Capital controls and the volatility of South African exchange rates

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This paper considers whether the imposition of capital controls in South Africa affected the stochastic behaviour of foreign exchange rates, and provided insulation to the commercial exchange rate of the rand. The conditional variances of various South African exchange rates are estimated using autoregressive conditional heteroschedastic (ARCH)-type models, and used to test for shifts in the volatility processes of these exchange rates. The common features methodology of Engle and Kozicki (1993) is employed to test for a common volatility process in the dual exchange rates, and the presence of volatility spillovers between the exchange rates is also investigated. The results of these tests suggest that the conditional volatility of South African exchange rates was lower during the financial rand period than in the contiguous periods when the exchange rate was unified, and that volatility in the financial rand did not impact on the commercial rand exchange rate. No evidence was found of a common volatility process in the dual foreign exchange rates, and although tests revealed volatility spillovers from the commercial rand exchange rate to the financial rand, volatility was not found to "spill over" in the opposite direction.

> "In a dual-rate system the commercial rate remains stable, whereas the free rate reflects the instability of portfolio holders' expectations, and hence of capital flows."
>
> Dornbusch and Kuenzler (1993:120)

1. Introduction

This paper considers whether the imposition of capital controls in South Africa affected the stochastic behaviour of foreign exchange rates, and provided insulation to the commercial exchange rate of the rand.[2] It models the volatility dynamics of South African exchange rates using the autoregressive conditional heteroschedastic (ARCH) models first introduced by Engle (1982), and examines whether the financial rand system of capital controls, imposed on non-resident portfolio capital outflows in the 1985-95 period, affected the volatility of the commercial rand exchange rate.

Theoretical analysis of controls suggests that they should reduce the volatility of exchange rates.[3] In particular, as the introductory quotation from Dornbusch and Kuenzler claims, a dual exchange rate system (DRS) is expected to insulate the market for current-account transactions from volatile capital account transactions. This is achieved by separating the two sets of transactions, and channelling the current-account transactions through the "commercial" foreign exchange market while the capital account transactions are restricted to the "financial" foreign exchange market. In the financial rand DRS imposed in South Africa in 1985, the primary aim was to separate the foreign exchange transactions of non-resident portfolio investors on the capital account from all other foreign exchange transactions.

Two main issues relating to the effectiveness of these controls in achieving this objective are considered in this paper. Firstly, if the financial rand system was successful in separating the two sets of transactions in the scenario mapped out above, then the volatility of the commercial rand exchange rate when the controls were in place should be lower than in the contiguous periods when the exchange rate was unified. Secondly, an implication of successful separation is that shocks specific to the financial rand market should not be evident in the commercial rand exchange rate. This suggests that in general the dual exchange rates should not exhibit a common volatility process, and that volatility in the financial rand market should not spill over into the commercial rand market.

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[1] Comments by Peter Sinclair, John Fender and Mark Taylor on my PhD thesis, where some of this research was originally reported, are gratefully acknowledged. This paper also benefited from comments received from an anonymous referee at the SARB. Remaining errors are, of course, my own.

[2] The effects of exchange rate policies in this regard have received some attention in the literature. Artis and Taylor (1988) and Pesaran and Robinson (1993), for example, investigate the impact of the European Exchange Rate Mechanism (ERM) on exchange rate volatility. Diebold and Pauly (1988), Hughes Hallett and Anthony (1997), and Hu, Jiang and Tsoukalas (1997) examine the impact of European monetary system membership on nominal exchange rate volatility, and Phylaktis and Kassimatis (1997) consider whether exchange controls in four Pacific Basin countries (Korea, Taiwan, Malaysia and Singapore) affected exchange rate volatility.

[3] This is important since exchange rate volatility is likely to impact negatively on an economy. Intuitively, volatility creates uncertainty regarding import and export prices, the valuation of foreign exchange reserves, and the repayment of debt and other open positions denominated in foreign currencies. Risk-averse agents respond by directing their resources toward less risky activities, causing trade volumes to contract, and investment levels to be depressed. The indirect impact on a country's subsequent economic growth may even exceed that of these initial effects, possibly as a result of hysteresis type effects. It is worth noting, however, that the significance of the problem posed by exchange rate volatility is not firmly established (Rogoff, 1998). The empirical evidence regarding the effects of exchange rate volatility on the volume of international trade, for example, is mixed (Côté, 1994 and Medhora, 1999). Also, in the Newbery and Stiglitz (1981) mean-variance analysis framework, an increase in the variance of prices (due to foreign exchange risk) has an ambiguous effect on trade. Though greater profit opportunities will attract individuals, the increase in risk will deter risk-averse individuals. In the case of investment, theoretical analysis by Darby et al (1999) suggests that there are situations where exchange rate volatility depresses the level of investment, and situations where it does not. Finally, it is possible that it is not (short-term) volatility which should be the major concern, but rather exchange rate misalignment (Williamson, 1985).

Empirically, as noted earlier, these issues are investigated in this study by modelling the volatility dynamics of various South African rand exchange rates using the family of ARCH models.[4] These models estimate the conditional variance as a proxy for exchange rate volatility, and provide a particularly appropriate means of capturing the volatility dynamics of exchange rates. They facilitate the tests undertaken here, for shifts in volatility processes and for volatility spillovers between exchange rates.

The paper is arranged as follows. Section 2 briefly describes the structure of the controls. The ARCH-type models used for modelling exchange rate volatility are set out in Section 3, and the data used in the study are introduced in Section 4. The remaining sections deal empirically with the issues raised earlier regarding the effectiveness of the controls. Section 5 describes the tests conducted for shifts in volatility in nominal and real commercial rand exchange rate series between periods when the financial rand and unified rand regimes were in place. In Section 6 the common features methodology introduced by Engle and Kozicki (1993) is employed to test for a common volatility process in the dual rates, and Section 7 investigates the presence of volatility spillovers between the commercial and financial rand exchange rates. Section 8 contains concluding comments.

2. Description of the controls

On 1 September 1985 the South African authorities declared a standstill on repayments of a large portion of the country's foreign debt commitments and reintroduced exchange controls over non-residents. These controls effectively recreated the financial rand DRS, which had been abolished thirty months earlier. Together with the controls that existed on resident capital account transactions, the debt standstill and the financial rand system constituted a comprehensive system of controls on the country's capital account. The intention is to describe briefly in this section the institutional design of the financial rand system in order to provide a benchmark against which its effectiveness can be assessed.

The financial rand system was an asymmetrically applied, partial DRS, which evolved from the application of exchange controls to non-residents in 1961.[5] It was a variant of the standard model of a DRS encountered in the literature.[6] Whereas the standard model is characterised by separate markets for all (resident and non-resident) current-account and capital account transactions, with a fixed exchange rate in the market for current-account transactions and a floating rate for capital account transactions, the financial rand system featured a two-tier float. It was partial in the sense that it incorporated only a subset of capital account transactions in the financial rand foreign exchange market, and it was asymmetrically applied in that free access to this market was generally restricted to non-residents (resident access was allowed only in approved cases).

As with any DRS, the key to the functioning of the financial rand system was the separation of the constituent foreign exchange markets. Although it has long been recognised that the complete separation of these foreign exchange markets is unlikely to be feasible in practice[7] because of the incentive to engage in illegal arbitrage between the markets, a complete inability to separate the markets implies *de facto* reunification. To the extent that a significant spread between the exchange rates is maintained, as was the case in South Africa, the controls are binding in a crude sense.[8] As noted earlier, a more stringent examination of the separation of the markets is pursued in this study by focusing on the volatility dynamics of the dual exchange rates.

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[4] *In the literature dealing with the impact of exchange rate volatility on trade flows, several measures of volatility have been used, including standard deviations, deviations from trend, the Gini mean difference coefficient and the scale measure of variability. Medhora (1999) provides a discussion of these measures.*

[5] *The institutional features of the system in the 1985-95 period were largely the result of historical influences. These included links with the British financial system, political and economic events resulting in shocks to the South African economy, and the recommendations of the De Kock Commission. For more detailed discussions, see Gidlow (1986, 1991), Garner (1994) and Farrell (2000).*

[6] *The classic analyses of Fleming (1971, 1974), Barattieri and Ragazzi (1971) and Lanyi (1975) were seminal in the literature on the functioning of dual exchange rate systems.*

[7] *Fleming (1974: 5) notes that this is not "administratively practicable". Lanyi (1975: 718 – 723) provided an early theoretical analysis of the links existing between the markets, and of the consequences of incomplete market separation. The incomplete separation of the exchange markets has been examined more rigorously in the recent literature by, inter alios, Bhandari and Decaluwe (1987), Gros (1988), Guidotti (1988) and Bhandari and Vegh (1990).*

[8] *This obviously does not imply that no illegal arbitrage took place, only that it was not of sufficient magnitude to arbitrage away the spread.*

A further characteristic of the financial rand system which is relevant to a discussion of its functioning is the “closed pool” nature of the arrangement, where only transactions associated with specific assets were channelled through the financial market. Purchasers of these assets were therefore required to obtain the necessary currency from sellers of the same assets, with the financial exchange rate adjusting to clear the market.[9] To the extent that this “closed pool” arrangement was maintained, it follows that non-residents as a group could not disinvest from the country (the system simply allowed alterations in the composition of the stock of assets held by non-residents). Non-resident disinvestment from the country via this mechanism therefore had no impact on the country’s balance of payments; by the same token, however, there could be no net investment via the financial rand either.

