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The Determinants of Trade Between China and Selected Sadc Countries: A Panel Data Approach (2000-2019)

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Abstract

Purpose: In the context of the increasing volume of trade between China and countries of the Southern African Development Community (SADC) region, this article examines the determinants of the China-SADC trade. The extended trade gravity model of international trade is used to conduct this analysis. **Methods:** The study estimates the extended trade gravity model using a panel data analysis in 9 SADC countries over 20 years (2000-2019). This research adopts the Fixed Effect (FE) and Random Effect (RE) estimation techniques. The Hausman specification is conducted to determine the appropriate estimation technique between the two. The test chooses the FE model whose results are reported. **Results:** The results show that Gross Domestic Product (GDP), availability of natural resources in selected SADC countries, and loan commitments are significant determinants of trade between China and selected countries in the SADC region.

Keywords: China-SADC trade. Determinants. Gravity model. GDP. Loan commitment. Natural resources.

Introduction

Several economists have argued about what drives trade between countries. Since the 1960's, trade theories on the drivers of trade have been developed from the earliest mercantilist theory to the latest new trade theory. Bilateral trade relations have grown worldwide, and China is the largest global trade partner in goods. According to Moyo (2021), countries in the southern part of Africa, particularly the Southern Africa Development Community (SADC) region, are the main exporters to China. The economies of this region are richly endowed with natural resources, such as oil in Angola, diamonds and platinum in Botswana, South Africa, Namibia, and Zimbabwe; copper and cobalt in Zambia and the DRC; and natural gas and forests in Mozambique. South Africa is not only China's major exporter but also China's major trading partner in Africa. Its trade volume amounted to 54 billion United States dollars (USD), representing 21% of China-Africa trade in 2021.

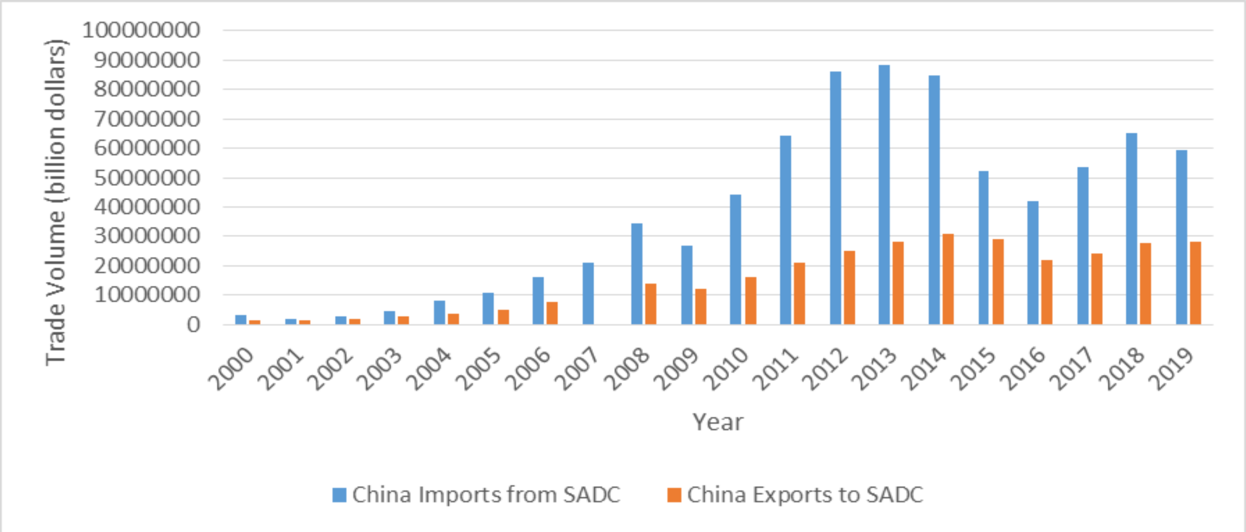
Recently, African markets have seen an influx of Chinese-made goods and services. According to the World Bank, trade between China and Africa has grown rapidly, leading to high growth rates in most African economies, mainly due to the export of natural resources. China's growing economy has increased its need for raw materials, particularly industrial metals and fuels. Most Southern African countries have vast endowments of these natural resources, which implies a considerable export potential for these natural resources. Statistics show that the main African exporters to China are South Africa, Angola, the Democratic Republic of the Congo and Zambia, with South Africa being the main exporter. China has turned itself into a global industrial hub for manufacturing low-cost goods, implying a considerable export potential. On the other hand, demand for Chinese products has surged across Africa. In 2021, Africa's significant importers from China were Nigeria, South Africa, Egypt, Ghana, and Kenya. Altogether, their imports comprised more than 50% of Chinese goods to Africa.

