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Regime Change and Weak Form Efficiency of South African Foreign Exchange Markets

Forename / Surname / Student Number

Kar Wing Kelvin / LAI / LXXKAR002

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of the degree of Master of Social Science

Faculty of the Humanities

University of Cape Town

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Declaration

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signature: Date: of Nov 2005

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Abstract

The paper examines the empirical evidence about how a change in monetary policy affects return predictability. Samples of daily Rand/dollar, Rand/euro and Rand/sterling exchange rates for 1995 to 2005 were used. February 2000 was the date for a regime-shift and the sample is divided into two sample periods. By using the likelihood ratio test proposed in Dickey Fuller, I find that the regime- shift does help the foreign exchange market in South Africa to be efficient in that past exchange rates cannot help in forecasting future exchange rate movements.

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Regime Change and Weak Form Efficiency of South African Foreign Exchange Markets

1. 1 Introduction

Exchange rate volatility is one of many factors that trouble developing economies, such as South Africa. Since the abolition of apartheid in 1994, the South African rand has been highly volatile (figure 1 and figure2). The South African Reserve Bank has tried many different ways to support the rand but mostly these measures have been unsuccessful. In 2000 the Government changed its monetary policy to inflation targeting. This new policy means that the inflation rate is used as an anchor to determine the country's interest rate. The inflation targeting requires monetary authorities to abandon any pre-commitment to an exchange rate regime, particularly any exchange rate interventions. This raises the important question about the effects of regime-shift on South African exchange market efficiency and the cause of such effects. To the extent that an inflation targeting regime stabilise interest rates by making them more predictable, the question then is whether such a reduction in the volatility of a key nominal variable can improve information processing by the market. I do not test this issue directly instead I link it to the concept of weak-form market efficiency. In this paper, I will use a simple test for market efficiency to determine whether the introduction of inflation targeting improves the market efficiency on the South African exchange market.

The rest of the paper is organized as follows: Section 1.2 gives an overview of

the South African exchange rate policy and capital control in the post-apartheid era. Section 2 provides a review of market efficiency literature. Section 3 describes testing methodology and empirical modelling and Section 4 presents the data and shows the data selection process that was used, and also gives empirical results. And finally, the conclusion is in Section 5.

1.2 Overview of the Exchange Rate Policy and Capital Control in Post-Apartheid South Africa

The South African foreign exchange market has experienced major changes in recent years and the introduction of inflation targeting is seen as a major step by the Government in moving towards a more liberalized exchange market. In March 1995, the Government unified the dual exchange rate that existed. The reason for the reform was that the Government had shifted its focus from maintaining a stable exchange rate through market interventions to a market-determined and competitive exchange rate policy. In addition, the Government decided to gradually relax its capital control regulation for residents. Although the South African Reserve Bank (SARB) was committed to a market-determined exchange rate from 1995, direct interventions in the foreign exchange market were apparent until 1998. In 1998 the SARB made a big forward sale of dollars to support the rand but this failed to prop up the local currency. Consequently, the SARB had a large sum of short-term foreign liability and this made the speculating in rand very easy. The SARB then announced that it would no longer make any attempt to defend the local currency and it would allow market forces to determine the value of the rand. In addition, the Government maintained its restrictions on capital movements by residents because it feared a big movement of capital out of the country as it

could lead to a collapse in the South African foreign exchange market. It was then that the policy decision was made to stabilise the exchange rate and to take a strong anti-speculation stand.

In February 2000, the South African government announced its intention to introduce the policy of inflation targeting¹. This meant that the SARB would address the problem of inflation directly. The SARB set the inflation target within a specific range for the next period. If the inflation rate goes below or above the range the SARB set, the SARB reacts with either an expansionary (reducing the interest rate) or a restrictive (increasing the interest rate) monetary policy. In a partly or fully open economy, such as South Africa, one of requirements for inflation targeting is that the Government must commit to non-intervention in the foreign exchange market. The credibility of the Government in committing to this target is very important because it influences agents' expectations about the exchange rate in the future. Expectations about future exchange rates influence current exchange rates. The effect of *regime shift* by inflation targeting on exchange rate movements, needs to be examined.

In the last quarter of 2001 the rand suffered a depreciation of 34% of its value against the dollar in comparison to its value in December 2000. But in 2002 the rand made a huge recovery and became one of few currencies in the world that performed well. Moreover, during this uncertain period the SARB has actively purchased foreign exchange to reduce its net open foreign currency position

¹ A timetable was set for the inflation targets for 2002 and 2003. For 2002 the target was 3% to 6% and for 2003 the target was reduced to 3% to 5%. However, the collapse of the rand in late 2001 has forced the government to revise its target. For 2003 the target changed to 3% to 6% and between 3% and 5% for 2004 and 2005.

(NOFP) and also announced its intention to reduce its foreign currency liability aggressively. The result of eliminating foreign liability was to make speculating in rand no longer easy. During the same period the Government relaxed capital control restrictions for residents and allowed them to have R 750 000 invested offshore. These developments mean that the South African foreign exchange market has become increasingly market orientated.

