchange rate. It then tests whether the relationships have changed due to the monetary policy regime change to inflation targeting. Using a systems approach that combines Johansen's (1995) multivariate cointegration technique with the long run structural modeling approach of Pesaran, Shin, and Smith (2002), the results indicate that economic fundamentals indeed do help to explain the long trends in the exchange rate. However, the relationship is regime-dependent. The monetary policy regime switch to inflation targeting appears to have affected exchange rate dynamics in two ways: (1) it has increased the role for funds; and (2) it has increased the importance of those fundamentals. The message that emerges from the study is that the policy regime change to inflation targeting did matter a lot for pricing of the currency.

Figure 1: Long trends in the exchange rate



The organization of the rest of the paper is as follows. Section 2 discusses briefly exchange rate policy in South Africa. The idea is to offer an understanding on how policy objectives have driven the choice of exchange rate regimes and, in turn, to evaluate how successful the regimes were in achieving the policy goals. This discussion is important because an understanding of currency movements requires an appreciation of the context in which such movements are occurring – that is, *of the institutions that condition the market*. Moreover, it helps to inform the resolution of the empirical questions of the choice of exchange rate horizon and the effect of regimes change. Section 3 examines the literature that seeks to explain long trends in currency movements. Section 4 outlines the empirical approach of the paper and discusses results thereof. Finally, section 5 contains concluding remarks.

2 Exchange rate policy in South Africa

South African management of the exchange rate is characterized by numerous regime changes. The changes are rooted in a myriad of causes, of which the most important is the Apartheid[3] and political instabilities and international isolation that it induced[4]. Table 1 shows how the exchange rate regime has changed since the 1960s, while figure 3 tries to show exchange rate movements have changed across those regime's changes.

Table 1: South Africa: Exchange rate regime changes

Episode	Date	Exchange rate regime
I	Feb 1961 – July 1971	Fixed exchange rate regime: rand pegged to the British pound
II	Aug 1971 – Nov 1971	Fixed exchange rate regime: rand pegged to the US dollar
III	Dec 1971 – Sept 1972	Fixed exchange rate regime: rand pegged to the British pound
IV	Oct 1972 – May 1974)	Fixed exchange rate regime: rand pegged to the US dollar
V	June 1974 – May 1975	Crawling peg rand: rand pegged to a basket of currencies
VI	June 1975 – May 1979	Fixed exchange rate regime: rand pegged to the US dollar
VII	June 1979 – Jan 1983	Dual exchange rate regime: Crawling peg commercial rand and free floating financial rand
VIII	Feb 1983 – Aug 1985	Unitary exchange rate: Managed float rand
IX	Sept 1985-Feb 1995	Dual exchange rate regime: managed float commercial and free float financial rand
X	Mar 1995 – Jan 2000	Unitary exchange rate : Managed float rand
XI	Feb 2000- present	Unitary exchange rate: free floating rand, with inflation-targeting framework of monetary policy

Source: Aron, Elbadawi and Kahn (**2000**), De Kock Commission (**1985**); Author's compilation

As can been seen from table 1, in the 1960s and most of the 1970s, exchange rates were held fixed, at adjustable parities to either the US dollar or British pound sterling at different times. Although, in June 1974, the exchange rate regime temporally moved to a crawling peg of a basket of currencies, it reverted to fixed peg to the US dollar in 1975. At that time, exchange rate stability was itself an objective, in part because of South Africa's signatory to the Breton Woods Agreement to manage fixed exchange rates (Wakeford, 2002; Van der Merwe, 1996; De Kock Commission, 1985), as did the rest of the world. However, the government sought also to maintain an overvalued currency, to aid importation of cheap capital goods to support a rapid industrialization program that it had started (Jones & Muller, 1992).

Integral to the exchange rate regime was a policy of strict foreign exchange control regulations, which helped to sustain the fixed rates. The regulations restricted capital account transactions of both residents and non-residents. The authorities tightened the regulations even more in 1961 after a series of political crises, triggered by the Sharpville shootings[5] early in 1960, resulted in massive outflow of capital (Van der Merwe, 1996). For instance, the regulations barred

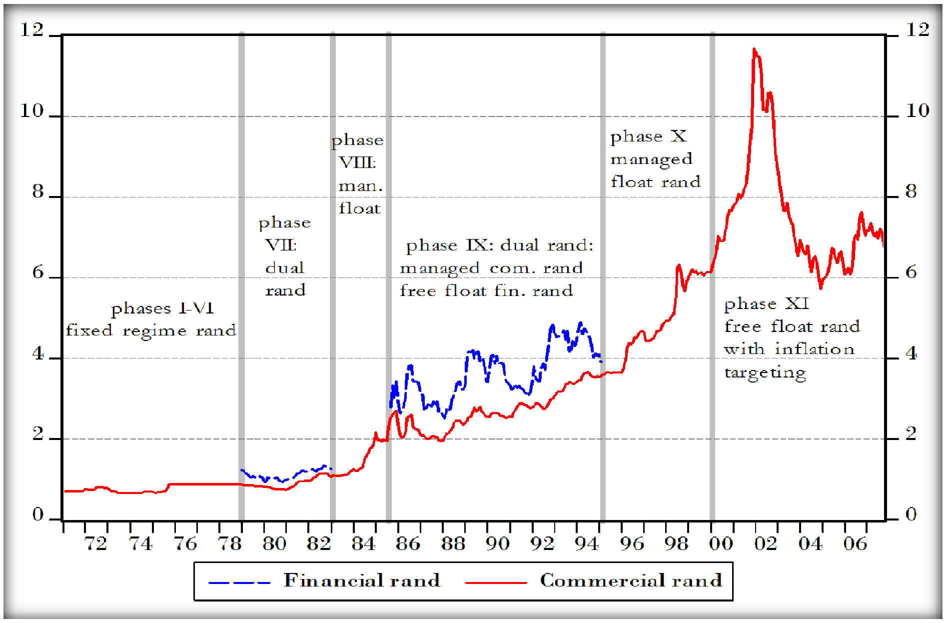
[3] *Apartheid* was an entrenched regime of extreme racial segregation introduced in 1948. It ended in 1994 with the election of a democratic government.

[4] Aron, Elbadawi, and Khan (2000; 1997), Khan (1992), and Van der Merwe (1996) offer much more detail of the regime changes

[5] The Sharpeville shootings relate to an incident on March 21, 1960 at which police killed 69 and injured 180 of the people that had gathered at Sharpeville to demonstrate against the stipulations of the Pass Law. That law had required Africans (black people) to identity cards.

non-residents from repatriating proceeds of their investments unless after a five-year period (Jonsson, 2001).

Figure 2: Exchange rate regime changes and exchange rates of the rand



Fixed pegging of exchange rates, however, proved unsustainable after political unrests and an international campaign against Apartheid intensified. Political protests of Apartheid became stronger through riots in 1976 after police killed hundreds of people as schoolchildren in Soweto protested inferior education for blacks. Supporting this campaign against Apartheid, the international community imposed a series of economic sanctions against South Africa. This combination of the tumultuous political environment at home and the international sanctions exerted severe pressure on the economy and caused a massive outflow of mainly non-resident capital. On top of that, adverse global economic developments, mostly the fall of the US dollar in 1978, made conditions even harder (De Kock Commission, 1985).

Therefore, as a countermeasure to the capital outflows, the authorities introduced a dual exchange rate system in 1979. The dual exchange rate regime comprised the commercial and financial rand rates. The commercial rand was the principal rate and applied to all transactions by residents. It was designated a floating rate, but subject to an official intervention policy by the South African Reserve Bank. The financial rand, on the other hand, was a secondary rate that applied only to capital transactions of non-residents. The idea was that in this way would insulate the economy from volatility in non-resident capital transactions, given the tumultuous political environment and economic sanctions. For that reason, the financial rand rate was priced under relatively free fully market conditions. However, the market's thinness made it volatile. Despite the regime change, exchange control policy on all resident transactions was continued.

In February 1983, guided by recommendations of the De Koch Commission (1985) to introduce flexibility in the domestic foreign exchange rate market, the exchange rate regime reunited to a managed float and the financial rand was discontinued. Exchange control over transactions of both residents and non-residents was also abolished. The authorities furthermore introduced a forward market, to enlarge the scope of the domestic foreign exchange market, although this was heavily regulated by the Reserve Bank (Van der Merwe, 1996; Aron, Elbadawi, & Kahn, 2000; 1997). Official intervention policy was nonetheless continued (Aron, Elbadawi, & Kahn, 2000; Aron, Elbadawi, & Kahn, 1997; Mboweni, 2002).

In September 1985, emergence of a debt crisis in May 1985 forced the authorities to reinstate the dual exchange rate regime of the commercial and financial rand rates. The debt crisis came after the United States of America joined the international campaign against Apartheid in placing economic sanctions against South Africa that included cessation of new lending and freezing of existing credit lines. This was problematic for South Africa because American banks, particularly Chase Manhattan Bank, held the bulk of its foreign debt, mostly short term. When therefore the American banks withdrew all their lending and refused to roll over maturing debt liabilities, South Africa defaulted in its foreign debt obligations by declaring moratorium on its repayments (Ayogu & Dezhbakhsh, 2008). Consequently, a foreign debt crisis emerged. This in turn impeded external financing of current account deficits, which the debt crisis induced. This problem had to be resolved by implementing absorption-reducing measures to generate and sustain current account surpluses, hence the dual rate regime.

Again, the commercial rand applied to transactions of residents while those of non-residents were valued at the financial rand rate. The commercial rand was maintained as a managed float, supported by interventions policy, while the financial rand freely floated. However, exchange control over both resident and non-resident transactions was reinstated. While often one can cite the debt crisis as the prime reason for reintroducing the dual rate regime at this stage, the evidence above suggests that political developments were the major contributor. Regrettably, this turbulent political environment did not subside until the early 1990s when the authorities took steps towards political reconciliation.

In March 1995, the exchange rate regime again reverted to a single managed float system, after the financial rand was withdrawn. This followed successful political reconciliation in 1994 that saw the political regime make the transition from Apartheid to all inclusive democracy that ended economic isolation. The change to exchange rate regime was part of a much broader process of gradually liberalizing the financial markets, to reinsert the country into the global economy. Official interventions to stabilize the rand however continued. Particularly during 1996 and 1998, the Reserve Bank fought hard to prevent rapid depreciations of the rand by growing its open position on its forward book in the forward foreign exchange market (Mboweni, 2004). Unfortunately, this practice culminated into a large net open position against the Reserve Bank (figure 4), with a negative effect on foreign investments into South Africa and the markets' assessment of domestic economic conditions (Ayogu & Dezhbakhsh, 2008).

The financial liberalization agenda also included a gradual process of dismantling exchange control regulations. Exchange control on transactions of non-residents was abolished immediately on eliminating the financial rand. Those on transactions of residents, on the other hand, were initially retained, but they have since been progressively slackened. The major changes that have occurred so far include allowing resident institutional investors (i.e. pension funds, insurers, unit trusts as well as other institutional investors) to invest abroad, initially, through foreign exchange asset swaps (Vittas, 2003; Farrell & Todani, 2004; Bruce-Brand, 2002), but later, in February 2001, outright acquisition of foreign investment was permitted. Residential companies, similarly, have been allowed since 1997 to acquire direct investments abroad and foreign funding against their domestic balance sheets. This was initially limited R3 billion. South African individuals above 18 years are also allowed to invest abroad. Overall, exchange decontrol is continuing, with the Ministry Finance announcing requisite changes each year.

In February 2000, inflation targeting was adopted as the operating framework for monetary policy. Under this framework, monetary policy is focused on announced inflation rate benchmarks to be met over a specified time frame, explicit inflation forecast as the intermediate variable, and interest rate as the policy instrument. For policy efficacy and thereby credibility, the regime of inflation targeting precludes pre-commitment to an exchange rate target (Masson, Savastano, & Sharma, 1998)[6]. For that reason, the Reserve Bank ceased its foreign exchange market interventions policy to stabilize the value of the rand, unless for reserve accumulation. This was helped with the closure of the Reserve Bank's negative net open position in May 2003 and cessation of its forward book in the foreign exchange market in February 2004 (International Monetary Fund, 2004; Mboweni, 2004). Inflation targeting so far has been implemented successfully.

With adoption of the inflation-targeting framework, therefore, the exchange rate regime has become consistent with a free float. However, unless exchange control is removed completely, the liberalization of the foreign exchange market will remain largely incomplete. Nevertheless, given ongoing debate about the appropriate financial architecture in the context of globalization and increased macroeconomic volatility, it is not clear that complete liberalization for an emerging market such as South Africa is the ideal.

