THE IMPACT OF REAL EXCHANGE RATE VOLATILITY ON SOUTH AFRICAN EXPORTS TO THE UNITED STATES (U.S.): A BOUNDS TEST APPROACH**

By

Lira Sekantsi††

ABSTRACT

This research paper empirically examines the impact of real exchange rate volatility on trade in the context of South Africa's exports to the U.S. for the South Africa's floating period January 1995-February 2007. In measuring real exchange rate volatility, this study utilised GARCH. After establishing the existence of cointegration among the variables involved in our two-country export model, we estimated long-run coefficients by means of ARDL bounds testing procedure proposed by Pesaran, et al.(2001). Our results indicate that real exchange rate volatility exerts a significant and negative impact on South Africa's exports to the U.S. Therefore, stable and competitive exchange rate and sound macroeconomic fundamentals are required in order to improve international competitiveness and greater penetration of South African exports to international markets.

Keywords: Exchange rate volatility, Autoregressive distributed lag (ARDL), Generalised Autoregressive Conditional Heteroskedasticity(GARCH) Bounds testing, unit root, Error Correction model, Cointegration

JEL Classification: F10, F31

†† Lira Peter Sekantsi is a lecturer at the National University of Lesotho. Correspondence should be directed to Lira Peter Sekantsi, Department of Economics, National University of Lesotho,P.O. Roma 180, Maseru 100 Lesotho. Email: **skantsy@hotmail.co.uk** .

1. INTRODUCTION

After breakdown of Bretton Woods system of fixed exchange rates in 1973,several countries adopted floating exchange rates system in order to reduce protectionist tendencies and promote trade as well as to gain overall macroeconomic independence, by bearing the burden of adjustment vis-à-vis imbalances in the current and capital accounts of the balance of payments. The countries adopted flexible exchange rates regime despite its exposure to exchange rate volatility, which is a threat to the growth of international trade and macroeconomic stability, because of the presence of hedging facilities that would be employed to protect one against exchange rate risk. However, the birth of this new system of exchange rate has engendered a 'hot' and extensive theoretical debate regarding the impact of exchange rate variability on foreign trade (Johnson, 1969; Kihangire, 2004).

One strand of theoretical models in the literature[‡‡] demonstrates that increased risk associated with exchange rate volatility is more likely to induce risk -averse agents to direct their resources to riskless economic activities since such variability generates uncertainty which increases the level of riskiness of trading activities and this will eventually depress trade. According to these economists, this occurs because markets may be imperfect particularly in less developed countries (LDCs) and also because hedging may not only be imperfect but also very costly as a basis for averting exchange risk. Hence in line with risk-aversion hypothesis exports may be negatively correlated with exchange rate volatility (Doroodian, 1999; Krugman, 1989).

On the contrary, other theoretical models in the literature[§§] show that higher risk associated with fluctuations in exchange rates present greater opportunity for profits and thus should also increase trade. According to Aziakpono, et al. (2005), this occurs because if exporters are sufficiently risk-averse a rise in exchange rate variability leads to an increase in expected marginal utility of exports revenue which acts as an incentive to exporters to increase their exports in order to maximise their revenues.

[‡‡] See Hooper and Kohlhagen, 1978; Clark, 1973; Mundell, 2000; Doroodian, 1999; Peree and Steinherr, 1989; among others.

[§§] See De Grauwe,1988; Asseery and Peel,1991;Chowdhury,1993 among others

This ambiguity in the theoretical literature causes similar ambiguity and inconsistencies in the empirical investigation of the effects of exchange rate volatility on exports flows. De Vita and Abbott (2004) associate this lack of a clear and consistent pattern of results with no consensus on whether exchange rate volatility should be measured on the basis of nominal or the real exchange rate, failure of the studies to reach consensus on the statistical technique that should be employed to construct the optimal measure of exchange rate volatility , the failure of some studies to consider the time series properties of the regressors entering the export equation and last, the use of aggregate data which constrains volatility estimates to be uniform across countries and the sectors of the economy in lieu of disaggregated markets and sector –specific data.

The impact of exchange rate volatility on trade has been studied more in industrialised countries than in less developed economies. Azaikpono, et al.(2005) and Vergil(2002) state that this lack of attention in developing countries is caused by insufficient time series data. According to Klaassen (1999) there is a need for this kind of empirical studies to be undertaken in developing countries (such as that are in Sub-Saharan Africa(SSA)) with time-variant exchange rates in order to counter this prevalent ambiguity in the literature and fill the research vacuum in less developed countries.

As an open and middle income country in SSA, South Africa is not an exception to this debate because ever since it adopted flexible exchange rates system in the mid 1990's to complement its outward looking trade policy which ensued export-led growth, its currency, Rand with over half of the South African transactions taking place offshore, has been very volatile. 'It has witnessed consistent depreciation of exchange rate to the lowest level in December 2001' and has experienced a sharp appreciation henceforth (see Todani & Munyama, 2005, p.1), subjecting South African importers and exporters to uncertainty regarding their payments and receipts in home currency terms (Aziakpono, et al., 2005).

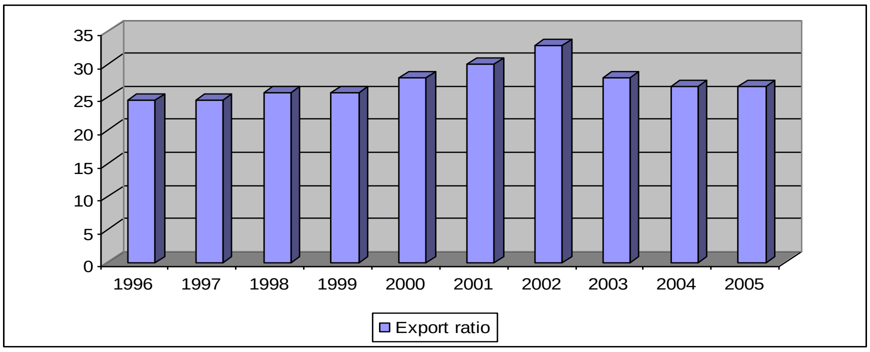
As stated by Aziakpono, et al.(2005) and Todani and Munyama(2005) this requirement by South African government to promote exports in an environment of flexible exchange rates which poses increased Rand volatility requires comprehensive understanding of how this highly fluctuating Rand impacts upon South African exports and the resultant effects on the economy at large. Hence this paper serves to fill the research vacuum on whether the Rand volatility engenders uncertainty with regard to profits and whether it impacts negatively on exports production in South Africa since,currently, there is little empirical evidence on the impact of exchange rate volatility on South African exports. Acquisition of such knowledge is, in fact, crucial for the design of both exchange rates and trade policies. For example, if the policy makers are knowledgeable about the volatility of exchange rates they could always ensure that trade-adjustment programs that put emphasis on export expansion are successful. In addition, possession of such knowledge would also make policy-makers to ensure that the intended effect of trade liberalisation policy is protected from volatile exchange rates in order to safeguard the country from balance of payment crises (Arize, at el., 2000).

