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The Threshold Effects of Exchange Rates on Agricultural Exports: A Flow from South Africa to the Southern African Development Community

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Abstract: The impact of exchange rates is a significant concern affecting trade in the SADC region. This study's purpose is to assess the threshold effects of exchange rates on agricultural exports from SA to SADC from 2010 to 2022. A panel threshold estimation technique is applied to assess the exchange rates effects in different regimes that can be below or above the threshold value. This can reveal non-linear relationships that are often overlooked in traditional linear models. In this analysis, exchange rates are disaggregated into appreciation and depreciation, as it is critical to determine how these changes affect agricultural exports, which has not been achieved in previous studies. The findings of this study confirm the existence of a non-linear relationship between several key variables (depreciation, South Africa's GDP, the GDP of the SADC, and South Africa's population and agricultural exports). This contributes new insights to the existing literature on the SADC economies. The policymakers could implement an exchange rate stabilisation mechanism and promote the diversification of both market destinations and agricultural export products. The SADC economies could consider adopting flexible exchange rate regimes that respond to market forces, while taking into account external shocks and economic indicators to mitigate the effects of depreciation shocks. Furthermore, the findings from this study can aid policymakers in formulating effective strategies for managing exchange rates fluctuations and promoting agricultural export growth. The findings show that different segments of agricultural exports can inform targeted interventions aimed at supporting exporters, and relevant industries within the SADC region. These results can aid policymakers to develop strategies to support sustainable agricultural practises, and ensure that the sector can meet the growing demands of a larger population.

Keywords: threshold; panel data; exchange rates; agricultural exports; South Africa; SADC

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1. Introduction

The examination of how exchange rates affect exports at specific points is mainly influenced by the complex and changing nature of global trade, with exchange rates playing a significant role. Fluctuations in exchange rates can greatly impact the competitiveness of goods in the market. When the local currency strengthens, prices of products increase for buyers, potentially leading to reduced demand and lower export levels. Conversely, if the local currency weakens this can improve the competitiveness of products on a global scale, thus increasing demand. Therefore, as indicated by Baek and Yoon (2022) and Mao (2019), these connections are not straightforward and might display threshold effects. This implies that how an exchange rates changes affect agricultural exports can vary depending on levels of currency valuation, highlighting the intricate nature of these relationships.

For South Africa (SA) and selected members of the Southern African Development Community (SADC), the agricultural sector plays a crucial role in their economies. This sector is estimated to contribute between 4 percent and 27 percent of Gross Domestic Product in the region (Department of Environmental Affairs, 2016). Furthermore, the Food and Agriculture Organization (FAO, 2022) indicated that the majority of individuals in the SADC region depend on agriculture for their livelihoods, emphasising the crucial role of the agricultural sector in sustaining communities across the region. Approximately 61 percent of the population in the SADC live in rural areas, and this consists of over 300 million people (FAO, 2022). This reliance on agriculture highlights the significance of supporting and investing in this sector to ensure food security, economic growth, and overall well-being within these communities. Therefore, it is of great significance to examine the agricultural exports in the region.

A panel threshold estimation technique is applied to assess the exchange rate effects in different regimes, which can be below or above the threshold value. This study aims to access the threshold effects of the exchange rate shocks on agricultural exports from SA to the SADC. The impetus of this method is that, compared to the traditional OLS, the Hansen (2000) model allows for the identification of distinct regimes based on threshold levels, thereby revealing the varying impacts of exchange rates on agricultural exports that OLS may overlook due to its assumption of a linear relationship. Therefore, using threshold values in linear regression expands the scope by permitting variations in coefficients among different regions. These regions are distinguished based on whether a threshold variable exceeds or falls below a specific threshold value (Han et al., 2020). There exists a linear relationship between agricultural exports and the exchange rate, which has been shown in studies by Ogunjobi et al. (2022), Iyke and Ho (2017), Musunuru (2017), and Sanjuán-López and Dawson (2010), which have contributed to the literature. However, studies such as those by Lu et al. (2022), Shuaibu and Isah (2020), Mao (2019), and Baum et al. (2004) have indicated that non-linearities may exist, hence it is significant to incorporate threshold variables that may trigger changes, or better explain the variation or regime effects, which can be used by analysing the fixed effects model which captures the within-individual variation over time, and heterogeneity, which exist in economies when examining the threshold effects of agricultural exports.

The study will add to the existing literature into two ways: Firstly, the study will focus on a specific sector and model the variation effect of exchange rates on agricultural exports from South Africa (SA) to the Southern African Development Community (SADC) instead of focusing on aggregate exports, as conducted by Keho (2021), and Shuaibu and Isah (2020). Secondly, it will assess the threshold effects of exchange rates shocks on agricultural exports in the SADC region, as this will be a one-of-its-kind study to explore the region. Therefore, if this study provides evidence of exchange rate depreciation shocks, these will be new findings in the region, and policymakers should prompt exchange rate stabilisation.

This study's aim is to assess the threshold effects of exchange rate shocks on agricultural exports from SA to the SADC by employing the threshold regression model. The study will answer the following research questions: I. Is there a threshold effect of exchange rates on agricultural exports? II. Are there threshold effects of appreciation and depreciation shocks on agricultural exports? This study employs three threshold estimates of exchange rates, appreciation and depreciation, to determine the positive and negative shocks on agricultural exports. The study will consist of the literature review, methodology and data description, results and interpretation, discussion, conclusion and policy recommendations, and limitations and suggestions for future studies.

2. Literature Review

A stable and favourable exchange rate can enhance a country's comparative advantage in agriculture, leading to increased exports and economic growth. Conversely, volatility in exchange rates can pose risks that may hinder agricultural trade and production. The correlation of purchasing power parity in the theoretical literature on agricultural exports and exchange rates focuses on the relationship between the prices of agricultural products in different countries and the exchange rates between their currencies (Lafrance & Schembri, 2002). In the literature, there exists a linear and non-linear relationship between exchange rates and exports. In developed economies, the exchange rates have been shown to reduce the impact of positive effects on appreciation shocks, while in developing economies, the exchange rate depreciation shock encourages positive effects.

The literature reviewing the linear relationship between exchange rates and agricultural exports in developing economies is extensive, such as in studies by Ogunjobi et al. (2022). Their findings provided robust evidence of a direct influence of exchange rates on agricultural exports, indicating a significant long-term correlation between these variables. The study emphasised the critical role of stable exchange rates in promoting agricultural export growth, and recommended that the Nigerian government enhance access to financial resources for farmers. Such measures would facilitate increased agricultural production for export, thereby improving the nation's balance of trade and contributing to economic development. They investigated the connection between exchange rates and agricultural exports in Nigeria, analysing data from the period 1981 to 2019. The authors utilised the ARDL model alongside Granger causality tests to assess the interdependencies between exchange rates and agricultural export performance. A similar study by Mpungose and Sekome (2023) revisited the effects of exchange rates on imports and exports in South Africa through the use of the VAR method. The study revealed that fluctuations in exchange rates significantly impact exports, imports, and inflation, ultimately influencing the trade balance and economic growth. Additionally, this study analysed agricultural export flows from South Africa to the SADC economies, providing insights into the multifaceted effects of exchange rate dynamics on trade performance in the agricultural sector. These studies have added to the vast number of linear studies in the literature. Therefore, there exists an extensive body of work about the linear relationship between exchange rates and agricultural exports in the developing economies, which has been presented in studies by Bosupeng et al. (2024), Ogunjobi et al. (2022), Iyke and Ho (2017), Musunuru (2017), and Sanjuán-López and Dawson (2010). However, there have been substantial studies that have shown the relationship to be asymmetric in nature.