Therefore, the monetary policy regime switch to inflation targeting in 2000 demarcates the previous years of controls from the present regime in which market conditions to influence the domestic foreign exchange market. For the most of that period, the exchange rate regime has been overly sensitive to political developments. With the regime change to inflation targeting, however, the concomitant dismantling of exchange controls, absence of foreign exchange market interventions, and the reinsertion of the economy into the global economy, the pricing of the currency can be recognized with economic forces, at in the "dejure" sense. Admittedly, since implementation of inflation targeting, economic policy is doing well, as was, for example, the handling of the 2001-rand crisis when the Reserve Bank resiliently relied on its interest rate policy as the operating tool[7]. Thus, testing whether the switch to inflation targeting did

[6] With a targeted exchange rate, there is no independent monetary policy – the goal of monetary policy becomes that of defending the exchange rate.

[7] Initially, this came at a cost of high interest rates but favorable realizations of inflation targeting have led to their subsequent decline gradually.

matter is relevant from a policy standpoint, as, if this was so, such information would assist the authorities in deciding which policy options would be the best to stabilize the currency.

3 Literature: what is known about currency pricing

Economists have so far found it notoriously difficult to explain currency movements. This difficult is mirrored in the myriad of approaches that have overtime generated a very large literature attempting to explain exchange rate determination (Williamson, 2008; De Grauwe, 2005; Sarno & Taylor, 2002; Isard P. , 1995; Taylor P. M., 1995). Unfortunately, there is presently no one overarching framework that seems to synthesize these approaches. Rather, what one finds is that each approach adds an important insight but by itself falling short in providing a definitive answer. This has resulted in disagreement over what the appropriate set of variables to include in an empirical exchange rate equation should be (Meese, 1990).

One approach stresses the role of trade flows. It includes models such as the Mundell-Fleming model (Mundell, 1960; 1963; 1968; Fleming, 1962) and the purchasing power parity hypothesis (Cassel, 1918; 1921). These are based on the notion that exchange rates arise from international trade in real goods and services. Liquidity or cash-in-advance models (Lucas, 1982; Obstfeld & Stockman, 1985), conversely, are models couched in the optimising paradigm, while accommodating a role for commodity and productivity shocks. By contrast, the new open economy macroeconomics literature (Obstfeld & Rogoff, 1995; 1996) emphasize the role of nominal rigidities and market imperfections in currency pricing in the context of dynamic general equilibrium models, alongside well specified micro foundations. Lane (2001) explains this in detail.

However, since the worldwide switch to floating of currencies in 1973, the asset approach is the conceptual and methodological workhorse that is widely used to empirically examine nominal exchange rate behaviour. This approach is appealing because it emphasizes the importance of capital markets and financial flows in determining exchange rates. Indeed, the lessons from the experiences since the era of floating exchange rates suggest that in comparison to merchandise trade, financial flows are the key drivers of foreign exchange market activities. This is reflected in the tremendous growth in global trade of foreign exchange that has since then become so much larger in volume than is that in merchandise – average daily turnover exceeded three billion US dollars as at April 2007 (Bank for International Settlement, 2007). This study will accordingly rely on the asset pricing approach in suggesting an analytical framework for modeling the kwacha's movements.

The asset approach spans is of two genres: the *monetary* and the *portfolio balance* models. The central idea underpinning the two strands is that national money (foreign exchange) is a financial asset and therefore the exchange rate should be viewed an asset price. Being relative prices of assets, exchange rates thereby are priced in an asset pricing framework, driven by portfolio considerations – in much the same way as any other asset price. Exchange rates thus depend not only on exogenous factors that induce changes in financial asset supplies and demands, but also expectations concerning the future course of those factors play a central role in affecting their current values.

Nonetheless, outside of this central theme, there is debate between the two strands regarding which financial assets are traded in foreign exchange markets, the risk characteristics of those assets, and the attitude towards risk of participants in those markets. This has inevitably resulted in differences not only about predictions on the set of factors that matter for understanding exchange rate behaviour, but also the transmission channels through which those factors interface with the foreign exchange market.

Monetary models (Frenkel J. A., 1976; Mussa, 1976; 1979) focus on national money as the only financial asset held by residents of different countries. Accordingly, these models argue that it is the interplay of the demand for and supply of money in each nation that is the key to understanding exchange rate behavior. This argument is born out on the assumption that international financial investors are risk neutral. They thereby substitute perfectly in their demand function domestic and foreign non-money assets such as bonds that are identical in all aspects other than the currency of denomination[8], while trading them internationally. But national moneys themselves are not internationally tradable. Consequently, the predicted set of fundamentals that matter for currency pricing are money supplies (monetary policies) and the determinants of money demands (product prices, interest rates, and real incomes or outputs) of countries, plus expectations with regard to those variables in the future (exchange rate expectations).

The monetary models also attempt to provide a basis for explaining exchange rate overshooting, according to which short run changes in exchange rates tend to exceed their eventual change required by the new long run situation. This is articulated in models that allow for short-term stickiness in prices such as the Dornbusch (1976) model. In models of this sort, exchange rate overshooting arises because prices of financial assets respond more quickly to policy changes than does the price level of goods and services, which inhibit stickiness. All the same, these models eventually predict a similar set of fundamental determinants.

Portfolio balance models (Kouri, 1976; Branson W. , 1977), in contrast, assume that international investors view bonds of identical default risk as imperfect substitutes, due to different currency denominations. This imperfect substitution produces a risk premium as differential rates of return on the foreign denominated and domestic bonds. Agents thereby allocate wealth among asset menu per equated relative returns. The result is that currency pricing is attributable to a richer menu of financial assets, including portfolio preferences, sterilised interventions, current account balance, fiscal positions, and wealth variables. The models also span a literature that seek to explain the existence of a risk premium, such as Hooper and Morton (1982), Fama (1984), and several other studies reviewed by Lewis (1995). This focus on a broad menu of assets makes them appealing over their monetary counterparts in providing richer insights into the forces influencing exchange rates. It also distinguishes them over their monetary counterparts in making an empirical distinction between the models in terms of their explanatory power.

However, the models - and fundamentals-based models generally – have not done very well in explaining currency movements. Despite initial successes

[8] The argument is that assets that are perfect substitutes must pay the same expected rate of return

(Frankel & Rose, 1995), a large and burgeoning literature has shown that floating exchange rates can neither be explained nor forecasted based on economic fundamentals at the short horizon of up to a year. At this horizon, a random walk model – a naïve strategy of using today's currency value as a predictor of all future values – *consistently and robustly fits the data* better than any combination of economic variables or structural model. This result, which was first established by Meese and Rogoff (1983a; 1983b), very much stands today, despite a larger literature that has used a plethora of estimation techniques. Rogoff (2008) has observed that most attempts at overturning this result have been, at best, fragile – while forecasts from economic fundamentals have tended to work well for some currencies during certain periods, the result is not replicable for other currencies or sample periods. One example is the study by Chueng, Chinn, and Pascaul (2005) that examines the predictability of a suite of structural models of the exchange rate, and concludes that none offers forecasts superior to a random walk model at any horizon. Some recent evidence from similar studies is discussed by Wang (2008), while Neely and Sarno (2002) provide a review of some earlier ones. Indeed, beating a random walk model's forecasts has become a benchmark for assessing the success or otherwise of empirical exchange rate modeling in the literature.

Nevertheless, the empirical evidence robustly suggests that economic fundamentals track floating exchange rates reasonably well at the long horizon – over a period of several years. In establishing this result, one strand of the literature uses the cointegration methodology[9] (MacDonald & Marsh, 2004) and finds that the linkage of the exchange rate and fundamental variables is valid as a long run relationship. Starting with Mark (1995), another strand of the literature has found evidence of long-horizon predictability - fundamentals variables are able to robustly predict exchange rates at the long horizon. Two contemporary examples are Rossi (2005) and Killian and Taylor (2003). Some studies such as Gourinchas and Rey (2007), Mark and Sul (2001), and Groen (2000; 2005) have established this result using panel forecasting methods, which involves pooling the data for a group of currencies. A recent line of inquiry has exploited the idea that if exchange rates are determined by expected future fundamentals in the asset-pricing framework, then today's currency values should help predict tomorrow's fundamentals. Engel and West (2005); Chen, Rogoff and Rossi (2008), and Engel, Wang, and Wu (2008) provide evidence in support of this conjecture.

Further support for the long-horizon predictability prediction is provided by research that uses monetary policy feedback rules - *Taylor rule fundamentals* – to model exchange rate determination. The intuition is that because policy makers usually consider exchange rate movements in deciding monetary policy variables such as short-term interests, therefore there should be a feedback from exchange rates to interest rates. Thus, for example, when news such as a Central Bank interest rate announcement arrives that raises market expectations about the future path of short-term interest rates, the tendency would be for the currency to appreciate. Indeed, incorporating such monetary policy feedback into structural exchange rate models, researchers have found that long horizon exchange rate data is replicated relatively well, including, in some instances, at the short

[9] The cointegration methodology is designed to seek for equilibrium relationship among variables, while allowing for their dynamic adjustment around such equilibrium.

horizon, notably, Molodtsova and Papell (2008), Molodtsova, Nikolsko-Rzhevskyy, and Papell (2008), Mark (2007), and Engel, West, and Mark (2007). Generally, given these empirical results, consensus has built that fundamental variables contain information relevant to understanding long run exchange rate movements, but not short run movements.

These empirical lessons nevertheless apply to developed countries and are inapplicable to developing countries. For many of these countries, commodities are a significant portion of their export basket, and therefore the expectation is that their export commodity's price is a key fundamental driving pricing of their currencies. The difficult however is that the exchange rate-commodity price relationship is poorly understood – the literature so far is thinly spaced. Moreover, in the few studies that exist, the focus has been in exploring the impact of commodity prices on the real exchange rate and not the nominal rate, which is the rate that is priced by the market. The study of Chen and Rogoff (2002), for instance, shows that the world price of major commodity exports of each of three OECD countries'(Australia, Canada, and New Zealand) holds the key to explaining their real currency movements, including predicting their future values. Likewise, for each of 58 commodity exporting countries, Cashin, Cespedes, and Sahay (2002), are able to find statistically significant linkages of commodity prices and the real exchange rate for two-fifths of the countries, many of them Sub-Saharan African.

Indeed, there are studies related to the work herein, which find various sets of economic variables to be an important determinant of the South African nominal exchange rate. These include Chinn (1999), Brink and Koekemoer (2000), and Gebreselaise, Akanbi, and Sichei (2005a; 2005b).

The present work nonetheless differs from those studies in that it explicitly models the possible impact of policy regime change. Frequent policy regimes change within a relatively short history pose empirical challenges that have not been addressed clearly in the literature on empirical modeling of the South African market. This gap is understandable. The traditional technique for analyzing exchange rate changes requires market generated data over a large number of observations. However, in South Africa's case, the exchange rate regimes have not been stable. Moreover, a free market in exchange rates is a relatively new phenomenon, having been in existence since February 2000.

Empirically modeling the exchange rate in the face of such instability of the exchange rate regime encounters the difficulty that, as the institutional setup in which currency movements are occurring, the exchange rate regime itself induces agents' expectations about the evolution of those movements in the future. Those expectations in turn influence currency movements in the present. Thus, an exchange rate regime change would generally be expected to alter the information set on which exchange rate expectations are formed. To the extent then that regimes change matters and agents take this into account, as Lucas (1976) argued, the process driving currencies would differ across the spectrum of regimes. Clearly, this is to be expected in South Africa's case where the exchange rate regime has kept changing. The set of relevant fundamentals that prevails under the current regime of free floating most likely differs from those that existed in previous regimes of very controlled floating.

4 Empirical approach and findings

The empirical approach is to uncover a set of fundamental exchange rate determinants from a structural model, test if those fundamentals help to explain the exchange rate, and test if the relationship has changed due to regime change. A hybrid *monetary* and *portfolio balance* model of exchange rate determination is thereby tested, which allows for testing for role for a wider range of potential determinants. The analysis uses only *in-sample* prediction tests to compare the statistical significance of the variables tested and does not attempt to offer *out-of-sample* predictions.

4.1 The model

The proposed model falls in the class of asset-pricing models in which the exchange rate is treated as a freely fluctuating asset price that depends on expectations of its future value and exogenous factors that affect asset supplies and demands. It thereby combines characteristics of both the monetary and portfolio balance approaches to exchange rate determination. By combining both features, the model acquires the advantage of allowing for specification and testing for a wider range of potential determinants of the exchange rate.