According to Mrdaković & Todorović, (2023), trade between China and natural resource-endowed countries in the SADC region comes with indirect impacts that challenge African countries that are more difficult to quantify for raw material market competition. For example, if Chinese demand for raw materials rises too steeply, it increases the prices on the world market. These may result in decreased terms of trade in countries such as Morocco or Ethiopia, which are net importers of raw materials. Furthermore, imports of Chinese manufactured goods can displace local workers and enterprises in the long run, and this area requires more empirical research. Chinese penetration of African markets could hinder the emergence of a nascent African manufacturing sector. Recent findings suggest that Chinese exports to Africa may be outstripping exports from the more industrialised economies of Africa, especially South Africa. Chinese investment capital is allocated to infrastructure and extraction of African raw materials. These are areas where Africa has a lot of undercapitalized assets.

Figure 1 below shows that the intensity of SADC exports to China has been rising enormously over the past 20 years compared to the region's imports from China. This implies that SADC has had a trade surplus against China over the same period. Due to the abundance of natural resources in the region and the demand of China, the country has recorded trade deficits with most SADC countries.

Figure 1

China-SADC trade summary (2000-2019)



Foreign Direct Investment (FDI) loans comprise an increasingly important component of China's economic relations with SADC countries (Gelpern *et al.*, 2021). This is another possible way for China to claim assets in African countries, often mentioned by critics who claim that the country has "neocolonial" ambitions and methods. This is among the reasons why Chinese lending to Africa has been debated and controversial. Some have suggested that Beijing is deliberately pursuing "debt trap diplomacy," imposing harsh terms on its government counterparties and writing contracts that allow it to seize strategic assets when debtor countries run into financial problems.

The Heckscher-Ohlin model states that a country that is abundant in a factor exports the good whose production is intensive in that factor (Krugman, 2012). According to recent statistics, Nigeria produced 86.9 million tons of crude oil instead of Angola, which produced

64.5 million tons. Angola exported $13.9 billion of crude oil to China, while Nigeria exported $1.02 billion to China[1] .[I]t is discrepancies such as these that this research paper seeks to investigate. Understanding the determinants of trade between China and SADC will help policymakers design and implement policies that will strengthen trade relations between the two parties.

Literature review

Although there have been various research papers on the determinants of trade between China and Africa using different data sources and empirical techniques, little research has been conducted on the determinants of trade between China and the SADC region. Research has been mainly done on the determinants of trade between China and individual African countries. Azu *et al.* (2016), conducted research on the economic determinants of trade between China and Nigeria. In this study, the gravity model was adopted using secondary data collected quarterly from 1992 to 2014. The Johansen and Julius technique was used in the research. The results showed that GDP, FDI, and trade openness positively influenced trade, while bilateral exchange rates negatively influenced trade.

Kanenga, (2017), conducted research on the determinants of trade between Zambia and 14 other countries, including China, using the gravity model in a space of 15 years (2000-2015). This research paper adopted the augmented and linearised basic GM of (J. Tinbergen, 1962) and also used by (Karamuriro & Karukuza, 2015), which they derived from the basic gravity equation of international trade. The linearized equation was extended to include other variables of interest, such as FDI and some dummy variables. The results showed that the GDP of Zambia, the population, FDI and the GDP per capita of China determined the trade between the two countries.

Igbinoba (2017), adopted the GM and used a generalized linear mixed approach on SADC panel data from 2001 to 2014 to determine what motivates China's trade decisions in Southern Africa. The results showed that China's trade decisions with SADC were based on factors such as GDP, population availability of mineral resources, and geographical location.
Akowuah *et al.* (2020), I performed a panel analysis on the determinants of China-Africa trade cooperation using the gravity model on 12 economic communities for member countries of West African States (ECOWAS) for the period between 2000 and 2017. The GM was extended to include more variables, such as the inflation rate and relative factor endowment. The coefficients were estimated using the generalized methods of moments. The results revealed that China's GDP and population have a positive impact on trade flows. The results also showed that the GDP of African nations does not have a significant impact on trade flows, whereas the population of African countries had a positive impact.

This paper adds to the extensive body of research on the determinants of trade using the gravity model and introduces a new variable, loan commitments from China to selected SADC countries instead of the total debt stock, as seen in previous studies. For instance, China has become SADC's major trading partner and the region's biggest creditor. The assertions may be that increasing debt has resulted in increased trade. Furthermore, FDI from China to SADC has also been on the rise, as has trade. In addition, it considers the effects of GDP, distance and availability of natural resources through a different lens than the papers above. Concerning Igbinoba (2017) what motivates China's trade decisions in Southern Africa, this article fills this lacuna by including other variables into the model, such as FDI, exchange rate as a measure of price competitiveness instead of inflation rate, and trade openness. This research paper

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[1].

investigates whether there is a correlation between China-SADC trade and these variables. It contains and resolves assertions surrounding what determines trade between China and SADC.

