Foreign Exchange Market Efficiency Tests in South Africa

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Abstract

Are frequent changes in freely floating exchange rates attributable to stabilising speculation reflecting changes in the fundamental determinants of currencies; or to destabilising behaviour of various kinds, driving prices away from fundamentals, and creating "excess" volatility? This paper, motivated by the need to assess appropriate tests for efficiency for the growing range of liberalised and liberalising foreign exchange markets in Sub-Saharan African countries, has the following objectives: (i) briefly to survey the empirical methodology for testing market efficiency in the forex market, with an emphasis on integrating the new cointegration methodology; (ii) highlighting the significant data difficulties in empirical work, given controls and frequent structural breaks, for the use of these techniques in Africa; (iii) illustrating the way in which some of these techniques can be applied in South Africa; and (iv) suggesting further research on efficiency that could be carried out using similar data.

1. INTRODUCTION

This paper was motivated by the approaching need to assess appropriate tests for efficiency for the growing range of liberalised and liberalising foreign exchange markets in Sub-Saharan African countries (SSA). In most of SSA, the introduction of floating exchange rates has lagged the floating of major currencies by almost two decades. During the 1970s, exchange rates were mostly held fixed, with infrequent adjustments; and following severe terms of trade shocks in the mid-1970s, overvalued exchange rates were sustained by more stringent rationing of foreign exchange. Grey (or parallel) markets consequently flourished throughout SSA, and proved significantly more substantial in the relative volume of illegal transactions and size of exchange rate premia than their counterparts in Latin America. The adverse macroeconomic consequences of large parallel markets are by now well-documented (e.g. Kiguel et al, 1997), and by the mid-1980s, encouraged by the Bretton Woods institutions, many countries had adopted transitional systems toward unified, market-determined and convertible exchange rates. With varying degrees of success, interbank markets for foreign exchange now operate in several SSA countries.[1]

The prospect of fully floating and convertible currencies introduces new policy dilemmas for SSA economies, already complicated by thin financial markets, rudimentary financial and regulatory institutions, the typical absence of forward markets, and low foreign exchange reserves. By contrast with a system where exchange rates change as infrequent step adjustments in a direction predictable from the balance of payments constraint and the size of reserves, and where the timing of these changes lies at the behest of policy-makers, there is potentially a large increase in exchange rate volatility under full floating. The rôle of the exchange rate is crucial in SSA's small import-dependent economies with highly concentrated export sectors. Policy concerns include the extent of allocational efficiency in thin markets with a volatile exchange rate, whether volatility deters investment or renders it inefficient, and whether the exchange rate can, or should be, smoothed through intervention mechanisms.

Such dilemmas revisit ongoing controversies in industrialised countries, where a very large literature has arisen attempting to explain the behaviour of floating exchange rates in the "post-Bretton Woods" era.[2] An important strand of this literature addresses whether or not foreign exchange markets are "efficient": that is, whether frequent changes in exchange rates are attributable to stabilising speculation which reflects changes in the fundamentals or long-run determinants of currencies; or

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[1] For instance, Ghana, Kenya, Mozambique, Nigeria, Tanzania, Uganda, Zambia and Zimbabwe moved to interbank systems by the late 1980s or early 1990s, either directly, or via an auction (some retain capital controls). Ethiopia currently conducts foreign exchange auctions in transition toward an interbank market.

[2] For instance, see Levich (1985), Meese (1990) and Taylor (1995).

whether such changes are due to destabilising behaviour of various kinds, driving prices away from fundamentals, and creating "excess" volatility.[3]

Proponents of the efficient markets view hold that destabilising speculation could not flourish because it would be unprofitable for investors (Friedman, 1953). By contrast, arguments originating with Nurkse (1937) suggest that excess volatility, caused by speculative runs, irrational behaviour and fads, will damage the real economy by imposing large costs on producers and consumers, who then make less than efficient allocative decisions. The potential costs of instability have been documented by Krugman (1989), and include the possibility that investors will adopt a wait-and-see attitude in the face of uncertain future exchange rates (see Dixit and Pindyk, 1994). If indeed foreign exchange markets were inefficient, and the source of efficiency understood, there could be a case for intervention (see Froot and Thaler, 1990).

However, compounding a complex and subtle empirical literature on testing asset market efficiency, where alternative tests may not be comparable and results have to be interpreted with considerable caution, it is not clear that structural characteristics in SSA economies currently properly allow for efficiency testing. Thus, rudimentary financial and regulatory institutions, the absence of freely-functioning forward markets, credit rationing and the continued maintenance of exchange controls in many cases, strictly limits the tests in the efficiency literature that can be applied in SSA. More seriously, there is insufficient data on recently floating rates to test efficiency[4], and these data are affected by market thinness and frequent policy and political regime changes.

In developing countries, free markets for foreign exchange may not have operated for sufficient periods, and it may be necessary to use monthly illegal parallel market rates for simple tests of efficiency. These rates are also not ideal, given uncertain quality of the data, the fact that they are subject to changing risk premia for illegality, and are influenced by frequent policy and other regime shifts in the economy. South Africa offers greater scope for efficiency testing than do most developing countries. There is a forward market (albeit highly regulated), longer official floating exchange rate series and the country has had an advanced financial structure for a long period. Moreover, the quality and breadth of macroeconomic data exceeds that of the other countries, and allows cointegration analysis of the exchange rate and its fundamental determinants.

[3] Surveys include Bollerslev and Hodrick (1995); Froot and Thaler (1990) and Fama (1970, 1991).

[4] The cointegration methodology requires long spans of data, and high frequency data adds little despite the large number of observations (see Kim and Mo,1995). Use of the forward rate in typical forward premium bias regressions comes up against an aggregation bias given overlapping contracts, which reduces available data (see Section 4), though there are instrumental variable estimation methods that can be used to compensate.

With the above caveats in mind, we have the following objectives in this paper: (i) briefly to survey the empirical methodology for testing market efficiency in the forex market, with an emphasis on integrating the new cointegration methodology; (ii) highlighting the significant data difficulties in empirical work, given controls and frequent structural breaks, for the use of these techniques in Africa; (iii) illustrating the way in which some of these techniques can be applied using South African data; and (iv) pointing the way ahead in terms of further specific work that could be carried out using similar data.

The remainder of the paper is structured as follows. Section 2 discusses the concept of market efficiency in foreign exchange markets, including its implications for empirical tests of efficiency. Section 3 examines alternative tests for efficiency, with an emphasis on the recent cointegration literature. Section 4 applies a subset of tests to South Africa. Finally, Section 5 contains concluding remarks, offers some policy implications, and suggestions for extensions of the study.

2. THE CONCEPT OF EFFICIENCY AND IMPLICATIONS FOR EMPIRICAL TESTS

The classic definition of an efficient market is due to Fama (1970), and is a market where prices *fully reflect* the information available, such that an unusual profit cannot be earned through exploiting this information set. In this case, decisions taken on the basis of these prices will promote the efficient allocation of resources (Levich, 1985).

More formally, expressing market equilibrium in terms of equilibrium returns, consider the following definition of the excess return Z_{t+1} in the context of foreign exchange markets:

$$Z_{t+1} = \Delta S_{t+1} - E(\Delta\tilde{S}_{t+1} / \Psi_t) \quad (1)$$

where the first term on the right hand side, ΔS_{t+1}, is the actual one-period percentage change in the spot exchange rate (or more precisely, the change in the log of the exchange rate); and the second term is the expectation at time t, given the market information set Ψ_t, of the equilibrium percentage change in the spot exchange rate.

A currency market is said to be efficient, given the information set, when the difference between these two terms in equation (1), or the excess returns series Z_{t+1}, is a "fair game" (or martingale difference - see LeRoy, 1989). This implies the series Z_{t+1} has an expected value of zero and is unforecastable given Ψ_t (i.e. the excess returns are independent of any information dated t or earlier in Ψ_t, especially S_{t-i}, for $i \geq 0$). Clearly there will be no systematic large profits or losses in such a market. Note that where there are positive information and trading costs, the definition implies that deviations from a fair game in equation (1) will be within transactions and trading costs (Fama, 1991).

