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The Impact of Exchange Rate Volatility on Trade Flows: New Evidence from South Africa

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This paper empirically investigates the impact of exchange rate volatility on trade in the context of South African exports to China by means of ARDL bounds testing procedure to cointegration developed by Pesaran, et al. (2001). Several alternative measures of short-term exchange rate risk were employed in which we selected for each equation, the 'optimal' ZAR/CYN volatility measure on the basis of relevant model selection criteria. Using both monthly and quarterly data disaggregated by sectors for the period 1992M1 to 2010M7 and 1995Q1 to 2010Q3 respectively, our results indicate that South African exports to China, at aggregate level, are generally income inelastic, relative price elastic, and largely unaffected by short-term exchange rate volatility. However, when data are disaggregated by sector, the demand for South African exports tends to be income elastic; and in the case where a significant relationship exists between exchange rate volatility and exports, such a relationship is either positive or negative. These results can be generalized to how ZAR/USD volatility impacts on South African-China trade.

Keywords: Exchange rate volatility, ARDL bounds tests, MASD, ARCH, EGARCH, Cointegration

JEL Classification: F14, F17 and F31

1. Introduction

Owing to the enormous importance of the potential impact of exchange rate risk on international trade, it is not surprising that the analysis of the nature and magnitude of the relationship between exchange rate volatility and exports remains a subject of key empirical concern to economists. After the collapse of the Bretton Woods system of fixed exchange rates in 1973, South Africa amongst several other 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 rate regimes despite 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 and empirical debate regarding the impact of exchange rate variability on foreign trade (Johnson, 1969; Kihangire, 2004).

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For instance, it is commonly believed that high exchange rate volatility leads to high uncertainty which eventually increases the trading risk. As a matter of fact, the literature of exchange rate volatility contains a lot of inconsistent theoretical results. Hooper and Kohlhagen (1978), Clark (1973), etc. have been cited as theoretical studies with conclusion that volatility decreases trade. These economists believe that one reason why this may occur is because of imperfect markets situation especially in less developed countries.

Contrary to this conclusion, some other theoretical models show that high exchange rate volatility (to the extent that it increases risk) should increase trade. Aziakpono, et al. (2005), believes that this may occur 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 maximize their revenues. 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

According to De Vita and Abbott (2004), the lack of a clear and consistent pattern of results resonates with a number of contentious issues that the empirical literature has brought to the fore. The first of these issues relates to the specification of the exchange rate volatility measure to be adopted and, in particular, over whether such a measure should be based on the nominal or the real exchange rate. Whilst it can be argued that the nominal series better captures the volatility driven uncertainty faced by exporters (Bini-Smaghi, 1991), it has also been suggested that because of the offsetting role that movements in costs and prices play with respect to fluctuations in the nominal exchange rate, the real exchange rate is the most appropriate measure (Gotur, 1985).

A second question concerns the statistical technique to be used to generate estimates of exchange rate volatility. Early studies employed the sample standard deviation of the exchange rate (see, for example, Akhtar and Hilton, 1984), a measure subsequently criticised because the statistical distribution of the exchange rate may be non-normal (Boothe and Glassman, 1987). The most common approach adopted in later work has involved the moving average standard deviation of the growth of the exchange rate (see Arize et al., 2000) The use of the moving average formulation, however, has also been questioned (see Arize, 1997) since it is likely to underestimate the effect of exchange rate risk, allows for an ad hoc specification of the order of the moving average process and, unlike conditional volatility models such as ARCH (Engle, 1982), is inconsistent with the rational behavior of economic agents. Evidently, despite the abundance of research, there is still no consensus on what technique should be used to construct the optimal exchange rate volatility measure. Given the many alternatives available, there is clearly a scope for considering and comparing multiple definitions.

Another contentious issue relates to the time series properties of the regressors included in the estimated export function. Most of the early studies ignored the need for investigating the order of integration of relevant variables and used standard OLS regressions under the erroneous assumption of stationarity of all the series. In the presence of nonstationarity, the Johansen cointegration procedure (Johansen, 1988, 1991) allows testing for the existence of a long-run relationship but it does so under the equally restrictive assumption that all the variables entering the model are integrated of order one, or I(1). Yet, the few studies that have investigated the time-series properties of relevant regressors have produced conflicting inferences. For example, while Arize (1995, 1997) and Aristotelous (2001) found that the exchange rate volatility series was the realisation of a stochastic process containing a unit root, Kroner and Lastrapes (1993) found the volatility measure to be stationary, thus making conventional cointegration tests unreliable.

A further concern is that most of the empirical work on the effect of volatility on exports has made use of aggregate trade data.[1] As noted by Bini-Smaghi (1991), data aggregation constrains the volatility estimates to be similar across countries, and indeed sectors of the economy. It follows that, as suggested by McKenzie (1999), the effect of exchange rate volatility should be tested in the context of disaggregated export markets, and making use of sector-specific data.

As an open and middle income country in Sub-Saharan Africa, 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 against the Chinese RMB to the lowest level in January 2002 and has experienced a sharp appreciation henceforth therefore subjecting South African importers and exporters to uncertainty regarding their payments and receipts in home currency terms.

Nevertheless, South Africa considers exchange rate as a key macroeconomic policy instrument that ensures export promotion and economic growth. The South African Reserve Bank 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 outward-looking trade policy ensured export growth that lead to long-term economic growth. The increased liberalization 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. As a result, the ratio of exports to GDP has accelerated substantially from 7.38% in 1993 to about 35.1% in 2008 as shown in Figure 2 of the appendix.

Given the problem of volatility of the South African Currency to the Chinese yuan, the objective and purpose of this study is to investigate how the volatile Rand affects South Africa-China trade. In estimating the relationship between exchange rate volatility and exports, the approach followed in our study is somehow close to that of Todani and Munyama (2005) and Sekantsi (2007), which adapts the empirical framework of De Vita and Abbott (2004). This framework involves estimating an encompassing equation linking exchange rate volatility (and other variables) to export performance making use of cointegration analysis. While cointegration procedures used in previous studies are only applicable when the regressors entering the determination of the dependent variable are all I(1), the recently developed ARDL bounds testing approach to cointegration (Pesaran et al., 2001) that we employ is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1) or mutually cointegrated. Given the uncertainty concerning the order of integration of the volatility measure, we consider this econometric procedure to be the most appropriate in this context. Our paper is different from previous papers in several ways:

First, our paper focuses on exports in terms of the Chinese market. Given the importance of exports to the growth of the South African economy, this market is worth considering since in fact China has taken over the United States to become South Africa's largest regional trading partner (for both imports and exports) since October 2009.

Second, this study makes use of 'optimal volatility measures' using both nominal and real exchange rates. As was earlier mentioned, this is an important factor in addressing some of the contentious issues and gaps in the literature of exchange rate volatility and exports.

Third, we make use of both market disaggregated data (in this case Chinese market) and sector disaggregated data (export by chapters), thus avoiding the pitfalls of data aggregation outlined earlier. We also pay special attention to sample period selection, for exchange rate regime switches as well as changes in the structure of trade, and the way in which trade data are compiled, represent important sources of potential bias.

