Exchange rate changes on export volumes in South Africa under the inflation targeting period

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Abstract
This paper examines the long run effects of the exchange rate changes on export volumes in South Africa under the inflation targeting period using the Johansen cointegration and the Engle–Granger approaches. This paper further examines whether the 2007 global financial crisis, rising government debt, and cost of credit post 2008Q4 impacted the magnitudes of determinants of export volumes. Both tests confirm a long run relationship amongst export volumes, exchange rate, and foreign income. The long run exchange rate impacts are bigger than the short run effects. Foreign income demand has bigger impact on export volumes than the exchange rate. Evidence shows that 2007 global financial crisis reduced the impact of the exchange rate depreciation on export volumes but increased the impact of the foreign income demand. This suggests relying on the exchange rate as a policy tool alone to achieve the external adjustment may not raise export volumes. The global financial crisis exacerbated the adverse effects of the exchange rate volatility on the export volumes, indicating that policymakers should implement policies that limit the exchange rate volatility. The adverse effects of the global financial crisis on export volumes were transmitted more via the consumer prices rather than the exchange rate, suggesting that South Africa lost its price competitiveness during the crisis period. Rising government debt and the cost of credit post 2008Q4 are transmitted more via the exchange rate than relative price ratios to reduce export volumes. The exchange rate volatility channel does not transmit the rising government debt shocks to export volumes.

Keywords Time series · Exchange rate elasticity · Income elasticity · Cointegration model · Government debt

JEL Classification C32 · C22 · F14

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Introduction

In April 2020, a combination of factors, which included the sovereign credit rating downgrades, the COVID-19 pandemic outbreak that led to the 21-day lockdown, and its 2-week extension, saw the rand to the US dollar exchange rate (R/US$) exceed the R19/US$ level daily. Such a level of exchange rate depreciation has not been seen for a long time and theoretical predictions suggest that the exchange rate depreciation may raise export volumes, ceteris paribus.

Kang and Dagli (2018) point to recent literature that looks at the relationship between the exchange rate level and international trade volumes. These authors indicate that, following the 2007 global financial crisis, there was a revival of both the academic and policy debates with a shift in the focus from the nominal or the real exchange rate volatility to the real exchange rate level, due to concerns about the global external imbalances. However, there have been no such discussions in South Africa regarding the shift in focus towards the currency levels from its volatility. This could be due to South Africa having adopted an inflation-targeting policy framework in February 2000 and floating exchange rate policy. The combination of these two policies will enable the economy to adjust to ensure external competitiveness. In this setting, the exchange rate can be a shock absorber and is also a policy tool that policymakers can use to adjust to external imbalances.

This paper examines the long run and short run effects of the exchange rate changes, foreign income demand, and exchange rate volatility on export volumes in South Africa under the inflation-targeting period. Between 2009 and 2020, the gross government loan debt to GDP increased from an average of 25 to 64% in 2020. The rising government debt between 2009 and 2019 triggered several sovereign credit rating downgrades, which raised the probability of default and the costs of credit defaults swaps which may impact export financing. The analysis determines whether the 2007 global financial crisis, rising government debt, and cost of credit post-2008 impacted the relationship between export volumes and its long run determinants in South Africa. The analysis interacts government debt to GDP ratio and the cost of credit with the exchange rate and the exchange rate volatility channels to determine their indirect effects on export volumes. Such augmentation of the basic long run export demand analysis has not been done in South Africa and other studies.

The analysis is motivated by several factors. First, the extent to which the 2007 global financial crisis impacted the long run and short run effects of the exchange rate changes on export volumes in South Africa is still unknown. Ndou (2021) concluded that the net trade balance responds more to the income effects compared to the real effective exchange rate effects in the short run. However, it is unknown whether the magnitudes of these effects were impacted by the global financial crisis. Such a determination would offer policymakers insights and invaluable lessons regarding what they can do during such an economic crisis. In addition, Ndou (2021) did not investigate how the 2007 global financial crisis affected the size of the impacts of the determinants of export volumes. The second motivation is that the South African government desperately needs to stimulate economic growth.
and the exchange rate is one of the important policy tools available to perform this task, but its efficacy during the 2007 global financial–economic crisis has not been examined in South Africa. This is even though the manufacturing sector lobby groups have for a long time called for a weaker exchange rate, when the exchange rate was below R10/US$ pre-2009 and the exchange rate has depreciated by nearly 80% to reach R19/US$ in April 2020. This analysis goes a step further to examine how the 2007 global financial crisis impacted the size of the estimated coefficients of the exchange rate and foreign income on export volumes.

The third motivation is that the contribution of the net trade balance to GDP has been persistently very small over a long period and there has been much focus on raising exports which should lead to an improvement in the trade balance. This is shown by the objective of the South African National Development Plan which points towards more export-led growth and the reduction of imports growth as a potential growth strategy. This paper contributes to the discussions on the export-led growth strategy by determining which one amongst the components of the real effective exchange rate (REER) is the biggest driver of export volumes. That is, which one, amongst the nominal effective exchange rate, domestic prices, and foreign prices is biggest driver of export volumes in South Africa. In addition, the lockdowns necessitated by the COVID-19 pandemic shock in several advanced and emerging market economies induced a structural change, and the extent of the economic crisis impacts on the long run and short run effects of foreign income demand, the level exchange rate, and its volatility on the export dynamics remain unknown.

The first contribution made by this paper is filling the gaps in Chiloane et al (2014), Schaling and Kabundi (2014) and Matlasedi et al (2015) who examined the effects of the exchange rate on the trade balance in South Africa, but did not investigate the effects of the exchange rate, foreign income, and the exchange rate volatility on the export volumes. In addition, these authors did not examine how the effects of these determinants were impacted by the 2007 global financial crisis. This indicates existing research gaps in modelling the export volume dynamics in South Africa. The second contribution of the study is determining the long run relationship between the export volumes, the exchange rate, and the income effects by estimating the relationship using the Engle–Granger and the Johansen cointegration methodologies. Thereafter, I estimate how the 2007 global financial crisis period affected the sizes of the impact of the nominal and real exchange rate level, real and nominal exchange rate volatilities, foreign income, and relative price ratio on the South African export volumes.

The main focus is on the long run relationship between the export volumes and its determinants. This will assist in achieving the objective of export-led growth aimed at raising the export volumes as envisaged in the South African National Development Plan. The third contribution is via the assessment of how the global financial crisis affected the reaction of export volumes to the REER, nominal effective exchange rate, the domestic price level, the foreign price level, and the ratio of South Africa’s consumer price level to the foreign consumer price level. The disaggregation of the REER allows for the determination of which one amongst these components played a bigger role in transmitting the 2007 global financial crisis effects. This will enable policymakers to identify between domestic indicators, the
appropriate policy variable which they can target to raise export volumes. This will reveal if it is the price competitiveness or the exchange rate depreciation or the level of the exchange rate or its volatility, that matters more, as well as test if the persistence of the exchange rate volatility matters. South African manufacturers have complained over a long time that the exchange rate volatility is bad for their export.

