THE EFFECTS OF EXCHANGE RATE VOLATILITY ON SOUTH AFRICA'S TRADE WITH THE EUROPEAN UNION

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ABSTRACT

In this paper we analyze the effects of the real exchange rate volatility on South Africa's trade flows with the European Union over the period 1980 to 2009. Our study uses quarterly trade flows on South Africa's exports and imports and utilizes the bounds testing approach to cointegration, and error-correction model. Our results reveal that imports depend positively on the levels of domestic economic activity and foreign exchange reserves but negatively on relative prices and exchange rate volatility. In addition, exports depend positively on the levels of foreign economic activity but negatively on relative prices and exchange rate volatility. Furthermore, the exchange volatility exerts mixed effects in the short-run and in the long-run.

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KEYWORDS: South Africa, imports, exports, exchange rate volatility, panel cointegration

INTRODUCTION

Despite the sizeable number of studies conducted, no real consensus about the impact of exchange rate volatility on exports has emerged. While a large number of studies find that exchange rate volatility tends to reduce the level of trade, others find either weak or insignificant or positive relationships. For example, Onafowara and Owoye (2008), Byrne, Darby, and MacDonald (2008), Choudhry (2005), Bahmanee-Oskooee (2002), Arize, *et al.* (2000), Arize (1995), Chowdhury (1993), Pozo (1992), and Bahmani-Oskooee and Ltaifa (1992), find evidence for negative effects. According to these scholars, exchange rate volatility may affect exports directly through uncertainty and adjustment costs for risk-averse exporting investors. Further, it may have an indirect effect through its impact on the structure of output, investment and government policy. On the other hand, Doyle (2001), Chou (2000), McKenzie and Brooks (1997), Qian and Varangis (1994), Kroner and Lastrapes (1993), and Asseery and Peel (1991) find evidence for a positive effect for volatility on export volumes of some developed countries because exchange rate volatility makes exporting more attractive to risk-tolerant exporting firms. However, other scholars such as Aristotelous (2001), Bahmani-Oskooee and Payestch (1993), Bahmani-Oskooee (1991), and Hooper and Kohlhagen (1978) have reported no significant relationship between exchange rate volatility and exports.

Reasons for contradictory results by different studies may be due to a variety of factors, among them: different methods used to measure exchange rate volatility; the use of different price deflators; the differential use of sample data, for example, the use of aggregate export data versus sectoral export data; different time-frame periods; ignoring import dependency on intermediate and capital goods of the receiving country, as is the case with many developing countries; and the absence of complex econometric methods for studying these variations. As a result scholars stopped investigating the exchange rate volatility-export nexus by the late 1990's. However, with better access to sectoral data and the development of more sophisticated econometric models, recent studies have begun evaluating the exchange rate volatility-export connection from a sectoral perspective. The rationale behind this is that different trade sectors would be impacted differentially by exchange rate volatility, and therefore may be more revealing than aggregate studies.

This study focuses on aggregate trade flows between South Africa, a developing country, and the member countries of the European Union (EU) to uncover the nature and sensitivity of the relationship between exchange rate volatility and trade flows. We use the recently developed panel unit root and panel cointegration techniques for this purpose. Using this approach we investigate the effects of exchange rate volatility on South Africa's exports to and imports from the EU countries over a period of 30 years using quarterly data from 1980:Q1 to 2009:Q4.

To this end we provide a brief review of the literature in the next section. Thereafter, we lay the empirical framework of our study by specifying our model. In the section following that we discuss variable definitions and outline our data sources. Empirical results from the bounds testing approach to cointegration, and error-correction model estimates are presented in the penultimate section. The final section presents a summary and conclusion of the results obtained in this study.

LITERATURE REVIEW

In this section we present a brief overview of studies that examine the exchange rate volatility-trade nexus. We begin by discussing the most recent and sophisticated studies, employing cointegration techniques and error-correction models, to older, less complex studies.

Bahmani-Oskooee and Hegerty (2009) investigate the effects of exchange rate fluctuations on trade flows between the U.S. and Mexico using disaggregated, industry-level annual export and import data for 102 industries from 1962 to 2004. They analyze both the short- and long-term effects of volatility in the peso/dollar real exchange rate on Mexican-United States trade. They conclude that in the short-term increased volatility negatively affects trade flows in most industries. Long-term effects however, are significant for only one-third of the industries studied, and of this, only two-thirds are negative. They speculate that increased Mexican integration and liberalization of economic policies allow for greater adjustments in the long-term so that volatility is less of a problem in the long-term than in the short-term.

