A Tale of Two Exchange Rates: South Africa's Dual-Rate Experiment

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Abstract

This paper investigates South Africa's dual exchange rate experiment during the period 1985–1995, wherein the commercial rand rate is set by current account transactions while the financial rand rate is set by capital account transactions. Tests show that the dual-rate system was highly effective in segmenting FX markets for the commercial *vs.* financial rands, thereby providing a 'controlled lab' setting to study key exchange rate questions. Our analysis reveals striking differences in empirical features of the commercial and financial rates. Although the financial rate follows a random walk process, the commercial rate does not and hence, is predictable. The financial rand rate exhibits a high, time-varying volatility occurring in clusters while the commercial rate shows a relatively low. The purchasing power parity (PPP) tends to hold for the commercial rate but fails to hold for the financial rate. Similarly, tests show that the commercial rate is linked to macroeconomic fundamentals but the financial rand rate is disconnected from the fundamentals. Finally, fundamental-based models outperform the random walk benchmark in predicting the commercial rate but fail to do so in predicting the financial rate. Overall, our findings suggest that the rising dominance of international investment over trade may be responsible for the well-known behavior of recent flexible exchange rates such as the random walk, failure of PPP, and a tenuous link with fundamental economic variables.

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Keywords: Dual Exchange Rates, Rand, Random Walk, Volatility, Purchasing Power Parity, Disconnect Puzzle, Predictability.

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1 Introduction

The collapse of the Bretton Woods System in the early 1970s ushered in a flexible exchange rate system. Although the majority of industrialized countries, including France, Germany, the United Kingdom, and the United States, first experienced floating exchange rates in the 1920s, recent floating rates differ substantially from earlier ones in terms of the behavior and the underlying driving forces. Specifically, the current flexible exchange rate regime has been characterized in the literature as a regime with exchange rates that are highly volatile and behaving like random walks, providing relatively little empirical support for the theory of purchasing power parity and other macroeconomic models of exchange rate determination.

One of the most remarkable empirical facts about the major exchange rates of the recent floating period is that they are seemingly immune to any systematic explanation. After about thirty years of data and research since the seminal work of Meese and Rogoff (1983), several empirical questions still keep researchers engaged. Questions, such as, why are nominal exchange rates so volatile, with volatility occurring in clusters and varying over time, why do exchange rates contain random walk components, why are the deviations from purchasing power parity (PPP) so persistent (PPP puzzle), and why are exchange rates disconnected from the macroeconomic fundamentals (so called the disconnect puzzle), remain among the key unresolved issues in international finance. Extended discussions of these and other empirical issues are given by excellent surveys of Frankel and Rose (1995), Taylor (1995), Obstfeld and Rogoff (2001), Mark (2001), and Sarno and Taylor (2002). However, it is worth noting that these questions do not seem to be universally relevant to all flexible exchange rate regime experiences and have more relevance to the recent floating period than the experiences some currencies had in the past. For example, Frenkel (1976, 1978, 1980, and 1981) finds that fundamentals-based models of exchange rate determination including the PPP performed reasonably well in the 1920s, but collapsed during the recent floating period.

What we aim to do in this paper is to offer new insights into the aforementioned questions by providing a clinical study of South Africa's exchange rate experiment that is operated by creating two separate exchange rates, where the commercial exchange rate is set exclusively by international trade and other current account transactions, whereas the financial exchange rate is set by capital account transactions. The dual-rate experiment lasted for nearly ten years from September 1, 1985 until March 12, 1995. During the period, both the commercial and financial exchange rates were floating.[1]

The South African dual-rate regime provides us with a controlled lab situation that allows us to isolate and study the effect of current vs. capital account transactions on the behavior of exchange rate. Presumably, the commercial rate would be sensitive to trade flows and news concerning international trade while the financial rate to capital flows and news about international investment. Investigation of this experiment can thus contribute to our understanding of the exchange rate behavior and hence provide useful insights into the questions discussed within the context of the recent floating period, especially in light of the current market environment where cross-border investment flows are becoming increasingly more important (and also more volatile) than international trade in goods and services. Consistent with this trend, foreign exchange (FX) trading activity has increased tremendously and reached a daily turn-over of about 4 trillion U.S. dollars. As reported by the Triennial Survey of the Bank for International Settlements (BIS, 2010), 65% of this daily turn-over constitutes cross-border transactions with about half (1.9 trillion U.S. dollars) conducted between dealers and "other financial institutions" which

[1]See Garner (1994) for details of the South African dual-rate regime.

include hedge funds, pension funds, mutual funds, insurance companies, and central banks.[2]

In this paper, we first establish evidence that shows segmentation of foreign exchange markets of commercial rands from those of financial rands. The South African experiment thus provides us with a unique opportunity to isolate and study the effect of commercial *vs.* financial transactions on the exchange rate behavior. Given the evidence on the segmentation of commercial and financial rand markets, our investigation of the South African experience leads to the following results. First, unit root and stationarity tests and variance ratio tests suggest the presence of random walk component in the financial rate. The evidence for random walk, on the other hand, breaks down for the commercial rate, suggesting that the exchange rate may be predictable if it were driven mainly by international trade but unpredictable if it were driven mainly by international investment. Second, investigation of the conditional mean and volatility of dual rate returns by estimating ARMA-GARCH models shows that lagged shocks tend to have more predictive power for daily commercial rand returns than the financial rand returns. Results reveal that the financial rand return is highly volatile with periods of excessive clustering and time-variation while the commercial rand return volatility dampens significantly after the initial phase of the dual-rate experiment and remains considerably low and tranquil. Estimates suggest that on average, the (unconditional) volatility of financial rand return was as large as nine times that of the commercial rand return.

Third, test of PPP with dual rates reveal that the long-run PPP is strongly rejected

[2]Over the past several decades, both trade in goods and services and capital flows between the countries have increased. However, the increase in capital flows outpaced the increase in trade significantly. As a result, the relative importance of capital and trade flows has dramatically changed. Not only capital flows between countries has increased dramatically over the last three decades but also exposure of countries to capital waves and hence volatility has increased in the 1980s, 1990s and 2000s. See Forbes and Warnock (2011) on the surge of capital flows and its volatility. See also King and Rime (2010) who shows that the surge in FX market is driven mainly by high-frequency traders, banks trading as clients of the biggest dealers, and online trading by retail investors.

for the financial rate, but not for the commercial rate. This implies that PPP may tend to hold if the exchange rate is mainly driven by international trade, unperturbed by investment flows that tend to be highly volatile and easily reversible. However, PPP may be violated even if there are no significant barriers to trade flows if investment flows become dominant over trade flows in currency transactions. Results also show that half-life of innovations to the real commercial exchange rate is much shorter with tight confidence bands than that of the real financial rate, indicating that PPP deviations for the financial rate are much more persistent than those for the commercial rate. This result holds true despite that the nominal financial rate responds faster to shocks than the nominal commercial rate, suggesting that it might be the nominal exchange rate (and the underlying capital flows and the currency trading activity dynamics) that generates persistent deviations from PPP in recent floating rate period.

Our fourth finding relates to the disconnect puzzle and shows that the commercial rate fluctuations can be accounted for, to a large extent, by the key macroeconomic variables. By contrast, the financial rate fluctuations remain largely unexplainable, especially in the short run. Related to this finding is our fifth finding showing that models with various fundamentals outperform the random walk benchmark in out-of-sample predictions for the commercial rate but fail to do so when it comes to the prediction of the financial rate.

Overall, our findings suggest that well-established empirical features and puzzles of free-floating exchange rates may be attributable to the relative dominance of international investment over international trade as the driver of exchange rates. In this context, the results of the paper are not only informative about the empirical features of dual exchange rates, but also have potential implications for exchange rate modeling and policy. For example, explicitly incorporating increasing dominance of cross-border investment transactions and the capital flows in exchange rate models might be fruitful. Results also suggest that a clear understanding of capital account transactions and especially the capital flow dynamics might be vital for policy makers. This might be especially important for emerging markets where capital account transactions are typically more volatile and large movements in the capital flows might be correlated with large movements in exchange rates and deviations from the long-run equilibrium levels of exchange rates (see Forbes and Warnock, 2011).

The remainder of the paper is organized as follows. Section 2 describes the historical background of the South African exchange rate regime. Section 3 discusses the data and examines insulating properties of the dual-rate system. Section 4 studies the empirical features of financial and commercial rand rates. Section 5 examines PPP and disconnect puzzles and the predictability of dual exchange rates. The final section provides a summary and our concluding remarks.

2 Exchange Rate Regimes in South Africa: A Brief History

2.1 Early periods

Exchange controls in South Africa have been in place since the outbreak of the Second World War when they were introduced as a part of the Emergency Finance Regulations of the United Kingdom and other members of the Sterling Area. The objective was to retain the free movement of funds between these countries, but to prevent hard currencies from flowing out of the Sterling Area. The Sterling Area exchange controls were gradually removed after the war.

Following the Sharpeville incident in March 1960, there was a large-scale capital outflow from South Africa and foreign exchange controls were subsequently intensified. From June 1961 to February 1976, the South African authorities strictly controlled the purchase of foreign exchange by non-residents. For example, non-residents could only purchase foreign exchange with the proceeds from selling securities on the Johannesburg Stock Exchange when given permission by the South African authorities. When permission was denied, the funds were designated as the "blocked rand." Blocked rands could not be directly transferred between non-residents, but could be used to buy quoted South African securities and long-term government bonds.[3] The securities could then be transferred to London and sold, generally at a discount. The discount emerged due to the combination of a lack of demand for South African securities by non-residents and an upward pressure on the security prices on the Johannesburg Stock Exchange related to exchange controls on residents. At the maturity of the government bonds, the proceeds could be freely transferred overseas at the commercial rate as long as they had been held for at least five years. In February 1976, the government introduced the "securities rand", which took the place of the blocked rand and could be transferred between non-residents without the need of government approval. From March 1978, however, the proceeds of government bonds could no longer be transferred overseas at the commercial rate. Instead, both the purchases and sales of government bonds were now to be made in the securities rand. However, interest payments on these securities were still paid in the commercial rand, thus diminishing the incentive of non-residents to invest in such securities.

In earlier periods, the South African exchange rate policy was characterized by frequent changes. On February 14, 1961, the South African pound was replaced by the South African rand when South Africa's membership of the British Commonwealth and of the Sterling Area was terminated. Following the collapse of the Bretton Woods System, the rand was pegged to the dollar in August 1971. After the rand was devalued

[3]In addition to government bonds, non-residents could also purchase bonds issued by government controlled companies called parastatals.

against the dollar by 12.28% following the currency realignments brought about by the Smithsonian Agreement, the rand was linked to sterling in June 1972. The rand was re-pegged to the dollar in October 1972, but when the dollar was devalued by 10% in February 1973, the rand did not follow suit. Instead, the rand was revalued against the dollar by about 5% in June 1973. The dollar peg was maintained until June 1974, when the South African Reserve Bank introduced a policy of independently managed floating with a fixed rand-dollar rate adjusting every few weeks. In June 1975, the policy was abandoned and a fixed dollar peg was re-established and maintained until 1978.

2.2 First implementation of dual exchange rate regime: January 1979 - February 1983

In January 1979, the securities rand was replaced by the financial rand. The principal reform was that non-residents were now free to use the financial rand to acquire non-quoted, as well as quoted, equities in South African companies. Non-residents could freely purchase securities traded on the Johannesburg Stock Exchange without prior approval from the Exchange Control Authorities. However, inward direct investment transactions using the financial rand were still subject to prior exchange control approval. Approved foreign direct investments by South African companies were to be routed through the financial rand market, but dividends and interest payments could be repatriated at the commercial rate. The reform was designed to correct a perceived imbalance between demand and supply in the old securities rand market: the supply of securities rands could come from the sale of any South African assets held by non-residents, but the demand could only come from those wishing to invest in quoted South African securities. During the implementation of the dual exchange rate regime in this period, the financial rate was left to float freely with occasional government interventions, whereas the commercial rate applicable to foreign trade and other current account items was pegged to the U.S.

dollar, but subject to intervention by the authorities.

On February 7, 1983, South Africa abolished the use of the financial rand and moved to a single exchange rate system. This change of foreign exchange rate policy was partly due to the recommendation by the De Kock Commission (Commission of Inquiry into the Monetary System and Monetary Policy in South Africa) and partly due to the significant improvements in domestic economic conditions. In 1978, the De Kock Commission recommended the financial rand system as an interim stage and a further step toward the longer-term objective of a market determined unitary exchange rate. In line with this long-term objective, the South African government decided that the abolition of the dual exchange rate regime was feasible in early 1983. Several economic improvements were cited by the South African Finance Minister to support his decision: a reduction of the current account deficit in 1982, forecasts for a current account surplus in 1984, a substantial capital inflow from trade and loan financing, a 10% appreciation in the real commercial rate from mid-1982 and a 3.6 billion rand increase in foreign reserves from 1982 (see Garner 1994). However, following the abolition of the dual exchange rate regime, the rand depreciated sharply. The sharp depreciation was due in part to the declining gold price and in part to the increased rate of divestment from South Africa.