Fourth, our study goes beyond investigating the long-run and short-run relationships between exports and their determinants by employing the CUSUM and CUSUM of Squares tests. These tests are necessary for establishing whether the regressors are in fact long-run forcing, and hence confirm the uniqueness and stability of the cointegrating relations.

Finally, we gauge the impact of exchange rate volatility on South African exports to China by using the fitted values for export volumes accounted for by the $\beta_3 V(h)_t$ component of (1), to reestimate the volume of exports that would have taken place had exchange rate volatility not been present. This analysis is important as it helps to test the robustness of our results.

The rest of this paper is organized as follows: Section 2 reviews the related literature. In Section 3, the methodology and estimation technique is explained. Section 4 presents our empirical results and analysis. In Section 5, we summarize and conclude the work providing some policy implication and direction for future research.

2. Literature Review

The literature of exchange rates volatility and trade is diverse. A lot of studies on this subject have been conducted internationally both theoretically and empirically. Over the years, two popular approaches have emerged. One approach is to estimate a simple export demand equation generally with real exports as a dependent variable and exchange rate volatility together with relative prices and a measure of economic activity variable as regressors. The other approach is to use the so-called gravity equation models, which explain bilateral trade flows between countries as depending positively on the product of their GDPs and negatively on their geographical distance from each other. We will however consider the empirical literature.

The impact of exchange rate volatility on trade has been studied more in industrialized countries than in developing or emerging market economies. In the context of South Africa, such a relationship is still unknown perhaps because of the research vacuum in this area. The few conducted studies, all undertaken in the context of co-integration are summarized below:

The first research in this area was conducted by Bah and Amusi (2003). They 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 – 2000 and found that the Rand's real exchange rate variability exerts a significant and negative impact on exports both in the long and short-run.

A similar study by Azaikpono, et al. (2005) extends the work of Bah and Amusa (2003) over the period 1992 to 2004 by employing EGARCH method proposed by Nelson (1991) as a measure of variability of exchange rate. His results boil down to those reached by Bah and Amusi (2003). However, another study by

Todani and Munyama (2005) used 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. They used the moving average standard deviation and GARCH (1, 1) as measures of variability. Their 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.

Sekantsi indicated that real exchange rate volatility exerts a significant and negative impact on South Africa's exports to the United States.

In this paper, we investigate the impact of exchange rate volatility on South African-China trade making use of the ARDL bounds testing approach to cointegration. Unlike most of the empirical literature discussed above, our study takes into consideration several controversial issues which include but not limited to: specification of the exchange rate volatility measure, statistical technique used in generating estimates of exchange rate volatility, time series properties of the regressors, data aggregation, etc.

3. Methodology and Estimation Technique

3.1 Model Specification

Based on standard trade theory, we adopt the two-country model of international trade specified as follows:

$$X_t = \beta_0 + \beta_1 Y_t + \beta_2 U_t + \beta_3 V(h)_t + \varepsilon_t \quad (1)$$

Where $X_t = \frac{XVAL_t}{XU_t}$ is the natural logarithm of South Africa's export volume[2] (export value divided by export price), $Y_t = \frac{YN_t}{CPI_t}$ denotes the natural logarithm of real foreign income proxied by Chinese industrial production since GDP data are not available at monthly frequency (nominal foreign income divided by Chinese CPI) and is used as an indicator of demand for South African exports, U_t denotes relative prices which act as an indicator of external competitiveness and is measured as a logarithm of real exchange rate, $V(h)_t$ is the measure of exchange rate volatility and measures uncertainty/risk associated with exchange rate fluctuations, , β_0 and ε_t are intercept parameter and stochastic error term respectively.

Economic theory dictates that β_1 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. Trade theory is not clear about the sign of β_3 , which is the main basis for this empirical research.

3.2 Data Sources & Variable Definitions

Since switches in exchange rate regime may lead to a change in the structure of trade and are likely to have a distorting effect on the exchange rate volatility measure (Aristotelous, 2001), our sample period focuses exclusively on the most recent freely-floating exchange rate regime using both monthly and quarterly data. The monthly data (used for estimating aggregate export equation) cover the South African floating period 1992M1 to 2010M7 while the quarterly data (used for estimating export by chapter[3] equations) cover the period 1995Q1 to 2010Q3. The data for this study are taken from:

Database base of the South African Dept. of Trade & Industry, Database of the South African Reserve Bank, National Bureau of Statistics of China, zhong jing wang,

3.3 Volatility Modeling

Here, we embark on modeling exchange rate volatility since it can not be observed directly. Given the numerous contentious issues in the literature as to which method is appropriate for modeling volatility, we experiment with several alternative measures of exchange rate volatility as proxies for exchange rate risk. To also answer the question of whether the nominal rate or real rate is better, we use both of these for each measure.

Standard Deviation Moving Average

First, we use time-varying measures of volatility constructed by the moving average standard deviation of the changes in the nominal (N-MASD) and real exchange rate (R-MASD) as given by the formula:

$$V(h)_{t_1} = \left[1/m\sum_{i=1}^{m}(e_{t+i-1} - e_{t+i-2})^2\right]^{1/2} \quad (2)$$

Where $V(h)_{t_1}$ is the volatility at time t, m denotes the order of the moving average, and e_t is the natural logarithm of the ZAR/CYN exchange rate

In order to obtain the optimal lag structure of the moving average for both real ZAR/CYN and nominal ZAR/CYN, we estimated alternative dynamic specifications with m set equal to 2, 4, 6 and 8, and then selected, for each equation, the order of the moving average which yielded the highest values of both the Akaike Information Criterion (AIC).

Autoregressive Conditional Heteroskedasticity (ARCH) Model

As a second measure of volatility, we use the following Conditional Heteroscedasticity models (introduced by Engle, 1982) to model the conditional variance of both the nominal ZAR/CYN and real ZAR/CYN exchange rates.

$$\Delta e_t = \omega_0 + \sum_{i=1}^{n}\omega_i \Delta e_{t-i} + u_t \quad (3)$$

$$V(h)_{t_2} = Var(u_t / \Omega_{t-1} = \alpha_0 + \sum_{j=1}^{q}\alpha_j u_{t-j}^2 \quad (4)$$

Where Δe_t = 100*[log (e_t / e_{t-1})] and e_t is the ZAR/CYN exchange rate, ω_0 is a constant, ω_i is a coefficient, $V(h)_{t_2}$ denotes the conditional variance of the ZAR/CYN exchange rate, α_0, and α_j are the parameters to be estimated, u_{t-j}^2 are the squared residuals generated from equation (3), called the ARCH term and measures information about volatility in the previous period.

The ARCH process estimates exchange rate volatility as a conditional variance using an AR (q) process of the squared estimated residuals from (3). In doing so it allows volatility clustering, so that for example large variances in the past generate large variances in the future. Equations (3) and (4) are estimated simultaneously using maximum likelihood estimation. Both α_0 and α_j are assumed to be positive, with $0 < \alpha_j < 1$, so that the conditional variance is a stationary process. The value of n is set to ensure an absence of serial correlation in the estimated residuals[4] of (3). The value of q is selected on the basis of the highest significant lag order.