In general, empirical tests of efficiency are difficult to formulate and interpret because the term "prices fully reflect", encapsulates a *joint* hypothesis (see Levich, 1985 and Fama, 1991). First, market equilibrium returns are assumed to be defined as some function of an information set Ψ_t (which is the implicit hypothesis); and then the hypothesis is tested that actual returns differ from their expected values only randomly (that is, the agents have rational expectations). A complete empirical formulation would thus require not only that one can test whether actual returns approximate expected (equilibrium) returns, but also the way in which the expectations are formed (since implicitly agents possess and use the “correct” model linking a particular information set to expected returns).

Turning to the question of equilibrium returns in the foreign exchange market, given a degree of capital mobility, and a deep and liquid market in short-term interest-bearing securities (such as a market in treasury bills or certificates of deposit in both currencies), by the hypothesis of uncovered interest parity (UIP) augmented by a time-varying risk premium, efficient arbitrage should ensure that the expected equilibrium return is given by

(2) $$E(\Delta\tilde{S}_{t+1}/\Psi_t) = (r - r*)_t + \xi_t$$

where r - $r*$ is the domestic and foreign interest rate differential for a horizon from t to t+1, and ξ is a risk premium.

If investors were risk neutral or perfectly able to hedge exchange rate risk, the risk premium would be zero. Further assuming rational expectations, the *ex post* spot rate will differ from its rational expectation only by a random term u_{t+1} with a mean of zero, so that $S_{t+1} = E(S_{t+1}) + u_{t+1}$. Combining these hypotheses yields the familiar testable condition for efficiency in the foreign exchange market (e.g. Froot and Thaler, 1990):

(3) $$\Delta S_{t+1} = (r - r*)_t + \epsilon_{t+1}\,.$$

where the prediction error ϵ_{t+1} is independent of all information in Ψ_t.[5] All available and relevant information is channelled into prices, and prices will thus only change because of the *unexpected* arrival of new information.

Given the assumptions above, if this joint test of efficiency is rejected, the cause may be that agents are inefficient at processing the available information, although they have the correct equilibrium model; or that agents have an incorrect specification of the relationship linking equilibrium returns to the information set, although they are rational in forming their price expectations. Thus, on the one hand, exchange rate expectations may not be fully rational, such as where there are heterogeneous expectations amongst traders, with one group forming rational expectations of future fundamentals, while a second group bases their forecasts on technical analysis of recent exchange rate behaviour.

On the other hand, there are a number of model-based explanations for rejection of the joint hypothesis which do not require rejection of the rational expectations hypothesis (Isard, 1995). These relate to different conceptual models of exchange rate behaviour such as including a time-varying risk premium (as in the UIP-augmented equation (2) above); rational learning in the presence of incomplete information (e.g. learning about policy changes); rational speculative bubbles; the "peso problem"[6]; and the endogeneity of the interest differential, which macro-policy may adjust to offset undesired movements in the exchange rate (McCallum, 1994). Most critical of these perhaps is the risk premium, and while in equity markets the assumption of a constant risk premium is still quite common, in foreign exchange markets it seems less tenable. However, attempts to put structure on the time-varying risk premium hypothesis by setting up theoretical stochastic equilibrium models and relating the hypothesised risk premium to observable macroeconomic variables suggested by theory have been largely unsuccessful (one recent exception is Dominguez and Frankel, 1993).

The joint hypothesis problem thus poses a far more serious problem than uncertain trading and information costs. According to Fama (1991), market efficiency *per se* is not testable: precise inferences about the degree of efficiency are likely to remain impossible since there is ambiguity in splitting excess returns between market inefficiency and a bad model of equilibrium returns. The difficulty of apportioning failure of the joint hypothesis to efficiency or an appropriate model of

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[5] Or alternatively, that $\log S_{t+1} = \log F_t + u_{t+1}$, where F is the forward rate, using the definition of covered interest parity, and μ is an unpredictable error with mean zero.

[6] Over extended periods, investors may believe there is a small probability of a substantial policy regime shift which would result in a marked change in the equilibrium exchange rate. Examples might be joining or departing from a currency block such as the ERM, or introducing or abandoning capital controls or trade barriers. Since investors build in this small probability when calculating $E(\Delta\tilde{S}_{t+1}/\Psi_t)$ there can then be a divergence from simple UIP.

equilibrium returns is obviously compounded many times in the context of developing countries with exchange controls, shallow foreign exchange and credit markets, poor information, high inflation and sharp regime changes. For instance, with repressed domestic financial markets, the interest rate on short-term deposits may be well below expected inflation, so that the interest differential $(r-r^*)_t$ may understate domestic returns available by holding goods, particularly durable goods with low storage costs, land or domestic equities. Thus, in a distorted high inflation environment, the relevant arbitrage opportunities for holding foreign currency (possibly illegally) may not be with domestic cash and short-term deposits, but with returns on these alternative domestic hedges against inflation.

In two surveys (Fama, 1970; Fama, 1976), Fama highlights the joint hypothesis by presenting two different types of categorisation of efficiency hypotheses. This two-fold taxonomy helps to emphasise the empirical problems posed by differing quality of information sets, as well as operationalising the equilibrium returns hypothesis. The first category assumes a particular relation between the equilibrium returns and the information set, and efficiency hypotheses are then ordered on the basis of the *nature of the information set* Ψ_t. In Fama (1970), three informational categories of market efficiency are distinguished: *weak form* (where Ψ_t consists at a minimum of historical prices), *semi-strong form* (where Ψ_t additionally includes information in the public domain) and *strong form* (where Ψ_t contains all available information, including insider information). In his later review of 1991, Fama extends the coverage of the weak form tests (which above are only concerned with past prices) to encompass the burgeoning work on forecasting returns with variables like dividend yields and interest rates ("tests for return predictability"). The semi-strong form tests of adjustment of prices to public announcements are now renamed "event studies", and strong form tests of whether or not specific investors have information not in the market prices are relabelled “tests for private information”.

On the other hand, in Fama (1976), for a particular information set Ψ_t, efficiency tests are categorised according to the *nature of the process or function linking expected returns,* and various alternative equilibrium returns processes are considered, such as constant returns, or returns generated by a market model. For instance, if equilibrium returns, $E(\Delta S_{t+1}/\Psi_t)$, are formulated as a constant ρ, then the assumption that was ubiquitous in many earlier studies of efficiency will hold, namely, that martingale behaviour for the log exchange rate S_{t+1} with a drift parameter ρ implies market efficiency (i.e. no predictability of returns). If, on the other hand, there are systematically varying equilibrium returns, then the finding of a martingale process will not equate with efficiency, since as with equilibrium returns, actual returns will be serially correlated. Random price movements in such a case thus constitute neither a necessary nor a sufficient condition for market efficiency (Levich, 1985).

In respect of formulating models for equilibrium returns, Levich (1985) argues that there is an important difference between foreign exchange and equity markets. Unlike the securities market, where there are several plausible equilibrium returns processes, there are as yet no commonly agreed models for the determination of equilibrium exchange rates[7]. However, a process of non-systematic variation for exchange returns is highly unlikely for several reasons, related both to the institutional context of foreign exchange markets and their strong linkages with the macro-economy. By contrast with the equity market, supplies of currencies are not fixed or predictable, while the demand for foreign exchange depends on a broader range of factors than the demand for a security. The foreign exchange market is affected by real shocks and by changes to monetary and fiscal policy such that both the level and the change in equilibrium currency returns will vary systematically. There are thousands of securities, but few major currencies, so that rebalancing portfolios creates a major impact on small perceived changes in risk/return properties. Further, currencies are more susceptible to government intervention and to sharp changes in macro-policy than are stocks, which depend largely on firm and market characteristics, and where risk/return behaviour can be deduced by investors in a fairly stable environment.[8]

The above discussion has pointed to sources of the typical non-stationarity of exchange rates. In the following section, we briefly review some applications of the recent cointegration literature to testing for foreign exchange market efficiency, currently the subject of a spirited debate on methodological issues. These techniques exploit the previously neglected time series properties of the exchange rate and the regressors typically used in market efficiency tests, and also present new opportunities for establishing simultaneously the short-run and long-run influences on equilibrium exchange rates. In section 4, we apply some of this literature to testing efficiency in five African countries.

