REAL EXCHANGE RATE VOLATILITY AND ITS EFFECT ON TRADE FLOWS: NEW EVIDENCE FROM SOUTH AFRICA[♣]

By

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ABSTRACT

This paper empirically re-examines the impact of real exchange rate volatility on South Africa's export flows to the United States for the period 1992:1 – 2004:4 using the two-country model of international trade. The exponential generalised autoregressive conditional heteroscedasticity (EGARCH) model is used to measure real exchange rate volatility. Cointegration and error- correction models are used to obtain the estimates of the cointegrating relations and the short-run dynamics, respectively. Further, variance decomposition analysis is used to show the dynamic adjustments of real exports to shocks in the fundamentals and the proportion thereof. The results obtained in this paper summarily provide evidence that real exchange rate volatility has a negative effect on real exports.

Key Words: Exchange rate volatility, Exports, South Africa, EGARCH model, Cointegration and Error Correction model.

JEL Classification: C32, O24, F1.

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1. INTRODUCTION

The collapse of the Bretton Woods system marked the arrival of the flexible exchange rate system in 1973. This system has produced significant volatility and uncertainty in exchange rates. The impact of this volatility on trade flows started a long debate among policy makers and researchers. Both the theoretical and empirical literature report conflicting results on the impact of exchange rate volatility on international trade flows (Vergil, 2002).

Most models of trade and some empirical works argue that increasing exchange rate volatility, which is a major source of exchange risks, has significant and negative implications for the volume of trade flows and a country's balance of payments (Walters and De Beer, 1999; Bah and Amusa, 2003; Vergil, 2002). On the other hand, other studies provide evidence supporting a positive relationship between exchange rate volatility and trade flows (see, for example, De Grauwe, 1988; Asseery and Peel, 1991; Chowdhury, 1993; among others). De Grauwe (1988) for instance argues that if exporters are sufficiently risk-averse then an increase in exchange rate volatility results in an increase in expected marginal utility of export revenue that serves as an incentive to exporters to increase their exports in order to maximise their revenues. This division amongst policy makers is reflected in the different exchange rate regimes that countries have pursued over time.

The South African Reserve Bank (SARB) has adopted a non-interventionist policy stance in the foreign exchange rate market since the mid 1990s to complement the outward looking trade policy, which forms a critical part of the government's Growth, Employment and Redistribution (GEAR)[1] strategy. The SARB's flexible exchange rate regime has resulted in volatility of the Rand since 1997 (Bah and Amusa, 2003). On the other hand, the outward looking trade policy has ensured that export growth plays a critical role in promoting long-term economic growth.

South Africa's need for high export growth in an environment of freely floating exchange rates and increased volatility of the Rand calls for an understanding of the effect of this highly fluctuating Rand on South Africa's exports and consequently, its impact on the economy. The question is whether the variability of the Rand has created uncertainty about profitability (because of exchange rate risk) and negatively affected export production or whether the depreciation of the Rand has improved the competitiveness of South Africa's exports in world markets.

[1] See the 1996 GEAR document for more details on this policy.

The impact of foreign exchange rate volatility on foreign trade has received more attention in developed countries than it has in developing countries. The cause of this lack of attention to this relationship in developing countries is the lack of sufficient time series data. In South Africa, Bah and Amusa (2003) examined the effects of volatility on exports for the period 1990:1 - 2000:4 and found that the volatility of the Rand's real exchange rate exerts a significant and negative effect on exports. The purpose of this paper is to provide further evidence by empirically examining the effect of real exchange rate volatility on South Africa's real exports to the United States of America (South Africa's largest single nation trading partner).

In estimating this relationship, the approach followed in our study is very close to that of Bah and Amusa's (2003) paper, which adapts the empirical framework developed by Savvides (1992). This framework involves estimating an encompassing equation linking exchange rate volatility (and other variables) to export performance. Our paper is different from previous papers in several ways. Firstly, our paper focuses upon the nature of non-stationarity apparent in various time series data. Arize (1995) explains the ambiguous results of other previous papers as partly due to their failure to consider possible non-stationarity of variables. Secondly, our paper extends the study by Bah and Amusa (2003) in two ways.

