South Africa's exchange rate and sectoral export performance

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Abstract:

The aim of this paper is to analyse the impact of changes in the exchange rate of the rand on South Africa's export sector. It is important to consider that different export sectors may react differently and sometimes in opposing ways, resulting in a subdued impact on total exports. The issue is examined using the Johansen Maximum cointegration technique and an Error Correction Model (ECM) to analyse the long run effects and the short-run dynamics of the effects of changes in the exchange rate on South Africa's export volume, total exports, manufacturing exports, mining and agricultural exports for the period 1988-2014. The results show that while there is a long-run equilibrium relationship between the real effective exchange rate (REER) and all the dependent variables (excluding export volumes), a real depreciation of the domestic exchange rate only has a positive long-run effect on manufacturing and mining export performance. In the short run, while the EC model shows that REER depreciation may increase total exports, mining and manufacturing exports, this is not the case for export volumes and agricultural exports. The results also show that manufacturing and mining exports are affected more by their previous values than the exchange rate. In addition, the paper finds that an increase in world income, compared to the exchange rate, has a much larger impact on total exports from South Africa.

Keywords: Export performance, total exports, manufacturing exports, mining exports, agricultural exports, real effective exchange rate, error correction model, cointegrating relationship

JEL codes: F1, F4, F14, F17, F31

1. Introduction

With the end of apartheid in 1994, South Africa has become more integrated with the global economy, exposing it to increased fluctuations of the exchange rate and great opportunity to increase trade. With an effort to promote sustainable economic growth and increase employment, South Africa's most recent policy document, the National Development Plan (NDP), emphasises the need for South Africa to increase its competitiveness in order to increase exports. The debate regarding the ideal level of exchange rate in South Africa has been going on for a long time, with different parties calling for a depreciation, an appreciation or a stabilisation of the exchange rate. Those who call for a depreciation of the rand, like the Congress of South African Trade Unions, argue that a weaker rand makes South African export goods more competitive. Further, a stronger rand is seen to negatively affect South African businesses, as cheaper import goods crowd out local products. While others argue that a stronger rand is beneficial to consumers as it increases their purchasing power, allowing them to purchase more with the wage that they are given. These parties therefore call for the South African Reserve Bank to play a more active role in the exchange rate market. Given such developments, the effect of a depreciation of the exchange rate on exports and therefore growth is an important issue, particularly from a policy making perspective. Consequently more research needs to be done on the effects of exchange rate changes on exports in order to know the appropriate policy action that is needed.

Given the importance of South Africa's current account balance not only for its economic performance but also financial stability, the effect of the substantial depreciation of the rand since the end of apartheid on exports should be considered. This is because, in theory, a depreciation is meant to enhance export competitiveness, encourage export diversification, protect domestic industries from imports and improve the trade balance. This topic is particularly important in South Africa given the fact that South Africa's real effective exchange rate (REER) has depreciated by 36 per cent from January 1990 to January 2014[1]. Therefore, this research paper will assess the relationship between South Africa's exchange rate and its export performance, assessing whether a depreciation of the rand against its major trading partners will benefit export companies in the country. The question is; has and can a change in the real effective exchange rate affect South Africa's economic growth through its effect on the country's exports. In other words, can the exchange rate be considered as an important macroeconomic instrument for promoting export and economic growth?

While there have been numerous articles addressing this issue, not only in South Africa but for both developed and developing countries, this research paper will concentrate on a part of this topic that has not been addressed fully yet. Specifically, this research paper will look more closely at disaggregated research at a sector level. Looking at the effects of exchange rate changes, not only on total exports but also on the export performance of manufacturing, mining and agricultural sectors can be seen as a different approach to answering the question of whether exchange rate depreciations increase a country's export performance. A large number of literatures concentrate on the effects of exchange rate changes and exchange rate volatility on total exports and on manufacturing exports, not considering that different export sectors may react in different and sometimes opposing ways, resulting in a subdued impact on total exports. The different reactions that each sector may have to a depreciation of the rand for example will have large implications for trade policy and budget considerations, and therefore more research on this issue needs to be done.

2. Literature review

2.1. Theoretical literature review

According to Sekkat and Varoudakis (2000: 238), the countries that have successfully promoted manufacturing exports have experienced depreciations in their exchange rate. Standard Trade Theory states that a depreciation of the exchange rate of a country is beneficial for the export performance of that country. This is because a depreciation makes home exports relatively cheaper to foreign buyers, resulting in them switching expenditure from their own goods and services to the cheaper imports (Appleyard, Field and Cobb, 2010: 575). While there are a number of approaches that explain how a depreciation of a currency improves export performance, this paper will consider two schools of thought. The first is the elasticities approach that states that the extent to which export volumes respond/increase as a result of currency depreciations depends on the elasticity of foreign demand for the country's exports and the elasticity of domestic supply of export goods. The elasticity of demand is defined as the quantity responsiveness of demanded goods or service to changes in price. If export goods are

[1] Figures based on IMF CPI-based REER data

price elastic, then the quantity demanded will rise more than the decrease in relative prices, resulting in a rise in total export revenues (Alemu and Jin-sang, 2014: 65). For Alexander (1952: 264), the elasticities approach implies that the effect of a depreciation of a currency depends on how the economic system behaves.

An extension of the elasticities approach, the Marshall-Lerner Condition, states that a depreciation of the exchange rate will improve the trade balance (i.e. increase exports and decrease imports) if the sum of the absolute values of the long run export and import demand elasticities exceed one (Lerner, 1944). This is because, while currency devaluations results in a positive quantity effect[2], there is also a negative cost effect since the cost of imports will be higher and export prices will be lower. Therefore under the Marshall-Lerner condition, for a depreciation of the exchange rate to increase export performance, the quantity demanded for exports should increase proportionally more than the decrease in their price. If this condition is met, then the total export revenue of the exporting country will increase. A dynamic view of Marshall-Lerner Condition is the J-Curve phenomenon. This effect states that in the short run, a depreciation of a currency actually decreases the performance of exports. This is because the price of exports changes while the volume of them does not change immediately[3] (Ali, Joharib and Alias, 2014: 4). Over time, however, the volume of exports may rise as the lower and more competitive prices increase foreign demand.

The elasticities approach is criticised for having the export supply function dependent only on the nominal prices rather than relative prices. Further, the approach does not explicitly take other markets or goods into account (Ogundipe, Ojeaga and Ogundipe, 2013: 235-236). Kim (2009: 214) further asserts that it ignores the feedback effects currency depreciations have on macroeconomic variables arising from price changes and production fluctuations. The second approach, the absorption approach, addresses these criticisms, as it looks at the relationships of real expenditure to real income and on the relationship of both the variables on the price levels. Further, along with the monetary approach, it relates currency depreciation to macroeconomic variables that usually undermine the favourable impact of the exchange rate devaluations on the trade balance. This approach, popularised by Alexander (1952), emphasises changes in real domestic income as a determinant of a country's exports.

Under the absorption approach, a devaluation of an exchange rate can affect exports in two ways. Firstly, there is a cash balance effect, where a currency depreciation reduces domestic purchases of goods and services (decreased absorption). This results not only in an increase in exportable goods and services, but also a transfer of resources to the production of exports. This effect is dependent on the assumptions that money supply is inflexible, money-holders want to maintain real cash holdings as prices rise[4] and that there is no capital mobility. The second effect is the idle resources effect. In this case, a currency depreciation can only increase exports of the devaluing country if the increased output of tradable goods and services do not result in an extensive rise in the price of these goods. Further, the extent to which the export level rises will depend on whether the rest of the world can absorb the increase in exports. If there is a global economic slowdown for example, the ability of the world to absorb exports may be limited. The next section of this paper will look at how these theories have been empirically tested for different countries.

2.1. Empirical literature review

There has been a large number of literature looking at the effects of the exchange rate on exports, with a large focus on the elasticity of the exports to exchange rate changes. Many of the literature compare the long run and short run elasticities. Such an analysis is important as economic theory states that, when there are no distortions in the economy, a depreciation of the currency has no long run effects on trade flows as it does not change the relative price. In the short run, however, changes in the exchange rate do affect prices and thus the allocation of resources between tradable and non-tradable goods and services (Auboin and Ruta, 2011: 10). Auboin and Ruta (2011), however, state that with the presence of market failure (distortions), an undervaluation of the exchange rate can have long run effects. Since such failures are more prominent in developing countries like South Africa, it is expected that movements in the exchange rate will have long lasting effects on exports in these countries.

[2] Given that domestic households will buy fewer imports and foreign households will buy more of the home country exports.
[3] This is because consumer behaviour is relatively rigid.
[4] In order to maintain cash holdings of a given value as prices increase (given that money supply is fixed), consumers would need to accumulate more cash though the reduction of real expenditures relative to real incomes.