Although there are substantial studies on the determinants of export demand even in the emerging market economies, the impact and the transmission shocks to export demand may be different in emerging market economies compared to advanced economies. This may reflect the difference in the structure of the economy, debt service costs, and access to capital markets. In these conditions, the role of government debt post the 2007 global financial crisis possibly impacted the export volumes directly and indirectly via other channels. The South African government has borrowed more to finance expenditures to mitigate the adverse effects of the 2007 global financial crisis and since then the gross government debt has kept rising. Studies should be interpreted with caution when assessing the determinants of export demand, especially after the recent economic crisis if they do not show how government debt impacted export demand via impacting the exchange rate, real and nominal exchange rate volatility, relatively price differential, and cost of credit of non-financial corporations. The rising government debt post-2008 impacted the sovereign credit default spreads which are the cost of insurance, and this impacts the cost of credit needed to finance the exports. Hence, the paper looks at the effects of government debt to GDP ratio on export volumes via the exchange rate and relative price ratio of domestic to foreign prices. This is to determine the prominent channel that transmits the government debt shocks into export volumes. Such analysis to show the channels through which government debt impacts export volumes has not been done.

In addition, Ndou et al. (2019) found that monetary policy rate increases are passed more through the lending rate increase than the policy rate decreases of the same magnitude. This indicates the asymmetric effects in the lending rate adjustment to increases and decreases in policy rate changes. Furthermore, the authors find that the speed of correction towards equilibrium is bigger when the lending rates are below the equilibrium compared to when lending rates are above the equilibrium. Ndou et al. (2019) also found that high economic policy uncertainty impacted bank intermediation. In this case, the interest rate passthrough was low with intermediation markups rising. Despite the historic low policy rate of 5.5% banks increased the markup due to heightened credit risk to maintain their profitability, leading to high weighted lending rates or cost of credit. Hence, this paper uses the cost of credit to non-financial corporations rather than the policy rate to capture the effects of financing costs on the domestic determinants of export demand. This has not been done in the literature.

Evidence indicates that the long run elasticities of the exchange rate are bigger than the short run elasticity coefficients. Export volumes respond more to foreign income in the short run than in the long run. Foreign income demand has a bigger effect than the exchange rate on the export volumes. The 2007 global financial crisis reduced the size of the impact of the REER and the nominal effective exchange rate (NEER) depreciation on export volumes, while it increased the impact of foreign income demand. Government debt effects are significantly transmitted more via the
NEER than the relative price ratios to export volumes. Across all models, the coefficient of the interaction between the cost of credit and the exchange rate is negative and significant. This suggests that the cost of credit to non-financial corporations post-2008Q4 reduced the effects of the NEER and REER depreciation on export volumes. The interaction between the cost of credit and the relative price differential is negative. This suggests that South Africa even lost price competitiveness on export volumes post-2008Q4. There is no evidence indicating that the adverse effects of the cost of credit and rising government debt to GDP are transmitted via the REER and NEER volatility channels. This suggests that the price of credit and government debt effects are not directly transmitted to export volumes via the exchange rate volatility channels. Finally, evidence reveals that rising government debt significantly lowers export volumes, which may be happening due to the higher cost of insuring export as sovereign credit default swaps increase following several sovereign credit rating downgrades. The high interest rate on credit to finance export shipments also explain these effects. Thus, the rising government debt effects are transmitted to export volumes mainly through the cost of credit channel.

The remainder of this paper is organized as follows: Sect. 2 shows the stylized facts between export volumes and their various determinants. Section 3 briefly discusses the relevant theory. Section 4 presents the econometric methodology used in this paper. Section 5 shows the unit root tests, while Sect. 6 discusses the empirical results. Section 7 provides the main conclusions and policy implications of the results contained in the paper.

Scatterplot

This section shows the relationship between (i) export volumes and the exchange rates and (ii) export volumes and foreign income measured by total OECD gross domestic expenditure (OECD GDE). The REER, NEER, and the export volumes index obtained from the South African Reserve Bank database are used. Total OECD gross domestic expenditure is sourced from the OECD database.

The bilateral relationships using quarterly data from 2000Q1 to 2019Q3 are shown in Fig. 1. The export volumes are negatively related to the real and nominal exchange rates. This suggests that the appreciation of the exchange rates lowers export volumes. The positive relationship between export volumes and foreign income demand suggests that an increase in foreign income raises the demand for South African exports. This preliminary evidence is consistent with the theoretical predictions.

Theory of demand of export and the role of government debt dynamics

The model for the demand of export volumes estimated in this analysis is based on the basic standard textbook econometric specification given by Eq. (1). This specification suggests that foreign income demand and the exchange rate are the main determinants of export volumes. In Eq. (1), $EXP_t$, denotes the export volumes, $EXH_t$, ...
denotes the exchange rate, $YF_t$ denotes the foreign income which captures foreign demand. Foreign income has a positive effect on export volumes. The exchange rate is inversely related to export volumes, suggesting that the exchange rate appreciation lowers export volumes:

$$EXP_t = f(EXH_t, YF_t).$$ \hspace{1cm} (1)

In this model, an increase in global income increases the demand for South African products. Depending on the value of the responsiveness of exports to foreign income, the South African exports can be income-elastic or income-inelastic. Similarly, an increase in the export price in South Africa relative to that of the country’s competitors will decrease the demand for its products. Depending on the absolute value of the price responsiveness, the South African exports can then be price-elastic or price-inelastic. Equation (1) is a basic depiction of the determinants of export volumes. Theory further suggests that exchange rate volatility matters. Hence, the above equation is adjusted to include the exchange rate volatility ($EXVOL_t$) in the following equation:

$$EXP_t = f(EXH_t, YF_t, EXVOL_t).$$ \hspace{1cm} (2)

As seen during the 2008 global recession, which disrupted labour markets and income, it is plausible the consumption function and patterns may have changed. Hence, there is a need to control for the economic crisis effects in the export demand equation.

The recent literature suggests that developments in government debt can spill over into export values via different channels. This literature includes Wu et al (2017) finding that the larger the government debt to GDP ratio, the lower the passthrough of the exchange rate to export prices. Cohen (2003) posits the nonlinear impact of government debt on investment, implying that up to a certain point, government debt accumulation can promote investment, while above this threshold point government debt overhang will exert adverse effects on the willingness of investors to provide capital for investment. This includes investment by exporting firms. Clements et al (2003) argue that the relationship can be extended to output growth and international trade. In this situation, higher government debt to GDP ratio in exporting countries makes importing firms fear the increased probability of defaulting from the export contract hence they pass a smaller share of the exchange rate changes. By contrast, lower government debt to GDP ratio in the exporting countries makes the importing firms have stronger confidence to expect the contract to be paid. The exporters pass-through a larger proportion of the exchange changes.