3. COINTEGRATION AND MARKET EFFICIENCY TESTS

Exchange rates, in common with many financial variables, typically exhibit non-stationary time series processes: that is, they are series trending over time, rather than mean-reverting or stationary series

[7] For instance, see Williamson (1994), encompassing a range of recent work in establishing theoretical priors and empirical regularities in the estimation of real equilbrium exchange rate functions.

[8] One might argue that Levich (1985) overstates the "absolute" case for systematic variation in the equities market, and that the difference between the two markets is rather one of degree. For instance, there has been a breakdown in the old consensus on efficient stock markets, so that there is no longer an agreed model (Shleifer, 1996); while stock market indices in a globalised market are similarly subject to the vicissitudes of macro-economic policy.

(though they may be stationary around a deterministic trend)[9]. A variable such as the spot exchange rate, S_t , is said to be integrated of order d , or $S_t \sim I(d)$, if the *dth* difference of S_t is stationary. When all or some of the variables involved in an econometrically estimable relationship are non-stationary (i.e. they are"integrated" series), then it is important to guard against spurious regressions, where integrated but unrelated series can imply an apparently significant relationship when one is regressed on another (Granger and Newbold, 1974).

However, the equilibrium relationship between a number of non-stationary variables can be expressed in a stationary model if a linear combination of these variables can be found to be stationary (termed a cointegrating vector)[10]. Here the variables can deviate from the implied long-run equilibrium relationship, but not by an ever-growing amount. Furthermore, the Granger-Engle Representation theorem (Engle and Granger, 1987) states that if series are cointegrated then the equation is not only interpretable as a long-run equilibrium, but is also consistent with a dynamic error-correction model (ECM), by which the change in at least one of the variables will be a function of the "disequilibrium" in a previous period. Cointegration thus implies predictability between the variables in the system.

To illustrate the bivariate case, let non-stationary series, S_t (the logarithm of the spot rate) and a variable X_t (say, the logarithm of the forward exchange rate), be integrated of order one, then cointegration implies the unique representation

$$S_t = b_0 + b_1 X_t + \epsilon_t \tag{4}$$

where ϵ_t is a stationary error term. Cointegration is a necessary condition for the following error correction model to hold:[11]

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[9] Formally, let $y_t = t + Z_t$ be an economic series composed of a deterministic trend t and a stochastic component. For simplicity assume that Z_t can be described by an autoregressive-moving average process: $A(L)\ Z_t = B(L)\ e_t$, where A(L) and B(L) are polynomials in the lag operator L and e_t is a sequence of i.i.d. innovations. The noise function Z_t is assumed to have mean zero, the moving average polynomial is also assumed to have roots strictly outside the unit circle. Then Z_t has a unit root if A(L) has one unit root and all other roots strictly outside the unit circle. In this case $(1\text{-}L)\ Z_t = \Delta Z_t$ is a stationary process and $(1\text{-}L)\ y_t = \Delta y_t$ is stationary around a fixed mean. If, on the other hand, A(L) has all its roots outside the unit circle, then Z_t is a stationary process and y_t is stationary around a trend.

[10] More formally, let the nx1-vector y_t be composed of $(y_{it}, \ldots\ y_{nt})$, where the y_{it} are defined as in the footnote above. Then y_t is said to be cointegrated if there exists at least one non-zero n-element vector β such that the linear combination $\beta' y_t$ is trend stationary. This is a mild definition of cointegration (Campbell and Perron, 1991), which is suited to analysis of economic data since it permits the inclusion of deterministic components in the cointegration model (such as trends and structural break dummies), along with other non-stationary stochastic variables.

[11] Note that the ECM is expressed in terms of lagged variables only, relative to the dependent variable.

(5) $$\Delta S_t = \alpha\,(b_0 + b_1 X_{t-1} - S_{t-1}) + \sum_{k=1} \beta_k \Delta X_{t-k} + \sum_{k=1} \gamma_k \Delta S_{t-k} + \zeta_t$$

where ζ_t is an i.i.d. residual. The first term on the right-hand side of the equation represents deviation from long-run equilibrium, with the speed of adjustment to equilibrium captured by the coefficient α which falls in the interval [0,1]. Temporary changes in the lagged X_t and S_t variables may also have short-run effects, captured by the coefficients β_k and γ_k. The single non-stationary variable X_t illustrated in equations (2) and (3) can be generalised to a vector of non-stationary variables, which may exhibit a long-run relationship with the spot exchange rate.

The use of this methodology for the testing of market efficiency relates to the correspondence between cointegration and error correction (and hence predictability), and originates in the work of Granger (1986), who argued that two price series (e.g. gold and silver commodity prices) determined in efficient markets cannot be cointegrated. It is important to note that, by contrast with the commodity price study above, for the cases of interest- or dividend-bearing assets it is insufficient to examine *price* predictability, but rather the *excess* returns (i.e. including the dividend for stocks and subtracting the alternative risk-free rate, and including the interest differential for foreign currency) should be unpredictable. For instance, while exchange rate depreciation under hyperinflation may be highly predictable, the excess return including the interest differential from a strategy which tries to exploit this should not be (Richards, 1995). Further, the implications for efficiency are not clearcut, since as we have seen in Section 2, returns also have to be risk-adjusted.

The recent literature applying the cointegration methodology to testing for foreign exchange market efficiency can be divided broadly into three categories.[12] The first category tests for cointegration amongst various international spot rates.[13] The claim is that efficiency requires no evidence of cointegrating vectors. A range of techniques is used to test for cointegrating vectors (see the discussion on methodological controversies below) for a range of currencies, with mixed results. However, as we have just stated, unless interest differentials prove unimportant, such tests for cointegration amongst exchange rates as evidence for or against market efficiency may be invalid (see Richards, 1995 and also Engel, 1996). Baffes (1994) makes a similar point, arguing that market efficiency does not imply that exchange rates are unpredictable, but rules out arbitrage opportunities

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[12] The discussion is confined to efficiency tests in the foreign exchange market: there is also a burgeoning cointegration literature in the equity and commodity markets (e.g. Richards, 1995).

[13] Studies include Baillie and Bollerslev, 1989; MacDonald and Taylor, 1989; Coleman, 1990; Sephton and Larson, 1991; Tronzano, 1992; Lajaunie and Naka, 1992; and Alexander and Johnson, 1992; and Alexakis and Apergis, 1996.

from such predictability. He emphasises that for the Granger (1986) cross-asset efficiency argument to apply, it needs first to be established that the different assets are determined by different sets of fundamentals (unlikely to be the case for cross-exchange rates). Finally, simulation evidence suggests that the finding of strong cointegrating relationships in many cases may be due to the failure to adjust asymptotic critical values for the small number of degrees of freedom remaining in the Johansen (1988) multivariate estimation procedure (see Richards, 1995).