The monetary features of our model draw on Frankel's (1979) *real interest rate differential model*, which is based on the notion that the exchange rate is a relative price of domestic and foreign moneys and thus depends on supplies and demands for those moneys. In particular, that the exchange rate arises from equilibrium conditions in domestic money markets. This in turn requires assuming a stable money demand that depends positively on real incomes and the price level but inversely related to the nominal interest rate, since this represents the opportunity cost of holding money. However, the money supply arises exogenously, through government policy actions. Money supply is also assumed to equal money demand continuously and therefore the condition for equilibrium in domestic money markets can be specified as

$$m_t - p_t = \delta y_t - \lambda i_t \tag{1}$$

Where m , p , y, and i are the log of the nominal money supply, national price level, real income, and the level of the nominal interest rate; δ and λ are the income elasticity and interest rate semi-elasticity of demand for money, respectively.

Monetary equilibrium condition is assumed identical[10] between countries and, accordingly, equilibrium in foreign money markets can be stated as

$$m_t^* - p_t^* = \delta^* y_t^* - \lambda^* i_t^* \tag{2}$$

where the asterisks (*) indicates the variables pertain to a foreign country.

[10] Use of this assumption here is not to deny its implausibility in the light of obvious differences between economies of South Africa and other countries. Even the question of to what extent the money supply can be regarded exogenous is still a matter of debate, as Goodhart (1989) argued; given the many factors are believed to impact the supply of money practically lie outside the influence of the monetary authorities. However, it is the model's predictions that are important and imposing these assumptions is necessary in showing how those predictions come about.

A second monetarist feature of the model is that we assume that purchasing power parity ties together relative prices of domestic and foreign goods. This relates the exchange rate to relative prices of domestic and foreign goods, wherein the exchange rate is required to adjust to maintain parity of international goods prices due to goods arbitrage. However, prices in both domestic and foreign goods markets are modeled as sticky; allowing for a sluggish response in the short to disequilibrium, but permitting full adjustment in the long run. Thus, purchasing power parity applies as a long run phenomenon and, accordingly, provides the long run exchange rate

$$\bar{s}_t = p_t - p_t^* \tag{3}$$

where $\bar{s}_t$ denotes the log of the nominal exchange defined as the domestic price of foreign currency and the bar over the variable indicates the relationship pertains to the long run.

Since goods' prices are sticky, short run violations from purchasing power parity occur and, in consequence, deviations of the current exchange rate from its long run value arise routinely. The model thus allows for long run behavior of the exchange rate and its short run transition dynamics onto the path to long run equilibrium.

In terms of long run behavior, we return to the monetary equilibrium conditions and solve the domestic and foreign money market equilibrium conditions (equations 1 and 2) for the relative price level by taking their difference and obtains[11]:

$$p_t - p_t^* = m_t - m_t^* - \delta(y_t - y_t^*) + \lambda(i_t - i_t^*) \tag{4}$$

This shows that relative prices of home versus foreign goods depend on relative money supplies and demands between the domestic and foreign countries

The relative price relationship (equation 4) is thereby combined with the purchasing power parity relation (equation 3) to obtain a prediction equation for the exchange rate in the long run as follows:

$$\bar{s}_t = m_t - m_t^* - \delta(y_t - y_t^*) + \lambda(i_t - i_t^*) \tag{5}$$

This anchors the exchange rate on the ratio of the domestic and foreign money supply $(m_t - m_t^*)$, the ratio domestic and foreign real incomes $(y_t - y_t^*)$, and the nominal interest rate differential on domestic and foreign assets $(i_t - i_t^*)$.

In terms of this prediction, these variables work their effects on the exchange rate through changing the price differential on domestic goods prices and through purchasing power parity. The money supply affects prices directly; growth in the money supply at home relative to money demand yields an equiproportionate increase of the price level, which, via purchasing power parity, depreciates the home currency. In contrast, the other variables affect prices via their effect on money demand. On the one hand, because growth in domestic real incomes raises

[11] It is assumed for simplicity's sake that the cross country money demand parameters match, that is $\delta=\delta^*$ and $\lambda = \lambda^*$

the demand for money relative to its supply, it leads to a fall in the price level and thereby induces an offsetting currency appreciation. Relatively higher domestic interest rates, on the other hand, mean a smaller demand for real money relative to money supply, which requires a rise in the price level to sustain monetary equilibrium and therefore brings about home currency depreciations.

However, nominal interest rates in our model are modeled as obeying the Fisher hypothesis, which argues that nominal interest rates embody a real interest rate and an expected inflation rate component. This relationship can be stated as;

$$i_t = r_t + \pi_{t+1}^e \tag{6}$$

And analogously, on foreign assets

$$i_t^* = r_t^* + \pi_{t+1}^{e*} \tag{7}$$

where r_t, r_t^*, π_{t+1}^e, $\pi_{t+1}^{e*}$are, correspondingly, the home and foreign real interest rates and expected inflation rates over a k maturity horizon of an underlying financial asset ($k = 1$, for simplicity).

Our assumption of long run purchasing power parity implies that real interest rates must converge internationally (Frankel J. A., 1979). Therefore, in long run equilibrium, nominal cross-country interest rates differ only because of differences in expected rates of inflation and, consequently, nominal interest rate differentials can be viewed as representing expected inflation differentials;

$$i_t - i_t^* = \pi_{t+1}^e - \pi_{t+1}^{e*} \tag{8}$$

Therefore, the prediction equation (5) for the long run exchange rate can be restated as in equation (9) below, wherein expected inflation differential replaces the nominal interest differential;

$$\bar{s}_t = m_t - m_t^* - \delta(y_t - y_t^*) + \lambda(\pi_{t+1}^e - \pi_{t+1}^{e*}) \tag{9}$$

Here the role of expected inflation rate differential is equivalent to that of the interest rate differential. Namely, an increase in the expected inflation differential at home induces agents to reduce their demand for real money balances, increases prices, and in so doing depreciates the home currency.

Concerning the short run deviations of the current exchange rate from its long run values, because the assumption of price stickiness means gradual price adjustment in the model, the adjustment is such that exchange rate will initially "overshoots" its long run value in response to fundamental determinants but returning to this long run value overtime. We thereby adopt a 'regressive' or mean reverting expectations mechanism (Frankel, 1979), according to which short run deviations of the current rate from its long run value are expected to damp out at a constant rate. Furthermore, when the exchange rate falls onto its equilibrium path, instead of being constant, it is expected to change by the expected inflation rate differential - reflecting the loss in value due to inflation. Thus, the path for short run transitional dynamics for the exchange rate can be stated as;

$$\Delta s_{t+1}^{e} = \phi(\bar{s}_t - s_t) + (\pi_{t+1}^{e} - \pi_{t+1}^{e*}) \tag{10}$$

Where $\Delta s_{t+1}^{e}$is the change in the exchange rate expected in period $t+1$, $(\bar{s}_t - s_t)$ is the short run disequilibrium gap that the exchange rate experiences relative to its long run value $\bar{s}_t$, ϕ is the parameter that captures the speed of adjustment, and $\pi_{t+1}^{e} - \pi_{t+1}^{e*}$ is the inflation rate differential expected in period $t+1$.

We rewrite equation (10) as equation (11) below to show explicitly how the short run gap depends on changes in expectations about inflation and the exchange rate in the future;

$$s_t = \bar{s}_t + \frac{1}{\phi}(\pi_{t+1}^{e} - \pi_{t+1}^{e*}) - \frac{1}{\phi}\Delta s_{t+1}^{e} \tag{11}$$

Obviously, there is dynamic dependence here, particularly via the expected exchange rate term Δs_{t+1}^{e}, but for now, we sidestep the question of how agents are forming those expectations.

We next describe features of the portfolio balance model that model acquires (Frankel, 1983). These can be summarized as follows. Portfolio balance models, which explain the existence of a risk premium, argue that agents allocate wealth among asset menu per expected relative returns internationally. Investors are assumed to view assets of identical default risk as imperfect substitutes due to the different currency denominations. This imperfect substitutability produces a risk premium as differential rates of return on the foreign denominated and domestic bonds. Combining this with the assumption of cross-country perfect capital mobility allows representing international capital markets equilibrium by an uncovered interest rate parity condition adjusted for a risk premium;

$$\Delta s_{t+1}^{e} = (i_t - i_t^{*}) - \rho_t \tag{12}$$

Where $i_t - i_t^{*}$ is the interest rate differential; $\rho_t$is a risk premium; and Δs_{t+1}^{e} is the change in the home currency expected in the future, where $\Delta s_{t+1}^{e} = E_t s_{t+1} - s_t$ and $\mathrm{E_t} s_{t+1} = \mathrm{E}(s_{t+1} \mathrm{I} \Omega_\mathrm{t})$ is the expectation of the future exchange rate conditioned on information set Ω_t available to economic agents at time t.

Our contribution is in how we exploit the argument (Frankel, 1983; Dooley & Isard, 1982) that the risk premium can be solved in terms of factors that determine the supplies and demands of domestic and foreign currency denominated assets. In particular, an investor desirous of spreading the risk due to exchange rate variability will allocate his domestic and foreign currency portfolio holdings in response to expected returns on each as;

$$\frac{B_j}{SF_j} = \sigma_j(i_t - i_t^{*} - \Delta s_{t+1}^{e}) \tag{13}$$

where B_j is the stock of domestic currency denominated asset held by investor j; F_j, the stock of foreign currency denominated asset held; S is the nominal exchange rate; and σ_j is a positive valued function (Frankel, 1983)with the property that

$$\sigma_j(i_t - i_t^{*} - \Delta s_{t+1}^{e}) = e^{[\alpha + \theta(i_t - i_t^{*} - \Delta s_{t+1}^{e})]} \tag{14}$$

We assume same portfolio preferences for all investors, thus allowing for addition of the individual demand functions into an aggregated asset demand equation;

$$\frac{B_t}{F_t S_t} = \sigma(i_t - i_t^* - \Delta s_{t+1}^e) \tag{15}$$

where $B = \sum_{j=1}^{n} B_j$, $F = \sum_{j=1}^{n} F_j$ are now net supplies of assets, and the function σ captures similarity of preferences.

Now the term in brackets on the left hand side of equation (15) is the risk premium, from the capital markets equilibrium condition internationally (equation 12). Therefore, the risk premium can be equivalently stated as;

$$\rho_t = \frac{1}{\sigma}\frac{B_t}{F_t S_t} \tag{16}$$

This illustrates more clearly the linkage of the risk premium to determinants of supplies and demands for domestic and foreign assets.

We sidestep that for the moment and focus, instead, on equation (15), which we re-express in log form, given (14), to yield;

$$b_t - s_t - f_t = \alpha + \theta(i_t - i_t^* - \Delta s_{t+1}^e) \tag{17}$$

This captures the idea that investors seeking diversify the resultant risk of exchange rate variability will balance their holdings of domestic and foreign asset holdings in portions that depend on a risk premium. Particularly, an increase in the relative supply of domestic assets, for example, will require an increased risk premium for these assets to be willingly held in international portfolios. The opposite would apply in domestic markets in the case of foreign currency denominated assets. Changes in the risk premium thereby accommodate underlying shifts of the supplies of domestic currency assets relative to foreign currency assets that are held in private portfolios.

We now synthesize the monetary and portfolio balance features elaborated above to form our model. This is done by first combining the equation for short run transition dynamics (equation 10) with the condition for international capital markets equilibrium (equation 12), but where equation (16) is used to describe the risk premium;

$$s_t - \bar{s}_t = -\frac{1}{\phi}[(i_t - \pi_{t+1}^e) - (i_t^* - \pi_{t+1}^{e*})] + \frac{1}{\phi}(i_t - i_t^* - \Delta s_{t+1}^e) \tag{18}$$

Notice that the expression in square brackets is now interpretable as the real interest rate differential and we have $(i_t - i_t^* - \Delta s_{t+1}^e)$ as the risk premium.

This shows that the exchange rate deviates from or 'overshoots' its long run value for two reasons; firstly sluggish price responses create a real interest rate differential, and, secondly, imperfect asset substitutability produce a risk premium. Note that the interest rate differential appears here with a negative coefficient. This is because existence of price stickiness allows changes in monetary equilibrium to have liquidity effects, wherein changes in nominal interest rate also imply changes in real interest rates. Therefore, when the nominal interest rate rises, it is because the real interest has risen, which attracts incipient capital inflows, thereby biding up demand for the home currency and causing it to appreciate. By contrast, the risk premium encapsulates a positive coefficient because imperfect asset substitutability means that investors will require a higher rate of return to hold home assets if they perceived to be relatively risk. Otherwise, they will attempt to switch to holding more of foreign assets. The resulting rise in the risk premium will thereby weaken the home currency. Consequently, if the interest rate differential is high, the exchange rate will lie below its equilibrium value. Conversely, if the risk premium is high, the exchange rate will lie above its equilibrium value.