These studies, by Victor and Onyeukwu (2022), Baek and Xu (2022), and Ali (2023), have indicated that the relationship of exchange rates on exports can be non-linear, hence the significance of incorporating threshold models to enhance the understanding of how exchange rates influence agricultural export performance under varying economic conditions. The commonly used models are the NARDL and GARCH models to show the non-linear relationship between exchange rate and agriculture exports. This was evidenced when Urgessa (2024) investigated the impact of real effective exchange rate (REER) volatility on Ethiopia's export earnings, focusing on the symmetric and asymmetric effects. The study employed the GARCH model to estimate the volatility of the real effective exchange rate, and utilised the autoregressive distributed lag (ARDL) and non-linear ARDL (NARDL) models to analyse the effects on total export earnings, commodity-level export earnings, and export earnings, based on countries of destination. The study revealed that exchange rate volatility significantly influences export earnings, with both linear and non-linear models used to estimate the effects. It also identified a gap in the existing literature, highlighting the need for more empirical evidence on the volatility of the real effective exchange rate

and its impact on the export of primary commodities in Ethiopia. This study aims to fill this gap by providing insights into the threshold effects of exchange rate volatility on SADC's main export commodities.

A similar study that used the ARDL and EGARCH models to measure the exchange rate volatility on commodity exports was by Handoyo et al. (2022). In the short term, their findings revealed that exchange rate volatility has a significant negative effect on the five main commodity exports to the Organisation of the Islamic Cooperation (OIC) countries, whereas, in the long-term, the volatility of the exchange rate negatively affects the twelve main commodity exports to OIC countries.

The relationship between exchange rates and exports has been extensively studied, with a growing body of literature focusing on non-linear dynamics. Non-linear models can capture the complexities of how exchange rate fluctuations impact export performance, revealing insights that traditional linear models may overlook. This review synthesises findings from various studies that employ non-linear methodologies to analyse the effects of exchange rates on exports.

The works of Mathur and Shekhawat (2018), Mao (2019), Edeme et al. (2022), Orman and Dellal (2021), Lestari et al. (2021), Victor and Onyeukwu (2022), Handoyo et al. (2022), Baek and Yoon (2022), Ali (2023), Bahmani-Oskooee et al. (2023), and Rasaki (2023) all analysed the non-linear effects between exchange rates and agricultural trade. This is evidenced by Rasaki (2023), who used the GARCH-based model to test asymmetric effects in Nigeria and which highlights the volatility of exchange rates that affect the trade flows directly. On the other hand, Edeme et al. (2022) discussed exchange rate volatility in relation to agricultural export and its impacts on export destination in a regional context, with trade policy co-integration. To investigate the long-run dynamics, Orman and Dellal (2021) applied a cointegration approach to investigate the impact of exchange rate volatility on the performance of agricultural exports in a developing country, Turkey. Reflecting the specificity of these effects and using Non-Linear Autoregressive Distributed Lag (NARDL), Lestari et al. (2021) analysed the asymmetries within the Indonesian agricultural subsectors. Measurement equations of exports such as linear models may, however, omit key dynamics, as pointed out by Mathur and Shekhawat (2018) in their study on India's exports to the USA. Therefore, the value of non-linearities in export demand equations cannot be ignored. Furthermore, Sugiharti et al. (2020), Victor and Onyeukwu (2022), and Ali (2023) investigated the effects of exchange rate fluctuations on agricultural exports across different agricultural commodities and market environments. In a recent study, Handoyo et al. (2022) focused on exchange rate volatility and its impacts on Indonesian pepper exports, thereby underlining the importance of these perspective vectors for agricultural products only; while Mao (2019) explored the changes in marginal effects in trade, which provides the confirmation that exchange rates can impact various sectors and products in different way. These studies have focused on various economies and employed a range of methods to analyse the exchange rate impact on agricultural exports, with the exception of the threshold approach. Therefore, this study focuses on SADC region to access the threshold effects of exchange rates on agricultural exports.

Agricultural exports are essential for the economic development of many emerging nations. However, the effects of exchange rate changes on them are yet to be understood in the SADC region. There are studies by Ogunjobi et al. (2022) and Musunuru (2017), which have shown the linear nexus between exchange rates and trade. However, some of the studies by Victor and Onyeukwu (2022), Ali (2023), and Handoyo et al. (2022) have sought to explore whether there is evidence of non-linear effects between exchange rates and agricultural trade, by estimating thresholds which can also be known as varying marginal effects across the trade flow. Therefore, this study examines more sophisticated empirical

tools to find evidence of non-linearities that have been limited for SADC countries in this contemporary period of growing globalisation and increasing trade agreements. The threshold model is in line with theoretical viewpoints such as purchasing power parity, and is employed to determine the threshold effects of the exchange rates on agricultural exports from South Africa to the Southern African Development Community.

3. Methodology

3.1. Panel Threshold Regression Model

To model the threshold effects of the exchange rates on agricultural exports from South Africa to SADC economies, a panel threshold regression is applied. This study adopted and incorporated the threshold model by Hansen (2000) and is integrated with the gravity model as followed by Xu et al. (2023) and Doudou et al. (2022) to analyse the agricultural export flows between SA and SADC economies to navigate the complexities of trade on exchange rates, and achieve the objectives of the study. The adopted model of the threshold effect can be written as follows:

$$y*_{it} = \beta'_1 x^*_{it} + e^*_{it}, \tag{1}$$

where β_1 is the regression parameter that is estimated by OLS. β'_1 is estimate variable and e^*_{it} is residuals. The above equation can be estimated as a single threshold equation with two regimes that can be written as:

$$y*_{it} = \beta'_1 x_{it}(q_{it} \leq \gamma) + \beta'_2 x_{it}(q_{it} > \gamma) + e^*_{it} \tag{2}$$

where $y*_{it}$ is the dependent variable, and β'_1 and β'_2 are the coefficients. Also, γ is the threshold variable and e^*_{it} is the error term.