In this study the main research question is 'What is the impact of real exchange rate volatility on South African exports to the U.S.?' In addressing this question we consider the afore-mentioned contentious issues and use GARCH (1, 1) as a measure of real exchange rate volatility. After estimating real exchange rate volatility we examine the existence of long-run relationship between real exports and the regressors, namely foreign income, real exchange rate and real exchange rate volatility. Due to the differences in the order of integration of the variables we apply ARDL bounds testing procedure proposed by Pesaran, et al. (2001) on both South African aggregate exports and goods exports to the United States. Now since the existence of cointegration implies the presence of short-dynamics associated with that long-run relationship, the study further examines the speed of adjustment of the variation in exports in the short-run and lastly provides policy recommendations. Unlike other studies carried out in South Africa, we also pay attention to sample period selection to avoid any exchange rate regime switches and also take the issue of trade integration between South Africa and the U.S. into consideration.

2.REAL EXCHANGE RATE VOLATILITY OF THE RAND AND SOUTH AFRICAN EXPORTS PERFORMANCE

As an open and middle income country, South Africa considers exchange rate as a key macroeconomic policy instrument that ensures export promotion and economic growth. SARB's exchange rate policy aims at providing an environment that promotes exchange rate stability and assists the government's objective of accomplishing export-led growth (Bah & Amusa, 2003).In line with this, the adoption of the outward-looking trade policy ensured export growth that lead to long-term economic growth. The increased liberalisation of trade and foreign exchange controls, exports promotion policies like General Export Incentive Scheme (GEIS) and multilateral trade agreements such as African Growth and Opportunity Act (AGOA) have led to greater penetration of South Africa exporters to the international markets such as the U.S. market. As a result, the ratio of exports to GDP has accelerated substantially from 24.5 percent in 1996 to about 32.71 percent in 2002.This is shown in figure 1 below:

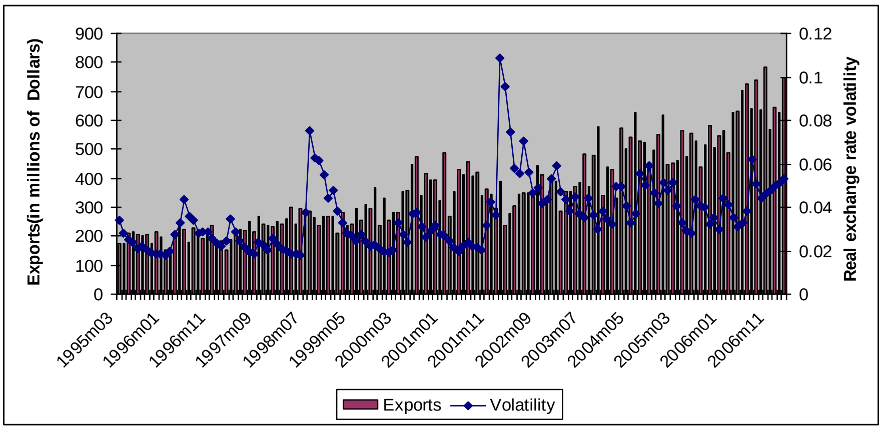
Figure 1: South African Exports as a Percentage of GDP



Source: *South Africa Department of Trade and Industry*

However, the current flexible exchange rate regime has led to greater volatility of the Rand against the major currencies such as the U.S. dollar and such variability has implications for South Africa's exports. Figure 2 below shows the performance of South Africa's exports to the U.S. alongside the bilateral real exchange rate volatility:

Figure 2 : Real Exchange Rate Volatility and South Africa's Exports Performance



Source: *IMF international Financial Statistics*

As shown in figure 2 above periods of low real exchange rate volatility were associated with increase in the growth of exports but those periods of high real exchange rate volatility such as 1998,2001 and 2002 were associated with a sharp decline in exports. This implies that real exchange rate volatility impacts negatively on South Africa's exports to the U.S. Since we can witness the importance of exports to the growth of South Africa's GDP, this implies that the effects of the volatility of the Rand should not be taken for granted but should be carefully considered by policy makers. Hence, this suggests a need for empirical research that provides further insight into the extent to which this variability of the real exchange rate impacts on exports and to provide possible suggestions of ways to control or alleviate it (See also Azaikpono, et.al, 2005, p.5).

3. REVIEW OF THE LI*TERATURE*

A broad and comprehensive review of the literature on the relationship between real exchange rate volatility and trade shows that there are theoretical models that postulate both positive and negative effects of the exchange rate volatility on trade. However, earlier empirical evidence, using different measures of exchange rate volatility, usually fails to establish statistically significant relationship between exchange rate variability and volume of trade, where such a relationship is established the coefficient of exchange rate volatility is either negative or positive.

More recent studies that utilize cointegration /error correction framework and also take into account the time-series properties of the data and the fact that the effects of exchange rate volatility varies across markets by using disaggregated data in lieu of aggregate data which constrains volatility estimates to be uniform across countries and the sectors of the economy gain greater success in finding a statistically significant relationship between exchange rate volatility and volume of trade.

The impact of exchange rate volatility on trade has been studied more in industrialised countries than in developing or emerging markets economies. In the context of South Africa such a relationship is still unknown since, to the best of our knowledge, Bah and Amusi (2003), Azaikpono, et al. (2005) and Todani and Munyama (2005) are the only published empirical studies*** on this issue. These studies, undertaken in the context of cointegration, are summarized below.

Bah and Amusi (2003) used ARCH and GARCH models to examine the effect of real exchange rate volatility on South African exports to the U.S. for the period 1990:1-2000:4.The findings are that Rand's real exchange rate variability exerts a significant and negative impact of exports both in the long and short-run. The similar study by Azaikpono, et al. (2005) extends the work of Bah and Amusa (2003) over the period 1992:1-2004:4 by employing EGARCH method proposed by Nelson (1991) as a measure of variability of exchange rate. The results of the latter boil down to those reached by the former.