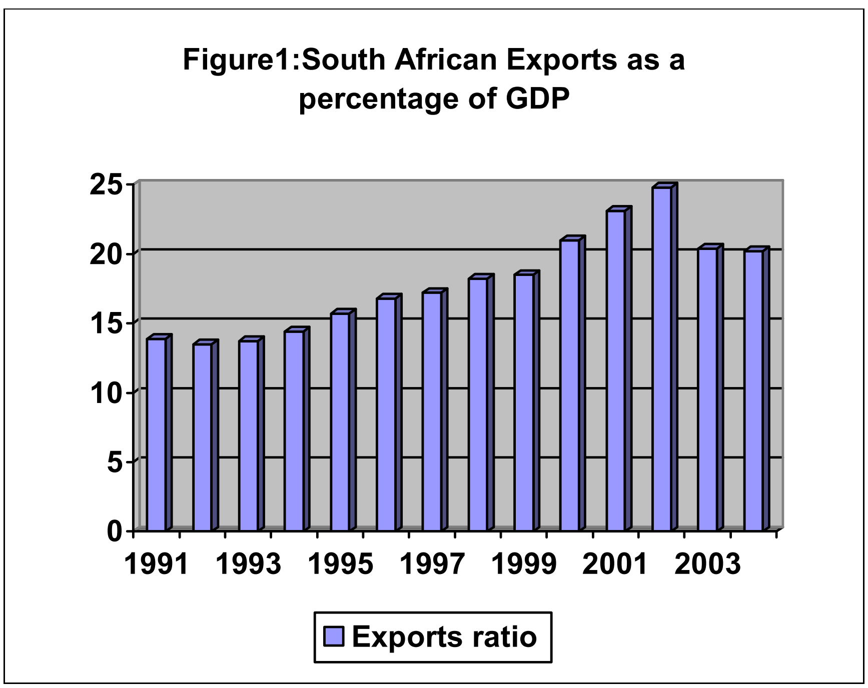
Firstly, we pay special attention to the specification of the volatility estimator. We employ the exponential generalized autoregressive conditional heteroscedasticity (EGARCH) method proposed by Nelson (1991) to measure exchange rate volatility. This method has several advantages over the pure autoregressive conditional heteroscedasticity (ARCH) and the generalized autoregressive conditional heteroscedasticity (GARCH) methods that were utilised in Bah and Amusa's study. By using an alternative measure of volatility, our result could confirm or refute the finding by Bah and Amusa.

Second, our study goes beyond investigating the long-run and short-run relationships between exports and their determinants by employing variance decomposition analysis to investigate the reaction of exports to shocks in any of the determinants. By so doing, we extend the previous work by Bah and Amusa and thus provide additional evidence on the effect of exchange rate volatility on trade flows in the context of developing countries.

The rest of this paper is organised as follows: Section 2 provides a brief overview of export performance since 1991 and relates this to the behaviour of the real exchange rate in South Africa. Section 3 describes the theoretical model, empirical methodology and the data utilised in this study while empirical analysis and results are presented in Section 3. Conclusions are drawn in the last section.

2. EXPORT PERFORMANCE AND REAL EXCHANGE RATE VOLATILITY IN SOUTH AFRICA

The outward-looking trade policy that formed part of the South African government's GEAR policy has ensured that export growth plays a critical role in promoting long term economic growth. The increased liberalisation of trade and exchange control, export promotion policies such as the General Export Incentive Scheme (GEIS), and the multilateral trade agreements have resulted in greater market penetration by South African exporters. Consequently, the contribution of South Africa's exports to its output has persistently increased since 1994. The ratio of exports to GDP has grown from 14% in 1991 to about 25% in 2002 representing more than 50% growth. This contribution is shown in Figure1.