2 Review of Relevant Literature

The efficient market hypothesis is widely accepted by academics as the theory that explain the movements in asset prices over many years despite challenges from the alternative theories such as behaviour finance. There are numerous studies such as Boothe and Longworth (1986) and Froot and Thaler (1994) on market efficiency in foreign exchange markets and these studies have focused on both the interest parity and the unbiasedness hypotheses. They find that the results are in favour of market inefficiency. Furthermore, Dooley and Shafer (1982), Bilson and Hsieh (1983) and Hodrick and Srivastava (1984) find that the profitable rules that seem to contradict market efficiency. However, these studies does not fit in the issue of weak form market efficiency that I interest in and in this paper I will review most of literatures from the stock market, because the stock market and foreign exchange market can be considered as a similar kind of asset market.

LeRoy (1989) explains that the theory about an efficient market is merely the theory of competitive equilibrium applied to the asset market. An important idea in the theory of competitive equilibrium is the Ricardian principle of comparative advantage. In terms of financial markets, the comparative

advantage is conferred by differences in information held by investors rather than differences in productivity among producers. Furthermore, Ricardo asserts that absolute advantage is irrelevant in financial markets, although the information is universally available, as this cannot provide the basis for profitable trading rules (LeRoy, 1989, 1583). Also, Fama's (1970) explanation of the efficient market hypothesis is that a security market is extremely efficient in reflecting information about individual stocks and about the stock market as a whole. According to this hypothesis, when information is available, news spreads fast and it is incorporated into the prices of securities immediately. There are profound implications for the presence of the efficient market hypothesis. Most individuals that participate in the asset markets, such as the stock market act on the assumption that the stocks they are buying are worth more than the price that they are paying, and that the securities they are selling are worth less than the selling price. But if the market is in indeed efficient and the current prices fully reflect all information, then buying and selling assets in an attempt to outperform the market will be a game of chance rather than skill. Therefore, the money spent every year on security analysis is entirely unproductive (LeRoy, 1989).

The origin of the efficient market theory is the random walk model and this model asserts that price movements will not follow any patterns or trends, and that past price movements cannot be used to predict future price movements. This was revealed by French mathematician, Louis Bachelier in his Ph.D. dissertation entitled "The Theory of Speculation" in 1900. Unfortunately his insights were so far ahead of the times that they went largely unnoticed for over 50 years until his paper was translated into English and published in 1964

(Cootner, 1964). Kendall (1953) found that stock prices follow a random walk and Granger and Morgenstern (1963) have done an econometric study using spectral analysis that supports the hypothesis that stock prices follow a random walk. The inadequacy of the random walk model is that it is not a *bona fide* economic model of asset prices. Subsequently, a so-called martingale model was developed by Samuelson (1965). LeRoy (1989, 1989) claims that the Samuelson's work is most important in the efficient capital market literature because of its role in bringing about this shift from the random walk to the martingale model. Unlike the random walk model, the martingale model does constitute a *bona fide* economic model of asset prices that can be linked to primitive assumptions on preferences and returns. According to Samuelson (1965) that a stochastic process is said to be a martingale, and one would expect that future expected prices is determined by the present price. Furthermore, the stochastic process is a fair game in which the forecast error is zero with any given information set. Moreover, the empirical work of Fama (1970) brought the term 'efficient market' into general use and his paper is widely interpreted as associating the market efficiency model with the martingale model. Fama (1970) pointed out that in order for the market to be efficient, the returns from the market need to make it a fair game. In his argument the fair game does not necessarily need to be zero but rather that it is only the deviation of price from its conditional expectation. Furthermore, Fama (1970) categorised the efficient market hypothesis into three forms. The weak form refers to all past market prices and the data are fully reflected in the asset price. This means that no trading rule based on historical prices alone can generally succeed. The semi-strong form asserts that all publicly available information is fully reflected in price. The implication is that an investment

strategy based on historical information and all publicly available information cannot yield an excess return. Lastly, the strong form includes all information, even insider information, reflected in the asset price. Fama's specifications provide a mathematical expression of conditional expectation that strong-form efficiency implies semi-strong efficiency, which in turn includes weak-form efficiency (LeRoy, 1989, 1592). Fama (1976) modified the definition of the efficient market. For a capital market to be efficient the market cannot neglect any information relevant to the determination of security prices and it involves rational expectation. By combining both these requirements, the definition of an efficient market is a market that uses all the relevant information to determine security prices and that uses the information correctly.

However, LeRoy (1989, 1613) argues that there are problems in Fama's (1970) efficient market hypothesis and says that:

' where market efficiency was described as a substantive theory generating falsifiable predictions, but where at the same time the mathematical formulation of the market efficiency was tautologous. '

Nevertheless, there is empirical evidence contradicting the theory of market efficiency. In the empirical work on variance-bounds violations by LeRoy and Porter (1981) and Shiller (1979, 1981) and they find that asset prices appear to be more volatile than is consistent with the efficient market model. Shiller uses the empirical results as the evidence that contradicts the theory of market efficiency and favours the existence of an element of irrationality in asset prices. On the other hand, LeRoy and Porter categorised the violations as