For South Africa, Edwards and Garlick (2008: 6) find that, depending on the estimation technique, estimates on aggregated trade data result in long run real exchange rate elasticities of between -0,43 and 2,8. They, however, state that historical evidence from South Africa suggests that a nominal depreciation has not led to a sustained improvement in total exports because inflation and wage growth tend to undercut the positive impact an exchange rate depreciation has on export performance. Poonyth and Van Zyl (2000) investigate the short run and long run relationship between the real exchange rate and South Africa's agricultural exports. They estimate an error correction model (ECM) using the Engel and Granger methodology and find that there is both a long run and short run relationship between the exchange rate and agricultural exports in South Africa. Further, they find that the relationship is unidirectional, flowing from the real exchange rate to agricultural exports.

Golub and Ceglowski (2002) use a simple ordinary least squares (OLS) model to estimate the correlation between different calculations of the REER and South African real manufactured exports. They find that manufactured exports respond strongly to improved competitiveness for the period 1970-1998 for all the different variations of the REER they use. For Edwards and Alves (2006: 490), the elastic response of manufacturing exports volumes to changes in relative prices is much larger when using a variation of the imperfect substitution model. Using the dynamic fixed effects and General Methods of Moments estimators, they find that exchange rate depreciations on average positively affect export performance because it raises the profitability of export supply, and not because it increases the cost competitiveness of South African products. Other studies that have found that manufacturing exports in South Africa are influenced by the exchange rate include Holden and Gouws (1997), Behar and Edwards (2004) and Chandra, Moorty, Rajaratnam, and Schaefer (2001). Chandra et al. (2001) differs from the above literature in that they concentrate more on firm level data and show that firms raised exports in response to the rand crisis of 1998.

Despite the above studies that have found that a depreciation in the exchange rate affects South Africa's export performance, there are, however, other studies that have failed to show the link. Naudé (2000) uses an OLS model to study the determinants of South African exports and found that none of the determinants outlined in literature, including the real exchange rate, can significantly explain South Africa's export volume for the period 1974-1998. Further, Edwards and Schoer (2002) find that while South Africa's REER depreciated during the 1990s, its export growth remained mediocre compared to other emerging market countries in the same period. Amiti, Itskhoki and Konings (2013) have attributed low exchange rate pass-through to the fact that large exporters are, at the same time, the largest importers in many countries. If this is true for South Africa, and given the fact that Rankin (2001) finds that large firms in South Africa are more likely to export not only to SADC countries but also to the global market, it could explain the disconnect between South African exports and the exchange rate.

In Africa, Ogundipe, Ojeaga, and Ogundipe (2013) investigated the impact of currency depreciations on Nigeria's trade balance using the Johansen co-integration and variance decomposition approaches spanning from 1970 to 2010. They find that, contrary to trade theory, a depreciation of Nigeria's exchange rate negatively affects its trade balance. They, however, note that the exchange rate is not the only variable that influences trade and, other variables (like domestic money supply volatility) have greater impact on the trade balance. In Sierra Leone, Tarawalie (2010) analyses the short-run and long-run dynamics of exchange rate changes using the Johansen cointegration technique, and an ECM estimation. He finds that, in the long run, a depreciation of the exchange rate increases net exports and thus economic growth through the multiplier effect. Using the simultaneous-equation model and the Seemingly Unrelated Regression method, Bouoiyour and Rey (2005) find that a misalignment (overvaluation) of the Moroccan exchange rate does not have a significant effect on exports but increased exchange rate uncertainty negatively affects exports.

Outside of Africa, Shirvani and Wilbratte (1997) use the Johansen-Juselius multivariate cointegration approach to analyse the bilateral trade between the US and other G-7 countries. They find that the exchange rate does affect the trade balance in the US in the long run. In the very short run, however, they find that the trade balance does not respond significantly to exchange rate shocks, needing up to two years to make an impact. A paper by Kim (2009) investigates the macroeconomic determinants of Korea's persistent bilateral trade deficit with Japan and the trade surplus it has with the US using the cointegration–VECM approach. The model includes bilateral trade balance, bilateral real exchange rate, domestic and foreign income and relative money supply of Korea with the US and Japan. The results show that Korea's bilateral trade balance with the US improves following a depreciation of Korean won against US dollar, while Korea–Japan bilateral trade balance deteriorates for first two quarters and thereafter improves supporting the J-curve effect, but the degree of its real improvement is negligible. Baharumshah (2001) also uses the Johansen-Juselius multivariate cointegration approach and estimates an unrestricted vector autoregressive (VAR) model and finds that a devaluation of the ringgit and baht causes an increase in the exports to the US and Japan from Malaysia and Thailand.

Abeysinghe and Yeok (1998) also use an ECM to assess the effects of exchange rate depreciations on different export categories in Singapore. They find that while currency depreciations do increase exports in all categories, the impact of the depreciation is dependent on their share of import content. Service exports, for example, are relatively less intensive in imported inputs and are thus most affected by a change in the exchange rate. Using a different perspective to address the question of whether a depreciation affects export performance, Berman, Martin and Mayer (2009) analyse French export firms. They find that high performance French firms react to currency depreciations by increasing their export price rather than their export volume, while low productivity export firms do the opposite.

A number of studies have looked at a cross-section of countries to assess the relationship between exports and the exchange rate. Bahmani-Oskooee (1998) uses the Johansen and Julius co-integration technique to estimate the trade elasticities in some less developed countries. It is found that the elasticities are large enough to encourage a devaluation of the currencies to improve the trade balance. Genc and Artar (2014) and Ghosh, Thomas, Zalduendo, Catao, Joshi, Ramakrishnan, and Rahman (2008) look at the effect of exchange rates and trade in emerging market countries (EME) with the first looking at 22 countries while the latter included 46 countries in their sample. The study by Genc and Artar (2014) conclude that there is a cointegrating relationship between the REER and the exports of the EME in the long run. The study by Ghosh et al. (2008) is important for this paper as it shows that the effects of exchange rate changes on the US dollar value of exports depend on the nature of the country's predominant export and the market structure of that country's exports. Ghosh et al. (2008) find that manufacturing and oil and non-oil commodities export volumes in EMEs have a very small short-run elasticity to nominal depreciation in exchange rates.

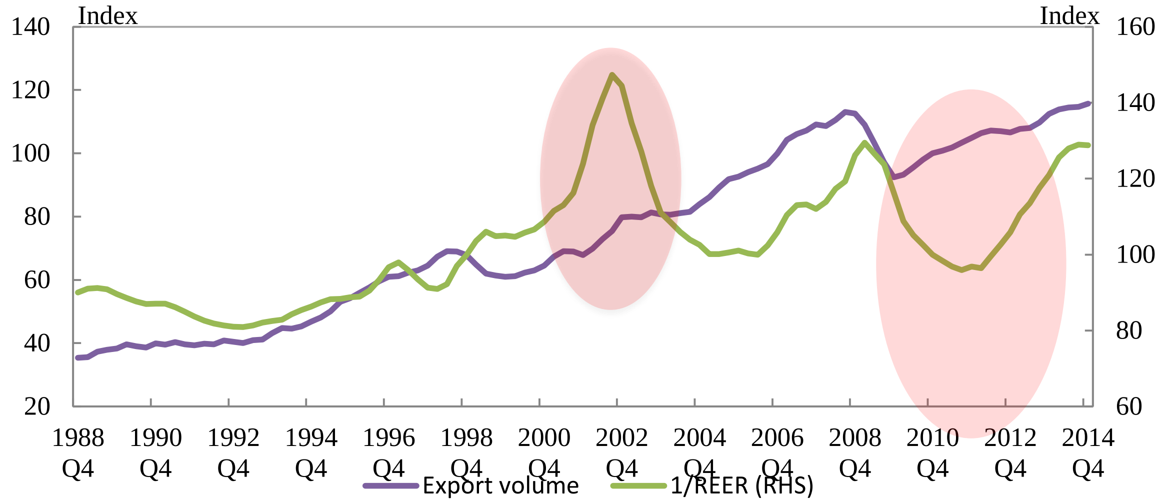
While an exchange rate depreciation improves the performance of manufactured exports in sub-Saharan African countries, according to Sekkat and Varoudakis (2000), the magnitude of the elasticities is below those found in other developing countries. A study by Sekkat and Varoudakis (2002) analyses the impact of trade and exchange rate policies in increasing manufactured exports in North Africa. The authors find that the exchange rate does not significantly affect manufactured exports. A reduction in the exchange rate misalignment, however, has a positive effect on the exports. Nabli and Véganzonès-Varoudakis (2004) find that an overvaluation of the exchange rates of MENA countries has cost the region in terms of exports.