We next use equation (9) to substitute for the long run exchange rate in the equation for short run transition dynamics (18), and solve for the current spot rate. On denoting the real interest rate as $i_t - \pi^e_{t+1}$ and thereby the resulting real interest rate differential as $r_t - r^*_t$, we obtain;

$$s_t = (m_t - m^*_t) - \delta(y_t - y^*_t) + \lambda(\pi^e_{t+1} - \pi^{e*}_{t+1}) - \frac{1}{\phi}(r_t - r^*_t) + \frac{1}{\phi}(i_t - i^*_t - \Delta s^e_{t+1}) \tag{19}$$

Thus, the model yields an equation in which the spot rate comes to depend on the relative money supply, the level of real income, the expected rate of inflation, the real interest rate differential, and a risk premium. This is the prediction that is tested.

However, the risk premium is unobservable and therefore not adaptable to empirical verification. Proxies for the risk premium are thus required. We finesse this by exploiting the insight of equation (17) wherein the risk premium is solved for the supplies of home versus foreign assets and solve for the current exchange rate. We thereby substitute the relative asset supplies in for the unobserved risk premium and obtain;

$$s_t = \beta_1(m_t - m^*_t) - \beta_2(y_t - y^*_t) + \beta_3(\pi^e_{t+1} - \pi^{e*}_{t+1}) - \beta_4(r_t - r^*_t) + \beta_5(b_t - f_t) \tag{20}$$

Where $\beta_1 = \frac{\phi\beta}{\phi\beta+1}$ $\beta_2 = \frac{\phi\beta\delta}{\phi\beta+1}$, $\beta_3 = \frac{\beta(\phi\lambda+1)}{\phi\beta+1}$, $\beta_4 = \frac{\beta}{\phi\beta+1}$, and $\beta_5 = \frac{1}{\phi\beta+1}$

The innovation in this specification is that the exchange now comes to depend on not only money supplies and demands, but it also acknowledges that expectations and exchange rate risk matters. The specification distinguishes the set of *empirically testable exchange rate fundamental determinants* as relative stocks of money supplies, relative real incomes or output levels, expected inflation rates, interest rate differentials, and risk premiums. Reflecting exchange rate overshooting due sluggish price responses and imperfect asset substitutability, rising interest rate differentials and risk premiums, respectively, cause the exchange rate to depreciate and appreciate. On the one hand, because a give increase in the money supply eventually inflates prices and a rising expected inflation rate differential reduces the value of a currency, both cause exchange rate depreciations. Rising relative incomes, on the other hand, eventually raise the demand for money and thereby appreciate the exchange rate.

However, we need to address a number of issues that are important for mapping equation (20) onto data. One is deciding on how to estimate the expected inflation rate, which, also, is *unobservable*. Unfortunately, knowing exactly what people's inflation expectations are is near impossible. Nevertheless, the economics literature uses three methods to measure inflation expectations: (1) surveys of people's expectations, (2) use market data (nominal and real interest rates) and (3) use the hypothesis of rational expectations. This says that expectations correspond to optimal forecasts, given available information, the optimality of which can be gauged using statistical methods. Of these three approaches, the second provides a more reliable measure of the expected inflation rate and is the most illuminating. However, available data for South Africa falls short of the period of interest of the present study. Instead, the expected inflation rate is measured following the third approach, that is, the rational expectations hypothesis. Specifically, we conjecture that the expected inflation rate equals the observed value and a stationary forecast error[12], and use stationarity tests to assess the optimality of this. Clearly, this is an unsatisfactory measure, as it is unhelpful in an economic environment that is constantly changing, as has happened in South Africa. Nonetheless, it is the most commonly applied in many empirical undertakings, as Patterson (2000) explains. One exception, however, is Frankel (1979) who proxied expected inflation by the long-term bond yield rate, on the ground that it captured future trends in inflation.

Another issue concerns which assets to use to measure the exchange rate risk premium to the satisfaction of the prediction equation (20). The risk premium can depend on many factors. Here, we have motivated this as arising from the private sector's preferences of domestic relative to foreign currency-denominated assets. However, a longer span of this data for South Africa is absent. We use instead the ratio of current account balance to nominal national income, measured cumulatively to capture the forward-looking nature of investment flows. This choice is justified by exploiting the argument (Sinn & Westermann, 2001; Hooper & Morton, 1982; Meese & Rogoff, 1983a; Pilbeam, 1995; Were, Geda, Karingi, & Ndung'u, 2001) that current account balances are variables that measure the net foreign indebtedness, and, thus, bring about changes in the private sector's holdings of foreign assets. The intuition is that, when a country registers a deficit on its current account, foreign residents are acquiring domestic assets. To the extent that these assets are interest bearing, and their supply is increased, then the value of the home currency can be expected to fall rather than rise when capital flows into the country increases. This contrasts a surplus on the current account balance, which is expected to create opportunities for domestic residents to hold foreign assets and, in turn, increase the value of the home currency. Of course, one can argue that this is inappropriate in South Africa's case where the current account was for a long time manipulated for political reasons, as the narrative in chapter has shown. However, investors probably used the same political events as a barometer for their risk assessment of South Africa's economy. Indeed, figure 5 seems to reflect this - the current account was in deficit for most the 1980s when foreign flows dried up and then fell into deficit from the mid-1990s onwards, as political reconciliation built investor confidence into South Africa and foreign capital began to flow in. Therefore, we view the use of this measure as a hypothesis to be tested.

[12] This is that $\pi^{e}_{t+1} = \pi_{t+1} + v_t$, where $v_t$has white noise properties

A final specification issue is deciding on which interest rate to include in the prediction equation. Here, we examine both the short term and long-term interest rates. In part, this is because, empirically, there is no consensus on the appropriate interest rate data to be employed in an exchange rate equation (Meese & Rogoff, 1988; Sarantis, 1995; Nadal-De Simone & Razzak, 1999). Theoretically, there is discussion only of the interest rate. But, the reality is that there is a range of interest rates across differentiated assets as well as at different horizons and interest rates have behaved differently across those maturities. This raises the empirical issue of which interest rate should be used. While, ordinarily either a short term or long term interest rate should be used, it is of interest to examine the two rates, to see if they provide the same information set for understanding the interest rate impact on the exchange rate.

Given all of the above, the empirical model that we map to data may be specified as;

$$s_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(r_t^{ST} - r_t^{ST*}) + \beta_4(r_t^{LT} - r_t^{LT*}) + \beta_5(\pi_t - \pi_t^*) + \beta_6(CA_t - CA_t^*) + \epsilon_t \quad (21)$$

The variables have the following interpretation:

- s_t is the log of the rand spot nominal rate;
- $m - m^*$ is the log of the ratio of South Africa's money supply to the foreign money supply;
- $y - y^*$ is the log of the ratio of South African to foreign real income
- $r^{ST} - r^{ST*}$ is the short term real interest rate differential
- $r^{LT} - r^{LT*}$ is the long term real interest rate differential,
- $\pi - \pi^*$ is the inflation rate differential,
- $CA - CA^*$ is South Africa's current account relative the foreign current account balances and, stands in for the risk premium.

An asterisk $(*)$ denotes counterpart foreign variables and ϵ_t is a stochastic error term satisfying white noise properties.

Some economic meanings can be given to the parameters β_2 to β_6.Each is interpreted as (partial) elasticity of the exchange rate variable with respect to a unit change of that respective determinant. The signs of estimates of those coefficients for the relative money supply, current account balance and inflation rate differential are all expected to be positive because a rise in the values these variable should depreciate the rand. That for the relative money supply, however, should yield a positive unity, since relative money supply exhibits first-degree homogeneity in this model. In contrast, the signs of the parameters on the two interest rates and real income variables should be negative coefficients, as their increase is expected to lead rand appreciations. Therefore, the testable priors are that:

$\beta_1 = 1, \beta_2 < 0, \beta_3 < 0, \beta_4 < 0, \beta_5 > 0,$ and $\beta_6 > 0$.

4.2 Data and their profile

4.2.1 Definitions and sources

The data used are sample at quarterly observations spanning the period 1984 through to 2005. Table 2 profiles their interpretation and sources.

Exchange rate data pertains to a trade weighted nominal rate, measured as the rand price of foreign currency[13]. The series is formed from a trade-weighted basket of currencies comprising the euro, the US dollar, the British pound, and the Japanese yen. Their choice is because most currency trading on the South African foreign exchange market involves those currencies, and the Euro area, the US, the UK, and Japan are the country's major trade partners.

Moreover, until 1999, the South African Reserve Bank actually relied on these four currencies to form the currency basket used to calculate both the nominal and real exchange rate indices (Farrell, 2001; Walters, 1999; Walters & De Beer, 1999)[14]. Even though the currency basket for calculating the exchange rate indices is now expanded to thirteen currencies, the four currencies are still dominant, accounting for 77.65% of the total weight (South African Reserve Bank, 2007)[15] . For the series used in this investigation, these trade weights have been normalized to 42% for the Euro, 21% for the US dollar, 21% for the British pound sterling, and 16% for the Japanese yen. These same normalized trade weights have then been used to make weighted averaged values of data series on variables of interest on the four trading partners, namely the Euro area, the USA, the UK, and Japan.

Note, however, that as the euro was introduced only in 1999, data on the euro rate series corresponds to the German mark prior to this date. While this increases the likelihood of a structural break in the euro rate series given its applicability to a much larger economic area than the German mark did, both are market-generated data. Thus, we think that it is unlikely its use may result in errors in modeling of the sort that would follow from a reconstituted series. Moreover, on inception, the euro replaced the German mark on a one to one basis in the South African Reserve bank's currency basket (Walters, 1999).

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13 The idea behind this choice is to obtain an average measure of the rand's value. Multilateral rates such as trade-weighted rates have the advantage of providing a much more complete picture of a currency's strength or weakness, given that bilateral rates may not necessarily move in the same direction. Bilateral rates, on the other hand, provide information only about a particular country and its currency, and thus, their relevance is confined to analysis of specific factors between two countries. Nonetheless, in South Africa's case where the US dollar and British pound sterling serve mainly as vehicle currencies, bilateral rates in these currencies can convey the same information.

14 There has been a significant change, over the years, in both the structure of the currency basket and the methods for calculating the trade weights used in the construction of the effective exchange rate index. Prior to 1999, the currency basket consisted of only the US dollar, the German Mark, the British pound and the Japanese yen. After 1999, the Euro replaced the German mark with a weight of 31.6%, while the US dollar, the British pound, and the Japanese yen represented weights of 42.8%, 16.7%, and 8.9% respectively. In terms of the methodology for actual calculation of the weights, the practice, prior to 2003, was to calculate exchange rate weights as a ratio of each respective country's share to total trade in merchandise and services based on the currency denominations of commodities traded on the international market. Following international practices, this changed, from 2003, to calculation of weights based on the terms of trade in consumption of manufactured goods rather the share in the volume of trade. For a detailed discussion of this issue, see Walters (1999) and Walters and De Beers (1999).

15 See page s-103

In terms of the variables that serve as regresssors, the choice of data is the following. Narrowly defined money, M1, is proxy for the money stock. Although the specification in our model is about nominal money balances, these data enter the analysis in real terms. The reason is to avoid collinearity with the inflation rate variable, which is also part of the specified empirical model. Moreover, money market equilibrium requires that real money supply equal real money demand. Each respective data series are therefore deflated using the consumer price index. For the rest of the regressors, the real income variable is represented by the value of GDP at 2000 constant prices. The annual (4 period change) percentage change in the consumer price index(2000=100) stand in for the inflation rate. The three-month Treasury bill rate is used for the short-term interest rate, while the ten-year Government bond rate is proxy for the long-term interest rate. Both data are adjusted for CPI-inflation to express their values in real terms. Current account data, which, as already stands in for the risk premium, are measured as a one-period-ahead cumulative values, captured as a share of nominal GDP. The use of cumulative values here is to try to capture the forward-looking nature of investment flows, which is what is the intended.

The graphs of the data are presented in figure 6. Several features of the data are evident. First, relative real M1 money stock differential falls rapidly during 1984 through to 1986 but recovers moderately thereafter up until 1994. It thereafter rises much more sharply and establishes its peak during 1998, and remains fairly stable in the remainder period.

Real GDP differential series is also rapidly trended downwards from 1984, but its rate of descent is much more severe, as this persists until 1993. Nonetheless, the series begins to rebound slowly in 1994, but picks up strongly only after 2000.

Trends in real interest rate differential data somewhat contrast that of other data. The three months Treasury bills rises much more sharply for the most part, except during 1984 to 1986 and 2002 when it falls sharply; apparently reflecting accelerated inflation in these periods. The ten-year government bond rate has a similar pattern, although the extent of its decline in 2002 is much more extensive.

