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The Relative Impacts of Real Exchange Rate Misalignment and Real Exchange Rate Volatility on Export Growth in South Africa

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Abstract
This research empirically analyses the relative impacts of real exchange rate misalignment and real exchange rate volatility on export growth in South Africa. The sample period for the study spans from 2000:2 to 2011:4. The degree of real exchange rate misalignment is computed as a deviation of the actual real exchange rate from its equilibrium using a single-equation error correction approach, while volatility is computed using the GARCH technique. The relative impacts of real exchange rate misalignment and real exchange rate volatility are investigated using the one-step Engle-Granger error correction model (ECM). Results indicate that both real exchange rate misalignment and real exchange rate volatility have adverse impacts on export growth; with real exchange rate volatility demonstrating more pronounced detrimental impacts on export growth relative to exchange rate misalignment, both in the short-run and long-run periods.
Keywords: real exchange rate misalignment, real exchange rate volatility, export growth

1. Introduction

Questions about the relative impacts of real exchange rate misalignment and real exchange rate volatility on export growth have persistently become a matter of concern to governments, monetary authorities and economic analysts in different sectors of the economy. Exchange rate misalignment occurs when the actual real exchange rate diverts from its long-run equilibrium (Edwards, 1989; and Sidek, 2011); while exchange rate volatility is a measure that captures the uncertainty faced by exporters due to unpredictable fluctuations in the exchange rates (Todani & Munyama, 2005). Proceeding with the analysis, the movement by most economies from fixed exchange rates regimes to flexible regimes following collapse of the Bretton Woods system led most countries' exchange rates across the world to fluctuate widely from time to time (Mukhtar & Malik, 2010). Since then, there has been consistent debate on the relative impacts of misalignment and volatility of the real exchange rate on export growth.

The objective of this paper is to examine the relative impacts of real exchange rate misalignment and real exchange rate volatility on export growth in South Africa. The paper is structured as follows: Section 2 reviews the literature and theoretical framework on exchange rate misalignment, exchange rate volatility and export growth. Section 3 specifies the econometric methodology and estimation procedure employed in the paper. Section 4 presents, analyses and interprets the findings, while Section 5 provides some concluding comments.

2. Literature Review and Theoretical Framework

Extensive theoretical and empirical literature linked to the subject of the relative effects of misalignment and volatility of the real exchange rate on export growth consistently remains dominant in most international finance policy discussions (Edwards, 1989). Several research findings from numerous studies indicate that prevalence of misalignment and volatility of the exchange rate for protracted periods depressingly affects competitiveness of the tradables sector.

The empirical studies that have found such results include Virgil (2000), Esquivel & Felipe (2002) and Onafowora & Owoye (2007). On the other hand, De Vita & Abbott (2004), and Hondroyiannis et al. (2006) did not find any significant relationship between export competitiveness and real exchange rate misalignment and volatility. As such, considerable literature linked to the subject of exchange rate management reveals that countries that have monitored their exchange rates properly, thus avoiding real exchange rate volatility, have been successful in promoting growth of their exports in the long run (Mustafa & Nishat, 2004).

In view of the evidence cited above, Diallo (2011) accentuates that proper alignment of the real exchange rate makes production of tradable goods profitable and sustainable in the long run. On contrary, maintaining the real exchange rate at "wrong levels" generates incorrect signals in the external sector and greatly impairs international competitiveness of the country's tradable goods and services (Edwards, 1989). In light of this background, traditional economic propositions suggest that determination of the real exchange rates should therefore consistently be monitored and adjusted in line with purchasing power parity developments, following the computation:

$$RER_t = E_t\left(\frac{P_t}{P_t^*}\right) = \frac{E_t P_t}{P_t^*} \quad (1)$$

where: t denotes time; RER is the real exchange rate; E is the nominal exchange rate defined using the direct quotation mode; P and P* are the domestic and foreign price indices, respectively; and * denotes the foreign country or trading partner.