Byrne, Darby, and MacDonald (2008) analyze the impact of exchange rate volatility on the volume of bilateral U.S. trade flows using homogenized and differentiated sectoral annual data over the period 1989-2001 for a cross-section of 6 EU countries and 22 industries. Their study finds that clustering all industries together provides evidence of a negative effect on trade from exchange rate volatility, which confirms findings of other studies using aggregate data. However, when investigating sectoral trade differences, the effects of exchange rate volatility on trade is negative and significant for differentiated goods and insignificant for homogeneous goods, confirming recent studies that sectoral differences are in fact crucial to explaining the differential impact of volatility on trade. They suggest that a greater degree of disaggregation at the industry level may provide more worthwhile results, which is what we do in this study.

Bahmani-Oskooee and Kovyryalova (2008) investigate the effect of exchange rate fluctuations on trade flows between the U.S. and the United Kingdom using disaggregrated annual export and import data for 177 commodities industries from 1971 to 2003. They analyze both the short- and long-term effects of real exchange rate volatility on trade between the U.S. and the UK. Their results reveal that the volatility of the real dollar–pound rate has a short-term significant effect on imports of 109 industries and on exports of 99 industries. In most cases, such effects are unfavorable. In the long run, however, the number of significant cases is somewhat reduced: only 62 import and 86 export industries are significantly and adversely affected by exchange rate volatility. The industries affected involve both durable and non-durable goods, and include small as well as large industries, supporting findings by aggregate studies.

In another study, Bahmani-Oskooee and Mitra (2008), investigate the effects of exchange rate volatility on trade flows between the U.S. and India, an emerging economy. Using annual data from 40 industries from 1962–2004, their results demonstrate that exchange rate volatility has more short-run than long-run effects. In the short-run, 17 industries were affected on the import side and 15 on the export side. The industries affected show India's increasing ability to produce import substitutable goods. However, in the long run, only a few industries are affected because the increasing dependence on trade between India and the US cause industries to respond inelastically to exchange rate volatility.

Using both the nominal and the real exchange rate between the United States dollar and the currencies of Canada and Japan, Choudhury (2005) investigates the influence of exchange rate volatility on U.S. real exports to Canada and Japan using aggregate monthly data ranging from January 1974 to December 1998. The study uses conditional variance from the GARCH (1, 1) model as a measure of exchange rate volatility, and finds significant and mostly negative effects of exchange rate volatility on real exports.

As in the above studies, Sukar and Hassan (2001) investigate the relationship between U.S. trade volume and exchange rate volatility using cointegration and error-correction models. Their study uses quarterly aggregate data covering the period 1975Q1 – 1993Q2 and a GARCH model to measure the exchange rate volatility. Paralleling other studies, the authors find evidence for a significantly negative relationship between U.S. export volume and exchange rate volatility. However, unlike other findings, they reveal that the short-run dynamics of the exchange rate volatility -trade relationship is insignificant. They argue that this result may be due to the existence of avenues for hedging against exchange risks so as to neutralize the negative impact of exchange rate volatility. Other scholars argue that this short-run insignificant relationship may be because of the investigators' use of aggregate data, which ignores sectoral differences. For example, while one sector may exhibit a negative relationship, another may exhibit an equal but opposite effect so that they offset each other.

Arize (1995), using monthly series from February 1978 to June 1986 analyzes the effects of real exchange rate volatility on the proportions of bilateral exports of nine categories of goods from the U.S. to seven major industrial countries. The volatility measure employed is the standard deviation of the monthly percentage change in the bilateral exchange rate between the U.S. and the importing country from t to $t-12$. The study reveals differential effects of exchange rate volatility across different categories of exports. The study also concludes that exchange rate uncertainty has a negative effect on U.S. real exports, and that it may have a major impact on the allocation of resources to different industries depending on trade elasticities.

Lastrapes and Koray (1990) analyze the interrelationships among exchange rate volatility, international trade, and macroeconomic variables using the vector autoregression (VAR) model. The model estimates U.S. multilateral trade from 1973 to 1990 and includes a moving standard deviation measure of real exchange rate volatility. While the results reveal some evidence of a statistically significant relationship between volatility and trade, the moving average representation of the model implies a rather small quantitative effect. The study concludes that exchange rate volatility is influenced by the state of the economy, a factor ignored in a variety of other studies.