3 Modelling exchange rate volatility using ARCH-type models

The volatility dynamics of exchange rates have recently been modelled in the literature using the family of ARCH models first introduced by Engle (1982).[10] Among this family of models, the generalised ARCH (or GARCH) model proposed by Bollerslev (1986) and the exponential GARCH or EGARCH specification of Nelson (1991) have proved particularly useful for this purpose.

There are several reasons for adopting the ARCH-type approach to modelling volatility. The primary motivation, however, appears to be the attractive approximation-theoretic properties of the models (Diebold and Lopez, 1995:8); they are able, at least partially, to describe the volatility clustering and leptokurtosis that are characteristic of high-frequency financial data (see Table A1, Appendix 1 for evidence of this in the data used in this study). ARCH models attempt to model the nature of this time-varying volatility directly, compared with the commonly employed “moving sample” measures of volatility which discard information. In addition, ARCH models focus on the conditional rather than the unconditional second moment of the process. This is appropriate, since from an economic perspective, any uncertainty that can be eliminated by conditioning on past values or additional variables is irrelevant (Diebold, 1988:36).

The most commonly used ARCH model in the literature is the GARCH (1,1) model. This model provides an important benchmark, since it has been estimated across a wide range of asset classes and sampling frequencies. Although it does not always provide the optimal specification of the return-generating process, Nelson (1992) and Nelson and Foster (1994) suggest that the GARCH model is robust to various types of misspecification; it is often able to estimate the unobserved volatility process consistently despite being misspecified.

The specification for the basic GARCH(1,1) model employed in this paper is as follows:

$$R_t = c + \theta v_{t-1} + v_t \qquad (1)$$

$$v_t \mid \Omega_{t-1} \sim N(0, h_t^2) \qquad (2)$$

$$h_t^2 = \alpha_0 + \alpha_1 v_{t-1}^2 + \beta_1 h_{t-1}^2 \qquad (3)$$

$$\alpha_0 > 0;\ \alpha_1 \geq 0;\ \beta_1 \geq 0;\ \alpha_1 + \beta_1 < 1 \qquad (4)$$

where the R_t are (100*) the log first differences of the exchange rate data (as presented in Section 4). Since the preliminary analysis presented in Appendix 1 reveals

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[9] *Examples of such arrangements have often involved residents’ trade in foreign securities; the UK investment currency market which operated between 1947 and 1979 was of this type, as was the French “devise titre” which operated both before and after a full DRS (from 11 August 1969 to 20 October 1971, and again from 21 May 1981 to 22 May 1986). Besides the South African system, the Netherlands’ “O-guilder” market for Dutch bonds serves as an example of a non-resident closed pool arrangement (this operated between 6 September 1971 and 1 February 1974). Interestingly, the UK also had a non-resident system which ran alongside its investment currency for residents until April 1967.*

[10] *This area of research has been something of a growth industry; Bollerslev, Chou and Kroner (1992), Bera and Higgins (1993), and Bollerslev, Engle and Nelson (1994) provide surveys. Diebold (1988) provides a detailed discussion of this approach to modelling exchange rate volatility.*

some evidence of serial correlation, an MA(1) model is initially estimated for the conditional mean equation (1) to capture this. The conditional distribution of the error term v_t provided in equation (2) is assumed to be normal in this specification, although fatter-tailed distributions will be discussed later. The conditional variance h_t^2 is a linear combination of its own lagged value and that of the squared residuals from the mean equation.[11] The restrictions set out in (4) are imposed on the parameters in equations (1)-(3) to ensure positive values for the conditional variance and the existence of the unconditional variance.[12, 13]

An alternative form of the conditional variance which is commonly used is that provided by Nelson's (1991) EGARCH model. This model is specified here as follows:

$$R_t = c + \theta v_{t-1} + v_t \tag{5}$$

$$v_t = h_t \varepsilon_t \tag{6}$$

$$\varepsilon_t \mid \Omega_{t-1} \sim N(0, 1) \tag{7}$$

$$\ln(h_t^2) = \alpha_0 + \alpha_1 g(\varepsilon_{t-1}) + \beta_1 \ln(h^2_{t-1}) \tag{8}$$

$$g(\varepsilon_t) = \pi\varepsilon_t + \gamma(|\varepsilon_t| - E[|\varepsilon_t|]) \tag{9}$$

Intuitively, the conditional variance specification in (8) and (9) implies that a deviation of ε_t from its expected value causes the conditional variance to be larger than otherwise in the following period (a magnitude effect in the spirit of GARCH models that enters α_1 through the γ coefficient).[14] Furthermore, if $\pi \neq \theta$ then the impact of positive surprises ($\varepsilon_t > 0$) and negative surprises ($\varepsilon_t < 0$) on the conditional variance will be asymmetric. If $-1<\pi<0$, it is clear that a positive surprise would increase the conditional variance (8) by less than a negative surprise would. When $\pi<-1$, a positive surprise will in fact decrease volatility. Obviously, when $\pi=0$ the asymmetry disappears.

A distinguishing characteristic of the EGARCH model is the log specification of (8). This ensures that the conditional variance is positive, regardless of the sign of the other coefficients. An important advantage of this over the GARCH model is therefore that no restrictions need to be imposed on (8) for the purposes of estimation, which in turn makes optimisation simpler. The parameters of the GARCH and EGARCH models are generally estimated using maximum likelihood estimation (MLE) techniques; the Berndt, Hall, Hall and Hausman (BHHH) (1974) algorithm, used here, is commonly employed.

In the discussion so far, the assumption has been made that the conditional distribution is normal. This is consistent with the approach adopted in a large body of work on modelling exchange rate returns, but is not always appropriate. It has been shown, for example, that although ARCH-type models are able to capture some of the observed leptokurtosis in the returns, they seldom capture all of it (Hsieh, 1989; Baillie and Bollerslev, 1990; Teräsvirta, 1996).

In cases where the normality assumption is inappropriate, two main approaches may be pursued. First, Bollerslev and Wooldridge (1992) show that the quasi-maximum likelihood estimates obtained under the normality assumption are asymptotically normal and consistent if the conditional mean and variance equations are correctly specified, but that the usual standard errors need to be modified. They derive robust standard errors that minimise the problem of conditional non-normality.

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[11] *It is evident from (3) that the ARCH(1) model is a special case of the GARCH(1,1) model with* $\beta_1 = 0$.

[12] *The unconditional variance of the GARCH model is given by* $E[(R_t - E[R_t])^2] = \alpha_0/[1-\alpha 1-\beta 1]$. *In the case of higher order GARCH models, Nelson and Cao (1992) show that the non-negativity constraints are sufficient rather than necessary conditions for the conditional variance to be positive.*

[13] *Note that in the special case where* $\alpha_1 + \beta_1 = 1$, *the integrated GARCH or IGARCH model results (Engle and Bollerslev, 1986). Here the variance of the process is nonstationary, and the conditional prediction error variance does not converge as the forecast horizon increases.*

[14] *Note that in the standard normal case,* $E|\varepsilon_t| = \sqrt{(2/\pi)} \approx 0{,}798$.

Alternatively, many studies replace the normal distribution with a non-normal conditional distribution; Bollerslev (1987), for example, proposes a conditional Student-*t* GARCH model with the degrees of freedom of the distribution being treated as another parameter to be estimated. Following Bollerslev's proposal, a GARCH(1,1)-*t* model is estimated here which differs from the GARCH(1,1) model set out earlier in that the conditional variance equation (2) is specified as $v_t \mid \Omega_{t-1} \sim t(0, h^2_t, j)$, where *j* represents the degrees of freedom (which are estimated as a parameter). The standard Student-*t* density for $j > 2$ is more peaked and has fatter tails than the standard normal. In this case, the likelihood of the model is given by:

$$\text{Log } L = \sum_{t=l}^{n} \left(\log \Gamma\left(\frac{j+l}{2}\right) - \log \Gamma\left(\frac{j}{2}\right) - \frac{l}{2} \log(j-2)\, h^2_t - \frac{l}{2}(j+l) \log \left[1 + v^2_t\, (h^2_t)^{-1} (j-2)^{-1}\right]\right)$$

where Γ(.) is the usual gamma function.

4 The data

The selection of the exchange rates to be used in the study requires comment, since the choices made in this regard determine the type of uncertainty captured by the volatility measure.

The first issue here concerns the use of bilateral and/or effective exchange rates. If the volatility of bilateral exchange rates is used, then the focus is on the uncertainty faced by a group of participants in the market (those with transactions denominated in this currency), as opposed to that faced by all participants where the effective rate is used. In this study, both bilateral and effective exchange rates are used.