Following Edwards (1989), assuming that P and P* in the PPP definition are geometrically weighted averages of the tradable (T) and nontradable (N) prices, with the respective weights α, (1- α), and β, (1- β), the real exchange rate is mechanically computed as:

$$RER_t = \frac{E_t P_{N_t}^{\alpha} P_{T_t}^{(1-\alpha)}}{P_{N_t}^{*\beta} P_{T_t}^{*\,(1-\beta)}} \quad (2)$$

Depending on whether P and P* are consumer- or producer price indexes, the RER_t should factor in the relative price of domestic to foreign consumption or production baskets. Although other indexes such as unit labour costs can be used in place of the consumer or producer price indexes, Edwards (1989) maintains that such indexes are not reliable in case of emerging economies since computation of the real exchange rate in emerging economies entails a non-stationary process. Furthermore, Dornbusch & Vogelsang (1991) augment that the purchasing power parity trajectory itself demonstrates diversions from the steady state long-run equilibrium.

Although Genberg (1978) argues that the consumer price index would provide as a comprehensive measure of the country's changes in export growth, Frenkel (1981) on contrary, argues that since the index comprises a large proportion of nontradable goods, it tends to provide as a biased estimator of changes in the degree of the country's export competitiveness. Hence, to address the limitations associated with the purchasing power parity model, the real effective exchange rate index provides as the ideal indicator of a country's degree of international competitiveness (Elbadawi, 1994). The real exchange rate can thus be maintained by consistently adjusting the nominal effective exchange rate for inflation differentials comprising of the ratio of domestic inflation to the weighted inflation baskets of the country's major trading partners.

3. Econometric Methodology and Procedure

3.1 Data

The time series data used for estimation of the export function are obtained from the International Monetary Fund's (IMF) financial statistics and South African Reserve Bank (SARB) macroeconomic indicator database. The data are collected on quarterly basis over the period 2000:1 -2011:4. The economic fundamental variables incorporated in estimation of the export growth function are real exchange rate misalignment, real exchange rate volatility, growth in real gross domestic product, capital controls and trade openness. Time series properties of data are investigated using E-Views prior to estimation of results. Logarithmic transformation systems are applied on all variables in order to ensure that estimates computed are not spurious.

3.2 Unit Root and Diagnostic Tests

The methodological procedure followed in estimating the export function begins by investigating time series properties of data used. For each discrete data series, the Augmented Dickey-Fuller (ADF) test is undertaken to detect the presence of unit root both at the intercept and intercept plus trend regression forms. The principal diagnostic tests undertaken include stability test, specification of the functional form, normality; serial correlation and heteroskedasticity tests. The CUSUM and CUSUM of squares tests, Ramsey RESET, Jacque-Bera normality test, and Breusch-Godfrey serial correlation LM test approaches are used to examine properties of model residuals. The normality test is undertaken to determine if the residuals are normally distributed, mean zero, homoscedastic and serially uncorrelated. Analysis of these properties is then followed by specification and estimation of the country's export growth function.

3.3 Empirical Model and Estimation

The standard approach adopted in estimating the export growth function is based on the imperfect substitution model proposed by Goldstein & Khan (1985). The empirical specification of the demand and supply functions of exports, which simultaneously determine the export price and export quantity, is based on this approach. The underlying assumption behind the conventional theory of demand is that consumers maximize utility subject to the budget constraint. Correspondingly, the proposition of the supply side theory is that, growth in exports is a positive function of the real exchange rate. The long-run market equilibrium condition for exports thus follows the system of export demand and supply structural equations specified as:

$$X_t^d = \alpha_0 + \alpha_1 RER_t + \alpha_2 Y_t^* + \Psi Z_t \qquad \alpha_1 < 0; \;\; \alpha_2 > 0 \tag{3}$$

$$X_t^s = \beta_0 + \beta_1 RER_t + \beta_2 RGDP_t + \Omega V_t \qquad \beta_1 < 0; \;\; \beta_2 > 0 \tag{4}$$