Exponential Generalized Autoregressive Heteroskedasticity (EGARCH) Model

Finally, we employ the E-GARCH (1, 1) model proposed by Nelson, 1991, as specified below:

$$\Delta e_t = \omega_0 + \sum_{i=1}^{n} \omega_i \Delta e_{t-i} + u_t$$

(5)

$$V(h)_{t_3} = \exp[\alpha_0 + \beta \log(\delta_{t-1}^2) + \theta \left| \frac{\varepsilon_{t-1}}{\sqrt{\delta_{t-1}^2}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\delta_{t-1}^2}}]$$

(6) Where $V(h)_{t_3}$ is the conditional variance of the ZAR/CYN exchange rate, ε_{t-1} are the residuals derived from equation (5) and α_0, β, θ and γ are parameters to be estimated. ε_{t-1} represents the ARCH term, while δ_{t-1}^2 is the GARCH term representing last period's forecasted variance.

This model has several advantages over the pure GARCH specification. First, since log($V(h)_t$) is modeled, then even if the parameters are negative, $V(h)_t$ would be positive, hence there would be no violation of the non-negativity condition. Second, asymmetries are allowed for under the E-GARCH formulation, since if the relationship between volatility and exports is negative, γ would be negative (Brooks, 2002). As in the ARCH process, equations (5) and (6) are estimated simultaneously assuming a generalized error distribution (GED) as was originally assumed by Nelson.

3.4 Selection of Optimal Volatility Measures

In order to formally compare the performance of the various exchange rate volatility measures, we re-estimated each export equation as an error-correction model using the different proxies, (N-MASD, R-MASD, N-ARCH, R-ARCH, N-EGARCH, R-EGARCH), and then selected the optimal one on the basis of the following model selection criteria:

$$AIC(M_1 : M_2) = LL_1 - LL_2 - (K_1 - K_2)$$

(7)

$$SBC(M_1 : M_2) = LL_1 - LL_2 - \frac{1}{2}(K_1 - K_2)\log(n)$$

(8)

where AIC and SBC are the Akaike Information and Schwarz Bayesian criteria, M_1 and M_2 are models 1 and 2, LL_1 and LL_2 are the values of their maximized log-likelihood function respectively, K is the number of regressors, and n denotes the number of observations. If $AIC > 0$ and $SBC > 0$ then M_1 is preferred to M_2, otherwise M_2 is chosen as the optimal model. For each estimated equation, the non-nested testing sequence followed a five-stage process. First, the export ECM for the N-MASD volatility measure (M_1) was tested against the ECM for the R-MASD formulation (M_2).In the second stage, the ECM using the N. ARCH model was tested against the ECM using the R. ARCH proxy. For the third stage, the ECM using the N-EGARCH was tested against the ECM using the R-EGARCH formulation. As for the fourth stage, the preferred model from the first stage was tested against the preferred model from the second stage. Finally, the preferred model from the fourth stage was tested against the preferred model from the third stage so as to obtain an optimal measure of exchange rate volatility for each case.

3.5 Autoregressive Distributed Lag (ARDL) Bounds Tests Approach

The two principal approaches to cointegration analysis, the Engle and Granger (1987) two-step residual-based procedure and the Johansen (1988, 1991) maximum likelihood reduced-rank approach, both require a certain degree of pre-testing to ascertain that all the explanatory variables are integrated of order one, or I(1). This is necessary because in the presence of a mixture of I(0) and I(1) regressors, standard statistical inference based on conventional cointegration tests is no longer vaild.

Even though our concern is to establish consistency of parameter estimates of (1), we must incorporate short-run dynamics into our testing procedure. Indeed, Laidler (1993, pp. 175-176) writes: “A complementary line of enquiry has investigated the possibility that some of the problems of instability in recent years have stemmed not from problems with the long-run function, but from inadequate modeling of the short-run dynamics characterizing departures from the long-run relationship.” With existing developments in time series modeling techniques, incorporating short-run dynamics into Equation (1) amounts to expressing (1) in an error-correcting format.

The ARDL bounds testing approach (Pesaran et al., 2001) employed in the present study was chosen because of the following reasons: First and foremost, this approach allows testing for the existence of a cointegrating relationship between variables in levels irrespective of whether the underlying regressors are I(0), I(1) or mutually cointegrated.[5] Second, the ARDL bonds testing procedure is simple. As opposed to other multivariate co-integration techniques, it allows the co-integration relationship to be estimated by OLS once the leg order of the model is identified. Finally, the bonds test is relatively more efficient in small or finite sample[6] data sizes as is the case in this study.

To carry out the bond testing approach, we model (1) into a conditional ARDL ECM as shown below:

$$\Delta X_t = \sum_{i=1}^{n} \alpha_i \Delta X_{t-i} + \sum_{j=0}^{m} \beta_j \Delta Y_{t-j} + \sum_{k=0}^{p} \delta_k \Delta U_{t-k} + \sum_{r=0}^{q} \phi_r \Delta V(h)_{t-r}$$
$$+ C_0 + C_1 t + \pi_1 X_{t-1} + \pi_2 Y_{t-1} + \pi_3 U_{t-1} + \pi_4 V(h)_{t-1} + \pi_5 D + \xi_t$$

(9)

where C_0 and $C_1 t$ denote the drift and trend components, ξ_t is the vector of white noise error process and all the other variables are the same as in (1). In the first stage, the dynamic structure of the first difference regressors is set to ensure an absence of serial correlation in the estimated residuals. Finally, we employ Akaike Information Criterion (AIC) for selecting the optimum number of lags on each variable. Yt, U_t, and $V(h)_t$ are regarded as long-run forcing[7] variables of X_t so that there is no feedback from level of X_t in (9). Given such assumption, it is presumed that the explanatory variables are not cointegrated among themselves and that, therefore, the size of the cointegrating space is restricted to unity (Vita and Abbott, 2004).