Methods

Research Design

This research deduced a quantitative analysis as it investigates the determinants of trade between China and selected SADC countries. Panel data was used in the study because it allows for different cross-sections to be used at different periods. The research adopted the trade volume as the dependent variable, taking GDP, availability of natural resources, Foreign Direct Investment, Trade openness, Distance, loan commitments, and REER as explanatory variables from data sources such as World Development Indicators (WDI) and World Bank's World integrated trade solutions (WITS).

Theoretical Framework

Developed by Isaac Newton, the gravity model was adopted to study bilateral international trade and improved by Tinbergen in 1962. This study innovatively used GM to incorporate other theories, such as comparative advantage, factor endowment, and new trade theories, to examine the determinants of trade cooperation between China and selected SADC countries. Various scholars have employed this model due to its many benefits, including its ability to allow empirical models to be easily augmented to consider different additional controls and policy variables, its ability to be easily derived from theoretical models, and its capacity to produce efficient estimates and parameters which can explain a huge proportion of the variation among others.

The original basic gravity model was given as:

$$F = G\frac{M1.M2}{R^2}$$

Where:
$F - force\ of\ attraction$, $G - Constant$, $M - Mass\ of\ object$ 1 $M2 - Mass\ of\ object$ two and $R - The\ distance\ between\ the\ objectives$.
The adopted trade gravity model is therefore given as follows:

$$Trade_{ij} = A\frac{GDP_i\ GDP_j}{Dist^2}$$

Where: $Trade_{ij}$ is the value of the bilateral trade between country i and country j, GDP_i and GDP_j are country i and country j's respectively. National income and distance measure the bilateral distance between the two countries, which is a constant of proportionality.

Model Specification

This study aimed to empirically examine the factors that determine trade using total trade flows between China and selected countries in the SADC region by employing the extended gravity model using Panel data. The basic gravity model was extended by incorporating other variables like availability of natural resources, real effective exchange rate, FDI, trade openness, and loan commitments. The function was thereby given as;

$$Trade = f\ (gdp_j, gdp_i, dist_{ij}, fdi_{ij}, openn_i, reer_{ij}, loanc_{it}, nat_i)$$

Say $i = sadc\ countries$ and $j = China$, $t = time\ annually$

Large variables such as FDI, GDP, distance, and bilateral trade volume were transformed to natural logarithmic form. In contrast, others, like real effective exchange rates, trade openness, and availability of natural resources, remained unadjusted since they are in ratios or percentages. The logarithmic transformation of variables helps to address the problem of endogeneity and to interpret the coefficients of the results in elasticity form. The extended gravity model was therefore given by the following functional form:

$$lnTrade_{ijt} = \beta_0 + \beta_1 lngdp_{it} + \beta_2 lngdp_{jt} + \beta_3 lndist_{ij} + \beta_4 lnfdi_{ijt} + \beta_5 lnloanc_{ijt} + openness_{it} + reer_{it} + nat_{it} + \varepsilon_t$$

Where:

gdp_{it}; $Gross\ domestic\ product\ for\ country\ i,$

gdp_{jt}: $Gross\ domestic\ product\ for\ country\ j$

$dist_{it}$: $Distance\ between\ country\ i\ and\ country\ j$

$reer_{it}$: $Exchange\ rate\ for\ country\ i$

$openn_{it}$: $Degree\ of\ trade\ openness\ for\ country\ i$

fdi_{ijt}: $Foreign\ direct\ invest\ inflows\ for\ country\ i\ from\ country\ j$

$loanc_{ijt}$: $loan\ commitments\ from\ country\ j\ to\ country\ i$

nat_i : $Availability\ of\ natural\ resources\ for\ country\ i$

ε_t : $is\ the\ error\ term$

Variable definition and measurement

To investigate the determinants of China-SADC trade, panel data analysis was employed using annual observations of variables. The SADC members selected for this research are made of 9 southern African countries which have formed a community and established strong trade cooperation with China and include countries that have been trading with China for many years. These countries include Zambia, South Africa, DRC, Angola, Lesotho, Mozambique, Namibia, Malawi and Tanzania. These are among the top importing and exporting countries in southern Africa. The period of the data used was 2000-2019.