2.3 Second implementation of dual exchange rage regime: September 1985 -March 1995

At the end of August 1985, following the refusal by a number of international banks to roll over short-term loans to South African borrowers, which was precipitated by the imposition of UN economic sanctions, South Africa declared a moratorium (also known as the debt standstill) on repayment of more than half of its international debt obligations. In response to this crisis, the financial rand mechanism was re-introduced on September 1st 1985, in essentially the same form as had existed before February 1983, except that both the commercial and financial rates were now floating, with the former subject to more active government interventions.

Figure 1 plots the exchange rates of South African rands against the U.S. dollar for the period January 1985 to December 1995. Important events during this period are illustrated in Figure 1 and a more detailed explanation of these events is provided in Table 1. As can be seen from Figure 1, there was a sharp decline in the dollar value of the South African rand from the mid-1985. This was mainly due to the imposition of economic sanctions by the UN on South Africa. On September 1, 1985, the South African government declared a state of emergency and the dual exchange rates system was re-established. The financial rand discount or the spread between the two rates widened (as can be seen from the distance between the two rates in Figure 1) until mid-1986, when the gold price started to rise. The rising gold price during the period from mid-1986 to March 1988 led to an appreciation of both the commercial and financial rands as well as a reduction of the financial rand discount. However, after reaching a peak in April 1988, the gold price started to decline. The decline in the gold price induced a crisis in the South African mining industry in May 1988. This crisis and the lower gold price led to the depreciation of both the commercial and financial rands and a widening of the financial rand discount during this period.

South Africa gained limited access to international debt markets in late 1988. In particular, there was a small private placement on behalf of the South African government in the Swiss capital market in December 1988. Subsequently, there were four private placements in the following year and seven placements in 1990. South Africa's access to international debt markets increased foreign investors' confidence in the domestic economy. Reflecting this positive development, the financial rand appreciated and the financial rand discount decreased during this period.

In February 1990, the ban on various political parties, such as African National

Congress (ANC), Pan Africanist Congress (PAC), and South African Communist Parity (SACP), was lifted. Subsequently, Nelson Mandela was freed and the first formal talks with ANC began. The stability of the political situation led to an appreciation of the financial rand and a decline of the financial rand discount. In late 1991, however, the increased uncertainty about the progress of the political transition and the rumors about the impending introduction of withholding taxes led to a depreciation of the financial rand and an increase in the financial rand discount.

In early 1992, the South African Reserve Bank liberalized the regime for overseas investments by residents. During this period, a number of large overseas investments were made by South African firms, the single largest being the Anglo American and Royal Foods purchase of Del Monte Foods International for more than $600 million. In granting approval for these investments, the South African Reserve Bank increased the aggregate supply of the financial rand and depressed its price when they were sold for US dollars. As a result, the financial rand depreciated and the financial rand discount widened during this period. Later, the South African Finance Minister reversed the previous policy and announced that from the beginning of December 1992, South African companies wishing to invest abroad would no longer have access to the financial rand market unless the investment was if immediate benefit to the country in the short-term. As a result, they would have to finance their investments by raising or issuing debts overseas. This new policy helped the recovery of the financial rand, leading to a decrease in the financial rand discount.

In early 1993, the government and the ANC agreed to share power for five years after the first all-race election. As the UN lifted most sanctions on South Africa, the financial rand started to appreciate and the financial rand discount narrowed. On May 10, 1994, Nelson Mandela's inauguration as the President of South Africa led to a further appreciation of the financial rand and a further decline of the financial rand discount.

Finally, the commercial rand and financial rand were unified on March 12, 1995, and the dual exchange rate regime was terminated.

3 Data and segmentation properties of the dual exchange rate system

3.1 Data and summary statistics

We obtain daily, weekly, and monthly data for the South African commercial and financial exchange rates from Datastream during the period January 1986-February 1995 (code SARCMUS and SARFNUS), and from the South African Reserve Bank for the period September 1985-December 1985. In Table 2, we report the summary statistics for monthly commercial and financial rand exchange rates against the U.S. dollar, the spread between the two rates (i.e., the dual-rate spread) and the financial rand discount defined as (commercial rate − financial rate)/commercial rate, and the commercial and financial rand returns. We also report Jerque-Bera normality test and Ljung-Box statistic for serial correlation.[4]

The average exchange rates in US dollars per commercial rand and financial rand are \$0.382/rand and \$0.267/rand, respectively, during the dual exchange rate period. The financial rand discount averages 29.3% over this period. Tests of normality and the excess skewness and kurtosis values show that neither the commercial rate nor the financial rate (both levels and returns) follows a normal distribution. Results show that the commercial rate has higher standard deviation than the financial rate during the dual exchange rate period. However, the monthly financial rand return has much larger dispersion over its mean than the commercial rand return as measured by the standard deviation. Ljung-Box tests (Q-statistics) reject the null hypothesis of white noise or no

[4]To conserve space, we do not report results for daily and weekly rates as they are qualitatively similar to monthly series. Complete results can be obtained upon request.

serial autocorrelation for both the commercial and financial rates, the dual-rate spread and the financial rand discount up to twelve-month intervals. Also, the test indicates the presence of serial correlation in the commercial rand returns but not in the financial rand returns up to twelve months, providing a preliminary evidence in favor of unpredictability of the financial rand returns and predictability of the commercial rand returns from the histories of returns.

3.2 Segmentation properties of the dual exchange rate system

For the purposes of this paper, it is important to first establish the effectiveness of the dual-rate system in segmenting FX markets for the commercial *vs.* financial rands. Otherwise, we will not be able to study the effect of current *vs.* financial transactions on the exchange rate behavior in isolation. Countries such as France, Italy, Belgium, the U.K. and the Netherlands also adopted dual exchange rates as an intermediate step during the transition from a fixed to a flexible exchange rate regime. The stated purpose of a dual exchange rate system is to insulate foreign trade from exchange rate fluctuations and, at the same time, remove pressure from official reserves caused by large shifts in capital flows (see Lanyi 1975). Countries, such as Mexico, Argentina, and Venezuela, also adopted a dual exchange rate regime for varying lengths of time during the debt crisis of the 1980. However, their dual exchange rate regimes were relatively short-lived and often accompanied by frequent changes of exchange rate policies. Moreover, in contrast to the South African dual exchange rate experiment, in most of these experiments, the exchange rate for current account transactions typically was pegged by the authorities (Marion 1991).

Gros (1988) points out that a dual exchange rate regime will eventually fail to segment current account transactions from capital account transactions because of cross-rate arbitrage activities.[5] Under the assumption of a fixed commercial rate and a floating financial rate, he shows that the two exchange rates eventually converge and lose the insulation property. He examines the cases of Belgium and Mexico and shows that the financial rate discounts (and hence the spread between the two rates) in these two countries were indeed converging to zero over the dual exchange rate period, except during the period with great turbulence. In contrast, inspection of the South African dual exchange rates in Figure 1 shows that the two rates did not converge over the experiment period. Ljung-Box test results reported in Table 2 also show that the dual-rate spread and the financial rand discount were serially highly correlated and hence the disparity between the financial rate and the commercial rate as measured by the dual rate spread and the financial rand discount were considerably persistent. This indicates that unlike other countries, South Africa was highly successful in limiting cross-rate arbitrage activities.

Incidentally, we should also indicate that in private correspondence with officials of the South African Reserve Bank (SARB), it was confirmed that all foreign exchange transactions were under the supervision of the Exchange Control Department of the SARB. In particular, only a few South African banks were authorized to buy and sell foreign currencies under certain conditions. All transactions were individually recorded by the banks and were subject to spot checks by the SARB. In addition, all assets in South Africa belonging to non-residents had a non-resident stamp put on them by the banks. Non-resident assets could only be sold via an authorized bank if another non-resident was willing to buy it. This tight control of foreign exchange transactions may explain why South African dual-rate system was able to prevent the commercial and financial rates from converging. As the above discussion suggests, there was an institutional structure

[5] The possible arbitrage activities are described in detail in Lanyi (1975). Most activities involve some form of trade mis-invoicing or the circumvention of regulations that separate the two markets, i.e., the foreign exchange is purchased at a lower rate (usually the commercial rate) and sold at a higher rate (usually the financial rate).

in place in South Africa that ensured the segmentation of foreign exchange markets for the financial *vs.* commercial rands.

In order to assess the segmentation of commercial and financial rand markets, we conduct three related analysis. First, we test stationarity of and unit root in the financial and commercial rates, the spread between the commercial and financial rates, and the financial rand discount.[6] In Table 3, we present results of Augmented Dickey-Fuller (ADF) test of Said and Dickey (1984) for a unit root and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test of stationarity. The ADF test has a null hypothesis of a unit root, while the KPSS test has a null hypothesis of stationarity. By using tests with different nulls, we do not make any a *priori* assumptions on the stationarity of the series.[7] Results clearly show that both the financial and commercial rand exchange rates are nonstationary with an order of integration of one. Tests provide strong support for the stationarity of both the commercial and financial rand returns. These results are robust to inclusion of a time trend. Results are consistent with previous findings in the literature that nominal exchange rates are nonstationary (see Baillie and Bollerslev 1989a, 1994 and Hsieh 1988). A striking result reported in Table 3 is the strong evidence in favor of nonstationarity of the dual-rate spread and the financial rand discount. ADF test fails to reject the null of a unit root in the dual-rate spread and the financial rand discount and, consistent with the above result, KPSS test strongly rejects the stationarity of the

[6] A process is said to be integrated of order d, denoted by $I(d)$, if it has to be differenced d times before it becomes stationary. For formal definitions of unit root, cointegration as well as the details of methods used see, Johansen (1995).

[7] We have also computed unit root tests of Phillips and Perron (1988) and of Elliott, Rothenberg, and Stock (1996). Since results are qualitatively similar, we report and discuss the ADF and KPSS statistics. Four outcomes are possible when one uses tests with different null hypotheses. If both the unit root tests and KPSS reject their respective null hypotheses, then this may constitute evidence on the presence of a fractionally integrated process with fractional parameter $0 < d < 1$. If unit root tests reject and KPSS fails to reject, then this may be considered strong evidence in favor of stationarity. On the other hand, if unit root tests fail while KPSS rejects their respective null hypotheses, then the process should follow a unit root process. Finally if both unit root and the stationarity tests fail to reject their nulls then one may not reach a conclusion. It is not clear how to interpret the evidence in this case. One may appeal to other tests and economic intuition to evaluate the findings however.

spread and the discount series. These findings provide evidence on the segmentation of the financial exchange market from the commercial exchange market. If these two markets were not effectively isolated, then cross-arbitrage activities would have lead to the elimination of the spread (and the discount) and hence tests would have suggested the stationarity of the dual-rate spread and the financial rate discount.

Second, we use the maximum-likelihood procedure of Johansen (1995) to test for cointegration between the logarithmic financial and commercial exchange rates. A set of variables are said to be cointegrated if a linear combination of the individually integrated series, $I(d)$, is stationary. In our case, $\boldsymbol{y}_t = (s_{Ft}, s_{Ct})$ represents a (2×1) vector of $I(1)$ time series where s_{Ft} and s_{Ct} denote the log financial rate and commercial rate, respectively. $\boldsymbol{y}$ is cointegrated if there exists a (2×1) vector β such that

$$\beta' \boldsymbol{y}_t = \beta_1 s_{Ft} + \beta_2 s_{Ct} \sim I(0). \tag{1}$$

The linear combination $\beta' \boldsymbol{y}_t$ is referred to as a long-run equilibrium relationship. The intuition is that an $I(1)$ series with a long-run equilibrium cannot drift too far apart because economic forces will bring it back to that long-run equilibrium. The Johansen procedure begins with a vector autoregression (VAR) model of order p for $\boldsymbol{y}_t$ and develops a Vector Error Correction (VEC) model by using the Granger representation theorem (Engle and Granger 1987). Johansen (1995) proposes two types of log-likelihood ratio tests to determine the number of cointegrating vectors, r, in the VEC model. The maximum eigenvalue test and the trace statistic. The null hypothesis of rank $r = 0$ (i.e., no cointegrating relationship) is first tested and, if rejected, subsequent null hypotheses (i.e., $H_0 : r = 1$ under the eigenvalue statistic and $H_0 : r \leq 1$ under the trace statistic) are tested until a null can no longer be rejected. When the rank is deemed to be r, then there are r cointegrating vectors. The existence of a long-run equilibrium or a cointegration between the commercial and financial rates implies that the financial and commercial exchange markets are not segmented and that any deviation between these two rates is mean-reverting. On the contrary, if the dual exchange rate system is effective in South Africa, we do not expect the two rates to be cointegrated as they are set in two segmented FX markets without referring to each other.

As reported in Panel A of Table 4, we find no cointegrating relationship between the commercial and financial rates. This implies that the deviation of dual exchange rates would not be mean-reverting. In other words, the financial rate can deviate from the commercial rate, and vice versa, without ever reverting back toward each other. This finding is the second piece of empirical evidence supporting the view that the South African dual exchange rate system was effective in segmenting the commercial exchange market from the financial exchange market.