The null hypothesis of 'no cointegration' is tested using an F-statistic for the joint significance of the coefficients of the lagged levels in (9), so that H_0: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$. Two asymptotic critical value bounds provide a test for cointegration when the system's variables are I(*d*) (where 0 ≤*d* ≤ I): a lower value assuming only I(0) regressors, and an upper value assuming purely I(1) regressors. If the test statistic exceeds the upper critical value we can conclude that a long-run relationship exists. If the test statistic falls below the lower critical value we cannot reject the null hypothesis of 'no cointegration'. If the statistic falls within the respective bounds, inference would be 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. . Critical values are also made available to encompass a range of different deterministic components: 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.[8]

As suggested by Pesaran and Shin (1999), the conditional long-run model for X_t can be obtained from the reduced form solution of (9), when

$\Delta X = \Delta Y = \Delta U = \Delta V(h) = 0$ and (9) therefore reduces to:

$$X_t = \phi_1 + \phi_2 t + \phi_3 Y_t + \phi_4 U_t + \phi_5 V(h)_t + \mu_t \qquad (10)$$

where: $\phi_1 = -C_0 / \pi_1$, $\phi_2 = -C_1 / \pi_1$, $\phi_3 = -\pi_2 / \pi_1$, $\phi_4 = -\pi_3 / \pi_1$, $\phi_5 = -\pi_4 / \pi_1$ and the error process μ_t follows an IID (0, δ^2). The OLS estimates of the long run parameters (β_1, β_2 and β_3) are therefore given as: $\hat{\beta}_1 = \hat{\phi}_3 = -\hat{\pi}_2 / \hat{\pi}_1$, $\hat{\beta}_2 = -\hat{\phi}_4 = -\hat{\pi}_3 / \hat{\pi}_1$, $\hat{\beta}_3 = \hat{\phi}_5 = -\hat{\pi}_4 / \hat{\pi}_1$

4. Empirical Results and Analysis

As was previously stated, our sample period focuses exclusively on the most recent freely-floating exchange rate regime using both monthly and quarterly data. The monthly data cover the floating period 1992M1 to 2010M7 while the quarterly data cover the period 1995Q1 to 2010Q3.The equations for export volume were estimated for the South African aggregate exports as well as export by chapters individually.

To investigate the time series properties of the variables, unit root tests were computed for each of the series in the system. While the bounds test procedure allows regressors to be either I(0) or I(1), it is still necessary to ensure that the level of the dependent variable is I(1) and exclude the possibility that any of the regressors are I(2) or higher. 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. The ADF test results are presented in Table 1. For the most part, export volume appears to be I(1) in levels, and hence first difference stationary[9]. Both U_t and Y_t are also I(1). Most importantly, regardless of the volatility proxy employed, there is strong evidence in the data that exchange rate volatility is I(0). The null hypothesis of unit root is therefore rejected in all of the 114 cases considered. Hence, this rules-out our suspicion that real exchange rate volatility is non-stationary and conforms to Nelson's (1990) 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 justifies why we have adopted ARDL bounds testing procedure advanced by Pesaran, et al. (2001).

The results of the non-nested testing tournament carried out to select the most appropriate measure of volatility are reported in Table 2. The main point to be noted is that the optimal measure of volatility is not the same across South African exports by chapters.

The F-statistics for the bounds tests from the ARDL-ECM are reported in Tables 3. Relevant critical values (see Pesaran et al., 2001) were used to ascertain whether the null hypothesis of the absence of a level relationship between X_t and the regressors could be rejected or not. As can be seen from the table, the F-Statistic exceeds the 10% upper critical value in all except two[10] of the thirteen cases considered, thus providing strong evidence in favor of the existence of a co-integrating level relationship between export volumes and the regressors.

To establish whether the regressors were in fact long-run forcing, and hence confirm the uniqueness and stability of the cointegrating relations found, we apply the CUSUM[11] tests to the residuals of the bounds tests equations. As can be seen from Figure 1, the plot of CUSUM statistics stay within the critical bounds in all of the twelve cases except one[12], thus providing strong evidence of parameters stability in the export demand function.

The long-run estimates from the ARDL approach are shown in Tables 4, together with the lag structure for the short-run dynamics of the ARDL-ECM. As can be observed, this lag structure is the same as that used for the bounds test, which we chose to ensure an absence of serial correlation.[13]

For South African aggregate exports to China, using the 10% critical values, the coefficients of foreign income and relative prices are significant with foreign income having the expected sign while relative price bearing a wrong negative sign. This is surprising because we expected *a priori* that this coefficient would have significant with a positive sign implying that depreciation of Rand to Renmibi real exchange rate increases South African exports to China. It can be observed that income elasticity is less than unity. 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. The exchange rate volatility coefficient is negative but insignificant. The demand for South African exports would, therefore, appear to be income inelastic, relative price elastic, and largely unaffected by exchange rate volatility.

Despite some variations in the sign and magnitude of the coefficients across exports by chapters, the general results for aggregate South African exports to China are to a certain extent confirmed by the analysis of the disaggregated data. For each South

African export by chapter except Chp-1 and Chp-9, growth in foreign industrial production has a positive and significant influence on export demand. Economic growth in China appears to be particularly important for South African exports of rubber & plastics products (Chp-7) as well as precious or semi-precious stones & metals (Chp-14). The income elasticity is greater than unity in eight of the ten cases considered. Hence, when data are disaggregated, the demand for South African exports tends to be income elastic.

The estimated coefficient of the relative price variable is negative and significant in five of the ten cases considered. For four cases the price elasticity is insignificant with negative coefficients while for one cases an insignificant positive coefficient is found. With the exception of South African exports of live animals & animal products (Ch-1), where we find insignificant price elasticity with a magnitude less than unity, the disaggregated results appear to confirm that demand for South African exports is relative price elastic and wrongly bears a negative sign.

Most interestingly, the impact of exchange rate volatility on South African exports by chapters to China is significant in only four cases, showing a negative effect on exports of Chp-2, Chp-7 and Chp-11 and a positive effect on exports of Chp-18. For Chp-2, Chp-11 and Chp-18, the coefficients are greater than unity and less than unity for Chp-7. In all the other cases, the volatility coefficient is insignificant with a mix of positive and negative signs. Even though most of the coefficients are insignificant, the disaggregated data suggest that exchange rate volatility affects exports by chapters differently.

Given that South African exporters in these ‘Chapters’ have the same opportunities to hedge their exchange risk, the most likely explanation for these different reactions to exposure is that exporters in different ‘Chapters’, possibly due to different levels of openness to international trade, profitability, competition and insutry concentration, are not equally risk-averse. From the disaggregated data, two observations are worth considering: First, considering the number of insignificant coefficients (six out of ten), the disaggregated focus some how confirms the results of the analysis for South African aggregate exports. Second, in the case where a statistically significant relationship exists between exchange rate volatility and exports, such a relationship is either positive or negative.

In order to judge the impact of exchange rate volatility on South African exports to China and hence a test of robustness, using the fitted values for export volumes accounted for by the $\beta_3 V(h)_t$ component of (1), we also estimated the volume of exports that would have taken place had exchange rate volatility not been present. Since as we have shown, the optimal measure of exchange rate volatility and its impact on export volumes varies across chapters of exports, we calculated the average monthly potential gain (or loss) from elimination of exchange rate volatility for each case.[14] Even though most of the coefficients were insignificant, the estimates showed that the potential gain/loss of exports varies from 0.001% of the average monthly volume (Chp-2) to