The second issue concerns the choice between nominal and real exchange rates. Since the time horizon for a study of the impact of exchange rate volatility is relatively short, this issue may not be that important. A standard assumption of macroeconomic models (for example, Dornbusch, 1976) is that goods prices adjust more slowly than asset prices (the exchange rate here); at least in the short term, therefore, a change in the nominal exchange rate would change the real exchange rate. Under floating exchange rates, a reduction in nominal exchange rate volatility is equivalent to a reduction in real exchange rate volatility. In this study, to the extent that data are available, both nominal and real exchange rates are nevertheless used.

The daily exchange rate data used here are mid-rates[15] for the financial rand against the US dollar and for the commercial rand against the US dollar, the British pound, the German mark, and the Japanese yen (the respective log differences, multiplied by 100, are denoted CDLFINUS, CDLZARUS, CDLZARGBP, CDLZARDM and CDLZARYEN here). In order to focus on behaviour in the financial rand period relative to the contiguous periods when the exchange rates were unified, the following sub-periods were identified: 7 February 1983 to 28 August 1985 (first unified period), 2 September 1985 to 10 March 1995 (financial rand period), and 13 March 1995 to 20 October 1998 (second unified period). Appendix 1 contains a preliminary analysis of the daily data in these periods, which finds evidence of the empirical regularities that support the use of ARCH-type models.

A significant proportion of South Africa's trade is denominated in the four commercial rand currencies selected here. The Reserve Bank's effective exchange rates, the real (REER, 1995=100 available at the monthly frequency[16]) and the underlying nominal effective exchange rate (NEER, with the log difference multiplied by 100 denoted

15 In fact, these are the weighted average mid-rates of the 10:30 fixes of the rates quoted by the four major commercial banks.

16 The weights were based on the value of South Africa's total trade in goods and services, adjusted for the currency denomination of major export and import commodities (Walters and de Beer, 1999). Producer or wholesale price indices were used to calculate the real effective exchange rate index.

CDLNEER), were in fact composed of these four currencies prior to 1999.[17] The weights used in calculating these rates were: US dollar 51,74 per cent, British pound 20,15 per cent, German mark 17,21 per cent and Japanese yen 10,9 per cent. Note that a depreciation of the rand is indicated by an increase in the exchange rate, except in the case of the REER and NEER where the opposite holds.

Data at the weekly frequency were obtained from the daily data above, sampled on a Wednesday to avoid the weekend effect, and because few holidays fall on this day. Note that the prefix 'L' denotes the natural logarithm of the variable in what follows. This log specification is used throughout, consistent with other studies which employ financial and exchange rate data. The technical advantages here include avoiding the prediction problems associated with Jensen's inequality[18] (Meese and Rogoff, 1983), and the fact that the log first differences approximate percentage changes (particularly when these are small).

5. The financial rand system and shifts in the volatility of rand exchange rates

This section investigates the effect of the financial rand system of controls on the volatility of commercial rand exchange rates. A number of such tests have been undertaken in the literature. Artis and Taylor (1988), for example, tested for shifts in the volatility of the conditional variances of European exchange rate mechanism (ERM) currencies (as well as applying non-parametric tests for volatility shifts in the unconditional variances). They found that the ERM resulted in a reduction in both the conditional and unconditional variances of the ERM currencies against the German mark. Pesaran and Robinson (1993) also used an ARCH approach to examine the impact of the ERM on the volatility of the Sterling-German mark exchange rate. They found that Britain's entry into the ERM changed the distribution of this exchange rate (the strong ARCH effects found in the pre-ERM period are not present in the ERM period). More generally, Caporale and Pittis (1995) considered how alternative nominal exchange rate regimes affect the volatility of a range of macroeconomic variables in eighteen OECD countries (including real exchange rates). They found that the mean and standard deviation of the conditional variances of the real exchange rates were invariably higher under the floating exchange rates that characterised the post-Bretton Woods period.

In Section 5.1, the first and second moments of the daily conditional variance proxies for volatility are compared in the financial rand and contiguous unified periods to determine whether or not a shift in the volatility of bilateral nominal exchange rates is evident. A slightly different test is conducted on the REER in Section 5.2, reflecting the availability of data at the monthly frequency only.

5.1 Tests for volatility shifts in nominal exchange rates

Initially, the conditional variance proxies for exchange rate volatility in each of the three time periods identified above were obtained from the ARCH-type models set out in Section 3, using MLE techniques.[19] When more than one competing model was estimated, an optimal model was selected using the Schwarz information criterion (Schwarz, 1978). The results obtained for the CDLZARUS, CDLZARGBP, CDLZARDM, CDLZARYEN, CDLNEER and CDLFINUS exchange rate returns described in Section 4 are presented in Appendix 2 in Tables A2.1 – 2.6, respectively. Tables A2.1 and A2.6 confirm that the mean conditional variance of the financial rand exchange rate was higher than that of the commercial rand rate when the controls were in place (2,664 as opposed to 0,724).

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[17] The SARB has recently introduced a new basket consisting of the currencies of 14 countries (including the euro area member states as a single country) (Walters and de Beer, 1999).

[18] Jensen's inequality implies that $E(1/S) \neq 1/E(S)$, although $E(\ln(1/S)) = -E\ln(S)$ (where S is the foreign currency to home currency exchange rate, and ln denotes the natural logarithm).

[19] All ARCH-type models in this paper are estimated using the EViews 3.1 software package.

The conditional variance proxies for exchange rate volatility were then compared for the various periods. In particular, the mean and standard deviation of the conditional variance were used to test the null hypothesis of no difference in volatility between two periods (Caporale and Pittis, 1995). Mean and variance ratio tests, with a null hypothesis of no difference between the first unified and financial rand periods, and the financial rand and second unified periods, are presented in Tables 5.1 and 5.2, respectively.

As is evident in Table 5.1, the mean and variance of the volatility of the various exchange rates are both significantly lower in the financial rand period than in the preceding unified period. The mean and variance ratio tests reject, at the 1 per cent level, the null hypothesis of no difference in the conditional variance of each of the bilateral commercial rand exchange rates, and of the nominal effective exchange rate.

Table 5.1 Changes in the mean and variance of the conditional variance: first unified period – financial rand period

	Sample period		Sign of change	Mean ratio test	Variance ratio test
	1st unified	Finrand			
Rand/US$					
mean	2,287	0,723	-	3,163**	-
standard deviation	3,322	2,805	-	-	1,403**
Rand/British £					
mean	1,778	0,786	-	2,262**	-
standard deviation	2,757	1,656	-	-	2,772**
Rand/German mark					
mean	1,810	0,602	-	3,007**	-
standard deviation	2,971	1,311	-	-	5,136**
Rand/Japanese ¥					
mean	2,453	0,734	-	3,342**	-
standard deviation	3,069	1,342	-	-	5,230**
NEER					
mean	2,352	0,605	-	3,888**	-
standard deviation	4,923	2,866	-	-	2,951**

Note: The mean and variance ratio tests are of the form x_1/x_2 where x_1 is the larger of the two periods. The variance ratio is the ratio of the squared standard deviations. The null hypothesis is that there is no difference between the means (variances) of the two periods, and the statistic is distributed as F(n_1,n_2) where n_1 and n_2 are the numbers of observations in the two periods. With n_1= 645 and n_2 =2394, the 5 per cent critical value is 1,107 and the 1 per cent critical value is 1,154.

The results are not as clear in Table 5.2. On average, as the tests on the NEER show, the mean level of volatility of the commercial rand exchange rate increased after the abolition of the financial rand system, although the variance of the volatility process decreased. The mean volatility of the individual bilateral exchange rates increased in three of the four cases (not significantly in the case of the British pound rate), though that for the US dollar exchange rate decreased significantly. The variances of the volatility processes were significantly lower in the second unified period in all cases.

Table 5.2 Changes in the mean and variance of the conditional variance: financial rand period – second unified period

	Sample period		Sign of change	Mean ratio test	Variance ratio test
	Finrand	2nd unified			
Rand/US$					
mean	0,723	0,531	-	1,362**	-
standard deviation	2,805	1,320	-	-	4,516**
Rand/British £					
mean	0,786	0,800	+	1,018	-
standard deviation	1,656	1,495	-	-	1,227**
Rand/German mark					
mean	0,602	0,823	+	1,367**	-
standard deviation	1,311	1,103	-	-	1,413**
Rand/Japanese ¥					
mean	0,734	1,092	+	1,488**	-
standard deviation	1,342	1,244	-	-	1,164**
NEER					
mean	0,605	0,696	+	1,150**	-
standard deviation	2,866	1,879	-	-	2,326**

Note: The mean and variance ratio tests are of the form x_1/x_2 where x_1 is the larger of the two periods. The variance ratio is the ratio of the squared standard deviations. The null hypothesis is that there is no difference between the means (variances) of the two periods, and the statistic is distributed as $F(n_1,n_2)$ where n_1 and n_2 are the numbers of observations in the two periods. With $n_1 = 2394$ and $n_2 = 900$, the 5 per cent critical value is 1,096 and the 1 per cent critical value is 1,139.

These results provide some evidence that nominal exchange rate volatility in South African commercial rand exchange rates was lower during the 1985-95 period when the financial rand system was in place than during periods when the rand was unified. Both the mean and variance of the volatility proxy for the bilateral and effective nominal exchange rates fell relative to the preceding unified period, and the mean (although not the variance) of the proxy increased once the system was abolished.