For instance Clement et al (2003) suggests, when the size of public debt rises, there is growing uncertainty about the actions and policies that the government will resort to applying to meet its debt servicing obligations. This has adverse effects on
the investments including those of exporters and may create impressions that it will be financed by distortionary measures such as inflationary tax increases. The quick accumulation of government debt can increase capital flight if the private sector fears imminent devaluation or an increase in taxes to service the debt. High government debt damps physical capital accumulation, total factor productivity growth, crowds out investment, and raises the government’s interest bill. The budget deficit reducing public savings may, in turn, raise interest rates or crowd out credit available for private investment, thus dampening growth, financing available for infrastructure and human capital. Some studies find that the external debt service costs dampen investment and total investments.

Kohn et al (2016) posit that frictions in financial markets distort firms’ export decisions, thus acting as a barrier to international trade. Access to external finance matters for international trade. Heightened financial frictions may force firms with low internal funds relative to their productivity to produce below optimal scale which limits their output and reduces their profits and returns from exporting. Due to financial frictions, productive firms with low assets may choose not to export. Borensztein and Panizza (2010) find that sovereign defaults hurt the export-oriented industries disproportionately through import sanctions and damage the creditworthiness of exporters. The country experiencing external financing distress often resorts to exchange controls or capital outflows restrictions which affect the repayment capacity of all private debtors even though they do not face solvency problems. This also affects export-linked credits which are of short maturity, raises the possibility to impair debt serviceability of private debtors, and the credit quality deterioration of exporters. Zymek (2012) shows that the trade costs of sovereign default include the reduction in the exporters’ access to foreign credit and that a sovereign default leads to a stronger contraction in the export of sectors that are more dependent on external financing. It also reduces access to international capital markets and shifts trade patterns. The shocks to foreign credit supply explain the trade costs of sovereign defaults.

The author is not aware of any empirical analysis that provides evidence on how government debt and the cost of credit affects export volumes, especially after the recent global recession Consequently, the study fills this gap in the literature with attention paid to determining whether government debt and the cost of credit indirectly impact export volumes.

The methodology

The long run and short run effects of the exchange rate depreciation on export volumes are estimated using two methodologies, namely (1) the Engel–Granger residual approach to co-integration, and (2) the Johansen cointegration approach. The specification given by Eq. (1) suggests that foreign income demand and the exchange rate are the main determinants of export volumes. The variables are log-transformed
so that the coefficients measure the elasticity. In the analysis, the exchange rate has been inverted, so an increase implies a depreciation.

**The Engle–Granger methodology**

The presence of the long run relationship is determined using the Engle–Granger test which requires the error correction term to be significant in the short run equation. The error term in the short run equation is the residual from the long run equation. The baseline long run relationship is given by Eq. (3). $\text{ect}_t$ is the error term:

$$
\text{LEXP}_t = \alpha + \delta \cdot \text{Trend} + \beta^{\text{LR}}_R \cdot \text{LEXH}_t + \beta^{\text{LR}}_Y \cdot \text{LYF}_t + \text{ect}.
$$

Equation (4) gives the short run equation which captures the speed of adjustment. $\text{GDP\_REC\_dummy}$ is equal to one when GDP growth is negative and zero otherwise:

$$
\text{DLEXP}_t = \text{constant} + \gamma \cdot \text{ect}_{t-1} + \beta^{\text{SR}}_R \cdot \text{DLEXH}_t + \beta^{\text{SR}}_Y \cdot \text{DLYF}_t
$$

$$
+ \delta \cdot \text{GDP\_REC\_dummy}_t + \theta_t,
$$

where

$$
\text{ect}_{t-1} = (\text{LEXP}_{t-1} - \alpha - \delta \cdot \text{Trend} - \beta^{\text{LR}}_R \cdot \text{LEXH}_{t-1} - \beta^{\text{LR}}_Y \cdot \text{LYF}_{t-1}).
$$

The finding of a significant error correction term indicates the presence of a long run relationship using the Engle–Granger test. The long run elasticities of export to the exchange rate and foreign income are given by $\beta^{\text{LR}}_R$ and $\beta^{\text{LR}}_Y$, respectively. The exchange rate has been inverted, so that an increase implies an exchange rate depreciation. The short run elasticities of export to the exchange rate and foreign income are given by $\beta^{\text{SR}}_R$ and $\beta^{\text{SR}}_Y$, respectively. The impacts of the exchange rate $\beta^{\text{LR}}_R$ and $\beta^{\text{SR}}_R$ should be positive, indicating that the exchange rate depreciation should raise export volumes. The impacts of the exchange rate captured by $\beta^{\text{LR}}_Y$ and $\beta^{\text{SR}}_Y$ should be positive pointing to the fact that the exchange rate depreciation raises export volumes. The impacts of the exchange rate $\beta^{\text{LR}}_Y$ and $\beta^{\text{SR}}_Y$ should be positive, indicating that increased foreign demand should raise export volumes. In Eq. (4), the speed of adjustment to the long run equilibrium is captured by $\gamma$. This gives the percentage correction per quarter after deviating from equilibrium.

In certain instances, the REER is disaggregated into the NEER, the domestic price level, and the foreign price level to determine which one amongst these components played a bigger role in driving export volumes. The ratio of the South African consumer price level to foreign consumer price level is used to determine its impact on the export volumes as this ratio is also part of the REER.

The robustness of the long run impact to the inclusion of the exchange rate volatility is tested using Eq. (6). The sign of the exchange rate volatility on export volumes can be either positive or negative:
EXVOL denotes the exchange rate volatility measured using the two quarters moving variance of the log of the exchange rates. Given the quarterly data and short period from 2000Q1 to 2019Q4, it is difficult to estimate quarterly variance using the GARCH methodology. Hence the study uses the moving variance. The model and various variables used in the model are shown in each equation. Some models include exchange rate volatility. I further determine the effects of the real and the nominal volatilities using the REER and NEER variances are presented in separate estimations.

The Johansen cointegration approach

The Johansen cointegration approach used to determine the presence of the long run relationship. The Johansen cointegration approach uses both the trace and the maxi-eigenvalue test statistics to determine the number of cointegrating relationships. The trace statistic indicates the exact number of cointegration relationships while the maxi-eigenvalue indicates the maximum number of relationships. This approach enables the estimation of the vector error correction mechanism (VECM), which allows the estimation of long run effects, short run impacts, and the speed of adjustment to the equilibrium. In addition, this allows the estimation of the impulse response of export volumes to foreign income demand and the exchange rate shocks. The interpretation of the coefficients in the long run equation is interpreted as indicated in the preceding section.