In contrast, the general pattern of developments in the inflation rate differential is a steady decline for the most part, except for occasional sharp increases observable in the mid 1985 and 2002. On the other, the relative current account balance remains significantly favorable (positive) throughout the 1980s and early 1990s, mainly underscoring the fact that, in this period, South Africa was forced to run a current account surplus due to financial sanctions (Jonsson, 2001). However, post 1994, the relative current account balance became unfavorable (negative), with the size of the deficit widening sharply after 2002, although there is a modest improvement from 1999 to 2001

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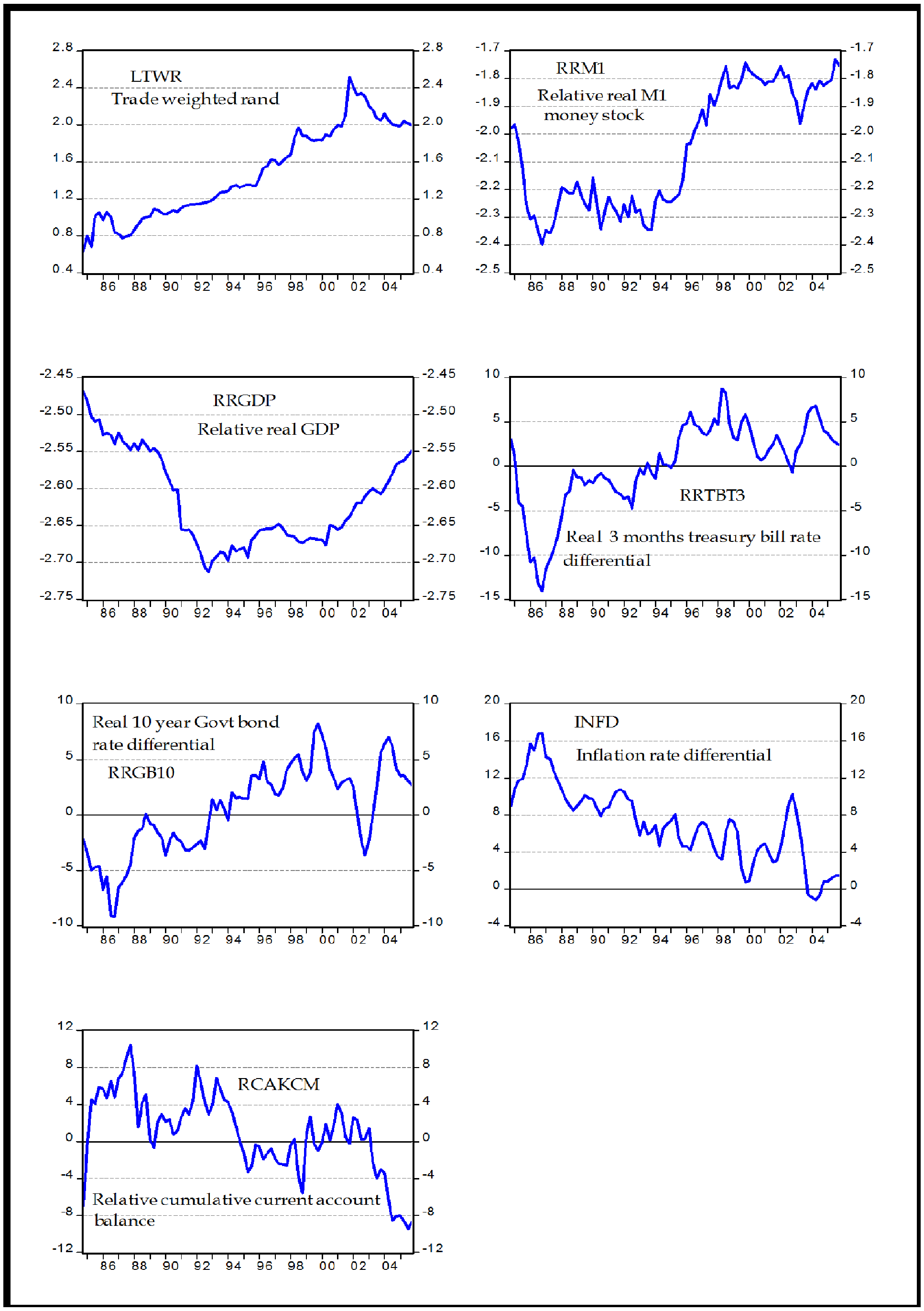
Figure 6: data trends



4.2.2 Unit root properties

Before applying the proposed empirical analysis, data are first examined for their statistical properties, partly to gain more knowledge of the time series properties of these series. There is now considerable evidence in the literature indicating that data generating processes that underlie many time series data such as those on macroeconomic variables typically embody non-stationary *stochastic trends* or *unit roots* in level; becoming stationary only after differencing[16]. These induce permanency in shocks, causing variables to grow overtime with no tendency to revert to their mean values. Their presence in the data poses the challenge that standard testing procedures such as t- and F-statistics do not lead to valid inferences. Nonetheless, even if data are non-stationary, Engle and Granger (Engle & Granger, 1987) have pointed out that valid inferences can be made, provided they share a common stochastic trend – if they are *cointegrated*. Otherwise, data would have to be estimated in their differenced form. Testing for stationarity of the data series is thus cruacial for our analysis because it affects choice the appropriate methodology to employ for the analysis.

To determine whether a series has a unit root, both the standard and augmented Dickey-Fuller tests (Dickey & Fuller, 1979; 1981)[17] are used. Thus, for each series of our data $\{y_t\}$, we estimate a regression of the following form.

$$\Delta y_t = \alpha_0 + \alpha_1 t + \theta y_{t-1} + \sum_{i=1}^{p-1} \varphi_i \Delta y_{t-i} + \epsilon_t \tag{22}$$

Where $\theta = \left(\sum_{i=1}^{p} \varphi_i\right) - 1$, $\varphi_j = -\sum_{k=j+1}^{p} \varphi_k$, α_0 is a constant, t is a deterministic trend, and p is the number of first differenced values of data series (.i.e. the order of augmentation). A test of the unit root hypothesis is that $H_0\!: \theta = 0$[against the alternative that $H_a\!: \theta < 0$ and hence $\rho < 1$] which, if valid, gives confirmation that $y_t$is a non-stationary process with a unit root. Otherwise, the evidence favors y_t as a stationary process. For series that do not show trend (all, except exchange rate and inflation; see figure 6), the drift stationary version of the tests are applied.

Table 4 reports test results for each data series. These suggest that trade-weight rand exchange rate, treasury bill rate differential, government bond rate differential, real GDP differential, M1 money stock differential, and current account balance differential are all non-stationary in level but stationary in first difference or growth. The evidence is less strong for the inflation rate differential, which is found non-stationary in level using 10% as the significance level. This is most likely because the series, and indeed the others, has structural breaks. In the presence of such structural breaks, Dickey-Fuller tests are known to have low power to reject the unit root hypothesis. We conclude therefore that all data series most likely exhibit a unit root and, accordingly, it is reasonable to treat them as non-stationary $I(1)$ series

[16] Nelson and Plosser (1982) were the first to make this traction. Following Meese and Singleton (1982), many authors identify exchange rates as essentially random walks, for example, Baillie and Bollerslev (1989).

[17] Several approaches to testing for unit roots in economic data now exist, some of which Maddala and Kim (1998) have aptly surveyed. However, the Dickey-Fuller procedure is considered the standard unit root test

4.3 Testing methodology

Given the non-stationarity of the data, the testing methodology is to use Johansen's (1988; 1991; 1995) cointegration method to test whether *cointegrating* or *long run relationships* exist between the exchange rate and the variables that serve as regressors. The long run relationships are then indentified and estimated using Pesaran, Shin, and Smith's long run structural modeling methodology.

In Johansen's (1988; 1991; 1995) method, data are thought of as being drawn from a data generating process that involves as an unrestricted vector autorgressive (VAR) model.

$$Z_t = \sum_{i=1}^{p} \Psi_i Z_{t-i} + \Theta W_t + U_t \qquad (23)$$

.where Z_t denotes a n vector of the variables to be investigated; w_t is a vector of deterministic variables; $\Psi_1, \dots, \Psi_p$ and Θ are matrices of coefficients to be estimated; and U_t is a vector of error terms satisfying white noise properties.

If data are non-stationary and cointegrated, the VAR model has a dynamic vector autoregressive (VEC) representation that is the stationary:

$$\Delta Z_t = \Pi Z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \Theta W_t + U_t \qquad (24)$$

Where $\Pi = \sum_{i=1}^{p} \Psi_i - I$ is a matrix of long run coefficients that produce linear combinations of the variables in Z_t and $\Gamma_i = -\sum_{j=i+1}^{p} \Psi_j$is matrix of coefficients capturing short run dynamic adjustments among the variables.

The presence of cointegration is indicated by the rank of $\Pi = \alpha\beta'$, and therefore the test for cointegration amounts to a test of the hypothesis that

$$\mathrm{H}_0(r): \beta' = r \leq n-1$$

where β is an $n \times r$ matrices of full rank r, α is loading matrix capturing the speed of adjustment of the variables to their previous period's disequilibrium. If:

- If Π is either full rank, r, or zero rank, Π =0, no cointegration exists among the variables in the model (in these instances, it is appropriate to estimate the model in, respectively, levels or differences)

- If Π is of reduced rank ($r \leq n-1$), then there exist at least $r \leq n-1$ cointegrating or long run relationships among the elements of Z_t.

Johansen has proposed two tests for determining the existence of cointegration among the variables of the model[18]. One, the Trace statistic, tests the null hypothes.of cointegrating relationships against the alternative of n cointegrating relationships, where n is the number of variables in the VAR, and $r = 0, 1, \dots\dots, n-2, n-1$:

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[18] While ordinarily, testing the null hypothesis has relied on critical values in Johansen (1988), other authors have also tabulated these critical values, for instance Osterwald-Lenum (1992). In this paper, we use the more recent critical values tabulated in MacKinnon, Haug, and Michelis (1999) that also allow for calculation of p-values. Note that Eviews 5.0 computes these MacKinnon, Haug, and Michelis (1999) p-values automatically.

$$LR_{trace} = -\mathrm{T} \sum_{i=r+1}^{n} log\left(1 - \hat{\lambda}_i\right)$$

Where λ_i is the i-th largest eigenvalue of Π .

The other is the Maximum Eigenvalue or $\lambda - max$ statistic. This tests the null hypothesis of r cointegrating relationships against the alternative of $r + 1$ cointegrating relationships present among data series. It's formula is

$$LR_{max} = -\mathrm{T}\ log\left(1 - \hat{\lambda}_{r+1}\right)$$

Both tests yield asymptotically nonstandard distributed under the cointegration hypothesis.

However, where evidence favors $r > 1$, the problem of *identification* arises; the presumptive behavioral relationship among the variables cannot be uncovered unless one elects to *specific out-of-sample* information. Unfortunately, there is yet no consensus on appropriate identification schemes and how to interpret the cointegrating relations so detected (Granger, 1997; Pesaran, 1997).

This paper resolves the identification problem using the *long run structural modeling* approach suggested by Pesaran and Shin (2002) and Pesaran, Shin, and Smith (2000). That approach advocates using information derived from economic theory to uniquely indentify the presumptive relationship sought, with option to test the validity of such restrictions on data. One can also use other out of sample information deemed relevant to the analysis. We follow the latter.

4.4 Empirical findings

This section discusses results from estimating the model using the methodology outlined above. Before that, however, we first address the issue of how the empirical question of how the impacts of regimes change is tested. It has been stressed early on that exchange rate pricing in South Africa has occurred in an environment of frequent policy changes. Most of the dramatic changes followed a combination of political events and changes in government policies. In terms of government policies, up until 2000, multiple periods of varying degrees of very controlled floating existed, together with capital controls and restricted trade with the global economy. It was not until trade and financial market liberalization, which began in the mid-1990s, resulted into adoption of inflation-targeting as the monetary policy framework did the exchange rate regime become a free-float.

Therefore, our premise is that the exchange rate and perhaps some of its determinants have experienced episodes in which the behavior of their time series seems to have changed dramatically. The analysis needs to uncover this from the data. In other words, the question that arises is whether regimes change is in the data and if accounting for it then improves the fit of data.

