The Effects of Currency Devaluation on the Bilateral Trade Balance of Sudan: Cointegration and Error-Correction Modeling

Abstract

The purpose of this research paper is to investigate the effects of exchange rate, income and money supply on the trade balance of Sudan over a fifty-year period from 1970 to 2020. The empirical model for this investigation is developed using a cointegration approach and error-correction technique to specifically examine the effects of currency devaluation on the trade balance of Sudan with its major partners. The bounds test shows that the variables of interest are bound together in the long-run. The associated equilibrium correction is significant, thus confirming the existence of a long-run relationship. Moreover, to analyze the dynamic interactions of the variables included in the estimated model, variance decomposition is employed. The study results from the variance decomposition show that innovations in foreign income contribute highly to the forecast error variance of the trade balance compared with other explanatory variables in the short-run. In contrast, the domestic money supply contributes highly to the trade balance compared with other variables in the long-run. A key finding of the study suggests that the devaluation of Sudan's currency is not an appropriate step toward improving the country's trade balance position.

Keywords: ARDL, currency devaluation, error-correction model, exchange rate, trade balance, Sudan.

JEL Code: C23, F10, F31

1. INTRODUCTION

"Currency devaluation is a stabilization policy measure that some countries employ to improve the competitive advantage situation of their economy by reducing imports and encouraging exports of goods and services with the aim to positively impact the balance of payments and restore economic growth" (Chinedum and Kenneth, 2016; Nguyen and Dang, 2022; Filardo et al., 2022). "Currency devaluation is a highly controversial issue in many countries. A major policy option for a country facing a persistent balance of payments deficit is the devaluation of its currency. Within international trade, it is not uncommon to find arguments about whether devaluation will improve the trade balance or the balance of payments. Each theoretical approach has its own set of arguments. For example, proponents of the elasticity approach describe the necessary and sufficient conditions for improving the trade balance in terms of the elasticities of demand and supply, referred to as the Marshall-Lerner condition. If the demand elasticities are sufficiently large and the supply elasticities sufficiently small, devaluation should improve the trade balance" (Robinson, 1947; Metzler, 1948; Dongfack and Ouyang, 2019). "Proponents of the absorption approach describe how devaluation may change the terms of trade, increase production, shift expenditures from foreign to domestic goods, or have some other effect on reducing domestic absorption relative to production, thus improving the trade balance" (Alexander, 1952; Johnson, 1971; Appleyard and Field, 2014). "International monetarists argue that devaluation reduces the real value of cash balances and/or changes the relative price of traded and nontraded goods, thus improving both the trade balance and the balance of payments" (Miles, 1979; Bahmani-Oskooee, 1985).

"Opponents have viewed devaluation as stagflationary, causing a decrease in real output and an increase in the rate of inflation in the domestic economy. This view caused policymakers in many countries to avoid devaluation wherever possible. Proponents of devaluation have argued that it is an important policy tool that assists in stimulating the balance of payments by affecting relative and absolute prices and real and nominal variables. Convinced by such arguments, some countries, mostly in Latin America and Asia, have been actively pursuing the exchange rate devaluation policy in an effort to maintain a balance of payments equilibrium. Pursuing these policies has contributed to the International Monetary Fund's (IMF) view that devaluation is a useful policy in resolving the problem of balance of payments" (Nicholas, 1983; Karim, 1983; Asheghian, 1988).

During the 1980s, Sudan suffered from an unprecedented economic crisis. This was characterized by a heavy debt burden associated with negative macroeconomic indicator indices. The drastic fall of the macroeconomic indicators, along with structural disequilibrium in the balance of payments, pushed the country to devalue the Sudanese pound in 1978. The main objective of the devaluation was to restore the competitive advantage of the Sudanese economy through the amelioration of the trade balance position. In this study, our main question is whether or not the devaluation of the pound enabled the country to reach this objective. In other words, did the episodes of Sudanese pound devaluation contribute to restoring the imbalances in Sudan's balance of trade? To answer this question effectively, we carried out the study from 1970 to 2020.