an anomaly in the asset market that needs to be explained. However, Flavin (1983) and Kleidon (1986) argue that variance-bounds tests were suffered from an econometric problem and both these authors find that the test may lead to bias against acceptance of efficiency in both small and large sample tests. Despite these setbacks in variance violation tests, Gilles and LeRoy (1988) and West (1988) and Mankiw, Romer and Shapiro (1985) tested the variance-bounds inequality using second moments around zero rather than around the sample means to avoid the problem pointed out by Flavin and they found excess volatility in the data. Fama and French (1988a) pointed out that the cause of the difference between the conventional efficiency tests and variance bounds tests is that the conventional tests use the orthogonality of returns over short interval such as successive daily or weekly data. In contrast, the variance-bounds class test examines the orthogonality of a smooth average of past returns over a period of years and a similar smooth average of future returns. They explained this difference in results by estimating the correlation between average returns over the interval periods. They found that the five-year returns have a large forecastable component exactly as what the variance bounds violations would lead one to expect. The significance of this finding is that it provided confirmation of the econometric soundness of the variance-bounds tests (LeRoy, 1989, 1601). Hence Fama and French (1988b) and Campbell and Shiller (1988a, 1988b) formed a hybrid of variance-bounds and return autocorrelation tests. They also designed tests to show whether price or other variables closely related to price such as the dividends-price ratio, predict future returns. Their results show a strong rejection of the martingale model.

Finally, LeRoy (1989) argues that the empirical work regarding market efficiency has always preferred these tests in which market efficiency implies the absence of a pattern such as the return autocorrelation tests over tests that do not have characteristics like those of variance-bounds tests. Furthermore, the arbitrage-based test is considered better than equilibrium based theories in market efficiency testing. The latter tests take away empirical work from attempting to specify an intellectually coherent alternative to market efficiency, and from analyzing the econometric properties of these alternatives relative to the null hypothesis of market efficiency. The implication of this is that much evidence in supporting of market efficiency has been dismissed (LeRoy, 1989, 1614).

One of the alternatives to the efficient market paradigm is shown by Shleifer and Summers (1990). They stress the roles that investor sentiment and limited arbitrage play in determining asset price. These findings show that the asset price deviates from the fundamental value. Similarly LeRoy (1989) argues that the advent of cheap computing and large financial data bases revealed market anomalies that contradict the efficient market hypothesis. One example is the 'P-E anomaly' (Dreman 1982) which the stock with low price earnings ratios appeared systematically to outperform those with high-price earning ratios. Another example is the 'January effect' (Thaler 1987, Clark and Ziemba 1987) where research results show that the stock returns averaged 3.5% in January while other months averaged 0.5%. This is in contrast with the martingale model. However, Merton (1987) argues these anomalies show the problem of data-selection bias and that a journal paper would be unlikely to report the results that failed to find any anomaly.

Finally, the debates on the market efficiency hypothesis have yet to be finalised and are unlikely to end soon. A quote from LeRoy (2004, 802) give a good description of this unresolved matter.

'The debate about capital-market efficiency looks increasingly like a dispute about whether the glass is half full or half empty.'

The contradictory conclusions reached by Shiller (2003) and Malkiel (2003) about the collapse of the internet bubble in late 2000 are one example of this phenomenon. Shiller (2003, 102) uses the concept of behaviour finance to show that there is a lack of evidence to support the theory of market efficiency. He questions the recent boom and crash of the stock market in 2000 to show that the stock market is indeed inefficient because this 'bust and boom' result from the foibles and arbitrary feedback that are part of human behaviour. In contrast, Malkiel (2003, 80) uses the same example but he argues that the market is extremely efficient in utilising information but that sometimes mistakes occur in the market and these should be treated as exceptions rather than the norm.

3.1 Testing Methodology

Within the weak-form efficient market literature, the *unit root* tests such as the likelihood-ratio statistics of Dickey and Fuller (1981) are convenient because they tabulate the distribution of the test statistic for the appropriate parameter restrictions necessary for the martingale test. Unfortunately the Dickey Fuller (DF) (1981) likelihood ratio test suffers from low power as most time series have an unknown distribution and do not converge to a Gaussian process. Many

researchers have tried to improve the power of the DF test. There are two main approaches to modifying the standard DF test. One of these approaches is the parametric approach proposed by Dickey and Fuller (1981) in which they changed the estimated regression by using the series' own lags. This kind of test is referred to as the augmented Dickey-Fuller test (ADF test). However, Schwert (1989) points out that the ADF test regression loses one degree of freedom when one more lag term is added to the model. The alternative test uses the non-parametric approach (Phillips-Perron test) proposed by Phillips and Perron (1988). The Phillips-Perron test (PP test) statistics are modifications of the Dickey-Fuller t-statistics that take into account the less restrictive nature of the error process. However, Schwert (1989) and De Jong et al (1992) criticize this test and say that there is a large size distribution in finite samples when the data generating process produces a negative autocorrelation for the first difference. Concerns have been raised about its usefulness when it tests for the first difference (that is, when it becomes less powerful than the ADF).

Sargon and Bhargava (1983) suggest another approach using the Durban-Watson framework. These authors generalize the Durban-Watson statistic (used for testing serial correlation) to the problem of testing the hypothesis. They theorise the residuals from the least-squares regression follow a random walk. They also provide an alternative: a Brerenblutt-Webb statistic and argue that it would be better alternative. Yet another approach is the KPSS test (Kwiatkowski, Phillips, Schmidt and Shin, 1992) in which they use stationarity as the null hypothesis rather than the presence of a unit root. But Leybourne and McCabe (1994) argue that the KPSS test has the problem of size distribution and low power properties. They suggest a modification of the

KPSS test and argue that the modified test is more powerful than the original KPSS test.