Table 2

Measurement of variables and data sources

Variable	**Measurement**	**Source**
Trade volume GDP	Sum of exports to China and imports from China Size of the economy	World Integrated Solutions (WITS)

Trade Openness Availability of natural resources Population Exchange rate	The sum of exports and imports as a share of GDP Ores and metals and fuels as a share of total exports Market size The measure of price competitiveness	World bank's World development indicators (WDI)
Distance	Geographical distance	CEPII Distance database: www.cepii.fr/
FDI	Investment inflows	The global economy

Pre-estimation Tests

Pre-estimation tests are some of the necessary tests to which all variables of interest in the study are subjected. This is important as these tests help researchers detect and solve any mishaps in the variables to prevent running a spurious regression that produces biased, inconsistent and inefficient results.

Stationarity/Unit Root Test

Im-Pesaran-Shin Im, Pesaran, & Shin, (2003) developed a set of tests that relax the assumption of a common auto regressive parameter; moreover the IPS does not require a balanced data set, although there can be no gaps within a panel. The starting point for the IPS test is a set of dicky fuller regressions of the form.

$$\Delta y_{it} = \emptyset_i y_{i,t-1} + Z'_{it}\gamma_i + \epsilon_{it}$$

Where: $\emptyset$ is panel-specific, indexed by i. Im, Peseran, and Shin assume that ϵ_{it} is independently distributed normal for all i and t , and they allow ϵ_{it} to have heterogeneous variance σ_i^2 across panels (Gujarati, 2009). Spurious correlation could persist in non-stationary time series even if the sample is very large. Hence, stationarity in the variables was tested and there was transformation of all non-stationary variables into stationary variables.

Cointegration Test

Westerlund (2005) derived test statistics based on a model in which the AR parameter either is panel-specific or is the same over the panels. The panel-specific-AR test statistic tests the null hypothesis of no cointegration against the alternative hypothesis that some panels are cointegrated. The same-AR test statistic tests the null hypothesis of no cointegration against the alternative hypothesis that all the panels are cointegrated.

The panel-specific-AR test statistic is given by:

$$VR = \sum_{i=1}^{N} \sum_{T=1}^{T} \hat{E}_{it}^2 \hat{U}_i^{-1}$$

The same-AR test statistic is given by:

$$VR = \sum_{i=1}^{N} \sum_{T=1}^{T} \hat{E}_{it}^2 \sum_{i=1}^{N} \hat{U}_i$$

Where:

$$\hat{E}_{it} = \sum_{j=1}^{t} \hat{e}_{ij},$$

$$\hat{U}_{i} = \sum_{t=1}^{T} \hat{e}_{it}^{2},$$

and the $\hat{e}_{it}$ are the residuals from the panel-data regression model. Economic theory is often expressed in equilibrium terms therefore cointegration tests were done to test if the variables have a long term or equilibrium relation.

Pearson Correlation Test

Pearson correlation test was employed to test for correlation among independent variables. A value exceeding 0.8 reported in the correlation matrix results in high correlation among independent variables. The correlation results also help in detecting the likelihood of having multicollinearity among independent variables.

Post-estimation Tests

Post-estimation tests such as multicollinearity, heteroscedasticity and normality tests were done to detect if the data and variables in the model obey the classical linear regression assumptions. Additionally, in the case of this study, the Hausman post estimation test was utilized to see what type of regression best fits the data. The following tests were made in this research.

Estimation Technique

The extended trade gravity model was estimated using the Random effects (RE) and Fixed effects (FE) estimation approaches since the data set employed **T<25** and **N<25**. Where T is the number of time series units, and N is the number of cross-section units. RE and FE were selected over Pooled OLS estimation method because pooled OLS ignores time and individual dimensions. For example, how much South Africa borrows from China differs from how much Lesotho borrows from China. However, in the pooled OLS, the estimated debt coefficient would not precisely define how much debt affects Lesotho's trade and South Africa's trade with China individually.

Results

Descriptive Statistics

Descriptive statistics were done on raw data before any transformations and regressions to help the researchers know how normally distributed the data is and detect if there are any outliers in the data. The information obtained was the measure of central tendency (mean), measure of dispersion (standard deviation) and measures of normality (skewness and kurtosis).