Third, we test for unit root and cointegration (if a unit root is found in the first step) in current and capital account balances and the Granger causality between these two balances. Since the data on the current and capital account balances are not available on a monthly basis, we conduct tests in this part based on the quarterly data. The data is obtained from the IMF IFS (code SAI78ALDA, SAI78BLDA, and SAI78BJDA) over the period from 1985:Q4 through 2005:Q4.[8] Not reported for the sake of brevity, unit root and stationarity tests show that both the current and capital account balances are stationary during the dual exchange rate period (i.e., 1985:Q4 through 1995:Q1). Ignoring the unit root test results and proceeding with the presumption that current account balance and capital account balance each has a unit root and testing for cointegration between the

[8]Based on the current reporting format of IFS, the capital account balance is separated from the financial account balance. In particular, IFS refers the capital account balance as capital transfers linked to the acquisition or disposal of fixed asset, and non-produced, non-financial assets. On the other hand, the financial account balance is referred by IFS as the transactions related to direct investment, portfolio investment, other investment transactions and financial derivatives. To follow the convention, we refer the sum of the capital account balance and financial account balance obtained from IFS as capital account balance in our paper.

two, both the trace and the maximum eigenvalue tests fail to reject no cointegration. Testing with the post-dual exchange rate period data (i.e., 1995:Q2 through 2005Q4) shows, on the other hand, that both the current and capital account balances have a unit root and the two balances are cointegrated during the unified period.[9]

We examine the link between current and capital account balances by estimating VAR models and testing Granger causality between the current and capital account balances under the dual exchange rate regime in South Africa. As argued by Gros (1988), a dual exchange rate regime may eventually fail mainly due to cross-rate arbitrage activities. Complete prevention of the arbitrage activities may be difficult due to the costs associated with such prevention. However, if the cross-rate arbitrage activities are sufficiently discouraged and infrequent, a dual exchange rate system may still be able to function effectively in terms of segmenting FX markets for commercial *vs.* financial transactions. If this is the case, there will be no causality between the current and capital account balances. We should emphasize that having Granger causality does not necessarily mean failure of market segmentation. However, not having Granger causality between the capital and the current account balances provides evidence in favor of market segmentation.

The test for Granger causality involves testing the joint significance of the lags of the capital (current) account transactions in the equation for the current (capital) account balance. If the null is rejected, this implies Granger causality. The Granger causality test results where the lag lengths in the VAR are given by the likelihood-ratio statistics are reported in panel B of Table 4. Test results indicate no Granger causality between the South African current and capital account balances in either direction during the dual exchange rate period. These results are robust to both using levels and changes in

[9] These results are available upon request.

capital and current account balances as can be seen from panel B of the table.[10]

Figure 2 plots the South African current account and capital account balances from 1985:Q4 to 2000:Q4. As can be seen from the figure, the current account and capital account balances fluctuated within a narrow band during the dual-rate period. In contrast, the capital account balance has become much more volatile following the unification of dual rates in March 1995. The different dynamic behaviors displayed by the current and capital account balances under the dual-rate *vs.* unified-rate regimes suggest that the dual-rate system helped stabilize the South African capital account during the period marked by a great political and economic turbulence. More importantly, the absence of causality between the South African current and capital account balances suggests that the dual-rate system effectively segments the South African current account transactions from capital account transactions.

4 Exchange rate dynamics: The commercial *vs.* financial rate

Given the segmentation between the South African current and capital accounts, the dual-rate regime provides us with a unique, natural experiment wherein we can observe the behavior of two distinct exchange rates, controlling for political and economic conditions: one mainly determined by international trade and the other by international

[10]This finding contrasts sharply to those reported by Wong and Carranza (1999) for Asian and Latin American countries using single exchange rates. Specifically, they find two-way causality for the two Asian countries and one-way causality running from the capital account to the current account for the two Latin American countries. We also conduct causality tests for the U.S. current account and capital account balances over the same period. We find one-way causality running from the current account to the capital account. Moreover, testing Granger causality by using the post-dual exchange rate period data for South Africa, we find strong causality in both directions between the current and capital accounts. This shows that dual exchange rate period is a unique period in terms of the linkages between the current and capital account balances for South Africa.

investment. In this section, first we examine a major hypothesis concerning the behavior of exchange rates, namely, the random walk hypothesis for the financial and commercial exchange rates. In order to gain more insights into the dynamic of exchange rates under a dual exchange rate regime, this analysis is followed by investigation of conditional volatilities of commercial and financial rand returns by using the Generalized Autoregressive Conditionally Heteroskedastic (GARCH) models.

4.1 Do rands walk randomly?

Understanding the random walk behavior of exchange rates is important as it has implications for the efficiency of foreign exchange markets. The findings of the extant literature that tests for random walk in exchange rates vary. In order to formally investigate whether the dual rates follow a pure random walk process, we conduct the heteroskedasticity-robust variance ratio test developed by Lo and MacKinlay (1988). The intuition behind the variance ratio test is that the variance of the increments of a random walk is proportional to the sampling interval. Therefore, under the random walk hypothesis, the variance of a $k-$period return to one-period return divided by the holding period, k, should be one.

In Table 5, we report estimated variance ratios and the p-values for the variance ratio tests for daily, weekly, and monthly financial and commercial exchange rates for 2, 4, 8, and 16-day, week and month intervals, respectively. The p-values from the heteroscedasticity robust variance ratio test, M_2, for the commercial rate are mostly very low in contrast to those for the financial rate. The null of random walk is rejected at 5 or 10 percent significance level for most of the sampling intervals for the commercial rate while the opposite result is obtained for the financial rate. The only rejection of the random walk null for the financial rate is obtained at daily frequency (which is at 10%

significance level only) for 2 and 4- day intervals. Note also that the estimated variance ratios are below one for the daily commercial and financial rates and above one for the weekly and monthly series, indicating that the daily commercial and rand returns are negatively serially autocorrelated while weekly and monthly returns tend to be positively autocorrelated (note that variance ratios at intervals 2 are approximately one plus the first-order autocorrelation coefficient of returns).

Overall, the variance ratio tests mostly reject the random walk in the commercial rate, but not in the financial rate. These results suggest that the pure random walk component is prevalent in the financial rate but not in the commercial rate. The results of variance ratio tests may also suggest that being driven solely by the capital account transactions, time series dynamics of the financial rate contain considerable noise and randomness and hence unpredictable compared to the commercial rate.[11]

4.2 Two conditional variance tales

In order to gain further insights into the behavior of dual exchange rates, in this section we investigate time series dynamics of exchange rate returns (i.e. the log daily returns) and volatility by using daily financial and commercial rand returns. For this purpose, we use GARCH models and after some preliminary investigation, we report the results from the following $MA(1) - GARCH(1, 1)$ model,

$$r_t = \mu + \theta\varepsilon_{t-1} + \varepsilon_t \tag{2}$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{3}$$

[11]In addition to Lo and MacKinlay (1988) test, we have also computed its modifications suggested by Wright (2000). The test of Wright (2000) that is based on the rank of the time series and its normal inverse transform, R_2, strongly rejects the random walk null in the commercial rate and not in the financial rate. These results are available upon request.

where $\varepsilon_t = \eta_t \sigma_t$ and η_t is a white noise process with $\sigma_\eta^2 = 1$ and error process is normally distributed, i.e., $\eta_t \sim N(0,1)$.[12] Notice that the parameter α in Eqn. (3) shows the extent to which a volatility shock today feeds through into next period's volatility and hence it can be used to measure "volatility of volatility" while $(\alpha + \beta)$ measures the rate at which this effect dies out over time (Campbell et al., 1997, p.483).

Regarding $(\alpha + \beta)$, a useful measure is the "half-life" which gives the necessary time after a shock to halve its impact and defined as: half-life $= \frac{\log(0.5)}{\log(\alpha+\beta)}$. For example, given $(\alpha + \beta) = 0.90$, it would take approximately 7 days after a shock to halve its impact while $(\alpha + \beta) = 0.80$ implies that half life is only 3 days, provided that there are no other shocks. Also notice that the unconditional mean of ε_t^2 (i.e., the unconditional variance) is given by $E(\varepsilon_t^2) = \frac{\omega}{1-\alpha-\beta}$, provided that $\alpha + \beta < 1$.

Estimation results are presented in Table 6. Results show that both commercial and financial rand daily log returns are characterized by a moving average component with the estimated moving average parameter (θ) for the commercial rate about twice that of the financial rate in absolute value. This suggests that similar to level of the series, lagged shocks have more predictive power for the commercial rate than the financial rate. This result is broadly consistent with the earlier findings so far presented. The estimated unconditional variances show that during the dual-rate regime, financial rand returns were much more volatile compared to commercial rand returns (estimated daily percentage unconditional variance is 3.324 and 0.368 for the financial and commercial rand returns, respectively). This also can be observed in Figure 3, where we plot the one-step ahead in-sample conditional volatility estimates for both series based on the estimated models reported in Table 6. As can be seen from the displayed plot, although both returns were equally volatile during the initial months of the dual-rate system, the

[12]Note we have also estimated the model under the assumption that the error term η_t follows a student's t distribution with ν degrees of freedom. Since the results were found to be qualitatively very similar, we report results under the normal distribution. Complete results can be obtained upon request.

volatility in the commercial rand return dampens considerably in the later periods of the dual rate regime and stays pretty low and tranquil with a few occasional relatively short-lived hikes. On the other hand, the estimated conditional volatility for the financial rate return shows considerable time-variations and clusterings with periods of heightened altitudes.[13]

Estimated α values suggest that for both returns, the persistence of volatility is very similar. In other words, the spillover effects of shocks to volatility were similar for both exchange rates. On the other hand, estimated half-lives show a striking difference between the two rates. Although it takes about 15 days to halve its impact for the financial rate, the half-life figure suggests more persistent effect of a shock to the volatility of the commercial rate (about 36 days). This finding shows that driven mostly by the flow of trade in goods and services, the commercial rate tends to show very low volatility with a considerably slow response to shocks. In contrast, the financial rate shows a similar volatility dynamics to freely floating currencies of the recent period as it fluctuates considerably with the depth and intensity of fluctuations, showing time-variation and clustering (see for example studies by Baillie and Bollerslev 1989b, Hsieh 1989, and recently by Kılıç 2011 and references therein that document the volatility dynamics of various floating exchange rates).

5 Exchange rate puzzles

The difficulties in establishing strong support in favor of Purchasing Power Parity (PPP) and the various versions of monetary models of exchange rate determination during the

[13]In order to allow the dual-rate regime to phase in, as a robustness check, we have estimated ARMA-GARCH models by removing the initial 12, 18 and 24 months of the experiment period and found quantitatively very similar results. Indeed the tranquility of the conditional volatility of commercial rand returns becomes more precise as the new exchange rate system settles down while the time-variation and clustering of the financial rand returns maintains its eminence irrespective of the sampling period. These results are available upon request.

recent flexible exchange rate period are respectively referred to as the "PPP puzzle" and the "disconnect puzzle" (see Obstfeld and Rogoff 2001 for an extensive discussion of empirical exchange rate puzzles). The terminology suggests that, should PPP not hold, it would be considered as an empirical anomaly, given that international economists tend to believe that some form of PPP must hold. A similar reasoning applies to the relationship between the exchange rate and fundamentals and hence the term disconnect puzzle refers to this lack of empirical evidence in favor of a connection between the floating exchange rates and relevant macroeconomic fundamentals. In this section, we explore these puzzles in the context of South African dual exchange rate experiment with the objectives: (1) to gain insights into the PPP and disconnect puzzles under a dual-exchange rate regime, and (2) to study the implications of different dynamic behaviors we have found so far for the commercial and the financial rates for the key empirical issues in the exchange rate literature.

5.1 The purchasing power parity puzzle

The purchasing power parity (PPP) puzzle highlights the weak link between exchange rates and national prices over the recent floating period (see Rogoff 1996). Surveys of the literature show that a very large number of studies, using widely varying techniques and data sets, have repeatedly found very long half lives (on the order of 3 to 5 years) for shocks to real CPI exchange rates (see Obstfeld and Rogoff 2001, Sarno and Taylor 2002, chapter 3 for an overview of the extant literature).

Interestingly enough, there is considerable evidence in favor of PPP during the floating period of 1920s. For example, Frenkel (1976, 1980, and 1981) document that the PPP held reasonably well during the floating exchange rate regime of the 1920s in Germany, a country with hyperinflation, as well as in the U.S., U.K. and France where inflation was at a more moderate rate. Taylor and Taylor (2004) note early studies which reported results that support the PPP during 1970s. Taylor and Taylor (2004) attribute these encouraging findings in part to the relative stability of the dollar during the first two or three years of the float (after an initial period of turbulence) and points out the increase in the volatility of the U.S. dollar towards the end of 1970s. Although it is beyond the scope of the current paper to explore reasons for the differences in the success of PPP between the 1920s and the recent floating period, in this paper we explore a conjecture that may provide some insights into our understanding of the puzzle at a general level. Specifically, we investigate the conjecture that the PPP puzzle in the recent floating period may be due to the increasing importance of international financial transactions relative to international trade as a driver of exchange rates, reflecting a greater integration of financial markets in recent years. If this conjecture is valid, we expect that PPP would hold better for the commercial rate than for the financial rate.