Klein (1990) is one of the first few scholars to analyze the effects of exchange rate volatility on the proportion of disaggregated bilateral exports of nine categories of goods from the U.S. to seven major industrial countries using fixed effects framework. Using monthly series data from February 1978 to June 1986, the study reveals that in six categories of exports exchange rate volatility significantly affects the volume of exports and in five of these categories the effect is positive, suggesting that real exchange rate volatility may in fact increase exports by risk-taking firms.

Koray and Lastrapes (1989) examine the relationship between real exchange rate volatility and bilateral imports from five countries, namely, the UK, France, Germany, Japan, and Canada, employing a VAR model. The study uses aggregate monthly data over a 17-year period from January 1959 to December 1985, and tests for different effects during both the fixed and the flexible exchange rate regimes. Results suggest that while the effects of volatility on imports is weak, permanent shocks to volatility experience a negative impact on imports. However, those effects are relatively more important during the flexible-rate than the fixed-rate period.

Finally, Cushman (1988) tests for real exchange rate volatility on U.S. bilateral trade flows using annual data from 1974-1983 to study the effects of the floating exchange rate regime on exchange rate volatility. The study finds evidence for significant negative effects in only two of six U.S. export flows with one export flow showing a significant positive effect, confirming other studies of a weak risk-averse effect of exchange rate volatility on exporting firms.

One major problem with most of the studies above is that the sample period includes the period prior to the end of the fixed exchange regime, so results may include the lag effects of fixed exchange rates on trade before 1973 lingering on during the transition period after the implementation of the floating exchange rate regime. The current study corrects for this potential bias by using South African quarterly aggregated trade data covering a 30-year period from 1980:Q1 to 2009:Q4. The methodology used in this study incorporates many of the recent developments in the literature, namely, panel unit roots and panel cointegration and error-correction models, which may uncover the nature and sensitivity of the exchange rate volatility-trade nexus.

METHODOLOGY

Model Specification

The objective of this study is to assess the effects of exchange rate volatility on the aggregated exports and imports flows between South Africa and the member countries of the European Union. Drawing on the existing empirical literature in this area, we specify that a standard long-run export demand function that may take the following form (see, for example, Ozturk and Kalyonku, 2009; Choudhry, 2005; Arize, 1998, 1996, 1995; and Asseery and Peel, 1991):

$$\ln X_t = \beta_0 + \beta_1 \ln Y_t + \beta_2 \ln RP_t + \beta_3 \ln RER_t + \beta_4 \ln VOL_t + \beta_5 D_t + \varepsilon_t \tag{1}$$

where X_t is real export volume of South Africa in period t, Y_t is the real income of foreign country in period t, RP_t is the relative price of exports in period t, RER_t is the real exchange rate between the South African rand and the local currency of a partner country in period t, VOL_t is a measure of exchange rate volatility between the South African rand and the local currency of a partner country in period t, D_t is a dummy variable representing the apartheid era (1980-1994) in South Africa, and ε_t is the error term bounded with classical statistical properties.

Economic theory posits that the real income level of the domestic country's trading partners would have a positive effect on the demand for its exports. Therefore, *a priori*, we would expect that $\beta_1 > 0$. On the other hand, if the relative price of exports rise (fall), domestic goods become less (more) competitive than foreign goods, causing the demand for exports to fall (rise). Therefore, *a priori*, one would expect that β_2, which measures the competitiveness of South African exports relative to the given country's domestic production, is negative. Similarly, if a real depreciation of the South African rand, reflected by a decrease in the RER, is to increase export earnings of industry i, we would expect an estimate of β_3 to be negative.

The last explanatory variable is a measure of exchange rate volatility. Various measures of real exchange rate volatility have been proposed in the literature. Some of these measures include (1) the averages of absolute changes, (2) the standard deviations of the series, (3) the deviations from the trend, (4) the squared residuals from the ARIMA or ARCH or GARCH processes, and (5) the moving sample standard deviation of the growth rate of the real exchange rate. Since the effects of exchange rate volatility on exports have been found to be empirically and theoretically ambiguous (Bredin, *et al.* 2003), β_4 could be either positive or negative.

South Africa is assumed to be a small developing open-economy, rendering it a price-taker with respect to imports, and therefore supports the use of single-equation techniques for estimating the aggregate import demand function. We further assume that only normal goods are imported, and that as a developing country, real foreign exchange reserves comprises an important variable in the function. Further, the apartheid structure and international sanctions have both had a significant impact on aggregate import demand and are therefore included in the model.