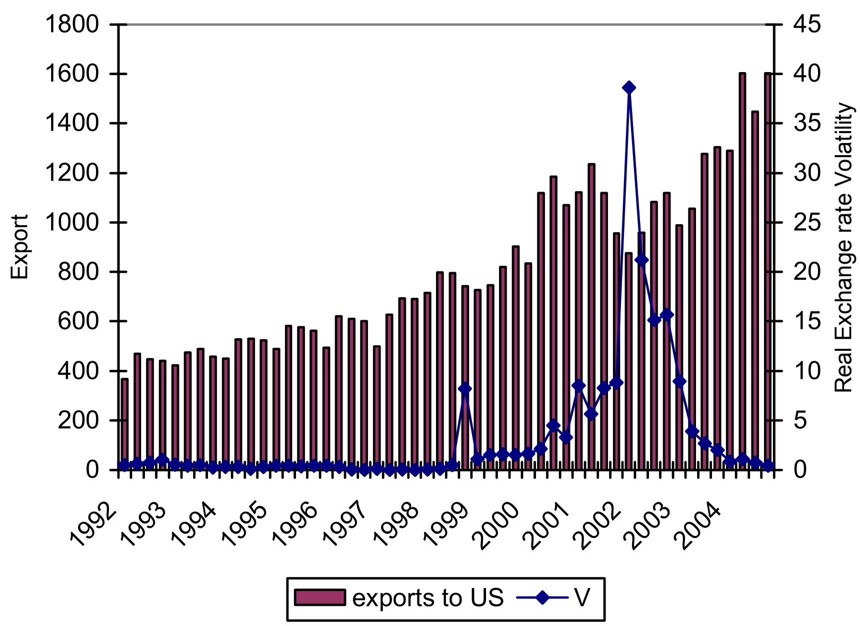


Source: The Department of Trade and Industry South Africa

The first democratic elections in South Africa in 1994 brought relief to the foreign exchange market by ending the destabilising political events that had forced the monetary authorities to maintain a direct capital control. A significant step was taken in March 1995 to relax exchange rate control by abolishing the financial Rand and reverting to a unitary exchange rate system. The unified system allows the Rand to find its level in a relatively competitive foreign exchange market. The current flexible regime has exposed the rand to shocks such as the August 1997 East Asian crisis. Consequently, the Rand's exchange rate has experienced some periods of high volatility.

Figure 2 shows the performance of South Africa's exports to the United States of America alongside the volatility of the bilateral real exchange rate.

Figure2: Real exchange rate volatility and Export Perfomance



Source: IMF's International Financial Statistics CD Rom 2005

Periods of stability in the real exchange rate (low volatility) were accompanied by growth in exports to the United States of America, but those periods of high volatility, such as in 1998, 2001 and 2002, were accompanied by an instant decline in exports. This suggests that real exchange rate volatility has a negative impact on export growth. Given the importance of export growth to South Africa's GDP growth, the effects of the Rand's volatility on exports should therefore not be overlooked. It calls for an empirical analysis to provide further insight into the extent of the effect of the volatility on exports and to suggest possible ways of controlling the situation. The method that is employed to empirically investigate this relationship follows in the next section.

3. ANALYTICAL FRAMEWORK

This section explains how the questions that we have raised in the previous section will be answered. The theoretical and empirical methodologies are specified first, followed by the sources of data and definitions of variables and lastly a brief explanation of the estimation techniques.

3.1 Model specification

Previous empirical works that have estimated the impact of exchange rate volatility on trade flows have estimated separate trade equations with a measure of exchange rate volatility as one of the explanatory variables in each equation. We follow Bah and Amusa (2003) by adopting the two-country model of international trade developed by Savvides (1992). The model combines the specification of the demand and supply of exports to come up with a long-run export demand function that is expressed empirically as:[2]

$$X_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 Q_t + \alpha_3 V_t + \varepsilon_t \qquad (1)$$

Where X_t denotes the logarithm of real exports at time *t*; Y_t is a measure of real foreign income (proxied by real U.S. GDP); Q_t denotes relative prices, which serves as an indicator of external competitiveness and is measured as a logarithm of real exchange rate; V_t is the measure of exchange rate volatility at time *t* and ε_t is an uncorrelated error term.

Economic theory suggests that an increase in the real income of trading partners should result in a greater volume of exports to those partners, thus a positive relationship is expected. Real exchange rate depreciation (an increase in the level of the directly quoted exchange rate) may lead to an increase in exports due to the relative price effect.[3] The relationship between the volatility of the real exchange rate and real exports is ambiguous from a theoretical point of view. The standard theoretical argument that exchange rate volatility may hinder trade flows is based on the notion that exchange rate volatility represents uncertainty and would raise costs for risk-averse traders, which would depress trade (see for example Wolf, 1995; Arize, 1995; among others). On the other hand, a number of other researchers have argued that if producers are sufficiently risk-averse, an increase in exchange rate risk raises the expected marginal utility of export revenue and induces them to export more (see De Grauwe, 1988; Franke, 1991; and Fountas and Aristotelous, 2000). Thus, it is expected that α_1 and $\alpha_2 > 0$ and $\alpha_3 <$ or > 0.

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[2] For the full derivation of the model see Bah and Amusa (2003: 9).

[3] The directly quoted exchange rate in Bah and Amusa and the expected relationship are not consistent with theory. An increase in the directly quoted exchange rate (depreciation) should lead to an increase in exports yielding a positive sign, which is the same as a negative relationship when the exchange rate is quoted in terms of foreign currency (indirectly quoted).

3.2 Variable definitions and data sources

South Africa's exports to the United States (US) are examined for the period between 1992:1 and 2004:4. This sample period is chosen to minimise the specification problems that may emerge as a result of the change in the exchange rate policies of South Africa from that of the earlier years.