The second category tests for cointegration between the spot rate and forward rate.[14] The finding of cointegration between the forward and spot rates is merely a "necessary" condition for efficiency (unbiasedness). The "sufficient" condition is for an unstructured error process, a rather stronger requirement than the cointegration requirement that there be no unit root in any autocorrelation pattern in the residuals (Copeland, 1991). With the caveat that a range of techniques is used (results prove sensitive to different estimation procedures, especially with overlapping observations), typically the "necessary" condition is strongly satisfied, while the "sufficient" condition is not (if it tested at all). This type of test probably does not add much to the traditional forward bias techniques (see Froot and Thaler, 1990; and Fama, 1984).[15]

The third and arguably most interesting category involves finding a long-run equilibrium relationship for the spot rate with a range of macro-fundamentals, and using the related error correction model to show predictability of future excess returns via the lagged long-run term as well as lagged short-run dynamics.[16] This type of test is a test of semi-strong efficiency (or in the recategorisation by Fama (1991), is a "test for returns predictability", encompassing the burgeoning work on forecasting returns - in stock markets- with variables like dividend yields and interest rates, and not simply historical prices). By contrast with the stock market, as Bekaert and Hodrick (1992) point out, the main variable used in establishing a predictable future spot rate is the forward premium (which is simply the familiar excess returns efficiency test of equation (3))[17]; however, their study using VARs

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[14] Studies include Copeland, 1991; Dutt, 1994; and Moore and Copeland, 1995.

[15] In the Froot and Thaler (1990) survey, 75 published studies across different exchange rates and various time periods found an average point estimate of -0.88 for the coefficient of the forward premium (rather than the theoretically expected 1, for an efficient market), when running a regression of the future change in the exchange rate on the current forward premium and a constant. The implied volatility of the risk premium appears implausible (Fama, 1984), which suggests it is possible to make a profit by betting against the forward rate.

[16] Related studies include Bekaert and Hodrick, 1992; and a volatility study by Bartolini and Bodnar, 1996.

[17] Studies include Naka and Whitney, 1995; and Hakkio and Rush, 1989.

additionally finds that dividend yields have predictive power in the foreign exchange market.[18] The current paper extends this category using a broader set of variables to predict excess currency returns. A quarterly single equation ECM model is presented for South Africa, and demonstrates the predictability of future excess currency returns using a range of lagged macro-fundamentals, such as the real dollar gold price, government expenditure, tariff policy and the stock of central bank reserves.

Finally, under the same category, a word should be said about cointegrating analyses that examine the purchasing power parity condition (PPP) for foreign exchange markets as a test for market efficiency.[19] PPP has been suggested as an alternative arbitrage condition for efficiency in countries (using parallel market data) where the interest parity condition is not expected to hold due to exchange and credit controls (El-Sakka and McNabb, 1994). The argument appears to be that establishing long-run PPP implies that the current difference of domestic and foreign inflation rates predicts the current spot return. However, three points should be made. Firstly, as shown in Patel (1990), it is not sufficient simply to show long-run PPP as in the study above, but the long-run PPP relation should be shown not to be useful in predicting future returns, in order to establish efficiency. Secondly, many studies of the real exchange rate cast doubt on the validity of PPP, except in the very long-run, and use instead broader structural models for real exchange rates (see Aron et al, 1997). Thirdly, an excellent critical review on cointegration studies of PPP shows that many recent studies fail to impose and test the appropriate restrictions for symmetry and proportionality, and represent weakenings of PPP (Boucher Breuer, 1994). For these reasons, and the many data difficulties one expects in testing for PPP, especially in developing countries with price controls and poorly disaggregated price series, one would not expect such tests to have implications for efficient markets.

For all the above categories, the interesting methodological issues concern which techniques are appropriate to use to establish cointegration. Typically the early literature has employed the Engle-Granger two-step method for bivariate cointegrating vectors. This method has even been used for multivariate vectors, though with caveats for its disadvantages with the number of cointegrating variables being larger than two (see Coleman, 1991; Alexander and Johnson, 1992). Later studies employ the multivariate Johansen method (Johansen and Juselius, 1990), which has the advantage of accommodating more than one cointegrating vector. There has been some concern in the literature

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[18] We emphasise again that models predicting excess returns should be distinguished from models predicting only the future spot exchange rate, which are not strictly tests of the efficiency hypothesis. In an example of the latter, the monthly ECM models of Kim and Mo (1995) show predictability at all horizons with a range of purely monetary models for the exchange rate, but improved predictability over a random walk model at longer horizons. Similarly, Mark (1995) uses a money and real income to predict long horizon exchange rates.

[19] These include Patel, 1990; and El-Sakka and McNabb, 1994.

about the Johansen technique's fragility to temporal changes for efficiency testing (see Sephton and Larsen, 1991). Examining cointegration between forward and spot rates, there is the additional problem of overlapping forward contracts, so that the error will be a moving average process (see Moore and Copeland, 1995, and references therein). This can be corrected for, but as they point out, the implications under cointegration testing are unexplored. Moore and Copeland use the Philips and Hansen (1990) technique, which in their context gives results broadly similar to the OLS estimates for static Engle-Granger, but rather different to the Johansen method.

What are the uses of this methodology for testing foreign exchange market efficiency in Africa? It is possible to conduct weak form tests of efficiency, examining the predictability of excess returns in foreign exchange markets based only on the past history of returns. The problem is that *excess* returns is a difficult concept in developing countries where interest differentials would not appear to be important for investors, given exchange and credit controls, and where the returns on alternative assets are not easily assessed (see Section 2). As pointed out above, exchange rates alone may be readily predictable in periods of hyper-inflation, which does not say anything about efficiency. Capital controls also mean that weak efficiency tests of cointegration amongst international rates are not meaningful (and there are again problems with excess returns concept here); on the other hand, using black market rates for different currencies is also suspect since they are typically very thin markets in all but the major (usually dollar) currency. Tests of forward market and spot cointegration are obviously impossible where forward markets are absent or highly regulated. Stronger tests of efficiency involving broader and also longer horizons returns predictability tests using macrofundamentals are promising, depending on the availability of monthly and quarterly data. The PPP tests are unlikely to be useful for establishing efficiency in practice.

4. EMPIRICAL APPLICATIONS

In this section, feasible tests for efficiency in South Africa’s foreign exchange market will be carried out. Employing the categorisation of Fama (1991), simple weak-form efficiency tests will be applied, which test how well past prices predict future returns; but generalising to broader forms of prices predictability tests, we additionally use a range of macroeconomic variables in error correction models to forecast returns.

In South Africa, the feasible subset of tests is larger than that which can be applied for other African countries. South Africa has possessed well-developed financial markets for a long period, and there are several floating rates to examine. Strict exchange controls on domestic residents have been operative since the early 1960s, but the principal exchange rate has been largely market-determined from 1979. Between the 1960s and 1994, except for a period of unification in the mid-1980s, separate floating exchange rates have been applied to non-residents' capital transactions. Monthly parallel market data (illegal market) stretches back to the 1950s. The forward market, albeit a highly regulated market, has operated since 1983. Finally, the quality and breadth of quarterly data on fundamental macroeconomic variables far exceeds that available for the other four countries.

First, the weak form efficiency hypothesis is tested for the floating rates in South Africa, and the potential for a forward market bias test is also illustrated, though controls preclude a meaningful test at present. More interestingly, it is possible to test a stronger form of efficiency, demonstrating the predictability of the future quarterly nominal exchange rate returns using a single equation error correction model, and conditioning for the domestic-foreign interest rate differential (from the Uncovered Interest Parity condition). Given the prevalence of capital controls over the period, Uncovered Interest Parity is not expected to define the marginal efficiency condition in South Africa, but is likely to be better than assuming a zero differential in alternative returns to holding foreign currency (see Section 2).

4.1 South Africa

South African exchange rate and monetary management has undergone numerous regime changes in the past three decades (see Table 1, and for details, Aron et al, 1997). After being pegged or fixed for most of the 1970s, the principal rate (or commercial rand) was designated floating from the second quarter of 1979, when an official dual regime with a fully-market-determined rate for capital transactions was instigated. The secondary rate, or financial rand, replaced an earlier floating capital transactions rate applying only to non-residents' purchases of shares, which were not transferable across non-residents. The commercial and financial rates were temporarily unified during 1983-85, but a dual system was reinstituted and persisted until the second unification in early 1995.