Another study by Todani and Munyama (2005) employed ARDL bounds testing procedure on quarterly data for the period 1984-2004 to examine the impact of exchange rate variability on aggregate South African exports to the rest of the world as well as on goods, services and gold exports. Todani and Munyama (2005) employed the moving average standard deviation and GARCH (1, 1) as measures of variability. The results show that depending on the measure of variability employed either there exists no statistically significant relationship between South African exports and exchange rate volatility or when such significant relationship exists it is positive.

4.1 MODEL SPECIFICATION

This study follows Aziakpono, et al. (2005) by adopting the two-country model of international trade specified as

$$X_t = \beta_0 + \beta_1 Y_t + \beta_2 Q_t + \beta_3 V(h)_t + \beta_4 D + \varepsilon_t \qquad (1)$$

where X_t denotes logarithm of real exports(nominal exports deflated by consumer price index(CPI)), Y_t is the logarithm of real foreign income(proxied by U.S. industrial production) and is used as an indicator of demand for South African exports. Q_t denotes relative prices which acts as an indicator of external competitiveness and is measured as a

*** And despite being few those studies are also fraught with ambiguity regarding the impact of exchange rate volatility on trade.

logarithm of real exchange rate. $V(h)_t$ denotes the measure of real exchange rate volatility and measures uncertainty/risk associated with exchange rate fluctuations. β_0 and ε_t are an intercept parameter and a normally distributed error term. We also include a dummy variable, D, to represent trade integration between South Africa and U.S. because since the year 2000 these two countries have been in bilateral trade agreements such as African Growth and Opportunity Act (AGOA) which increased South African exports to the U.S.. Thus, our export demand equation therefore states that exports of South Africa are linearly dependent on foreign income, relative prices, South Africa-U.S. trade integration and uncertainty brought about by fluctuations in real exchange rates.

Economic theory dictates that β_1 is expected to be positive since an increase in the real income of trading partners should lead to greater volume of exports to those partners. Depreciation in real exchange rate (an increase in the level of directly quoted exchange rate) may lead to a rise in exports as a result of relative price effect, hence β_2 is expected to be positive(Aziakpono, et al., 2005; Todani & Munyama, 2005). Trade theory is not clear about the sign of β_3, which is the main basis for this empirical research.

4.2 VARIABLE DEFINITIONS AND DATA SOURCES

This study uses monthly over the South Africa floating period 1995:1 to 2007:2.This sample period is chosen in order to remove specification problems that may arise as a result of the change in the exchange rate policies of South Africa from that of the previous years. The data for South African total (aggregate) nominal exports to the U.S was obtained from IMF's International Financial Statistics (Direction of Trade Statistics) database whereas nominal South Africa exports of goods to the U.S. were gathered from the U.S. Census Bureau and both were expressed in terms of U.S. dollars. Following Aziakpono, et al. (2005) we express South Africa's exports in real terms by deflating them using the U.S consumer price index (CPI).Although, economic theory requires that quantity rather than value be used, we use this in value terms[†††] since trade data in South Africa are available in value terms rather than in terms of volume. U.S industrial production was directly observable and gathered from IMF's International Financial Statistics database.

[†††]since changing data back into price and quantity components often raises difficulties and complexities

Following Aziakpono, et al. (2005), Bilateral (real) exchange rates (RER) between South Africa and the U.S. was derived from monthly and directly quoted nominal exchange rates(ER) for the South African Rand against U.S. dollar as follows:

$$RER = \frac{(ER \times CPIUS)}{CPISA} \qquad (2)$$

where $CPISA$ and $CPIUS$ are SA and Consumer price index and U.S. price index respectively

Consumer Price indices and nominal exchange rates were gathered from the IMF's International Financial Statistics database. Real exchange rate volatility is not directly observable and its measurement is discussed in section 5.

4.3. ESTIMATION TECHNIQUE: AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) BOUNDS TESTING APPROACH

According to Gujarati (2003) and Veerbik (2004) there are various econometric techniques that can be employed to estimate equation (1).If all the variables are stationary or I (0), then equation (1) can be simply estimated by ordinary Least squares (OLS).On the other hand if some or all variables are integrated of order one or I (1), the data is first of all transformed by differencing before applying OLS on the first differences. If there exist some cointegration among the variables in equation (1), then there are a number of cointegration approaches that can be applied. Some principal approaches to cointegration analysis are the Engel and Granger (1987) two-step residual-based procedure and the Johansen (1991, 1995) maximum likelihood reduced rank procedure. These two techniques require a certain degree of pre-testing to ensure that all the regressors are I (1).This is necessary because the standard statistical inference based on conventional cointegration tests becomes invalid in the presence of the mixture of I(0) and I(1) explanatory variables. For instance, the trace and maximum eigenvalue tests from the Johansen approach becomes difficult to interpret in the presence of stationary series in the model because I (0) variables are likely to generate spurious regression with other variables in the system (De Vita & Abbott, 2004).In addition, these two cointegration techniques do not provide robust results in finite samples (Narayan & Narayan, 2004).

This empirical research borrows methodological technique from Aguirre, et al. (2003), De Vita and Abbott (2004) and Todani and Munyama (2005) by utilising ARDL bounds testing approach proposed by Pesaran, et al.(2001).Unlike the afore-mentioned approaches to cointegration, this procedure allows testing for the existence of a level relationship between a dependent variable and a set of regressors regardless of whether the underlying regressors are I(0),I(1) or mutually cointegrated. Another advantage of ARDL bounds testing procedure is that it has better small-sample properties than both the Johansen (1991, 1995) maximum likelihood reduced rank and Engel and Granger (1987) procedures. Furthermore in the context of ARDL framework OLS estimators of the short-run parameters are [square root of (T)]-consistent and the estimators of the long-run parameters are super-consistent in small sample sizes (Pesaran & Shin, 1999).

In order to implement the bounds testing approach, equation (1) is modelled into a conditional ARDL-ECM as follows:

$$\Delta X_t = c_0 + c_1 t + \pi_1 X_{t-1} + \pi_2 Y_{t-1} + \pi_3 Q_{t-1} + \pi_4 V(h)_{t-1} + \pi_5 D + \sum_{i=1}^{n} \alpha_i \Delta X_{t-i} \quad (3)$$
$$+ \sum_{j=0}^{m} \beta_j \Delta Y_{t-j} + \sum_{k=0}^{p} \delta_k \Delta Q_{t-k} + \sum_{r=0}^{q} \phi_r \Delta V(h)_{t-r} + \xi_t$$

where c_0 and $c_1 t$ are the drift and trend components, D is the dummy variable representing South Africa-U.S. bilateral trade agreement. ξ_t is assumed to be a vector of white noise error processes and the rest of the variables are as defined in equation (1). As stated by De Vita and Abbott (2004) the structure of the first difference of the explanatory variables is set to ascertain that there is no serial correlation in the estimated residuals. Y_t, Q_t and $V(h)_t$ are regarded as long-run forcing variables for X_t, so there is no feedback from level of X_t in equation (3)

The first step in estimation is to run OLS on the conditional ECM in (3) and determine or select the optimal structure for the final ADRL specification by following general-to-specific approach which involves selecting the best specification by starting with a maximum lag order of 18 $(\max n = \max m = \max p = \max q = 18)$, and then dropping out all insignificant stationary regressors (Shin and Yu, 2006).