The threshold regimes of exchange rates are presented by β'_1 and β'_2 parameters which will outline the lower and upper regimes. In the interest of the analysis, the study will have multiple threshold estimates (γ), namely exchange rates (ER), appreciation (ER_POS), and depreciation (ER_NEG), which are shown in Equations (4)–(6). To track fluctuations in the exchange rates, appreciation and depreciation series were used. The POS_{ij} variable signifies the currency's increase in value, while the NEG_{ij} variable denotes its decline in value. The hypothesis of the threshold must be determined and be significant. The non-linearity hypothesis of a threshold is written as follows:

$$\begin{aligned} H_0 &: \ \beta_1 = \beta_2 \\ H_1 &: \ \beta_1 \neq \beta_2 \end{aligned} \tag{3}$$

β_1 and β_2 are vectors of the parameters[1]. The panel threshold regression by Hansen (2000) showed that data in the model can be divided into different groups or regimes based on a particular threshold variable. The threshold value is determined using two regimes that can either be below the threshold value or can be represented by $\leq \gamma$; the upper regime which is above threshold value can be indicated by $> \gamma$. Each group is then analysed separately using threshold regression models which take into account nonlinearity, individual-specific and time-invariant characteristics in the regression model, to control for unobserved heterogeneity. This study takes a different approach by examining the effects of agricultural exports and the exchange rates as a threshold variable. Furthermore, this study will integrate the gravity model to take into account the flows of agricultural exports from SA to the SADC. The above model will be modified and will be the model of the study. The study incorporates the two threshold conditions $if -\infty < \omega_t \leq \gamma$ and $if -\infty > \omega_t > \infty$ with a single expression as follows:

$$LGEX*_{it} = \alpha + y_1 ER_{ij} + y_2 LGDP_i + y_3 LGDP_{ij} + y_4 LPOP_i + y_5 LPOP_{ij} + y_6 D_{ij} + y_7 INF_{ij} + e^*_{it} \quad (4)$$

where α is an intercept, $LGEX$ represents the natural logarithm of agricultural exports which is the dependent variable, and the explanatory variables are as follows:

ER represents the exchange rates.
$LGDP_i$ represents the natural logarithm of the gross domestic product (current US$) of South Africa.
$LGDP_{ij}$ represents the natural logarithm of the gross domestic product (current US$) of the SADC economies.
$LPOP_i$ denotes the population of SA in natural logarithm.
$LPOP_{ij}$ denotes the total population of SADC in natural logarithm.
The distance in latitude and longitude is represented as (D_{ij}).
Inflation is denoted by INF_{ij}.
ω_t represents the threshold value.

Also, the objective of the study is to disentangle the changes in exchange rates from appreciation and depreciation, which can show the non-linearity of agricultural exports from South Africa and SADC economies. Moreover, it expands the scope by disaggregating the exchange rates variable into two series to analyse both appreciation and depreciation, as adopted from Shin et al. (2014). The above Equation (2) will be disentangled into two series, namely appreciation (ER_POS), which is Equation (5), and depreciation (ER_NEG), which is Equation (6), and will be re-estimated using the two threshold conditions $if -\infty < \omega_t \leq \gamma$ and $if -\infty > \omega_t > \infty$ are both applied in each equation. The dependent variable will be agricultural exports, which is written as follows:

$$LGEX*_{it} = \alpha + y_1 LER\_POS_{ij} + y_2 LGDP_i + y_3 LGDP_{ij} + y_4 LPOP_i + y_5 LPOP_{ij} + y_6 D_{ij} + y_7 INF_{ij} + e^*_{it} \quad (5)$$

$$LGEX*_{it} = \alpha + y_1 ER\_NEG_{ij} + y_2 LGDP_i + y_3 LGDP_{ij} + y_4 LPOP_i + y_5 LPOP_{ij} + y_6 D_{ij} + y_7 INF_{ij} + e^*_{it} \quad (6)$$

All the other coefficients have been explained above in Equation (4), except that ER_POS represents appreciation and ER_NEG represents depreciation.

Panel threshold regression is an extension of fixed-effects or random-effects panel models. It extends regression by introducing a threshold variable that divides the data sample into regimes or groups Hansen (2000), therefore, showing the significance of examining the non-linear effect of exchange rates on agricultural exports. The Hansen (2000) model offers a more nuanced approach compared to traditional OLS by identifying distinct regimes based on threshold levels. This allows for the detection of varying impacts, such as those of exchange rates on agricultural exports, which the traditional linear assumption of OLS might overlook. The use of threshold regression is advantageous as it enables variations in coefficients among different regions by distinguishing whether a threshold variable goes beyond a certain threshold value (Han et al., 2020).

In this study, estimation, testing, and inference will be applied to model the threshold effects of agricultural exports of SADC economies. This model accounts for individual heterogeneity and helps to identify the causal relationship between variables on the threshold. The study will examine three threshold estimates in all three models to establish if there is the existence of non-linearity between exchange rates and agricultural exports. This regression will determine and compare the coefficients and standard error if there is a significant difference in the relationships between the variables that are above and below the threshold. Lastly, robustness checks are computed to test for a threshold in linear regression allowing for heteroskedasticity, and the Lagrange multiplier (LM) bootstrap procedure to verify if a threshold exists in both regimes.

The study focuses on the threshold effect of the exchange rates on agricultural exports from South Africa and the SADC for the period 2010–2022. All the variables used in the study are found in Table 1. Lastly, the threshold regression methodology framework of the study is shown in Figure 1.

Table 1. Data Description and Sources.

Variable	Measure	Source
Agricultural exports (LGEX)[2]	Gross Exports in 1000 USD of all products	https://wits.worldbank.org/ (acessed on 3 March 2023)
Official exchange rates (ER)	LCU per US$, period average	International Monetary Fund, International Financial Statistics.
Gross domestic product SA (LGDPs)[3]	Current US$	World Bank
Gross domestic product SADC(LGDPf)	Current US$	World Bank
Population of SA(LPOPS)	Total in millions	World Bank
Population of SADC (LPOPf)	Total in millions	World Bank
Distance (Ldij)[4]	Distance in longitude and latitude.	https://www.distancefromto.net/countries.php (accessed on 10 February 2023)
Inflation, consumer prices (INF)	Annual %	World Bank

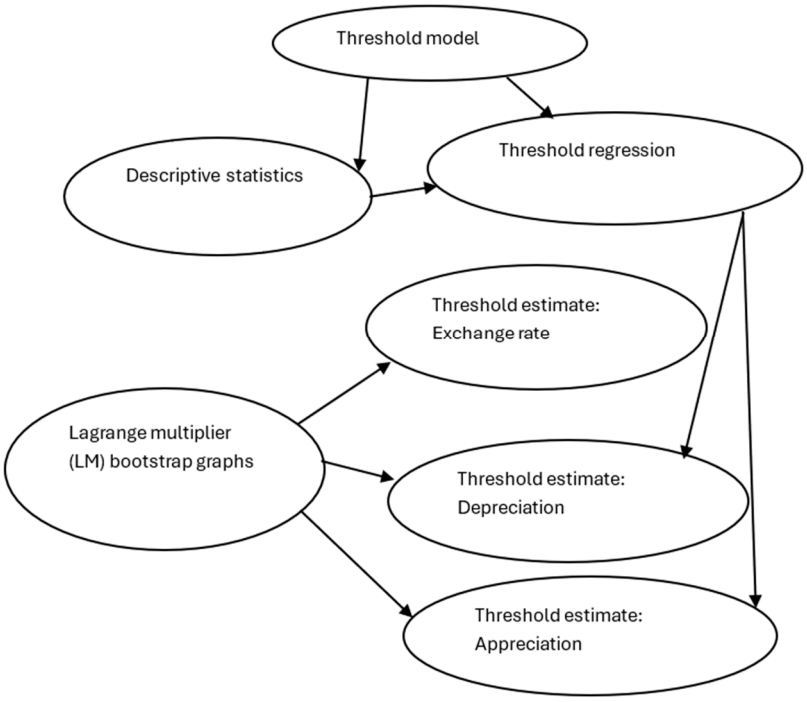

Figure 1. Threshold regression methodology framework. Author's compilation.