The main objective of this article is to determine which of the three policy instruments—fiscal policy, monetary policy, and exchange rate—has a long-run relationship with the trade balance in Sudan. The rest of the paper is organized as follows: Section 2 reviews the literature in the field. Section 3 describes the model, data, and econometric methodology. Section 4 discusses the empirical results. Finally, Section 5 concludes with findings and policy recommendations.

2. LITERATURE REVIEW

In this section, we can divide the literature review into two parts. First is the theoretical foundation, and the second part is the empirical studies as follows:

2.1 Theoretical Foundation

"There are three different approaches to a country's balance of payments. The first is the elasticity approach, which identifies the exchange rate as a major determinant of the trade balance and adheres to devaluation as a policy to cope with the trade deficit. The second is the Keynesian income approach, which identifies the level of economic activity, measured by domestic income, as a major determinant of trade balance, and recommends any income-reducing policy (contractionary fiscal policy), to reduce a country's trade deficit. The third and last approach is the monetary approach, which argues that any balance of payments deficit is due to an excess supply of money. Thus, after identifying money as a major determinant, the monetary approach favors the use of monetary policy to cope with the disequilibrium in the balance of payments" (Mundell, 1971; Frenkel and Rodriguez, 1975). "In emphasizing the use of monetary policy, monetarists take some additional steps and criticize the two other approaches. They argue that the Keynesian balance-of-payments adjustment models focus on the short-run. These models, such as the IS-LM-BP model (investment-savings, liquidity preference-money supply, and balance of payment), fail to recognize that in the long-run, the cause and cure of any disequilibrium in the balance of payments lie in the application of monetary policy. They hold that fiscal policy and exchange rate changes do not cause and cannot be used to change the position of the balance of payments" (Bahmani-Oskooee, 1992; Dongfack and Ouyang, 2019). "Alexander's absorption model supposes that the current account balance of a nation is determined by the difference between real revenue and absorption. He went on further by stating that devaluation affects two things: firstly, gross domestic product (GDP), and secondly, expenditure through the revenue effect" (Alexander, 1952; Appleyard and Field, 2014).

"The elasticity approach is mainly criticized for being a partial equilibrium approach, which does not account for the macroeconomic effects of price changes and production fluctuations in response to currency devaluation. It only accounts for value and volume responses to price changes. On the other hand, in the case of the absorption and monetary approaches, depreciation is related to macroeconomic variables that usually undermine the favorable impact of exchange rate devaluation on the trade balance. The absorption approach merges the elasticity approach with Keynesian macroeconomics. The monetary approach suggests that devaluation should be understood in a monetary context. Thus, a balance of payments deficit is purely a monetary phenomenon primarily caused by excessive money supply. Currency devaluation has an impact on the balance of payments only through its effect on the real money supply. Therefore, devaluation increases the balance of payment by increasing domestic prices and thereby reducing the real money supply" (Ali et al., 2014).

"Theoretically, numerous studies have attempted to identify the determinants of trade balance by incorporating various elasticities, Keynesian, and monetary approaches". The empirical studies in this area include the works by Dornbusch (1975), Johnson (1972), Frenkel et al. (1980), Bahmani-Oskooee (1985, 1992), Murli et al. (1996), Nachane and Prasad (1998), Upadhyaya et al. (1999), and Ali et al. (2014).

In conclusion, the absorption approach to the balance of trade emphasizes that an increase in domestic income relative to the income of the rest of the world (trading partners) would lower the trade balance due to increased demand for imports. On the other hand, the monetary approach identifies a relative decline in domestic money supply, which creates excess demand for money and a desire to hoard cash as a way to lower the trade deficit. Lastly, the elasticity approach emphasizes the exchange rate as a major determinant of trade balance and recommends devaluation to eliminate trade balance.

2.2 Empirical Review

"There exist several empirical studies on the effects of exchange rates on the balance of trade, with varied results. There is a substantial evidence that the depreciation of currency decreases the deficit in the balance of trade" (Mahmoud, 2022).

Amaliawiati et al. (2022) examined "the effect of the exchange rate on Indonesia's trade balance during both the managed and floating exchange rate systems. They found that the exchange rate affects the trade balance in a flexible system, while in a managed floating system, it has no effect in the short-term. Meanwhile, the exchange rate affects the trade balance in a flexible system, while in a managed floating system, it has no long-run effect".