Although the ADF and the PP tests have low power in analyzing the presence of a unit root, they remain the preferred test in testing for a unit root. Therefore, many researchers try to improve the power of both tests; Perron and Ng (1996) modified the PP test. Elliott, Rothenberg and Stocks (1996) modified the ADF test, Fuller (1996) and Leybourne (1995) used the test based on reverse and forward Dickey Fuller regression. Despite the enormous differences obtained when using the various tests to explore the presence of unit roots in time series, the question about which of these tests is better has not yet been answered. According to Maddala and Kim (1998, 99) the difficulties in determining a suitable unit root test arise because:

'there are no comprehensive studies comparing all of these tests and that even if there is such study the result will not give any clear cut evidence in favour of one or the other.'

This paper has arbitrarily selected the augmented Dickey Fuller test as the method for testing market efficiency in a foreign exchange market, and uses the DF-GLS test (a modified Dickey Fuller test) as confirmatory. Therefore, a comprehensive discussion on both tests is presented. Bearing this in mind, there are some methods that can help in improving the power of the unit root test. One such method is that of using high frequency data rather than low frequency data. Maddala and Kim (1998) and Lopez, Murray and Pappell (2004) suggest that a carefully selected lag length can have an impact on the power of the unit

root test. Hall (1994) and Ng and Perron (1995) say that the ADF test suffers from low power when the lag length is too small and Ng and Perron (2001) show that the DF-GLS test suffers from size distortions when the lag is too small. The solution suggested by Hall (1994) is for the ADF tests to select the lag using the general to the specific (GS) procedure. Ng and Perron (2001), on the other hand, show that the Modified Akaike Information Criterion (MAIC) can be adapted for the DF-GLS tests.

3.2 Empirical Modelling

As previously noted the Dickey Fuller test was originally developed to apply the random walk model, of which the martingale is subset (LeRoy, 1989). The random walk model suggests that it may outperform many of the structural models in out-of-sample prediction (Mussa, 1979). Due to the restrictions of the *random walk* model it also failed to qualify as a *bona fide* economic model for asset price. Therefore, the martingale model is a usable alternative for empirical modelling.

A martingale process means that a stochastic process with an information set has an expected successive change equal to zero. In addition, there will be no systematic forecasting errors based on the available information (LeRoy, 1989, 1589).

We can express this as:

$$E_t(y_{t+1} / I_t) = y_t \quad \text{and}$$

$$E_t(e_t / I_t) = 0 \quad \text{where } y_t \in I_t$$

We can specify a null hypothesis for market efficiency by implementing a

two-stage testing procedure with the likelihood-ratio test of Dickey and Fuller (1981). This was adapted and elaborated by Ayogu (1997) to test for weak-form market efficiency in Nigeria (See Ayogu 1997 for more detail).

Because the Dickey Fuller test is a low power test, I chose to improve my analysis by using the DF-GLS confirmation test proposed by Elliott, Rothenberg and Stocks (1996). This test derives the asymptotic power envelope for point optimal tests of a unit root in the autoregressive representation of a Gaussian time series, under various specifications of the trend. A point optimal test, according to King (1987), means that the test optimises power at a predetermined point. This test is the second best test to use when uniformly more powerful test does not exist (Maddala and Kim, 1998, 112). Elliott *et al.* (1996) propose a family of tests whose power functions are tangent to the power envelope at one point, and are never too far below the envelope. This test is also referred to as $P_T(0.5)$.

The DF-GLS t-test is performed by testing the hypothesis $a_0 = 0$ in the regression

$$\Delta y_t^d = a_0 y_{t-1}^d + a_1 y_{t-1}^d + \dots + a_p y_{t-p}^d + error$$

y_t^d is the locally detrended series y_t . The local detrending depends on whether we consider a model with drift only or a linear trend. The linear trend model is most commonly used. The detrending process can be expressed as follows:

$$y_t^d = y_t - \hat{\beta}_0 - \hat{\beta}_1 t$$

where $(\hat{\beta}_0, \hat{\beta}_1)$ are obtained by regressing \bar{y} on \bar{z} where

$$\bar{y} = \{y_1, (1 - \alpha L)y_2, \dots, (1 - \alpha L)y_T\}$$

$$\bar{z} = \{z_1, (1 - \alpha L)z_2, \dots, (1 - \alpha L)z_T\}$$

and

$$z_t = (1, t)', \bar{\alpha} = 1, \bar{c} = T$$

The $\bar{\alpha}$ that produces the asymptotic power depends on the significance level, ε used, and the DF-GLS model fixes $\bar{c} = -7$ in the model with drift and $\bar{c} = -13.5$ in the linear trend case. The DF-GLS test applied to the locally trended data is within 0.01 of the power envelope for $0.01 < \varepsilon < 0.10$. The critical values for 10%, 5% and 1% level are -2.57 , -2.89 and -3.48 respectively for a sample size which approaches infinity (Elliott, Rothenberg and Stock (1996, table 1, 825)).

4.1 Data and Data Selection Processes

The data selection processes follow two principles. Firstly the period selected needs to avoid the problem of a structural break because of the nature of the unit root test. Any structural break in the sample will have a significant impact on the power of the Dickey Fuller test. Secondly, the paper uses high frequency data such as the daily exchange rates because these help to improve the power of the unit root test.