Determining the impact of the 2007 global financial crisis, government gross loan debt, and the cost of credit

As stated in the introduction, after estimating the long run relationship, the next objective is to determine the effect of the 2007 global financial crisis (CRIS) on the size the of impact of the exchange rate and foreign income on export volumes dynamics. The VECM cannot be used in the estimation that uses interactive terms. The CRIS dummy is equal to one from 2007Q3 to 2009Q3, and zero otherwise. This captures the beginning of the 2007 global financial crisis in 2007Q3 to the end of the South African recession in 2009Q3:

$$\text{LEXP}_t = \alpha + \delta \text{Trend} + \beta_R^{LR} \text{LEXH}_t + \beta_Y^{LR} \text{LYF}_t + \beta_{\text{VOL}}^{LR} \text{EXVOL}_t.$$  \hspace{1cm} (6)

Equation (7) is expanded to determine the effects of the CRIS on the exchange rate volatility. The expanded model is given by Eq. (8) and the model allows capturing the persistence of the exchange rate volatility on export volumes:

$$\text{LEXP}_t = \alpha + \delta \text{Trend} + \beta_R^{LR} \text{LEXH}_t + \beta_Y^{LR} \text{LYF}_t + \beta_{\text{VOL}}^{LR} \text{EXVOL}_t \times \text{CRIS}$$

$$+ \beta_R^{LR} \text{LEXH}_t \times \text{CRIS} + \beta_Y^{LR} \text{LYF}_t \times \text{CRIS} + \varepsilon_t$$  \hspace{1cm} (7)
Equation (9) captures the government debt to GDP (DEBT) effects on the level of the exchange rate and its volatility on export volumes. The negative sign on the interaction terms \((\text{LEXH}_t \times \text{DEBT})\) implies that rising government debt reduces the effects of the exchange rate depreciation on export volumes. The negative sign on \(\text{DEBT}_t \times \text{EXVOL}_t\) and on the lagged term implies that the rising cost of credit increases the adverse effects of the exchange rate volatility on export volumes:

\[
\text{LEXP}_t = \alpha + \delta \text{Trend} + \beta_{y}^{LR} \text{LYF}_t + \beta_{r}^{LR} \text{LEXH}_t + \beta_{rc}^{LR} \text{LEXH}_t \times \text{CRIS} + \beta_{y}^{LR} \text{LYF}_t + \beta_{v}^{LR} \text{EXVOL}_t + \beta_{v}^{LR} \text{EXVOL}_t \times \text{DEBT} + \beta_{y}^{LR} \text{LYF}_t + \beta_{v}^{LR} \text{EXVOL}_t \times \text{DEBT} + \epsilon_t
\] (8)

Equation (10) determines the effects of the cost of credit (COST) on the level of the exchange rate and its volatility. The negative sign on the interaction terms \((\text{LEXH}_t \times \text{COST})\) implies that the rising cost of credit reduces the effects of the exchange rate depreciation on export volumes. The negative sign on \(\text{LEXH}_t \times \text{EXVOL}_t\) and on the lagged term implies that the rising cost of credit increases the adverse effects of the exchange rate volatility on export volumes:

\[
\text{LEXP}_t = \alpha + \delta \text{Trend} + \beta_{y}^{LR} \text{LYF}_t + \beta_{r}^{LR} \text{LEXH}_t + \beta_{rc}^{LR} \text{LEXH}_t \times \text{COST} + \beta_{y}^{LR} \text{LYF}_t + \beta_{v}^{LR} \text{EXVOL}_t + \beta_{v}^{LR} \text{EXVOL}_t \times \text{COST} + \beta_{y}^{LR} \text{LYF}_t + \beta_{v}^{LR} \text{EXVOL}_t \times \text{DEBT} + \epsilon_t
\] (9)

Equation (10) determines the effects of the cost of credit (COST) on the level of the exchange rate and its volatility. The negative sign on the interaction terms \((\text{LEXH}_t \times \text{COST})\) implies that the rising cost of credit reduces the effects of the exchange rate depreciation on export volumes. The negative sign on \(\text{LEXH}_t \times \text{EXVOL}_t\) and on the lagged term implies that the rising cost of credit increases the adverse effects of the exchange rate volatility on export volumes:

\[
\text{LEXP}_t = \alpha + \delta \text{Trend} + \beta_{y}^{LR} \text{LYF}_t + \beta_{r}^{LR} \text{LEXH}_t + \beta_{rc}^{LR} \text{LEXH}_t \times \text{COST} + \beta_{y}^{LR} \text{LYF}_t + \beta_{v}^{LR} \text{EXVOL}_t + \beta_{v}^{LR} \text{EXVOL}_t \times \text{DEBT} + \epsilon_t
\] (10)

In other estimations, the REER is replaced with the NEER, the domestic price level, and the foreign price level. In other specifications, the REER is replaced with both the NEER and the ratio of the South African consumer price level to the

\[
\begin{array}{c|c|c|c|c|c}
\text{YF} & 4.93 & -1.11 & -3.94 & -5.23 \\
\text{NEER} & -3.44 & -0.90 & -5.34 & -5.20 \\
\text{EXP} & 0.14 & -2.70 & -6.89 & -6.95 \\
\text{REER} & -1.15 & -1.65 & -2.15 & -3.65 \\
\end{array}
\]

The Augmented Dickey–Fuller critical test values at 1%, 5%, and 10% level of significance are −3.57, −2.92, and −2.599. The Augmented Dickey–Fuller critical test values for differenced data at 1%, 5%, and 10% levels of significance are −3.57, −2.924, and −2.5999
foreign consumer price level. All the results are corrected for heteroscedasticity and autocorrelation using the HAC estimator.

**Unit root tests**

This section begins by showing the results of the unit-roots based on the Augmented Dickey-Fuller unit root tests. However, the focus is on the inflation-targeting period. The unit root tests use quarterly (Q) data from 2000Q1 to 2019Q3. The null hypothesis is that the series is not stationary, or the series has a unit root. The results in Table 1 conclude that the variables are non-stationary at different significance levels and become stationary after differencing once.