Given pervasive capital controls on domestic residents, a parallel currency market exists and monthly data are available from the 1950s. A forward market was introduced in 1983, which does not allow a market-determined rate, but has been strongly managed by the Reserve Bank (liberalisation of the market was initiated in late 1995). The evolution since 1970 of the three nominal exchange rates and the nominal effective exchange rate defined for four trading partners (see Aron et al, 1997), is shown in Figure 1.

4.1.1 Weak Form Efficiency Tests in South Africa

Weak form efficiency tests are carried out on monthly data for the four floating rates: the commercial and financial rands, the nominal effective (commercial) rand and the parallel exchange rate. The "float" period that can be tested for the commercial rand ($/R or nominal effective rate index) is 1979:2-1995:3. The financial/securities rand floats over the split period 1973:2-1983:1, 1985:9-1995:2, being temporarily unified with the commercial rand in 1983-85. Illegal parallel rate data can be tested over the entire period 1970:1-1995:2.

These weak tests test only whether the nominal exchange rate returns are predictable from past exchange rates.[20] The starting point is establishing the order of stationarity for the data. If the exchange rates prove to be stationary, then returns are by definition predictable from past values, and the spot market will therefore not be efficient. The stationarity test is typically carried out using an augmented Dickey and Fuller test. For a variable *S*, the augmented Dickey Fuller (1979) statistic is the t ratio on π from the regression:

(6) $$\Delta S_t = \pi S_{t-1} + \sum_{i=1}^{k} \theta_i \Delta S_{t-i} + \psi_0 + \psi_1 t + \epsilon_t$$

where k is the number of lags on the dependent variable, ψ_0 is a constant term and t is a trend. The *kth*-order augmented Dickey-Fuller statistic is reported, where k is the last significant lag of the six lags employed (the trend is included only if significant).

The statistics for the augmented Dickey and Fuller tests for the logarithms of the various rates and the relevant time periods are presented in Table 2. The results suggest that all series have a unit root. These tests are hampered by the low power of the standard Dickey and Fuller test in detecting unit roots. Further, these tests assume an i.i.d. Gaussian error process, which is not expected to apply to financial time series. As a result, we also apply the Phillips and Perron (1988) methodology for testing non-stationarity, which is a non-parametric method, and allows greater dependence, including conditional heteroscedasticity. The finding of unit root non-stationarity for all the above series is confirmed by the non-parametric Phillips and Perron (1988) tests reported in Table 2.

Having established, using Dickey and Fuller tests, that the coefficient, π, for the lagged level of the spot rate is insignificant in predicting ΔS_t, this term is dropped from equation (6). We then establish

[20] Thus, the test is not for the excess return defined to net off the interest rate differential, which would have been theoretically more appropriate. But since on monthly data for South Africa, this excess return is hugely dominated by ΔS_t, the results would have been similar. Note that only if the interest differential and the risk premium were both equal to zero, we would be testing a martingale difference model for returns, or equivalently, whether the exchange rate followed a martingale process (LeRoy, 1989).

whether the coefficients, θ_i, on the lagged differenced terms of S_t have any power in explaining S_t. The following restricted regression was run against the unrestricted regression, and an F test used to test the restriction that the exchange rates are not predictable from their own lagged differenced values:

(7) $$\Delta S_t = \sum_{i=1}^{k} \theta_i \Delta S_{t-i} + \psi_0 + \psi_1 t + \epsilon_t$$

where $\theta_i=0$, for all i (and $\psi_1=0$, where a trend is used).

The F statistics for the respective series are also reported in Table 2, and they show that the restrictions are rejected for all the series, except the financial rand series. Thus, lagged differences help to predict future exchange rates for three of the series, and none of these markets is efficient, even in this weak and rather uninteresting sense. The fact that the financial rand rate proves unpredictable from past differences and the trend makes it a possible candidate for efficiency.

Three points need to be made. First, the fact that ψ_0, the coefficient of the constant term is not restricted to be zero in equation (7) is irrelevant in the event that the restrictions were rejected. If it had been accepted that the $\theta_i=0$, then the significance of the constant term would have had to be examined. The implication of a significant constant term would be ambiguous for determining efficiency, since the constant could be proxying for a constant interest differential and risk premium. In the case of the financial rand, in each of the three regressions, the constant is insignificant. The apparent one month ahead lack of predictability of the rate in this thin market, which operated as a dual or second rate for capital transactions of foreign investors only, is perhaps not surprising. In fact, the financial rand premium (Figure 1) was used by investors as a barometer for foreign opinion of South African macroeconomic and political credibility. A simple model of this sort is inadequate to capture factors proxying for a time-varying risk premium.

Secondly, although the errors in equation (7) are not normal by Jarque-Bera statistics, the F tests remain valid asymptotically. Given the substantial rejection margins for the commercial rand and the parallel rate, it is unlikely that a small sample correction for non-normality would have overturned these results.

A third point concerns the potential difficulty in distinguishing non-stationarity in equation (4) in the presence of structural breaks in the data series. Recent work has shown that tests that do not account for structural breaks may erroneously find non-stationarity (e.g. Perron, 1989; Banerjee et al, 1992). Perron (1989) assumes the timing of the regime shifts to be known[21]; while the others cited above offer tests of a unit root that may also determine the timing of the structural breaks. We do not attempt to carry out these tests for South Africa because of the difficulty in identifying exogenous structural breaks, but this technique is illustrated in Section 4.2, below, on Ghana and other SSA countries.

4.1.2 The Forward Market Unbiasedness Test

For illustrative purposes only (given the degree of intervention in the market), a test of forward market bias was carried out for the period 1987:1 to 1995:5 (while the market was established in 1983, published data begins only in 1987). To avoid the aggregation problem from overlapping contracts every fourth observation was used (see Levich, 1985). An alternative would be to use generalised least squares, incorporating the moving average structure of the error term at the monthly level. The bivariate regression of levels of the three month ahead spot rate on the current forward rate (for a three month contract) achieves the theoretical result for an efficient market of a zero intercept term and a slope coefficient of unity.[22] However, this only confirms lack of systematic bias over the period as a whole. As the Durbin Watson test amply demonstrates, the residuals are highly positively autocorrelated (as is common in such studies, see Naka and Whitney, 1995), suggesting that in the short-run, lagged residuals are relevant in forecasting the spot rate. This violates efficiency, and obviously is the expected result in this highly regulated forward market, where only in recent years, covered interest parity has been used by the Reserve Bank to set rates on forward contracts. Note also, that while the two rates are found to be cointegrated by the simple bivariate cointegration test, which is a necessary condition for efficiency, the sufficient condition for efficiency additionally requires the error term to be white noise, which is clearly rejected.

4.1.3 Returns Predictability in South Africa Using Macroeconomic Variables

A more interesting and stronger hypothesis of efficiency can be tested by establishing whether there is cointegration between spot exchange rates and a range of macro-fundamentals (see the third category of

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[21] Perron (1989) computed critical values for Dickey-Fuller and Augmented Dickey-Fuller tests that include two types of structural breaks: one causing a shift in the intercept, and the other a change in the slope. A key assumption of the Perron test is that these shocks are exogenous and are not a realization of the underlying data generating mechanism. Furthermore, his test requires that the timing of the shocks be known.

[22] $\log(\text{commercial rand})_{t+3} = -.0495 + 0.952 \log(\text{forward rate})_t$

(-1.201) (23.798)

(Std. error of regression = 0.0417, Adjusted R-squared = 0.946; DW = 0.00; N = 33, after using every fourth observation for 1987:1-1995:5; ADF test of the residual = -4.177**) cointegration tests discussed in section 3). If cointegration can be demonstrated, and hence a reasonable predictability of the future spot rate via an error correction model using lagged levels and differences in economic fundamentals, this runs counter to the joint hypothesis of efficiency, where such lagged information should already be embodied in the price (conditioning on the interest rate differential).