Having determined the optimal structure for the ARDL specification of the short-run dynamics, the next step is to test the existence of a long-run relationship between the variables involved in the export demand equation. This is done by conducting the null hypothesis of ‘no cointegration’ using an F-statistics for the joint significance of lagged levels of variables involved in the error correction model (3), so that $H_0 : \pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$.According to Pesaran, et al.(2001) the asymptotic distribution of F-statistic is non-standard under the null hypothesis of the absence of level relationship between the included variables, regardless of whether the regressors are purely I(0),purely I(1) or mutually cointegrated. The decision rule is made on the basis of F-statistic which is compared with the critical value tabulated by Pesaran, et al[‡‡‡]. (2001).If the computed value of the F-statistic in the ECM is greater than the upper bound, then a conclusive inference can be made that there exist a long-run relationship between the variables without needing to know the order of integration of the regressors. However, if the F-statistic falls below the lower bound the null hypothesis of absence of a long-run relationship among the variables under analysis cannot be rejected. If the computed F-statistic falls inside the critical value bounds, inference is inconclusive and knowledge of the order of integration is required prior to making conclusive inferences. When the knowledge about the order of integration is obtained and it is found that all the regressors are I (1), this test reduces to the no cointegration test so that the null hypothesis means no cointegration. In this case the decision rule is simplified as follows: if the valued of the F-test is greater than the upper bound we reject the null, otherwise we do not reject the null. Therefore extra information that the order of integration of the regressors is I (1) removes an inconclusive region (Pesaran, et al., 2001).

As suggested by Pesaran and Shin (1999), once the existence of a long-run relationship is established, the following conditional long-run model for X_t can be obtained from the reduced form solution of equation (3) when $\Delta X = \Delta Y = \Delta Q = \Delta V(h) = 0$:

$$X_t = \Theta_1 + \Theta_2 t + \Theta_3 Y_t + \Theta_4 Q_t + \Theta_5 V(h)_t + \mu_t \qquad (4)$$

where $\Theta_1 = -c_0/\pi_1$, $\Theta_2 = -c_1/\pi_1$, $\Theta_3 = -\pi_2/\pi_1$, $\Theta_4 = -\pi_3/\pi_1$, $\Theta_5 = -\pi_4/\pi_1$ and it is assumed that μ_t is an $IID(0,\sigma^2)$ error process. That is, the estimates of the long-run coefficients of are given by $\hat{\Theta}_3 = -\hat{\pi}_2 \big/ \hat{\pi}_1, \hat{\Theta}_4 = -\hat{\pi}_3 \big/ \hat{\pi}_1$ and $\hat{\Theta}_5 = -\hat{\pi}_4 \big/ \hat{\pi}_1$ [§§§].

‡‡‡ These encompass a range of various deterministic components which are: no drift and no trend, unrestricted intercept and no trend, restricted intercept and no trend, unrestricted intercept and unrestricted trend, and unrestricted intercept and restricted trend.

§§§ Note that these are the estimates of long-run coefficients of β_1, β_2 and β_3.

4. EMPIRICAL ESTIMATION AND RESULTS ANALYSIS

We construct a measure of real exchange rate volatility first before we examine the nature of our data and then continue to undertake ADRL Bounds testing procedure for cointegration.

4.1 Measuring Real Exchange Rate Volatility

Previous empirical studies in the literature have used different statistical measures of exchange rate volatility. However, most of these studies have applied standard deviation method. The standard deviation method has two distinct shortcomings. Firstly, it wrongly assumes that the empirical distribution of the exchange rate is normal and secondly, it discards the distinction between predictable and unpredictable elements in the exchange rate (Bah & Amusa, 2003; Aziakpono, et al., 2005).

We use the conditional variance of the first difference of the logarithm of real exchange rate to model exchange rate volatility and we assume that the first difference of the logarithm of real exchange rate can be represented by the following autoregressive process:

$$\Delta \log RER_t = \alpha_0 + \partial_1 \Delta \log(RER_{t-1}) + \mu_t , \mu_t / \Omega_{t-1} \sim N(0, h_t^2) \tag{5}$$

where α_0 is a constant, ∂_1 is a coefficient, , $\Delta \log(RER_t) = \log(RER_t / RER_{t-1})$ and RER_t denotes Rand/U.S. Dollar real exchange rate. This conditional variance is estimated by the simplest version of GARCH called GARCH (1, 1) proposed by Bollerslev (1986) given by:

$$h_t^2 = Var(\mu_t / \Omega_{t-1}) = \lambda_0 + \phi_1 \mu_{t-1}^2 + \delta_1 h_{t-1}^2 \tag{6}$$

where h_t^2 denotes the conditional variance of real exchange rate, and λ_0, ϕ_1 and δ_1 are the parameters to be estimated, μ_{t-1}^2 are the squared residuals generated from equation (5), called ARCH term and measures information about volatility in the previous period and where h_{t-1}^2 is the GARCH term representing the last period's forecast variance. This GARCH (1, 1) model states that the conditional variance of a time series is dependent upon the squared residuals of the process and has the advantage of including heteroskesticity into the estimation procedure of the conditional variance (as referenced by Choudhry, 2005).

The following inequality restrictions, $\lambda_0 > 0$, $\phi_1 > 0$, $\delta_1 > 0$ are imposed to ascertain that the conditional variance (h_t^2) from the GARCH (1,1) model is always positive. According to Choudhry (2005) the size and significance of ϕ_1 demonstrates the presence of ARCH process in the residuals (volatility clustering).

We adopt GARCH (1, 1) process because it is parsimonious since it has only three parameters in the conditional variance equation and is used quite often in academic finance literature as a result of its sufficiency in capturing volatility clustering. GARCH (1, 1) model also avoids overfitting and is less likely to breach non-negativity constraints (Brooks, 2002). The results from equation (6) may be interpreted as the exporters' prediction of the variance of the real exchange rate in the current period. Hence the predicted value of the conditional variance in equation (6) provides us with the measure of real exchange rate volatility of Rand against the U.S. dollar.