Keho (2021) examined "the determinants of the trade balance in the West African and Monetary Union (WAEMU) during 1975–2017. The results revealed that the trade balance is negatively related to domestic and foreign income, whereas real effective exchange rate depreciation improves the trade balance in the long-run. Conversely, the results do not confirm the short-run deterioration of the trade balance. Foreign real income is the only factor that affects the trade balance in the short-run; domestic income and the real exchange rate are not".

Eshetu and Eshetu (2021) investigated "the effect on the trade balance of Ethiopia. Their results revealed that devaluation improves the trade balance in both the short and long term. Conversely, there is no evidence of the J-curve phenomenon. Both home and foreign income were positively and significantly related to the improvement in the trade balance. In contrast, the money supply and government expenditure were negatively and significantly related to the improvement in the trade balance".

Iqbal et al. (2021) investigated "the J-curve at the bilateral level between Pakistan and its eight major trading partners. They found significant evidence that the non-linear ARDL model performs better than the linear ARDL. In the case of linear ARDL, there is no evidence of the J-curve at the bilateral level. However, when we used non-linear ARDL, the J-curve was supported in the cases of Malaysia, China, and the United States".

Bao and Le (2021) examined "the asymmetric impacts of bilateral as well as vehicle currency exchange rates on Vietnam's trade balance with EU-27 countries and the UK in the period 2000–2018. Their results indicate strong support for the vital role of the USD as a vehicle currency".

Befikadu (2021) examined "the determinants of the trade balance in Ethiopia for the period 1990–2020. The findings indicate that foreign exchange availability has long-run negative effects and short-run positive effects on the trade balance. While lag trade balance has a positive relationship with trade balance over the short-term, the real exchange effective rate has a negative relationship with trade balance over the long and short-term".

Ceyhan and Gürsoy (2021) examined "the validity of the J-curve hypothesis in Turkey for the period 1996-2019. The findings show that the J-curve hypothesis is not confirmed in Turkey".

Kamugisha and Assoua (2020) examined "the effects of a devaluation on the trade balance in Uganda. They found that incomes significantly affect trade balances in the long and short-run; however, real exchange rates only affect trade balances in the short-run".

Bahmani-Oskooee and Arize (2020) investigated "the effect of exchange rate changes on the trade balance of 13 African nations. Among the countries in their sample, they found significant short-run asymmetric effects in ten countries and short-run adjustment asymmetry in eight countries. Additionally, they found that short-run asymmetric effects were translated into long-run effects, supporting the new concept of the J-curve phenomenon in six countries".

Ibrahim and Bashir (2020) investigated "the effect of changes in the real exchange rate on the trade balance in Sudan for the period 1978-2017. They found that exchange rate devaluations do not affect the trade balance, hence the J-curve hypothesis is not valid".

Ambe (2019) examined "the determinants of the trade balance in Ethiopia. The findings show a long-run negative relationship with the trade balance, while the lag trade balance and real exchange rate showed a long-run positive relationship with the trade balance. Some variables, such as GDP, trade liberalization, and exchange rate, are insignificant".

Taşseven et al. (2019) analyzed "the determinants of the trade balance in Turkey from 1998–2018. They found that in the long-run, the GDP of Turkey and European Union countries affects the trade balance in a positive and significant way. In contrast, the appreciation of real exchange rate and oil prices reduces the trade balance in a significant way. The researchers discovered that a rise in oil prices and a rise in the real exchange rate significantly lowered the trade imbalance of Turkey. Specifically. They indicated that the appreciation of the real exchange rate and oil prices has a significantly negative impact on the trade balance".

Akoto and Sakyi (2019) examined "the case of Ghana. Their results indicated that the depreciation of the exchange rate did not improve the trade balance of Ghana. It also showed that household consumption expenditure, government consumption expenditure, and domestic prices are negatively and significantly related to the trade balance in both the long and short-runs. Conversely, foreign income and money supply have a positive and significant relationship with the trade balance in the short-run".