The exchange rate data used are from daily observations of the US dollar, Euro² and UK sterling and, the Figure 1 shows the movements of these three currencies between 1995 and 2005. The reported daily rates are the selling rates during the period January 1995 to February 2000 and the period March 2000 to September 2005. Using February 2000 must be considered a structural break. It was the time when the Government announced its intension to change the country's monetary policy to inflation targeting. The two periods are used to

² Only the US dollar and U.K sterling are used in the sample period between January 1995 and February 2000 because the Euro was only introduced in 1999.

compare the effect of the change in policy on exchange market efficiency. A summary of the descriptive statistics is shown in Tables 1 and 2 for the sample periods.

The results of the martingale tests for both currency samples at the daily rates are shown. For each regression, the hypothesis here is that the error term is independently and identically distributed. The regression diagnostics reported in Tables 3 and 4 show the LM test for no residual autocorrelation. Engle's test for no ARCH effects and a test for no heteroscedastic errors. As can be seen, the test of the martingale hypothesis is valid only if the process is exactly a unit root and the series in both samples are $I(1)$.

4.2 Results of Empirical Estimates

The test results for the null hypothesis of market efficiency using the daily data for the period January 1995 to February 2000 are tabulated in Table 5 and 6. The estimated values of β for both dollar and sterling, with miniature values, show that there is unlikely to be a trend component in the data. The Dickey and Fuller Φ_2 statistic for the null hypothesis $(\alpha, \beta, \rho) = (0, 0, 0)$ is 4.97 for the dollar and 5.16 for sterling and we can reject the dollar and sterling at the 5% level as not significant. This is confirmed by the marginal significance level of the lagged value of the dependent variable. Therefore, we can conclude, based on the evidence about the dollar and the sterling that returns from the market are not martingale and it means that the return is not market efficient. This is confirmed by the DF- GLS test tabulated in Table 9 with a lag of 2 for the both dollar and sterling. The test statistic for the dollar is -2.96 and -3.35 for sterling, and the critical value for the 5% significant level is -2.89. Therefore, the

DF-GLS statistic allows us to reject the null hypothesis at 5% level and this means that both the dollar and sterling were not martingale and not weak form efficient between January 1995 and February 2000.

On the other hand, the test results for the null hypothesis for market efficiency, using daily data for the period March 2000 to October 2005 are tabulated in Table 7 and 8. The estimated values of β for the dollar, the euro and the sterling using immature values show that there is no trend component in the data. In this case the statistics for the null hypothesis are 4.08, 4.35 and 4.12 for the dollar, the euro and the sterling respectively. Therefore, I failed to reject all the series at the 5% significant level, the critical value for 5% being 4.68. This means that all three currencies in this sample period follow martingale. The computed marginal significance levels for the lagged dependent values lead to the support of the martingale hypothesis for all sample currencies. The DF-GLS test statistics (table 10) are -0.72, -1.20 and -1.11 for the dollar, the euro and the sterling respectively, and the critical value for 5% significance is -2.86. Therefore, I cannot reject the null hypothesis for all three currencies, and this confirms that all currencies follow martingale. Thus, all the currencies tested have weak-form market efficiency for the period March 2000 and October 2005.

To summarise, test results suggest that the market was inefficient in the pre-inflation targeting period but the results from the post-inflation targeting period show weak form market efficiency. Therefore, the monetary regime shift to inflation targeting does increase market efficiency on the foreign exchange market. However, the tests for market efficiency only provide the answer

regarding whether there is market efficiency. The tests do not give the answer regarding how efficient the market is.

5. Summary and Conclusions

In this paper I provide an overview of the South African exchange market in the post-apartheid era. The Government took steps to liberalise the foreign exchange market by gradually relaxing the control of citizens' capital. The monetary policy regime shift to inflation targeting in February 2000 marked a significant date for South Africa. It meant a new era for the country's financial market because it meant that the interest rate is now determined in accordance with inflation, and the Government has put an end to intervention in the foreign exchange market. Therefore, there is now room for testing the effect of the introduction of inflation targeting on the foreign exchange market efficiency in South Africa. The relevant literature on market efficiency have been discussed and I find that the theoretical basis for market efficiency is far from perfect, and that there is evidence to dismiss the validity of the theory. However, empirical tests on weak form market efficiency can still be performed where the tests focus on whether past information can help in predicting future movements in the exchange rate. I also faced problems on which empirical methodology to select for examining market efficiency through unit root tests. The literature shows that most unit root tests suffer from low power and no comprehensive study has been done on all the unit root tests. Thus, there is difficulty in selecting the best. I selected the likelihood Dickey Fuller test as a primary test and the DF-GLS test as a confirmation test to identify the weak form market efficiency in the rand/dollar, the rand/euro and the rand/sterling exchange rates. The test results show that during the pre-regime shift sample period (January

1995 to February 2000) the movements in the rand/dollar and the rand/sterling exchange rates is not weak form efficient which means that the information about past exchange rate movements does help the prediction of future exchange rate. On the contrary, in the post-inflation targeting period (March 2000 to October 2005), the exchange rates (rand/dollar, rand/euro and rand/sterling) have shown weak form market efficiency. This means that investors are no longer able to use the information about past price movements to predict future exchange rates. Therefore, the introduction of inflation targeting in South Africa does help the foreign exchange market to be weak form efficient. Despite the empirical results suggesting that weak form market efficiency in the post inflation targeting period, one need to bear in mind that the testing methodology used in this paper was far from perfect. The low power of the unit root tests remains a matter of concern because I may make the mistake of accepting the null hypothesis of market efficiency.