In this GARCH(1,1) model when $\phi_1 + \delta_1 < 0$ the variance process exhibits mean reversion to the unconditional expectation given by $\lambda_0 / (1 - \phi_1 - \lambda_1)$.If $\phi_1 + \delta_1 = 1$,this implies persistence of a forecast of the conditional variance over all finite horizons and infinite variance for the unconditional distribution of μ_t.That is to say the current shocks continue to exist indefinitely in conditioning the future variance and such a model is called Integrated –GARCH or IGARCH model. However as the sum of these two coefficients approaches unity this implies that the persistence of shocks to conditional variance (volatility) is greater and the rate of decay of the shock is slower (Choudhry, 2005).

Before estimating GARCH (1, 1) model, we first test for the presence of the ARCH effects in the real exchange rate process by using the LM-ARCH test. In testing for ARCH effects, we follow the normal procedure of collecting residuals from equation (5), square them and then regress them on q lags of their own. Then R^2 obtained from this regression is multiplied by the number of observations in order to construct the test statistic that is distributed as a chi-square. The decision rule for this test is such that if the value of the test statistic is greater than the critical value from chi-square distribution, the null hypothesis of no ARCH effects is rejected and vice-versa (Brooks, 2002).

The test for ARCH effects was carried on the basis of the residuals obtained from equation (5). Estimation results gave LM statistic and F-statistic of 3.67 and 3.68 respectively, both of which are very significant at 10 percent level suggesting the presence of ARCH effects in the real exchange rate series. This allows us to continue with the estimation of the GARCH (1, 1) process in equation (6). Estimation of GARCH (1, 1) model was done assuming student-t density distribution for the conditional distribution of the errors because the unconditional distribution of many financial time series such as exchange rates seems to have heavier tails than allowed by the normal distribution (Bollerslev, 1987). The results of the GARCH (1, 1) estimation are shown in table 1 in the Appendices. This model is significant, and the Wald test for the null that the coefficients are equal to zero is significantly rejected at 5 percent level. Therefore variability is time-varying and shocks are persistent. We also note that $\phi_1 + \delta_1$ is approximately equals to unity. Now suspecting that the process might be IGARCH(1,1), we tested the null hypothesis that $\phi_1 + \delta_1 = 1$ and results from the test suggested that the process is indeed IGARCH(1,1) implying non-stationarity in variance which has undesirable properties such as no convergence of the conditional variance forecast upon the long-term average value of the variance as the prediction horizon increases(Brooks,2002).

However Nelson (1990)[****], as referenced by Patterson (2000) and Hamilton (1994), states that this process is stationary in the sense that the conditional variance tends to unconditional (long-run) variance despite $\phi_1 + \delta_1 = 1$.Hence our GARCH (1, 1) process is stationary in the strict sense. Therefore we conclude that Rand to dollar real exchange rate follows the GARCH process and the conditional variance can be used as measure of exchange rate volatility (Kikuchu, 2004).

4.2 Preliminary Data Examination

In this study we plot all other variables except real exchange rate volatility in their logarithm forms and real exchange rate volatility in its level form against time in order to have an idea of how they behave as time progresses. Figures 1-5 in the appendices show the plots of these variables. We observe from these plots that only real exchange rate and its volatility indicate a change in the pattern of their movements. While real exchange

[****] Theorem 1 and 2

rate shows a change in pattern of movement since 2002 when it started to appreciate and correcting back to its long term trend after following a weakening trend, its volatility tends to show a change in pattern in 1998 when it fluctuated (showed a significant jump) after which it corrected to long term trend and then started to fluctuate again since 2002.

4.3 Unit Root Test Results

Testing for the stationarity of economic time series is crucial since standard econometric methodologies assume stationarity in the time series while they are, in fact, non-stationary and thus leading to inappropriate statistical tests and erroneous and misleading inferences. Despite the fact that ARDL bounds testing procedure adopted in this study does not necessarily require knowledge about the order of integration of the variables involved in the export equation, we need to check for the stationarity of each data series before undertaking any estimation. We employ Augmented Dickey Fuller (ADF) test which is based on the regression equation with the inclusion of a constant but no trend and regression equation with both constant and trend. Unit root test results are presented in table 1 below:

Table 1 ADF Unit Roots Test Results

Variables	ADF statistic	5% critical value
X_t	-1.5759	-2.8832
X_t^*	-1.4585	-2.8832
Y_t	-2.7147	-3.4440
Q_t	-2.1050	-2.8832
$V(h)_t$	-3.9393	-2.8835

Note: X_t^* denotes logarithm of real exports of good while X_t is the logarithm of total real exports. The lag order for the series was determined by Schwarz information criterion (SBC). All variables includes an intercept and Y_t includes an intercept and trend

Unit root test results in table 1 above indicate that all other variables; X_t, Y_t and Q_t are I(1) whereas $V(h)_t$ is I(0).This rules-out our suspicion that real exchange rate volatility is non-stationary and conforms with Nelson(1990)'s theorem that this process may still be considered stationary in a strict sense. The differences in the order of integration of the variables involved in the export model therefore justify why we have adopted ARDL bounds testing procedure advanced by Pesaran, et al. (2001).

4.4 Estimation of Error Correction Model (ECM)

Having undertaken unit root testing and found that ARDL bounds testing approach is appropriate, we use general-to-specific approach to estimate the ECM in equation (3) whereby we start with a maximum lag order of 18 and in each stage drop out all insignificant stationary regressors until the best specification is obtained. As we have earlier mentioned, a dummy variable was included in the equation to take into account bilateral trade agreement between South Africa and the U.S. which also plays an influential role in the growth of South African exports to the U.S. This dummy variable was given a value 'one' for the period 2001m1- 2007m2 and value 'zero' elsewhere. The estimation results of ECM model in equation (3) for both aggregate exports and goods exports models are presented in table 2 and 3 in the appendices. These results suggest that the ECM for both aggregate exports and goods exports models is correctly specified since all the diagnostic tests are satisfactory and the coefficients involved in the model are all statistically significant at 5 percent level.