The long-run aggregate import demand function for South Africa (in natural logs) is thus specified as:

$$\ln M_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 \ln RP_t + \alpha_3 \ln FR_t + \alpha_4 \ln VOL_t + \alpha_5 D_t + \varepsilon_t \quad (2)$$

where M_t is real import volume of South Africa in period t, Y_i is the real income of South Africa in period t, RP_t is the relative price of imports in period t, FR_t is the real foreign exchange reserves of South Africa in period t, VOL_t is a measure of exchange rate volatility between the South African rand and the local currency of a partner country in period t, D_t is a dummy variable representing the apartheid era (1980-1994) in South Africa, and ε_t is a white-noise disturbance term bounded with classical statistical properties.

The first explanatory variable, Y_t, in the specified model measures real domestic economic activity, or the real GDP of South Africa. Economic theory suggests that income in the importing country is a major determinant of a country's imports and has a positive impact. Thus, *a priori*, it is expected that $\alpha_1 > 0$. The second explanatory variable, the relative price of imports, is calculated as the ratio of import price to domestic price. Economic theory posits that an increase in the relative price of imports discourages imports and therefore α_2 is expected to be negative. The third explanatory variable is a measure of availability of foreign exchange, which can be used to represent the ability to import. Following Hoque and Yusop (2010), we have included the real foreign exchange reserve variable to capture the impact of export earnings on import demand, as export earning is one of the major sources of foreign reserves. This variable does not appear in the traditional import demand function. However, it is an important determinant of imports for developing countries. Since higher real foreign reserves tend to encourage imports, we would expect that $\alpha_3 > 0$. The expected signs of α_1, α_2, and α_3 are borne out in empirical results by Hoque and Yusup (2010), Akinlo (2008), Agbola and Damoense (2005), Narayan and Narayan (2005), Razafimahefa and Hamori (2005), Dutta and Ahmed (2004), Tsionas and Christopoulos (2004), Tang (2004, 2002a), Matsubayashi and Hamori (2003), Gumede (2000), Senhadji (1998), and Mwega (1993), among others. Since the effects of exchange rate volatility on imports have been found to be empirically and theoretically ambiguous, α_4 could be either positive or negative.

Equations (1) and (2) shows the long-run relationships among the dependent and independent variables in our models. They can be represented within a panel setting by incorporating a subscript "i" depicting each of the European Union countries in the sample. This can be represented as follows:

$$\ln X_{i,t} = \beta_{0i} + \beta_{1i}\ln Y_{i,t} + \beta_{2i}\ln RP_{i,t} + \beta_{3i}\ln RER_{i,t} + \beta_{4i}\ln VOL_{i,t} + \varepsilon_{i,t} \tag{3}$$

$$\ln M_{i,t} = \alpha_{0i} + \alpha_{1i}\ln Y_{i,t} + \alpha_{2i}\ln RP_{i,t} + \alpha_{3i}\ln FR_{i,t} + \alpha_{4i}\ln VOL_{i,t} + \varepsilon_{i,t} \tag{4}$$

Panel unit root tests

Before proceeding to cointegration techniques, we need to verify that all of the variables are integrated to the same order. In doing so, we have used the panel unit roots test proposed by Breitung (2005) and Breitung and Pesaran (2008).

Panel Cointegration Tests

We investigate the existence of cointegrating relationship using the standard panel tests for no cointegration proposed by Pedroni (1999, 2004). These tests allow for heterogeneity in the intercepts and slopes of the cointegrating equation. Pedroni's tests provide seven test statistics: Within dimension (panel tests): (1) Panel ν-statistic; (2) Panel Phillips–Perron type ρ-statistics; (3) Panel Phillips–Perron type t-statistic; and (4) Panel augmented Dickey–Fuller (ADF) type t-statistic. Between dimension (group tests): (5) Group Phillips–Perron type ρ-statistics; (6) Group Phillips–Perron type t-statistic; and (7) Group ADF type t-statistic. These statistics are based on averages of the individual autoregressive coefficients associated with the unit root tests of the residuals for each country in the panel. All seven tests are distributed asymptotically as standard normal. Following Pedroni (1999, 2004), the heterogeneous panel and heterogeneous group mean panel of rho (ρ), parametric (ADF), and nonparametric (PP) statistics are calculated as follows:

Panel ν - statistic:

$$Z_{\nu} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, \hat{e}_{it-1}^{2} \right)^{-1} \tag{5a}$$

Panel ρ - statistic:

$$Z_{\rho} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, \hat{e}_{it-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, (\hat{e}_{it-1} \, \Delta\hat{e}_{it} - \hat{\lambda}_i) \tag{5b}$$