Table 3

Descriptive statistics

Variable	Mean	Std. Dev	Kurtosis	Min	Max	Obs.
Trade	5933699.566	12370386.97	7.910722485	4895.67	65219201.5	180

Gdps	55298015354	1.02514E+11	5.66483002	775780697.7	4.582E+11	180
Gdpc	6.54592E+12	4.44433E+12	1.359256722	1.21135E+12	1.428E+13	180
Dist	11196.66633	777.2711083	0.444689578	9670.167	12372.95	180
Reer	105.8424444	29.65989964	21.80502921	50.64	340.5	180
Loanc	356958356.8	1527040528	126.2010151	0	1.9021E+10	180
Open	77.8064945	34.63582495	0.017556185	23.9808677	165.059397	180
Nat	11.70012495	10.97670749	3.198841594	0.6056333	55.8521703	180
Fdi	19244524878	38037691521	6.951909039	70531000	1.7956E+11	180

Table 3 describes detailed statistics of the raw data employed in this research. The mean of each variable represents the average value of the data, which is a statistical standard measure of the center of the distribution of the data. With respect to the variable trade, the center of the distribution of data with the lowest value being 4895.67 and highest value being 65219201.5 is 5933699.566.

Standard deviation measures how the data is dispersed in relation to the mean. The standard deviation for every variable was not high, signaling no outliers. The variable *loanc* had a relatively higher standard deviation due to the heterogeneity characteristic of panel data.

For measures of normality, Kurtosis of 3 represents a normal distribution. The variable *nat* had a kurtosis of 3.19, representing a Mesokurtic or normal distribution. The variable openness had a Kurtosis of 0.02 representing a Platykurtic or negative (flatted curve) distribution and the variable *loanc* Kurtosis of 126.2 representing Leptokurtic or positive (peaked curve) distribution. The variable *gdpc* was asymmetric around its mean, while the variable *reer* had a long right-tail due to high skewness. The Obs. Column (that is, observations column) indicates the number of observations (or cases) that were valid or not missing for each variable.

Pre-estimation Test Results

Pearson Test for Correlation Results

Correlation refers to the linear relationship between two variables. One important assumption of linear regression is that a linear relationship should exist between each predictor (regressor) x_i and the outcome (regressand) y_i. So, a strong relationship between these variables is considered a good thing. However, when a strong correlation exists between two predictors, we can no longer examine the effect of one while holding the other constant because the two variables change together, so their coefficients will become less exact and less interpretable. The Pearson test for correlation was conducted and the following results in table 4.4 below were produced.

Table 4

Correlation Results

```
. pwcorr lntrade reer nat lngdps lndist lnloanc lngdpc lnfdi openness
```

	lntrade	reer	nat	lngdps	lndist	lnloanc	lngdpc
lntrade	1.0000						
reer	0.0029	1.0000					
nat	0.3614	0.0094	1.0000				
lngdps	0.9046	0.1641	0.2072	1.0000			
lndist	0.0040	-0.2225	0.0844	-0.1394	1.0000		
lnloanc	0.4812	0.1672	0.3912	0.3701	0.0431	1.0000	
lngdpc	-0.1088	-0.0420	0.0645	-0.0538	0.0000	-0.0664	1.0000
lnfdi	-0.0716	-0.0403	0.0613	-0.0467	-0.0307	-0.0294	0.1861
openness	-0.0820	-0.1120	0.0179	-0.0665	-0.0395	-0.0286	0.1849

	lnfdi	openness
lnfdi	1.0000	
openness	0.0224	1.0000

Each numerical figure in table 4 above represents the correlation coefficient (r) between two variables. Table 5 below represents some general guidelines for assigning the strength of association between variables as provided by (Cohen, 1998).

Table 5

Correlation Key

Coefficient Value	Strength of association
0.1 < | r | < 0.3	small correlation
0.3 < | r | < 0.5	medium/moderate correlation
| r | > 0.5	large/strong correlation

The variables employed in the study were found to be uncorrelated as most coefficients between regressors had absolute values of less than 0.3 as observed in table 4. The absence of correlation means the coefficients produced in the regression analysis would be more exact and more interpretable. Hence, this model will pass the multicollinearity test.

Unit Root Tests Results

Table 6

Results for the IPS test

Variables	Root Status at level	Levels (p-value)	1st difference (p-value)	2nd difference (p-value)
Intrade	Stationary	0.0001		

Ingdps	Stationary	0.0141		
Ingdpc	Non-stationary	0.1288	0.4380	0.0000
Inloanc	Stationary	0.0000		
Infdi	Non-stationary	0.0910	0.0000	
REER	Stationary	0.0007		
Openness	Non-stationary	0.1267	0.0000	
Nat	Stationary	0.0203		

Table 6 above shows the results of the IPS test for unit roots conducted on original raw data to determine the Stationarity or to simply confirm the order of cointegration for each variable. The test has the following hypotheses.

$$H_0 : All\ panels\ contain\ unit\ roots$$

$$H_1 : Some\ panels\ are\ stationary$$

Trade, loan commitments, GDP for SADC, REER and availability of natural resources are stationary at levels, that is, they are integrated of order I (0), while trade openness and FDI are stationary at first difference, meaning they are integrated of order I (1). Further, China's GDP is stationary at second difference, which implies integration of order I (2). Thus, the results obtained from the IPS test suggest that the maximum order of integration is two.