**Empirical results**

**The results from the Engle–Granger cointegration test**

The results from the estimations of the Engle-Granger cointegration test are shown in Table 2. The results are separated according to the exchange rate used. This will determine if the definition of the exchange rate matters. The long run exchange rate elasticity is bigger than the short run impact. The size of the short run elasticity of foreign income exceeds the long run impact. The error correction term is significant and has the expected sign. The magnitude suggests that about 70% of the

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**Table 2** Results based on OLS estimations

| Variable      | Model using the REER | Model using the NEER |
|---------------|-----------------------|-----------------------|
|               | Coefficient | p value | Coefficient | p value |
| Long run equations |           |          |             |          |
| Constant      | −28.78      | 0.00     | −28.58      | 0.00     |
| Trend         | −0.02       | 0.00     | −0.02       | 0.00     |
| LEXH<sub>t</sub> | 0.19       | 0.00     | 0.13        | 0.00     |
| LYF<sub>t</sub> | 1.98       | 0.00     | 1.96        | 0.00     |
| Short run equations |           |          |             |          |
| Constant      | −0.02       | 0.01     | −0.02       | 0.01     |
| ect<sub>t−1</sub> | −0.72     | 0.00     | −0.69       | 0.00     |
| DLEXH<sub>t</sub> | 0.14       | 0.03     | 0.12        | 0.05     |
| DLYF<sub>t</sub> | 2.43       | 0.00     | 2.36        | 0.00     |
| GDPGREC       | −0.03       | 0.02     | −0.03       | 0.02     |

The dependent variable in the long run equation is log export volumes. The dependent variable in the short run equation is the changes in the log export volumes. Coefficient denotes coefficient and p values denote significance. The standard errors are HAC estimators.
| Hypothesized no. of CE(s) | Eigen value | Statistic  | 0.05 critical value | p value** | Decision |
|--------------------------|-------------|------------|---------------------|-----------|----------|
| Trace test               |             |            |                     |           |          |
| None*                    | 0.291208    | 45.11045   | 42.91525            | 0.0296    |          |
| At most 1                | 0.163667    | 17.91916   | 25.87211            | 0.3494    |          |
| At most 2                | 0.046958    | 3.799645   | 12.51798            | 0.7709    | One CE   |
| Maximum Eigenvalue test  |             |            |                     |           |          |
| None*                    | 0.291208    | 27.19129   | 25.82321            | 0.0328    |          |
| At most 1                | 0.163667    | 14.11951   | 19.38704            | 0.2462    |          |
| At most 2                | 0.046958    | 3.799645   | 12.51798            | 0.7709    | One CE   |

*Denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p values. CE denotes the cointegrating equation.
disequilibrium is eliminated within a quarter. The results are robust to the use of the nominal and the real effective exchange rates in the estimation. The Engle–Granger test confirms the existence of the long run relationship amongst the export volumes, the exchange rate, and the foreign income.

The results from the Johansen cointegration test

The second method used to determine the long run relationship is the Johansen cointegration test. The trace and maxi-eigenvalue tests indicate that there is one long run relationship, amongst export volumes, the real effective exchange rate, and the foreign income as shown in Table 3. The cointegration is found when the trend is included in the model. This suggests that the long run relationship can be estimated using the Johansen cointegration test and this allows the relationship to be estimated using the ordinary least squares approach.

The results from VECM

A VECM is estimated to determine the long run and the short run relationships and the speed of adjustment to the equilibrium once a deviation has occurred. The results are shown in Table 4. The exchange rate depreciation and foreign income have positive effects on export volumes. The elasticity of export volumes to foreign demand is about 1.77. The positive impacts are consistent with the theoretical
predictions. The speed of adjustment is negative which indicates the existence of the cointegrating relationship. The coefficient of the ECT indicates that about 75% of the disequilibrium is corrected every quarter. The magnitude of the speed of adjustment is closer to that of the Engle-Granger approach in Table 2.

The impulse responses and proportion of fluctuations from the VECM are shown in Figs. A1 and A2 in Supplementary material. The results show that the log export volumes rise very much, due to the real effective exchange rate depreciation. In addition, the log export volumes rise due to a positive foreign income shock. The responses are consistent with theoretical expectations. However, the results indicate that the foreign income shock has a bigger effect on the export volumes.

### The impact of the 2007 global financial crisis on the exchange rate, the exchange rate volatility, and the foreign income effects

Various models are estimated to determine the impact of the CRIS on the determinants of export volumes, in the long run, using the variables in level format. Col is used to denote the different models estimated.

Table 5, col 1 gives the results from the baseline long run equation. Both the exchange rate depreciation and the foreign income raise the export volumes. This is consistent with theoretical expectations. Col 3 shows the results from the baseline model including the exchange rate volatility. The exchange rate volatility has a big and negative impact on export volumes. In addition, the finding that foreign demand has a bigger effect on export demand than exchange rate does not change, after including exchange rate volatility. Col 2 shows the results including

| Variable | col 1 | col 2 | col 3 | col 4 | col 5 |
|----------|-------|-------|-------|-------|-------|
|          | Coeff | p value | Coeff | p value | Coeff | p value | Coeff | p value | Coeff | p value |
| Constant | −28.78 | 0.00    | −32.96 | 0.00    | −30.29 | 0.00    | −33.78 | 0.00    | −28.60 | 0.00    |
| Trend    | −0.02  | 0.00    | −0.02  | 0.00    | −0.02  | 0.00    | −0.02  | 0.00    | −0.02  | 0.00    |
| LEXCHt   | 0.19   | 0.00    | 0.22   | 0.00    | 0.23   | 0.00    | 0.24   | 0.00    | 0.22   | 0.00    |
| LEXCHt*CRIS | −0.25 | 0.08    | −0.22  | 0.15    | −0.22  | 0.15    | −0.22  | 0.15    | −0.10  | 0.31    |
| LYFt    | 1.98   | 0.00    | 2.24   | 0.00    | 2.08   | 0.00    | 2.29   | 0.00    | 1.98   | 0.00    |
| LYFt*CRIS | 1.80 | 0.00    | 1.78   | 0.00    | 2.20   | 0.00    | 1.78   | 0.00    | 2.20   | 0.00    |
| CRIS    | −32.76 | 0.00    | −32.35 | 0.00    | −32.35 | 0.00    | −32.35 | 0.00    | −39.12 | 0.00    |
| EXVOLt  | −3.69  | 0.05    | −2.49  | 0.06    | −2.49  | 0.06    | −2.49  | 0.06    | −4.04  | 0.00    |
| EXVOLt−1*CRIS | 92.2% | 93.8%   | 93.1%  | 94.4%   | 94.4%  | 94.7%   | 94.4%  | 94.7%   | 94.7%  | 94.7%   |
| EXVOLt−2*CRIS | 91.9% | 93.3%   | 92.7%  | 93.9%   | 93.9%  | 94.0%   | 93.9%  | 94.0%   | 94.0%  | 94.0%   |