As emphasised in Sections 2 and 3, the appropriate dependent variable for excess returns, in a market with a degree of international capital mobility, is the future change of the spot rate corrected for the current interest rate differential between domestic and foreign interest rates. Then the set of fundamentals regressors can also include the interest differential. This correction is important in principle, because if one simply regressed the differenced spot rate on lagged fundamentals, finding significance for a number of these variables as predictors may simply be because they are proxies for the interest differential (which by Uncovered Interest Parity one *expects* to be have predictive power for the future spot rate). To the extent that exchange controls are binding on domestic residents in South Africa in this period[23], the interest differential also serves as a proxy for the alternative relevant arbitrage opportunities in South Africa between foreign exchange and other assets. There is obviously some measurement error in this measure relative to an ideal measure of alternative rates of return, but clearly, as we have argued, some proxy needs to be included in order to test the unpredictability of excess returns (we return to this issue in the concluding section of this paper).

In what follows, we extend the existing literature by including a broad range of monetary and real macroeconomic fundamentals in the Fama (1991) category of "tests for returns predictability" (see section 3), and specifically employ an error correction formulation with lagged macro-variables. The test then resembles the familiar efficiency condition for excess returns in the foreign exchange market (equation (3)), but with additional variables as potential predictors of excess returns on the right hand side. Under risk neutrality and negligible transactions costs, efficiency would imply the unpredictability of excess returns. The set of macro-fundamentals considered was drawn from the theory-based estimation of a real effective exchange rate error correction model for South Africa (Aron et al, 1997). A number of these fundamentals only become available at a quarterly frequency (for instance, GDP and fiscal data), and the subset of the fundamentals used in the models is defined in Table 3.

Analysis of the individual time series properties of the quarterly exchange rate and the variables defined in Table 3 is given in Table 4. The time series structure of the variables expected to have a long-run impact are non-stationary. Given quarterly data from 1979:2 to 1995:1 (the commercial rand floated only from 1979:2 onwards), it is possible to estimate a Hendry-style single

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[23] Note that while capital flight may have flourished for individuals in South Africa, the large players, major pension and insurance funds, were effectively constrained by exchange controls over the period.

equation error correction model[24] with a multivariate cointegrating vector, of the form given in equation (5).

Given a vector F of potential fundamentals determining the exchange rate for South Africa (see Aron et al, 1997):

(8) $$F = [\ \log(TARIFF)_t,\ \log(GOVEXP)_t,\ RESERVES_t,\ \log(PGOLD)_t\ ]$$

the following general single equation error correction model was estimated for excess currency returns during the "float period" of the commercial rand (1979:2-1995:1):

(9) $$\begin{aligned}\Delta\log(S)_{t+1} - (r-r*)_t &= \alpha\,[\,b_0 + b\,F_t - (\log(S) + \log(P/P*))_t] \\ &+ \sum_{k=0}^{n} \beta_k\,\Delta F_{t-k} + \sum_{k=0}^{n} \gamma_k\,(\Delta\log(S) + \Delta\log(P/P*))_{t-k}) \\ &+ \sum_{k=0}^{n} \delta_1 (r-r*)_{t-k} + \sum_{k=0}^{n} \delta_2\, DTECHPRO_{t-k} + \delta_3\, DDUALR_t\end{aligned}$$

for n lags, where α is the error correction adjustment coefficient, b_0 is a constant and b is a vector of coefficients for the long-run cointegrating equation, β is a vector of coefficients on lagged differenced terms for macro-fundamentals, and the γ are the coefficients on lagged differenced terms for real exchange rate. In addition, two I(0) variables and a dummy are present in the equation. The interest differential is also included as a regressor since it might be one determinant of a risk premium. The variable DTECHPRO is the relative real per capita GDP growth between South Africa and her trading partners, which captures relative technical progress as well as the political shocks and consequent disinvestment and sanctions applied to South Africa from 1976 onwards (Aron et al, 1997); while DDUALR is a dummy for the public announcement in September, 1985 of the reintroduction of a dual exchange rate regime.

Note that the term for the exchange rate in the ECM, $(\log(S) + \log(P/P*))_t$, imposes the constraint that the coefficients of the relative price term and S in the ECM are equal (this restriction is necessary to avoid long-term money illusion, and is tested in the general model). The simplified term thus corresponds to a conventional definition for the real exchange rate. Note also that the real exchange rate approximates to the integral of the dependent variable and hence is the appropriate levels term in the error correction model.[25]

[24] A categorisation of single equation error correction models is given in Phillips and Loretan (1991).

[25] Clearly the approximation would be exact if the real interest rate differential between South Africa and her trading partners was constant, in which case the nominal interest rate differential would be equal to the inflation differential.

Interviews with investors and economists in the financial sector in South Africa suggests that they base their nominal exchange rate expectations on U.S. interest rates relative to domestic rates, on the state of government finances, on the size of foreign exchange reserves and other factors related to capital flows (like trade liberalisation and trade shocks), on differential real growth forecasts relative to trading partners, and, finally, on announcements about exchange rate policy. The above model contains these ingredients.

The signs of the estimated long-run coefficients for trade policy (TARIFF), government expenditure (GOVEXP), foreign reserves (RESERVES) and the real dollar gold price (PGOLD), are all expected to be positive. Tariff protection enables a higher real exchange rate to be sustained. The effect of government expenditure is theoretically ambiguous. A positive coefficient is likely to reflect expectations of high domestic interest rates, though interpretation in terms of a higher risk premium is also possible. Foreign reserves have a clear positive impact as a relatively liquid indicator of the stock of national wealth as well as a measure of the Central Bank's ability to defend the currency. The real gold price is a terms of trade effect which theory suggests should be positive, as the income effect of a higher gold price surely dominates the substitution effect, given South Africa's major role as a gold producer and the relative enclave status of the gold sector.

The expected sign of the coefficient on the interest rate differential, δ_1, is ambiguous. As has been pointed out, a coefficient of zero implies the differential is not a predictor of returns; however, the differential could also in part be proxying for components of the risk premium. The sign on the coefficient for the differential real growth relative to trading partners, δ_2, is expected to be positive. The differential growth variable, which has been purged of gold and other terms of trade changes (Table 3), partly reflects differences in underlying productivity growth which should raise the exchange rate, but also reflects political shocks and other cyclical influences. The final coefficient, δ_3, on the dual regime dummy, which captures the announcement in September, 1985 of the return, in the shadow of the debt crisis, to a dual market regime in the following quarter, is expected to be negative.

The results for parsimonious versions of the model are shown in Table 5. Two sets of two regressions are presented. Note that for the long-run terms, the coefficient presented is (αb_i), for all i . The sets of equations, 1 and 2, are parsimonious equations using different definitions of the exchange rate, and are both presented to indicate robustness of these results. Equations 1a and 2a have the dependent variable as defined above, using the bilateral $/Rand exchange rate in the first case, and the more plausible nominal effective exchange rate in the second case[26]. Given the size of the standard

[26] While, strictly, using the NEER requires a weighted average of trading partners' interest rates instead of the dollar interest rate that we otherwise use in the differential, the approximation is probably reasonable since the differential is likely to be dominated by movements in the domestic rate.

errors, and especially for the more plausible NEER regression, the data can accept the hypothesis that the interest differential as a relevant predictor of returns (δ_1) is insignificant. Equations 1b and 2b exclude this variable, and the results appear robust.

These dynamic equations in general have fair predictive power, and moreover are consistent with the theoretical priors discussed above (see also Aron et al, 1997). Chow tests establish parameter constancy for the models when the sample is divided into equal sub-samples, and also offer evidence for exogeneity. A curiosity is that the level of the real gold price is not significant over the period , which is a consequence of manipulation of the exchange rate by the authorities to stabilise the rand gold price for domestic gold producers (discussed in Aron et al, 1997). The stock of reserves thus moves closely with and proxies for the gold price. The differenced gold price performs better than differenced reserves in the dynamics of the model and was included in the parsimonious representation, although a reasonable model can be obtained by eliminating the gold price altogether (that is, using differenced reserves).