The implication of weak form foreign exchange market efficiency is that the speculator is no longer able to use the past foreign exchange rate movements to predict the future exchange rate. Therefore, speculators cannot make excess profits by exploring past exchange rate movements. Since speculators are now out of the equation in determining exchange rates, we can expect that exchange rate movements would only reflect the fundamental value of the rand and that any volatility in the market would be eliminated by the market forces.

Despite the conclusion that shows that the foreign exchange market is indeed weak efficient, there is still no explanation for the sharp decline of the South African rand that occurred at the end of 2001 and the gradual improvement in

the value of the rand since 2002. I believe that this could be an interesting area for future research.

University of Cape Town

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Figure 1

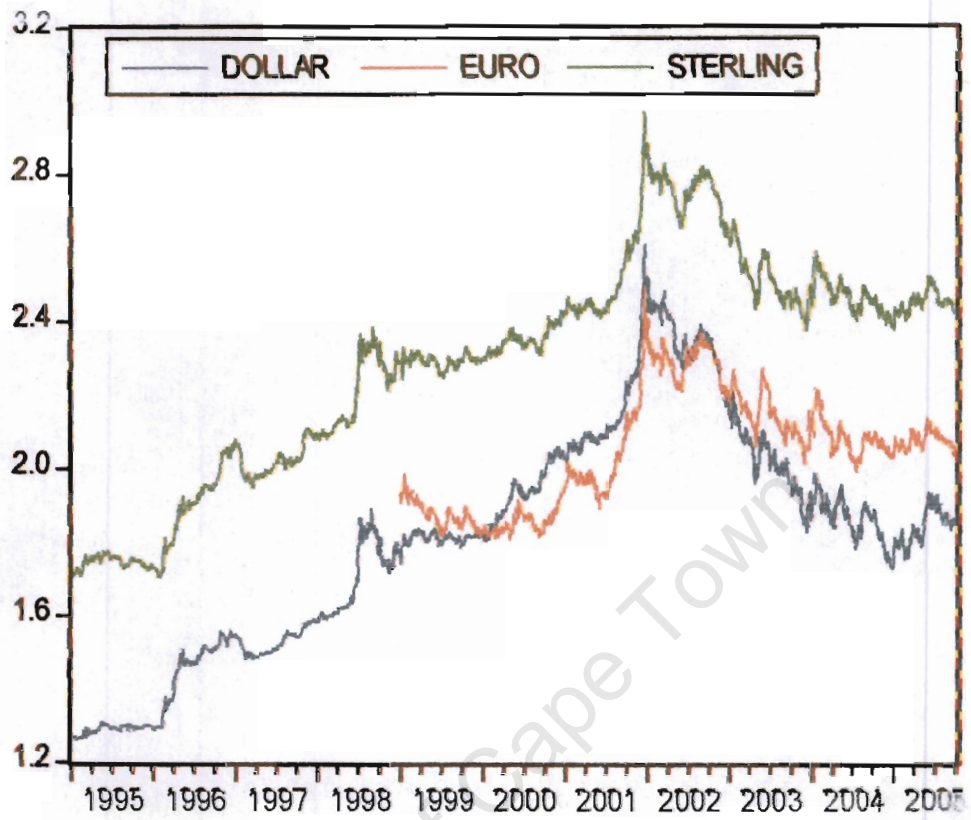


Figure 1: The daily movements (data are in log) of Dollar, Euro and Sterling
1995:01-2005:10.