Panel *ADF* - statistic:

$$Z_{t} = \left(\tilde{s}_{NT}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, \hat{e}^{*2}_{it-1} \right)^{-\frac{1}{2}} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, \hat{e}_{it-1}^{*} \, \Delta\hat{e}_{it}^{*} \tag{5c}$$

Panel *PP* - statistic:

$$Z_{pp} = \left(\tilde{\sigma}_{NT}^{2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, \hat{e}_{it-1}^{2} \right)^{-\frac{1}{2}} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \, (\hat{e}_{it-1} \, \Delta\hat{e}_{it} - \hat{\lambda}_i) \tag{5d}$$

Group ρ - statistic:

$$\widetilde{Z}_{\rho} = \sum_{i=1}^{N}\left(\sum_{i=1}^{T}\hat{e}_{it-1}^{2}\right)^{-1}\sum_{i=1}^{T}(\hat{e}_{it-1}\ \Delta\hat{e}_{it} - \hat{\lambda}_{i}) \tag{5e}$$

Group *ADF* - statistic:

$$\widetilde{Z}_{t} = \sum_{i=1}^{N}\left(\sum_{i=1}^{T}\bar{s}_{i}^{*2}\ \hat{e}_{it-1}^{*2}\right)^{-\frac{1}{2}}\sum_{i=1}^{T}\hat{e}_{it-1}^{*}\ \Delta\hat{e}_{it}^{*} \tag{5f}$$

Panel *PP* - statistic:

$$\widetilde{Z}_{pp} = \sum_{i=1}^{N}\left(\sum_{i=1}^{T}\hat{\sigma}_{i}^{2}\ \hat{e}_{it-1}^{2}\right)^{-\frac{1}{2}}\sum_{i=1}^{T}(\hat{e}_{it-1}\ \Delta\hat{e}_{it-1} - \hat{\lambda}_{i}) \tag{5g}$$

where

$$\hat{\lambda}_{i} = \frac{1}{T}\sum_{j=1}^{k_i}\left(1-\frac{j}{k_i+1}\right)\sum_{t=j+1}^{T}\hat{\mu}_{it}\hat{\mu}_{i,t-j}\ ;\ \hat{s}_{i}^{2} = \frac{1}{T}\sum_{t=1}^{T}\mu_{it}^{2}\ ;\ \hat{\sigma}_{i}^{2} = \hat{s}_{i}^{2} + 2\hat{\lambda}_{i}\ ;\ \widetilde{\sigma}_{NT}^{2} = \frac{1}{N}\sum_{i=1}^{N}\hat{L}_{11i}^{-2}\hat{\sigma}_{i}^{2}\ ;\ \hat{s}_{i}^{*2} = \frac{1}{T}\sum_{t=1}^{T}\hat{\mu}_{it}^{*2}\ ;$$

$$\widetilde{s}_{NT}^{*2} = \frac{1}{T}\sum_{i=1}^{N}\hat{s}_{i}^{*2}\ ;\ \text{and}\ \hat{L}_{11i}^{2} = \frac{1}{T}\sum_{t=1}^{T}\hat{\eta}_{it}^{2} + \frac{2}{T}\sum_{j=1}^{k_i}\left(1-\frac{j}{k_i+1}\right)\sum_{t=j+1}^{T}\hat{\eta}_{it}\hat{\eta}_{i,t-j}\ .$$

The error terms $\hat{\mu}_{i,t}$, $\hat{\mu}_{i,t}^{*}$, and $\hat{\eta}_{i,t}$ are respectively derived from the following auxiliary regressions: $\hat{\varepsilon}_{it} = \hat{\rho}_{i}\hat{\varepsilon}_{i,t-1} + \hat{\mu}_{it}$; $\hat{\varepsilon}_{it} = \hat{\rho}_{i}\hat{\varepsilon}_{i,t-1} + \sum_{j=1}^{k_i}\hat{\rho}_{ik}\Delta\hat{\varepsilon}_{i,t-j} + \hat{\mu}_{it}$; and $\Delta y_{it} = \sum_{m=1}^{M}\hat{\gamma}_{mi}\Delta x_{mit} + \hat{\eta}_{it}$.

Of the seven test statistics, except for the panel ν - statistic, the other six Pedroni test statistics are left-tailed tests. In order to find evidence for long-run relationship between the variables, the null hypothesis of no cointegration for these tests should be rejected. If the null hypothesis cannot be rejected, there is no long-run relationship between the variables.