Dongfack and Ouyang (2019) found that "the real exchange rate depreciation improves the trade balance in the long-run in Cameroon".

Nusair (2017) reveals "the J-curve phenomenon for 16 European transition economies. The analysis of this study estimates the linear and nonlinear ARDL model using quarterly data from 1994 to 2015. The analysis shows that when the linear ARDL model is used, they do not find evidence for the J-curve phenomenon. Besides, when the nonlinear ARDL model is used, they find support for the J-curve phenomenon in 13 countries".

Arize et al. (2017) and Bahmani-Oskooee and Kanitpon (2017) also extended "the same analysis to include Asian countries".

On the empirical ground regarding Sudan, the authors did not come across studies on Sudan that used the three approaches mentioned above to a country's balance of payments and the ARDL and ECM models. This provides an additional justification for undertaking the current study. The overall objective of the current study is to investigate the long-run relationship between Sudan's trade balance and selected macroeconomic variables such as exchange rate, money supply, and domestic and foreign national income.

3. METHODOLOGY

3.1 Model Specification

Following Miles (1979), Himarios (1985, 1989), Bahmani-Oskooee and Pourheydarian (1991), Murli et al. (1996), Upadhyaya et al. (1999), and Yang and Yang (2021), this study uses a linear regression model incorporating all the variables. We specify the trade balance as a function of some macroeconomic variables as follows:

$$TB_t = \beta_0 + \beta_1 DY_t + \beta_2 FY_t + \beta_3 DM2_t + \beta_4 FM2_t + \beta_5 ER_t + \mu_t \quad (1)$$

where:

TB = trade balance

DY = domestic national income (real GDP)

FY = foreign national income (major trading partners' GDP)

DM2 = domestic money supply

FM2 = foreign money supply

ER = real exchange rate

μ= an error term

3.2 Data Sources

All data are annual and measured in US dollars, covering the period between 1970 and 2020. They are taken from both national and international sources. The data are derived from national statistical yearbooks and the Central Bank of Sudan (CBS). The primary international source of data was the IMF's direction of trade statistics (DTS) and international financial statistics (IFS). Sudan's four main trading partners are China, the eurozone, Japan, and Saudi Arabia.

3.3 Method of Estimation

In this paper, we adopt the vector autoregression (VAR) approach to time series analysis to investigate the effects of three policy tools, including fiscal policy, monetary policy, and exchange rate effects, on Sudan's trade balance. This analysis involves cointegration analysis, an error correction model, impulse response functions, and variance decomposition. The VAR is useful in forecasting systems of interrelated time series and analyzing the dynamic impact of random disturbances on the system of variables (Ibrahim & Bashir, 2020).

3.4 Testing for Unit Root

Before testing for a causal relationship between the time series, we check the stationarity of the variables used as regressors in the models to be estimated by employing the Augmented Dickey-Fuller (ADF) test. It has become standard practice to begin the analysis by examining the time series properties of the data. We utilize two asymptotically equivalent procedures for detecting unit roots in the data: the ADF and the Phillip and Perron (PP) tests, which are widely used for testing stationarity in macroeconomic data (Ibrahim & Bashir, 2019).

3.5 Cointegration Process

Cointegration analysis is used to examine the long-run relationship between trade balance (TB) and some macroeconomic variables: domestic national income (DY), foreign national income (FY), domestic money supply (DM2), foreign money supply (FM2), and the real exchange rate (ER). The basic idea of cointegration is that two or more variables may be regarded as defining a long-run equilibrium relationship if they move close together in the long-run, even though they may drift apart in the short-run. This long-run relationship is referred to as a cointegrating vector.

When the variables are stationary, they move together in the long-run. The existence of cointegration thus suggests a long-run equilibrium among the series. An approach to testing for cointegration is to construct test statistics from the residuals of cointegrating regression. The short-run dynamics and movement toward equilibrium can be captured using a vector error-correction model (VECM), in which the long-run equilibrium relationship is entered into a short-run model. If the unit root analyses suggest that all the variables are I(1) and the residuals in the model are stationary, we can conclude that the series are cointegrated in order I(1). The advantage of cointegration and error correction techniques is that they provide more efficient short-run and long-run coefficient estimates and avoid the problems of spurious regression (Bashir & Ibrahim, 2020). The ARDL bounds testing procedure is sensitive to the selection of the lag structure. The determination of optimal lag can be used to set the value of lag based on the Akaike information criteria (AIC) and Schwarz information criteria (SIC) tests, which result in a minimum value.