Cointegration Test Results

Table 7

Westerlund Cointegration test results

	Statistic	**p-value**
Variance ratio	1.8707	0.0307

Following the tests for unit roots, the study employed the Westerlund test for cointegration. Table 7 above shows the obtained result.

It is quite possible that the two non-stationary series share the same common trend so that the regression of one on the other will not be necessarily spurious, Gujarati, (2009), thus the rationale for the cointegration test is to determine whether the non-stationary time series have a stable long-run relationship. Nonstationary time series tend to wander, however, cointegration says that they wander together, meaning there is a long run equilibrium relationship among the series. The Westerlund cointegration test has the following hypotheses:

$$H_0 : No\ cointegration$$

$$H_1 : Some\ panels\ are\ cointegrated$$

As per decision rule, we reject the null hypothesis that there is no cointegration since the P-value of the variance ratio is less than 0.05, that is ***(P = 0.0307 < 0.05).*** This means our series are cointegrated or simply put; they have a long-run relationship and hence our regression will not necessarily be spurious or nonsensical.

Pooled OLS Estimation Results

The extended gravity model was estimated using the pooled OLS regression, and the results are given as follows.

Table 8
Pooled OLS results

No. of observations	162	R-squared	0.9028
No. of Panels (countries)	9	Prob > F	0.0000
No. of Obs/Panel	18		
Variable	**Coefficient**	**P value**	
Lngdps	1.299483	0.000	
Lngdpc	-1.982676	0.038	
Lndist	3.009653	0.000	
Lnfdi	-.3178664	0.129	
Lnloanc	.0254126	0.000	
Nat	.024814	0.000	
Openness	-.0018375	0.745	
REER	-.0042376	0.150	
Con. Coef.	-45.0813	0.000	

As postulated in the gravity model, GDP and distance are significant factors in determining China’s trade with selected SADC countries. The pooled OLS estimation technique results were consistent with the gravity model as both GDP and distance were significant at 1% 5% and 10% significance levels. GDP for selected SADC countries had a positive impact on China-SADC trade, while China's GDP had a negative impact, implying that as China's GDP increased, *Ceteris Paribas*, the volume of China-SADC trade declined.

Pooled OLS as an estimation technique ignores time and individual dimensions. For example, how much South Africa has in terms of loan commitments to China is different from how much Lesotho has; however, in the pooled OLS, the estimated coefficient of the loan commitments variable will not precisely define how much loan commitments affect Lesotho's trade and South Africa's trade with China individually. For this reason, Pooled OLS could not be entirely relied on to estimate the model, hence FE and RE estimation techniques were employed in the study due to their ability to handle the problems presented by the former technique. However, the Pooled OLS model was used to perform diagnostic tests per procedural requirement.

Post-estimation Test Results

Performing a panel data regression analysis requires additional diagnostic tests to detect potential problems with residuals and model specification. To rely on the estimated coefficients and consider them accurate representations of the true parameters, it is of utmost importance that the assumptions of linear regressions formulated in the Gauss-Markov theorem are met. Most of the assumptions relate to the characteristics of the regression residuals. The latter should be independent, without serial correlation, and homoscedastic. The latter means residuals should have equal variance.

For these reasons, the necessary diagnostic tests such as the Breusch-Pagan and Cook-Weisberg test for heteroscedasticity is shown in Table 9, the VIF test for multicollinearity is shown in Table 10 and the Skewness Kurtosis test for the normality of the residuals is shown in Table 11.

Heteroscedasticity Test Results

Since linear regression assumes homoscedasticity, a heteroscedastic model violates this assumption. A test for heteroscedasticity is essential if we are to make sure our inferences are not baseless. The Breusch-Pagan and Cook-Weisberg tests for heteroscedasticity were employed. The test works off the null hypothesis that variance is homoscedastic, this means that the variance for each observation is around the same finite value (i.e., variance is uniform). If a linear regression contains heteroscedasticity, we are saying that rather than a uniform variance, the variance is influenced by one or more variables. The following results were obtained for the test.