The dependent variable in the long run equation is log export volumes. Coeff denotes coefficient. The standard errors are HAC estimators.
**Table 6** Short run equation and effects of the CRIS

| Variable       | Model with REER |         |         |         |         |         |         |         |
|----------------|-----------------|---------|---------|---------|---------|---------|---------|---------|
|                | Col 1           | Col 2   | Col 3   | Col 4   | Col 5   | Col 6   |         |         |
|                | Coeff | p value | Coeff  | p value | Coeff  | p value | Coeff  | p value |
| Constant       | − 0.02 | 0.03    | − 0.02 | 0.04    | − 0.02 | 0.05    | − 0.02 | 0.02    |
| ect\textsubscript{t−1} | − 0.79 | 0.00    | − 0.76 | 0.00    | − 0.78 | 0.00    | − 0.75 | 0.00    |
| ect\textsubscript{t−1} × CRIS | 0.41  | 0.27    | 0.38   | 0.29    | 0.15   | 0.00    | 0.13   | 0.02    |
| DLEXCH\textsubscript{t} | 0.16   | 0.01    | 0.14   | 0.02    | 0.16   | 0.01    | 0.15   | 0.00    |
| DLEXCH\textsubscript{t} × CRIS | − 0.15 | 0.44    | − 0.02 | 0.92    | − 0.14 | 0.39    | − 0.05 | 0.69    |
| DLY\textsubscript{t} | 2.33   | 0.00    | 2.17   | 0.00    | 2.23   | 0.00    | 2.32   | 0.00    |
| DLY\textsubscript{t} × CRIS | 1.07   | 0.41    | 0.33   | 0.73    | 1.26   | 0.31    | 0.67   | 0.50    |
| DEXVOL\textsubscript{t} | − 1.00 | 0.32    | − 0.30 | 0.76    | − 1.02 | 0.09    | − 0.42 | 0.42    |
| DEXVOL\textsubscript{t} × CRIS | − 1.53 | 0.39    | − 0.97 | 0.30    |         |         |         |         |
| GDPGREC        | − 0.03 | 0.04    | − 0.02 | 0.29    | − 0.03 | 0.04    | − 0.03 | 0.03    |
| R\textsuperscript{2} | 0.57   | 0.54    | 0.57   | 0.54    | 0.52   | 0.55    |         |         |
| Adjusted R\textsuperscript{2} | 0.54   | 0.49    | 0.52   | 0.50    | 0.47   | 0.49    |         |         |

The dependent variable in the short run equation is the change in log export volumes. Coeff denotes coefficient. The standard errors are HAC estimators.
the exchange rate depreciation and foreign income when interacting with CRIS. The CRIS has a negative sign, which indicates the CRIS has reduced the impact of the exchange rate depreciation on export volumes. By contrast, the interaction between CRIS and foreign income is positive indicating that CRIS had a positive effect. However, the statistical significance of the interaction between CRIS and the exchange rate disappears after including the exchange rate volatility in Col 4 and Col 5 in Table 5. This may imply that the exchange rate volatility has a big drag on export volumes. The results also show that the persistence of the exchange rate volatility matters.

Table 6 shows the results of estimation determining the effects of the CRIS on short run impacts of the exchange rate depreciation, foreign income, the exchange rate volatility, and the speed of adjustment. The results are separated according to the exchange rate used in the estimation, that is the nominal effective exchange rate and the real effective exchange rate.

The speeds of correction are negative and significant, which indicates that there are significant corrections after deviating from equilibrium. In the short run, the exchange rate depreciation has a positive effect on the export volumes, irrespective of the exchange rate used. In addition, the increase in foreign income in the short run raises export volumes. However, the increase in the exchange rate volatility does not affect the export volumes in the short run.

The effects of the CRIS on the short run exchange rate depreciation, the exchange rate volatility, foreign income is further examined by interacting these variables with CRIS. The interactive terms are insignificant, which indicates that the CRIS did not impact the exchange rate depreciation, the foreign income, and the exchange rate volatility in the short run. In addition, the CRIS did not affect the speed of correction after deviating from equilibrium. This evidence concludes that CRIS did not affect the short run effects of the determinants of export volumes.

**Determining the transmission via the REER components**

This section examines the effects of the disaggregated effects of the REER on export volumes. As indicated in the methodology section, the REER is disaggregated into the nominal effective exchange rate, the domestic consumer price, and the foreign consumer price levels. The prices are interacted with the CRIS to determine how these variables were impacted during the 2007 global financial crisis. The domestic CPI index (PD) and the OECD total CPI index (PF) are used in the estimations. The price level indices are obtained from the OECD database. The results based on different models are shown in Table 7. The price indicators are included in the models, with and without interaction with the CRIS dummy. In other models, the relative price ratio of the domestic consumer price level to the foreign price level is used.

In Table 7 cols 4 and 5, the interaction between CRIS and NEER is significant and negative. In addition, the exchange rate volatility has significant and negative effects. The interaction between CRIS and NEER volatility is negative and big in magnitude. This suggests that the CRIS exacerbated the adverse effects of
Table 7  The results from models including the interactive terms using the NEER

| Variable | Col1 |      |      |      |      |      |      |      |      |      |      |
|----------|------|------|------|------|------|------|------|------|------|------|------|
|          | Coef | p value | Coef | p value | Coef | p value | Coef | p value | Coef | p value | Coef | p value |
| Constant | -28.58 | 0.00 | -31.73 | 0.00 | -30.32 | 0.00 | -33.40 | 0.00 | -29.41 | 0.00 |
| Trend    | -0.02 | 0.00 | -0.02 | 0.00 | -0.02 | 0.00 | -0.02 | 0.00 | -0.02 | 0.00 |
| LEXCH, | 0.13 | 0.00 | 0.16 | 0.00 | 0.16 | 0.00 | 0.18 | 0.00 | 0.17 | 0.00 |
| LEXCH, * CRIS | -0.21 | 0.03 | -0.17 | 0.09 | -0.10 | 0.04 |      |      |      |      |
| LYF, | 1.96 | 0.00 | 2.15 | 0.00 | 2.07 | 0.00 | 2.25 | 0.00 | 2.02 | 0.00 |
| LYF, * CRIS | 1.96 | 0.00 |      |      | 1.82 | 0.00 | 2.34 | 0.00 |      |      |
| CRIS     | -35.43 | 0.00 |      |      | -32.83 | 0.00 | -41.45 | 0.00 |      |      |
| EXVOL, | -2.36 | 0.06 |     |      | -1.47 | 0.06 | -2.49 | 0.01 |     |      |
| EXVOL, * CRIS |     |      |      |      |     |      | -4.62 | 0.00 |     |      |
| EXVOL, -1 * CRIS |     |      |     |      |     |      | -3.51 | 0.00 |     |      |
| $R^2$    | 91.7% | 93.4% | 92.6% | 94.1% | 94.4% |     |     |     |     |
| Adjusted $R^2$ | 91.4% | 92.9% | 92.2% | 93.5% | 93.6% |     |     |     |     |