3.2. Description of Data

To model the threshold effect of agricultural exports from South Africa and SADC economies from 2010 to 2022 with balanced panel cross-sectional data, panel data of 169 observations is used to analyse agricultural exports from SA to SADC countries, capturing post-free trade agreement and the aftermath of the 2008 global financial crisis, which affected exchange rates. All countries that are members of the SADC region included in the study are Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar,

Malawi, Mauritius, Mozambique, Namibia, South Africa, Seychelles, Swaziland, Tanzania, and Zambia, but excluding Comoros and Zimbabwe due to unavailability of data for the specified period. In Section The Description and Sources of the Variables, the description and sources of the variables are shown in Table 1.

The Description and Sources of the Variables

The data description and sources of the study are as follows:

4. Results and Discussion

4.1. Results and Discussion

In examining panel data segmented by different threshold variables, the study predominantly utilised three essential thresholds: exchange rate (LER), appreciation (LER_POS), and depreciation (LER_NEG). Using these thresholds allowed for a detailed analysis of multiple regimes, which was pivotal in understanding the diverse effects of exchange rates on agricultural exports from SA to SADC. Each threshold regression provided deeper insights into the interplay between exchange rate variations and agricultural exports.

4.1.1. Descriptive Statistics

The descriptive statistics of all the variables used in the study are presented in Table 2 below:

Table 2. Descriptive statistics of the variables.

Variable	Obs	Mean	Std.dev	Min	Max
Agricultural exports (LGEX)	169	13.6330	1.2397	10.73	15.58
Exchange rates (ER)	169	98.8340	14.5776	65.33	148.47
Gross domestic product SA (LGDPS)	169	25.3323	3.1778	17.9	26.85
Gross domestic product SADC (LGDPf)	169	23.2089	1.1047	20.71	25.65
Population SA (LPOPS)	169	19.2007	3.2266	17.76	26.76
Population SADC (LPOPf)	169	15.6978	1.8846	11.38	18.41
Inflation (INF)	169	7.4334	6.4598	−10	30.7
Distance (dij)	169	7.5253	0.6135	6.26	8.401782
Depreciation (ER_NEG)	169	42.2683	294.6752	0	3116.11
Appreciation (ER_POS)	169	514.139	932.3672	0	3787.75

Source: own compilation.

The study employed descriptive statistics to show a summary of the data that included the mean, observations, standard deviation, minimum, and maximum to manage and describe the data in a sample period of 2010 to 2022. Based on the provided descriptive statistics in Table 2, agricultural exports account for an average of about 13. The exchange rate has an average of US$ 98.83, while the average SADC GDP and South Africa's GDP are 25.33 and 23.20, respectively. Distance and inflation play a role as well, with an average impact of 7.52. Population in the SADC region contributes to approximately 15.69, while

South Africa's population (LPOPS) makes up to 19.20. Depreciation (ER_NEG) has an average impact of 42.26, whereas appreciation (ER-POS) stands at about 514.13. Furthermore, the threshold tests of Equations (4)–(6) are estimated to determine the threshold effects on agricultural exports in Table 3. This will allow us to comprehend the patterns and trends present in the variation effects of agricultural exports and exchange rates, and whether they are linear or non-linear.

Table 3. Threshold effects test.

Countries	Threshold Estimate	LM-Test	Bootstrap—*p* Value
Panel All countries: ER	44.18	66.88	0.000
Panel All countries: ER-POS	44.18	41.93	0.000
Panel all countries: ER-NEG	12.06	17.33	0.006

Source: own compilation.

4.1.2. Threshold Critical Values on Agricultural Exports

In Table 3, the threshold values of exchange rates (ER1), appreciation (ER_POS), and depreciation (ER_NEG) are determined and the threshold effects tests on agricultural exports are displayed.

Table 3 presents the results of the heterogeneity Lagrange multiplier (LM) bootstrap procedure for the three Equations (4)–(6) in the study, demonstrating the presence of non-linearity. The exchange rates (ER) equation yielded a Lagrange multiplier statistic of 44.18, while appreciation (ER_POS) and depreciation (ER_NEG) equations showed statistics of 44.18 and 12.06, respectively. Table 3 shows the bootstrap *p* values for the three equations (ER, ER_POS and ER_NEG) were found to be 0.000, 0.000, and 0.006, indicating significant evidence of non-linearity (Hansen, 1996). This implies that the variables in the study confirm the existence of threshold effects between ER, appreciation (ER_POS), and depreciation (ER_NEG).

4.2. Panel Threshold Regressions

The study used three threshold variables, which are exchange rates (ER), appreciation (ER_POS), and depreciation (ER_NEG) and their regression results are in Tables 4–6, respectively.

Table 4. Panel exchange rates threshold regression results.

Dependent Variable: Agricultural Exports Threshold Variable: Exchange Rates (ER)			
Threshold Estimate (r) 44.18			
	Linear Model OLS Without Threshold	Lower Regime (<r)	Upper Regime (>r)
		ER1 < 44.18	ER1 > 44.18
Intercept	6.8964 (0.3168)	6.9989 (0.5714)	−12.1596 (0.6253)
Exchange rates (ER)	−0.0005 *** (−12.7177)	0.0106 *** (30.7730)	−0.0003 *** (6.0427)
SA GDP (LGDPS)	0.0962 (0.1945)	−0.0980 (−0.3487)	0.8570 *** (1.9895)
SADC GDP (LGDPf)	0.3166 *** (4.5507)	0.86079 *** (19.7698)	−0.1311 *** (3.1031)

Table 4. *Cont.*

Dependent Variable: Agricultural Exports Threshold Variable: Exchange Rates (ER)			
Threshold Estimate (r) 44.18			
Population SA (LPOPS)	0.13025 (0.2675)	−0.09284 (0.3364)	0.8562 *** (2.0182)
Population SADC (LPOPf)	0.2905 *** (7.9764)	0.0716 *** (2.0921)	1.3092 *** (12.5797)
Inflation (INF)	−0.0475 *** (7.3610)	0.0017 (0.4007)	−0.0262 *** (3.3186)
Distance (Ldij)	−1.2487 *** (−17.4126)	−1.2659 *** (31.574)	−4.0472 *** (−9.9421)
R-square	0.834979521	0.9765198	0.879029359
Heteroscedasticity test (*p* value)	0.002	-	-
No. of Observations	169	97	72
Sum of squared residuals	42.613	44.389	6.421

Source: own processing. Notes: The numbers in parentheses are standard errors. *** denotes significance at 10% level.

Table 5. Appreciation threshold regression results.