To model the likely change in the processes of the variable that we study due to regimes change, the analysis proceeds as follows. We first take the regime switch to an Inflation Targeting monetary policy framework in 2000 as a point of reference. We argue that since inflation targeting was implemented in February 2000, obvious interventions have been notably nonexistent, save for reserve build up. Furthermore, its application has permitted the Government to set monetary policy by determining interest rates based on the inflation rate as a nominal anchor, and rely instead on the market to set the exchange rate. This is important because it means that interest rates, which area a key fundamental, have become more predictable, and therefore it should improve information processing by the market. Thus, post-2000, we can expect market forces rather than government interventions to have a major influence on exchange rate determination. Moreover, as the institutional setup in which currency movements are occurring, we can expect that regime change in itself should alter the information set the on which agents are forming expectations, since it induces agents expectations about future exchange rate movements.

We thus truncate the sample period at February 2000, the date of the regime change to inflation targeting, and estimate our empirical model on both a truncated and full sample data[19]. We thereby implement a three step testing strategy:

a) First, estimation of the model is made on a sub-sample data set, 1984q4 to 1999q4, which is split at February 2000 – outside the period of inflation targeting. Results obtained using the sub-sample estimations are catalogued model 1A.
b) Second, the same estimation is repeated on full sample data, from 1984q4 to 2005q4, which incorporates the regime change to inflation targeting. The estimations results thereof are labeled model 1B.
c) Third, we thereby compare the results of the two estimations.

The idea is to establish if there is a difference in the relationship of the rand and its determinants due to the regime change. That is, if the relationship has remained the same before and after the regime-switch to inflation targeting. If regime change is not binding, there should be no significant change in the relationship of the exchange rate and the fundamental determinants. Otherwise, we should expect to observe a breakdown in the relationship, whereby either previously insignificant variables gain their significance. Alternatively, those previously significant variables lose their significance. Thus, our null is that regime change - the switch to inflation targeting - has not affected the linkage of the exchange rate rand to its fundamental determinants.

This approach nonetheless has the handicap that some valuable degrees of freedom are lost due to splitting the sample period. In addition, exogenously selecting regimes change dates may lend itself open to criticisms of data mining. Thus, other alternatives that overcome these constraints have become available, such as the *regimes-switching* modeling methodology[20]. Nevertheless, we think

[19] Enders (1995) provides further discussion of this in the context of unit root testing. Studies that make similar treatments include Ott and Veugelers (1986). These authors examined whether changes in US monetary policy regimes affected forward rate forecast errors of spot rates of the dollar, finding that they did.

[20] This allows modeling time series models as processes that shift direction in each of a fixed number of states, the '*regimes*'. The stochastic process assumed to generate the regimes is then included as part of the model. Usually, the regime is unobservable and the researcher must make inference about the regime the process was in at past periods in time. Regime-switching models are of two categories. Markov-switching models, pioneered by Hamilton (1988; 1989) and first applied to exchange rate analysis by Engel and Hamilton (1990), rely on a latent variable called a markov chain to signal the probability of a regime shift. Hamilton (2008) has provide a more recent review of this literature. In contrast, Threshold

that our approach contains a useful way of addressing the impact of regime change on the relationship examined, since the regime change that we model is exogenously given – *it is a known event.*

Cointegration tests

We first consider the results of cointegration tests[21]. Table 7 reports Trace and Maximum Eigenvalue statistics from sequentially conducting the Johansen's test for cointengrating relationships among the data series. These indicates that at least two cointegrating relationships may be present when sub-sample data (model 1A) are used in the estimations, and one cointegrating relationship with full sample data (model 1B). Consequently, we find evidence that the exchange rate and the set of fundamental determinants posited by our model *form a long run relationship.*

However, the two cointegrating relationships uncovered in the first case pose the difficulty of how to identify the two relationships. This is resolved following on Pesaran, Shin, and Smith's (2000) advice who have argued that when more than one cointegrating relationships are present, the decision concerning the choice of the number of cointegrating relationships must be made in conjunction with other out of sample information available such as economic theory. Indeed, our primary concern here is discriminating the linkage of the rand to the set of factors we have posited. We can only achieve this if we take into account all the variables of interest. We also face the difficulty that the other cointegrating relationship is not interpretable as an exchange rate equation, since it relate to a separate equilibrium relationship among some of the variables in the model[22]. Therefore, we impose a rank of $r = 1$ on the model, which results into cointegration relationship normalized on the exchange rate variable ($ltwr$) shown below;

$$\xi_{1t} = \beta_{11}ltwr - \beta_{12}rrm1 + \beta_{13}rrgdp + \beta_{14}rrtbt3 + \beta_{15}rrgb10 - \beta_{16}infd - \beta_{17}rcakcm + \mu \qquad (25)$$

Where the just identifying restriction is set as $\beta_{11} = 1$

Table 8 reports estimated coefficients associated with this relationship. Broadly, these results corroborate apriori expectations, in the sense that coefficients of the variables have hypothesized signs. Relative money supply (M1), inflation rate differential, and current account balance all have positive coefficients, though, for current account balance, this fails on full sample data. Given that upward movements in the exchange rate data series denote

models, first suggested by Tong (1983), model regime shifts in terms of observed variables assumed to be related to the unobserved threshold. Piper (2007) offers a summary the literature of this genre.

21 In making cointegration tests, the data trend specification choice made is to restrict the intercept in the test VAR. Two lags of each data series in their first differences are added, on the strength of the Schwartz Bayesian and Akaike information criteria for lag selection, alongside three centred seasonal dummies (sr1, sr2, & sr3) intended to account for seasonality in the data. Also included in each specification is a series of first-differenced values of the real gold price (Δlgolpr), intended to control for the impact of changes in the terms of trade. Gold mining has a historical importance to the South African economy. Lastly, a dummy variable, D2001=1 in 2001q1-2002q1, is added to the specification estimated on full sample data, to capture the effect on the rand of its rapid collapse in that period.

22 See also the exposition in MacDonald and Ricci (2003) and Chinn (1999)

depreciation, this indicates that higher relative money supply have tended to depreciate the exchange rate. So too has been a higher inflation rate differential and larger current account deficits. Relative real output (real GDP), in contrast, has a negative coefficient, suggesting correctly that rising incomes or, alternatively, strong economic growth in South Africa has tended to appreciate the exchange rate.

However, the evidence of the direction of impact of the interest rate differential conflict; the signs of the coefficients of the shortterm and longterm interest rate differential interest rates contrast. For both the real short-term and long-term interest differential, the hypothesized a priori is that their coefficients should be negative, which would suggest that a higher interest rate differential should appreciate the exchange rate. But the real 3 months Treasury bill rate differential has a positive coefficient, whereas that of the real 10-year Government bond rate differential is correctly negative. This suggests that increases of short-term interest rate differentials in favor of South Africa have tended to depreciation the exchange rate, while long term interest rate differential appreciates have an appreciating influence. Thus, from the data, it does appear South African investors have tended to sell the rand when faced with higher short-term interest rates, but buy it when long-term inters rates are relatively higher.

Table 2: First stage estimation of the cointegrating equation for the exchange rate model

		Dependent variable: *trade weighted rand*	
Regressor	**name**	**Model 1A** *(1984q4-1999q4)*	**Model 1B** *(1984q4-2005q4)*
Relative money supply	rrm1	1.00	1.56
		[2.73]	[6.59]
Relative real income	rrgdp	-0.64	-2.16
		[-0.99]	[-3.26]
Interest rate differential			
Short term rate	rrtbt3	0.11	0.07
		[3.03]	[3.75]
Long term rate	rrgb10	-0.05	-0.11
		[-1.49]	[-4.56]
Inflation rate differential	infd	0.03	0.01
		[0.56]	[0.23]
Cumulated current account balance	rcakcm	0.04	-0.004
		[2.29]	[-0.28]
Constant	c	1.47	-0.97

Note: t-statistic in square brackets

Nonetheless, it can be argued that having the two interest rates in the same equation may introduce colinearity, which may be contaminating their separate influences, hence their opposite signs. To see if this may be the case here, we rerun the estimations, with the two interest rates introduced separately into the analysis. Table 9 reports the results. These show that the two interest rates continue to retain coefficients with opposing signs. The results therefore seems a property of the data.

This might seem puzzling at first, but careful examination dispels the appearance of a contradiction. Intuitively, the finding may be justified on the ground that, given the evidence of non-stationarity of their data, in their local domains, domestic short term and long-term interest rates are governed by a common stochastic trend, or *are cointegrated*. Thus, their predictability rather than their colinearity is what may drive this relationship. Indeed, theoretical arguments support such conjecture. From the theory of the term structure of interest rates, long-term investors should be rewarded more than short-term investors should and, as such, yield rates on assets of shorter maturities should follow those on longer maturities. This suggests a positive relation between long term and short-term rates. Certainly, large deviations between the two rates are not to be expected to persist because arbitrageurs should keep the relation in equilibrium[23].

Moreover, theoretically, the question of which interest rate is relevant is not even settled. There are conflicting predictions for the interest rate variable. Under the flexible price assumption, the presumption is that nominal interest rates represent inflationary expectations, and therefore their changes should eventually lead to depreciated exchange rates. On the other hand, if price stickiness is hypothesized, nominal interest rates embody a real and inflationary component, so that it is possible to see appreciated exchange rates from interest rate changes. This follows from the conjecture that a rising real interest rate differential should attract a capital inflow, which, in turn, appreciates the exchange rate. Finally, similar results are also commonplace in demand for money studies, where the short-term interest rate is added to represent the own yield rate on money assets[24].

4.4.1 Impact of regime change

The normalization used to derive these results are nonetheless arbitrary because they just aid identification of the relationship. To locate uniquely robust relationships capturing interactions among the variables, a number of hypotheses relating to whether some variables can be excluded from the equation forming the long run equilibrium are tested. This is done following Pesaran, Shin, and Smith (2000) and Pesaran and Shin's (2002) long run structural modeling methodology, as previously indicated. Recall that this advocates using economic theory or any relevant out of sample information to test the validity of the estimated relationships.

In doing this, we begin by noting that the model that we have tested posits that changes in relative monies will bear equal-proportionate changes in the exchange rate. The coefficient of the relative money stock variable should therefore equal unity in the exchange rate equation. The identification process thus starts with testing the validity of this homogeneity hypothesis. To do this, the cointegration equation is re-estimated together with the over-identifying restriction that $\beta_{12} = -1$ in equation (25) shown earlier. The results are reported in table 10.

(a) Sub-sample estimations

We first consider the results of estimations using sub-sample data (model 1A; 1984-1999). The log-likelihood ratio statistic for testing the above restriction is given as $X^2(1) = 0.00006$, which, with a p-value of 0.99, means that the

[23] See also the discussion in Woodridge (2006) as well as Gujarati (2003)
[24] A South African perspective is Todan (2007)

restriction is easily supported by the data. Notice also from table (8) that both the relative real GDP and inflation differential data are insignificant when estimated using the sub-sample. Consequently, the coefficients on these variables are each restricted to zero by testing the over-identifying restrictions that $\beta_{13} = 0$ and $\beta_{16} = 0$, which, if accepted, implies the variables may be removed from the analysis. The test yields a log-likelihood statistic of $X^2(3) = 0.29$, with p-value of 0.96, which is also statistically insignificant. Data thus fits the restrictions. Next, the coefficient on the current account variable is restricted to zero by testing the extra restriction that $\beta_{17} = 0$, providing a log-likelihood statistic of $X^2(4) = 3.02$, with a p-value of 0.55. Again, this is insignificant. Thus, the four restrictions jointly are not binding. This means therefore that real incomes, the inflation rate differential, and the current account balance do not explain the exchange rate. Essentially this leads us to the conclusion that, for the sample period from 1984q4 through to 2005q4, it is only the relative money supply (M1), the short term interest rate differential (real 3 months Treasury bill rate) and the long term interest rate differential (real 10 year Government bond rate) that map long trends in the exchange rate. We may write the long run relationship that arises from this estimation as equation (26) below. This is also provided in table (10) labeled *Coint.Eq Model 1A*.

$$ltwr = rrm1 + 0.25rrtbt3 - 0.30rrgb10 + 3.43 \qquad (26)$$

Thus, in terms of this relationship, a one percent increase in the South African real M1 would depreciate the exchange rate by one percent. Similarly, the exchange rate would tend to depreciate by an average of 0.25% if the real short term interest rate differential favoring South Africa were to rise by a 100 basis points. On the other hand, the effect of an increase in the long-term interest rate differential of 100 basis points would be to appreciate the rand by an average 0.30%.