Table 9

Breusch-Pegan / Cook – Weisberg heteroscedasticity test results

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lntrade

         chi2(1)      =     0.76
         Prob > chi2  =   0.3844
```

The test generated a p-value of 0.3844, which is greater than the significance value of 0.05, indicating a statistically insignificant Chi-square test. The result indicates the absence of heteroscedasticity in the dependent variables.

VIF Test for Multicollinearity Results

One of the key goals in regression analysis is to isolate the relationship between each independent variable and the dependent variable. The idea is that you can alter the value of one dependent variable and not the others.

Table 10

VIF Test for Multicollinearity Results

Variable	VIF	1/VIF
Lnloanc	1.41	0.707968
Nat	1.30	0.769595
Ingdps	1.22	0.822219
REER	1.18	0.848305
Lngdpc	1.08	0.921944

Lndist	1.07	0.933017
Openness	1.06	0.942098
Lnfdi	1.04	0.958544
Mean VIF	1.17	

However, when independent variables are correlated, it indicates that changes in one variable are associated with shifts in another variable. In the presence of multicollinearity, it becomes challenging for the model to estimate the relationship between each dependent variable and the independent variable independently as variables tend to move in unison. Furthermore, multicollinearity reduces the precision of the estimated coefficients, which weakens the statistical power of the regression model. The generated p-values cannot be trusted to identify the independent variables that are statistically significant.

Table 10 gives the result of the VIF, which was conducted to test for multicollinearity among the independent variables. A VIF equal to 1 indicates that variables are not correlated. As observed from the table, the VIF for each variable is equal to 1 when rounded off to the nearest whole number, hence we conclude that our model is free from multicollinearity among independent variables, implying that they do not move in unison.

Skewness/Kurtosis Test for Normality Results

One of the basic assumptions of the classical normal linear regression is that each residual is normally distributed with a mean equal to zero and constant variance (Gujarati, 2009). If the residuals are not normal, it indicates that the model is inadequate, meaning the error terms in the model are not consistent across variables and observations, that is, they are not random. Table 11 below shows the results obtained after performing the skewness kurtosis test.

Table 11

SK Test for Normality Results

Variable	Obs	Pr (skewness)	Pr (Kurtosis)	Adj Chi2(2)	Prob>Chi2
Residuals	162	0.0002	0.1218	13.47	0.0012

The test results in the table above show the number of observations (which is 162), the probabilities of skewness, and kurtosis, which are 0.0002 and 0.1218, respectively. The null and alternative hypotheses for the test are given as follows.

$$H_0 : the\ data\ follows\ a\ normal\ distribution$$
$$H_1 : the\ data\ does\ not\ follow\ a\ normal\ distribution$$

The probability of skewness implies that skewness is not asymptomatically normally distributed (p-value of skewness < 0.05), however, Pr (Kurtosis) indicates that Kurtosis is asymptomatically normally distributed (p-value of kurtosis > 0.05). Finally, Chi (2) is 0.0012, which is less than 0.05, implying its insignificance at a 5% level. The result of the latter and that of the skewness requires that we reject the null hypothesis, however on the basis of kurtosis results, the null hypothesis that the data follows a normal distribution is accepted.

Hausman Test Results

Test $H_0: Difference\ in\ coefficients\ not\ systematic$

Table 12: Hausman test results

chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)	66.77
Prob>chi2	0.0000

The p-Value of 0.0000 which is less than the 0.05 deems the fixed effect as an appropriate model to adopt. In other words, the null hypothesis is rejected.

FE, RE Regression Results

After diagnostic tests, the extended gravity equation was run using the Fixed-effects model to examine the determinants of the SADC-China bilateral relations. With this method, the time-invariant variable (distance) was omitted. The data was further run using the Random-effects model to capture the effect of distance, an integral variable in the gravity model. Table 13 below presents the regression results of both FE and RE regression.

Table 13

Regression results for the determinants of SADC-China Trade

	Fixed effects (1)		**Random Effects (2)**	
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Lngdps	1.392642	0.000	1.299483	0.000
Lngdpc	-17.20003	0.000	-1.982676	0.036
Lndist	0	-	3.009653	0.000
Lnfdi	-0.0964435	0.432	-0.3178664	0.127
Lnloanc	0.0110983	0.010	0.0254126	0.000
Nat	0.0200448	0.011	0.0024814	0.000
Openness	0.0006268	0.855	-0.0018375	0.745
REER	-0.0098927	0.001	-0.0042376	0.148
Con. Coef.	-19.57005	0.000	-45.0813	0.000
No of Obs	162		162	
R-squared: within	0.9137		0.8012	
Between	0.9513		0.9771	
Overall	0.9391		0.9028	
Prob > F, Prob > Chi (2)	0.0000		0.0000	

The R-Squared of 0.9137 implies that 91.37% of the Variations in the percentages of Trade across all cross sections is explained or caused by the independent variables. The Prob > F = 0.0000 signifies that the data fits the model perfectly.

Discussion

Concerning Table 10 columns (1) and (2) above, it is observed that what determines the SADC-China trade relations is SADC's GDP, such that when all other factors are held constant, a percentage increase in SADC's GDP will lead to a 1.39 percent increase in the trade volume. The result is consistent with gravity equation theory. With a positive coefficient, and a p-value of 0.000, the variable is statistically significant at 5% level of significance. This suggests that SADC's GDP is a key determinant of the region's capacity to export to and import from China. A higher GDP entails a higher production capacity and rise in consumption which translates into increased exports and imports. The finding is in sync with many other studies that used the gravity model, for example Akowuah *et al*. (2020) and Azu *et al.* (2016) both found GDP to be a significant determinant of trade.