Dependent Variable: Agricultural Exports			
Threshold Variable ER_POS			
Threshold Estimate (r) 69.47(1)			
	Linear Model OLS without Threshold	Lower Regime (<r)	Upper Regime (>r)
		Ler_pos < 69.47	Ler_pos > 69.47
Intercept	15.3587 (0.6514)	−3.8891 (−0.1900)	−29.8022 *** (2.0404)
Appreciation (ER_POS)	−0.0005 *** (10.4908)	0.0065 *** (1.8070)	−0.0004 *** (7.7981)
SA GDP (LGDPS)	−0.0930 (0.1743)	0.2042 (0.4263)	0.7527 *** (2.2248)
SADC GDP (LGDPf)	0.3537 *** (4.8707)	0.7788 *** (7.6260)	−0.0111 (0.0333)
Population SA (LPOPS)	−0.0570 (0.1082)	0.2048 (0.4391)	0.7674 *** (5.3713)
Population SADC (LPOPf)	0.2518 *** (6.1009)	0.0800 (1.2663)	0.7720 *** (5.4038)
Inflation (INF)	−0.0467 *** (7.0072)	−0.0097 (−0.7843)	−0.01425 *** (2.1898)
Distance (Ldij)	−1.2999 *** (17.3952)	−1.3951 *** (−18.0170)	−0.4169 (0.53562)
R-square	0.814540363	0.902308771	0.846178866

Table 5. *Cont.*

Dependent Variable: Agricultural Exports			
Threshold Variable ER_POS			
Threshold Estimate (r) 69.47(1)			
Heteroscedasticity test (*p* value)	0.140	-	-
No. of Observations	154	108	61
Sum of squared residuals	13.284	19.947	3.748

Source: own processing in Stata17. Notes: The numbers in parentheses are standard errors. *** and denotes significance at 10% level.

Table 6. Depreciation threshold regression results.

Dependent Variable: Agricultural Exports Threshold Variable ER_NEG			
Threshold Estimate (r)16.92(1)			
	Linear Model OLS Without Threshold	Lower Regime (<r)	Upper Regime (>r)
		Ler_neg < 16.92	Ler_neg > 16.92
Intercept	−2.6211 (0.0890)	12.3413 (0.3995)	194.7597 (1.4928)
Depreciation (ER_NEG)	−0.0002 *** (2.8598)	0.0013 (0.1169)	−0.0008 *** (6.5093)
GDP SA (lGDPS)	0.3692 (0.5534)	0.0283 (0.0404)	−3.5868 (1.2743)
GDP SADC (lGDPf)	0.4775 *** (6.5122)	0.5189 *** (6.9337)	−0.8051 *** (3.2055)
Population SA (LPOPS)	0.3723 (0.5662)	0.0234 (0.0339)	−3.4826 (1.2427)
Population SADC (lPOPf)	0.0496 (1.2052)	0.0131 (0.2972)	0.4407 *** (5.5377)
Inflation (INF)	−0.0276 *** (3.6022)	−0.0232 *** (2.9413)	−0.0274 (0.8857)
Distance (Ldij)	−1.5806 *** (−22.7399)	−1.59348 *** (22.48714)	−1.3731 *** (3.4251)
R-square	0.706814657	0.729640157	0.959773898
Heteroscedasticity test (*p* value)	3.773	-	-
No. of Observations	169	155	14
Sum of squared residuals	75.709	64.430	0.791

Source: own processing in Stata17. Notes: The numbers in parentheses are standard errors. *** denotes significance at 10% level.

4.2.1. Panel Exchange Rates Threshold Regression Results

The findings from Table 4 present both the OLS and threshold regression results for the study. The findings of the OLS show that exchange rates, the SADC GDP, both SA and the SADC population, inflation, and distance are significant at 10%, indicating that there is

a statistically significant relationship between the majority of independent variables and the dependent variable. However, the OLS regression analysis in Table 4 is not the interest of this study, as the aim of the study is "to assess the threshold effects of the exchange rates shocks on agricultural exports". Therefore, the threshold regressions results in Table 4 present the impact of the exchange rates (ER) on agricultural exports, with a threshold estimate of 44.18. The results are divided into two regimes: the lower regime (ER < 44.18) and the upper regime (ER > 44.18).

The exchange rates (ER) coefficient is 0.0106, which is positive and significant at the 10% level. This positive coefficient suggests that in this lower regime, an increase in the exchange rates, which is depreciation, is associated with a slight increase in agricultural exports. This implies that when the exchange rates are low, a stronger currency may enhance export competitiveness. Also, in the upper regime, ER is significant at the 10% level. This negative coefficient indicates that in the upper regime, further increases in the exchange rates (indicating depreciation) are associated with a decrease in agricultural exports. This suggests that when the exchange rates are high, the adverse effects of currency depreciation outweigh any potential benefits, leading to reduced agricultural export levels. These findings confirm the non-linear model, that demonstrates that the exchange rates have deviated from the influence of linearity on agricultural export flows from South Africa to SADC economies. A few studies, like those of Bahmani-Oskooee and Harvey (2010) and Bahmani-Oskooee et al. (2023), have shown a threshold effect in the relationship between exchange rate volatility and exports. These studies suggest that the impact of exchange rate changes on exports is non-linear and depends on the level of exchange rate. Hence, for the promotion of international trade, the exchange rate must be stable (Zhang et al., 2006).

South Africa's GDP (LGDPS) coefficient is −0.0980, but it is non-significant. This indicates that in the lower regime, changes in South Africa's GDP do not have a statistically significant impact on agricultural exports. However, SA GDP coefficient is 0.8570, which is significant, suggesting a positive relationship between SA GDP and agricultural exports when the exchange rate is below the threshold value of 69.47. This coefficient is statistically significant at the 10% level. This suggests that in the upper regime, an increase in South Africa's GDP is positively associated with agricultural exports. A stronger economy in this regime likely supports higher export levels, indicating that economic growth enhances export capacity. There is another, non-linear relationship between the SADC GDP and agricultural exports. This is evident as the SADC GDP (LGDPf) coefficient is 0.8607, which is significant. This indicates that in the lower regime, a higher GDP in SADC countries is positively associated with agricultural exports, suggesting that economic growth in the region enhances demand for South African exports. Furthermore, in the upper regime, the coefficient is −0.1311, which is significant. This negative relationship indicates that in the upper regime, the effect of the SADC GDP on exports becomes less favourable, possibly due to increased competition or market saturation.

The SADC population (LPOPf) is positive and statistically significant in both lower and upper regimes, with coefficients of 0.0716 and 1.3092, respectively. This indicates that in the lower regime, an increase in the SADC population is positively associated with agricultural exports, suggesting that a larger population increases demand for exports in the region. Furthermore, this further emphasises that in the upper regime, the demand for agricultural exports from South Africa increases significantly with a growing SADC population, highlighting the importance of regional demographics in driving export performance. These findings can be a result of when the population of these economies grows, the more labourers they may have, and this will expand exports by increasing the employment pool. These findings are similar to those of Amadou and Kebalo (2019), Banik and Ray (2021), and Hassan Khayat (2019). The contrasting results of SA population (POPi) show

a decrease in agricultural exports. However, the results show a new finding for South Africa's population, as the coefficient is −0.0928, indicating a negative relationship between South Africa's population and agricultural exports in the upper regime. This coefficient is statistically significant at the 10% level. The negative relationship could be attributed to factors such as increased foreign domestic investment and increased employment of the population in the agricultural sector. However, according to Bucci (2023), an economy may grow even with a negative population growth.

There is a non-linear relationship between inflation and agricultural exports with a threshold estimate of 44.18 over the analysis period. The inflation coefficient is 0.00176, but it is insignificant. This suggests that inflation does not have a meaningful impact on agricultural exports in the lower regime, whereas, when inflation is above the threshold estimate the coefficient is −0.02621, which is significant. This negative relationship indicates that higher inflation in this regime is associated with a decrease in agricultural exports, likely due to increased costs and reduced competitiveness. These results are supported by Seleteng (2012) with a threshold of inflation at 18.96 percent, while contrasting findings by Pambu (2023) and Oloo et al. (2022) had a threshold estimate that is lower than 18.96 percent.