3. Correlation between the REER and South African exports

This section depicts the movement of the volume of South Africa's total exports, South African total exports, manufacturing exports, mining exports and agricultural exports in relation to the REER[5] of the rand. Figure 1 depicts the 1 year moving average of the volume of South African total exports and the REER. The figure shows that while there seems to be co-movement between the two variables, with a depreciation resulting in an increase in export volumes and vice versa, the volume of exports does not seem to respond as strongly to steep depreciations and appreciations of the rand. This can be seen in 2002 where the export volume did not respond as strongly to the steep depreciation of the rand and in 2011 where it did not respond as strongly to the appreciation of the exchange rate (highlighted in red). This suggests that there are other factors that may also be driving the movement of export volumes. The variables, however, show a particularly strong degree of correlation during the 2006-2008 time period.

[5] The REER has been inverted so that an increase in the index represents a depreciation of the rand i.e. an increase in competitiveness.

Figure 1 South African export volume and the REER

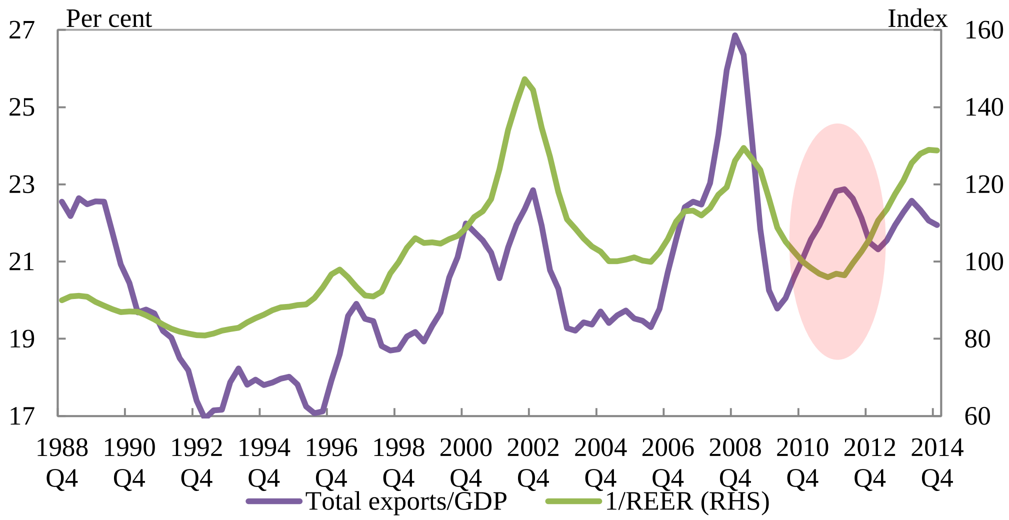


Source: Own calculations from SA Reserve Bank and Quantec data

Figure 2 shows the 1 year moving average of South African total exports and the REER. The figure shows that, while both these variables move together over time (when the rand depreciates, the volume of exports also increase), there are other factors that help determine the movement of South African total exports. This is particularly true for the 2011-2012 period, where South Africa's total exports increased at a time when there was an appreciation of the rand. Similarly for agricultural exports and the REER (as shown by Figure 3), mining exports and the REER (Figure 4) and manufacturing exports and the REER (Figure 5). Of particular interest is the fact that when the exchange rate appreciated in the last quarter of 2010, total exports, mining exports, agricultural exports and manufacturing exports increased, in contrast with theoretical presumptions.

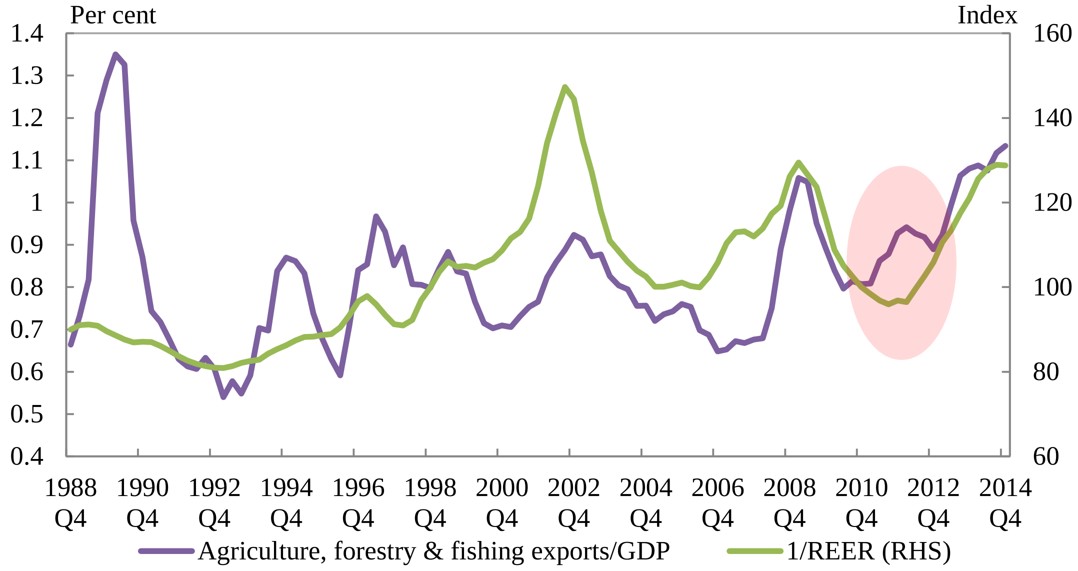
Therefore, one can see from the figures presented that, while there is a positive correlation between the inverted exchange rate and total, mining, agricultural and manufacturing exports, there are periods within the period under review where other factors played a stronger role in driving the performance of South African exports, both at an aggregated and disaggregated level.

Figure 2 South African total exports and the REER



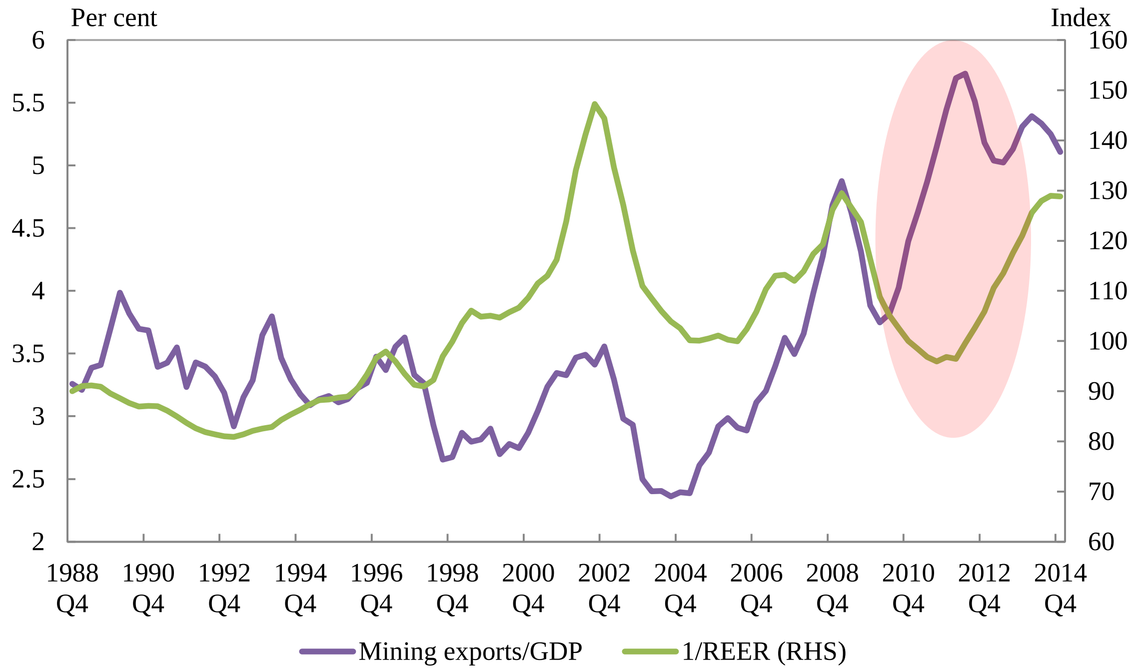
Source: IMF, Quantec and own calculations