Nominal South Africa exports to the US where gathered from the US Census Bureau and were defined in US dollars. We follow Vergil's (2002:87) approach and deflate South Africa's exports using the US consumer price index to define them in real terms. While theory suggests that quantity rather than value should be used, trade data are available in value term rather than volume in South Africa. The need to convert data back into price and quantity components often raises difficulties and complexities.[4] Real US GDP was the only directly observable variable and it was obtained from the July IMF's International Financial Statistics CD Rom 2005.

The second explanatory variable in the export equation is the bilateral real exchange rate (RER) between South Africa and the US. Real exchange rates were derived from quarterly nominal exchange rates (NOM) for the South African Rand against the US dollar (directly quoted rates). Following Caporale and Doroodian (1994), we used the quarterly consumer price index from South Africa (CPISA) and the US (CPIUS) to convert nominal exchange rates to real as follows:

$$RER = (NOM * CPIUS)/CPISA \tag{2}$$

CPI indices and the nominal exchange rate were obtained from the IMF's International Financial Statistics CD Rom 2005. The measurement of exchange rate volatility is explained in Section 4.

3.3 Estimation techniques

In order to estimate the long-run co-movement and the short-run relationship among the variables included in equation (1), the multivariate cointegration method developed in Johansen (1991) and Johansen and Juselius (1990) is employed. This approach is preferred as it captures the underlying time series properties of the data and is a systems equation test that provides estimates of all cointegrating relationships that may exist within a vector of variables (Hook and Boon, 2000 as quoted in Bah and Amusa, 2003). This test for

[4] See Bah and Amusa (2003) for detail on this argument.

cointegration also allows us to estimate a dynamic error correction specification, which provides estimates of both the short-run and the long-run dynamics in equation (1).

We also employ variance decomposition analysis, as developed by Lutkepohl and Reimers (1992), to investigate the effect of shocks (to the explanatory variables) on real exports and the proportion of the variance in real exports that is accounted for by each variable over time.

4. EMPIRICAL ESTIMATION AND RESULTS ANALYSIS

A measure of volatility is constructed first before we examine the nature of the data and then proceed to undertake the Johansen test for cointegration. Finally, variance decomposition results are presented at the end of this section.

4.1 Measuring real exchange rate volatility

Different statistical measures of exchange rate volatility have been proposed in the literature.[5] However, two measures have widely been used in the literature on this subject. These are the simple standard deviation method and a volatility measure generated from a generalised autoregressive conditional heteroscedasticity (GARCH) process. The standard deviation method has been criticised for wrongly assuming that the empirical distribution of the exchange rate is normal and for ignoring the distinction between predictable and unpredictable elements in the exchange rates process (Musonda, 2000; Hook and Boon, 2000). The GARCH method has two distinct problems. Firstly, the non-negativity conditions of the variance may be violated by the estimated model. Secondly, the models cannot account for leverage effects, although they can account for volatility clustering and leptokurtosis in the series.[6] Our study therefore follows the exponential generalised autoregressive conditional heteroscedasticity (EGARCH) methodology, which was proposed by Nelson (1991) and which has several advantages over the pure GARCH specification. These advantages are discussed below.

However, before applying the EGARCH estimation procedure, we have to test for the presence of ARCH effects in the real exchange rate process by employing the LM-ARCH test. We follow Brooks (2002) and Gonzalez *et al*., (2003) in specifying the mean equation as:

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[5] Vergil (2002) provides a list of these measures.
[6] Brooks (2002) Chapter 8 provides detail on this issue.

$$Q_t = \alpha + \varepsilon_t \quad (3)$$

Where Q_t is the natural logarithm of the real exchange rate, α is a constant that represents the expected exchange rate and ε_t denotes the uncorrelated error term at time *t*.[7]

In testing for ARCH, the normal procedure is to collect residuals from equation (3), square them and then regress them on q own lags. R^2 from this regression is obtained and multiplied by the number of observations to construct a test statistic that is distributed as a Chi-square. If the value of the test statistic is greater than the critical value from the Chi-square distribution, then reject the null hypothesis of no ARCH effects and vice-versa. The ARCH test was carried out based on the residuals of equation (3), following the routine performed by E-view 5. We specified 5 lags since we are dealing with quarterly data. Table 1 presents the results of the ARCH test.