According to PPP, since the nominal exchange rate (S_t) is the relative price of two currencies (without making any distinction between commercial and financial rate for the sake of brevity), in equilibrium it should reflect their relative purchasing powers. So, if P_t is the price level in the U.S. and P_t^* is the price level in South Africa, then PPP requires:

$$S_t = \frac{P_t}{P_t^*}. \tag{4}$$

Therefore, the logarithm of the real exchange rate (i.e., deviations from PPP), defined as $q_t = \log\left(\frac{S_t P_t^*}{P_t}\right)$, should be zero if PPP holds at every point in time (i.e. strong form of PPP). Similar to the large PPP literature, we investigate a weak form of PPP which requires PPP to hold in the long run. To test the long run PPP, we follow the literature and utilize (i) the unit root and stationarity tests to check if the log real exchange rates follow a unit root or a stationary process, and (ii) cointegration tests to see if there is a long run equilibrium relationship between the log nominal exchange rate, i.e., $s_t = \log S_t$, and the log relative prices, i.e., $(p_t - p_t^*)$, where p_t and p_t^* denote the logarithm of the consumer price level (CPI) in the U.S. and South Africa, respectively.

Before moving into the formal tests of PPP, in Figure 4 as a preliminary exercise we display plots of the autocorrelation functions for the nominal and real dual exchange rates. Figure 4 shows that autocorrelation functions for the nominal and real commercial and financial rand rates decay at different rates. Plots on Panel A show that the autocorrelation function for the financial rate drops faster than that of the commercial rate but the plots on Panel B show that the opposite holds for the real rates, namely the autocorrelation function for the real commercial rate decays faster than that of the real financial rate. Considering that the nominal commercial rate is the relative price of South African rand determined by international trade, its slowly decaying autocorrelation function may reflect the relatively rigid nature of the trade flows and hence sluggishness of relative goods prices as discussed by Dornbusch (1976). On the other hand, given that the financial rate is the relative price of rand based on capital account transactions, the behavior of its autocorrelations may suggest that the financial rate is an asset price (as the underlying market is based on the movement of financial assets) and hence it responds faster to external shocks (see Chari, Kehoe, and McGrattan 2002). This argument is supported also by the observed difference in the decay rates of real commercial and financial rand rates in that the real commercial rate is closely tied to the relative prices and hence deviations of nominal commercial rate from the relative prices is less persistent while the deviations of the financial rate from the relative price is more persistent despite the fact that the nominal financial rand responds faster to external shocks.

Moving to formal tests, in Panel A of Table 7, we report unit root (i.e., ADF test) and stationarity test (i.e., KPSS test) results. Reported results show that the real exchange rate for financial rand has a unit root and hence is nonstationary. Results for the commercial real exchange rate, on the other hand, are somewhat mixed in that the ADF test rejects the null of a unit root at 1% significance level while KPSS test, rejects that the real commercial rand rate is level stationary at 5% significance level. Therefore, findings from the unit root and stationarity tests show strong rejection of the long run PPP for the financial rate and somewhat mixed evidence for the commercial rate.[14]

In Panel B of Table 7, we report results of Johansen's cointegration tests for both exchange rates. Unreported in Table 7, but available upon request, unit root and stationarity tests for relative prices strongly suggest presence of a unit root component. Inspection of the results confirms the findings from the unit root and stationarity tests for the financial rate in that both the trace and the maximum eigenvalue statistics reject the presence of cointegration between the financial rate and the relative prices. In contrast, both tests provide strong support for the presence of a long run relationship between the commercial rate and the relative prices.[15] Given the evidence for the PPP between the commercial rate and the relative prices, we specify and estimate a VEC model. The cointegration vector is estimated to be $(s_{tC}, (p_t - p_t^*)) = (1, -0.917)$. The likelihood ratio test fails to reject the existence of the cointegrating vector, $(1, -1)$, between the commercial rand rate and relative prices. Results of both the trace and maximum eigen-

[14]Strictly speaking, results for the commercial real exchange rate may also be interpreted as evidence for the fractional integration which is beyond the scope of the current paper, however. We should also indicate that Odedokun (1997) and Kahn and Parikh (1998) find evidence supporting the long-run PPP for South African commercial rate over the period of 1986-1992 and 1975-1994, respectively. In addition, Odedokun (1997) documents evidence supporting monetary models using South African commercial rate.

[15]Both the unit root and stationarity and the cointegration test results are qualitatively similar across different trend and/or drift specifications for the real exchange rates and the relative prices. The number of lags for the unit root test are selected by using Ng and Perron (2001) method. Note also that we proceed under the presumption that the real commercial rate has a unit root in conducting the cointegration analysis in this part of the paper. The lag selection for the cointegration tests are based on MAIC. Number of lags were pretty consistent across various criteria (i.e. MAIC, SIC, likelihood ratio and final prediction error criteria) and tests computed with different lags provided qualitatively similar results. Complete results can be obtained upon request.

value statistics find no cointegration between the financial rand rate and relative prices. Despite this strong evidence against the cointegration, as a robustness check, we assume that a cointegration vector exists between the financial rate and the relative prices and estimate the cointegrating vector. The likelihood ratio test (not reported in Table 7) strongly rejects the existence of a cointegrating vector of $(1, -1)$ between the financial rate and the relative prices.[16]

It is remarkable that PPP tends to hold for the commercial rate during our sample period when South Africa was subjected to international trade sanctions imposed by the UN. Needless to say, the economic sanctions imposed on South Africa should have hampered international arbitrage of goods and services, making it more difficult for PPP to hold. Our findings in this section lend credence to the conjecture that when the exchange rate is mainly driven by international trade, PPP tends to hold. By contrast, if the exchange rate is mainly driven by international financial transactions, PPP tends not to hold. It appears that the violation of PPP in recent flexible exchange rate era can be attributable to the dominance of cross-border capital flows over international trade as much as to the impediments to international trade, if not more.

An equally interesting question is how persistent are the deviations from PPP under dual exchange rate system. As discussed above, a measure of persistence is the half-life of PPP deviations. To illustrate the measure in its simplest form, suppose that the deviations of the logarithm of the real exchange rate q_t from its long run equilibrium value q^*, which is constant under PPP, follow an autoregressive process of order one:

$$q_t - q^* = \rho\left(q_{t-1} - q^*\right) + u_t \tag{5}$$

[16]Removing the first year of the sample to allow for the settling of the dual exchange rate regime and conducting the same tests provides similar results for the financial rate, but strengthens the evidence in favor of PPP for the commercial rate. These results can be obtained upon request.

where u_t is a white-noise process. Then, at horizon h, the percentage deviation from equilibrium is ρ^h. The half-life deviation from PPP is defined as the smallest value of h such that $E\left(q_{t+h} - q^* | q_{t-s} - q^*, s \leq 0\right) \leq \frac{1}{2}\left(q_t - q^*\right)$, where E is the expectation operator. That is:

$$\rho^h \Rightarrow h = \max\left(\frac{\ln(0.5)}{\ln(\rho)}, 0\right).$$

Using data under flexible exchange rate regimes, estimates of half-life range between 2 to 5 years for most countries, with an average of 3.7 years (see Table 7.2 in Mark 2001). Although PPP is compatible with high short-term volatility of real exchange rates, it implies that deviation should be short-lived, as they can only occur during a time frame in which nominal wages and prices are sticky (Rogoff 1996). Given the unit root and stationary test results, one cannot reject that half-life for the real financial rate can be infinity. However, to determine how persistent are the real financial and commercial rates and how low is the lower bound for the estimated half-life for the real financial rate, we proceed by estimating half-lives and the associated 95% confidence intervals both by using the standard asymptotic method and methods that are robust to highly persistent variables (for details of methods, see Rossi 2005a and references therein).

Table 8 reports the point estimates and corresponding 95% confidence bounds from the standard method, $\hat{h}$, (see Abuaf and Jorion 1990) and the median unbiased method , $\widehat{h}_{med}$, of Andrews (1993). The standard half-life measure is based on the AR(1) coefficient in the ADF regression and the associated 95% confidence intervals are constructed by using the delta method. The median unbiased estimate of the half-life is based on the median unbiased estimate of the largest autoregressive root coefficient by the Least Absolute Deviations (LAD) estimation as proposed by Andrews (1993) and is robust to persistence in the time series process. The confidence intervals for the median unbiased estimate of the half-life are computed by the method proposed by Ellliot and Stock

(2001). These methods are discussed and applied to several real exchange rates in Rossi (2005a). As discussed in Rossi (2005a) standard confidence intervals (i.e., the asymptotic confidence intervals based on the delta method) may under-estimate the half-lives if the time series are persistent.

The reported results in Table 8 show that even relying on the standard methods, point estimate of the half-life of PPP deviations for the commercial rate is much lower (only 6.8 months) than that of the financial rate (11.5 months) and the 95%confidence interval for the real financial rate is considerably wider, compared to the real commercial rate. The median unbiased estimate gives a half-life estimate of 11.7 months for the commercial rate and 37.9 months for the financial rate. A striking difference between the two rates is observed for the estimated upper bounds of 95% confidence intervals. While the upper bound for the commercial rate PPP deviations is finite, the upper bound is infinite for the financial rate. The important result here is the considerably tight confidence interval for the commercial rate. Although the upper bound is large (78.4 months), the fact that it is estimated to be finite shows a stark difference in the degrees of persistence of the two real rates. Note that although the lower bounds for both series are consistent with PPP, the upper bound of infinity for the financial rate makes it impossible to provide conclusive evidence in favor of PPP for the financial rate. This result is consistent with the findings on several flexible exchange rates (see for example the findings in Rossi 2005a). Although the upper bound for the commercial rate is pretty large, given the median unbiased half-life estimate of 11.7 months and the lower bounds, we can argue that there is considerable evidence in favor of PPP for the commercial rate.

5.2 Exchange rate disconnect puzzle

Broadly speaking, the exchange rate disconnect puzzle refers to the weak linkage between exchange rates and virtually *any* macroeconomic variables (Obstfeld and Rogoff 2001). In this sense, the PPP puzzle can be thought to be an important example of the disconnect puzzle. An important manifestation of the exchange rate disconnect puzzle is the seminal work of Meese and Rogoff (1983) which shows that the standard macroeconomic exchange rate models fail to beat a naive random walk model in forecasting the exchange rates at short to medium horizons even when one uses the ex post data on the fundamentals such as money, output, price or interest rate differentials. We study the disconnect puzzle during dual exchange rate period in South Africa first by testing cointegration between the dual exchange rates and the macroeconomic fundamentals and then by exploring the predictability of dual rates by using macroeconomic fundamentals.

In conducting the cointegration analysis, we follow the literature (see Mark 1995, Clark and West 2006, and Rossi 2005b, among others) and test for cointegration between the dual exchange rates and a set of fundamentals given by $\{f_{0t}, f_{1t}, f_{2t}\}$ where $f_{0t} = (m_t^{us} - m_t^{sa}) - (y_t^{us} - y_t^{sa})$, $f_{1t} = (m_t^{us} - m_t^{sa}) - (y_t^{us} - y_t^{sa}) - (i_t^{us} - i_t^{sa})$, and $f_{2t} = (m_t^{us} - m_t^{sa}) - (y_t^{us} - y_t^{sa}) - (i_t^{us} - i_t^{sa}) + (p_t^{us} - p_t^{sa})$, where $(m_t^{us} - m_t^{sa})$ is the log of money supply differential (money supply is measured by M2) between the US and South Africa, $(y_t^{us} - y_t^{sa})$ is the income differential (as measured by the monthly industrial production index), $(i_t^{us} - i_t^{sa})$ is the short term interest rate differential (i.e. 3-month treasury bill rate differential), and $(p_t^{us} - p_t^{sa})$ is the log price differential (measured by the log differential of CPI between the US and South Africa).[17]

[17] We have also tested for cointegration between the dual exchange rates and $\{(m_t^{us} - m_t^{sa}), (y_t^{us} - y_t^{sa}), (i_t^{us} - i_t^{sa}), (p_t^{us} - p_t^{sa})\}$. Since results were qualitatively similar, we report and discuss the findings from the tests between exchange rates and the fundamentals as defined above. The approach taken here is consistent with the recent methods of testing for a link between exchange rates and macroeconomic fundamentals. Complete results can be obtained upon request. The data for the analysis in this section is obtained from IFS.

Panel A of Table 9 presents our findings on testing for the unit root and stationarity in macroeconomic fundamentals. Reported results are based on inclusion of a drift term in each given series. We should note that results with a trend term and without a drift and trend terms were qualitatively similar and not reported here to conserve space. Both reported and unreported test results clearly show that fundamentals follow a nonstationary process with a unit root. Reported in Panel B of the table, both the trace statistics and the maximum eigenvalue tests strongly support the presence of a cointegrating relationship between the commercial rate and each of the fundamentals. On the other hand, cointegration tests show no evidence of a long-run equilibrium relationship between the financial rate and any of the fundamentals. These results show that disconnect puzzle still applies to the financial rate, but not the commercial rate.