4.5 Cointegration Analysis

Now that our ECM for both aggregate exports and goods exports models is adequately estimated, we proceed to employ ARDL bounds testing to test the null hypothesis that lagged levels of the variables involved in the ECM of both aggregate exports and goods exports models are jointly equal to zero. As we have earlier mentioned, this test is based on F-statistic which is non-standard and critical values are presented by Pesaran, et al.(2001) regardless of whether the variables are purely I(0) or purely I(1). The results for this test are presented in table 2 below:

Table 2: Variable Deletion test: Null of no Cointegration

	F-statistic	**Table CI(iv) K=3**	**Decision rule**
Aggregate exports ECM	25.54	(4.01,5.07)	Reject null
Goods exports ECM	27.84	(4.01,5.07)	Reject null

Note: Critical bound is based on 5 percent level

The results in table 2 above indicate that there exists a long-run relationship between exports (both aggregate and goods exports), and real exchange rate, its volatility, and foreign income. This is denoted by the F-statistics that are greater than the upper bounds and thus significantly rejecting the null hypothesis of no level relationship between these variables at 5 percent level.

The establishment of the long-run relationship among the variables involved in the export equations allows us to proceed with the estimation of the long-run parameters in equation (4) following a procedure advanced by Pesaran, et al.(2001) available in the Microfit software written by Pesaran and Pesaran(1997). Estimates of the long-run coefficients for both the aggregate exports and goods exports models are presented in table 3 below:

Table 3: Long-run Coefficients

Variables	**Aggregate exports model**		**Goods exports model**	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**
Y_t	1.97	2.6831[.008]	1.56	2.2306[.027]
Q_t	-0.14	-1.0866[.279]	-0.19	-1.4537[.148]
$V(h)_t$	-2.76	-2.2903[.024]	-2.50	-2.0331[.044]

Note: The numbers in parentheses next to the t-ratios are p-values

As reported in table 3 above all long-run coefficients (foreign income and real exchange rate volatility) except real exchange rate present the *a priori* expected signs that are statistically significant at 5 percent level. That is, foreign income bears a significant positive sign and has a coefficient of 1.97 and 1.56 for aggregate exports and goods exports models respectively. For aggregate exports model this implies that an elasticity of aggregate South African exports with respect to foreign income is 1.97(a 1 percent increase in foreign income leads to 1.97 percent increase in aggregate South African exports to the U.S.).For goods exports model, it implies that a 1 percent increase in foreign income increases South African goods exports to the U.S. by 1.56 percent.

We observe that for both aggregate exports and goods exports models the long-run income elasticities are greater than unity and these values for these income elasticities are consistent with estimates obtained by other studies in terms of the positive sign. Riedel (1988) maintains that in aggregate or single country export demand estimations for both developed and less developed countries, the coefficients of income elasticities generally lie between 2.0 and 4.0. However in our case these income elasticities for aggregate exports and goods exports models are less than 2. If these income elasticities were relatively high in magnitude, then several explanations could be made. According to Adler (1970) different elasticities of income reflect the degree to which exports have been adapted to the local tastes of the importing country, where higher income elasticity indicates greater adaption. On the other hand, Riedel (1988, 1989) conjectured that higher income elasticities reflect insufficient treatment of supply of exports.

A significant negative coefficient,-2.76, for real exchange rate volatility in the case of aggregate exports model implies that an absolute 1 percent increase in the variability of the Rand per Dollar real exchange rate reduces aggregate South African exports to the U.S by 2.76 percent. In the case of the goods exports model, a significant negative coefficient of -2.50 for real exchange rate volatility has the implication that an absolute 1 percent increase in the volatility of the Rand per U.S. Dollar real exchange rate decreases South African goods exports to the U.S. by 2.50 percent.

The observed negative impact of real exchange rate volatility on South African exports to the U.S. is consistent with findings of Bah and Amusa (2003) and Aziakpono, et al. (2005).This negative variability effect supports the hypothesis that South Africa exporters are risk-averse and hence they tend to reduce their exports to international markets (U.S.) and produce more for domestic market in order to secure relatively certain profits rather than uncovered profits which are subject to exchange rate fluctuations. According to Doroodian (1999), this may be attributed to lack of well-developed hedging facilities and institutions in South Africa that can protect exporters against exchange risk.

Now from the policy perspective, while South Africa needs to maintain competitive exchange rate in order to sustain its exports performance, it cannot ignore real exchange rate variability of the Rand in relation to policies that aim at enhancing its exports performance and overall macroeconomic stability. Therefore, South African policy-makers should enact intervention policies that aim at reducing excessive variability of real exchange rate of the Rand in order to improve its export sector and economic growth, and overall external macroeconomic stability (Kihangire, 2004).

The coefficients, -0.14 and -0.19, on relative prices for both aggregate exports and goods exports models, respectively, bear wrong negative signs and are statistically insignificant at conventional level of significance. This is surprising because we expected *a priori* that these coefficients would have significant positive signs implying that depreciation of Rand to dollar real exchange rate increases South African exports to the U.S.

4.6 Short-Run Dynamics

According to the presentation theorem of Angel and Granger, the existence of the long-run relationship between variables implies existence of short-run error correction relationship associated with them. As stated by Aziakpono, et al. (2005) such a relationship represents an adjustment process by which the deviated actual export is anticipated to adjust back to its long-run equilibrium path, and thus reflecting the dynamics that exists between real exports and its major determinants.

As reported in table 7 in the appendices the coefficients of error correction term,-0.8707 and -0.8671 for aggregate exports and goods exports models respectively, are negative and statistically significant as expected *a priori* and are therefore supportive of the validity of the long-run equilibrium relationship between the variables. These coefficients are very large suggesting a quick adjustment process and indicate what proportion of the disequilibrium is corrected each month. For instance, in both aggregate exports and goods exports models the coefficients imply that about 87 percent of the disequilibrium of the previous month's shock adjusts back to equilibrium in the current month.

To sum up, we conclude that the established negative relationship between real exchange rate volatility and South African exports to the United States indicates that GARCH class models can capture volatility correctly and can therefore act as a good measure of volatility.

5.CONCLUSION AND POLICY IMPLICATIONS

One of the principal concerns since the flexible exchange rate regime was introduced has been whether the increase in exchange rate volatility has impacted on trade. In this research paper, we examined the impact of real exchange rate variability on South African exports to the U.S. using both aggregate and disaggregated monthly data over the South Africa's floating period January 1995 –February 2007.In measuring real exchange rate variability of the Rand against the U.S. dollar, we employed GARCH (1, 1) model advanced by Bollerslev (1986).