Table1: Testing the residuals from the mean equation for ARCH effects

ARCH Test:

F-statistic	21.28873	Probability	0.000000
Obs*R-squared	33.93060	Probability	0.000002

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 07/26/05 Time: 10:23
Sample (adjusted): 1993Q2 2004Q4
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.691717	0.485444	1.424917	0.1617
RESID^2(-1)	1.107396	0.155715	7.111661	0.0000
RESID^2(-2)	-0.420623	0.227670	-1.847509	0.0719
RESID^2(-3)	0.267932	0.232819	1.150813	0.2565
RESID^2(-4)	-0.305793	0.227174	-1.346073	0.1857
RESID^2(-5)	0.081125	0.156273	0.519122	0.6065

Both the F-statistic and the LM-statistics are very significant, suggesting the presence of ARCH effects in the real exchange rate series. Thus it is necessary to proceed with the estimation of the EGARCH process.

For the variance specification, we employ an EGARCH (1, 1) model:

[7] An alternative mean equation specification ($Q_t = \alpha + Q_{t-1} + \varepsilon_t$) was explored, but it did not produce robust results.

$$\log(\sigma_t^2) = c + \beta \log(\sigma_{t-1}^2) + \alpha \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \qquad (4)$$

Where σ_t^2 is the conditional variance of the real exchange rate, ε_{t-1} are the residuals derived from equation (3) and c, β, α and γ are parameter estimates. ε_{t-1} represents the ARCH term, which is a measure of information about volatility in the previous period while σ_{t-1}^2 is the GARCH term representing last period's forecast variance.

This model has several advantages over the pure GARCH specification. First, since $\log(\sigma_t^2)$ is modelled, then even if the parameters are negative, σ_t^2 would be positive, hence there would be no violation of the non-negativity condition. Second, asymmetries are allowed for under the EGARCH formulation, since if the relationship between volatility and exports is negative, γ would be negative (Brooks, 2002).

Nelson (1991) originally assumed a generalised error distribution (GED) structure for the errors, but, owing to its computational ease and intuitive interpretation, we employ conditionally normal errors rather than GED. For us to be sure of the robustness of the estimation of volatility that is derived from the EGARCH process, we again tested whether there was any ARCH effect remaining in the residuals from the EGARCH (1, 1) specification. Table 2 provides the results of the ARCH test.

Table 2: Test for ARCH effects in the residuals from the EGARCH (1, 1)

ARCH Test:

F-statistic	0.282665	Probability	0.919944
Obs*R-squared	1.566164	Probability	0.905311

The insignificance of the F-statistic and the LM- statistic as evidenced by high probabilities in Table 2 suggests that there is no evidence of any remaining ARCH effects. Thus, the predicted values of $\log(\sigma_t^2)$ from equation (4) provide us with an estimate of real exchange rate volatility that we have used as one of the explanatory variables in equation (1).

4.2 Preliminary data examination

Examination of the data set is very important before one carries out any form of analysis. This examination allows one to detect any data capturing errors, check for structural breaks and have an idea of the trends and stationarity of the data. We plot the logarithm of all the other variables, except the exchange rate that is in level form, against time to have an idea of their behaviour. Figures 3-6 show these plots. Only the real exchange rate and its volatility show a change in pattern since the year 2002. The exchange rate followed a weakening trend until 2002, when it started to appreciate correcting back to its long term trend.