Figure 3 South African agricultural exports and the REER



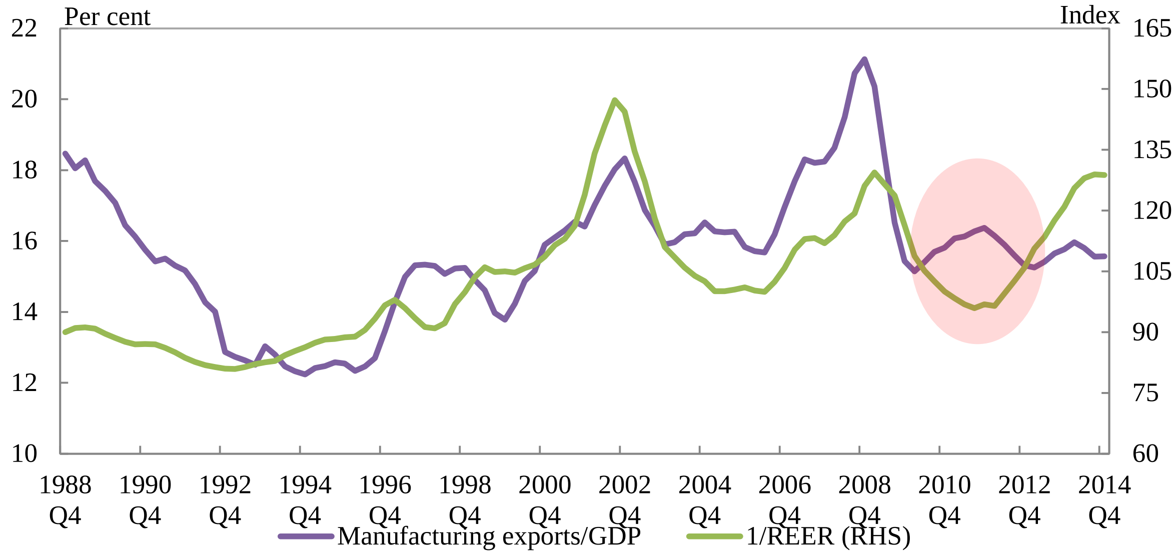
Source: IMF, Quantec and own calculations

Figure 4 South African mining exports and the REER



Source: IMF, Quantec and own calculations

Figure 5 South African manufacturing exports and the REER



Source: Own calculations from IMF and Quantec data

A simple correlation test, presented in Table 1, confirms a weak negative relationship between the REER (not inverted) and South African export volume, total exports, manufacturing exports, mining exports and agricultural exports. The strongest relationship (where there is a correlation of -24,3 per cent) is between the REER and total South African exports. The weakest correlation (of -0,52 per cent) is between the REER and volume of South Africa's total exports.

Table 1 Correlation results[6]

	DREER
DAGRI	-0.057072
DEXPVAL	-0.242828
DEXPVOL	-0.005193
DMANU	-0.227736
DMINE	-0.160010
DREER	1.000000

4. Model framework

4.1. The empirical export equation

A variation of the imperfect substitution model presented by Goldstein and Khan (1985) is used to specify the equation that depicts the relationship between exports and the exchange rate. The model used in this paper is a reduced form equation of the export demand (X^d) and supply (X^s) equations. The relationships are given by:

$$X^d = \delta_0 - \delta_1 P_x + \delta_2 E + \delta_3 P^* + \delta_4 Y^* \quad (1)$$

And

$$X^s = \theta_0 + \theta_1 P_x - \theta_2 P + \psi Z \quad (2)$$

Where

X = exports
P_x = domestic price of exports
E = currency exchange rate
P* = foreign domestic price
Y* = foreign income
P = domestic price
Z = vector of real variables that influence the supply of exports

Given equation (1) and (2), the reduced form equation can be given as[7]:

[6] The data used is quarterly and covers the period from 1988 quarter 1 to 2014 quarter 4 for South Africa. All variables are used in their natural log form and have been differenced to control for non-stationarity.

$$X = \frac{1}{1+\lambda}\left[\sigma_0 + \sigma_1 (E + P^* - P) + \sigma_2 Y^* + \sigma_3 Z\right] \quad (3)$$

Where

$$\lambda = \frac{\theta 1}{\delta 1},\ \sigma_0 = \frac{\theta 1 \delta 0}{\delta 1},\ \sigma_1 = \theta_1,\ \sigma_2 = \frac{\theta 1 \delta 4}{\delta 1},\ \sigma_3 = \psi$$

For this paper, the reduced form equation for the relationship between South African exports and the exchange rate, controlling for foreign income and investment (presented in log form), can be written as:

$$\ln X_{it} = \beta_0 + \beta_1 \ln REER_t + \beta_2 \ln INV_{it} + \beta_3 \ln INC_t + \nu_t \quad (4)$$

Where

i represents the type of South African export and type of investment to be modelled[8]
X_{it} = the different types of exports
$REER_t$ = real effective exchange rate
INV_{it} = the different types of investments
INC_t = foreign income
V_t = error term

4.2. Data description and analysis

The data used for this study is quarterly and covers the period from 1988 quarter 1 to 2014 quarter 4 for South Africa. The sample period has been decided purely by data availability of South African exports. All variables are used in their natural log form. The data are constructed as follows:

a. Dependent variables

XVol: South African export volumes excluding gold exports represented as an index with 2010 being the base period. The data is collected from the South African Reserve Bank.
XVal: Real South African value of total exports are constructed as nominal total exports deflated by the GDP deflator. The total export data is collected from Quantec and the GDP deflator data is collected from the South African Reserve Bank.
AgriX: Real South African agricultural exports are constructed as nominal agricultural exports deflated by the GDP deflator. The agricultural export data is collected from Quantec.
MineX: Real South African mining exports are constructed as nominal mining exports deflated by the GDP deflator. The mining export data is collected from Quantec
ManuX: Real South African manufacturing exports are constructed as nominal manufacturing exports deflated by the GDP deflator. The manufacturing export data is collected from Quantec.

b. Independent variables

REER: Real effective exchange rate of the South African rand is constructed using the South African Consumer Price index (CPI). The data is collected from the International Monetary Fund (IMF) International Finance Statistics (IFS). Golub and Ceglowski (2002:1058), show that the choice of which REER variable to use is irrelevant as REER's calculated using different country weights and different price indices generally have very little variation

INC: Industrial production of advanced economies is used as a proxy for foreign income given that it is the general tradition in literature. The data is collected from the IMF IFS. The data is represented as an index with 2010 being the base period.

INV: Gross fixed capital formation by general government in South Africa represented in 2010 constant prices. The data is collected from the South African Reserve Bank.

ManuINV: Gross fixed capital investment in the manufacturing sector in South Africa represented in 2010 constant prices. The data is collected from the South African Reserve Bank.

MineINV: Gross fixed capital investment in the mining sector in South Africa represented in 2010 constant prices. The data is collected from the South African Reserve Bank.

4.3. Theoretical framework

[7] Refer to Edward and Alves (2006) for a detailed explanation of the full derivation.
[8] In this paper X_{it} is total exports, total export volume, manufacturing exports, mining exports and agricultural exports. INV_{it} is total investments, investment in the mining sector and investments in the manufacturing sector.

The non-stationary nature of time series data can often lead to spurious regressions and misleading results when conventional empirical analysis is used. Further, the effects of a change in the exchange rate on exports is not purely instantaneous and may take more than one period of time to affect exports, thus making equation (4) restrictive. An increasingly interesting concept in econometrics is cointegration. When variables in a model are integrated of the same order, but their combination produces an error term that is stationary, it is said that they are cointegrated, in that they move together on a non-stationary path and there is some long-run equilibrium relationship tying the individual components together. Engle and Granger (1987) show that the ECM can capture the cointegrating, long run and dynamic nature of cointegrated variables. The ECM representation of equation (4) can be written as:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta X_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta INV_{t-i} + \sum_{i=1}^{n} \alpha_4 \Delta INC_{t-i} + \gamma_1 ECT_{t-1} + \xi_t \quad (5)$$

Where

$$ECT_{t-1} = x_{t-1} - \beta_0 - \beta_1 REER_{t-1} - \beta_2 INV_{t-1} - \beta_3 INC_{t-1} \quad (6)$$

The coefficient γ_1 is the error-correction coefficient that measures the response of each variable to the degree of deviation from long-run equilibrium in the previous period. The error correction term (ECT) therefore measures the speed of adjustment of X_t to a discrepancy between the dependent variable (Exports) and the regressors. The ECM therefore captures the short-run and long-run dynamics between the variables in the cointegrated relationship. Equation (5) illustrates a model where there is only one cointegrating relationship, but it is possible to have more cointegrating relationships, resulting in multiple ECTs given the multiple regressors.