After undertaking careful unit root testing and finding that all other variables except real exchange rate volatility are I (1), we applied ARDL- bounds testing approach advanced by Pesaran, et al. (2001) to study existence of long-run relationship between real exports, on one hand and its determinants, that is foreign income, relative prices and real exchange rate volatility, on the other hand. The derived empirical results provide evidence of a significant cointegrating level relationship between exports and the explanatory variables involved in the export function. In addition, estimated long-run elasticities, with an exception of the elasticity for relative prices, are consistent with the predictions of economic theory. In particular the long-run elasticity of foreign income indicates that an increase in income of the South African trading partner, the U.S., leads to exports growth. The negative long-run elasticity of real exchange rate volatility implies that a rise in real exchange rate volatility has an adverse effect on exports. Relative prices proxied by real exchange rate are found to have insignificant negative effect on exports. This is, in fact, surprising because according to economic theory an increase in relative prices (depreciation of real exchange rates) is expected to have positive effect on exports. This long-run relationship is substantiated by the short-run estimates of the error correction model which are negative and statistically significant. The ECM coefficient in each case implies that about 87 percent of the disequilibrium of the previous month's shock adjusts back to equilibrium in the current month.

What are the policy implications that can be drawn from this study? The obtained detrimental effect of exchange rate volatility on exports implies that the government of South Africa has to look for intervention policies targeting at minimising the excessive volatility of the Rand. Following a relatively successful approach adopted by Malaysia in tackling its volatility during the Asian crises in 1998,a proposition can be made that South African authorities might find it appropriate to impose the Tobin tax on foreign exchange transactions(Bah & Amusa,2003).The advocates of Tobin tax policy argue that such policy reduces profits of short-term speculation by discouraging short-term speculative capital and therefore makes exchange rates to better reflect long-term factors in the economy. In addition to that South African government via its apex monetary policy body, the SARB, in formulating its policy statements particularly those policies related to exchange controls and exchange rate policy ' should be wary of sending signals that encourage external investors adopting negative sentiments towards the domestic financial market'(see Bah & Amusa,2003,p.17).

Since the results also suggests that South African exporters are risk-averse because they tend to reduce their exports to international markets and instead produce more for domestic in order to secure relatively certain profits rather than uncovered profits which are subject to exchange rate fluctuations, then this implies that South Africa should also consider developing well-developed hedging facilities and institutions that can protect its exporters against exchange risk.

Furthermore, the current objective of South Africa in ensuring sustainable economic growth through increased exports should be substantiated by a stable and competitive exchange rate, viable fiscal and monetary policies as well as structural reforms that contribute to decline in per unit cost of production and the improvement in international competitiveness of South African exporters.

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APPENDICES

Table 1: Estimates of the GARCH (1, 1) model

	α_0	∂_1	λ_0	ϕ_1	δ_1
GARCH(1,1)	0.00266 (1.2845)	0.2823 (2.9538)	0.1175E-3	0.4183	0.5734

Note: The number in parentheses below coefficient is the t-ratio statistic. The degrees of freedom of t-distribution of the and GARCH (1, 1) is 4.9350

Table 2: Estimation results of the Error Correction Model (ECM) model

Aggregate export ECM **Dependent variable=** dX_t			**Goods exports ECM** **Dependent variable=** dX_t^*	
Regressors	**Coefficient**	**T-ratio**	**Coefficient**	**T-ratio**
Intercept	-6.6245	-2.4861	-4.9489	-2.0106
Trend	0.0029	1.4400	0.0031	1.4897
X_{t-1}	-0.8707	-10.0277	-0.8671	-10.4874
Y_{t-1}	1.7109	2.6228	1.3522	2.2005
Q_{t-1}	-0.1201	-1.0841	-0.1638	-1.4477
$V(h)_{t-1}$	-2.4050	-2.2725	-2.1657	-2.0212
$D2000$	-0.0663	-0.7595	-0.0779	-0.8717
dX_{t-18}	0.1453	2.2249		

Note: X_t^* denotes logarithm of real exports of goods

Table 3: Measure of goodness of fit and diagnostic tests (LM version

Aggregate exports ECM **Dependent variable=** dX_t		**Goods exports ECM** **Dependent variable=** dX_t^*
R-Squared	0.50	0.45
χ^2_{SC}	18.5210(.101)	17.0535(.143)
χ^2_H	0.2557(.613)	0.9887(.320)
χ^2_{FF}	0.2981(.585)	0.4399(.507)
χ^2_N	2.7517(.253)	1.6994(.428)
F-test	16.7694(.000)	18.5658(.000)

Notes: χ^2_{SC} , χ^2_H , χ^2_{FF} and χ^2_N denote LM tests for serial correlation, heteroskedasticity; Ramsey's RESET test and normality test respectively. Figures in parentheses are the associated p-values.

Figure 1: The plot of X (Log of real aggregate exports)

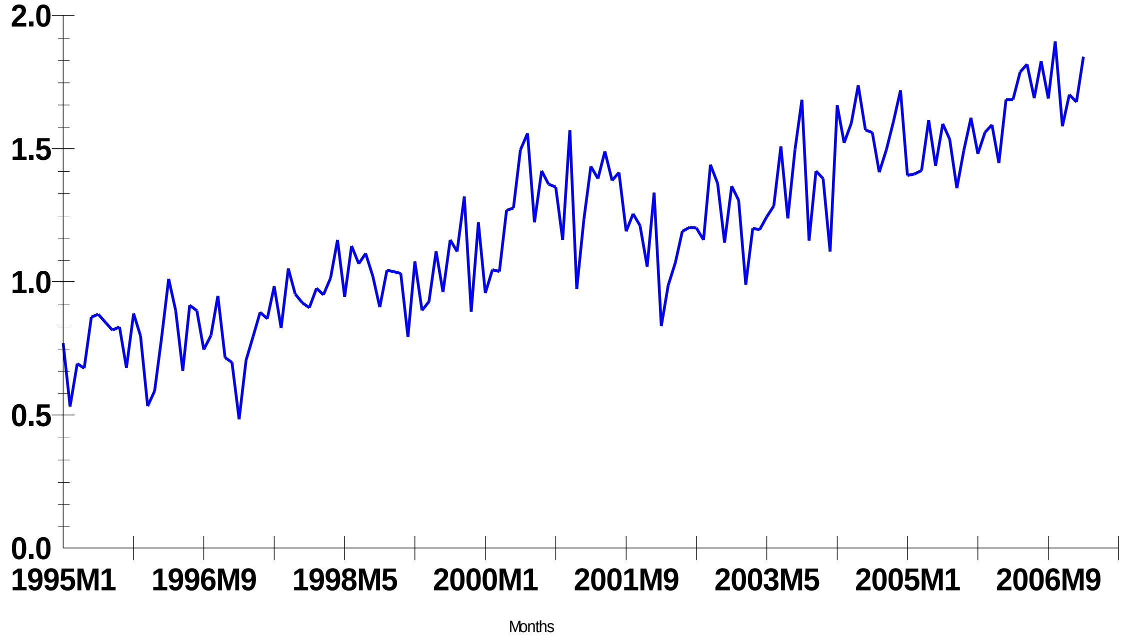

Figure 2: The plot of X (log of real goods exports)