The dependent variable in the long run equation is log export volumes. Coef denotes coefficient. The standard errors are HAC estimators.
Table 8  The results from models including interaction terms using the NEER and relative prices

| Variable                  | Col 1 Coeff | Col 1 p value | Col 2 Coeff | Col 2 p value | Col 3 Coeff | Col 3 p value | Col 4 Coeff | Col 4 p value |
|---------------------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|
| Constant                  | -26.593     | 0.000         | -27.828     | 0.000         | -22.578     | 0.003         | -23.016     | 0.001         |
| Trend                     | -0.015      | 0.003         | -0.016      | 0.001         | -0.011      | 0.114         | -0.011      | 0.072         |
| LEXCH_t                   | 0.145       | 0.000         | 0.173       | 0.000         | 0.180       | 0.000         | 0.183       | 0.000         |
| LEXCH_t*CRIS              | -0.085      | 0.423         | -0.083      | 0.468         | -0.123      | 0.044         | -0.108      | 0.026         |
| LYF_t                     | 1.847       | 0.000         | 1.925       | 0.000         | 1.672       | 0.000         | 1.687       | 0.000         |
| LYF_t*CRIS                | 2.037       | 0.000         | 1.958       | 0.000         | 0.566       | 0.499         | 2.716       | 0.000         |
| LCPIRATIO_t               | -0.059      | 0.749         | -0.106      | 0.562         |             |               |             |               |
| LCPIRATIO_t*CRIS          | -0.504      | 0.023         | -0.406      | 0.030         |             |               |             |               |

The dependent variable in the long run equation is log export volumes. Coeff denotes coefficient and Signif denotes significance. The standard errors are HAC estimators

Table 9  Results including the exchange rate volatility

| Variable                  | Model with REER Coefficient | Model with REER p value | Model with NEER Coefficient | Model with NEER p value |
|---------------------------|-----------------------------|-------------------------|----------------------------|-------------------------|
| LYF_t                     | 0.668                       | 0.000                   | 0.585                      | 0.000                   |
| LEXCH_t                   | 0.176                       | 0.007                   | 0.077                      | 0.078                   |
| DEBT*LEXCH_t              | -0.021                      | 0.000                   | -0.021                     | 0.000                   |
| EXVOL_t                   | -4.240                      | 0.064                   | -1.429                     | 0.217                   |
| EXVOL_t*CRIS              | -7.778                      | 0.001                   | -1.907                     | 0.099                   |
| DEBT*EXVOL_t              | -0.130                      | 0.965                   | -0.725                     | 0.666                   |
| DEBT*EXVOL_t-1            | 4.040                       | 0.273                   | 0.011                      | 0.994                   |
| DEBT                      | -0.002                      | 0.035                   | -0.002                     | 0.111                   |
| GDPREC                    | -0.040                      | 0.044                   | -0.038                     | 0.078                   |
| Constant                  | -6.183                      | 0.000                   | -5.194                     | 0.000                   |
| R^2                       | 0.930                       | 0.942                   | 0.918                      | 4.624                   |
| Adjusted R^2              | 0.923                       | 0.934                   | 0.910                      | 0.910                   |

The trend was dropped from the model because its inclusion led to an unstable model.
exchange rate volatility on export volumes. The results using the relative price ratios (CPIRATIO\(_t\)) are shown in Table 8.

In Table 8, col 1, and col 2, the relative price ratio is negative but insignificant, indicating that the increase in the South African consumer price level relative to the foreign price level reduces export volumes. The interactions between the CRIS, the domestic prices, and foreign prices are negative and significant. This suggests that the relative price differential played a significant role in the reduction of export volumes during the global financial crisis. In col 4 both the domestic and foreign prices are insignificant but have the expected signs. In col 3, the interaction between domestic consumer price and the CRIS is negative, which indicates that the CRIS increased the adverse effects of rising domestic consumer prices on export volumes. The interaction between CRIS with foreign prices is positive. This indicates that rising foreign prices during the CRIS led to a rise in export volumes. Overall, based on the domestic determinants of export volumes, a big adjustment of the export volumes during the CRIS has been happening via the consumer price changes rather than the nominal effective exchange rate. In addition, the exchange rate volatility had a bigger impact on export volumes than the level of the exchange rate during the CRIS.

### The role of government debt channel

The 2007 global financial crisis was accompanied by a rise in the ratio of government gross loan debt to GDP. The analysis in this section evaluates the effects of the rise in government debt to GDP ratio on export volumes both directly and

### Table 10  The role of government debt via NEER and the relative price ratio

| Variable           | Model 1         | Model 2         | Model 3         |
|--------------------|-----------------|-----------------|-----------------|
|                    | Coefficient     | \( p \) value   | Coefficient     | \( p \) value   | Coefficient     | \( p \) value   |
| LYF\(_t\)          | 0.971           | 0.000           | 0.960           | 0.000           | 0.921           | 0.000           |
| LEXCH\(_t\)        | 0.098           | 0.077           | 0.132           | 0.036           | 0.183           | 0.001           |
| DEBT* LEXCH\(_t\)  | -0.075          | 0.001           | -0.072          | 0.001           | -0.060          | 0.023           |
| CPIRATIO\(_t\)     | -0.001          | 0.560           | -0.002          | 0.373           | -0.003          | 0.161           |
| DEBT*CPIRATIO\(_t\)| -0.011          | 0.003           | -0.010          | 0.004           | -0.008          | 0.057           |
| EXVOL\(_t\)        | -2.346          | 0.045           | -2.907          | 0.023           |
| EXVOL\(_{t-1}\)    |                |                 | -2.525          | 0.051           |
| DEBT* EXVOL\(_t\)  | 0.766           | 0.585           | 0.601           | 0.817           |
| DEBT* EXVOL\(_{t-1}\)|              |                 | 1.644           | 0.515           |
| DEBT                | 0.007           | 0.001           | 0.006           | 0.001           | 0.005           | 0.059           |
| GDPREC              | -0.204          | 0.091           | -0.023          | 0.077           | -0.025          | 0.177           |
| Constant            | -12.122         | 0.000           | -11.773         | 0.000           | -10.853         | 0.000           |
| \( R^2 \)          | 0.939           | 0.943           | 0.946           |
| Adjusted \( R^2 \) | 0.933           | 0.935           | 0.937           |
indirectly via the exchange rate, exchange rate volatility, and price levels channels. The indirect effect is examined via the interaction between the determinants of export demand and the dummy for the ratio of government gross loan debt to GDP beginning in 2009Q1 to 2019Q4. The dummy equals one from 2009Q1 to the end of the sample and zero otherwise. In Table 9, both foreign income and exchange rate raises the export volumes significantly. However, the real exchange rate volatility and lagged exchange rate volatility lead to declines in export volumes. This differs from the finding that current nominal exchange rate volatility does not matter while the lagged effects significantly reduce export volumes. The interaction between the exchange rate volatility and government debt (DEBT*LEXCHt) has no significant effect on export volumes. This suggests that the exchange rate volatility does not transmit the government debt shocks.