where (all variables in logarithms) X= exports; RER= real exchange rate; Y*= real foreign income; RGDP = real gross domestic product; Z= vector of economic fundamentals that influence demand for exports; and V= vector of economic variables that influence export growth.
Based on the conventional theories of demand for and supply of exports specified above, the empirical estimation of the export growth function proceeded as follows:

$$\log EXP = \alpha + \beta_1 RER\_MIS + \beta_2 RER\_VOL + \vartheta_i \Psi + u_t \qquad \beta_1 < 0; \;\; \beta_2 < 0 \tag{5}$$

where: ϑ_i = m x n vector containing coefficients of the exogenous variables; and Ψ = vector of economic fundamentals that influence export growth.
To measure the magnitude of real exchange rate misalignment, the equilibrium real exchange rate is estimated as a function of the observed macroeconomic fundamentals using a single equation approach (Baffes, Elbadawi & O'Connel, 1997). First, the univariate time series properties of the real exchange rate and its fundamentals are investigated to determine the appropriate estimation technique. The order of integration of the discrete macroeconomic data series is determined and all variables are integrated of order one, indicating cointegration between the real exchange rate and its fundamentals. The steady-state equilibrium real exchange rate is computed conditional on a vector of permanent values for the relative macroeconomic fundamentals from the general error correction representation:

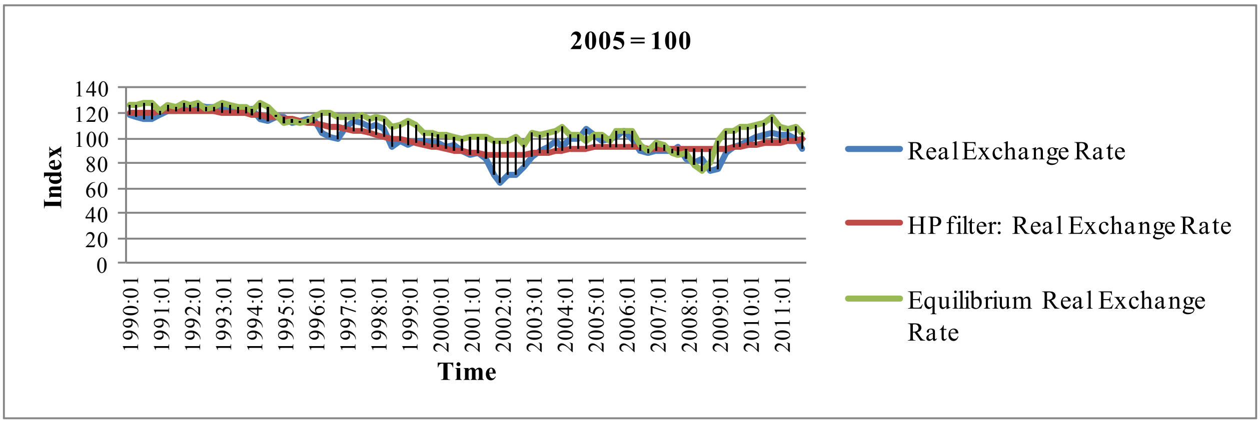
$$\Delta \log RER_t = \alpha\left(\log RER_{t-1}\, \beta^{/} F_{t-1}\right) + \sum_{j=1}^{p} \varphi_j \,\Delta \log RER_{t-j} + \sum_{j=0}^{p} \vartheta_j^{/}\, \Delta F_{t-j} + \upsilon_t \;; \tag{7}$$

where F = [open, tot, gen_g, cap_con, ξ] is the vector of fundamentals stationary in first differences [I(1)]; and υ_t is an i.i.d., stationary stochastic variable with zero mean.
The long-run parameters generated from (7) above are then fixed on permanent values of the respective real exchange rate fundamentals to calculate the equilibrium real exchange rate. The degree of real exchange rate misalignment (rer_mis) is calculated as a percentage difference between the real exchange rate and its computed equilibrium value.

$$RER\_MIS_t = \left[\frac{\log\left(RER_t\right)}{\log\left(ERER_t\right)}\right] - 1 \tag{8}$$

The Hodrick-Prescott (HP) filter smoothing method is applied on the actual real exchange rate to detect how this trend evolves over time in relation to the smoothed equilibrium level (Figure 1).