For distance (Ldij), the coefficient is −1.2659, which is significant. This indicates that greater distance negatively impacts agricultural exports, likely due to higher transportation costs in the lower regime, while in the upper regime the distance coefficient of −4.0472, is also significant. This suggests that the negative impact of distance on exports is even more pronounced in the upper regime, reinforcing the idea that logistical challenges become more critical as the exchange rate increases.

The threshold regression results indicate that the exchange rate has a significant and varying impact on agricultural exports, depending on the regime. In the lower regime, a stronger currency (appreciation) is beneficial for exports, while in the upper regime, further depreciation of the currency leads to reduced exports. Other factors such as GDP, population, inflation, and distance also play critical roles, with significant implications for agricultural export performance. The results highlight the importance of economic conditions and exchange rate fluctuations in shaping the agricultural exports dynamics between South Africa and the SADC region.

4.2.2. Panel Appreciation Threshold Regression Results

Table 5 presents the results for estimation of Equation (5). The intention of the model was to determine the effect of positive shocks of exchange rates on agricultural exports between South Africa and SADC countries. The results of the linear model of OLS without the threshold show appreciation (ER_POS), economic activity (GDP SADC), SADC population (LPOPf), inflation (Inf), and distance (Dij) are the only significant variables, indicating that there is a statistically significant relationship between the independent variables and the dependent variable in the OLS results. However, the OLS regression analysis is not the focus of this research, as sufficient studies have shown the linear relationship that exists between appreciation and agricultural exports. The threshold value is 69.47, which separates the two regimes, the lower regime and upper regime.

In the lower regime, the coefficient for appreciation (ER_POS) is 0.0065, indicating a positive relationship with agricultural exports, which is statistically significant at the 10% level in Table 5. This suggests that as the exchange rate increases (appreciation), agricultural exports also tend to increase in this regime. These findings correlate with studies by Musunuru (2017) and Nweke et al. (2020), which had similar results. In the upper regime, the ER_POS coefficient is −0.0004, which indicates a negative effect on agricultural exports, which also is significant at the 10% level. This implies that once

appreciation (ER_POS) surpasses the threshold of 69.47, further appreciation could result in a negative impact on agricultural exports. This will result in the domestic economies of SADC being expected to pay more to purchase agricultural imports. The findings correlate with studies by Cardebat and Figuet (2019), Sugiharti et al. (2020), and da Silva Souza and de Mattos (2022). Therefore, there exists a non-linear relationship between appreciation and agricultural exports.

For South Africa's GDP (SA GDP), in the lower regime, the coefficient is 0.02042, but it is insignificant, suggesting that SA GDP does not have a meaningful impact on agricultural exports when the positive exchange rate (appreciation) is below the threshold. In the upper regime, the coefficient increases to 0.7527 and is significant, indicating that a higher SA GDP positively influences agricultural exports when the exchange rate is above the threshold.

For SADC GDP In the lower regime, the coefficient is 0.7788 and significant, indicating that SADC GDP positively influences agricultural exports when the exchange rate is low. A study by Kumar and Ahmed (2015) showed similar results, that GDP is significant for export and import flows. However, in the upper regime, the coefficient is −0.0111, which is insignificant, suggesting that the negative impact of SADC GDP on agricultural exports weakens when the exchange rate is high.

For the South Africa Population (LPOPS), the coefficient in the lower regime is 0.2048, which is insignificant, indicating no impact on agricultural exports. In the upper regime, the coefficient is 0.7674 and significant, suggesting that a larger SA population positively influences agricultural exports when the exchange rate is high. The findings of Ilmas et al. (2022) support this study. Looking at the SADC population, the coefficient in the lower regime is 0.0800, which is insignificant, indicating the SADC population does not significantly affect agricultural exports in this regime. In the upper regime, the coefficient is 0.7720 and significant, suggesting that a larger SADC population positively impacts agricultural exports when the exchange rate is high. The results emphasise the potential role of population growth in driving demand for agricultural products, ultimately boosting export activity. Additionally, the statistical significance of these coefficients reinforces the reliability of the observed relationships, underscoring the importance of demographic factors in influencing agricultural export trends within South Africa and the SADC region. Similar findings by Nuroğlu (2010) support these results.

The results show that the appreciation coefficient is 0.0065, while inflation and distance both have a negative impact on agricultural exports. The inflation coefficient in the lower regime is −0.0097, which is insignificant, indicating that inflation does not significantly affect agricultural exports when appreciation is low. In the upper regime, the coefficient is −0.0142 and significant at the 10 percent level, indicating that higher inflation negatively impacts agricultural exports when the exchange rates is above the threshold, while the distance coefficient in the lower regime is −1.3951, which is significant, indicating that distance has a strong negative effect on agricultural exports in this regime. The negative impact on agricultural exports is evident in the upper regime, for which the distance coefficient is −0.4169, which is non-significant, suggesting that the impact of distance on agricultural exports diminishes when the exchange rate is high. Therefore, Equation (5) indicates that there exists a J-curve for the appreciation threshold estimate.

The appreciation threshold regression results indicate that the relationship between the exchange rate and agricultural exports is complex and varies significantly across different regimes. While appreciation of the exchange rate can initially boost exports, it may have adverse effects once a certain threshold is crossed. Additionally, the significance of other variables such as GDP, population, and inflation also varies between the two regimes, highlighting the importance of considering the exchange rate context when analysing agricultural export dynamics.

4.2.3. Panel Depreciation Threshold Regression Results

The depreciation threshold regression results, as presented in Table 6, analyse the impact of the exchange rates (ER_NEG) on agricultural exports, with a threshold estimate of 16.92. The analysis is divided into two regimes: the lower regime (ER < 16.92) and the upper regime (ER > 16.92).

In the lower regime (ER < 16.92), the coefficient for the depreciating exchange rate is 0.0013, which is non-significant in Table 6. This implies that low exchange rates do not have a meaningful positive effect on agricultural exports. Studies by Musunuru (2017) and Nweke et al. (2020) had similar results. Conversely, in the upper regime (ER > 16.92), the coefficient is −0.0008 and is significant at the 10% level. This indicates that as the exchange rates continues to depreciate beyond this threshold, it negatively affects agricultural exports, suggesting that further depreciation could be detrimental to agricultural exports.

In the lower regime, the SA GDP coefficient is 0.0283, which is insignificant, indicating that SA GDP does not have a significant impact on agricultural exports when the exchange rate is below the threshold. In contrast, in the upper regime, the coefficient decreases to −3.5868 and is significant, suggesting that a higher SA GDP negatively influences agricultural exports when the depreciation is elevated. This unexpected finding may indicate that other factors linked to a stronger economy could be contributing to a decline in agricultural exports. Therefore, there is a non-linear relationship between SA GDP and agricultural exports from SA to the SADC.