DATA SOURCES AND VARIABLES

Our export and import data time series span a 30-year period from 1980:Q1 through 2009:Q4, leading to 120 quarterly observations. Of the 27 member countries of the European Union, only 20 countries were used in the study due to the unavailability of all relevant data. Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Malta, and Slovenia were dropped from the sample, and the rest of the following countries were used in the study: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and the United Kingdom. In addition, while the majority of the countries had data for the entire study period, the following five countries had data only for the period specified: Czech Republic, 1993:Q1-2009:Q4; Hungary, 1995:Q1-2009:Q4; Ireland, 1997:Q1-2009:Q4; Poland, 1991:Q1-2009:Q4; and Slovakia, 1993:Q1-2009:Q4. Quarterly data on exports and imports are taken from the International Monetary Fund, *Direction of Trade Statistics Database*. Quarterly nominal data on exports were converted into real export series by deflating them using the export price index with 2005 serving as the base (=100). The export price index series are taken from the International Monetary Fund, *International Financial Statistics Database*.

The real foreign income variable for EU countries is the real quarterly GDP. The underlying series is obtained from the Organization for Economic Cooperation and Development's online database. The real income variable for South Africa is the real quarterly GDP of South Africa. The underlying series is obtained from the International Monetary Fund's *International Financial Statistics database*.

The data on nominal imports, the import price index, foreign exchange reserves series, and domestic price index are taken from the International Monetary Fund's *International Financial Statistics database*. Nominal quarterly imports in local currency are deflated by the import price index (2005 = 100) to obtain the real import variable for South Africa. The real GDP variable is computed in millions of 2005 constant *Rand.* The relative price of imports series is constructed as the ratio of the import price index (2005=100) to domestic price index, as measured by the consumer price index (CPI) (2005=100). To obtain the real foreign reserves series, we deflated the nominal foreign exchange reserves series by the CPI (2005=100).

Following Bahmani-Oskooee and Wang (2008, 2009), and Sekkat and Varoudakis (2000), the real exchange rate, RER_t, is constructed as:

$$RER_t = \left(\frac{ER_t \times P_t^f}{P_t^{SA}} \right) \tag{6}$$

where RER_t is the real exchange rate, ER_t is the bilateral nominal exchange rate between South Africa and a given OECD country at time t, P_t^f is the consumer price index (2005=100) of a given OECD country at time t, and P_t^{SA} is the consumer price index (2005=100) of South Africa at time t. The quarterly data on nominal exchange rates are taken from the IMF, *International Financial Statistics database*.

Finally, we use a commonly used measure of exchange rate volatility in this study, though there are several alternative measures are available. It should be noted at this juncture that there is no unique way to measure real exchange rate volatility. Our measure of volatility is constructed following Bredin, Fountas, and Murphy (2003), Weliwita, Ekanayake, and Tsujii (1999), Chowdhury (1993), Lastrapes and Koray (1990), and Koray and Lastrapes (1989). Following these authors the real exchange rate volatility measure is constructed as:

$$VOL_t = \left[\frac{1}{m} \sum_{i=1}^{m} (\ln RER_{t+i-1} - \ln RER_{t+i-2})^2 \right]^{1/2} \tag{7}$$

where VOL_t is the volatility of real exchange rate, RER_t is the real exchange rate and $m = 4$ is the order of the moving average. According to Koray and Lastrapes (1989), this measure can capture general movements in real exchange rate volatility and exchange rate risk over time.

EMPIRICAL RESULTS

Panel Unit Root Tests

Table 1 shows the summary statistics of the main variables for the full sample. The starting point of our econometric analysis is to check whether the variables included in Equations (3) and (4) contain panel unit roots. In other words, in Equation (3), we need to check whether [X, Y, RP, RER, VOL] contains a unit root and also whether [M, Y, RP, FR, VOL] contains a unit root in Equation (4). While there are several panel unit root tests are available, this study uses the unit root test developed by Breitung (2000, 2005). These results of the exports model and the imports model are presented in Table 2.