Figure 1: Real Exchange Rate and Equilibrium Level



Volatility of the real exchange rate is tested using autoregressive conditional heteroscedasticity (ARCH) and the generalized autoregressive conditional heteroscedasticity (GARCH) models:

$$RER_t = \gamma_0 + \gamma_1 RER_{t-1} + u_t \tag{9}$$

$$\sigma_t = \lambda_0 + \lambda_1 u_{t-1}^2 + \lambda_2 \sigma_{t-1} \tag{10}$$

where RER_t is the real exchange rate expressed in natural logarithm and u_t is a random error. The conditional variance equation (10) is a function of three terms; namely: (i) the mean (λ_0); (ii) the ARCH term, which captures news about volatility for the previous period measured as the lag of the squared residual from the mean equation (u^2_{t-1}); and the GARCH term, which is the last period's forecast error variance (σ_{t-1}).

Subsequent to the above, the unit root tests of all variables are performed to examine the order of integration at which all model variables become stationary. This is done to confirm whether the difference between non-stationary series becomes stationary when the same variables move together in the long run, even though they may drift apart in the short run. Following investigation of the order of integration, the study further tests for the presence of cointegration among variables using the Johansen (1988) maximum likelihood cointegration technique. The maximum eigenvalue (λ_{max}) method is applied to detect existence of cointegrating vectors based on the premise that the technique is more reliable in small samples (Hamilton, 1994).

$$\lambda_{max} = -T\log\left(1-\lambda_{r+1}\right) \tag{11}$$

where the null hypothesis $r \leq g$ cointegrating vectors, with (g = 0, 1, 2, 3, ---) is tested against the alternative hypothesis $r = g + 1$.

4. Estimation and Interpretation of Results

4.1 Real Exchange Rate Volatility

Preceding examination of stationarity and cointegration, the real exchange rate is first tested for the presence of volatility using the ARCH (Engle, 2001) and GARCH (Bollerslev, 1986) models.

Table 1: Results of ARCH Model - Real Exchange Rate Volatility

Variance Equation:	Diagnostic Tests on Residuals:	ARCH LM Test:
ARCH 7.089 (0.0000) **	Normality 0.3684 (0.8317)**	F- Statistic 124.7293 (0.0000) **

The coefficients of the variance equation are significant at 5 percent level; with the p-value of the GARCH (1 1) variance equation (p = 0.0000) indicating presence of the ARCH effect (volatility) in the real exchange rate during the period under review.

4.2 ADF Unit Root Test

The first step prior to estimation of the one-step error correction equation is investigation of the order of integration of the variables. The ADF tests are conducted for the series in levels, as well as at first differences, both with and without trend (Table 2). The ADF tests are applied on the premise that they perform satisfactorily even when the sample is small (Hamilton, 1994).

Table 2: ADF Test Results

Data Series	With Intercept		With Intercept and Trend	
	Level	First Diff	Level	First Diff
Export growth	-9.15^{***}	-13.16^{***}	-9.53^{***}	-13.08^{***}
Real exchange rate misalignment	-3.51^{***}	-8.76^{***}	-3.55^{***}	-8.71^{***}
Real exchange rate volatility	-6.45^{***}	-11.01^{***}	-4.29^{***}	-10.95^{***}
Real gross domestic product	-4.12^{***}	-7.96^{***}	-4.33^{***}	-7.92^{***}
Capital control	-2.45	-8.85^{***}	-3.21^{*}	-8.81^{***}
Openness	-0.65	-6.13^{***}	-3.78^{**}	-6.10^{***}

$^{***;**;*}$ denote significance at 1 percent, 5 percent and 10 percent levels; respectively.

The unit root test results confirm that the all variables are stationary in first difference at 1 percent level, both with and without trend. Proceeding further, the presence of cointegrating relationships between variables is tested using Johansen eigenvalues and L.R. statistics (Table 3).