In order to provide further insight into the relationship between dual rates and the macroeconomic fundamentals, we conduct out-of sample predictability tests. Following Mark (1995), the most widely used approach in evaluating out of sample predictive ability of exchange rate models is to represent the h-step ahead logarithm of the exchange rate changes as a function of its current deviations from its fundamental value,

$$s_{t+h} - s_t = \alpha_h + \beta_h z_t + \eta_{t+h} \tag{6}$$

where $z_t = f_{jt} - s_t$, $j = 0, 1, 2$.

The literature on exchange rate predictability compares out-of-sample predictability of the model in Eqn. (6) with various fundamentals to a random walk by using different forecast comparison measures. The most commonly used measure of predictive ability is the mean squared prediction error (MSPE). This approach involves evaluating the out-of-sample performance of the models based on the MSPE comparison tests for equal predictability of two non-nested models, introduced by Diebold and Mariano (1995) and

West (1996) (and henceforth DMW tests). Given that the exchange rate models based on Eqn. (6) and random walk models are nested, it is well known that mechanical application of DMW procedure leads to non-normal test statistics and use of standard normal critical values usually results in very poorly sized tests, with far too few rejections of the null (McCracken 2007). Since the null is a random walk, all tests with fundamentals based models are nested and typically result in non-rejection of the random walk null. To circumvent these problems, we apply the recently developed inference procedure proposed by Clark and West (2006, 2007) for testing the null of equal predictive ability of the linear specification in Eqn. (6) to a random walk null. This approach is recently also applied to exchange rate predictability by Molodtsova and Papell (2009). The test statistic is denoted by CW and takes into account that under the null the sample MSPE of the alternative model is expected to be greater than that of the random walk model, and adjusts for the upward shift in the sample MSPE of the alternative model.

We construct one, three, and six-month ahead forecasts for the linear regression model in (6) with each of the fundamentals described above. We use data over the period January 1986-December 1990 for estimation and reserve the remaining data for out-of-sample forecasting. To evaluate the out-of-sample performance of the models, we estimate the models by OLS in rolling regressions and construct the MSPE ratio of a given fundamentals based model with and without a constant to that of random walk and the CW statistics with the associated asymptotic critical values. Each model is initially estimated by using the first 60 observations and the h-period-ahead forecast is generated. We then drop the first observation, add an additional observation at the end of the sample, and re-estimated the model. An h-month-ahead forecast is generated at each step.

Table 10 presents the ratios of MSPE from the fundamentals based models to the MSPE from a random walk model and p-values for testing the equal predictive ability between the null of a random walk and the alternative models of exchange rate with different fundamentals with and without a constant. In order to gain further insights into the predictive ability of various fundamentals based models, in addition to monetary fundamentals (f_{0t}, f_{1t} and f_{2t} defined above), we also consider the PPP implied fundamentals (i.e., $(p_t^{sa} - p_t^{us})$). As can be observed from the table, MSPE ratios are mostly less than one for the commercial rate and mostly greater than one or in the vicinity of one for the financial rate. A formal testing of this observation by CW statistic clearly shows the unpredictability of financial rand rate from any of the macroeconomic fundamentals in one, three, and six-month horizons. This is not only consistent with our results on random walk behavior of financial rand rate during the dual exchange rates period in South Africa, but also with the findings of several studies that test predictability of exchange rates during the floating period. In contrast, the CW test strongly supports the predictability of commercial rand rate on the basis of fundamentals during the dual-exchange rate period in South Africa at 5% for one-month horizon. Reported results show that performance of fundamentals against the random walk varies for longer horizons for the commercial rate, however. Despite some setbacks, fundamentals-based models continue to outperform random walk in three and six months horizons. These results are striking especially when the unpredictability of many exchange rates from macroeconomic fundamentals over the floating period is considered.

5.3 Composite exchange rate and exchange rate puzzles

In order to provide an overall assessment of the implications of our analysis, Table 11 reports summary results on the estimated unconditional variance from the fitted MA-GARCH(1,1) model, variance ratios and p-values from Lo and Mackinaly (1988) test of the random walk, tests of PPP, and disconnect puzzle by using "composite" dollar-rand exchange rates over the dual exchange rate period. The composite exchange rate is defined by $S_{wt} = w \times S_{Ft} + (1 - w) \times S_{Ct}$ where $w = 0.0, 0.1, \cdots, 0.9, 1.0$ so that $w = 0$ and $w = 1$ correspond to the commercial rate and the financial rate, respectively. In other words, the composite rate gradually moves from the commercial rate towards the financial rate as w moves from zero to one.

The unconditional variance estimates are based on the fitted MA(1)-GARCH(1,1) model for daily composite exchange returns. Variance ratios and the variance ratio test results are based on weekly and monthly composite exchange rates. The rest of the results are based on monthly observations.[18] Results for $w = 0$ and $w = 1$ are already reported and discussed in Tables 3-10. As the composite rate moves from the commercial rate to the financial rate, we obtain the following key results: (1) unconditional volatility of daily returns increases gradually (after slight ups and downs up to $w = 0.4$) from 0.37% to 3.32% (an increase of nine-folds); (2) variance ratios start off at 1.329 and 1.515 for weekly and monthly observations, respectivley and gradually decreases and approaches to one with p-values for the variance ratio test increasing especially after $w = 0.6$ and the random walk null is no longer rejected at 10% significance level after w reaches to 0.7 for both weekly and monthly observations; (3) ADF test rejects the null of a unit root in PPP deviations at 1% significance level up to $w = 0.3$ and rejects at 5% level for $w = 0.4$ and $w = 0.5$, and at 10% level at $w = 0.6$ and fails to reject once w exceed 0.6. The median unbiased half-life estimates increases gradually from 11.7 months to 37.9 months with w, suggesting increases in the persistence of PPP deviations; and (4) the trace statistic stops rejecting the null of no-cointegration between the composite exchange rate and the monetary fundamentals once w exceed 0.4, and the ratio of MSPE and the p-values for CW test gradually increases and the predictability of exchange rates on the

[18] To conserve space, we report only the summary measures from the analysis as results were qualitatively similar to the findings reported in Table 11. Full results are available on request.

basis of fundamentals diminishes significantly especially after w reaches to 0.6.

These findings provides further evidence in support of the conjecture that the increasing dominance of international investment over trade might be a key factor in characterizing the behavior of recent flexible exchange rates such as the high volatility of exchange rate returns, random walk behavior, persistence in PPP deviations, the disconnect between fundamentals and exchange rates, and failure of fundamentals in predicting the short term exchange rate changes.

6 Conclusion

This paper provided a clinical analysis of the South African dual exchange rate experiment during the period 1985-1995, with the objective to provide insights into our understanding of the behavior of flexible exchange rates. Our findings can be summarized as follows: First, the South African dual-rate regime effectively segments FX markets between current account and capital account transactions. The segmented FX markets in South Africa provides us with a unique lab environment in which we can isolate and study the effect of international trade *vs.* investment on the behavior of exchange rates, controlling for other economic and political conditions.

Second, the random walk hypothesis tends to hold for the financial rate, but not for the commercial rate, implying that the commercial rate may be predictable but the financial rate is not. The unpredictability of exchange rates repeatedly documented in the literature thus may be due to the dominance of investment flows over trade in recent years. Third, the commercial rand returns are relatively tranquil while the financial rand returns show a high, time-varying volatility occurring in clusters.

Fourth, purchasing power parity is found to hold for the commercial rate, but not for the financial rate and deviations from PPP are much more persistent for the financial rate than for the commercial rate. This implies that PPP may hold when FX transactions are dominated by international trade, but it may not hold when FX transactions are dominated by financial transactions even if there may not be significant barriers to international trade. Fifth, the exchange rate models with fundamentals have a much greater explanatory power for the commercial rate than for the financial rate and models with fundamentals outperform random walk in out-sample forecasting for the commercial rate, suggesting that a rather weak linkage between the exchange rate and economic fundamentals observed in the recent flexible exchange rate period may be attributable to the rising importance of cross-border investment relative to international trade in FX transactions.

In summary, the evidence from the South African experiment with the dual-rate system suggests that the rising importance of international financial transactions in FX markets may be responsible for the well known behavior of recent flexible exchange rates, such as the random walk behavior, the lack of empirical support for PPP, and a tenuous link between the exchange rates and fundamental economic variables. The findings in the paper point to the important differences when the relative price of a currency is driven by the flow of goods and services and the flow of capital. The analysis in the paper suggests that the observed excess volatility of exchange rates (over economic fundamentals), random walk in exchange rates, and the difficulties the extant international finance literature encounter in establishing strong evidence in favor of PPP and the link between economic fundamentals and exchange rates and the predictability of exchange rates from fundamentals may be associated with the degree to which an exchange rate is driven by the transactions in financial markets *vs.* the transactions in goods markets.

References

Abuaf, Niso, and Philippe Jorion, 1990, Purchasing Power Parity in the Long Run. Journal of Finance 45, 157-174

Baillie, Richard T., and T. Bollersleb 1989a. The message in daily exchange rates: A conditional variance tale. Journal of Business and Economic Statistics 7, 297-305.

Baillie, Richard T., and T. Bollerslev, 1989b. Common stochastic trends in a system of exchange rates. Journal of Finance 44, 167-181.

Baillie, Richard T., and T. Bollerslev 1994. Cointegration, fractional fointegration, and exchange rate dynamics. Journal of Finance 49, 737-745.

Bank for International Settlements April 2010. Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in 2010, Final Results, December 2010 (www.bis.org).

Campbell, J. Y., Lo, A. W., and MacKinlay, A. C., 1997. The Econometrics of Financial Markets. Princeton University Press, New Jersey.

Chari, V. V., Kehoe, P. J., and McGrattan, E. R., 2002. Can sticky price models generate volatile and persistent real exchange rates? Review of Economic Studies 69, 533-563

Clark, T.E., West, K.D., 2006. Using out-of-sample mean squared prediction errors to test the Martingale difference hypothesis. Journal of Econometrics 135, 155-186.

Clark, T.E., West, K.D., 2007. Approximately normal tests for equal predictive accuracy in nested models. Journal of Econometrics 138, 291-311.

Diebold, F., Mariano, R., 1995. Comparing predictive accuracy. Journal of Business and Economic Statistics 13, 253-265.

Dornbusch, Rudiger, 1976. Expectations and Exchange Rate Dynamics. Journal of Political Economy 84(6): 1161-1177.

Elliott, G., Rothenberg, T. J. & Stock, J.H., 1996. Efficient tests for an autoregressive unit root. Econometrica 64, 813-836.

Elliott, G., and J. & Stock, J.H., 2001. Confidence intervals for autoregressive coefficients near one. Econometrica 103, 155-181.

Engle, R.F. and C.W.J. Granger, 1987. Cointegration and Error Correction: Representation, Estimation, and Testing. Econometrica 55: 251-276

Forbes, J. Kristin and Francis E. Warnock, 2011. Capital Flow Waves: Surges, Stops, Flight, and Retrenchment. Working Paper, Darden Business School, University of Virginia.

Frankel, J. and A. Rose, 1995. Empirical research on nominal exchange rates. In: G. Grossman and K. Rogoff (Ed.), Handbook of International Economics. North-Holland, Amsterdam.

Frenkel, Jacob A., 1976. Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence. Scand. Journal of Economics 78: 200-224.

Frenkel, Jacob A., 1978. Purchasing Power Parity-Doctrinal Perspective and Evidence from the 1920s. Journal of International Economics 8: 169-191.

Frenkel, Jacob A., 1980. Exchange Rates, Prices, and Money: Lessons from the 1920?,?American Economic Review 70(2): 235-242.

Garner, Jonathan, 1994. An analysis of the Financial rand mechanism. Centre for Research into Economics and Finance in South Africa, Research Paper no. 9.

Glen, J., 1992. Real exchange rates in the short, medium, and long run. Journal of International Economics 33: 147-166.

Gros, Daniel, 1988. Dual exchange rates in the presence of incomplete market separation. IMF Staff Paper 35: 437-460.

Hobijn BP, Franses H, Ooms M, 2004. Generalizations of the KPSS-test for stationarity. Statistica Neerlandica 58: 483-502.

Hsieh, David, 1988. The statistical property of daily foreign exchange rates: 1974-1983, Journal of International Economics 24:129-145.

Johansen, Soren, 1995. Likelihood-Based Inference in Cointegrated Vector Autoregressive Models. Oxford University Press.

Kahn, Brian, 1992. South African Exchange Rate Policy, 1979-1991. Centre for the Study of the South African Economy and International Finance, Research Paper No. 7.

Kahn, Brian, and Ashok Parikh, 1998. Does Purchasing Power Parity Survive Political Shocks in South Africa? Weltwirtschaftliches Archiv (Review of World Economics) 134(1): 99-116.