5.2 The financial rand system and shifts in the volatility of the real effective exchange rate

At this point, it is interesting to extend the investigation of volatility shifts to include the real effective exchange rate, and to consider whether or not the financial rand system had a significant effect on the volatility of this important macroeconomic indicator. This issue is related to a wider literature, dating back to Mussa (1986), which considers the relationship between nominal exchange rate regimes and real macroeconomic variables. A number of studies in this literature find that REERs exhibit greater volatility under flexible exchange rate regimes than under fixed,[20] consistent with the assumption of "sticky" goods prices made in many models. To the extent that this assumption holds, it is expected that the finding of reduced nominal exchange rate volatility during the financial rand period will be replicated here for the REER.

Since data on home and foreign price levels are only available at lower sampling frequencies, monthly data for the REER are used here for the period from February 1983 to March 1998. The fact that there are fewer observations to work with requires a slightly different methodology to test for volatility shifts. The MA(1)-GARCH(1,1) and MA(1)-EGARCH models for the REER are estimated over the full sample, with a dummy variable (DUMFINR) added to the conditional variance

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[20] *Note that this finding does not carry over to other macroeconomic variables (Caporale and Pittis, 1995; Flood and Rose, 1999).*

equation to account for the financial rand period. In the GARCH(1,1) model set out earlier, therefore, equation (3) becomes

$$h_t^2 = \alpha_0 + \delta_1 *DUMFINR + \alpha_1 v^2_{t-1} + \beta_1 h^2_{t-1} \qquad (3')$$

and in the EGARCH(1,1) model, equation (8) becomes

$$\ln(h_t^2) = \alpha_0 + \delta_1 *DUMFINR + \alpha_1 g(\varepsilon_{t-1}) + \beta_1 (h^2_{t-1}) \qquad (8')$$

In both cases, DUMFINR takes the value 1 for observations between September 1985 and March 1995, and zero otherwise. If $\delta_1 = 0$, therefore, the intercept of the conditional variance equation, indicative of the level of the volatility process, does not depend on whether or not the financial rand system was in place. If it is significant and positive (negative), then the conditional variance was higher (lower) in the presence of the financial rand system.

The estimation results for the two models, presented in Table 5.3, allow some general conclusions to be drawn regarding the volatility dynamics of the REER, as well as testing for volatility shifts. In both models, strong GARCH effects are evident, and in the EGARCH(1,1) model the $\alpha_1\pi$ coefficient rejects at the 1 per cent level the null hypothesis that positive and negative surprises have a symmetric effect on the conditional variance. The coefficient suggests that a positive surprise will increase the conditional variance by less than a negative surprise will. The $\alpha_1\pi$ coefficient is also significant at the 1 per cent level, implying that shocks in one period increase volatility in the next.

Table 5.3 MLE parameter estimates: Real effective exchange rate

Sample period	February 1983 – March 1998	
Model	GARCH*	EGARCH
Conditional distribution	N	N
c	0,030	-0,201
	(0,161)	(0,186)
θ	0,239*	0,631**
	(0,100)	(0,035)
α_0	1,640*	0,564*
	(0,650)	(0,236)
α_1	0,091	
	(0,054)	
β_1	0,840**	0,548**
	(0,049)	(0,074)
δ_1	-1,537*	-0,707**
	(0,647)	(0,217)
$\alpha_1 \pi$		-0,850**
		(0,126)
$\alpha_1 \gamma$		0,826**
		(0,113)
$\alpha_1+\beta_1$	0,931	
Diagnostics		
Log L	-430,36	-437,41
Akaike	4,593	4,678
Schwarz	4,696	4,798
Conditional variance (h_t^2)		
mean	10,432	36,532
Standard deviation	11,698	185,168

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*)

More to the point, however, the results in Table 5.3 suggest that the volatility of the REER was lower during the 1985-95 period when the financial rand system was in place than in the periods when the exchange rate was unified. The coefficient on the dummy DUMFINR, δ_1, is significantly negative in both models (at the 5 per cent level in the GARCH model, and at the 1 per cent level in the EGARCH model).[21]

6. Common volatility in the financial rand system

The "commonality of volatility changes", observed across domestic and international markets, is often remarked upon.[22] The intention in this section is to investigate, using a methodology developed by Engle and Kozicki (1993), whether the commercial and financial rand exchange rates shared the same volatility process. The presence, or absence, of a common volatility process is of interest since it provides further insight into the extent to which the financial rand system separated its constituent foreign exchange markets and insulated the commercial rand exchange rate from events in the financial rand market.

The Engle and Kozicki (1993) methodology tests whether a feature that is present in each of several variables is common to them. In general, features (such as serial correlation, trends, seasonality, heteroscedasticity, ARCH or excess kurtosis) are detected in individual series using standard tests. Once the presence of a feature in individual series has been established, "common features" are detected by tests which look for linear combinations of the series which do not have the feature.[23, 24]

A more formal definition of a feature, and a discussion of ARCH as a feature, is provided in Section 6.1. The Engle-Kozicki common features test is set out in Section 6.2, and the results of the tests on the South African dual exchange rates are presented in Section 6.3.

6.1 ARCH as a common feature

Formally, a "feature" can be defined as follows (Engle and Kozicki, 1993:370; Alexander, 1994:2):

F is a "feature" if for all series x_1, x_2

1. x_1 has F implies $a+bx_1$ has F
2. x_1 does not have F and x_2 does not have F implies x_1+x_2 does not have F
3. x_1 has F and x_2 does not have F implies x_1+x_2 has F

If x_1 and x_2 both have F, however, this does not necessarily imply that x_1+x_2 has F. A feature is a common feature of series x_i only if each has F and a_i exists such that $y = \sum a_i x_i$ does not have F.

To illustrate the common feature result for ARCH processes (Alexander, 1995; Engle and Susmel, 1993), consider two stationary time series which individually have ARCH effects, namely

$$x_t = v_t + e_{xt} \quad \text{and} \quad y_t = w_t + e_{yt}$$

where:
- $v_t \mid I_t \sim D(0, h_t^2)$
- $w_t \mid I_t \sim D(0, k_t^2)$

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[21] *It is interesting to note that the sum of the α_1 and β_1 coefficients falls sharply when the DUMFINR dummy variable is included in the conditional variance equation of the GARCH model. This is consistent with Diebold's (1986:55) suggestion that regime shifts may contribute to a finding of integrated GARCH or IGARCH (where $\alpha_1 + \beta_1 = 1$ in the GARCH model).*

[22] *Bollerslev et al (1994), for example, make this point.*

[23] *It is interesting to note that cointegration analysis is a special case of the common features approach, where the common feature is a stochastic trend.*

[24] *Tests for common volatility focusing on ARCH as a feature have been applied to international equity markets (Engle and Susmel, 1993; Alexander, 1994; Arshanapalli et al, 1997), and also to foreign exchange markets (Alexander, 1995; Funke and Hall, 1995).*

- I_t is the information available at time t
- e_x and e_y are mutually independent homoscedastic error terms

Since h_t^2 and k_t^2 are time varying, it follows that x_t and y_t are time varying. The question that Engle and Kozicki (1993) ask, then, is whether a linear combination of x_t and y_t exists which does not exhibit time-varying volatility. To see why this is important, consider the portfolio $x_t + \rho y_t$. The variance of this portfolio is

$$v_t\,(x_t + \rho y_t) = h_t^2 + \rho^2 k_t^2 + 2\rho\, cov_t(v_t, w_t) + constant$$

In general, this will be time varying. If, and only if,

$$v_t = -\rho w_t + constant$$

the variance of the portfolio will be independent of time.[25] A linear combination of the series which displays no ARCH therefore exists if and only if the series share a common ARCH effect.

Finally, note that the sign of the scale factor ρ determines the relationship between the means. If, in order to minimise the volatility of a portfolio, a negative coefficient is required, this suggests that the changes in the volatility processes are generally in the same direction. By contrast, if the changes are generally in opposite directions, then a positive coefficient will clearly allow the individual fluctuations to offset one another and in this way minimise the fluctuations of a combination of the processes.

6.2 The Engle-Kozicki common feature test

Engle and Kozicki (1993:370) suggest a two-step test. First, the series (say x_t and y_t from above) are tested to ensure that they exhibit the feature individually. To test for ARCH, the LM test developed by Engle (1982) is used here; the null hypothesis is formulated as H_0: no ARCH, with the alternative being H_1: ARCH. The univariate *ARCH(j)* test regresses the own squared returns on a constant and *j* lags to obtain the TR^2 statistic (i.e. sample size multiplied by uncentred R^2), which is distributed as χ^2(j).[26]

If ARCH effects are found in the series, then the second step in the Engle-Kozicki methodology entails testing for common ARCH. Here tests similar to those used in the first stage are applied to a linear combination of the variables $z_t = x_t + \rho y_t$, for various values of ρ. More precisely, the test for common ARCH involves minimising over the parameter ρ the TR^2 statistic from the regression of z_t on a constant, and lagged squares and cross-products of x_t and y_t. The TR^2 statistic is distributed as χ^2 with degrees of freedom equal to the number of overidentifying restrictions, i.e. the number of instruments included in the regression minus 1 (in the context of a bivariate test). Note that the null hypothesis for tests on the portfolio z_t is now H_0: common ARCH, with the alternative being H_1: no common ARCH. A grid search method is used here to find the value of ρ which minimises the TR^2 statistic.