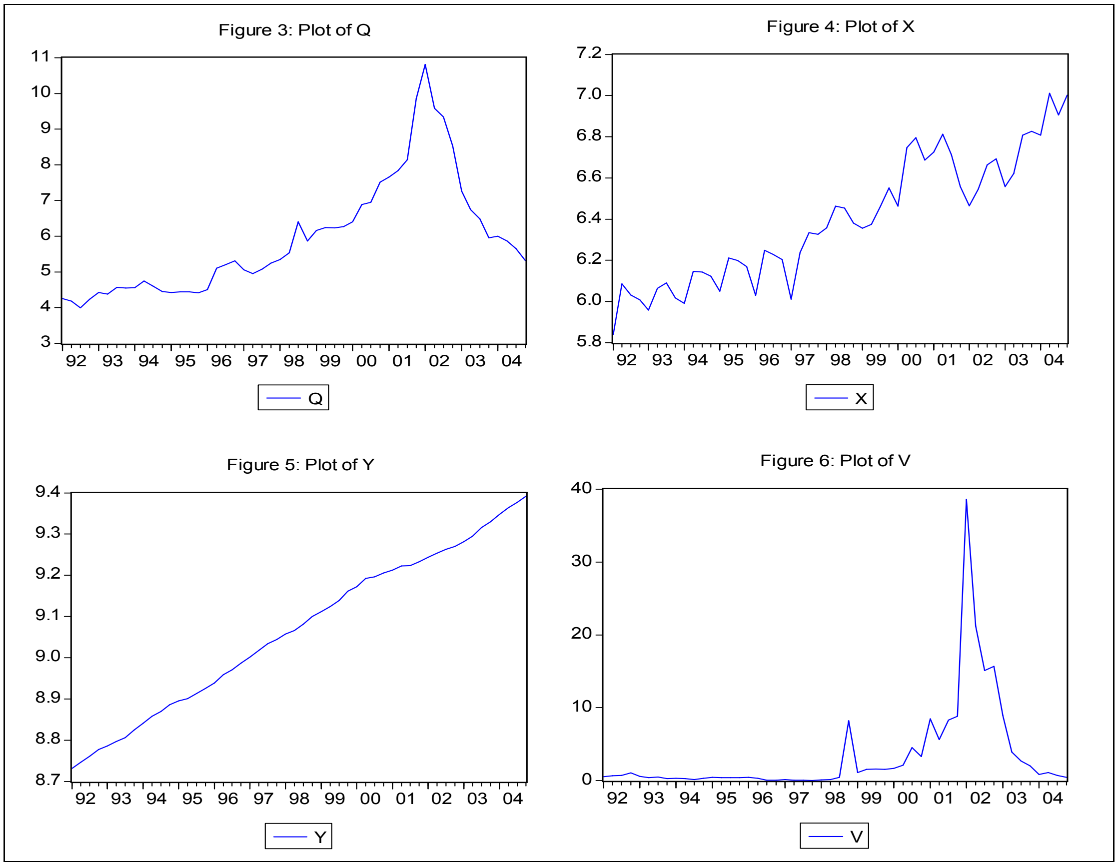

Figure 3: Plot of Q
Figure 4: Plot of X
Figure 5: Plot of Y
Figure 6: Plot of V

4.3 Unit root test and result

The first step of the Johansen cointegration procedure is to determine the order of integration of the variables in equation (1). In this study, we employ the ADF and the Phillips-Perron (PP).We estimated both the ADF and the PP with no intercept and no trend, with intercept but no trend and with intercept and trend options. The first option resulted in positive coefficients that were not significant. The option with trend and intercept did not produce significantly different results in all the variables. Table 3 shows the ADF and PP results of estimation with an intercept only. The results in Table 3 show that all the variables are first difference stationary.

Table 3: Unit root test (with intercept)

	ADF Test		Phillips-Perron Test	
Variables	Level	1st difference	Level	1st difference
Q	-1.977026	-5.001660***	-1.732059	-5.102074***
X	-1.178462	-7.435311***	-0.762360	-15.52332***
Y	-0.595575	-3.110883**	-0.538079	-5.914330***
V	-2.767298	-8.741830***	-2.674559	-8.771016***

Notes: *** and ** denote the rejection of the null hypothesis of unit root at the 1 % and 5 % level of significance, respectively. The lag order for the series was determined by the Schwarz information criterion

4.4 Cointegration analysis

The next step is to test whether a long-run relationship exists among the variables of equation (1). The Johansen maximum likelihood procedure is applied for this purpose to a vector autoregression (VAR) version of equation (1). Typically, the finite VAR of order k is given as:

$$\Delta X_t = \Pi X_{t-1} + \sum_{t=i}^{k} B_I \Delta X_{t-i} + \varepsilon_{kt} \qquad (5)$$

Where X_t is a vector of $I(1)$ variables, ΔX_t are all $I(0)$ and Π is the cointegrating rank, with n being the full rank and r its reduced rank. If there is a cointegrating relation, Π_i will have a reduced rank; that is $r \leq (n-1)$. Then we have: $\Pi_i = \alpha\beta^{'}$ (6)

where α is a $n \times r$ matrix and $\beta^{'}$ is a $r \times n$ matrix. Then $\beta^{'} X_{t-1}$ are the r cointegrated variables, $\beta^{'}$ is the matrix of coefficients of the cointegrating vectors, i.e. the long-run coefficients, and α is interpreted as the matrix of error correction terms.

The Johansen procedure did not only required us to determine the order of integration among the variables *i.e.* r, but also to choose an optimal lag length for the VAR. Table 4 shows the result of the lag length selection for the VAR by different information criteria. Since the series are quarterly data, the selection was drawn from a maximum of four lags. As the results show, two optimal lag lengths were chosen by the different information criteria. The LR, FPE and the AIC chose two lags whereas the SC and the HQ chose one lag. Both lag lengths were explored and we found that lag length one, as chosen by the SC and HQ, produces economically meaningful results.