In the lower regime, with the low exchange rates (depreciation), the coefficient for the SADC GDP is 0.5189 and is significant. This indicates that as the GDP of the Southern African Development Community (SADC) increases, agricultural exports also rise. This positive relationship suggests that a stronger regional economy can enhance the performance of agricultural exports, likely due to increased demand for agricultural products or improved economic conditions that facilitate trade. Conversely, in the upper regime, where the exchange rates are high, the coefficient for SADC GDP decreases to −0.8051 and remains significant. This shift indicates that the previously positive impact of the SADC GDP on agricultural exports diminishes and turns negative when the exchange rates are elevated. This unexpected outcome may imply that in a high exchange rate environment, factors such as increased production costs, reduced competitiveness of exports, or shifts in consumer preferences could be at play, leading to a decline in agricultural exports despite a stronger regional economy. Thus, while a robust SADC GDP can support agricultural exports at lower exchange rates, it becomes detrimental in the upper regime. This implies that minor shifts in currency values can affect the competitiveness of agricultural goods. Furthermore, these results could be attributed to the unstable climate conditions, such as drought, that have negatively affected the growth of the SADC, since the countries are dependent on exports and risk the development of agricultural exports (Cheng et al., 2022).

In the lower regime, the significant coefficient of −0.0232 indicates that when the exchange rates are low, inflation has a detrimental effect on agricultural exports. This suggests that rising inflation can increase production costs and reduce the competitiveness of agricultural products in international markets, leading to decreased export performance. In the upper regime, the coefficient rises to −0.0274, which remains significant, indicating that the negative impact of inflation on agricultural exports persists even when the exchange rate is high. This implies that regardless of the exchange rate level, inflation continues to exert pressure on agricultural exports, potentially due to ongoing increases in costs and reduced purchasing power, which can hinder export activities. The results highlight the importance of managing inflation to support agricultural export development in the SADC region, particularly in the context of exchange rate fluctuations.

In the lower regime, distance has a significant negative coefficient of −1.5934, indicating that greater distance from markets significantly hampers agricultural exports. In the upper regime, the coefficient is −1.3731, which remains significant, showing that distance still negatively impacts agricultural exports, though the effect is somewhat less pronounced. As the distance increases by one unit, the expected change in the outcome variable would decrease by 1.373 units. This relationship implies that transportation and logistical elements influence the number of exports, showing that longer distances present a hurdle for the trading of agricultural exports. Therefore, the impact can be notable, because the extended distance from one SADC economy to another may probably lead to increased transportation expenses, lengthier shipping durations, and potential logistical challenges that may discourage and reduce the demand for agricultural exports. Distance can act as a barrier to trade and economic integration, thus explaining the negative association with agricultural exports.

The findings of this study confirm the existence of a non-linear relationship between several key variables and agricultural exports. Specifically, the variables are ER_NEG, (depreciation), South Africa's GDP (SA GDP), the GDP of the Southern African Development Community (SADC GDP), and South Africa's population (SA population).

4.2.4. Lagrange Multiplier (LM) Bootstrap Procedure

The Lagrange multiplier is estimated in all three models from Equations (4)–(6), and are reported as an output of the following bootstrap graphs for Figure 2.

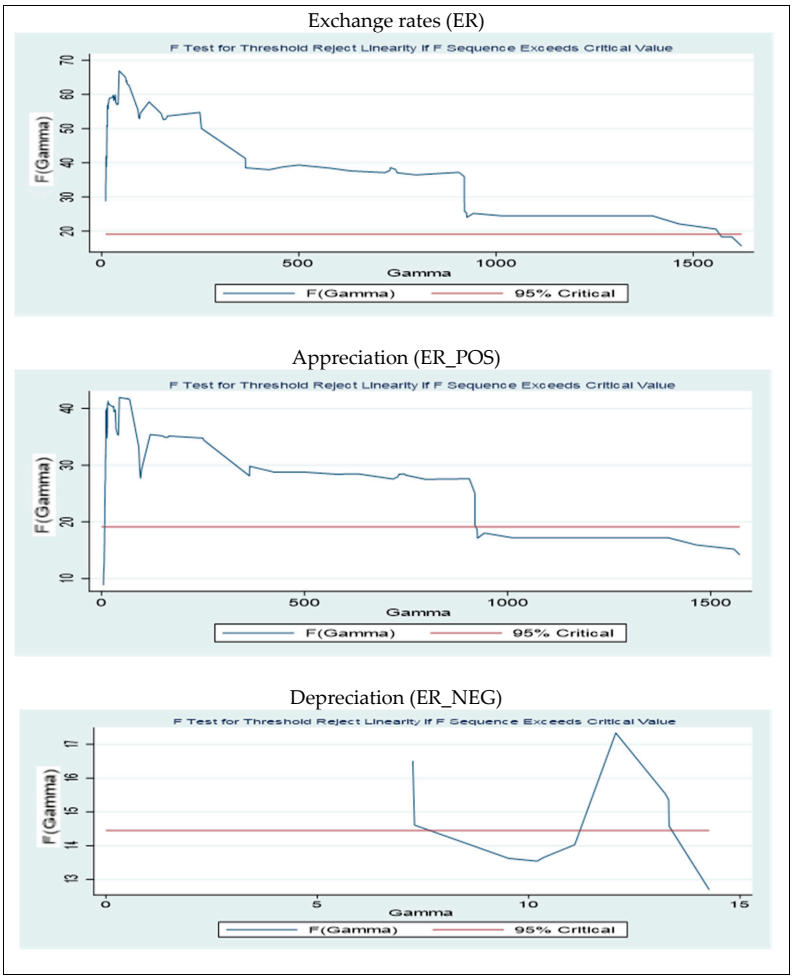

Figure 2. Lagrange multiplier (LM) bootstrap graphs.

Figure 2 presents the bootstrap graphs of the LM test. The null hypothesis is that there is no threshold, and the alternative hypothesis is that there is a threshold. The results of the bootstrap procedure indicate that the F test for threshold rejects linearity, since the F sequence exceeds the critical value with a *p*-value of 0.0000 for ER, ER_POS, and ER_NEG, respectively, which was statistically significant. This indicates that there is non-linearity between the exchange rates and agricultural exports. This indicated that all three models have a non-linear behavioural effect on agricultural exports and exchange rates.

5. Discussion

This study finds that there is a non-linear effect of the exchange rates on agricultural exports (LGEX) flows from South Africa to the SADC economies. The results of the three equations show that the exchange rates are statistically significant and that a threshold does exist, giving the three threshold values. This study confirms the existence of a non-linear relationship between several key variables and agricultural exports on all three threshold regression models. Specifically, in the exchange rates threshold, the variables are exchange rates, South Africa's GDP (SA GDP), the GDP of the Southern African Development Community (SADC GDP), South Africa's population (SA population) and inflation. In the threshold of exchange rates (ER), in all regimes the exchange rate was negative and significant. The results are supported by studies such as Doudou et al. (2022), and Baum et al. (2004), that show that exchange rates depreciation shocks lead to positive effects, resulting in import substitution and increase in agricultural exports.