Table 1: *Unit root tests*

South African aggregate exports and exports by chapters

Export	X_t	U_t	Y_t	N-MASD	m	R-MASD	m	N-ARCH	R-ARCH	N-EGARCH	REGARCH
				Volatility measures							
Agg.	-0.4	-2.6	1.0	-3.9**	6	-3.5**	6	-14.8**	-13.0**	-7.9**	-3.6**
	(-12.1**)	(-11.2^{t*})	(-3.2^{t**})	(-9.8**)		(-8.5**)		(-11.5**)	(-13.7**)	(-13.9**)	(-14.8**)
Ch-1	-1.5	-2.2	-0.8	-4.7**	8	-5.7**	2	-7.3**	-7.5**	-5.9**	-4.0**
	(-8.0**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-12.2**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-2	-0.4	-2.2	-0.8	-4.7**	8	-4.7**	4	-7.3**	-7.5**	-5.9**	-4.0**
	(-5.8**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-9.3**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-4	-1.3	-2.2	-0.8	-4.7**	8	-4.7**	8	-7.3**	-7.5**	-5.9**	-4.0**
	(-7.5**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-6.8**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-5	-0.4	-2.2	-0.8	-4.7**	8	-4.7**	8	-7.3**	-7.5**	-5.9**	-4.0**
	(-12.5**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-6.8**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-6	-1.2	-2.2	-0.8	-4.9	4	-4.7**	4	-7.3**	-7.5**	-5.9**	-4.0**
	(-9.1**)	(-7.3**)	(-1.8^{t})	(-10.0**)		(-9.3**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-7	-1.1	-2.2	-0.8	-3.9**	6	-4.7^{**-}	8	-7.3**	-7.5**	-5.9**	-4.0**
	(-14.8**)	(-7.3**)	(-1.8^{t})	(-9.8**)		(-6.8**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-8	-3.0	-2.2	-0.8	-6.3**	2	-5.7**	2	-7.3**	-7.5**	-5.9**	-4.0**
	(-14.7**)	(-7.3**)	(-1.8^{t})	(-13.1**)		(-12.2**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-9	-2.3	-2.2	-0.8	-3.9**	6	-3.3**	6	-7.3**	-7.5**	-5.9**	-4.0**
	(-10.7**)	(-7.3**)	(-1.8^{t})	(-9.8**)		(-8.5**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-10	-3.1**	-2.2	-0.8	-4.7**	8	-3.3**	6	-7.3**	-7.5**	-5.9**	-4.0**
	(-10.5**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-8.5**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-11	-11	-2.2	-0.8	-6.3**	2	-4.7**	4	-7.3**	-7.5**	-5.9**	-4.0**
	(-8.1**)	(-7.3**)	(-1.8^{t})	(-13.1**)		(-9.3**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-12	-5.8**	-2.2	-0.8	-3.9**	6	-3.3**	6	-7.3**	-7.5**	-5.9**	-4.0**
	(-8.4**)	(-7.3**)	(-1.8^{t})	(-9.8**)		(-8.5**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-13	-4.3**	-2.2	-0.8	-4.9	4	-4.7**	4	-7.3**	-7.5**	-5.9**	-4.0**
	(-11.2**)	(-7.3**)	(-1.8^{t})	(-10.0**)		(-9.3**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-14	-0.2	-2.2	-0.8	-6.3**	2	-3.3**	6	-7.3**	-7.5**	-5.9**	-4.0**
	(-4.9**)	(-7.3**)	(-1.8^{t})	(-13.1**)		(-8.5**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-15	-1.5	-2.2	-0.8	-3.9**	6	-4.7**	8	-7.3**	-7.5**	-5.9**	-4.0**
	(-12.8**)	(-7.3**)	(-1.8^{t})	(-9.8**)		(-6.8**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-16	-3.1**	-2.2	-0.8	-6.3**	2	-5.7**	2	-7.3**	-7.5**	-5.9**	-4.0**
	(-12.2**)	(-7.3**)	(-1.8^{t})	(-13.1**)		(-12.2**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-17	-5.0**	-2.2	-0.8	-4.7**	8	-4.7**	8	-7.3**	-7.5**	-5.9**	-4.0**
	(-11.3**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-6.8**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-18	-1.5	-2.2	-0.8	-4.9	4	-4.7**	4	-7.3**	-7.5**	-5.9**	-4.0**
	(-6.7**)	(-7.3**)	(-1.8^{t})	(-10.0**)		(-9.3**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)
Ch-20	-3.7**	-2.2	-0.8	-4.7**	8	-4.7**	8	-7.3**	-7.5**	-5.9**	-4.0**
	(-9.6**)	(-7.3**)	(-1.8^{t})	(-6.8**)		(-6.8**)		(-8.7**)	(-13.8**)	(-11.2**)	(-8.6**)

Notes: The ADF test for the first difference of each variable is shown in parentheses. ** denote the rejection of the null hypothesis of unit root at the 10% significance level using the Mackinnon (1996) critical values. *t* indicates a significant trend term. N-MASD (R-MASD) is the moving average standard deviation of the percentage changes in the nominal (real) exchange rate (m refers to the order of moving average process selected). N-ARCH (R-ARCH) is the autoregressive conditional heteroskedasticity volatility process based on a model of the percentage changes in the nominal (real) exchange rate. N-EGARCH (R-EGARCH) is the exponential to generalized autoregressive conditional heteroskedasticity volatility process of nominal (real) exchange rate. A full description of the various chapters is shown in Table 5 of Appendix A.

Table 2: Model selection criteria from non-nested testing

Export	Competing rounds between volatility measures				
Agg.	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. R-ARCH	R-ARCH vs. R- EGARCH
AIC	-0.713	-76.527	-5.738	-90.856	1.7
SBC	-0.883	-76.834	-5.738	-90.856	1.7
Ch-1	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. R-ARCH	R-ARCH vs. N-EGARCH
AIC & SBC	1.230	-1.614	1.581	-1.852	0.851
Ch-2	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. N-ARCH	R-MASD vs. N-EGARCH
AIC & SBC	-1.208	0.460	0.814	1.834	0.927
Ch-4	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. R-ARCH	R-ARCH vs. R- EGARCH
AIC & SBC	4.780	-0.664	-1.439	-0.089	-1.376
Ch-5	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. N-ARCH	N-MASD vs. N-EGARCH
AIC & SBC	0.367	1.085	0.369	0.644	1.705
Ch-6	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. R-ARCH	N-MASD vs. N-EGARCH
AIC & SBC	0.594	-278.330	29.887	1.108	12.975
Ch-7	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. R-ARCH	R-ARCH vs. R- EGARCH
AIC & SBC	0.320	-4.629	-0.720	-3.409	4.670
Ch-8	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. R-ARCH	N-MASD vs. R-EGARCH
AIC & SBC	1.724	-1.071	-1.417	0.808	-0.225
Ch-9	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. N-ARCH	R-MASD vs. N-EGARCH
AIC & SBC	-0.451	1.022	0.297	2.297	1.451
Ch-10	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. R-ARCH	R-ARCH vs. N-EGARCH
AIC & SBC	0.498	-0.811	0.764	-0.324	0.189
Ch-11	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARC	R-MASD vs. R-ARCH	R-MASD vs. R-EGARCH
AIC & SBC	-5.618	-8.599	-1.600	0.411	5.669
Ch-12	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. N-ARCH	N-MASD vs. N-EGARCH
AIC & SBC	0.053	0.276	1.619	0.296	-1.577
Ch-13	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. N-ARCH	R-MASD vs. R-EGARCH
AIC & SBC	-0.846	5.368	-2.427	-90.602	3.152
Ch-14	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. R-ARCH	R-MASD vs. N-EGARCH
AIC & SBC	-0.577	-0.118	0.411	0.628	0.491
Ch-15	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. R-ARCH	R-MASD vs. R-EGARCH
AIC & SBC	-2.060	-3.758	-4.484	1.566	-2.519
C-16	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. N-ARCH	N-MASD vs. N-EGARCH
AIC & SBC	0.596	3.376	2.934	-107.329	-0.413[
Ch-17	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. N-ARCH	N-MASD vs. N-EGARCH
AIC & SBC	2.761	1.990	5.816	2.623	-3.659
Ch-18	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	N-MASD vs. N-ARCH	N-MASD vs. N-EGARCH
AIC & SBC	2.391	0.516	1.271	2.989	2.090
Ch-20	N-MASD vs. R-MASD	N-ARCH vs. R-ARCH	N-EGARCH vs.R-EGARCH	R-MASD vs. R-ARCH	R-ARCH vs. R- EGARCH
AIC & SBC	-2.305	-2.396	-3.094	-0.843	-1.466