6.3 Results

The results of the ARCH tests on the financial (CDLFINUS) and commercial rand (CDLZARUS) weekly exchange rate returns are presented in Table 6.1.[27] It is clear that both series display strong ARCH effects on the basis of tests using 1 to 4 lags. This is important, since the inclusion of a variable which does not exhibit the ARCH

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[25] *To see this: if $v_t = -\rho w_t$ + constant, then $h_t^2 = \rho^2 k_t^2$, and $cov_t(v_t, w_t) = -\rho k_t^2$. Writing the series with the common ARCH factor w_t (i.e. $x_t = -\rho w_t + e_{xt}$ and $y_t = w_t + e_{yt}$, up to a constant), the variance of the portfolio is :*

$v_t\,(x_t + \rho y_t) = h_t^2 + \rho^2 k_t^2 + 2\rho\, cov_t(v_t, w_t)$ + constant = constant.

[26] *What Engle and Kozicki term "multivariate ARCH" may also be tested using MARCH(j) tests, which add j lags of the squared values of other explanatory variables to the above. The purpose of the MARCH tests is to determine whether ARCH effects would be revealed using a wider information set in cases where no ARCH effect is detected by the univariate test. Since the univariate tests revealed strong ARCH effects, this test was not necessary in this case.*

[27] *In common with other studies (for example, Alexander, 1995), the analysis of daily data failed to reveal common volatility processes. A possible reason is that daily data contain too much noise for the tests to detect the common feature, hence the use of weekly data here.*

feature in bivariate portfolios will tend to result in a weight of zero being assigned to the other variable in the common ARCH tests undertaken next. Effectively, the minimum TR^2 test then has no power since it becomes a test on the variable which does not have the feature.

Table 6.1: ARCH(j) tests

	ARCH(1)	ARCH(2)	ARCH(3)	ARCH(4)
CDLFINUS	25,454**	39,319**	65,131**	65,138**
CDLZARUS	76,409**	82,713**	82,534**	83,382**
$\chi^2(j)$ 5% critical value	3,841	5,991	7,815	9,488

Note: The TR^2 statistic is generated from regressions of squares of the row variable on a constant, and j lags of own squares.

The test for common ARCH in a portfolio of the dual exchange rates, described in Section 6.2, was applied and the results are reported in Table 6.2. A specification with one lag was adopted for the tests, with a grid search over the range -5 to 5 at intervals of 0,01 being undertaken to determine the value of ρ which minimises the TR^2 statistic. This approach ensures that the test statistic which comes as close as possible to eliminating the feature from the portfolio over this range, is tested.

Table 6.2: Common features ARCH tests

Common ARCH(1) test: $\chi^2(2)$ 5 per cent critical value = 5,991

Portfolio	Minimum TR^2
CDLFINUS-1,27*CDLZARUS	13,093** [0,0014]

Note: The common ARCH tests involved minimising over the parameter ρ the TR^2 statistic from the regression of z_t on a constant, and lagged squares and a cross-product of x_t and y_t.

On the basis of the common features ARCH test presented in Table 6.2, the minimum TR^2 portfolio of the financial and commercial rand exchange rates returns a test statistic of 13,093, which rejects the common ARCH null hypothesis at the 1 per cent level.[28] The dual rates therefore do not appear to share a common volatility process. Note that the negative sign and the magnitude of the ρ coefficient suggest that the heteroscedastic movements in the exchange rates are nevertheless in the same direction (i.e. that they weaken and strengthen in tandem) and that the movements in the financial rand exchange rate exceeded those in the commercial rand. [29]

7. The volatility dynamics of the commercial and financial rand exchange rates: a test for volatility spillovers

In this final empirical section, an approach pioneered by Hamao et al (1990) is used to test whether volatility in either of the dual exchange rate markets spills over into the other. Whereas the common features approach adopted in Section 6 tested for a concurrent common ARCH process in the markets, the intention in this section is to test whether volatility shocks were transmitted between the markets, with a lag.

[28] Plots of the TR^2 statistic as a function of the ρ coefficient, not presented here, reveal that the minimum is well defined in the common features test although the shape of the function is not globally convex.

[29] Although the common ARCH concept is intuitively appealing in the present context, it is important to note some potential shortcomings in the procedures adopted. First, a limitation of the common features tests that might be relevant in at least some cases tested above concerns the dating of the series. As Ericsson (Engle and Kozicki, 1993:380) has pointed out, if the relative lag between the series is not correctly specified, the tests may reject a common feature even when one exists. The tests undertaken here test only for a concurrent common ARCH feature, so the possibility of leads or lags in the relationship between the series is not taken into account. A second limitation of the tests, also identified by Ericsson, concerns their bivariate nature. If the data are multivariate, placing the common ARCH hypotheses in a bivariate context may be too restrictive, resulting in inappropriate rejection.

The spillover models estimated here are based upon the EGARCH models selected earlier for the commercial and financial rand exchange rates (results presented in Appendix 2). In these models, the volatility shock estimated for each of the exchange rates is included as an explanatory variable in the conditional variance equation of the other. Equation 8 of the EGARCH model set out in Section 3 therefore becomes

$$\ln\left(h_t^2\right) = \alpha_0 + \alpha_1 g(\varepsilon_{t-1}) + \beta_1 \ln(h^2_{t-1}) + \lambda_1 v^2_{t-1} \qquad (8'')$$

where v^2_{t-1} is the past squared unexpected return used to proxy the volatility shock in the dual foreign exchange market not modelled. The volatility shock from the financial rand exchange rate is therefore included in the EGARCH model for the commercial rate, and vice versa. It follows that the statistical significance of the coefficient λ_1 indicates the presence of volatility spillovers to the market under consideration.

The results obtained from the respective augmented EGARCH models are presented in Table 7.1. It is evident from this table that the λ_1 coefficient is significant at the 5 per cent level in the model for the financial rand-US dollar exchange rate, but is not significant at this level in the case of the commercial rand-US dollar exchange rate. Furthermore, the positive sign on the coefficient indicates that positive volatility shocks in the commercial rand market increase the conditional variance of the financial rand exchange rate in the following period. Volatility is therefore found to "spill over" from the commercial rand market to the financial rand market.[30]

Table 7.1 MLE parameter estimates: Volatility spillover EGARCH models

Sample period	Financial rand period	
Exchange rate (against the US$)	Commercial rand	Financial rand
Conditional distribution	N	N
c	0,011	0,028
	(0,008)	(0,038)
θ	-0,071**	
	(0,023)	
α_0	-0,207**	-0,010*
	(0,032)	(0,041)
α_1		
β_1	0,987**	0,958**
	(0,007)	(0,014)
$\lambda 1$	-0,001	0,004*
	(0,002)	(0,002)
$\alpha_1\ \pi$	0,043	0,050
	(0,023)	(0,035)
$\alpha_1\ \gamma$	0,256**	0,186**
	(0,034)	(0,062)
$\alpha_1+\beta_1$		
Diagnostics		
Log L	-1912,16	-4271,03
Akaike	1,605	3,576
Schwarz	1,622	3,591

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*).

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[30] *Note that this result appears to contradict that of a causality-in-variance test reported in Farrell (2000), which found that causality-in-variance ran from the financial rand to the commercial rand market. The tests were, however, conducted using different data sets and, what is possibly more important, over slightly different sample periods. When the causality-in-variance test was conducted using the present data and sample period, no causality-in-variance in either direction was found.*

8. Concluding comments

This paper has found some evidence that the financial rand set of capital controls affected the stochastic behaviour of the commercial rand exchange rate in the 1985-95 period. The results presented show that the proxies for the volatility of various nominal commercial rand exchange rates, the mean conditional variances obtained from ARCH-type models, were lower in all but one case in the period when the controls were in place than in periods when the rate was unified. Although the variances of these volatility proxies decreased when the controls were introduced in 1985, they were also significantly lower in all cases in the second unified period. In the case of the real effective exchange rate, a dummy variable in the conditional variance equation was used to model the impact of the financial rand system on the volatility of the rate. The coefficient on this dummy variable was found to be negative and significant, indicating that the conditional volatility of the real exchange rate was lower during the 1985-95 period when the financial rand system was in place than in the contiguous periods when the exchange rate was unified.

Furthermore, the tests undertaken in this study show that volatility in the financial rand foreign exchange market was on average higher than that in the commercial rand market, and, more important, that it did not impact on the commercial rand exchange rate. No evidence was found of a common volatility (ARCH) process in the dual foreign exchange rates using the “common features” methodology of Engle and Kozicki (1993), and although tests revealed volatility spillovers from the commercial rand exchange rate to the financial rand, volatility was not found to “spill over” in the opposite direction.