We also establish that at a quarterly frequency the spot rate is cointegrated with macroeconomic fundamentals.[27] In consequence we reach the unsurprising result that the South African commercial rand market fails to pass the joint efficiency hypothesis test in the time period considered, at least for the case of a constant risk premium. However, the market could still be efficient if the entire combination of variables on the right-hand-side of equation (8) could be attributed to a variable risk premium. Note that a rise in the risk premium at time t implies that investors require a bigger reward in expected appreciation. However, the empirical results in Table 5 imply, for example, that when the real exchange rate is high relative to long-term fundamentals, the nominal exchange rate tends to fall in the next period. But if the real exchange rate is unusually high, investors should have an unusually high risk premium, requiring expected appreciation to follow, contrary to these results. Thus, the above risk premium interpretation is unlikely to be valid, suggesting that the joint efficiency hypothesis test indeed fails.

This result was wholly expected. In the period up to 1995:1, the presence of exchange controls on foreigners, and domestic residents (including surrender requirements on export receipts), imperfect capital markets, as well as a controlled forward market for foreign exchange, obviously would leave little room for speculation in the domestic market. With further deregulation of the foreign exchange and financial markets in prospect (see Aron and Elbadawi, 1997a), reestimation of the same equation in a few years would be expected to fit far less well. Further discussion of the implications of these results for efficiency is presented in the concluding section, Section 5.

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[27] Note that the ADF test of the estimated long-run equilibrium residual includes the dummy term.

5. CONCLUSIONS

Even in developed economies, under relatively clean floating regimes, much empirical research on foreign exchange markets finds evidence that the uncovered interest parity condition (or its equivalent in the forward premium unbiasedness hypothesis) does not hold. The controversy between efficient markets proponents and their opponents centres on whether the small measured deviation from efficiency is due to the presence of a time-varying risk premium or such factors as the "peso effect" (where there is a small probability every period of a big regime change affecting the exchange rate), which will not detract from the efficient markets hypothesis; or whether investors, or a subset of investors, make systematic predictive errors (e.g. Froot and Thaler, 1990).

In the African developing country context, we obviously expect to find inefficiency in the presence of institutional imperfections such as interest rate regulation, credit rationing and exchange controls. Furthermore, these are frequently thin markets with high transactions costs (including the cost of illegal dealing on parallel markets), and subject to frequent policy and other structural breaks. Thus, in contrast to the more subtle debate associated with developed country findings of small deviations from efficiency, the finding of inefficiency in such economies is somewhat "crude", in the sense that for the least financially developed countries, it can be attributed to market structural characteristics, in addition possibly to risk premia and non-rational expectations.

The importance of this study is to establish a benchmark for the future analysis of foreign exchange market efficiency in African economies. With the progressive liberalisation of the foreign exchange markets in many of these countries, the deepening of these markets, the development or liberalisation from heavy regulation of forward markets, and the liberalisation of exchange controls, it is expected that relatively clean floats may result. The role of Central Banks will probably diminish, and with replenished foreign exchange reserves will largely be to intervene to smooth short-run shocks to the nominal rate. In the future, when floats are cleaner, it would be useful to have exchange rate expectations data, collected on a monthly basis, which could be used when explaining forward market bias to distinguish between the explanations of risk premia and systematic errors in expectations (or at least errors by a subset of investors -"noisy trading") .

In this paper, we have surveyed efficiency tests which use the cointegration methodology and have highlighted the significant data difficulties in empirical work, given credit and exchange controls and frequent structural breaks, for the use of these techniques in Africa. Using monthly parallel market and official exchange rates for South Africa, we tested for weak form efficiency by a variant of the martingale model (i.e. testing that the log exchange rate is a martingale, possibly with drift, against autoregressive alternatives). For South Africa, it was found that exchange rate returns (defined without removing the interest rate differential) were predictable by past values of the exchange rate. Thus, the market is inefficient for the period considered, in this weak and rather uninteresting sense.

Historically, South Africa has been successful at avoiding extremes of inflation - the peak post-war annual inflation rate was about 19 percent in 1986. While short-term real interest rates were negative for parts of the 1970s and early 1980s, that was also common in the 1970s in the wider industrial world. Thus, short-term interest differentials have not been such a bad proxy for the relevant foreign exchange arbitrage opportunities in South Africa and this is why the South African model can be formulated theoretically more satisfactorily as a test of *excess returns* predictability, incorporating the uncovered interest parity condition. We can strongly reject the hypothesis of no predictability of excess returns for South Africa, using error correction models for exchange rate returns and various macro-fundamentals. As noted in Section 4.1, it is implausible that a time-varying risk premium is the sole cause of this rejection (which could rescue the hypothesis of efficiency in the market). More likely to be implicated are the exchange controls, past interest rate regulation and credit rationing mentioned above. But, as we know, simple tests for uncovered interest parity or unbiasedness of the forward premium in foreign exchange markets also tend to be rejected in advanced industrial countries less subject to these market constraints. It seems plausible that were a similar methodology using error correction models and real and monetary determinants for excess currency returns to be applied to the £ sterling or the DM exchange rate, one would find a far lower degree of predictability in these countries. Such a comparison deserves further consideration.

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Table 1: Regime Changes in the South African Foreign Exchange Market

Episode	*Date*	*Exchange Rate Regime*
1	1961q1-1971q2	Pegged to fixed £
2	1971q3-1974q2	Pegged in episodes to floating $ or £
3	1974q3-1975q2	"Controlled Independent Float": devaluations every few weeks
4	1975q3-1979q1	Fixed regime: pegged to the $
5	1979q2-1982q4	Dual foreign exchange system: controlled floating commercial rand and floating financial rand
6	1983q1-1985q3	Unification to a controlled floating rand
7	1985q4-1995q1	Return to a dual system
8	1995q1-	Unification to a controlled floating rand

1. During episodes 1-4, a securities (or "switch") rand was operative for the purchase of South African securities by non-residents, but these securities were not transferable between non-residents. This rate was replaced by the financial rand in episode 5.

Table 2: Unit Root and Weak Form Efficiency Tests for Monthly South African Exchange Rates

Null Order:	*I(1)*		*I(2)*		*I(1)*	*I(2)*	
Test Statistic:	*ADF*	*k*	*ADF*	*k*	*Z(t_π)*	*Z(t_π)*	*F Test*
log (NEER)							
1979:2-1995:2	-2.474	12	-4.999**	6	-0.304	-10.222*	F(7,177): 7.327**
log (Commercial Rand)							
1979:2-1995:2	-2.551	12	-4.861**	6	-0.795	-9.900*	F(7,177): 6.132**
log (Financial Rand)							
1973:2-1995:2	-2.309	10	-4.557**	9	-1.061	-17.490*	F(7,250): 0.893
1979:2-1995:2	-2.250	10	-3.758**	9	-0.452	-15.199*	F(7,185): 0.759
1973:2-83:1/1985:9-95:2							F(7,219): 1.187
log (Pick's Parallel Rate)							
1970:1-1995:2	-2.754	12	-4.088**	11	-0.631	-20.547*	F(12,276): 4.307**

*1. For a variable X, the augmented Dickey Fuller (1981) statistic (ADF) is the t ratio on π from the regression: $\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{k} \theta_i \Delta X_{t-i} + \psi_0 + \psi_1 t + \epsilon_t$, where k is the number of lags on the dependent variable, ψ_0 is a constant term and t is a trend. The kth-order augmented Dickey-Fuller statistic is reported, where k is the last significant lag of the 13 lags employed (trend included only if significant). For null order I(2), Δx replaces x in the equation above. Asterisks * and ** denote rejection at the 5% and 1% critical values. Critical values are obtained from MacKinnon (1991).*

2. The 5% critical values for the Phillips-Perron Z test for sample size of 100 (250) is -3.18 (-2.88) (Phillips and Perron, 1988).