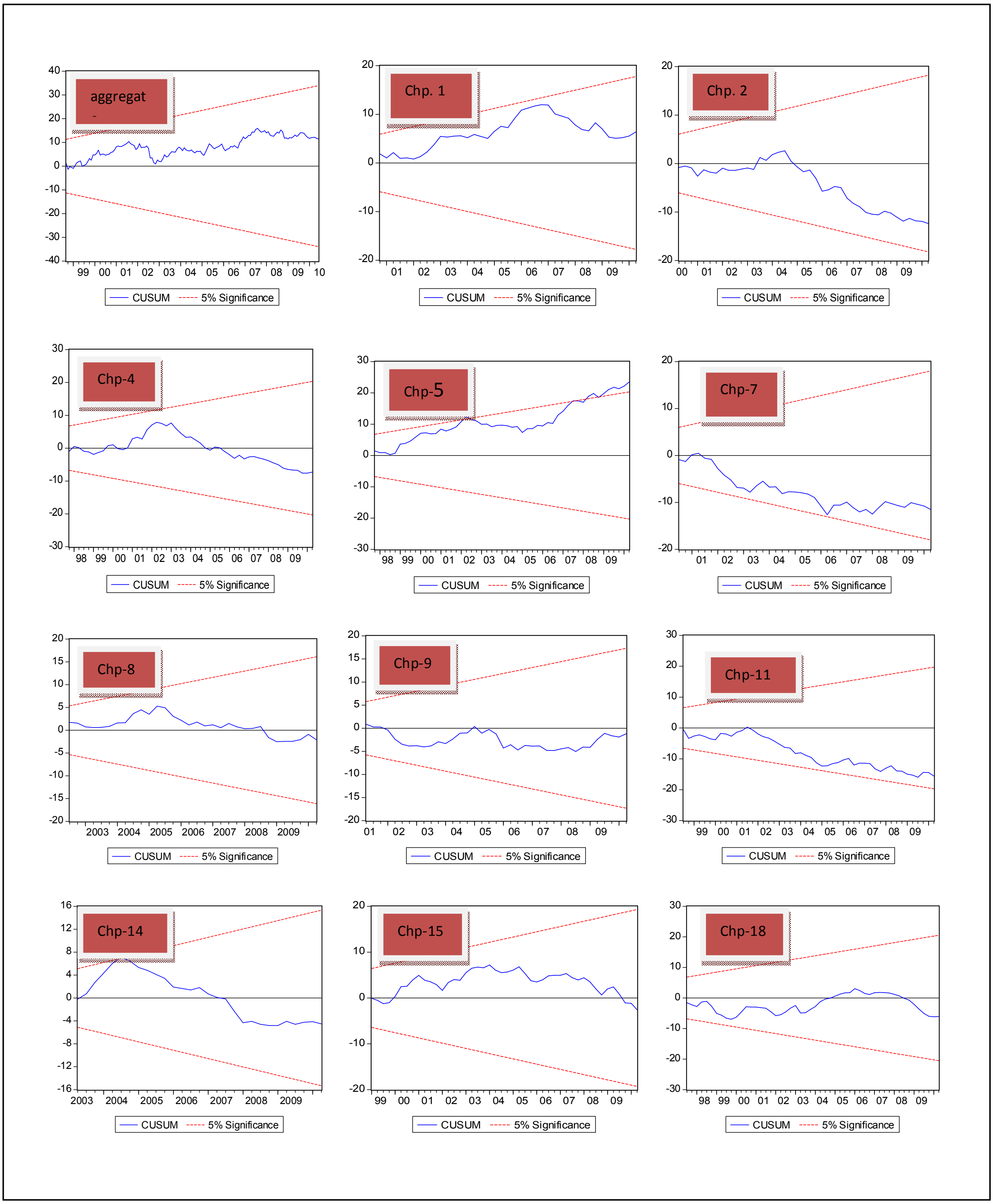
Notes: AIC and SBC are used for the choice between models M_1 (e.g. using N-MASD, N-ARCH, N-EGARCH) and M_2 (e.g. using R- MASD, R-ARCH, R-EGARCH). A positive value indicates that M_1 is preferred to M_2

Table 3: Bounds tests for South African aggregate exports and export by Chapters

Export (ARDL lag specification)	F-Statistic	Critical value bounds (10%)	Optimal volatility
Agg. (8,13,9,2)	3.584 [b]	(2.37, 3.20)	R-ARCH
Chp-1 (5,2,1,0)	6.130 [c]	(2.97, 3.74)	R-ARCH
Chp-2 (5,0,0,0)	4.816 [b]	(2.37, 3.20)	R-MASD
Chp-4 (1,0,0,0)	3.751 [b]	(2.37, 3.20)	R-EGARCH
Chp-5 (1,0,0,0)	6.304 [b]	(2.37, 3.20)	N-MASD
Chp-6 (5,3,0,0)	2.017 [b]	(2.37, 3.20)	N-MASD
Ch-7 (5,3,0,0)	5.087 [b]	(2.37, 3.20)	R-ARCH
Ch-8 (1,5,5,5)	3.114 [b]	(2.01, 3.20)	R-EGARCH
Chp-9 (5,4,0,0)	9.660 [b, d]	(2.37, 3.20)	R-MASD
Chp-11 (1,1,1,1)	8.134 [b]	(2.37, 3.20)	R-MASD
Chp-14 (4,2,2,2)	5.070 [b]	(2.37, 3.20)	R-MASD
Chp-15 (1,0,0,1)	4.794 [b, d]	(2.37, 3.20)	R-EGARCH
Chp-18 (1,0,0,0)	4.788[a]	(2.37, 3.10)	N-MASD

Notes: [a] Indicates that the ARDL-ECM was estimated without drift and trend. [b] Refers to the bounds tests for the restricted intercept and no trend case. [c] Refers to the bounds tests for the unrestricted intercept and restricted trend case. [d] Indicates that the ARDL-ECM was estimated with a dummy variable to allow for outlier observations in the series.