4.4. Model specification

Given that this paper attempts to capture the effects of changes in the REER on different types of South African exports (thus resulting in multiple dependent variables), in the presence of cointegration, five EC models, would need to be specified with export volume, total exports, manufacturing exports, mining exports and agricultural exports as dependent variables. The equations are specified as follows[9]:

$$\Delta XVol_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta XVol_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta INV_{t-i} + \sum_{i=1}^{n} \alpha_4 \Delta INC_{t-i} + \gamma_1 ECT_{vol,t-1} + \xi_t \quad (7)$$

Where

$$ECT_{vol,t-1} = XVol_{t-1} - \beta_0 - \beta_1 REER_{t-1} - \beta_2 INV_{t-1} - \beta_3 INC_{t-1} \quad (8)$$

$$\Delta XVal_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta XVal_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta INV_{t-i} + \sum_{i=1}^{n} \alpha_4 \Delta INC_{t-i} + \gamma_1 ECT_{val,t-1} + \xi_t \quad (9)$$

Where

$$ECT_{val,t-1} = XVal_{t-1} - \beta_0 - \beta_1 REER_{t-1} - \beta_2 INV_{t-1} - \beta_3 INC_{t-1} \quad (10)$$

$$\Delta ManuX_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta ManuX_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta ManuINV_{t-i} + \sum_{i=1}^{n} \alpha_4 \Delta INC_{t-i} + \gamma_1 ECT_{manux,t-1} + \xi_t \quad (11)$$

Where

$$ECT_{manux,t-1} = ManuX_{t-1} - \beta_0 - \beta_1 REER_{t-1} - \beta_2 ManuINV_{t-1} - \beta_3 INC_{t-1} \quad (12)$$

$$\Delta MineX_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta MineX_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta MineINV_{t-i} + \sum_{i=1}^{n} \alpha_4 \Delta INC_{t-i} + \gamma_1 ECT_{minex,t-1} + \xi_t \quad (13)$$

Where

$$ECT_{minex,t-1} = MineX_{t-1} - \beta_0 - \beta_1 REER_{t-1} - \beta_2 MineINV_{t-1} - \beta_3 INC_{t-1} \quad (14)$$

$$\Delta AgriX_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta AgriX_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta REER_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta INV_{t-i} + \sum_{i=1}^{n} \alpha_4 \Delta INC_{t-i} + \gamma_1 ECT_{agrix,t-1} + \xi_t \quad (15)$$

Where

$$ECT_{agrix,t-1} = AgriX_{t-1} - \beta_0 - \beta_1 REER_{t-1} - \beta_2 INV_{t-1} - \beta_3 INC_{t-1} \quad (16)$$

[9] Δ indicates first differenced variables.

5. Methodology

In order to formulate an ECM outlined in Section 4.2, the variables discussed above have to meet the appropriate properties, namely, they have to be non-stationary, integrated of the same order and cointegrated. There are three steps involved when formulating an ECM. Firstly, there is a need to test for unit root and order of integration. Secondly, if all variables are integrated of order 1, one needs proceed to testing for cointegration. Thirdly, if cointegration is present, an ECM can be built to capture the long run relationships and short run dynamics.

5.1. Testing for stationarity

The estimation of an equation using data that is non-stationary often leads to spurious results. When data is non-stationary and needs to be differenced d-times to be made stationary, it is said to be integrated of order d [I(d)]. In time series analysis, the most common feature is having data that has a unit root (integrated of order one). Given that data that contain unit roots often lead to invalid results, it is important to test it for unit root. The series in this paper are tested for stationarity using the Augmented Dickey-Fuller unit root test (ADF) by Said and Dickey (1984), and the Phillips-Perron (PP) unit root test by Phillips and Perron (1988). The ADF test is carried out in the same way as the DF test but is applied to a model that includes the lagged values of the dependent variable so as to control for serial correlation in the error term. Therefore, for the ADF test, the following regression is estimated in log form for each of the variables in the model:

$$\Delta Y_t = \sigma_0 + \sigma_1 Y_{t-1} + \sum_{i=1}^{t} \gamma_i \Delta Y_{t-i} + \varepsilon_t \qquad (17)$$

Where $\sigma_1 = 1 - \rho$

The number of lags is dependent on the number of lags required to control for serial correlation. The following t-statistic is then computed:

$$\tau = \frac{\hat{\sigma}}{se(\hat{\sigma})} \qquad (18)$$

The unit root test is then carried out under the null hypothesis $\sigma_1 = 0$ against the alternative hypothesis of $\sigma_1 < 0$. When the null hypothesis is rejected then no unit root is present.

The PP test also builds on the DF test but instead of adding lags of the dependent variables, it uses non-parametric statistical methods to address the issue of serial correlation and heteroskedasticity. It takes the same estimation scheme as in the DF test, but corrects the test statistic to control for autocorrelation and heteroskedasticity. Therefore, for the PP test, the following regression is estimated in log form for each variable in the model:

$$Y_t = \rho_0 + \rho_1 Y_{t-1} + \varepsilon_t \qquad (19)$$

Then the t-statistic is computed (same as ADF test) and then modified to control for serial correlation. The unit root test is then carried out under the null hypothesis $\rho_1 = 1$ against the alternative hypothesis of $\rho_1 < 1$. As with the ADF test, when the null hypothesis is rejected then no unit root is present.

5.2. Testing for cointegration

The best way to test for cointegration is to use the Johansen cointegration procedure (Johansen and Juselius, 1990) because it not only allows one to test for multiple cointegrating vectors but also to test for restricted versions of the cointegrating vectors and speed of adjustment parameters (Enders, 2004). The testing procedure starts with assuming the following VAR model:

$$X_t = A_1X_{t-1} + A_2X_{t-2} + A_3X_{t-3} + \ldots + A_pX_{t-p} + U_t \qquad (20)$$

Where

X_t are endogenous variables and X_t and U_t are (mx1) vectors while Π_1 through Π_p are (mxm) coefficient matrices. In this paper the variables X_t = (XVol, XVal, AgriX, MineX, ManuX, REER, INC, INV, ManuINV, MineINV) are I(1).

By re-parameterising the VAR, it becomes the VECM:

$$\Delta X_t = \Pi_1 \Delta X_{t-1} + \Pi_2 \Delta X_{t-2} + \ldots + \Pi_{p-1} \Delta X_{t-p+1} - \Pi X_{t-p} + U_t \qquad (21)$$

Where

$\Pi_1 = A_1 - I$, $\Pi_2 = A_2 - I$, etc. and $\Pi = I - A_1 - A_2 - \ldots - A_p$

The matrix Π determines the extent to which the system is cointegrated. Further, the rank of Π is equal to the number independent cointegrating vectors, and therefore, if rank(Π) = 0, then there is no stationary linear combination of the X_t processes, the variables would not be cointegrated and equation (21) is the usual VAR model. However, if rank(Π) = r then there are r number of cointegrating vectors. If the variables in X_t are I(1), then the rank(Π) = r < m (i.e. Π has reduced rank) and Π can be written as:

$\Pi = \alpha\beta'$ (22)

Where

β is the matrix of cointegrating parameters

α is the matrix of the speed of adjustment parameters

All linear combinations of βX_{t-p} are stationary.

Johansen's cointegration testing approach is based on maximum likelihood estimation and likelihood ratio testing of the VECM. It maximises the likelihood function over a subset of parameters and treats the other parameters as known, given the number r of cointegrating vectors. The VECM is estimated under various assumptions about the number of cointegrating vectors (r), the trend or intercept parameters and by assuming that the VECM errors $U_t \sim$ iid N[0,S]. Maximum likelihood estimation allows for the following: the estimation of equation (20) as a VECM, the determining of the rank of Π by conducting likelihood ratio (LR) tests, the use of r most significant cointegrating vectors to form β' and the selection of α such that $\Pi = \alpha\beta'$.

The number of cointegrating vectors is equal to the number of characteristic roots (eigenvalues) of Π that are significantly different from zero. The Johansen approach allows one to determine the number of eigenvalues that are significantly different from zero by using two types of test statistics:

1. *The trace test*

   $\lambda_{trace}(r) = -T\sum_{i=r+1}^{m} \ln(1-\hat{\lambda}_i)$ (23)

   Where

   $\hat{\lambda}_i$ = The estimated eigenvalues obtained from the estimated Π matrix

   T = the number of usable observations.

   This test is conducted sequentially for r = k-1,...,1,0. The name comes from the fact that the test statistic involved is the trace (i.e. the sum of the diagonal elements) of a diagonal matrix of generalised eigenvalues. It tests the null hypothesis that the cointegration rank is equal to r against the alternative that the cointegration rank is k.

2. *The lambda-max test*

   $\lambda_{max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1})$ (24)

   This test is conducted sequentially for r = 0,1,..,k-1. The name comes from the fact that the test statistic involved is a maximum generalised eigenvalue. It tests the null hypothesis that the cointegration rank is equal to r against the alternative that the cointegration rank is equal to r+1.

   The critical values for both test statistics are found in Johansen and Juselius (1990).