Figure 2

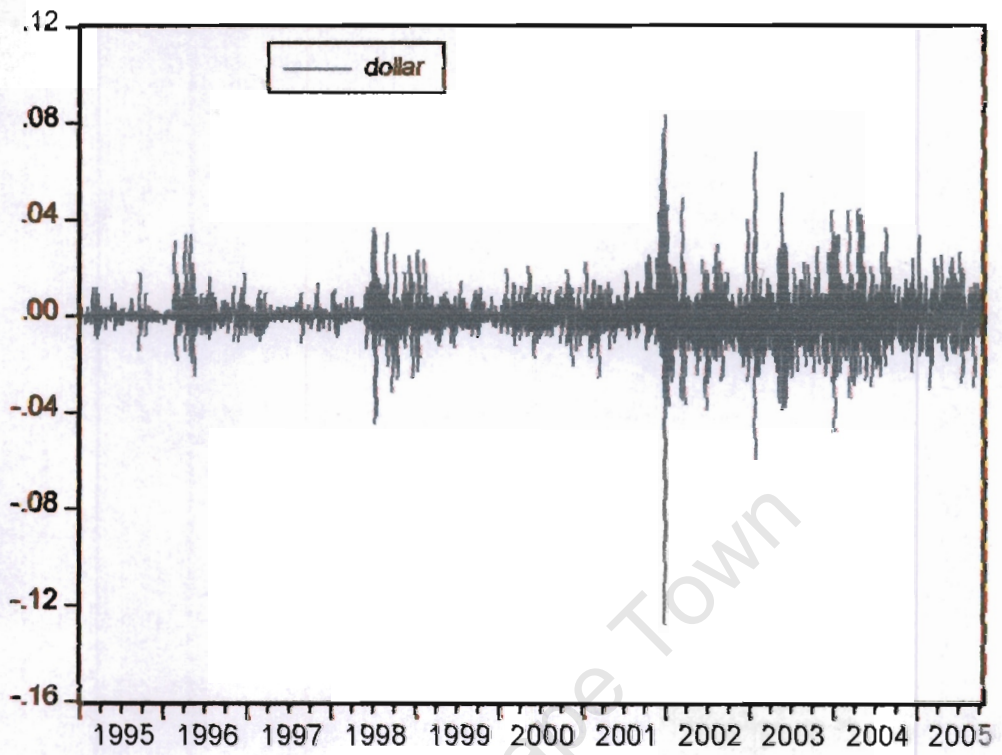


Figure 2: The daily movements (data are in log 1st differences) of Rand/ Dollar exchange rate 1995:01-2005:10.

Tables

Table 1:

Descriptive Statistics of the Daily Exchange Rates 1995:1 – 2000:2: 1305

Currency	Mean	Min	Max	Standard Deviation	Skewness	Excess kurtosis
Dollar	4.838	3.5371	6.611	0.193375	0.006488	1.741637
Sterling	7.7345	5.5449	10.8587	0.211005	-0.073631	1.670681

Notes: The means, minimum and maximum values are from the exchange rate series in their levels. The rest of the statistics relate to the log levels. Sample size is 1305.

Table 2:

Descriptive Statistics of the Daily Exchange Rates 2000:3 – 2005:10: 1502

Currency	Mean	Min	Max	Standard Deviation	Skewness	Excess kurtosis
Dollar	7.78546	6.1288	13.591	0.193844	0.708713	2.501046
Euro	8.090635	6.0785	12.1203	0.146699	0.016115	2.328318
Sterling	12.43255	9.9135	19.49379	0.141268	0.897417	2.829001

Notes: The means, minimum and maximum values are from the exchange rate series in their levels. The rest of the statistics relate to the log levels. Sample size is 1502.

Table 3
Regression Diagnostics on the Martingale Test of Daily Exchange Rates
1995:1–2000:2

Test	Dollar	Sterling
LM test for autocorrelation (U)	0.08 [0.38]	0.04436 [0.11]
LM test for auto correlation (R)	0.0801 [0.4]	0.04425 [0.11]
Test for ARCH residuals (U)	0.373 [0.004]	0.117 [0.002]
Test for ARCH residuals (R)	0.374 [0.0042]	0.174 [0.0001]
Test for heteroscedasticity (U)	0.00072 [0.0113]	0.0018 [0.0012]
Test for heteroscedasticity (R)	0.00073 [0.0106]	0.0018 [0.0011]

Note: U and R refer to the unrestricted and the restricted regressions respectively. Reported statistics are F-form with asymptotic p-values in parentheses.

Table 4
Regression Diagnostics on the Martingale Test of Daily Exchange Rates 2000: 3
-2005:10

Test	Dollar	Euro	Sterling
LM test for autocorrelation (U)	-0.0944 [0.33]	-0.0389 [0.133]	0.0075 [0.77]
LM test for auto correlation (R)	-0.0951 [0.32]	-0.04 [0.12]	0.0064 [0.8]
Test for ARCH residuals (U)	0.317 [0.0001]	0.3727 [0.0001]	0.438 [0.0001]
Test for ARCH residuals (R)	0.311 [0.0001]	0.3805 [0.0001]	0.432 [0.0001]
Test for heteroscedasticity (U)	0.0107 [0.0001]	0.0107 [0.0001]	0.014 [0.0001]
Test for heteroscedasticity (R)	0.0108 [0.0001]	0.011 [0.0001]	0.0143 [0.0001]

Note: U and R refer to the unrestricted and the restricted regressions respectively. Reported statistics are F-form with asymptotic p-values in parentheses.

Table 5

Stage one of Dickey and fuller likelihood ratio test 1995:1 – 2000:2

	α	β	ρ	κ
Dollar (U)	0.0093 [0.029]	3.43×10^{-6} [0.05]	-0.0072 [0.04]	2
Sterling (U)	0.014 [0.02]	4.19×10^{-6} [0.04]	-0.008 [0.03]	2

Notes: the statistic Φ_2 is the Dickey and Fuller (1981) likelihood ratio statistic for the null hypothesis $(\alpha, \beta, \rho) = (0, 0, 0)$ in the unrestricted regression $Y_t = \alpha + \beta t + \rho Y_{t-1} + \sum_{i=1}^k \gamma_i Y_{t-i} + \varepsilon_t$. The p-values are in the parentheses. The results shows that null hypothesis can not be rejected

Table 6

Stage two of Dickey and Fuller likelihood ratio test 1995:1 – 2000:2

	Φ_2	κ	γ	γ_1	γ_2
Dollar (R)		2	-0.0154	0.08 [0.034]	-0.1 [0.23]
Dickey Fuller Sterling (R)	4.97	2	0.009	0.044 [0.04]	-0.035 [0.2]
Dickey Fuller	5.16				