Table 4: Lag length selection

VAR Lag Order Selection Criteria
Endogenous variables: X Y Q V
Exogenous variables: C
Date: 07/26/05 Time: 11:06
Sample: 1992Q1 2004Q4
Included observations: 48

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-140.0052	NA	0.004742	6.000218	6.156152	6.059146
1	111.8254	451.1965	2.57e-07	-3.826056	-3.046389*	-3.531419*
2	129.1122	28.09107*	2.47e-07*	-3.879674*	-2.476273	-3.349326
3	142.1508	19.01471	2.90e-07	-3.756284	-1.729150	-2.990227
4	159.6292	22.57628	2.94e-07	-3.817885	-1.167017	-2.816118

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Based on the optimal lag length as selected above, we employed the Johansen maximum likelihood procedure to find the number of cointegration relationships in equation (1). This approach uses likelihood ratio (LR) test, based on Trace and Maximum Eigenvalue statistics. For the Maximum Eigen value and Trace statistics, the null hypothesis is that there are *r* or fewer cointegration vectors, whereas the alternative hypotheses are *r*+1 and at least *r*+1 cointegrating vectors for the Maximum Eigen value and Trace statistics, respectively.

Table 5 presents the results of the Johansen cointegration test, based on the optimal lag length 1 as chosen by the SC and HQ information criteria.

Table 5: Johansen Cointegration test results

Series: X Y Q V
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.391515	53.74953	47.85613	0.0126
At most 1	0.361030	28.91034	29.79707	0.0630
At most 2	0.122127	6.515470	15.49471	0.6346
At most 3	5.66E-05	0.002830	3.841466	0.9550

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.391515	24.83918	27.58434	0.1080
At most 1 *	0.361030	22.39487	21.13162	0.0331
At most 2	0.122127	6.512641	14.26460	0.5483
At most 3	5.66E-05	0.002830	3.841466	0.9550

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The upper part of Table 5 presents the Trace statistics while the lower part shows the Maximum Eigen values. The results in Table 5 show that there is one cointegrating relationship according to the Trace statistic while the Maximum Eigen value statistic finds no cointegration at the 0.05 level. Luintel and Khan (1999: 392) show that the Trace test is more robust than Maximal Eigen value statistics in testing for cointegration. Therefore, using the Trace statistic, we conclude that the variables are tied together in a single way in the long-run, that is, there is a unique long-run equilibrium relationship.

In order to determine the true long-run relationship, tests of weak exogeneity were carried out by placing a zero restriction on the loading factor (the matrix of error correction terms) in equation (6). The weak exogeneity tests reported in Table 6 confirm that export is the only possible endogenous variable in the model, while the other variables are exogenous. Thus, the export equation represents the true long-run relationship.

Table 6: Weak Exogeneity Test

Weak exogeneity test on restricted $\Pi_i = \alpha\beta'$	LR test	p-value
X weakly exogenous to vector	2.443030	0.118048
Y weakly exogenous to vector	1.222603	0.268850
Q weakly exogenous to vector	0.176464	0.674430
V weakly exogenous to vector	0.472138	0.492005

Thus the model was normalised on the export variable in order to obtain the long-run parameter estimates. The result of this normalisation yields estimates of long-run elasticities since we have used variables in logarithm form (with the exception of the volatility variable), while the values in parenthesis are t-values.

$$X_t = -1.974046Y_t + 0.095264Q_t - 0.010065V_t \quad (7)$$

(-9.22840) (2.01693) (-1.12921)

All the estimated coefficients carry the expected signs except for foreign income. This is rather surprising since it is expected that an increase in the income of a trading partner should lead to an increase in exports. The income elasticity is statistically significant and its magnitude is consistent with estimates found in other studies such as Arize *et al*., (2000) and Bah and Amusa (2003), among others. The estimated competitiveness variable, the real exchange rate, has the expected positive sign and is statistically significant. This finding conforms to theory in that the depreciation of the Rand leads to an increase in exports. The variable of focus in this study, the volatility measure, has a negative sign, though not significant at the usual 10 percent significant level. This finding is indicative of the seriousness of a volatile exchange rate of the Rand for exports from South Africa. The coefficient of volatility suggests that, on average, a one basis point increase in the volatility of the Rand/US$ exchange rate will result in a drop in exports from South Africa to the USA by some US$10m. Such a loss in export earnings can definitely not be ignored by any conscious policy makers. Next we proceed to the final stage of cointegration analysis – the construction of error-correction models.