6. Empirical results

This section presents the results from the procedure described above in order to assess the relationship between South African total exports, manufacturing exports, mining exports and agricultural exports and the real effective exchange rate of the rand, controlling for world income and investments.

6.1. Unit root tests results

The results of the ADF and PP unit root test are presented in Table 2 and show non-stationarity in levels for all the variables but stationarity in their first difference at a 1 per cent level of significance when using the ADF test without trend. When using the PP test without trend, all variables, except the AgriX variable, are non-stationary in levels and stationary in their first difference at a 1 per cent level of significance. The AgriX variable is stationary in its level at 1 per cent level of significance.

When looking at the ADF test with trend, all variables except the AgriX and ManuINV variables, are non-stationary in levels and stationary in their first difference at a 1 per cent level of significance. The AgriX and ManuINV variables are stationary at a 1 per cent level of significance both in levels and in their difference. When using the PP test with trend, all variables, except the AgriX variable, are non-stationary in levels and stationary in their first difference at a 1 per cent level of significance. The AgriX variable is stationary in its level at 1 per cent level of significance. In general, one can conclude that all the variables can be considered to be non-stationary in their levels (while the AgriX variable is trend stationary in its level). However, all variables are stationary in their first differences, making them integrated of order 1.

Table 2 Augmented Dickey-Fuller and Phillips-Perron unit root tests

Variable	Without trend				With trend			
	ADF		PP		ADF		PP	
	Level	1st diff	Level	1st diff	Level	1st diff	Level	1st diff
REER	-1.563	-8.869**	-1.834	-8.875**	-2.266	-8.834**	-2.644	-8.839**
XVal	-0.585	-5.328**	-0.731	-12.562**	-3.914*	-5.356**	-3.707*	-12.512**
XVol	-0.974	-10.614**	-1.106	-13.333**	-3.299	-10.580**	-3.083	-13.512**
AgriX	-1.556	-7.643**	-5.927**		-4.400**		-7.874**	
ManuX	-0.758	-5.122**	-0.889	-13.420**	-2.893	-5.140**	-3.395	-13.510**
MineX	-1.031	-15.993**	-1.3088	-20.603**	-2.624	-15.944**	-4.000*	-21.976**
INC	-1.169	-5.741**	-1.395	-14.071**	-1.760	-5.7308**	-2.845	-14.051**
INV	-0.071	-4.036**	0.0172	-12.603**	-3.231	-4.519**	-2.524	-12.91**
ManuINV	-0.973	-5.353**	-1.754	-10.166**	-4.942**		-3.744*	-10.132**
MineINV	-1.031	-15.993**	-1.309	-20.602**	-2.624	-15.943**	-4.000*	-21.976**

Notes: Figures denote t-statistics. ** and * indicate the rejection of the null hypothesis at the 1% and 5% levels respectively. Lag lengths for the ADF tests were chosen using Scharz Info criterion (SIC) to be: 7(without trend) and 8 (with trend and intercept) for AgriX, 4 (without trend) and 0 (with trend and intercept) for xVal, 0(with and without trend) for XVol, 4 (without trend) and 0 (with trend and intercept) for INV, 8 (with and without trend) for ManuX, 5 (without trend) and 4 (with trend and intercept) for ManuINV, 1 (with and without trend) for MineX, 4 (with and without trend) for MineINV, 0 (with and without trend) for REER, 5 (with and without trend) for INC .

6.2. Cointegration test results

Table 3 shows the results obtained of the Johansen cointegration test described in Section 5.2 applied to equation (4)[10]. Given that the results of the Johansen procedure are sensitive to lag length and the assumption about the deterministic trend of the cointegrating equation and the VAR, it is important to ensure appropriate lag length and trend assumption for each equation[11].

a. Results for XVol equation

In order to test for cointegration, the following VAR was specified:

$$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + \ldots + A_6X_{t-6} + U_t \quad (25)$$

Where

X_t = XVol, REER, INV, INC

The Akaike information criterion (AIC) and the final prediction error (FPE) both chose an optimal VAR lag length of 6. The following cointegration equation was then modelled:

$$\Delta X_t = A_0 + \Pi_1\Delta X_{t-1} + \Pi_2\Delta X_{t-2} + \ldots + \Pi X_{t-6} + U_t \quad (26)$$

The calculated λ_{trace} and λ_{max} for the possible values of r are reported in Table 3, the first row. For this equation, the null of no cointegration (r = 0) was rejected only by the λ_{trace} test. Therefore, by use of the Pantula Principle[12], it is concluded that there is no cointegrating relationship between South African export volumes and the variables included in the model. Therefore one should estimate equation (7) but without the ECT using OLS.

b. Results for XVal equation

In order to test for cointegration in this equation, the following VAR was specified:

$$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + \ldots + A_5X_{t-5} + U_t \quad (27)$$

Where

X_t = XVal, REER, INV, INC

The AIC, FPE and LR chose an optimal VAR lag length of 5. The following cointegration equation was then modelled:

$$\Delta X_t = A_0 + \Pi_1\Delta X_{t-1} + \Pi_2\Delta X_{t-2} + \ldots + \Pi X_{t-5} + U_t \quad (28)$$

---

[10] The test is applied to five equations, each with a different dependent variable and corresponding explanatory variables. Therefore, the test was applied to 1. $XVol_t = \beta_0 + \beta_1REER_t + \beta_2INV_t + \beta_3INC_t + \nu_t$, 2. $XVal_t = \beta_0 + \beta_1REER_t + \beta_2INV_t + \beta_3INC_t + \nu_t$, 3. $ManuX_t = \beta_0 + \beta_1REER_t + \beta2ManuINV_t + \beta_3INC_t + \nu_t$, 4. $MineX_t = \beta_0 + \beta_1REER_t + \beta_2MineINV_t + \beta_3INC_t + \nu_t$, 5. $AgriX_t = \beta_0 + \beta_1REER_t + \beta_2INV_t + \beta_3INC_t + \nu_t$

[11] Refer to notes in Table 3 for assumptions chosen.

[12] According to the Pantuala principle, one keeps rejecting the null hypothesis of no cointegration until you cannot anymore and the test that first fails to rejects the null is the test that is used.

The calculated λ_{trace} and λ_{max} for the possible values of r are reported in Table 3, the second row. For this equation, the null of no cointegration was not rejected in both tests, thus meaning that one should estimate equation (9) but without the ECT using OLS.

c. Results for ManuX equation

In order to test for cointegration, the following VAR was specified:

$$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + \ldots + A_6X_{t-6} + U_t \quad (29)$$

Where

X_t = ManuX, REER, ManuINV, INC

The AIC, FPE and LR chose an optimal VAR lag length of 6. The following cointegration equation was then modelled:

$$\Delta X_t = A_0 + \Pi_1\Delta X_{t-1} + \Pi_2\Delta X_{t-2} + \ldots + \Pi X_{t-6} + U_t \quad (30)$$

The calculated λ_{trace} and λ_{max} for the possible values of r are reported in table 3, the third row. For this equation, the null of no cointegration was not rejected in both tests, thus meaning that one should estimate equation (11) but without the ECT using OLS.

d. Results for MineX equation

In order to test for cointegration in the equation, the following VAR was specified:

$$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + \ldots + A_6X_{t-6} + U_t \quad (31)$$

Where

X_t = MineX, REER, MineINV, INC

The FPE chose an optimal VAR lag length of 6. The following cointegration equation was then modelled:

$$\Delta X_t = A_0 + \Pi_1\Delta X_{t-1} + \Pi_2\Delta X_{t-2} + \ldots + \Pi X_{t-6} + U_t \quad (32)$$

The calculated λ_{trace} and λ_{max} for the possible values of r are reported in table 3, the fourth row. For this equation, the null of no cointegration was rejected in both tests against the alternative of one cointegrating equation. Further, the null of $r \leq 1$ versus $r = 2$ was not rejected. Given that the test shows one cointegrsting relationship for this model, it suggests both long run relationship and short run dynamics between MineX, REER, MineINV and INC and the estimation of equation (13).

e. Results for AgriX equation

In order to test for cointegration, the following VAR was specified:

$$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + \ldots + A_6X_{t-6} + U_t \quad (33)$$

Where

X_t = AgriX, REER, MineINV, INC

The AIC and FPE chose an optimal VAR lag length of 6. The following cointegration equation was then modelled:

$$\Delta X_t = A_0 + \Pi_1\Delta X_{t-1} + \Pi_2\Delta X_{t-2} + \ldots + \Pi X_{t-6} + U_t \quad (34)$$

The calculated λ_{trace} and λ_{max} for the possible values of r are reported in Table 3, the fifth row. For this equation, the null of no cointegration was rejected only by the λ_{trace} test. Therefore one should estimate equation (15) but without the ECT using OLS.