Kılıç, R., 2011. Long Memory and Nonlinearity in Conditional Variances: A Smooth Transition FIGARCH Model. Journal of Empirical Finance 18, 368-378.

King, M.R. and Rime, D., 2010. The $4 trillion question: what explains FX growth since 2007 survey? BIS Quarterly Review, December 13, 2010.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y., 1992.Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root? Journal of Econometrics 54, 159-178.

Lanyi, Anthony, 1975. Separate exchange markets for capital and current transactions. IMF Staff Paper 22: 714-749.

Lo, Andrew W., and Craig MacKinlay, 1988. Stock market prices do not follow random walks: Evidence from a simple specification test. Review of Financial Studies 1(1) 41-66

Lyons, Richard, 2001. The Microstructure Approach to Exchange Rates. MIT Press: Cambridge, MA.

Marion, N. P. 1991. Empirical evidence on European dual exchange rates and its relevance for Latin America. NBER 3809.

Mark, Nelson, 1995. Exchange rates and fundamentals: Evidence on long-horizon predictability. American Economic Review 85, 201-218.

Mark, Nelson M., 2001. International Macroeconomics and Finance: Theory and Empirical Methods. Blackwell Publishers.

McCracken, M.W., 2007. Asymptotics for out-of-sample tests of Granger causality. Journal of Econometrics 140, 719-752.

Meese, Richard and Kenneth Rogoff, 1983. Empirical exchange rate model of the seventies: Do they fit out of sample? Journal of International Economics 14: 3-24.

Molodtsova, T. and D. Papell, 2009. Out-of-sample exchange rate predictability with Taylor rule fundamentals. Journal of International Economics 77, 167-180.

Obstfeld, Maurice, and Kenneth Rogoff, 2001. The six major puzzles in international macroeconomics: Is there a common cause? In: Ben Bernanke and Kenneth Rogoff (Ed.), NBER Macroeconomics Annual Year 2000 (Cambridge and London: MIT Press).

Odedokun, M.O., 1997. The Monetary Approach to Analysing Floating Exchange Rate Behaviour in Developing Countries: Evidence from Sub-Saharan African Countries, 1986-1992. Journal of Development Economics 52: 463-481.

Obstfeld, M., Shambaugh, J C., and Taylor, A.M., 2005. The trilemma in history: Tradeoffs among exchange rates, monetary policies, and capital mobility,. Review of Economics and Statistics 87, 423-438.

Rogoff, Kenneth, 1996. The purchasing power parity puzzle. Journal of Economic Literature 34, 647-668.

Rogoff, K., Stavrakeva, V., 2008. The continuing puzzle of short horizon exchange rate forecasting. NBER Working Paper No. 14071.

Rossi, B. 2005a. Confidence intervals for half-life deviations from purchasing power parity. Journal of Business and Economic Statistics 23(4), 432-442.

Rossi, B., 2005b. Testing long-horizon predictive ability with high persistence, and the Meese-Rogoff puzzle. International Economic Review 46, 61-92.

Rossi, B., 2006. Are exchange rates really random walks? Some evidence robust to parameter instability. Macroeconomic Dynamics 10, 20-38.

Said, E. and Dickey, D. A., 1984. Testing for unit roots in autoregressive moving average models of unknown order. *Biometrika* 71, 599-607.

Sarno, Lucio and Mark P. Taylor, 2002. The Economics of Exchange Rates. Cambridge University Press, Cambridge.

Taylor, Mark P., 1995. The economics of exchange rates. Journal of Economic Literature 33(1): 13-47.

Taylor, M. A. and M.P. Taylor, 2004. The purchasing power parity debate. Journal of Economic Perspectives 8, 135-158.

West, Kenneth D., 1996. Asymptotic inference about predictive ability. Econometrica 64, 1067-1084.

Wong, Chorng-Huey and Luis Carranza, 1999 Policy Responses to External Imbalances in Emerging Market Economies: Further Empirical Results,IMF, Staff Paper.

Wright, J.H., 2000. Alternative variance ratio tests using ranks and signs. Journal of Business and Economics Statistics 18, 1-9.

Table 1: **Chronology of dual exchange rate system in South Africa**

Date	Event
August 1985	UN economic sanctions and declaration of a state of emergency.
	Sharp deterioration of the value of the South African rand.
September 1, 1995	Imposition of a dual exchange rate regime.
June 1986-March 1988	Gold price hike and appreciation of the commercial and financial rands.
April 1988-Sep. 1988	Gold price peak in April 1988 and subsequent decline.
	Mining industry crisis and depreciation of the financial and commercial rands.
December1988	South Africa's access to the international debt markets.
	Confidence in the domestic economy and the decline of the financial rand discount.
February 1990	Lifting of the ban on ANC, PAC, and SACP. Nelson Mandela's release.
	Political stability and appreciation of the financial rand.
Late 1991	Uncertainty about the political progress and depreciation of the financial rand.
	Rumors on the withholding tax.
Early 1992	Liberalization of overseas investment and subsequent increase in investment by South African firms.
December 1992	Announcement by the Finance Ministry that limits the access of firms to the financial rand market.
Early 1993	Agreement of government and ANC to share power for five years.
	Lift of most sanctions by the UN and appreciation of financial rand.
May 10,1994	Inauguration of Nelson Mandela as president and further appreciation of the financial rand.
March 12, 1995	Unification of the dual exchange rates.

Key: Table displays key historical economic and political events relevant for the dual exchange rate in South Africa between 1985 and 1995.

Table 2: **Summary statistics for monthly financial and commercial USD/Rand rates, returns, dual rate spread and financial rand discount**

Series	Mean	Median	St. Dev.	Skew	Kurt	JB	$Q(12)$
Commercial rate	0.382	0.379	0.066	0.228	2.228	6.66(0.036)	884.6(0.000)
Financial rate	0.267	0.258	0.043	0.410	2.264	7.68(0.022)	270.7(0.000)
Dual-rate spread	0.116	0.115	0.054	0.500	2.700	5.13(0.077)	615.9(0.000)
Financial rand discount	0.293	.305	0.105	0.116	2.684	17.14(0.000)	387.7(0.000)
Commercial rand return	-0.004	-0.004	0.030	0.718	7.378	21.21(0.000)	36.9(0.000)
Financial rand return	-0.001	-0.002	0.080	0.626	6.322	17.14(0.000)	9.1(0.695)

Key: Table displays summary statistics, (mean, median, standard deviation (stdv), skewness and kurtosis), Jerque-Bera (JB) test for normality and the Ljung-Box statistics for serial correlation up to 12 lags. The values in parentheses are the corresponding p-values. Dual rate spread is the monthly difference between commercial and financial rand rates while discount is the percentage financial rand discount and is calculated as (Commercial rate-Financial Rate)/Commercial rate. All series are monthly observations for the period between September1985 and February 1995.

Table 3: **Unit Root and stationarity tests for monthly financial and commercial USD/Rand rates, returns, dual rate spread and financial rand discount**

	ADF	KPSS	Evidence
Commercial rate	-0.520	0.899^{***}	I(1)
Financial rate	-2.541	0.493^{**}	I(1)
Commercial rand return	-11.152^{***}	0.125	I(0)
Financial rand return	-9.603^{****}	0.0552	I(0)
Dual-rate spread	-1.145	0.963^{****}	I(1)
Financial rand discount	-1.530	0.917^{****}	I(1)

Key: Table reports unit root test results (Augmented Dickey-Fuller (ADF) which test the null of a unit root against the alternative of a stationary process and the results of stationarity test of KPSS which tests the null of stationarity. 1%, 5%, and 10% critical values for the ADF test for the null of a unit root with a drift are -3.44, -2.87, -2.57 respectively. 1%, 5%, and 10% critical values for the KPSS test for testing the null that the series is stationary around a constant are 0.739, 0.463 and 0.347 respectively. We use the automatic bandwidth selection routine of Hobijn et al. (2004) in computing the KPSS test. $*$, $**$, and $***$ show rejection of a given null hypothesis at 10, 5 and 1% levels respectively. The column for "Evidence" gives the decision from the unit root and the stationarity tests. An evidence of I(1) indicates that the given time series is nonstationary with a unit root and that of I(0) indicates stationarity.

Table 4: **Tests of FX market segmentation: Cointegration and Granger causality tests**

Panel A. Tests of cointegration between commercial and financial rates				
λ_{trace}		λ_{max}		Evidence
$H_0 : r = 0$	$H_0 : r \leq 1$	$H_0 : r = 0$	$H_0 : r = 1$	
12.608	0.451	12.157	0.451	No cointegration

Panel B. Granger causality tests for the current and capital account balances			
Granger Causality	F-statistic	p-value	d.f.
Current account balance $\rightarrow$ Capital account balance	3.054	0.549	4
Capital account balance $\rightarrow$ Current account balance	7.163	0.128	4
ΔCurrent account balance $\rightarrow$ ΔCapital account balance	3.362	0.339	3
ΔCapital account balance $\rightarrow$ ΔCurrent account balance	1.705	0.636	3

Key: Panel A reports the Johansen's Trace and Maximum Eigen value statistics for testing cointegration between the commercial and the financial rates. 5 and 1% critical values for the Trace statistic are 15.41 and 20.04 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r \leq 1$. 5 and 1% critical values for the maximum eigenvalue test are 14.07 and 18.63 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r = 1$. The evidence for cointegration or no no cointegration from the tests is indicated in the column titled as "Evidence". Panel B reports the results of Granger Causality tests which test the null that a given variable, say Current account balance does not Granger cause to another variable, say Capital account balance and vice versa. The number of lags in cointegration and Granger causality tests are chosen based on the AIC, SIC, and Likelihood Ratio tests. Reported results are based on the highest number of lags chosen by any of the above criteria. Δ indicate the change in the variable is used for the purposes of test.

Table 5: **Variance ratio tests of the random walk hypothesis for the commercial and financial exchange rates**

Interval		2	4	8	16
Series	Frequency	$VR(pM_2)$	$VR(pM_2)$	$VR(pM_2)$	$VR(pM_2)$
	Daily	0.874(0.000)	0.843(0.007)	0.835(0.056)	0.759(0.066)
Commercial rate	Weekly	1.088(0.344)	1.329(0.061)	1.662(0.010)	1.950(0.006)
	Monthly	1.096(0.341)	1.515(0.006)	1.653(0.034)	2.292(0.007)
	Daily	0.925(0.059)	0.861(0.096)	0.837(0.106)	0.773(0.104)
Financial rate	Weekly	1.021(0.729)	1.099(0.367)	1.121(0.469)	1.234(0.329)
	Monthly	1.060(0.596)	1.063(0.774)	1.182(0.469)	1.309(0.490)

Key: VR is the estimated variance ratio and pM_2 is the p-value for heteroscedasticity robust overlapping Lo and Mackinlay (1988) variance ratio test for random walk null. k gives the intervals over which the tests are computed in daily, weekly, and monthly periods.

Table 6: **Estimated $MA(1) - GARCH(1,1)$ model for the financial and commercial rand returns**

series	μ	θ	ω	α	β	$\ell\ell$	σ_r^2	$half\text{-}life$
r_{Ct}	-0.010	-0.163	0.007	0.104	0.877	-2282.93	0.368	36.134
	(0.008)	(0.018)	(0.001)	(0.008)	(0.008)	.	.	
r_{Ft}	0.006	-0.087	0.149	0.109	0.846	-4649.19	3.324	15.070
	(0.027)	(0.024)	(0.012)	(0.007)	(0.009)	.	.	

Key: Table reports the QMLE results and log-likelihood values ($\ell\ell$) and implied unconditional variance and half-life estimates. r_{Ft} and r_{Ct} denote the daily log financial and commercial rand returns. The values in parentheses are the standard errors that are computed by the outer product of the gradient vector. $\ell\ell$ is the value of the maximized log-likelihood function, σ_r^2 is the estimated unconditional variance and half-life gives the estimated half-life from the reported MA(1)-GARCH(1,1) model as described in the text.