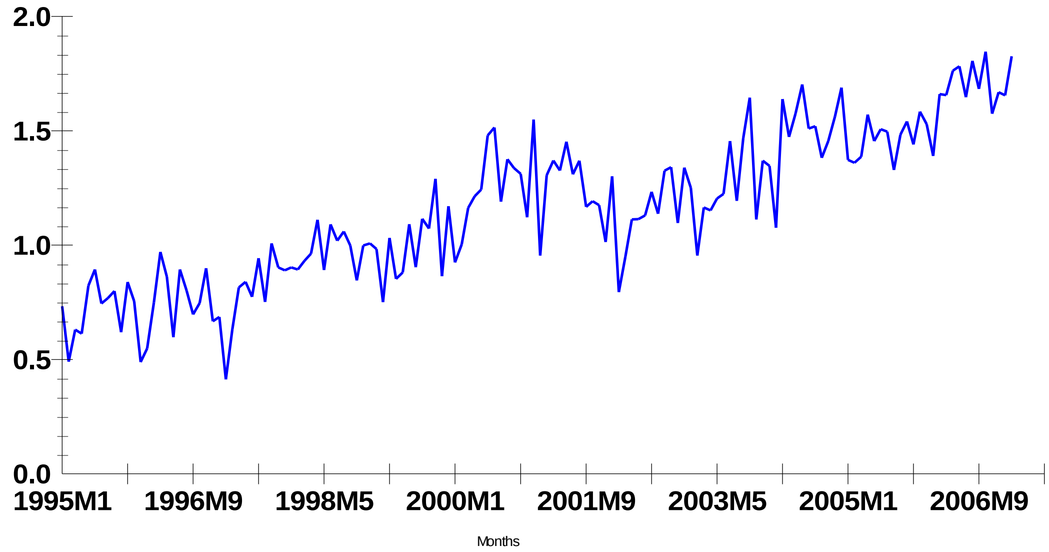

Figure 3:The plot of Y (Log of foreign income)

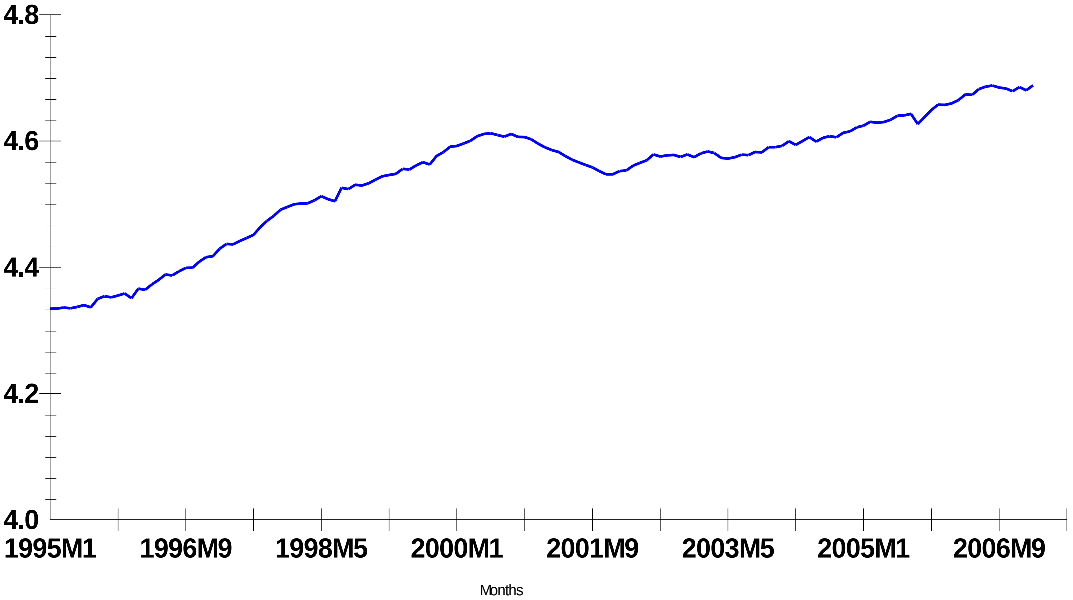

Figure 4: The plot of Q (Log of real exchange rate)

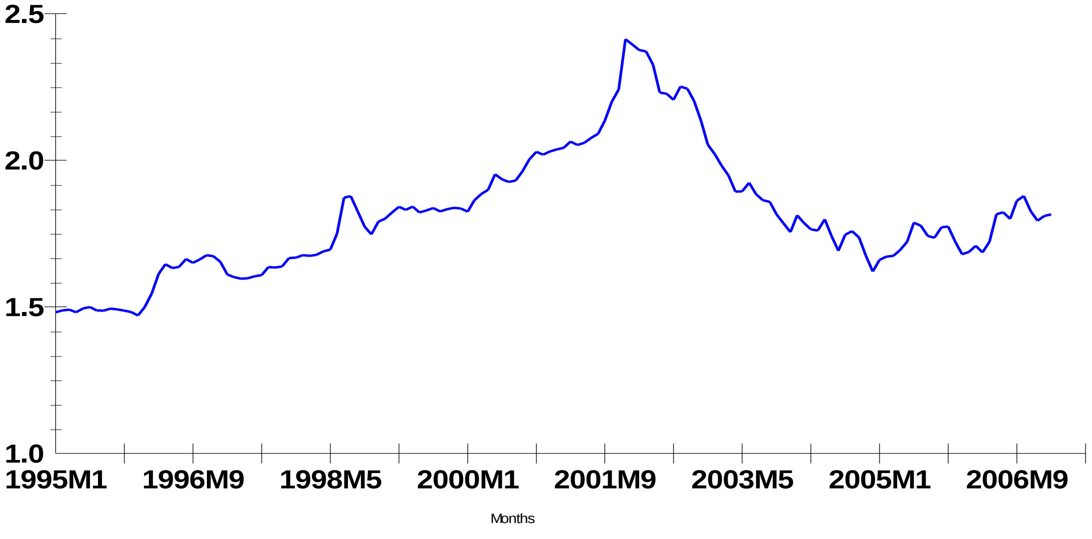

Figure 5: The plot of V (h) (Real exchange rate volatility)