Table 3 Johansen cointegration tests

		Trace statistics				**Max-Eigen statistics**			
Equation	H_0 H_a	$r = 0$ $r = 1$	$r \leq 1$ $r = 2$	$r \leq 2$ $r = 3$	$r \leq 3$ $r = 4$	$r = 0$ $r = 1$	$r \leq 1$ $r = 2$	$r \leq 2$ $r = 3$	$r \leq 3$ $r = 4$
XVol, REER, INV,INC		47.88* (47.86)	25.44 (29.80)	10.70 (15.49)	2.89 (3.84)	22.44 (27.58)	14.74 (21.13)	7.81 (14.26)	2.89 (3.841)
XVal, REER, INV,INC		40.59 (47.856)	20.57 (29.80)	8.69 (15.49)	0.52 (3.841)	20.01 (27.58)	11.88 (21.13)	8.18 (14.26)	0.52 (3.84)
ManuX, REER, ManuINV,INC		43.93 (47.86)	20.20 (29.80)	5.91 (15.49)	1.61 (3.84)	23.73 (27.58)	14.29 (21.13)	4.30 (14.26)	1.61 (3.84)
MineX, REER,		50.31*	21.52	6.95	0.65	28.79*	14.58	6.29	0.65

MineINV,INC		(47.86)	(29.80)	(15.49)	(3.84)	(27.58)	(21.13)	(14.26)	(3.84)
AgriX, REER, INV,INC		48.71* (47.86)	22.78 29.80	8.06 (15.49)	1.29 (3.84)	25.93 (27.58)	14.72 (21.13)	6.78 (14.26)	1.29 (3.84)

Notes: * indicate the rejection of the null hypothesis at the 5% level. r denotes the number of cointegrating vectors. The critical values (at 5%) are in parentheses. For situations where the two tests show contrasting results, the Pantula principle was applied, i.e. when one of the tests (either Trace or Max Eigenvalue) fails to reject the null hypothesis of no cointegration. That means one keeps rejecting the null hypothesis of no cointegration until you cannot anymore and the test that first fails to rejects the null is the test that is used. For all the models, it is assumed that the series follows a linear trend in levels and therefore the Π matrix was restricted by including an intercept term in the cointegrating equation and in the VAR.

6.3. Long run analysis

Given that the MineX equation is the only model that shows a cointegrating relationship between the variables included, below is the equation that shows the long run coefficients (cointegrating equations) of the MineX equation. The reported coefficients are obtained by normalising the estimates of the unconstrained cointegrating vectors with respect to mining exports (MineX)[13]:

$$\underset{}{MineX_t} = \underset{(0.44)}{0.801INC_t} - \underset{(0.32)}{0.185REER_t} - \underset{(0.07)}{1.062MineINV_t} \qquad (35)$$

The speed of adjustments parameters (α) are:

$$\underset{(0.157)}{\alpha_{mineX} = -0.130}, \quad \underset{(0.019)}{\alpha_{INC} = 0.018}, \quad \underset{(0.068)}{\alpha_{REER} = -0.061}, \quad \underset{(0.068)}{\alpha_{MineINV} = 0.296}$$

As can be seen from equation (35), the REER and INC variables display the signs that are consistent with theory. The results show that changes in world income have a larger effect on mining exports than exchange rate changes meaning that world income is more important in determining the performance of mining exports than the exchange rate. This finding is in line with the statement made by Edwards and Garlick (2008)[14] that, in the long run, a real depreciation of the rand does not lead to a substantial and sustained improvement in South Africa's mining export performance. Investment in the mining sector has a negative but the largest impact, in the long run, on mining exports (in contrast with theory).

6.4. Short run dynamics

a. Error correction model

According to the Granger representation theorem, if there exists a cointegrating relationship between variables that have a unit root (in this case, between MineX, REER, INC and MineINV), then there also exists a dynamic EC representation of the data[15]. Given that only one cointegrating relationship is identified by the Johansen cointegration test, only one ECT, generated from the Johansen procedure, is included in the VECM for MineX. Table 4 shows the results of estimating equation (13) using the Johansen procedure with 5 lags. The results show that while ECT is negative and significant, there is a low speed of adjustment. The value of 0,19 means that at least 19 per cent of the disequilibrium divergence tends to be eliminated after 1 quarter.

The coefficients for the exchange rate variable (REER) and the world income variable (INC) are the expected sign with the world income variable having the largest impact on mining exports (MineX). Mining investments (MineINV) is the only variable where none of the lag terms are statistically significant. Of the statistically significant variables in the model, the world income variable has the largest impact on mining exports than the statistically significant mining exports variable and the real exchange rate variable. This finding is in line with the observations made about Figure 4 and shows that, while the exchange rate affects the performance of mining exports, world income has a relatively higher impact.

Table 4 ECM regression results for South African mining exports

Regressors	Coefficients	Standard error	t-statistics

[13] The numbers in parentheses below the coefficients are the standard errors. Further, the results mean that β=(1, 0.801.-0.185,-1.062)
[14] Refer to page 6.
[15] Refer to Engle and Granger (1987) for a full explanation of the theorem.

Constant	0.010053	0.018	0.551
ECT_{t-1}	-0.189306*	0.139	-1.362
$\Delta MineX_{t-1}$	-0.410988***	0.155	-2.659
$\Delta MineX_{t-2}$	-0.147472	0.153	-0.963
$\Delta MineX_{t-3}$	-0.066569	0.152	-0.438
$\Delta MineX_{t-4}$	-0.049584	0.144	-0.345
$\Delta MineX_{t-5}$	-0.081406	0.120	-0.676
$\Delta MineINV_{t-1}$	-0.137879	0.233	-0.590
$\Delta MineINV_{t-2}$	-0.108408	0.230	-0.471
$\Delta MineINV_{t-3}$	-0.005348	0.235	-0.023
$\Delta MineINV_{t-4}$	-0.144006	0.228	-0.632
$\Delta MineINV_{t-5}$	-0.098817	0.230	-0.429
$\Delta REER_{t-1}$	-0.597138*	0.381	-1.564
$\Delta REER_{t-2}$	-0.409888	0.382	-1.071
$\Delta REER_{t-3}$	-0.006780	0.372	-0.018
$\Delta REER_{t-4}$	-0.344109	0.385	-0.893
$\Delta REER_{t-5}$	-0.020749	0.374	-0.056
ΔINC_{t-1}	0.391097	0.872	0.449
ΔINC_{t-2}	0.254573	0.689	0.369
ΔINC_{t-3}	0.986128*	0.619	1.594
ΔINC_{t-4}	0.852686*	0.661	1.289
ΔINC_{t-5}	-0.575992	0.799	-0.721
Adjusted R^2	0.136944		

Note: *, ** and *** indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels respectively.

b. OLS regressions

Given the fact that there was no cointegrating relationship between the other types of South African exports (namely, total exports, export volumes, manufacturing exports and agricultural exports) and the other variables included in their respective models, estimating equations (7), (9), (11) and (15) without the EC term is most appropriate (resulting in estimating OLS equations). The results of the estimations are presented in Tables 5, 6, 7 and 8. Table 5 shows that the instantaneous effects of all the included variables (except the REER variable) are the expected sign and statistically significant at a 1% level of significance. While the effect of an exchange rate change is the expected sign and statistically significant (at a 5% level of significance) after one quarter, both world income and investments (INV) have a larger effect on South Africa's total export volumes. In a year (the fourth quarter), the effects of the changes in the variables becomes less intense and are statistically insignificant.

For South Africa's total exports (Table 6), all the instantaneous effects of all the variables are the expected sign and statistically significant (at least at a 10% level of significance). Further, while a depreciation of the rand does positively affect South Africa's total exports, increases in world income have a much larger effect, even after three quarters. Table 7 shows that the instantaneous effects of the exchange rate and world income are the expected sign and statistically significant. As with total exports, however, world income has a larger impact on manufacturing exports, which continues to be statistically significant (at a 10% level of significance) in the fourth quarter. Finally, agricultural exports (Table 8), unlike the other export variables, are negatively affected by growth in world income (contrasting with theory). Further, the exchange rate effects are statistically insignificant at time t and t-1, implying a relatively delayed reaction by agricultural exports to exchange rate changes. While not the expected sign, world income is the largest contributor to the performance of agricultural exports.