Taken together, these results suggest that the financial rand set of controls was successful in achieving the primary objective of a dual exchange rate system, namely that of providing the necessary separation between the dual exchange rate markets. Although a “no financial rand system” counterfactual is virtually impossible to provide, it seems likely that the financial rand system insulated the commercial rand exchange rate from volatility in non-resident portfolio capital flows in the 1985-95 period.

Appendix 1: Preliminary descriptive statistics

In Table A1, summary statistics for the post-1983 period are presented for the exchange rates described in Section 4. In line with the objectives of this paper, three subperiods are identified: the first unified period of the rand (7 February 1983 to 28 August 1985, resulting in 645 daily exchange rate changes), the financial rand period (2 September 1985 to 10 March 1995, resulting in 2 394 daily exchange rate changes), and the current unified period (13 March 1995 to 20 October 1998 in this study, resulting in 900 daily exchange rate returns).

A depreciation of the rand is indicated by an increase in the exchange rate, except for the NEER where the opposite applies. This is clearly evident in Table A1, where the mean changes in all three periods for the NEER have the opposite signs to those of its constituent exchange rate series. Overall, the mean changes in the various exchange rates are largest in the first unified period, although the spread between the minimum and maximum daily changes is largest in the financial rand period.

Excess kurtosis (ExKurt) is clear for all series, especially in the financial rand period. The standard errors for the kurtosis estimates under the null hypothesis of normality are $\sqrt{(24/645)}=0{,}193$, $\sqrt{(24/2394)}=0{,}100$ and $\sqrt{(24/900)}=0{,}163$ in the first unified, financial rand and second unified periods, respectively. This kurtosis, along with the significant Ljung-Box (1978) tests on the squared residuals (LB^2) and ARCH tests, is consistent with the findings reported in other studies dealing with high-frequency exchange rate data.

As the skewness statistic (Skew) reveals, the distributions of the series are not symmetric. The skewness estimates suggest that shocks resulting in depreciations were dominant in all three periods. These estimates are statistically significant, since their standard errors under the null hypothesis of normality are $\sqrt{(6/645)}=0{,}096$, $\sqrt{(6/2394)}=0{,}050$ and $\sqrt{(6/900}=0{,}082$ in the first unified, financial rand and second unified periods, respectively. Non-normality is confirmed in all cases by the significance of the Doornik-Hansen (1994) test statistic (χ^2_{ND}).

Finally, the results of the first-order serial correlation coefficient $\rho(1)$ and the Ljung-Box statistic applied to the raw data (LB) suggest that there is autocorrelation in the mean. Although these tests are not robust to GARCH effects, other studies have linked similar findings of negative serial correlation to the intervention policies of monetary authorities (Vlaar and Palm, 1993), and of positive serial correlation to the presence of positive feedback traders (De Long et al, 1990) or the implementation of stop-loss strategies (Krugman and Miller, 1993).

Table A1 Summary statistics: daily data

Variable	Mean	SD	Skew	ExKurt	Min	Max	$\rho(1)$	LB(36)	LB^2(36)	ARCH(1)	ARCH(2)	ARCH(4)	χ^2_{ND}
1st unified period: 7 February 1983 - 28 August 1985 (645 observations)													
CDLZARUS	0,138	1,448	0,137	8,256	-7,821	8,617	-0,008	49,783	378,13**	45,420**	47,637**	63,387**	538,2**
CDLZARGBP	0,126	1,294	0,405	10,720	-7,746	7,104	0,011	43,066	297,37**	20,434**	24,479**	58,532**	702,74**
CDLZARDM	0,121	1,297	0,607	12,522	-8,113	8,135	0,018	40,566	243,55**	18,889**	20,666**	46,560**	792,78**
CDLZARYEN	0,141	1,542	0,332	6,796	-8,113	9,403	-0,108	44,737	229,09**	25,947**	27,510**	43,834**	395,42**
CDLNEER	-0,130	1,309	-0,412	11,577	-8,229	7,890	0,010	42,931	300,28**	28,823**	31,228**	53,063**	773,06**
Financial rand period: 2 September 1985 - 10 March 1995 (2 394 observations)													
CDLZARUS	0,021	0,821	2,195	50,168	-6,006	14,432	-0,044	114,0**	512,7**	61,715**	472,165**	416,772**	8428,2**
CDLZARGBP	0,027	0,873	1,306	34,377	-7,134	13,494	-0,015	95,438**	556,89**	59,312**	241,079**	518,944**	7709,9**
CDLZARDM	0,050	0,800	2,101	45,112	-7,049	13,507	-0,014	124,53**	439,3**	60,433**	296,807**	423,760**	7469,4**
CDLZARYEN	0,061	0,882	1,803	32,879	-6,454	13,894	-0,036	112,94**	490,92**	66,297**	334,124**	425,256**	5371,1**
CDLNEER	-0,032	0,721	-3,086	75,622	-13,982	6,407	-0,028	168,33**	470,02**	64,300**	409,312**	486,096**	10074,0**
2nd unified period: 13 March 1995 - 20 October 1998 (900 observations)													
CDLZARUS	0,050	0,764	1,186	16,880	-4,628	7,263	-0,024	139,19**	1041,4**	193,660**	200,318**	231,179**	1121,4**
CDLZARGBP	0,058	0,855	0,992	9,663	-4,603	6,806	-0,016	102,37**	751,05**	122,897**	135,643**	231,179**	550,95**
CDLZARDM	0,033	0,907	0,960	7,641	-4,766	6,307	-0,028	70,430**	535,64**	116,541**	129,984**	144,490**	382,52**
CDLZARYEN	0,023	1,030	1,039	5,481	-4,118	6,766	0,011	58,216*	532,32**	38,629**	86,789**	95,694**	193,77**
CDLNEER	-0,045	0,758	-1,451	15,668	-6,945	4,584	-0,026	132,58**	938,59**	160,297**	175,237**	198,080**	772,96**

Note: LB(q) [LB^2(q)] are the q-lag Ljung-Box versions of the portmanteau test for the [squared] series concerned. The null hypothesis is that the observations in the series are uncorrelated, which is equivalent to a null of no ARCH or GARCH in the case of the LB^2(q) statistic. ARCH(q) is the Engle (1982) LM test for the presence of (G)ARCH effects, with the null of no (G)ARCH. The statistics all have asymptotic χ^2(q) distributions under the null, e.g. the relevant 5 per cent critical values are $\chi^2(1) = 3{,}841$, $\chi^2(2) = 5{,}991$, $\chi^2(4) = 9{,}488$, $\chi^2(36) = 50{,}998$.

Appendix 2: Maximum likelihood estimation parameter estimates of ARCH models

The MLE parameter estimates for the ARCH-type models set out in Section 3 are presented here. The results obtained for the CDLZARUS, CDLZARGBP, CDLZARDM, CDLZARYEN, CDLNEER and CDLFINUS exchange rate returns described in Section 4 are presented in Tables A2.1 – 2.6, respectively. Note that only valid models are reported here; GARCH and GARCH-*t* models where $\alpha_1 + \beta_1 > 1$, for example, are excluded. An optimal model, denoted by an asterisk (*), is selected from the remaining models on the basis of the (lowest) Schwarz information criterion (Schwarz, 1978).

Table A2.1 MLE parameter estimates: Commercial rand/US$ exchange rate

Sample period	1st unified	Financial rand		2nd unified
Model	EGARCH	GARCH	EGARCH*	EGARCH
Conditional distribution	N	N	N	N
c	0,055**	0,008	0,011	0,040**
	(0,020)	(0,008)	(0,008)	(0,011)
θ		-0,064**	-0,071**	
		(0,022)	(0,023)	
α_0	-0,269**	0,004*	-0,214**	-0,405**
	(0,051)	(0,002)	(0,028)	(0,093)
α_1		0,123**		
		(0,021)		
β_1	0,979**	0,875**	0,984**	0,938**
	(0,009)	(0,021)	(0,005)	(0,033)
$\alpha_1 \pi$	0,064		0,043	0,122*
	(0,060)		(0,023)	(0,054)
$\alpha_1 \gamma$	0,382**		0,259**	0,435**
	(0,074)		(0,033)	(0,078)
j				
$\alpha_1+\beta_1$		0,998		
Diagnostics				
Log L	-853,65	-1930,79	-1922,29	-507,10
Akaike	2,662	1,617	1,611	1,138
Schwarz	2,697	1,629	1,625	1,165
Conditional variance (h_t^2)				
mean	2,287	0,860	0,724	0,531
standard deviation	3,322	3,548	2,809	1,320

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*).