Table 3: Cointegration Test Results with Linear Deterministic Trend - Lag Interval: 1 to 1

Eigenvalue and L.R. Test Statistics				
H_0 H_1	r = 0 r = 1	$r \leq 1$ r = 2	$r \leq 2$ r = 3	$r \leq$ r = 4
Eigenvalue L.R. statistic	0.668195 161.1954^{**}	0.623911 109.3446^{**}	0.423561 63.38192^{*}	0.312318 37.49028
$^{*(**)}$ denotes rejection of the null hypothesis at 5% (1%) significance level				
Critical Values				
1% Sig. level 5% Sig. level	114.90 124.75	87.31 96.58	62.99 70.05	42.44 48.45

The eigenvalue and the likelihood ratio (LR) test statistics confirm existence of three cointegrating relationships at 5 percent level of significance. Given the presence of cointegrating equations, the final estimates of the export growth model (Table 4), together with the associated diagnostic tests (Table 5), are estimated using the one-step error-correction mechanism.

Table 4: One-Step Error Correction Model for Export Growth

Dependent Variable: log(Export_Growth)	Coefficient	Std. Error	T-Statistic	Prob.
Adjustment Speed	-0.368295	0.123341	-2.985977	0.0051
Long-Run Parameters:				
log(RER_MIS(-1))	-0.210931	0.236572	-0.89112	0.3785
log(RER_VOL)	-0.805077	0.341892	-2.354773	0.0241
log(RGDP_G(-1))	2.649412	1.122160	2.360993	0.0238
Constant	113.0397	44.32951	2.549987	0.0152
Dynamic Terms:				
Δlog(RER_MIS(-4))	-0.037890	0.217365	-0.174315	0.8626
Δlog(RER_VOL(-2))	-0.627412	0.357688	-1.754075	0.0879
Δlog(RGDP_G)	2.953345	0.917371	3.219359	0.0027
Δlog(CAP_CON(-1))	-7.163738	1.984991	-3.608953	0.0009
Δlog(OPENNESS)	1.075043	0.292910	3.670214	0.0008

R-squared	0.667199	Mean dependent var	3.171739
Adjusted R-squared	0.583998	S.D. dependent var	17.25258
S.E. of regression	11.12760	Akaike info criterion	7.846394
Sum squared resid	4457.645	Schwarz criterion	8.243925
Log likelihood	-170.4671	F-statistic	8.019182
Durbin-Watson stat	1.775110	Prob(F-statistic)	0.000002

Table 5: Diagnostic Statistics

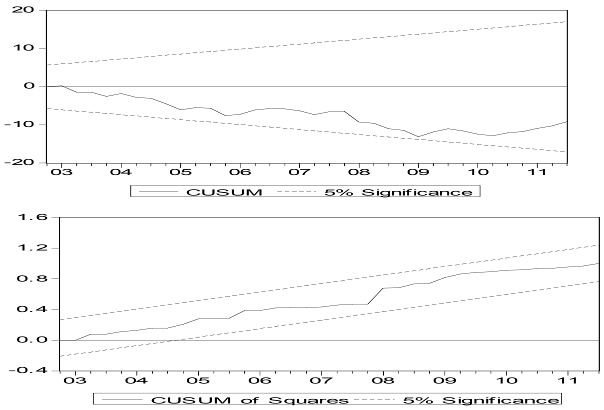
Diagnostic Test	Statistic		Prob.
Normality: Jacque-Bera	JB – statistic Skewness Kurtosis	1.503923 0.292124 2.334184	0.471441 - -
Serial Correlation: Breusch-Godfrey Serial Correlation LM Test	F – Statistic Obs*R^2	0.926163 1.185862	0.342464 0.276166
Specification Error: Ramsey RESET Test	F - Statistic LR- Statistic	0.827972 11.21125	0.596533 0.261506
Autoregressive Conditional Heteroscedasticity: ARCH LM Test	F – Statistic Obs*R^2	0.449561 0.465603	0.506129 0.495017
Heteroscedasticity: White Heteroscedasticity Test	F - Statistic Obs*R^2	0.697858 14.60580	0.784047 0.688833