For the appreciation threshold, the variables that showed non-linearity are appreciation (ER_POS) and SADC GDP. Also, the lower regime and upper regime of the LER_POS coefficients correlate with the J-curve effect, because when it comes to agricultural exports, the J-curve effect happens when a country's currency decreases in value, which can result in demand and possibly increased export quantities. Furthermore, exchange rates show a negative impact on agricultural exports. This will result in the domestic economies of SADC being expected to pay more to purchase agricultural imports. The findings correlate with studies by Cardebat and Figuet (2019), Sugiharti et al. (2020), and da Silva Souza and de Mattos (2022). Therefore, there exist non-linear relationship between appreciation and agricultural exports.

For the depreciation threshold regression, the results of Equation 6 showed that the findings of a negative sign on the depreciation exchange rates are similar to those in a study conducted by Ndou (2022), which found that the depreciation of the South African Rand led to a diminished effect on export volumes due to the global financial crisis of 2007. This finding is supported by a study by Bashir and Luqman (2014). Therefore, there is a non-linear relationship between SA GDP and agricultural exports from SA to the SADC. The SADC GDP has negatively affected the growth of the SADC, since the countries are dependent on exports and risk the development of agricultural exports (Cheng et al., 2022). Similar results are found in studies by Lianos et al. (2023). Therefore, there is a non-linear relationship between the SADC GDP and agricultural exports from SA to the SADC. Inflation shows a decrease, and this implies that regardless of the exchange rate level, inflation continues to exert pressure on agricultural exports, potentially due to ongoing increases in costs and reduced purchasing power, which can hinder export activities. The results highlight the importance of managing inflation to support agricultural export development in the SADC region, particularly in the context of exchange rate fluctuations.

The impact can be notable because the extended distance from one SADC economy to another may probably lead to increased transportation expenses, lengthier shipping durations, and potential logistical challenges that may discourage and reduce the demand for agricultural exports. Distance can act as a barrier to trade and economic integration,

thus explaining the negative association with agricultural exports. The findings of this study confirm the existence of a non-linear relationship between several key variables and agricultural exports. Specifically, the variables are ER_NEG, (depreciation), South Africa's GDP (SA GDP), the GDP of the Southern African Development Community (SADC GDP), and South Africa's population (SA population).

6. Conclusions and Policy Recommendations

The study indicated that there is non-linearity between exchange rates and agricultural exports from South Africa to SADC economies for the period of 2010–2022. The model by Hansen (2000) is used in this study to capture the threshold effects between agricultural exports and the exchange rates. Compared to the traditional OLS, this model allows for the identification of distinct regimes based on threshold levels, thereby revealing the varying impacts of exchange rates on agricultural exports that OLS may overlook, due to its assumption of a linear relationship. The findings of the study highlight the significance of threshold effects, demonstrating that the exchange rates, and both appreciation and depreciation of the exchange rates, have distinct impacts on agricultural export performance. Specifically, the results indicate that when the exchange rates exceed certain thresholds, the negative effects on agricultural exports become more pronounced, particularly in the context of inflation. This underscores the importance of maintaining stable exchange rates and managing inflation to support the agricultural sector's competitiveness in international markets.

For the analysis, this study used three Equations, (4) to (6), to explore three estimate thresholds. The exchange rate threshold regression results identified the threshold level of 44.18, at which the exchange rate begins to significantly affect agricultural exports. This provides a baseline for understanding how fluctuations in the exchange rates impact agricultural exports dynamics. The appreciation threshold regression results highlight the threshold level of 44.18, at which currency appreciation starts to negatively impact agricultural export volumes, therefore informing stakeholders about the critical exchange rates levels that could threaten agricultural export competitiveness. Lastly, the depreciation threshold regression results show how depreciation impacts on agricultural exports, with an estimated threshold of 12.06, specifically when economic activity, population, and inflation are considered. It provides insights into the conditions under which depreciation can either benefit or hinder agricultural exports, emphasising the need for careful monitoring of exchange rate movements and inflationary pressures. There have been studies by Musunuru (2017) and Victor and Onyeukwu (2022) analysing thresholds in OLS. However, there have been solid grounds to look into panel cross-sectional data, because this takes into account the individual effects of the SADC economies. Therefore, this study is one-of-a-kind for examining the non-linearity of exchange rates on a specific sector, that is, agricultural exports in the SADC region. The study's findings are new evidence and will add to the existing literature on SADC economies, which could assist researchers and enhance policies and programmes such as the Comprehensive African Agricultural Development Programme, (Comprehensive African Agricultural Development Programme (CAADP)) is an agenda of 2063 expediting the goal of advancing agricultural research, technology dissemination, and adoption.

This study assessed the threshold effects on the exchange rate shocks on agricultural exports from SA to the SADC. The findings of the study on the three models showed the non-linear shocks on agricultural exports. The threshold estimations of both appreciation and depreciation are significant and negative in the upper regime. The policy recommendation is that the SADC economies are encouraged to promote the stabilisation of exchange rates. As a result, the economies could consider adopting flexible exchange rate regimes that respond to market forces, while taking into account external shocks and economic indicators.

The threshold estimates of exchange rates in both regimes indicate both positive and negative shocks on agricultural exports. The policymakers could implement an exchange rate stabilisation mechanism and promote diversification of both market destinations and agricultural export products. Improved insights into how exchange rates fluctuations affect different segments of agricultural exports can inform targeted interventions aimed at supporting exporters, and relevant industries within the SADC region. These results can aid policymakers to develop strategies to support sustainable agricultural practises and ensure that the sector can meet the growing demands of a larger population.

7. Limitations and Suggestions for Future Studies

- The study had the challenge of missing data for Zimbabwe and Comoros for exchange rates, and so these countries were omitted from the study. The data were not available at OECD and World Bank databases.
- The limitations of the current study underscore the necessity for a focused examination of export diversification, particularly in the agro-processing sector, which is pivotal for enhancing economic resilience within the Southern African Development Community (SADC) economies. The reliance on specific commodities exposes these economies to significant risks associated with price shocks, which can destabilise their economic frameworks. Focusing on export-diversification such as agro-processing, as agriculture is one the key focus sectors in the region, will enable the economies to be able to minimise and mitigate the risks associated with specific commodity price shocks to improve the economic resilience of the SADC economies.
- Future research should also delve into the dynamics of exchange rates and their impact on agricultural exports, utilising quarterly data to provide a more nuanced understanding of these relationships. In addition, researchers can focus on a comparative study and combine high- and low-income regional studies. The fluctuations of exchange rates have been shown to significantly influence agricultural export performance, so, as a result, there is a need for policymakers to consider other macroeconomic variables that were not included in the study when formulating agricultural trade policies. In addition, researchers can include other developing regions that are dominant in agricultural exports.

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Notes

[1] The estimation of the parameter gamma in a threshold model for panel data, incorporating the method of least squares and two regimes to identify threshold effects. This approach assists to determine the optimal threshold value by observing changes in parameters across the two different regimes.

[2] LGEX-these exports of Harmonized System (HS) codes H3, H4, and H5 nomenclature of all total products inclusive of various products such as crops, fishery products, livestock (beef, poultry), dairy products, forestry products, fish and seafood, fruits, vegetables, and processed food items derived from agricultural commodities (Tebadul, 2023).

[3] World Bank (2023)—GDP at purchasers prices is the sum of gross value added by all resident producers in the economy plus any product taxes minus any subsidies not included in the value of the products.

[4] In relation to agricultural exports, it can indicate the distance between the origin country (SA) that produces goods and the market (SADC economies) where the products are sold.

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