However, contrary to the economic theory of the gravity model, though significant, China's GDP was found to be negative, the implication being that for every percentage increase in China's GDP, the trade volume would decrease by 17.20 percent. This hypothetically signifies that as China amasses enough wealth from SADC in the form of raw materials, the nation becomes self-reliant and can produce enough goods for its local demand without relying on trade. Furthermore, since China's major interest in trade with SADC is importation of raw materials, which are a diminishing resource, as natural resources reduce, so does the trade relation.

SADC's loan commitments to China, which were used as a proxy for debt, weres found to be statistically significant with a coefficient of 0.0110983, implying that as SADC's indebtedness to China increases by 1 percent, trade would increase by about 0.01 percent. Although no economic theory relates foreign trade to debt, some recent developments indicate that China could be directly linking SADC indebtedness to the extraction of natural resources which will conspicuously be presented as trade in the form of exports.

It is not surprising that availability of natural resources in SADC was found to be a very significant determinant of the trade relationship under discussion. With a coefficient of 0.020048, *nat* was found to be significant at 95% level of significance with a p-value of 0.011. The implication is that for every unit increase in the availability of natural resources in SADC, trade would increase by about 2 percent. Pollar (2016) found results similar to the ones in this research. In the paper, it was found that China, which was poor in natural resources, boasted a rapidly growing labor force which gave the country comparative advantage in manufacturing. By contrast, Africa was relatively resource-rich, with a labor force significantly smaller than China's. Thus, it was logical for China to import natural resources from Africa, hence the positive relationship between trade and availability of natural resources.

Another important determinant of trade between SADC and China was found to be REER. The variable was significant with a p-value of 0.001 and a negative coefficient of 0.0098927, implying that a unit increase in REER will result in a 0.9 percent increase in trade volume and vice versa. This coincides with some empirical accuracy because imports are negatively inclined in relation to real effective exchange rate implying that at a lower REER, prices of foreign assets are relatively cheaper, therefore imports will be high. Conversely, at higher REER, imports will be low due to the high prices of foreign assets induced by high exchange rates (Salvatore, 2013)

According to the gravity model distance has a substantial negative effect on trade, which is an increase in physical distance will translate into a collapse in trade between two trading countries. This is contrary to the random effect coefficient of *dist* which depicts a positive relation despite it being a significant in the model. On the other hand, the fixed effect regression omitted *dist* because of its time-invariant properties.

In summary, the linear extended gravity equation by regression and interpretation with significant determinant variables is given by.

$$\widehat{lntrade} = -19.57005 + 1.392642lngdps - 17.20003lngdpc + 0.0110983lnloanc + 0.0200448nat - 0.0098927reer$$

Conclusion

The gravity model's approach to allow other variables with a long run relationship with total trade to be deliberated into the model permitted this research to examine the determinants of trade apart from GDP and distance. Macroeconomic indicators such as exchange rate and natural resource endowment that are very cardinal in international trade were fused into the model to form an extended gravity model. The extended gravity model used in this analysis yielded results that indicate that economic growth is positively related to trade and that a larger economy trades more than minor economies.

Loans from China have significance on the trade between China and selected SADC countries. This significance of loans from China coincides with recent developments of certain SADC countries that link debt repayment with extraction of natural resources like oil and minerals. Natural resources which are traditional exports for most SADC countries are conspicuously presented as trade in the form of exports. That is why natural resources have direct relation with trade. REER showed a negative inclination with trade, since appreciation of a currency translates into local products becoming more expensive than foreign products and vice versa.

Limitations

Macroeconomic indicators like inflation, trade policy rate, GDP per capita and population that may have a long run equilibrium relationship with international trade are impending essential variables to incorporate in the extended gravity model. This is due to the fact that they have not been previously studied with China and the SADC member countries. This will allow policymakers to be cognizant of the measured impact of macroeconomic indicators on international trade and formulate policies. This will support the improvement of international trade and eventually economic growth as trade is a major economic driver of economic growth. More countries from SADC, preferably all, should be included in future studies with respect to trade with China because China is the major trading partner with SADC.

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