3. The F test for weak form efficiency assumes a unit process for the series (by the standard ADF test), and tests the following restrictions for a variable X: $\Delta X_t = \sum_{i=1}^{k} \theta_i \Delta X_{t-i} + \psi_0 + \psi_1 t + \epsilon_t$; all $\theta_i=0, \psi_1=0$, against the unrestricted equation . Residuals are non-normal in each case (Jarques-Bera statistics are not reported), but the F test remains valid asymptotically with critical values at 1% (5%) of 2.64 (2.01) and 2.18 (1.75) for $\upsilon_1=7$ and 12, respectively.

4. The financial rand series is interpolated using the parallel rate (Picks Currency Yearbook) for the unified period (see Table 1), or alternatively, this period is omitted.

5. The sample standard deviations for $\Delta log S_{t+1,}$ for the periods indicated, and for each of the exchange rates, are respectively: NEER (2.5%); Commercial rand (2.9%); Financial rand for the split period (7.1%); Pick's parallel rate (7.4%).

Table 3: Definitions of Variables in the South African Quarterly Nominal Exchange Rate Regressions

Variable	*Definition*
log (NEER)	Nominal effective exchange rate from the South African Reserve Bank: a multilateral trade-weighted index for the nominal exchange rates of four trading partners (an increase in the index denotes appreciation).
log (WH)	Bilateral exchange rate with the U.S.A. ($/R)
P/P*	The South African CPI over either the US WPI, or a weighted average of the WPI's of four trading partners, using the same weights from the NEER.
log (PGOLD)	Log (Real Dollar Gold Price)
log (TARIFF)	Log ((Customs Receipts+Surcharge)/Imports)
RESERVES	Rand Gross Reserves of the Reserve Bank/GDP
log (GOVEXP)	Log (Total Government Expenditure/GDP), using a four quarter moving average
DTECHPRO	The annual rate of change of per capita real GDP (South Africa) averaged over the previous three years, minus the equivalent for per capita real GDP (OECD countries). The variable is constructed using the residual of a parsimonious equation for real per capita GDP (SA) on lags of the dependent variable, the terms of trade and real gold price, in order to purge the effects of trade shocks.
(r-r*)	South African Treasury Bill rate (3 months) minus the London Eurodollar rate, where each has been divided by 400.
DDUALR	Dummy for the announcement of the reestablishment of a dual exchange rate regime, in September, 1995: DDUALR=1 for 1985:3, and =0, otherwise.

Table 4: Unit Root Tests for Quarterly South African Macroeconomic Fundamentals

Null Order	*I(1)*	*I(2)*
log (NEER)	-2.83	-4.20**
log (WH)	-2.54	-4.41**
log (TARIFF)	-2.72	-4.82**
RESERVES	-2.77	-5.24**
log (GOVEXP)	-2.52	-5.41**
log (PGOLD)	-2.86	-3.79**
log (WH. P/P*)	-2.03	-4.43**
log (NEER. $P/P^*_{weighted}$)	-2.00	-4.69**
Δlog(NEER) $_{+1}$ - (r-r*)	-3.72**	
Δlog(WH) $_{+1}$ - (r-r*)	-4.01**	
DTECHPRO	-4.12**	
(r-r*)	-3.75*	

1. For a variable X, the augmented Dickey Fuller (1981) statistics is the t ratio on π *from the regression:*

$$\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{k} \theta_i \Delta X_{t-i} + \psi_0 + \psi_1 t + \epsilon_t$$

, where k is the number of lags on the dependent variable, ψ_0 *is a constant term and t is a trend. The kth-order augmented Dickey-Fuller statistic is reported, where k is the last significant lag of the 6 lags employed. The trend was included only if significant. For null order I(2),* Δx *replaces x in the equation above. Asterisks * and ** denote rejection at the 5% and 1% critical values. Critical values with constant, and with and without trend, are obtained from MacKinnon (1991).*

2. The sample is 1970:1-1995:1, except for the exchange rate variables, in which case it is 1979:2-1995:1. This is because the exchange rates undergo a regime shift on floating from 1979:2 (however, similar results are found for the longer sample).

Table 5:Single Equation Error Correction Models for South African Nominal Exchange Rate Returns

Float Period: (1979:2-1995:1)		***Equation 1a***	***Equation 1b***	***Equation 2a***	***Equation 2b***
Dependent Variable:		$\Delta\log(S)_{t+1} - (r - r^*)_t$	$\Delta\log(S)_{t+1} - (r - r^*)$	$\Delta\log(S)_{t+1} - (r - r^*)_t$	$\Delta\log(S)_{t+1} - (r - r^*)$
Exchange Rate(s) used:		WH ($/R)	WH ($/R)	NEER(90=100)	NEER(90=100)
Long-run Terms:					
α	$\log(S.\ P/P^*)_t$	0.182	0.189	0.197	0.203
		(2.971)	(3.122)	(3.338)	(3.685)
αb_0	constant	0.436	0.446	1.261	1.292
		(2.592)	(2.667)	(3.975)	(4.378)
αb_1	$\log(TARIFF)_t$	0.071	0.076	0.064	0.066
		(1.983)	(2.166)	(2.302)	(2.392)
αb_2	$\log(GOVEXP)_t$	0.400	0.425	0.206	0.213
		(2.809)	(3.067)	(2.191)	(2.387)
αb_3	$RESERVES_t$	0.597	0.759	0.547	0.595
		(1.997)	(3.466)	(2.411)	(3.867)
Dynamic Terms:					
β_4	$\Delta\log(PGOLD)_{t-1}$	0.240	0.249	0.157	0.160
		(2.938)	(3.071)	(2.526)	(2.603)
δ_1	$(r - r^*)_t$	-0.728	-	-0.211	-
		(-0.803)		(-0.287)	
δ_2	$DTECHPRO_t$	1.347	1.500	1.212	1.263
		(2.335)	(2.765)	(2.670)	(3.048)
δ_3	$DDUALR_t$	-0.134	-0.138	-0.185	-0.187
		(-2.310)	(-2.405)	(-4.171)	(-4.304)
γ_1	$\Delta\log(S)_{t-1}$	-0.203	-0.184	0.142	-0.134
		(-1.658)	(-1.535)	(-1.342)	(-1.324)
γ_2	$\Delta\log(S)_{t-2}$	0.298	0.314	0.389	0.393
		(2.657)	(2.857)	(4.009)	(4.125)
Diagnostics:	(t statistics in parenthesis)				
Std. error of regression		0.051	0.050	0.040	0.039
R-squared		0.534	0.528	0.661	0.660
Adjusted R-squared		0.446	0.449	0.596	0.603
Durbin-Watson statistic		1.674	1.639	1.892	1.880
Chow statistic		0.636	0.522	1.038	1.123
Jarque-Bera test		3.740	5.212	0.484	0.445
Breusch/Godfrey LM:AR/MA4		1.602	1.859	0.747	0.735
ADF test of regression resid.		-4.483**	-4.373**	-4.055**	-4.033**
ADF test of equilibrium resid.		-3.424	-3.572*	-3.658**	-3.646**

1. Coefficients correspond to equations (5) and (8) in the text, and all variables are defined in Table 3. Under risk neutrality and negligible transactions costs, foreign exchange market efficiency would imply unpredictability of $\Delta\log(S)_{t+1} - (r - r^*)_t$

2. Preferred equations (2a,b) use the trade-weighted effective exchange rate, rather than a bilateral exchange rate, and accordingly P is the weighted price of trading partners' WPI's (see Table 3).*

3. Note that the term for the nominal exchange rate in the ECM, $\log(S\ .\ P/P^*)_t$, imposes the constraint (accepted by the data) that the coefficients of the relative price term and S in the ECM are equal. The simplified term thus corresponds to a conventional definition for the real exchange rate.

4. Tests of the estimated equilibrium residual incorporate the dummy term.