(b) Full sample estimations

Comparing the estimations using the pooled sample (model 1B, table 10) with those that apply sub-sample data, the results differ markedly only in respect of the real income variable. Relative real GDP now evidence a significant coefficient based on the just indentifying restriction (i.e. setting $\beta_{11} = 1$ in equation 25). However, as is with sub-sample data, both the inflation rate differential and the current account maintain their lack of significance. The null of first-degree money supply homogeneity is thus tested jointly with those that the inflation rate differential and the current account balance do not matter in this equation. This is done by imposing the over identifying restrictions $\beta_{12} = -1, \beta_{16} = 0$, and $\beta_{17} = 0$, which gives a log-likelihood statistics of $X^2(3) = 4.36$, with p-value of 0.22, and does not reject the joint hypothesis. Therefore, the inflation rate differential and the current account balance continue to maintain their lack of significance in explaining the exchange rate. However, real GDP does not. Consequently, from table (10), the relation characterizing the long run relationship that explains the exchange rate may be written as

$$ltwr = rrm1 - 1.3rrgdp + 0.09rrtbt3 - 0.10rrgb10 + 0.24 \qquad (27)$$

As can be seen from this equation, extending sampling data to incorporate the period of Inflation Targeting reveals an extra and very important piece of information. Particularly, there is the additional evidence of statistically significant responses of the exchange rate to variability in relative real GDP. According to its estimated parameter, the exchange rate would, on average, tend to appreciate by 1.3% if the South African economy grew by one percent relative to those of its trading partners. Therefore, it appears the regime shift to Inflation Targeting has had the effect of illuminating to the market the importance of information on the economic growth of the country, as data did not support this variable in preceding analysis. Examining figure 6 readily reveals why this must be so. Having begun to rebound from mid-1992, the South African economy accelerated after 2000, which is supporting of this inference.

Table 3: Second stage estimation of long run relationships

		Dependent variable: *trade-weighted rand*	
Regressor	**Var. name**	**Model 1A** *(1984q4-1999q4)*	**Model 1B** *(1984q4-2005q4)*
Relative money supplu	rrm1	1.00	1.00
Relative real income	rrgdp	0.00	-1.27
			[- 2.51]
Interest rate differential			
Short term rate	rrtbt3	0.26	0.09
		[6.08]	[6.52]
Long term rate	rrgb10	-0.31	- 0.10
		[-5.00]	[-4.84]
Inflation rate differential	infd	0.00	0.00
Cumulated current account balance	rcakcm	0.00	0.00
Constant	c	3.43	0.24
No of tested restrictions		4	3
Chi-sq stat (p-value)		3.02 (0.55)	4.36 (0.22)
Indentifying restriction		$\beta_{12} = 1$	$\beta_{12} = 1$
Included exogenous varibles		$\Delta lgolpr$	$\Delta lgolpr$, D2001

Note: t-statistic in square brackets

Importantly, however, the parameters of the two interest rates display large movements. Although maintaining their signs and statistical significance, their magnitudes fall dramatically. In this instance, every 100 basis points increase in the real 3 months Treasury bill rate differential is associated with approximately a 0.09% exchange rate depreciation. This compares with a 0.26% depreciation when sub-sample data are used. Similarly, for the relative 10-year government bond rate, its rise by 100 basis points appreciates the exchange rate by an average 0.10%, whereas it was 0.30% previously. This exceptionally large decrease in the interest rate sensitivities may be explained by the fact that, with inflation targeting, the Reserve Bank has been intervening in money markets through interest rate announcements, as this policy regime has replaced money targeting with smoothing of short-term interest rates, using the repo rate, as the operating target of monetary policy. In turn, this has had the unintended consequence of smoothing out the information content from interest rates for currency pricing. This is likely to reflect into long-terms interest rates also because those rates are the average of anticipated short-term rates that agents anticipate in future.

To sum up, data sustains evidence of a strong correspondence of the exchange rate to a subset of fundamental factors that we have posited. However, only relative money supply, the short-term and the long-term interest rate differential form a statistically significant relationship when the model is examined on a sub-sample data set, from 1984 through to 1999. When, on the other hand, full sample data encompassing the regime switch to inflation targeting are used, there is the added statistical significance of the relative real income variable. This demonstrates that accounting for the regime change to inflation targeting improves the fit of the data. What the study then establishes is that the linkage of the rand to fundamentals is regime-dependent. Nevertheless, data does not validate the hypothesized influences of the expected inflation rate differential and the risk premium.

(c) Alternative method : the dummy variable procedure

Although testing for regime change by way of partitioning the sample period succeeds in isolating the difference in the relationship due to a regime shift, as detailed above, it does not allow us to distinguish the source of the break in the relationship. Therefore, as a verification test of robustness of results obtained above, the evidence is re-examined by investigation whether the structural break is due to a changes in the slope coefficients. The investigation of this proceeds as follows.

a) A regime shift dummy is created, D2000, which equals unity in 2000q2-2005q4, the period of Inflation Targeting, and zero elsewhere.

b) Each respective explanatory variable in the test VAR model is then interacted with dummy variable, D2000 (i.e. multiplied by D2000) to create another variable, a *multiplicative dummy*, labeled MD2000, which takes the value of a respective explanatory variable when D2000=1, i.e. in the period of Inflation Targeting. This means $MD2000 = f_{it}$ only in 2000q2-2005q4 and zero otherwise, where f_{it} represents explanatory variable i, in the VAR model.

c) Rather than truncate the sampling period, the estimation is made on full sampling data only, but introducing the multiplicative dummy on each explanatory variable, $MD2000$, separately into the analysis as an additional regressor.

In brief, the intuition underpinning the testing procedure is the following. For each variable in the VAR model, we consider its correspondence with the rand as possibly driven by a process that undergoes a regime change of the form[25]

$$s_t = \delta_0 + \delta_{1i} f_{it} + \delta_{2i}(D_t f_{it}) + \epsilon_t \qquad (28)$$

Where $s_t$represents the rand exchange rate, $f_{it} \in Z_t$is a fundamental determinant in the VAR model, $D_t = D2000$ is the regime shift dummy, $D_t f_{it} = MD2000$ is the multiplicative dummy variable, and ϵ_t satisfies white noise properties.

The impact of regimes change is then assessed by examining the statistical significance of δ_{2i}, the coefficient on the multiplicative dummy variable $D_t f_{it}$. This tells by how much the slope coefficient on an explanatory variable differs before and after the regime change. To see how, note that before the regime change, when $D_t = 0$, the mean value function for the model above is

$$\mathrm{E}(s_t | D_t = 0, f_{it}) = \delta_0 + \delta_{1i} f_{it} \qquad (29)$$

[25] See, for example, the discussion in Gujarati (2003) and Thomas (1997)

But after the regime, when $D_t = 1$, the mean value function is now

$$E(s_t | D_t = 1, f_{it}) = \delta_0 + \vartheta_1 f_{it} \quad (30)$$

Where $\vartheta_1 = \delta_{1i} + \delta_{2i}$. As can be seen from (4-36) and (4-37), it is δ_{2i} that distinguishes the slope coefficients from the two periods (pre and post regime). Without the regime change, the slope coefficient on the fundamental determinant is simply δ_{1i}, whereas, with the regime change, a different coefficient exists, namely $\vartheta_1 = \delta_{1i} + \delta_{2i}$.

Therefore, the null hypothesis is stated as that $\delta_{2i} \neq 0$, which is assessed using a standard t-test for statistical significance of the estimated coefficient. Thus, the value of δ_{2i}can be either negative or positive. A positive value of the parameter δ_{2i} is interpretable as suggesting that the slope coefficient is larger in the post-regime change period relative to that of the pre-regime change period. This in turn is signifying the predictive power of the fundamental variable is enhanced by the regime change. A negative value of δ_{2i}, conversely, implies the slope coefficient is smaller in the post regime-change period, which is indication that the regime change diminishes the predictive impact of the fundamental variable. In these two instances, the implication is that regime change has a binding effect on the relationship. Otherwise, (i.e. if $\delta_{2i} = 0$) the relationship is invariant to the regime change.

Table 11 reports the test results. The coefficient estimate for multiplicative dummy is statistically only for the relative real M1 and relative real GDP. It is insignificant for all the other variables. In terms of this result for the two variables (M1 and real GDP), the results support evidence of the regime change to Inflation Targeting affecting the linkage of the exchange rate with respect to relative real M1 and relative real GDP, but not with the other variables tested. Our earlier finding of an improvement in the fit of the data from accommodating regime change into the analysis is thus confirmed by results provided in table 11.

In particular, the estimated multiplicative dummy coefficient for relative real M1 is 0.09, while that on the relative real GDP is 0.06. Given that relative real M1 enters the cointegrating equation with a negative sign, the above estimate means that the shift to inflation targeting appears to have diminished the predictive impact of relative real M1 by about 0.09. By contrast, for the relative real GDP variable, it has increased its predictive impact, on the average, by 0.06.

For the relative real GDP variable, this finding supports earlier findings obtained from using the sample-truncation technique. However, there is now the benefit of unearthing the extra evidence indicating the regime change appears to have diminished the importance of news about money supply changes in deciding the exchange rate. This finding of a regime dependent money supply impact on the exchange rate is an advance in our analysis; the result could not be found using the sample-truncation method applied earlier on. Thus, tests of the regime change dummy also support the finding that the connection of the exchange rate to fundamentals seems regime-dependent.

5 Conclusion

The body of evidence presented in this paper suggests that policy regime change has a significant impact on pricing of the currency with regard to fundamental determinants. South Africa's switch in 2000 to an inflation-targeting regime for conducting monetary policy isolates the previous years of very controlled floating from the current in which obvious foreign exchange interventions are absent and there is substantial liberalization of financial markets. In comparison to the previous period, one would thus expect the exchange rate-fundamentals relationship to have altered.

Indeed, testing for the impact of the change inflation targeting on the relationship of the exchange rate with a set of fundamental determinants found a relationship that is sensitive to the regime change. On the one hand, in the period pre-inflation targeting period, a smaller set of fundamentals explain the exchange rate. In the post-inflation targeting era, on the other hand, the set of fundamental anchoring the exchange rate is not only expanded but their impact is also enhanced. Thus, although fundamental tie the rand during the period covered by the study, the anchorage seems regime-dependent - *it has depended on the regime in which the exchange rate is in*. In short, the relationship differs on both sides of the regimes break.

It is here where the major contribution of the study lies and thereby extends the South African literature. Existing literature has not explored the significance of regimes change on exchange rate dynamics. The findings also have a much wider implication. At one level, the evidence uncovered here suggests that exchanges can differ in the degree to which they are connected to underlying determinants when the environments in which they are determined continuously change. This calls for more caution in comparing and interpreting results across spectrum of regimes change. At another level, results lend empirical support to the ongoing debate - the bi-polar view - on the choice of exchange rate regimes for developing countries with large exposures to international capital in the light of recent financial crises that rocked emerging market economies. The massage of this study is that regime change, or more generally institutional change, matters for currency pricing. Likewise, this can pose policy challenges.

Equally, the evidence provided on the direction of causation between the exchange rate and the fundamentals that we examined has policy implications. Of significance is the positive impact of the short-term interest rate of the exchange rate. Given that current monetary policy relies on setting short term interest rates, this suggests that it would be difficult to achieve exchange rate stabilization through raising short term interest rates, as is often suggested by a number of commentators. It is speculated that such a strategy would add to currency instability, especially if the currency is already unstable. Rather, it would appear that the only circumstance in which monetary policy would be more supportive is if interest rates rose faster at the longer maturity end of the yield curve.