Table A2.2 MLE parameter estimates: Commercial rand/British pound exchange rate

Sample period	1st unified	Financial rand			2nd unified	
Model	EGARCH	GARCH	GARCH-t*	EGARCH	GARCH-t*	EGARCH
Conditional distribution	N	N	t	N	t	N
c	0,040	0,029**	0,041**	0,031**	0,029*	0,040*
	(0,028)	(0,011)	[0,009]	(0,012)	[0,016]	(0,019)
θ			-0,050**			
			[0,020]			
α_0	-0,263**	0,009**	0,017**	-0,172**	0,026**	-0,396**
	(0,368)	(0,003)	[0,003]	(0,029)	[0,008]	(0,079)
α_1		0,102**	0,124**		0,262**	
		(0,018)	[0,019]		[0,054]	
β_1	0,976**	0,883**	0,858**	0,982**	0,731**	0,921**
	(0,018)	(0,017)	[0,017]	(0,006)	[0,042]	(0,029)
$\alpha_1 \pi$	0,090			0,021		0,147
	(0,066)			(0,022)		(0,078)
$\alpha_1 \gamma$	0,368**			0,214**		0,447**
	(0,105)			(0,037)		(0,088)
j			3,771**		4,577**	
			[0,247]		[0,670]	
$\alpha_1+\beta_1$		0,985	0,982		0,993	
Diagnostics						
Log L	-843,12	-2338,52	-2212,88	-2337,98	-839,20	-889,74
Akaike	2,630	1,957	1,854	1,957	1,876	1,988
Schwarz	2,664	1,967	1,868	1,969	1,903	2,015
Conditional variance (h_t^2)						
mean	1,778	0,901	0,786	0,783	0,800	0,770
standard deviation	2,757	3,075	1,656	2,393	1,495	1,445

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*)

Table A2.3 MLE parameter estimates: Commercial rand/German mark exchange rate

Sample period	1st unified	Financial rand			2nd unified		
Model	EGARCH	GARCH	GARCH-t*	EGARCH	GARCH	GARCH-t*	EGARCH
Conditional distribution	N	N	t	N	N	t	N
c	0,053	0,036**	0,043**	0,048**	-0,001	-0,009	0,031
	(0,033)	(0,010)	[0,009]	(0,010)	(0,023)	[0,018]	(0,021)
θ		-0,049*	-0,069**	-0,059*		-0,075*	
		(0,024)	[0,019]	(0,024)		[0,034]	
α_0	-0,285**	0,009**	0,013**	-0,126**	0,044*	0,047**	-0,260**
	(0,065)	(0,002)	[0,003]	(0,019)	(0,021)	[0,015]	(0,060)
α_1		0,079**	0,094**		0,201**	0,164**	
		(0,015)	[0,016]		(0,071)	[0,042]	
β_1	0,966**	0,896**	0,879**	0,986**	0,764**	0,781**	0,935**
	(0,019)	(0,013)	[0,017]	(0,004)	(0,070)	[0,046]	(0,027)
$\alpha_1 \pi$	0,075			0,043*			0,092
	(0,073)			(0,018)			(0,065)
$\alpha_1 \gamma$	0,412**			0,148**			0,313**
	(0,094)			(0,025)			(0,072)
j			4,322**			4,325**	
			[0,270]			[0,584]	
$\alpha_1 + \beta_1$		0,975	0,973		0,965	0,945	
Diagnostics							
Log L	-862,30	-2107,69	-2003,66	-2096,18	-1043,37	-973,78	-1033,21
Akaike	2,689	1,765	1,679	1,756	2,327	2,177	2,307
Schwarz	2,724	1,777	1,693	1,771	2,349	2,209	2,334
Conditional variance (h_t^2)							
mean	1,810	0,740	0,602	0,678	0,881	0,823	0,821
standard deviation	2,971	2,787	1,311	2,399	1,269	1,103	1,047

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*)

Table A2.4 MLE parameter estimates: Commercial rand/Japanese yen exchange rate

Sample period	1st unified		Financial rand			2nd unified		
Model	GARCH*	EGARCH	GARCH	GARCH-t*	EGARCH	GARCH	GARCH-t*	EGARCH
Conditional distribution	N	N	N	t	N	N	t	N
c	0,078*	0,106**	0,035**	0,036**	0,055**	-0,036	-0,053*	-0,010
	(0,034)	(0,035)	(0,011)	[0,011]	(0,012)	(0,025)	[0,024]	(0,026)
θ	-0,204**	-0,186**	-0,067**	-0,076	-0,071**			
	(0,051)	(0,055)	(0,022)	[0,021]	(0,023)			
α_0	0,157*	-0,159**	0,012**	0,016**	-0,118**	0,071**	0,081**	-0,231**
	(0,077)	(0,042)	(0,003)	[0,003]	(0,016)	(0,027)	[0,025]	(0,058)
α_1	0,225**		0,090**	0,087**		0,174**	0,192**	
	(0,068)		(0,015)	[0,014]		(0,057)	[0,045]	
β_1	0,726**	0,892**	0,887**	0,886**	0,984**	0,760**	0,741**	0,906**
	(0,076)	(0,050)	(0,015)	[0,016]	(0,004)	(0,065)	[0,051]	(0,034)
$\alpha_1\ \pi$		0,047			0,040*			0,109*
		(0,074)			(0,017)			(0,051)
$\alpha_1\ \gamma$		0,349**			0,142**			0,287**
		(0,078)			(0,021)			(0,072)
j				5,349**			4,673**	
				[0,380]			[0,802]	
$\alpha_1+\beta_1$	0,951		0,977	0,973		0,934	0,933	
Diagnostics								
Log L	-1076,23	-1079,93	-2464,15	-2430,36	-2465,54	-1175,24	-1138,39	-1172,54
Akaike	3,353	3,367	2,063	2,035	2,065	2,621	2,541	2,617
Schwarz	3,387	3,409	2,075	2,050	2,079	2,642	2,568	2,643
Conditional variance (h_t^2)								
mean	2,453	2,259	0,885	0,734	0,819	1,057	1,092	1,018
std deviation	3,069	2,101	2,965	1,342	2,537	1,187	1,244	1,017

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*)

Table A2.5 MLE parameter estimates: NEER of the commercial rand

Sample period Model Conditional distribution	1st unified EGARCH N	Financial rand EGARCH N	2nd unified EGARCH N
c	0,018	-0,024**	-0,011
	(0,014)	(0,005)	(0,009)
θ		-0,135**	
		(0,026)	
α_0	-0,422**	-0,243**	-0,471**
	(0,064)	(0,024)	(0,091)
α_1			
β_1	0,972**	0,988**	0,953**
	(0,014)	(0,004)	(0,020)
$\alpha_1\ \pi$	-0,087	-0,074**	-0,141
	(0,079)	(0,029)	(0,074)
$\alpha_1\ \gamma$	0,595**	0,297**	0,547**
	(0,094)	(0,031)	(0,100)
$\alpha_1+\beta_1$			
Diagnostics			
Log L	-718,93	-1069,93	-534,36
Akaike	2,245	0,899	0,199
Schwarz	2,279	0,913	1,225
Conditional variance (h_t^2)			
mean	2,352	0,605	0,696
standard deviation	4,923	2,866	1,879

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*).

Table A2.6 MLE parameter estimates: Financial rand/US$ exchange rate

Sample period	Financial rand	
Model	GARCH	EGARCH*
Conditional distribution	N	N
c	-0,009	0,031
	(0,028)	(0,038)
θ		
α_0	0,113**	-0,101*
	(0,032)	(0,040)
α_1	0,124**	
	(0,035)	
β_1	0,839**	0,961**
	(0,036)	(0,014)
$\alpha_1\ \pi$		0,051
		(0,035)
$\alpha_1\ \gamma$		0,188**
		(0,062)
j		
$\alpha_1+\beta_1$	0,963	
Diagnostics		
Log L	-4285,03	-4277,25
Akaike	3,583	3,577
Schwarz	3,593	3,590
Conditional variance (h_t^2)		
mean	2,812	2,664
standard deviation	2,742	2,214

Notes:
- The Bollerslev and Wooldridge (1992) robust standard errors are in ( )
- Test statistics which are significant at the 1 (5) per cent level are shown by ** (*).

References

Alexander, C.O. 1994. Cofeatures in international bond and equity markets, *University of Sussex Discussion Paper in Economics*, 1/94, September.

Alexander, C.O. 1995. Common volatility in the foreign exchange market, *Applied Financial Economics,* 5, pp. 1-10.

Arshanapalli, B., Doukas, J. and Lang, L.H.P. 1997. Common volatility in the industrial structure of global capital markets, *Journal of International Money and Finance,* 16(2), pp. 189-209.

Artis, M.J. and Taylor, M.P. 1988. Exchange rates, interest rates, capital controls and the European Monetary System: assessing the track record. In F. Giavazzi, S. Micossi and M. Miller (eds.) *The European Monetary System,* CUP: Cambridge.

Baillie, R.T. and Bollerslev, T. 1990. A multivariate generalized ARCH approach to modeling risk premia in forward foreign exchange rate markets, *Journal of International Money and Finance*, 9, pp. 309-24.

Barattieri, V. and Ragazzi, G. 1971. An analysis of the two-tier exchange market, *Banca Nazionale del Lavoro Quarterly Review*, 24, pp. 354-72.

Bera, A.K. and Higgins, M.L. 1993. ARCH models: properties, estimation and testing, *Journal of Economic Surveys,* 7, pp. 305-66.

Berndt, E.R., Hall, B.H., Hall, R.E. and Hausman, J.A. 1974. Estimation and inference in nonlinear structural models, *Annals of Economic and Social Measurement*, 3, pp. 653-65.

Bhandari, J. and Decaluwe, B. 1987. A stochastic model of incomplete separation between commercial and financial exchange markets, *Journal of International Economics,* 22, pp. 25-55.