Table 5 OLS regression results for South African total export volumes (XVol)

Regressors	**Coefficients**	**Standard error**	**t-statistics**
Constant	0.013285**	0.005530	2.402380
$\Delta XVol_{t-1}$	-0.335691***	0.101309	-3.313549
$\Delta XVol_{t-2}$	-0.397807***	0.101180	-3.931686
$\Delta XVol_{t-3}$	0.097264	0.093155	1.044101
$\Delta XVol_{t-4}$	0.001202	0.101519	0.011842
ΔINV_{t}	0.342937***	0.094961	3.611339
ΔINV_{t-1}	-0.021596	0.089741	-0.240650
ΔINV_{t-2}	0.135499	0.091045	1.488262
ΔINV_{t-3}	0.019405	0.085638	0.226600
ΔINV_{t-4}	-0.217160**	0.090253	-2.406118
$\Delta REER_{t}$	-0.091871	0.106214	-0.864962
$\Delta REER_{t-1}$	-0.231189**	0.106262	-2.175644
$\Delta REER_{t-2}$	0.072500	0.110311	0.657229
$\Delta REER_{t-3}$	0.071885	0.111073	0.647184
$\Delta REER_{t-4}$	0.071011	0.107963	0.657730
ΔINC_{t}	0.939562***	0.262408	3.580533
ΔINC_{t-1}	0.157678	0.236014	0.668089
ΔINC_{t-2}	0.201597	0.223879	0.900475
ΔINC_{t-3}	0.436593**	0.215701	2.024067
ΔINC_{t-4}	-0.403972	0.250241	-1.614333
Adjusted R^2	0.329964		
F-statistic	3.565966 (0.000034)		
Durbin-Watson stat	1.896628		

Note: ***, ** and * indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. Lag length was chosen to be 4, given that the data is quarterly. All variables are have been logged.

Table 6 OLS regression results for South African total exports (XVal)

Regressors	**Coefficients**	**Standard error**	**t-statistics**
Constant	-0.000463	0.007491	-0.061772
$\Delta XVal_{t-1}$	-0.336152***	0.111079	-3.026230
$\Delta XVal_{t-2}$	-0.224859*	0.115669	-1.943995
$\Delta XVal_{t-3}$	-0.288935**	0.122617	-2.356401
$\Delta XVal_{t-4}$	0.084754	0.113636	0.745830
ΔINV_{t}	0.222039*	0.131553	1.687833
ΔINV_{t-1}	0.067633	0.131621	0.513846
ΔINV_{t-2}	0.095371	0.128839	0.740232
ΔINV_{t-3}	0.201300	0.121528	1.656411
ΔINV_{t-4}	-0.181834	0.126109	-1.441881
$\Delta REER_{t}$	-0.458129***	0.154538	-2.964502
$\Delta REER_{t-1}$	-0.234928	0.158371	-1.483406
$\Delta REER_{t-2}$	-0.100482	0.158958	-0.632133
$\Delta REER_{t-3}$	-0.113660	0.161665	-0.703056
$\Delta REER_{t-4}$	0.054368	0.155819	0.348915
ΔINC_{t}	1.037153**	0.413106	2.510623
ΔINC_{t-1}	-0.063208	0.355213	-0.177943
ΔINC_{t-2}	0.930112***	0.329016	2.826948
ΔINC_{t-3}	0.663763	0.340208	1.951053
ΔINC_{t-4}	-0.683711*	0.375505	-1.820776
Adjusted R^2	0.489645		
F-statistic	4.191157 (0.000003)		
Durbin-Watson stat	1.985057		

Note: ***, ** and * indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. Lag length was chosen to be 4, given that the data is quarterly. All variables are have been logged.

Table 7 OLS regression results for South African manufacturing exports

Regressors	**Coefficients**	**Standard error**	**t-statistics**
Constant	-0.002035	0.008362	-0.243419
$\Delta ManuX_{t-1}$	-0.316995***	0.110008	-2.881555
$\Delta ManuX_{t-2}$	-0.202793*	0.113036	-1.794067

$\Delta ManuX_{t-3}$	-0.250316**	0.120722	-2.073495
$\Delta ManuX_{t-4}$	0.155879	0.116668	1.336092
$\Delta ManuINV_{t}$	0.216016	0.135444	1.594868
$\Delta ManuINV_{t-1}$	-0.024526	0.129581	-0.189271
$\Delta ManuINV_{t-2}$	0.093422	0.135404	0.689950
$\Delta ManuINV_{t-3}$	-0.056595	0.120803	-0.468490
$\Delta ManuINV_{t-4}$	-0.036340	0.117797	-0.308495
$\Delta REER_{t}$	-0.434625**	0.165705	-2.622889
$\Delta REER_{t-1}$	-0.314930*	0.174942	-1.800196
$\Delta REER_{t-2}$	0.041797	0.175940	0.237566
$\Delta REER_{t-3}$	-0.253211	0.177375	-1.427544
$\Delta REER_{t-4}$	0.104846	0.173187	0.605393
ΔINC_{t}	1.029140**	0.444509	2.315227
ΔINC_{t-1}	-0.049116	0.393495	-0.124820
ΔINC_{t-2}	0.774377*	0.394163	1.964612
ΔINC_{t-3}	0.712486*	0.392515	1.815183
ΔINC_{t-4}	-0.763474*	0.444765	-1.716578
Adjusted R^2	0.355507		
F-statistic	3.961266 (0.000006)		
Durbin-Watson stat	2.039474		

Note: ***, ** and * indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. Lag length was chosen to be 4, given that the data is quarterly. All variables are have been logged.

Table 8 OLS regression results for South African agricultural exports

Regressors	Coefficients	Standard error	t-statistics
Constant	0.011705	0.025717	0.455128
$\Delta AgriX_{t-1}$	-0.515123***	0.106655	-4.829797
$\Delta AgriX_{t-2}$	-0.379379***	0.110670	-3.428034
$\Delta AgriX_{t-3}$	-0.255286**	0.109906	-2.322764
$\Delta AgriX_{t-4}$	0.080310	0.105530	0.761019
ΔINV_{t}	0.690650	0.442316	1.561442
ΔINV_{t-1}	0.443066	0.417789	1.060501
ΔINV_{t-2}	0.736402*	0.421657	1.746449
ΔINV_{t-3}	0.650496	0.419085	1.552180
ΔINV_{t-4}	-0.238850	0.451108	-0.529473
$\Delta REER_{t}$	-0.409963	0.532835	-0.769400
$\Delta REER_{t-1}$	-0.329720	0.527388	-0.625195
$\Delta REER_{t-2}$	-0.968178*	0.527862	-1.834149
$\Delta REER_{t-3}$	-0.573138	0.547165	-1.047469
$\Delta REER_{t-4}$	0.616596	0.537713	1.146701
ΔINC_{t}	-2.744323*	1.421476	-1.930615
ΔINC_{t-1}	0.219473	1.365661	0.160709
ΔINC_{t-2}	2.273493*	1.231385	1.846290
ΔINC_{t-3}	-0.447991	1.265765	-0.353929
ΔINC_{t-4}	-3.765703***	1.297938	-2.901298
Adjusted R^2	0.640558		
F-statistic	10.56701 (0.000000)		
Durbin-Watson stat	1.953300		

Note: ***, ** and * indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. Lag length was chosen to be 4, given that the data is quarterly. All variables are have been logged.

7. Conclusion

This paper examined the impact of changes in the exchange rate of the rand on South Africa's export performance, both on an aggregate level and on different sectors of the economy. Despite the fact that economic trade theory states that a depreciation of the exchange rate of a country is beneficial for the export performance of that country, because it makes home exports relatively cheaper to foreign buyers, past empirical research results on the issue have been mixed. In this paper, the issue is examined using the Johansen cointegration procedure and an ECM to analyse the long run effects and the short-run dynamics of the effects of changes in the exchange rate on South Africa's mining exports. Given that a cointegrating relationship is not found between South Africa's export volumes, total, manufacturing, and agricultural exports and the variables in each respective model, OLS regressions are used to analyse the impact of the exchange rate on these exports.

For mining exports, the results show that while there is a long-run equilibrium relationship between the real effective exchange rate and mining exports, with a real depreciation of the domestic exchange rate having a positive long-run effect on mining export performance, world income has a much larger effect on mining exports than the exchange rate. This means that world income is more important in determining the long term performance of mining exports than the exchange rate. For the other dependent variables (export volumes, total, manufacturing, and agricultural exports), the Johansen cointegration test shows that there was no long run relationship between them and the variables included in each respective model.

Therefore, South African mining exports may perform better in the long run, if South African trade policy focuses its resources on forming trade partnerships and trade agreements with countries that show strong and sustainable income growth as opposed to trying to improve competitiveness by depreciating the rand.

In the short run, the EC model shows that a deprecation in the exchange rate does improve the performance of mining exports, but improvements in world income have relatively larger positive effects. The same result is found for export volumes, total exports and manufacturing exports when OLS regressions are used. For agricultural exports, while increased world income negatively affects its performance, this effect is still larger than the positive effects of an exchange rate depreciation.