Table 7: **PPP puzzle and the dual exchange rates**

Panel A. Unit root and stationarity tests

Series	ADF	KPSS	Evidence
q_{Ct}	-4.128^{***}	0.639^{**}	Mixed
q_{Ft}	-2.027	0.965^{***}	I(1)

Panel B. Tests for cointegration between dual rates and relative prices

	λ_{trace}		λ_{max}		Evidence
	$H_0 : r = 0$	$H_0 : r \leq 1$	$H_0 : r = 0$	$H_0 : r = 1$	
s_{Ct}, $(p_t - p_t^*)$	31.906^{***}	2.369	29.537^{***}	2.369	cointegration
s_{Ft}, $(p_t - p_t^*)$	27.321^{***}	9.516^{***}	17.805^{**}	9.516^{***}	no cointegration

Key: Panel A provides the results of unit root test (ADF) and the stationarity test (KPSS) for the log real exchange rates and the relative prices between the U.S.A. and South Africa (i.e. log price differential). The column for "Evidence" gives the decision from the unit root and the stationarity tests and the cointegration tests. An evidence of I(1) indicates that the given time series is nonstationary with a unit root and that of I(0) indicates stationarity. If ADF test rejects the null of a unit root and KPSS test rejects the null of stationarity, then the outcome is mixed. Panel B reports the Johansen's trace and maximum eigenvalue coinetgartion tests between log dual exchange rates and relative prices. s_{tC} and s_{tF} denote the monthly logarithm of the nominal commercial and financial and rand rates, respectively. q_{tC} and q_{tF} are the real commercial and financial rand rates, and $(p_t - p_t^*)$ denotes the monthly log relative price differential between the USA and SA. 1%, 5%, and 10% critical values for the ADF statistic for testing a unit root with a drift are -3.43, -2.87, -2.57 respectively. 1%, 5%, and 10% critical values for the KPSS statistic for testing the null that the series is stationary around a constant are 0.739, 0.463 and 0.347 respectively. We use the automatic bandwidth selection routine of Hobijn et al. (2004) in computing the KPSS test. Reported cointegration test results are based on the lag numbers selected by AIC. 5 and 1% critical values for the Trace statistic are 15.41 and 20.04 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r \leq 1$. 5 and 1% critical values for the maximum eigenvalue test are 14.07 and 18.63 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r = 1$. $*$, $**$, and $***$ show rejection of a given null hypothesis at 10, 5 and 1% levels, respectively. The evidence for cointegration or no no cointegration from the tests is indicated in the column titled as "Evidence".

Table 8: **Half-life and confidence interval estimates for PPP deviations**

	$\widehat{h}$	$(\widehat{h}^l, \widehat{h}^u)$	$\widehat{h}_{med}$	$(\widehat{h}^l_{ES}, \widehat{h}^u_{ES})$
Commercial rate	6.8	$(1.2, 12.5)$	11.7	(4.1, 78.4)
Financial rate	11.5	$(0.0, 43.3)$	37.9	$(5.7, \infty)$

Key: $\hat{h}$ is the point estimate of half-life with the associated 95% confidence interval given by $(\hat{h}^l, \hat{h}^u)$ based on the method proposed by Rossi (2005a, Eqns. 17 and 21). The median unbiased point half-life estimate $\hat{h}_{med}$ is based on Andrews (1993) with the 95% confidence intervals $(\hat{h}^l_{ES}, \hat{h}^u_{ES})$ computed by the methods suggested in Elliot and Stock (2001), respectively. Reported half-life and confidence intervals are in months.

Table 9: **Exchange rate disconnect puzzle and the dual exchange rates**

Panel A. Unit root and stationarity tests for fundamentals

Fundamentals	ADF	KPSS	Evidence
f_{0t}	-0.509	1.710***	I(1)
f_{1t}	-0.665	0.468**	I(1)
f_{2t}	-0.669	0.674**	I(1)

Panel B. Tests for cointegration between dual rates and fundamentals

	λ_{trace}		λ_{max}		Evidence
	$H_0 : r = 0$	$H_0 : r \leq 1$	$H_0 : r = 0$	$H_0 : r = 1$	
$(s_{Ct},\ f_{0t})$	22.949***	0.332	22.618***	0.332	cointegration
$(s_{Ct},\ f_{1t})$	18.166**	0.170	17.996**	0.170	cointegration
$(s_{Ct},\ f_{2t})$	17.033**	0.922	16.111**	0.922	cointegration
$(s_{Ft},\ f_{0t})$	12.620	0.312	12.307	0.312	no cointegration
$(s_{Ft},\ f_{1t})$	28.344***	9.012***	18.564**	9.780***	no cointegration
$(s_{Ft},\ f_{2t})$	26.217***	9.012***	17.205**	9.012***	no cointegration

Key: Panel A of the table provides the results of unit root test (ADF) and the stationarity test (KPSS) for the fundamentals $f_{0t} = (m_t^{us} - m_t^{sa}) - (y_t^{us} - y_t^{sa})$, $f_{1t} = f_{0t} - (i_t^{us} - i_t^{sa})$, and $f_{2t} = f_{1t} + (p_t^{us} - p_t^{sa})$. Panel B reports the Johansen's trace and maximum eigenvalue coinetgartion tests between log dual exchange rates and fundamentals. 1%, 5%, and 10% critical values for the ADF test are -3.43, -2.87, -2.57 respectively. 1%, 5%, and 10% critical values for the KPSS test for testing the null that the series is level stationary are 0.739, 0.463 and 0.347 respectively. Note that reported results for both unit root and stationarity tests assume a drift term for all series. The column for "Evidence" gives the decision from the unit root and the stationarity tests and the cointegration tests. An evidence of I(1) indicates that the given time series is nonstationary with a unit root and that of I(0) indicates stationarity. 5 and 1% critical values for the Trace statistic are 15.41 and 20.04 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r \leq 1$. 5 and 1% critical values for the maximum eigenvalue test are 14.07 and 18.63 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r = 1$. $*$, $**$, and $***$ show rejection of a given null hypothesis at 10, 5 and 1% levels, respectively. The evidence for cointegration or no no cointegration from the tests is indicated in the column titled as "Evidence".

Table 10: **Predictive ability of macroeconomic fundamentals**

	without a constant				with a constant			
	PPP	f_{0t}	f_{1t}	f_{2t}	PPP	f_{0t}	f_{1t}	f_{2t}
	1-month ahead forecast accuracy							
$\frac{MSPE^C_{model}}{MSPE^C_{RW}}$	0.919	0.927	0.896	0.879	0.916	0.902	0.911	0.891
	(0.014)	(0.021)	(0.017)	(0.019)	(0.025)	(0.033)	(0.027)	(0.026)
$\frac{MSPE^F_{model}}{MSPE^F_{RW}}$	1.117	1.009	1.008	1.014	0.985	0.963	0.988	0.991
	(0.346)	(0.425)	(0.717)	(0.732)	(0.501)	(0.409)	(0.803)	(0.805)
	3-month ahead forecast accuracy							
$\frac{MSPE^C_{model}}{MSPE^C_{RW}}$	0.765	0.852	0.904	0.900	0.988	0.836	0.660	0.655
	(0.092)	(0.048)	(0.048)	(0.048)	(0.934)	(0.069)	(0.007)	(0.008)
$\frac{MSPE^F_{model}}{MSPE^F_{RW}}$	0.976	0.967	0.982	0.983	0.965	0.966	0.959	0.958
	(0.239)	(0.104)	(0.168)	(0.178)	(0.821)	(0.626)	(0.189)	(0.200)
	6-month ahead forecast accuracy							
$\frac{MSPE^C_{model}}{MSPE^C_{RW}}$	0.763	0.846	0.922	0.916	0.935	0.886	0.778	0.772
	(0.016)	(0.011)	(0.131)	(0.109)	(0.094)	(0.088)	(0.098)	(0.084)
$\frac{MSPE^F_{model}}{MSPE^F_{RW}}$	0.986	1.330	1.068	1.072	1.078	1.077	1.203	1.198
	(0.178)	(0.219)	(0.312)	(0.315)	(0.381)	(0.379)	(0.215)	(0.275)

Key: Table reports the ratios of MSPEs from the given fundamentals-based model to the random walk the p-values (in parentheses) for 1-month, 3-month, and 6-month ahead Clark West (CW) tests of equal predictive ability between the null of a random walk process and the alternative of a linear model with various fundamentals (with and without a constant) including the PPP fundamentals, $(p_t^{us} - p_t^{sa})$ and monetary fundamentals as defined by f_{0t}, f_{1t}, and f_{2t}. Reported p-values are based on the standard normal critical values for the one-sided test. $MSPE^F_{model}/MSPE^F_{RW}$ and $MSPE^C_{model}/MSPE^C_{RW}$ denote the ratio of the MSPE from the given model to the MSPE of a random walk for the financial rand and the commercial rand rates respectively.

Table 11: **Volatility, random walk, PPP and disconnect puzzle and composite dollar-rand rate**

Weight	Variance	Random walk (k=4)		PPP		Disconnect puzzle	
	$\widehat{\sigma}_r^2$	$Weekly$	$Monthly$	ADF	$\widehat{h}_{med}$	λ_{trace}	$\frac{MSPE_{f_0}}{MSPE_{RW}}$
0.0	0.37	1.329(0.061)	1.515(0.006)	-4.128^{***}	11.7	22.949^{***}	0.846(0.011)
0.1	0.33	1.350(0.051)	1.578(0.003)	-3.953^{***}	14.4	22.344^{***}	0.906(0.021)
0.2	0.78	1.355(0.045)	1.601(0.002)	-3.748^{***}	18.2	19.969^{**}	0.928(0.033)
0.3	0.66	1.343(0.044)	1.576(0.004)	-3.520^{***}	21.7	17.939^{**}	0.929(0.063)
0.4	0.72	1.315(0.047)	1.512(0.010)	-3.276^{**}	23.0	16.322^{**}	0.940(0.043)
0.5	0.89	1.278(0.058)	1.428(0.030)	-3.026^{**}	29.9	15.098	0.948(0.080)
0.6	1.14	1.237(0.079)	1.338(0.085)	-2.781^{*}	31.1	14.173	0.954(0.118)
0.7	1.48	1.197(0.116)	1.253(0.201)	-2.551	33.4	13.508	0.958(0.119)
0.8	1.93	1.160(0.175)	1.179(0.376)	-2.346	35.5	13.050	0.961(0.121)
0.9	2.52	1.128(0.259)	1.116(0.580)	-2.346	36.5	12.763	0.962(0.197)
1.0	3.32	1.099(0.367)	1.063(0.774)	-2.027	37.9	12.620	1.133(0.219)

Key: Table reports summary results for volatility estimates (estimated unconditional variance from MA(1)-GARCH(1,1,1) model) for the daily synthetic rand returns, variance ratios and p-values for overlapping heteroscedasticity robust variance ratio test for weekly composite exchange rates for 4-week interval and monthly exchange rates for 4-month interval, ADF unit root test for real composite exchange rates, estimated median half-lives for composite PPP deviations, Johansen's trace statistics for testing the null of no-cointegration (i.e., $H_0 : r = 0$) between the composite exchange rate and monetary fundamentals (i.e., $f_{0t} = m_t - m_t^*$) and MSPE ratios and the associated one-sided p-values for Clark and West (2007) statistic for testing the null that there is no difference in MSPEs of the model with monetary fundamentals and the random walk model. 5 and 1% critical values for the Trace statistic are 15.41 and 20.04 respectively, for testing $H_0 : r = 0$ and are 3.76 and 6.65 respectively, for testing $H_0 : r \leq 1$. The composite rand rate is computed as $S_{wt} = w \times S_{Ft} + (1 - w) \times S_{Ft}$ where $w = 0, 0.1, \cdots, 0.9, 1.0$ and S_{Ct} and S_{Ft} are the (weekly or monthly) commercial and financial exchange, respectively. $*$, $**$, and $***$ show rejection of a given null hypothesis at 10, 5 and 1% levels, respectively. Note also that we fail to reject the null $H_0 : r \leq 1$ for all w and hence not reported the test results.

Figure 1: **Time series plot of the commercial (CR) and financial (FR) exchange rates with important historical events**

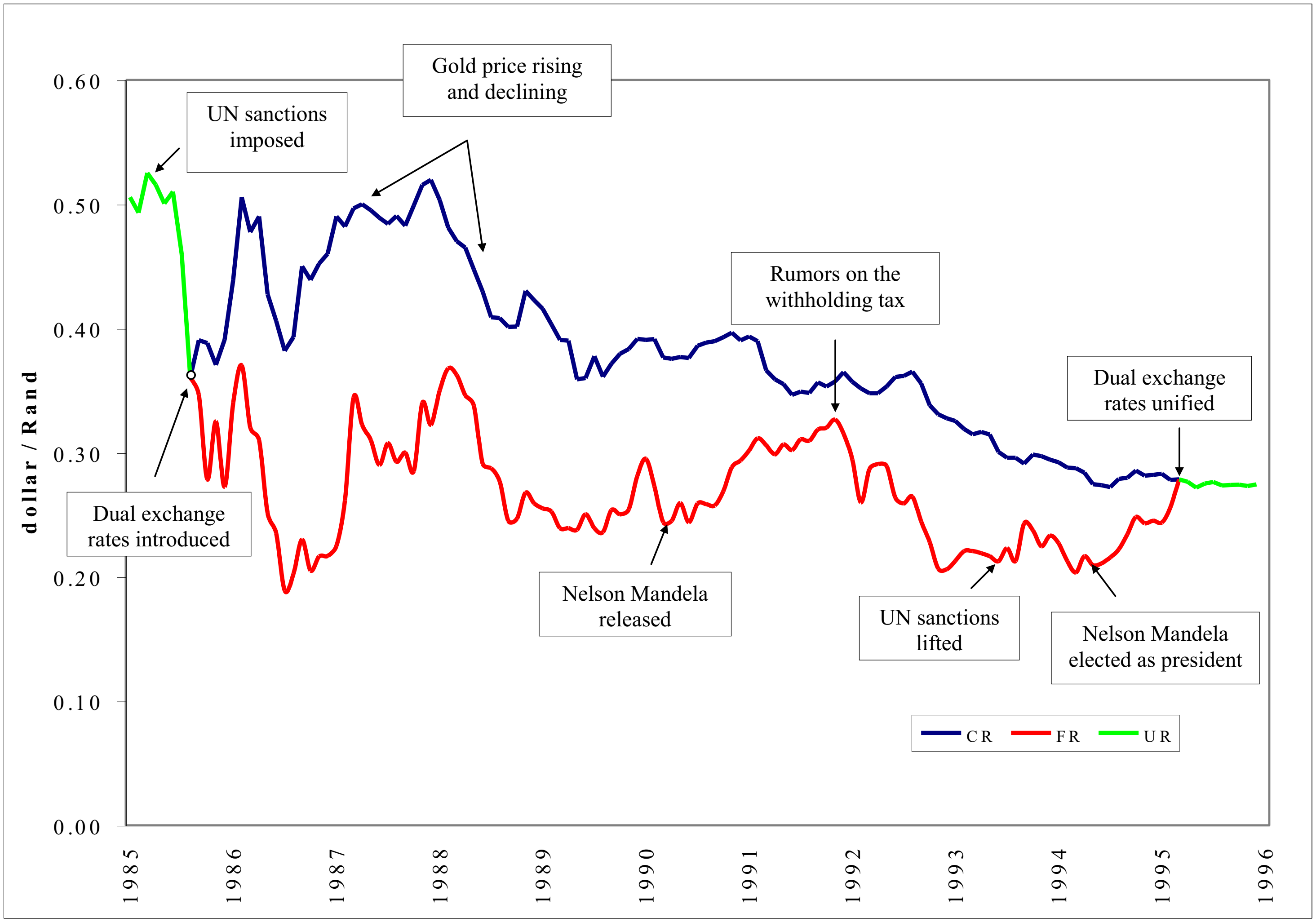


Figure 2: **Time series plots of South African current (SACUR) and capital (SACAP) account balances**