4.5 Short-run dynamics of the export function

Based on the Engle and Granger representation theorem, the existence of the cointegrating relationship among a set of variables that are not stationary in levels, implies there will be a short-run error correction relationship associated with them. This relationship represents an adjustment process by which the deviated actual export is expected to adjust back to its long-run equilibrium path. Table 7 provides the results for the error correction result and the short-run dynamics.

Table 7: Error correction modelling

Variable	Coefficient	Std error	t-statistic
ECM(-1)	-0.661639	0.15013	-4.40718
ΔY(-1)	-3.755982	3.44800	-1.08932
ΔQ(-1)	0.047582	0.03574	1.33140
ΔV(-1)	-0.003651	0.00275	-1.32805

The error correction term's coefficient is negative and statistically significant, further confirming that the variables are cointegrated. The magnitude of the error correction term indicates the change in real exports per quarter that is attributed to the disequilibrium between the actual and equilibrium levels. The adjustment speed of approximately 66%

occurs in one quarter for South Africa. The short-run coefficients follow the same pattern as the long-run coefficients, with the exception that none of the short run coefficients is significant at the standard significant levels.

4.6 Variance decomposition

The generalised variance decomposition analysis provides information on the relative importance of each random innovation in affecting the variables in the VAR (E-view 5 manual). In this section we focus on the effects of a shock to each of the other variables on South African exports to the USA[8]. This is presented in Table 8.

Table 8: Variance Decomposition of X

Period	S.E.	X	Y	Q	V
1	0.089445	100.0000	0.000000	0.000000	0.000000
2	0.098785	98.12670	0.764980	0.303636	0.804686
3	0.102034	92.54068	0.871112	2.909996	3.678215
4	0.106413	85.21263	2.528838	5.681714	6.576820
5	0.111855	77.67928	4.741490	8.385089	9.194145
6	0.117536	71.08538	6.925859	10.64383	11.34493
7	0.123186	65.48874	8.844831	12.54024	13.12619
8	0.128679	60.77025	10.49639	14.12487	14.60850
9	0.133987	56.76340	11.90972	15.46668	15.86020
10	0.139108	53.32893	13.12630	16.61470	16.93006

It is interesting to note that 100% of the variation in exports is accounted for by its own innovations in the first quarter. However, the proportions explained by the other variables increased dramatically over time and they explain about 40% of the variance after two years. The variable that accounts for relatively speaking, the greatest impact, is the volatility of the exchange rate, which accounted for about 14.6% of the 40% after two years. The exchange rate itself was next in importance, accounting for 14.1 %. It is therefore evident that the real exchange rate and its volatility are the most important determinants of exports from South Africa.

5. CONCLUSION AND POLICY IMPLICATIONS

This paper re-examined the impact of real exchange rate volatility on South Africa's exports to the United States using quarterly data covering the period 1992-2004. This study employed the EGARCH framework, as developed by Nelson (1991), to measure

[8] The full variance decomposition of all the variables is presented in Figure 1 in the Appendix.

the real exchange rate volatility of the US dollar against the Rand. We confirmed that the volatility estimator adequately measured the volatility of the real exchange rate by testing for ARCH effect after running the EGARCH model. The empirical results based on the cointegration analysis show that real exports are cointegrated with foreign income, real exchange rate and exchange rate volatility in a single way. By normalisation on exports, all the other estimated long-run elasticities are consistent with predictions of economic theory except for foreign income.

Foreign income is found to have a significant negative effect on exports, which is rather surprising since an increase in the income of trading partners is expected to positively affect export. The real exchange rate (as a proxy for improvements in external competitiveness) carries an expected positive sign, while exchange rate volatility has a strong adverse impact on South Africa's exports to the US. The short-run dynamics show that about 66 percent of variation in exports is corrected within a quarter. Further, the generalised variance decomposition analysis revealed that the fundamentals explain some, but not all, of the variations of real exports. However, the proportion explained by the fundamentals increases gradually with time and real exchange rate volatility is the most important factor for South Africa's exports to the United States of America.

These results on the whole provide strong evidence that real exchange rate volatility has a negative impact on real South Africa exports. The findings provide additional evidence of the negative impact of real exchange rate volatility. One implication of the findings emanates from the significant positive effects of the real exchange rate on exports. It supports the view that some form of depreciation of the Rand will stimulate exports and thus economic growth. This will help improve the competitiveness of South African goods abroad. A major caution, however, is that the exchange rate should be carefully managed to ensure a stable non-volatile behaviour that could hamper export growth. To this end we call for further research on the causes of the volatility of the Rand, in order to proffer specific policy guidelines to stem the trend in the future.

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APPENDIX

Figure 1: Variance decomposition analysis