Table 1: Basic Summary Statistics

	Exports Model					Imports Model				
	X	Y	RP	RER	VOL	M	Y	RP	FR	VOL
Mean	888.09	175.55	1.82	0.24	0.02	1207.25	1232.22	2.24	47.17	0.02
Median	502.39	163.97	1.40	0.23	0.02	923.59	1125.23	1.52	13.10	0.02
Maximum	3297.96	272.25	3.85	0.31	0.07	4606.02	1824.38	6.25	235.97	0.07
Minimum	71.78	105.42	0.83	0.15	0.00	122.18	914.08	0.79	3.84	0.00
Std. Deviation	795.33	50.89	0.93	0.04	0.01	1062.62	259.76	1.54	58.79	0.01
Skewness	0.99	0.37	0.79	-0.06	1.17	1.07	0.96	1.16	1.59	1.17
Kurtosis	3.06	1.86	2.19	2.15	4.51	3.61	2.71	3.03	4.53	4.51
Jarque-Bera	582.72	276.86	468.00	110.53	923.11	748.81	561.93	802.03	1859.86	923.11
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400

Note: This table shows the summary statistics of the main variables for each of the six regions.

Table 2: Breitung Panel Unit Root Test Results

Exports Model (Model 3)		Imports Model (Model 4)	
Variable	Breitung t-statistic	Variable	Breitung t-statistic
Level:		**Level:**	
ln(EXP)	-0.42 (0.337)	ln(IMP)	-1.74 (0.337)
ln(Y)	3.03 (0.997)	ln(Y)	-0.51 (0.307)
ln(RER)	-0.89 (0.185)	ln(FR)	1.22 (0.997)
ln(RP)	10.57 (0.998)	ln(RP)	-1.03 (0.152)
ln(VOL)	-1.68 (0.264)	ln(VOL)	-1.33 (0.254)
First Differences:		**First Differences:**	
Δln(EXP)	-5.46 (0.000)***	Δln(IMP)	-14.94 (0.000)***
Δln(Y)	-15.29 (0.000)***	Δln(Y)	-14.20 (0.000)***
Δln(RER)	-2.44 (0.007)***	Δln(FR)	-27.14 (0.000)***
Δln(RP)	-10.87 (0.000)***	Δln(RP)	-13.17 (0.000)***
Δln(VOL)	-12.43 (0.000)***	Δln(VOL)	-31.14 (0.000)***

*Notes: Breitung indicates the Breitung and Pesaran (2008) Breitung t-test for panel unit root tests. This test examines the null hypothesis of unit root (non-stationary). The figures in parentheses are the p-values. *** indicates the significance at the 1 percent level.*

The panel unit root tests indicate all the variables in both the exports model and the imports model are integrated of order one.

Panel Cointegration Tests

With the respective variables integrated of order one, the heterogeneous panel cointegration test advanced by Pedroni (1999, 2004), which allows for cross-section interdependence with different individual effects, is performed and the results are presented in Tables 3. The results for both within and between dimension panel cointegration test statistics are given in the table. All seven test statistics reject the null hypothesis of no cointegration at the 1% significance level for both exports model and imports model, indicating that the five variable are cointegrated in each model.

Table 3: Heterogeneous Panel Cointegration Results

(a) Exports Model (Eq.3)	
Panel Cointegration Statistics (within-dimension)	**Test Statistic**
Panel ν-statistic	10.378 (0.000)***
Panel ρ-statistic	-18.995 (0.000)***
Panel *t*-statistic	-15.731 (0.000)***
Panel *t*-statistic	-16.038 (0.000)***
Panel Cointegration Statistics (within-dimension)	
Group PP type ρ-statistic	-19.998 (0.000)***
Group PP type *t*-statistic	-18.621 (0.000)***
Group ADF type *t*-statistic	-19.016 (0.000)***
(b) Imports Model (Eq.3)	
Panel Cointegration Statistics (within-dimension)	**Test Statistic**
Panel ν-statistic	55.545 (0.000)***
Panel ρ-statistic	-27.950 (0.000)***
Panel *t*-statistic	-18.261 (0.000)***
Panel *t*-statistic	-17.577 (0.000)***
Panel Cointegration Statistics (within-dimension)	
Group PP type ρ-statistic	-29.616 (0.000)***
Group PP type *t*-statistic	-20.891 (0.000)***
Group ADF type *t*-statistic	-20.050 (0.000)***

*Notes: The number of lag length was selected automatically based on SIC with a maximum lag of 15. The figures in the parentheses are p-values. *** indicates the significance at the 1 percent level.*