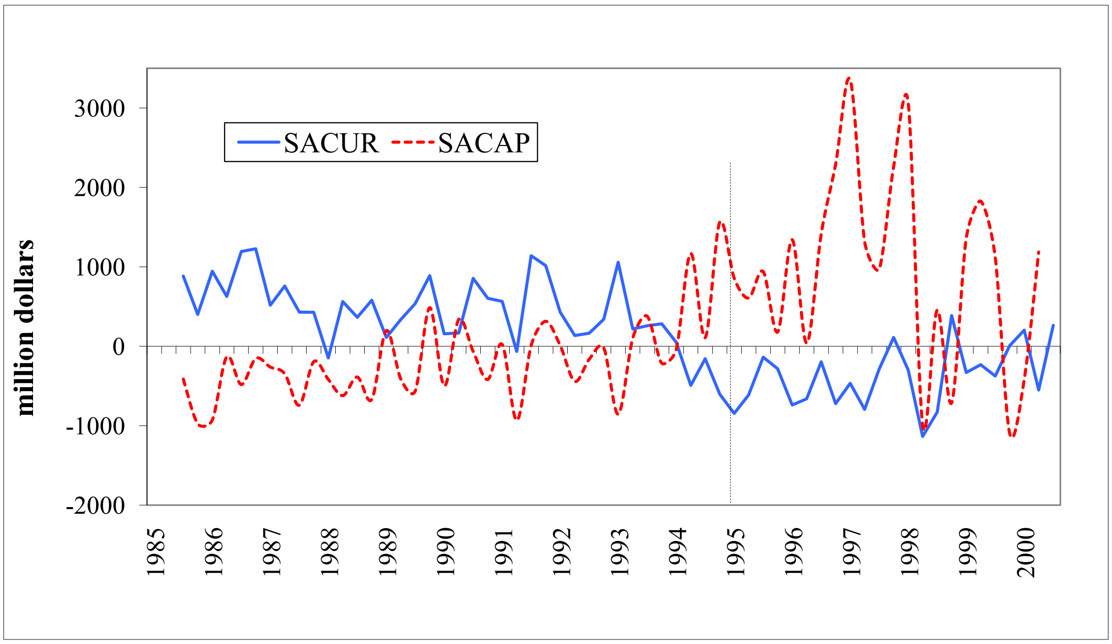


Figure 3: **Daily conditional variances of financial and commercial rand returns**

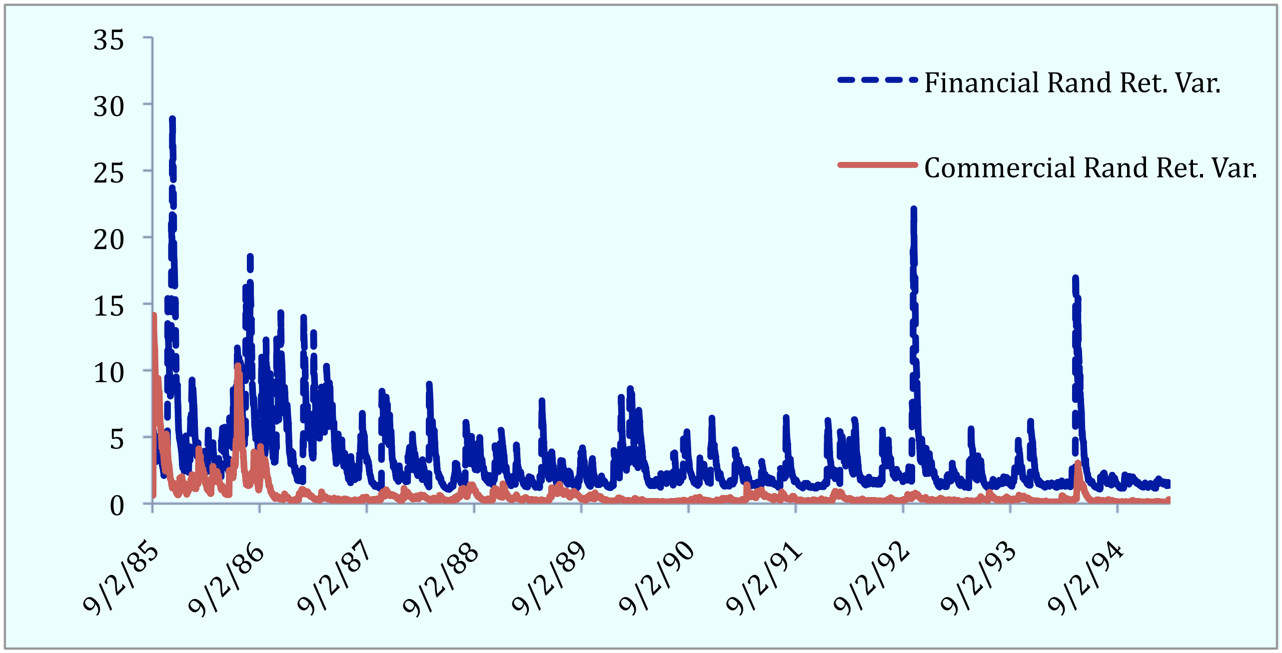
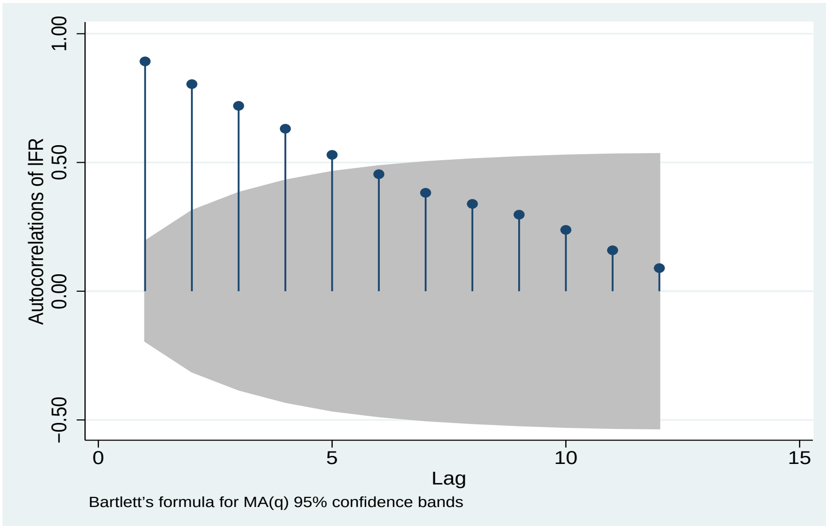


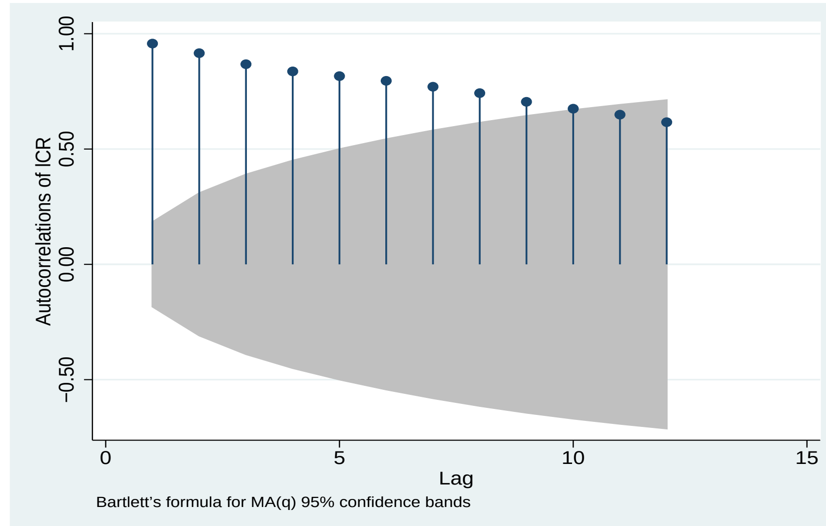
Figure 4: **Autocorrelation functions for the monthly nominal and real financial and commercial rand rates**

Panel A. Autocorrelation function for nominal financial and commercial rand rates

Financial Rand Rate

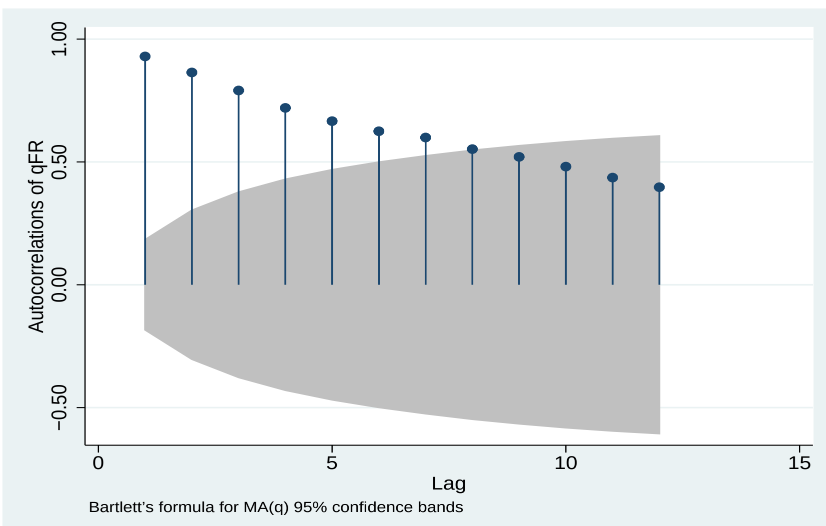


Commercial Rand Rate

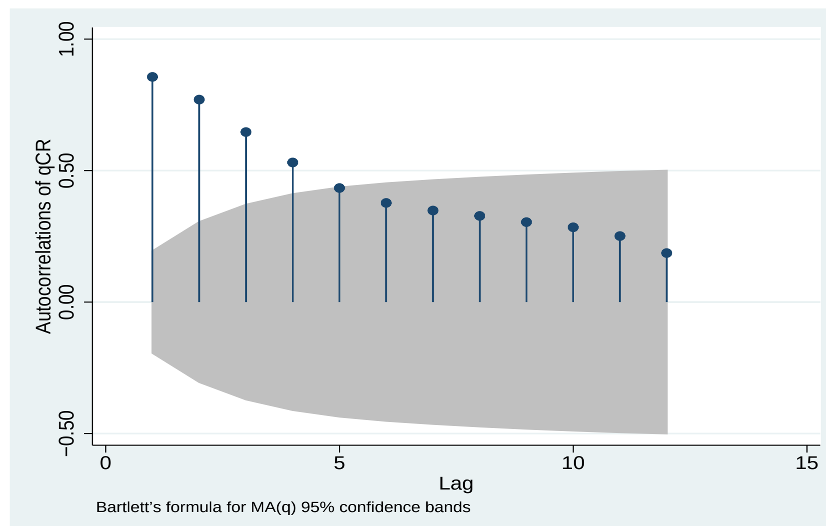


Panel B. Autocorrelation function for real financial and commercial rand rates

Real Financial Rand Rate



Real Commercial Rand Rate



Key: The top panel shows the autocorrelation functions for the nominal financial and commercial rand rates while the bottom panel displays the autocorrelation functions for the real financial and commercial rand rates. The shaded regions are the 95% confidence intervals.