Based on theoretical predictions, all the explanatory variables in the specified model have the expected signs. In the long-run, the implied elasticity for real exchange rate misalignment signifies that a 1 percent increase in exchange rate misalignment (commonly in form of overvaluation) leads to about 0.21 percent decrease in export growth. Regarding real exchange rate volatility, a 1 percent increase in volatility causes export growth to deteriorate by approximately 0.81 percent in the long-run. Regarding other export growth determinants, growth in real gross domestic product by 1 percent leads to approximately 2.65 percent growth in exports. The statistically significant positive impact of growth in real gross domestic product on export growth confirms the Balassa-Samuelson effect which states that productivity increases faster in tradables sector than in the non-tradables sector (Diallo, 2011).

In the short-run, a 1 percent rise in real exchange rate misalignment leads to nearly 0.03 percent decline in export growth, while a 1 percent increase in real exchange rate volatility depressingly affects export growth by approximately 0.62 percent. Results also further indicate that an increase in productivity and improvement in trade openness have significant positive impacts on export competitiveness. Growth in real gross domestic product by 1 percent significantly leads to about 2.95 percent growth in exports, while an improvement in openness by 1 percent leads to nearly 1.07 percent export growth. Capital controls demonstrate a strongly significant negative impact on export growth, signifying that a 1 percent rise in tightening of capital flow causes nearly 7.1 percent decline in export growth. This result is consistent with the finding by Tamirisa (1998) in which capital controls are found to be a significant impediment to export growth.

Furthermore, an equally important observation is the adjustment speed. The estimated adjustment coefficient of the cointegrating is statistically significant and different from zero. The coefficient signifies a moderate adjustment to the past disequilibrium in export growth, suggesting that the error correction mechanism is stable. The result of the adjustment parameter asserts that, on average, 36.8 percent of the departure from the equilibrium is adjusted in the current period, while the remaining 63.2 percent is corrected as variables become cointegrated. Overall, the adjusted R-squared show that about 58 percent of the variation in export growth is accounted for by the variables captured in the estimated model. The results on diagnostic tests of the estimated export function reveal that the model is correctly specified (RESET), normally distributed (JB); no serial correlation (LM) and no heteroscedasticity (ARCH) in the residuals. Finally, the stability of the model parameters is examined by applying the CUSUM and CUSUM of Squares techniques (Figure 2).

Figure 2: CUSUM and CUSUMQ



The stability tests on the entire estimated export growth model confirm that the coefficients in the error correction model are stable. The realisation that neither CUSUM nor CUSUMSQ plots cross the critical bounds confirms absence of significant structural instability.

5. Conclusion and Policy Implications

This paper examines the relative impacts of real exchange rate misalignment and real exchange rate volatility on export growth in South Africa from 2000:1 to 2011:4. The results from the cointegration analysis reveal that there exists a long run equilibrium relationship among export growth, real exchange rate misalignment, real exchange rate volatility, real gross domestic product growth, openness and capital controls. Based on the one-step error correction approach, the findings reveal that real exchange volatility has a significant and higher impact on export growth relative to misalignment. As expected, trade openness and real gross domestic product have strong positive impacts while capital control has a strong negative impact on export growth.

From the policy perspective, real exchange rate misalignment in form of overvaluation could entail deprived performance of the tradables sector since real overvaluation leads a loss in a country's export competitiveness. Furthermore, undervaluation may perhaps result in economic overheating thereby aggravating pressure on inflation and generating market speculation and unexpected currency appreciation. Hence, monitoring of the real exchange rate developments therefore becomes vital in order to reduce the degree of uncertainty faced by the tradables sector.

Having based the analysis of this paper on the assumption of linear relationships between export growth and its determinants, future work on this issue will apply nonlinear techniques to establish whether significantly improved results can be obtained.

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