Notes: the statistic Φ_2 is the Dickey and Fuller (1981) likelihood ratio statistic for the null hypothesis $(\alpha, \beta, \rho) = (0, 0, 0)$ in the restricted regression $\Delta Y_t = \sum_{i=1}^k \gamma_i \Delta Y_{t-i} + \varepsilon_t$. The statistic Φ_2 is computed as a standard F-test is $F = (T-p) (RSS_R - RSS_U) / q(RSS_U)$. RSS is the sum of squared residuals. T is the number of observations (sample size) and p is the number of estimated parameters in the unrestricted regression. For each regression, the selected lag length (k) ensures no autocorrelation in residuals. 1% (5%) critical values are 6.09 (4.68) for a sample size approaching infinity in Dickey and Fuller Table V. In each case, reported $\gamma_1, \gamma_2 \dots$ value is for the each lagged variables and γ refers the sum of all the lagged variable value Related P-values are in parenthesis. The F-test is $F = (T-p) (RSS_R - RSS_U) / q(RSS_U)$. RSS is the sum of squared residuals. T is the number of observations (sample size) and p is the number of estimated parameters in the unrestricted regression

Table 7

Stage one of Dickey and Fuller likelihood ratio test 2000:3- 2005:10

	α	β	ρ	K
Dollar (U)	0.008 [0.033]	-1.76×10^{-6} [0.002]	-0.003 [0.05]	3
Euro (U)	0.007 [0.01]	-4.6×10^{-7} [0.01]	-0.003 [0.001]	3
Sterling (U)	0.008 [0.042]	-7.53×10^{-6} [0.021]	-0.003 [0.025]	3

Notes: the statistic Φ_2 is the Dickey and Fuller (1981) likelihood ratio statistic for the null hypothesis $(\alpha, \beta, \rho) = (0, 0, 0)$ in the unrestricted regression $\Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \sum_{i=1}^k \gamma_i \Delta Y_{t-i} + \varepsilon_t$. The p-values are in the parentheses. The results shows that null hypothesis can not be rejected

Table 8

Stage two of Dickey and Fuller likelihood ratio test 2000:3- 2005:10

	Φ_2	K	γ	γ_1	γ_2	γ_3
Dollar (R)		3	-0.177	-0.1 [0.15]	-0.035 [0.17]	-0.042 [0.08]
Dickey Fuller	4.08					
Euro (R)		3	-0.103	-0.041 [0.12]	-0.04 [0.11]	0.022 [0.42]
Dickey Fuller	4.35					
Sterling (R)		3	-0.057	0.005 [0.25]	-0.028 [0.28]	-0.034 [0.18]
Dickey Fuller	4.12					

Notes: the statistic Φ_2 is the Dickey and Fuller (1981) likelihood ratio statistic for the null hypothesis $(\alpha, \beta, \rho) = (0, 0, 0)$ in the restricted regression $\Delta Y_t = \sum_{i=1}^k \gamma_i \Delta Y_{t-i} + \varepsilon_t$. The statistic Φ_2 is computed as a standard F-test is $F = (T-p) (RSS_R - RSS_U) / q(RSS_U)$. RSS is the sum of squared residuals. T is the number of observations (sample size) and p is the number of estimated parameters in the unrestricted regression. For each regression, the selected lag length (k) ensures no autocorrelation in residuals. 1% (5%) critical values are 6.09 (4.68) for a sample size approaching infinity in Dickey and Fuller Table V. In each case, reported $\gamma_1, \gamma_2, \dots$ value is for the each lagged variables and γ refers the sum of all the lagged variable value Related P-values are in parenthesis. The F-test is $F = (T-p) (RSS_R - RSS_U) / q(RSS_U)$. RSS is the sum of squared residuals. T is the number of observations (sample size) and p is the number of estimated parameters in the unrestricted regression

Table 9
DF-GLS unit root tests results 1995:1 – 2000:2

Currency	DF-GLS	Lag length (MAIC)
Dollar	-2.96	2
Sterling	-3.35	2

Table 10
DF-GLS unit root tests results 2000: 3 -2005:10

Currency	DF-GLS	Lag length (MAIC)
Dollar	-0.72	3
Euro	-1.20	3
Sterling	-1.11	3

Notes: The linear trend model is most commonly used. The detrending process can be written as follows $y_t^d = y_t - \hat{\beta}_0 - \hat{\beta}_1 t$ where $(\hat{\beta}_0, \hat{\beta}_1)$ are obtained by regressing y on z where

$$y = [y_1, (1 - \alpha)y_2, \dots, (1 - \alpha)y_T]$$

$$z = [z_1, (1 - \alpha)z_2, \dots, (1 - \alpha)z_T]$$

and

$$z_t = (1, t)', \quad \alpha = 1 - c/T$$

The α that produces the asymptotic power depends on the significance level ε used and the DF-GLS model fixes $c = -13.5$ in the linear trend case. The DF-GLS test applied to the locally trended data is within 0.01 of the power envelope for $0.01 < \varepsilon < 0.10$ and the critical values for 10%, 5% and 1% level are -2.57 , -2.89 and -3.48 respectively for a sample size which approaches infinity (Elliott, Rothenberg and Stock (1996, Table 1, 825)).