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Data Appendix

Figure2: Short run volatility of the exchange rate

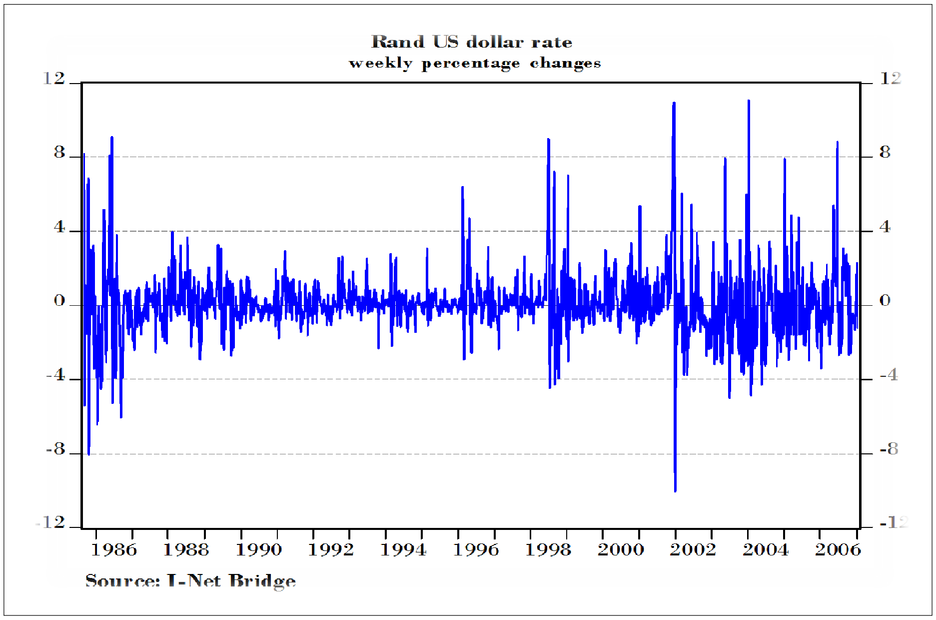

Figure 4: Net open position of the South African Reserve Bank

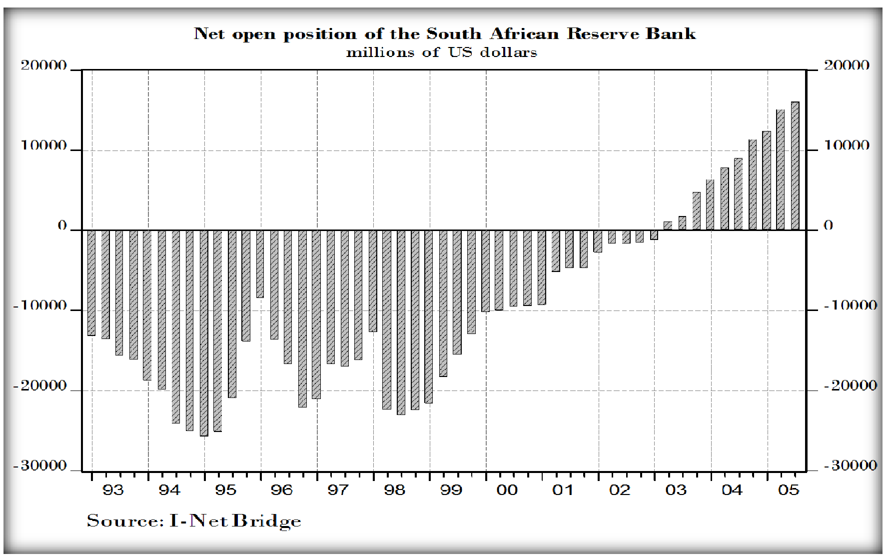

Figure 5: South Africa; cumulative current account balances (% of GDP)

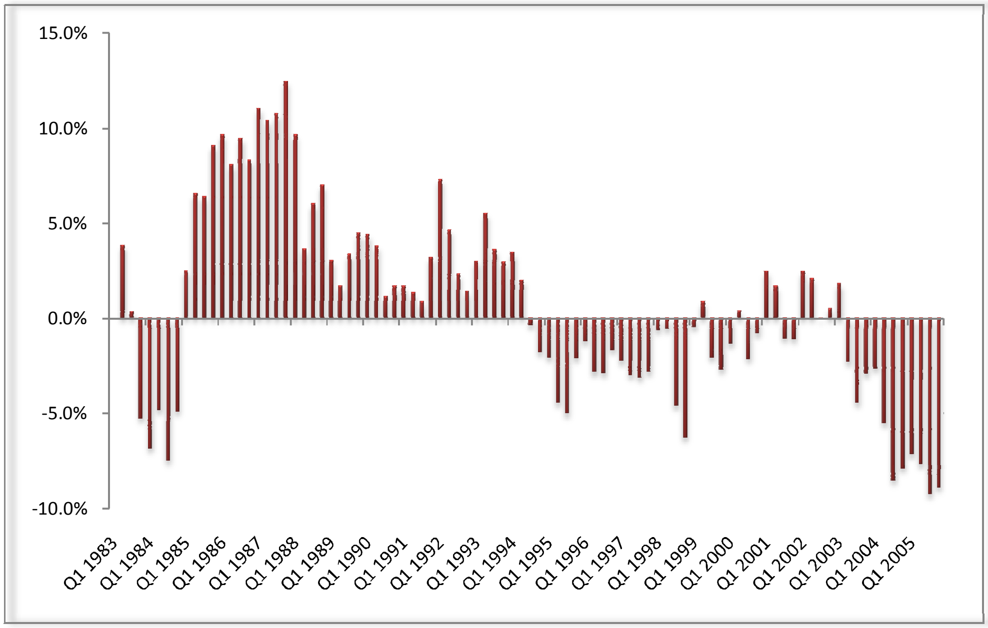

Table 3: Data and sources; exchange rate and fundamental determinants

Variable name			Description	Source: basic data
Nominal rand rate	s_t	ltwr	Log of trade weighted exchange rate for the rand's nominal bilateral exchange rates with the euro (42%), the US dollar (21%), the British pound (21%), and the Japanese yen (16%), trade weights in brackets. An increase in the value denotes depreciation	InetBridge
Relative money supply	$m_t - m_t^*$	rrm1	Relative real money stock, defined as the log of M1 over CPI for South Africa minus a corresponding weighted average measure for the four trading partner countries, using the same weights from the trade weighted exchange rate	Inet-Bridge, South African Reserve Bank for South Africa. International Financial Statistics (IFS) for trading partners
Relative real income	$y_t - y_t^*$	rrgdp	Relative real gross domestic product (GDP), calculated as the log of South Africa's GDP at constant 2000 prices minus the log of a corresponding trade weighted value for the four trading partners (billions of local currency)	South African Reserve Bank for South Africa, IFS, for trading partners
Short term interest rate differential	$r_t^{ST} - r_t^{ST*}$	rrtbt3	Real short term interest rate differential, calculated as the log of the three months treasury bill rate minus annual CPI-inflation [log(1+(tbt3-infl/100))*100] less a corresponding weighted average for the four trading partners (% per annum)	Inet-Bridge, South African Reserve Bank for South Africa, IFS, for trading partners
Long term interest rate differential	$r_t^{LT} - r_t^{LT*}$	rrgb10	Real long term interest rate differential, calculated as the log of the 10 year government bond rate minus annual CPI-inflation [log(1+(gb10-infl/100))*100] less a corresponding weighted average for the four trading partners (% per annum)	South African Reserve Bank for South Africa, IFS, for trading partners
Inflation rate differential	$\pi_t - \pi_t^*$	infd	Inflation rate differential, calculated as annual percentage change of the log of South Africa's consumer price index (CPI) minus a corresponding weighted average for the four trading partners (2000=100)	IFS
Current account balance	$CA_t - CA_t^*$	rcakcm	Relative cumulative current account balance, calculated as the share of South Africa's one period ahead current account balance in GDP minus a corresponding trading weighted measure for the four trading partners (billions of local currency)	South African Reserve Bank for South Africa, IFS, for trading partners

Table 4: Unit root test results (1984Q4-2005Q4)

Description	Null order series	I(1) in level ADF$_c$	ADF$_{ct}$	P	I(1) in 1st difference ADF	P
Trade weighted rand	ltwr		-2.52	1	-8.59***	0
Long term interest rate differential	rrgb10	-2.07		1	-7.17***	0
Short term interest rate differential	rrtbt3	-1.53		0	-7.17***	0
Relative money supply	rrm1	-0.66		0	-8.87***	0
Relative real income	rrgdp	-2.39		0	-8.38***	0
Inflation rate differential	infd		-3.78	5	-4.66***	4
Cumulative current account balance differential	rcakcm	-1.63		2	-9.91***	1

Explanatory notes:

(a) The ADF$_{ct}$, ADF$_c$ and ADF denote the Augmented Dickey-Fuller test statistic, including a constant and trend, a constant only, and no constant and no trend in respective order.

(b) The asterisks (***) denote rejection of the unit root hypothesis at the 1% critical values.

(c) P, the order of augmentation (lag length) of the ADF test regression, is the last significance lag of the 11 employed, based on Schwartz Bayesian Information criteria (SBC) for selecting the lag length.

(d) The critical values are the non-standard Dickey-Fuller regression as reported in Mackinnon (1991; 1996), and are provided here as part of *Eviews 5.0* output.

(e) With a sample size of 85, the 1%, 5%, and 10% ADF test critical values are -4.07, -3.46, and -3.16, when a constant and trend are included, -3.51, -2.90, & -2.59 with constant, and -2.59, -1.94, & -1.61 when neither constant nor trend are included in the test regression.

Table 7: Johansen's test for cointegration among data series

	Trace test				Maximum eigenvalue test			
	Model 1A (1984q4-1999q4)		Model 1B (1984q4-2005q4)		Model 1A (1984q4-1999q4))		Model 1B (1984q4-2005q4	
Tested number of CEs	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value
None	177.7**	0.0000	161.8**	0.0001	59.4**	0.0012	70.8**	0.0000
At most 1	118.2**	0.0006	91.0	0.1022	49.5**	0.0033	39.3	0.0606
At most 2	68.8	0.0611	51.6	0.5658	31.1	0.1024	22.9	0.5382
At most 3	37.6	0.3211	28.7	0.7809	20.4	0.3171	12.3	0.9178
At most 4	17.2	0.6250	16.4	0.6850	11	0.6493	8.3	0.8854
At most 5	6.2	0.6692	8.1	0.4550	6.2	0.5932	4.5	0.8002
At most 6	0.1	0.7982	3.6	0.0587	0.1	0.7982	3.6	0.0587
No of CEs by model	*2*		*1*		*2*		*1*	

Note: (1) the asterisks (**) denote rejection of the cointegration hypothesis at the 5% level
(2) p-values are calculated using Eviews5.0 econometric software, based on MacKinnon, Haug & Michelis (1999)

Table 9: Differential impact of the short term and long term interest rate differential on the exchange rate

Regressor	name	Model 1A *1984Q4 1999Q4*	Model 1A *1984Q4 1999Q4*	Model 1B *1984Q4 2005Q4*	Model 1B *1984Q4 2005Q4*
		Dependent variable: *trade weighted rand*			
Relative money supply	RRM1	1.099	1.82	1.11	3.41
		[5.25]	[6.25]	[4.54]	[5.39]
Relative real income	RRGDP	-1.14	-1.62	-2.03	-2.98
		[-2.64]	[-2.53]	[-3.73]	[-2.31]
Short term rate	RRTBT3	0.062		0.068	
		[2.48]		[3.84]	
Long term rate	RRGB10		-0.06		-0.38
			[-1.77]		[-4.78]
Inflation rate differential	INFD	0.03	-0.075	0.085	-0.26
		[0.87]	[-2.17]	[4.33]	[-3.23]
Cumulated current account balance	RCAKCM	0.03	0.003	0.009	-0.06
		[2.64]	[0.23]	[0.70]	[-2.28]
constant		0.38	1.53	-2.17	2.78

t-statistics in [ ]

Table 11: Tests of regime change on the rand: 1984q4-2005q4

Dependent variable: *trade-weighted rand*						
			Interest rate differential			
Interacted regressor	*Money supply (RRM1)*	*Real income (RRGDP)*	*Short term rate (RRTBT3)*	*Long term rate (RRGB10)*	*Inflation rate (INFD)*	*Current account balance (RCAKCM)*
RRM1	1.76	1.75	1.96	1.97	2.06	2.06
	[7.78]	[7.59]	[8.27]	[8.76]	[8.98]	[9.54]
RRGDP	-2.88	-2.86	-2.83	-2.89	-3.02	-3.55
	[-6.50]	[-6.41]	[-4.98]	[-5.25]	[-5.43]	[-6.34]
RRTBT3	0.05	0.05	0.06	0.06	0.06	0.04
	[3.78]	[3.85]	[4.16]	[3.90]	[3.95]	[3.15]
RRGB10	-0.09	-0.09	-0.12	-0.12	-0.13	-0.12
	[-5.14]	[-5.16]	[-5.70]	[-5.52]	[-5.73]	[-5.83]
INFD	0.00	0.00	0.00	0.00	0.00	0.00
RCAKCM	0.00	0.00	0.00	0.00	0.00	0.00
Tests of the Multiplicative Dummy Variable						
DTRRM1	-0.09					
	[-2.03]					
DTRRGDP		-0.06				
		[-2.07]				
DTRRTBT3			0.00			
DTRRGB10				0.00		
DTINFD					0.00	
DTRCAKCM						0.00
Constant	-2.43	-2.44	-1.86	-2.00	-2.14	-3.54
Tested restrictions	2	2	3	3	3	3
Chi-sq stat (p-value)	1.13 (0.57)	1.24 (0.53)	0.81 (0.81)	0.72 (0.87)	0.85 (0.84)	5.89 (0.12)
Incl exog var.	$\Delta lgolpr$	$\Delta lgolpr$	$\Delta lgolpr$	$\Delta lgolpr$	$\Delta lgolpr$	$\Delta lgolpr$

t-statistic in squared brackets