The analysis further determines the component of the real effective exchange rate that transmits the rising government debt effects to export volumes. This is determined by decomposing the real effective exchange rate into the nominal effective exchange rate and relative price ratios. The nominal effective exchange rate and relative price ratio have been interacted with a rising government debt dummy for the period 2009Q1 to 2019Q4. In Table 10, the decomposition reveals that the nominal effective exchange rate has a bigger impact on the export volumes than the relative price ratio. The foreign income and the nominal effective exchange rate depreciation raise export volumes. The interaction terms reveal that rising government debt’s effects are significantly transmitted more via the nominal effective exchange rate than the relative price ratios. In addition, there is no evidence indicating that government debt is transmitted via exchange rate volatility. Higher government debt should imply a higher cost of insuring export in sovereign credit default swaps and probably a high-interest rate on credit to finance export shipments.

The role of the cost of the credit channel

Table 11 shows the results examining the role of the cost of credit channel during the period when the ratio of government debt to GDP was increasing between 2009Q1 and 2019Q4. The cost of credit reflects the prevalence of financial frictions, changes in the monetary policy transmission mechanism, and effects of sovereign credit rating downgrades. The effect is determined by the interaction of the cost of credit to non-financial corporations post-2008Q4 and determinants of export demand. This is to determine if the cost of credit impacted the size of the effects of determinants of export demand. Various models estimated in Table 11 are separated according to the exchange rate used. Across all models, the interaction of the cost of credit and the exchange rate is negative and significant. This suggests that the cost of credit post 2008Q4 reduced the effects of the nominal and real exchange rate depreciation on export volumes. The cost of credit also impacts the relative price differential. The cost of credit post 2008Q4 lead to more adverse effects on the relative price differential suggesting that South Africa even lost competitiveness on export volumes.
Table 11  The role of the cost of credit via NEER and the relative price ratio

| Variable     | Coefficient | p value | Model with REER | Coefficient | p value | Model with NEER | Coefficient | p value | Coefficient | p value |
|--------------|-------------|---------|-----------------|-------------|---------|-----------------|-------------|---------|-------------|---------|
|              |             |         |                 |             |         |                 |             |         |             |         |
| LYFT         | 0.663       | 0.000   | 0.668           | 0.000       | 0.599   | 0.000           | 0.585       | 0.000   | 0.960       | 0.000   |
| LEXCH        | 0.138       | 0.008   | 0.176           | 0.007       | 0.061   | 0.105           | 0.077       | 0.078   | 0.132       | 0.036   |
| COST*LEXCH   | −0.021      | 0.000   | −0.021          | 0.000       | −0.021  | 0.000           | −0.021      | 0.000   | −0.072      | 0.001   |
| CPIRATIO     | −0.002      | 0.373   |                 |             |         |                 |             |         |             |         |
| COST*CPIRATIO| −0.010      | 0.004   |                 |             |         |                 |             |         |             |         |
| EXVOLt       | −4.240      | 0.064   |                 | −1.429      | 0.217   | −2.346          | 0.045       |         |             |         |
| COST*EXVOLt  | −0.130      | 0.965   |                 | −0.725      | 0.666   | 0.766           | 0.585       |         |             |         |
| DEBT         | −0.002      | 0.072   | −0.002          | 0.035       | −0.001  | 0.137           | −0.002      | 0.111   | 0.006       | 0.001   |
| GDPREC       | −0.042      | 0.027   | −0.040          | 0.044       | −0.040  | 0.054           | −0.038      | 0.078   | −0.023      | 0.077   |
| C            | −6.294      | 0.000   | −6.183          | 0.000       | −5.514  | 0.000           | −5.194      | 0.000   | −11.773     | 0.000   |
| R²           | 0.924       | 4.624   | 0.924           | 4.624       | 0.916   | 4.624           | 0.918       | 4.624   | 0.943       | 4.624   |
| Adjusted R²  | 0.919       | 0.110   | 0.923           | 0.110       | 0.910   | 0.110           | 0.910       | 0.110   | 0.935       | 0.110   |
There is evidence indicating that the cost of credit is transmitted via the exchange rate volatility channel. The finding does not depend on whether it is the nominal or real exchange rate volatility used in the model.

**Conclusions and policy implications**

This paper examined the long run and short run effects of the exchange rate changes on export volumes in South Africa under the inflation-targeting period using the Johansen cointegration and the Engle–Granger approaches. The findings reveal that the long run elasticities of the exchange rate are bigger than the short run elasticity coefficients. The export volumes respond more to foreign income in the short run than in the long run. Foreign income demand has a bigger effect than the exchange rate on the export volumes Evidence reveals that the 2007 global financial crisis reduced the sizes of the impact of the real and the nominal effective exchange rate depreciation on export volumes, while it increased the impact of foreign income demand. Thus, policymakers should be cognisant of the adverse effects of the global financial crisis in dampening the stimulatory ability of the exchange rate depreciation to raise export volumes. Thus, the over-reliance on the exchange rate depreciation to raise export volumes may not achieve the desirable results. Second, the 2007 global financial crisis exacerbated the adverse effects of the exchange rate volatility on export volumes. This means that policymakers should mitigate the adverse effects of the financial crisis on the exchange rate volatility and export volumes by putting policy measures in place to limit the exchange rate volatility. Third, empirical evidence indicates the 2007 global financial crisis made the ratio of South African consumer price to the foreign consumer price level reduce export volumes significantly. Amongst the domestic variables, the adverse effects of the 2007 global financial crisis on the export volumes were transmitted more via consumer prices rather than the exchange rate. This means that the relative price differential played a significant role, suggesting that South Africa lost price competitiveness during the crisis period, and this matters most.

Evidence reveals that the rising government debt’s effects are significantly transmitted more via the nominal effective exchange rate than the relative price ratios to export volumes in South Africa. There is no evidence indicating that rising government debt and the cost of credit 2008Q4 are transmitted via the real and nominal exchange rate volatilities. Across all models, the interaction between the cost of credit and the exchange rate is negative and significant. This suggests that the cost of credit to non-financial corporations, post 2008Q4 reduced the effects of the nominal and real exchange rate depreciation on export volumes. The negative effects of the cost of credit on the relative price differential suggest that South Africa lost price competitiveness on export volumes post 2008Q4. Lastly, evidence reveals that government debt significantly lowers export volumes, which may be happening through the higher cost of insuring export by the sovereign credit default swaps following several sovereign debt credit rating downgrades and probably a high-interest rate on credit to finance export shipments.
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Declarations

Conflict of interest I declare that there is no conflict of interest.

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