***Figure 1**: Plot of Cumulative Sum of Recursive Residuals (CUSUM Tests)*



Notes: the straight lines represent critical bonds at the 5% significance level.

Table 4: Long-run estimates for South African aggregate exports and exports by chapters using 'optimal' short-run measure of exchange rate volatility

Export (ARDL lag specification)	Intercept	Y	U	$V(h)$	X_{t-1}
Agg. (8,13,9,2)	2.015** (3.123)	0.554** (3.267)	-1.758** (-3-393)	-0.005 (-0.755)	-0.354** (-3.154)
Chp-1 (5,2,1,0)	48.598** (5.235)	-7.233** (-4.483)	-0.725 (-0.416)	-0.020 (-0.599)	-1.759** (-5.426)
Chp-2 (5,0,0,0)	10.812** (4.150)	1.730** (4.228)	-4.358** (-2.133)	-77.263** (-2.157)	-1.275** (-4.738)
Chp-4 (1,0,0,0)	5.164** (3.277)	1.512** (3.782)	-1.609 (-0.732)	-0.011 (-0.180)	-0.789** (-4.200)
Chp-5 (1,0,0,0)	10.271** (4.916)	1.592** (5.036)	-2.887* (-3.741)	1.014 (0.110)	-0.885** (-5.028)
Ch-7 (5,3,0,0)	4.898** (3.839)	4.757** (4.657)	-8.757** (-3.827)	-0.093** (-2.583)	-1.783** (-4.795)
Chp-9 (5,4,0,0)	8.139** (4.913)	-0.676** (-3.124)	-2.575 (-1.330)	27.004 (1.019)	-0.427** (-4.322)
Chp-11 (1,1,1,1)	7.382** (4.697)	1.042** (5.115)	-3.743** (-4.886)	-37.370** (-3.643)	-0.672** (-4.747)
Chp-14 (4,2,2,2)	-3.363** (-1.899)	5.657** (2.555)	4.90 (1.332)	64.458 (0.883)	-1.628** (-2.567)
Chp-15 (1,0,0,1)	4.586** (3.763)	0.542** (2.550)	-2.591** (-2.829)	-0.024 (-1.107)	-0.346** (-3.314)
Chp-18 (1,0,0,0)	-	1.656** (3.704)	-3.022 (-1.444)	63.919** (1.962)	-0.673** (-4.096)

Notes: **Denotes significance at the 10% level. X_{t-1} is the error correction term. T-ratios are shown in parentheses

0.013 (Chp-18) in nine of the eleven cases considered.

Given such modest or small potential exports gains/loss from the elimination of exchange rate volatility, the over-all generalization is that exchange rate volatility appears to have a statistically insignificant impact on South African exports to China.

On the one hand, the observed statistically insignificant impact of exchange rate volatility on South African exports to China is to a certain extent (even though not fully) consistent with the findings of Todani and Munyama (2005) and De Vita and Abbott (2004). On the other hand, direct comparison of our results with the findings of previous studies undertaken in the South African context has proven to be somewhat misleading. This should not be very strange given the differences in methodologies, sample selection and measures of volatility employed. However, it is still important to offer an explanation as to why export volumes might appear to be relatively insensitive to exchange rate movements.

One possible reason why exchange rate volatility does not show up significant may be that it is rather stable over time. Alternatively, the results obtained may have to do with the role played by adjustment or switching costs involved in selling into foreign markets (the costs being either at home or abroad).

Having interpreted our long-run estimates, we now throw some light on the error correction term. 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. 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 can be observed from Table 4, the coefficients of the error correction term in our export models range from -0.346 (Chp-15) to -1.783 (Chp-7). It should be noted that these coefficients are all 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/quarter. For instance, the coefficients imply that from 34.6 percent to 178 percent of the disequilibrium of the previous month's/quarter's shock adjusts back to equilibrium in the current month/quarter.

5. Conclusion & Policy Implication

5.1 Conclusion

In this study, we investigated the impact of exchange rate volatility on South African exports to China using a newly developed cointegration approach and a dataset disaggregated by market of destination (Chinese market) and sector type (export by Chapters). Estimation of seasonally adjusted monthly and quarterly data for the freely-floating exchange rate period 1992M1 to 2010M7 and 1995Q1 to 2010Q3 respectively, was undertaken within a standard framework which explains export volume as a function of foreign income (proxy by foreign industrial production), relative prices (proxy by ZAR/CYN real exchange rates), and a measure of short-term exchange rate volatility. For each equation, selection of the ‘optimal’ short-term volatility measure was done against competing alternatives on the basis of relevant model selection criteria. There are several conclusions that can be drawn from the results that have been obtained.

First, while foreign income and relative price series are found to be I(1), evidence from the unit root tests strongly indicates that all the short-term exchange rate volatility measures examined are stationary. Since correct treatment of regressions containing a mixture of I(1) and I(0) explanatory variables is essential for meaningful results, this finding suggests that the ARDL bounds testing approach which we employ, is the most appropriate econometric procedure in this context.

Second, implementation of a non-nested testing tournament carried out to select the most useful risk proxy among the six alternatives considered, shows that the ‘optimal’ short-term volatility measure is not the same across sector type (export by Chapters), suggesting that the selection of exchange rate risk proxies should always entail case specific testing.

Third, not only did we find evidence of a significant cointegrating level relationship between export volume and the regressors in each of the cases considered, such relationship was established to be long-run forcing and stable. In fact, the 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 from 34.6 percent to 178 percent of the disequilibrium of the previous month’s/quarter’s shock adjusts back to equilibrium in the current month/dquarter.

Fourth, our results indicate that South African exports to China are generally income inelastic, relative price elastic, and largely unaffected by short-term exchange rate volatility. However, two points are worth noting: First, when data are disaggregated, the demand for South African exports tends to be income elastic. Second, in the case where a significant relationship exists between exchange rate volatility and exports, such a relationship is either positive or negative. In fact, from the sectorial analysis, we found very strong implications for some chapters. For Chp-2, and Chp-11, the volatility coefficients are very high in magnitude and statistically significant with a negative sign. This suggests that: (i) risk-averse exporters of these chapters will strongly reduce their activities, switch sources of supply and demand or change prices in order to minimize their exposure to the effect of exchange rate risk. This, in turn, can alter the distribution of output across some other sectors in each country. (ii) trade policy actions aimed at stabilizing the export market of these chapters are likely to generate uncertain results, at best, if policymakers ignore the stability, as well as the level, of the real exchange rate. (iii) trade adjustment programs in South Africa that have mostly stressed the need for export expansion (of Chp-2 and Chp-11) may lose their appeal to local policymakers in periods of high exchange-rate volatility. Also, the intended positive effect of a trade liberalization policy may not only be doomed by a variable exchange rate but could also precipitate a balance-of-payments crisis. While exchange rate volatility appears to have a seriously dangerous effect on Chp-2 and Chp-11, it seems to be especially important for Chp-18 as demonstrated by the very high volatility coefficient which is positive and statistically significant. The implications this might have are simply the reverse of the above arguments in (i), (ii) and (iii). On the other hand, no evidence of a cointegarting level relationship was found for Chp-6 and Chp-8. This implies that these chapters are to a larger extent risk-free in the long run since they are not subject to exchange rate risk, foreign income and relative prices.