After having found consistent evidence of cointegration, the Dynamic Least Squares (DOLS) technique for heterogeneous cointegrated panels is estimated. The results of the DOLS are presented in Table 4 for both exports model and for imports model. As the results for the exports model show, all the coefficients have the expected signs and all the coefficients are statistically significant at the 1% level of significance. Exchange rate volatility variables has a positive sign indicating that exchange rate volatility does not have any adverse impact on South Africa's exports to the European Union. Given that the variables are expressed in natural logarithms, the coefficients can be interpreted as elasticity estimates. The results indicate that, in the exports model, a 1% increase in real foreign income increases real exports by 4.62%; a 1% increase in real exchange rate decreases real exports by 0.19%; and a 1% increase in the relative price decreases real exports by 2.28%. Similarly, as the results for the imports model show, all the coefficients have the expected signs and all the coefficients are statistically significant at the 1% level of significance. Exchange rate volatility variables has a positive sign indicating that exchange rate volatility does not have any adverse impact on South Africa's imports from the European Union. However, in both models, the dummy variable representing the apartheid era has a negative sign indicating that trade flows between South Africa and the European Union declined during the apartheid period.

Table 4: Dynamic Least Squares (DOLS) Long-Run Elasticities

Dependent Var:	ln(Y)	ln(RER)	ln(RP)	ln(VOL)	D
	4.622***	-0.193***	-2.279***	0.044***	-1.440***
Ln(X)	(9.84)	(3.44)	(6.51)	(5.51)	(7.49)
Dependent Var:	**ln(Y)**	**ln(FR)**	**ln(RP)**	**ln(VOL)**	**D**
	3.013***	0.126***	-0.081***	0.131***	-1.205***
Ln(M)	(9.92)	(8.88)	(3.74)	(9.51)	(8.67)

*Notes: The figures in parentheses are absolute values of t-statistics. *** indicates the statistical significance at the 1 percent level.*

Finally, in order to evaluate the impact of exchange rate volatility on trade flows during the short-run, a panel vector error correction model (VECM) proposed by Pesaran et al. (1999) is estimated. The results of these models are presented in Table 5 for exports model and for imports model. These results show evidence that exchange rate volatility has an adverse impact on exports in the short-run.

Table 5: Dynamic Least Squares (DOLS) Short-Run Elasticities

Dep. Var.	**Δln(Y)**	**Δln(RER)**	**Δln(RP)**	**Δln(VOL)**	**D**	**ECM_{t-1}**
	3.107***	-0.605***	-2.010***	-0.014**	0.011	-0.372***
Δln(X)	(9.29)	(8.44)	(4.68)	(1.99)	(1.17)	(9.67)
Dep. Var.	**Δln(Y)**	**Δln(FR)**	**Δln(RP)**	**Δln(VOL)**	**D**	**ECM_{t-1}**
	1.034***	-0.020	-0.636	0.009	0.031	-0.497***
Δln(M)	(8.70)	(1.39)	(1.53)	(0.90)	(2.87)	(9.52)

*Notes: The figures in parentheses are absolute values of t-statistics. ** and *** indicate the statistical significance at the 1 percent and 5 percent level, respectively. All the variables (except the dummy variable) are expressed in natural logarithm and therefore the coefficients can be interpreted as elasticities.*

SUMMARY AND CONCLUSIONS

In this paper we have examined the dynamic relationship between trade flows and exchange rate volatility in South Africa's trade with the European Union in the context of a multivariate error-correction model. Estimates of the long-run export and import demand functions were obtained by employing the panel cointegration using quarterly data for the period 1980:Q1 - 2009:Q4.

The panel unit root tests indicate all the variables in both the exports model and the imports model are integrated of order one. The heterogeneous panel cointegration test advanced by Pedroni (1999, 2004) was used to test for panel cointegration for both exports and imports models. The results for both within and between dimension panel cointegration test statistics reject the null hypothesis of no cointegration at the 1% significance level for both exports model and imports model, indicating that the five variable are cointegrated in each model.

After having found consistent evidence of cointegration, the Dynamic Least Squares (DOLS) technique for heterogeneous cointegrated panels is estimated. As the results for the exports model show, all the coefficients have the expected signs and all the coefficients are statistically significant at the 1% level of significance. Exchange rate volatility variables has a positive sign indicating that exchange rate volatility does not have any adverse impact on South Africa's exports to the European Union. However, the results show evidence that exchange rate volatility has an adverse impact on exports in the short-run. Similarly, as the results for the imports model show, all the coefficients have the expected signs and all the coefficients are statistically significant at the 1% level of significance. Exchange rate volatility variables has a positive sign indicating that exchange rate volatility does not have any adverse impact on South Africa's imports from the European Union. However, in both models, the dummy variable representing the apartheid era has a negative sign indicating that trade flows between South Africa and the European Union declined during the apartheid period.

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