Bhandari, J. and Vegh, C.A. 1990. Dual exchange markets under incomplete separation, *IMF Staff Papers*, 37(1), pp. 146-167.

Bollerslev, T. 1986. Generalised autoregressive conditional heteroscedasticity, *Journal of Econometrics,* 31, pp. 307-27.

Bollerslev, T. 1987. A conditionally heteroskedastic time series model for speculative prices and rates of return, *Review of Economics and Statistics,* 69, pp. 542-47.

Bollerslev, T., Chou, R.Y. and Kroner, K.F. 1992. ARCH modeling in finance: a review of the theory and empirical evidence, *Journal of Econometrics,* 52, pp. 5-59.

Bollerslev, T. and Wooldridge, J.M. 1992. Quasi-maximum likelihood estimation and inference in dynamic models with time varying covariances, *Econometric Reviews,* 11, pp. 143-72.

Bollerslev, T., Engle, R. F. and Nelson, D.B. 1994. ARCH models. In R.F. Engle and D.L. McFadden (eds.) *Handbook of Econometrics,* volume IV, North-Holland: Amsterdam.

Caporale, G.M. and Pittis, N. 1995. Nominal exchange rate regimes and the stochastic behaviour of real variables, *Journal of International Money and Finance,* 14(3), pp. 395-415.

Côté, A. 1994. Exchange rate volatility and trade: a survey, *Bank of Canada Working Paper* No. 94-95.

Darby, J., Hughes Hallett, A., Ireland, J. and Piscitelli, L. 1999. The impact of exchange rate uncertainty on the level of investment, *Economic Journal*, 109, pp. c55-c67.

De Long, J.B., Schleifer, A., Summers, L. and Waldmann, R.J. 1990. Positive feedback investment strategies and destabilizing rational speculation, *Journal of Finance,* 45(2), pp. 379-95.

Diebold, F.X. 1986. Modeling the persistence of conditional variances: comment, *Econometric Reviews,* 5, pp. 51-56.

Diebold, F.X. 1988. *Empirical modeling of exchange rate dynamics,* Springer-Verlag: New York.

Diebold, F.X. and Lopez, J.A. 1995. Modeling volatility dynamics. In K. Hoover (ed.) *Macroeconometrics – developments, tensions and conflicts,* Kluwer: Boston, pp. 427-72.

Diebold, F.X. and Pauly, P. 1988. Has the EMS reduced member-country exchange rate volatility? *Empirical Economics,* 13, pp. 81-102.

Doornik, J.A. and Hansen, H. 1994. An omnibus test for univariate and multivariate normality, Discussion Paper, 24 November. Oxford: Nuffield College. www.nuff.ox.ac.uk/Users/Doornik.

Dornbusch, R. 1976. Expectations and exchange rate dynamics, *Journal of Political Economy,* 84, pp. 1161-76.

Dornbusch, R. and Kuenzler, L. T. 1993. Exchange rate policy: options and issues. In R Dornbusch (ed.) *Policymaking in the open economy: concepts and case studies in economic performance*, EDI Series in Economic Development, OUP (for the World Bank).

Engle, R.F. 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation, *Econometrica,* 50, pp. 987-1008.

Engle, R.F. and Bollerslev, T. 1986. Modeling the persistence of conditional variances, *Econometric Reviews,* 5, pp. 1-50.

Engle, R.F. and Kozicki, S. 1993. Testing for common features, *Journal of Business and Economic Statistics,* 11, pp. 369-79 (including discussion).

Engle, R.F. and Susmel, R. 1993. Common volatility in international equity markets, *Journal of Business and Economic Statistics,* 11, pp. 167-76.

Farrell, G.N. 2000. *An empirical analysis of South Africa's financial rand exchange rate system, 1985-95,* unpublished PhD thesis, University of Birmingham.

Fleming, J.M. 1971. Dual exchange rates for current and capital account transactions. In J. Fleming (ed.) *Essays in International Economics,* London: Allen & Unwin.

Fleming, J.M. 1974. Dual exchange rates and other remedies for disruptive capital flows, *IMF Staff Papers,* 21, pp. 1-20.

Flood, R.P. and Rose, A.K. 1999. Understanding exchange rate volatility without the contrivance of macroeconomics, mimeo (http://haas.berkeley.edu/~arose).

Funke, M. and Hall, S. 1995. Common features in the Sterling/Deutschmark, the Sterling/Dollar and the Deutschmark/Dollar exchange rates, Centre for Economic Forecasting, London Business School, *Discussion Paper* No. DP 8-95 (March).

Garner, J. 1994. An analysis of the financial rand mechanism, Centre for Research in Economics and Finance in South Africa (CREFSA), *Research Paper* No. 9, LSE.

Gidlow, R.M. 1986. The financial rand market, *The Securities Markets*, 1, pp. 37-39.

Gidlow, R.M. 1991. The financial rand market. In W.J. Potgieter et al, *The Foreign Exchange Market*, Johannesburg: Southern Book Publishers.

Gros, D. 1988. Dual exchange rates in the presence of incomplete market separation, *IMF Staff Papers,* 35, pp. 437-60.

Guidotti, P. 1988. Insulation properties under dual exchange rates, *Canadian Journal of Economics,* 21, pp. 114-33.

Hamao, Y., Marsaulis, R.W. and Ng, V. (1990). Correlations in price changes and volatility across international stock markets, *Review of Financial Studies,* 3, pp. 281-307.

Hsieh, D.A. 1989. Modeling heteroskedasticity in daily foreign exchange rates, *Journal of Business and Economic Statistics,* 7, pp. 307-17.

Hu, M.Y., Jiang, C.X. and Tsoukoulas, C. 1997. European exchange rates before and after the establishment of the European monetary system, *Journal of International Financial Markets,* 7, pp. 235-53.

Hughes Hallett, A. and Anthony, M.L. 1997. Exchange rate behaviour under the EMS regime: was there any systematic change? *Journal of International Money and Finance,* 16(6), pp. 537-60.

Krugman, P.R. and Miller, M. 1993. Why have a target zone?, *Carnegie-Rochester Series on Public Policy,* No. 38, pp. 279-314.

Lanyi, A. 1975. Separate exchange markets for capital and current account transactions, *IMF Staff Papers,* 22, pp. 714-749.

Ljung, G.M. and Box, G.E.P. 1978. On a measure of lack of fit in time series models, *Biometrika,* 65, pp. 297-303.

Medhora, R. 1999. Exchange rates, real-financial and micro-macro linkages, paper prepared for the IDRC project on Finance and Competitiveness, and the Trade and Industrial Policy Secretariat (TIPS) Annual Forum, Glenburn Lodge, Muldersdrift.

Meese, R. and Rogoff, K. 1983. Empirical exchange rate models of the 1970s: do they fit out of sample? *Journal of International Economics,* 14, pp. 3-24.

Mussa, M.L. 1986. Nominal exchange rate regimes and the behaviour of real exchange rates: evidence and implications, *Carnegie-Rochester Conference Series on Public Policy,* 25, pp. 117-214.

Nelson, D.B. 1991. Conditional heteroscedasticity in asset returns: a new approach, *Econometrica,* 59, pp. 347-70.

Nelson, D.B. 1992. Filtering and forecasting with misspecified ARCH models: 1, *Journal of Econometrics,* 52, pp. 61-90.

Nelson, D.B. and Cao, C.Q. 1992. Inequality constraints in the univariate GARCH model, *Journal of Business and Economic Statistics,* 10, pp. 229-35.

Nelson, D.B. and Foster D.P. 1994. Asymptotic filtering theory for univariate ARCH models, *Econometrica,* 62, pp. 1-41.

Newbery, D.M. and Stiglitz, J.E. 1981. *The theory of commodity price stabilization: a study in the economics of risk,* Oxford: Clarendon Press.

Pesaran, B. and Robinson, G. 1993. The European exchange rate mechanism and the volatility of the Sterling-Deutschemark exchange rate, *The Economic Journal,* 103, pp. 1418-31.

Phylaktis, K. and Kassimatis, Y. 1997. Black and official exchange rate volatility and foreign exchange controls, *Applied Financial Economics,* 7, pp. 15-24.

Rogoff, K. 1998. Perspectives on exchange rate volatility, Princeton University, mimeo.

Schwarz, G. 1978. Estimating the dimension of a model, *Annals of Statistics,* 6, pp. 461-64.

Teräsvirta, T. 1996. Two stylized facts and the GARCH(1,1) model, *SSE/EFI Working Paper Series in Economics and Finance* No. 96, Stockholm School of Economics, January.

Vlaar, P.J.G and Palm, F.C. 1993. The message in weekly exchange rates in the European Monetary System: mean reversion, conditional heteroscedasticity and jumps, *Journal of Business and Economic Statistics,* 11, pp. 351-60.

Walters, S.S. and de Beer, B.C. 1999. An indicator of South Africa's external competitiveness, *South African Reserve Bank Quarterly Bulletin,* 213, September, pp. 54-67.

Williamson, J. 1985. *The Exchange Rate System,* Policy Analyses in International Economics No. 5, Institute for International Economics, June.

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