Finally, in interpreting our results, it should be borne in mind that in our sample period, the Chinese Yuan is most of the time closely linked to the US dollars. Hence, the volatility of the South African currency, Rand, to Chinese Yuan, RMB, (in fact it can also be generalized to other currencies with Yuan) reflects to a large extent the volatility of Rand to US dollars. Our results therefore say something more general: how ZAR/USD volatility affects South African-China trade; not just ZAR/CNY volatility on South African-China trade.

Policy Implication

A major caution is that exchange rate be carefully managed to ensure a stable non-volatile behavior that could hamper export growth of some products or chapters. For South African exports of vegetable products (Chp-2) as well as exports of textiles & textile articles (Chp-11), if policymakers wish to target exports, it is likely that policies which affect the level of economic activity should be most effective.

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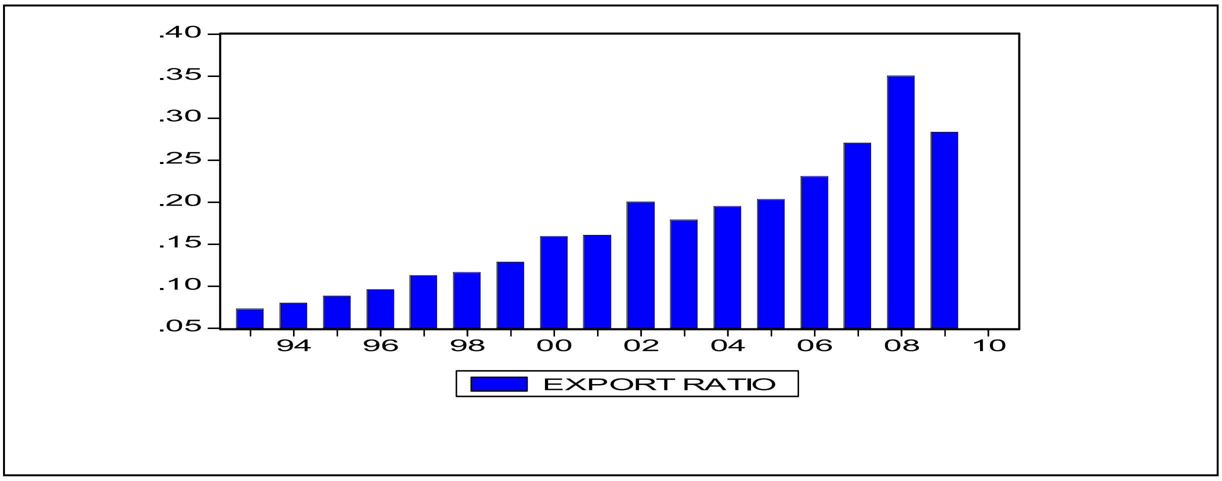
APPENDIX

Table 5: Chapter description

Chapter	Description
Ch-1	Live animals, animal products
Ch-2	Vegetable products
Ch-4	Prepared foodstuffs, beverages, spirits & vinegar, tobacco & manufactured tobacco substitutes
Ch-5	Mineral products
Ch-6	Products of the chemical or allied industries
Ch-7	Plastics & articles thereof, rubber & articles thereof
Ch-8	Raw hides & skins, leather, furskins & articles thereof; saddler & harness,; travel goods, handbags & similar containers; articles of animal gut (other than silkworm gut)
Ch-9	Wood & articles of wood; cork & articles of cork; manufactures of straw, of esparto or of other plaiting materials; basketware & wickerwork
Ch-10	Pulp of wood or other fibrous cellulosic material; waste & scrap of paper or paperboard; paper & paperboard of paper or paperboard, paper & paperboard of articles thereof
Ch-11	Textiles & textile articles
Ch-12	Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops & parts thereof; prepared feathers & articles made therewith; artificial flowers; articles of human hair
Ch-13	Articles of stone, plaster, cement, asbestos, mica & similar materials; ceramic products; glass & glassware
Ch-14	Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal & articles thereof; imitation jewellery; coin
Ch-15	Base metals & articles of base metal
Ch-16	Machinery & mechanical appliances; electrical equipment; parts thereof; sound recorders and reproducers, television image & sound recorders & reproducers, & parts & accessories of such articles
Ch-17	Vehicles, aircraft, vessels & associated transport equipment
Ch-18	Optical, photographic, cinematographic, measuring, checking, precision, medical & surgical instruments & apparatus, Clocks & watches; musical instruments; parts & accessories thereof

Ch-20	Miscellaneous manufactured articles

Figure 2: South African Exports as a Percentage of GDP



Source: South African department of trade and industry

Endnotes

[1] For a comprehensive review of this literature, see Mckenzie (1999)
[2] For instance, Learner and Stem (1970) suggest that trade volume is a more appropriate measure than value.
[3] A full description of the various Chapters is presented in Table 8 of the appendix.
[4] In the ZAR/CYN case, the values of n which ensured the absence of serial correlation in the estimated residuals were 1 and 6 for the nominal and real exchange rate respectively. The highest significant lag (value of q) was 1
[5] For other applications of this methodology, see Henry and Nixion (2000).
[6] See Pesaran & Shin, 1999
[7] We later test this assumption by applying the CUSUM tests to the residuals of equation (12). These tests that are proposed by Brown *et al.* (1975) are updated recursively and are plotted against the break points. For stability of long-run as well as short-run coefficient estimates, the plot of the two statistics must stay within 5% significant level.
[8] The restricted intercept case involves a test for the joint significance of the coefficients of the lagged levels and the intercept, the restricted trend case tests for exclusion of the trend term and the lagged levels.

[9] Since Chapters 10, 12, 13, 16, 17 and 20 appear to be I(0), we exclude these chapters from the co-integration analysis

[10] The only exceptions are Ch-6 (export products of the chemical or allied industries) and Chp-8 (raw hides & skins, leather, etc.).
[11] In order to ensure robustness of the results, we also applied the CUSUM of Squares tests to the residuals of each bond test equation. In all cases, the results from the CUSUM of Squares tests showed strong evidence of stability in the long run relationship and hence, confirming the results from the CUSUM tests.
[12] The only case in which the CUSUM statistics went out of the 5% critical bonds is that of Ch-5 (export of mineral products). However, the result from the CUSUM of Squares tests indicated stability in the export of mineral products function. These mixed results therefore led us to an inconclusive evidence of the stability of Ch-5.
[13] All other diagnostic tests for heteroscedasticity, non-normal errors, and functional form misspecification were passed. See Table 7 of the appendix for these results.
[14] The estimated results, which are not reported to conserve space, are available upon request from the authors.