3.6 ARDL Model Specification

Pesaran et al. (2001) developed a bounds testing (or the ARDL cointegration) procedure to empirically analyze the long-run relationships and dynamic interactions among the variables of interest. This method was used to estimate the model. This approach involves two stages. The first stage involves testing the existence of a long-run equilibrium relationship between observed variables, i.e., cointegration among variables such as trade balance (TB), domestic national income (DY), foreign national income (FY), domestic money supply (DM2), foreign money supply (FM2), and exchange rate (ER), if the coefficients θ_1, $\theta_2, \theta_3, \theta_4, \theta_5$ *and* θ_6 are different from zero. The second stage involves defining the error-correction term, particularly the cointegration vector (Ibrahim & Bashir, 2020).

3.7 Error Correction Model (ECM)

Since tests involving differenced variables can be misspecified and some important information can be lost if the variables are cointegrated, the error correction term (ECT), which is derived from long-run relationships using the ARDL procedure, is included as an independent variable. Since all the variables are stationary in the system, the short-run adjustment mechanism can be modeled as an ECM. This ECT, lagged by one year, is used in the ECM, together with the current and past differenced fundamentals and other variables that affect the trade balance and its determinants in the short-run.

This procedure of differencing results in the loss of valuable " long-run information" in the data. The theory of cointegration addresses this issue by introducing an ECT. The ECT lagged for one period (i.e. EC_{t-1}) integrates short-run dynamics into the long-run of determinants' trade balance. This leads us to the specification of a general ECM:

$$\Delta TB_t = \alpha_0 + \sum_{i=1}^{n} \alpha_1 \Delta DY_{t-1} + \sum_{i=1}^{n} \alpha_2 \Delta FY_{t-1} + \sum_{i=1}^{n} \alpha_3 \Delta DM2_{t-1} + \sum_{i=1}^{n} \alpha_4 \Delta FM2_{t-1} + \sum_{i=1}^{n} \alpha_5 \Delta ER_{t-1} + \emptyset_1 EC_{t-1} + \mu_t$$

(2)

where EC_{t-1} is an ECT lagged by one period.

An ECM is estimated after Granger causality and cointegration testing to determine the determinants of the trade balance. In other words, to test the determinants of trade balance, we must incorporate short-run dynamics into the long-run model, as in the error-correction modeling below (Pesaran et al., 2001). Since the observations are annual, we choose 2 lags as the maximum order of the lags in the ARDL model and carry out the estimation from 1970–2020.

The error-correction version of the ARDL (2,2,2,2,2) model pertaining to the variables in (1) is defined as follows:

$$\Delta \ln TB_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta TB_{t-i} + \sum_{i=1}^{n} \beta_2 \Delta \ln DY_{t-i} + \sum_{i=1}^{n} \beta_3 \Delta \ln FY_{t-i} + \sum_{i=1}^{n} \beta_4 \Delta \ln DM2_{t-i} + \sum_{i=1}^{n} \beta_5 \Delta \ln FM2_{t-i} + \sum_{i=1}^{n} \beta_6 \Delta \ln ER_{t-i} + \delta_1 \ln TB_{t-1} + \delta_2 \ln DY_{t-1} + \delta_3 \ln FY_{t-1} + \delta_4 \ln DM2_{t-1} + \delta_5 \ln FM2_{t-1} + \delta_6 \ln ER_{t-1} + \mu_t$$

(3)

If $(\delta_1 - \delta_6)$ are jointly significant, the variables are said to be cointegrated.

The short-run effects of the determinants of trade balance are inferred by the estimates of δ_i'.

3.8 Impulse Response Functions (IRFs) and Variance Decomposition within a VAR Framework

To investigate the determinants of trade balance, we will use two different econometric frameworks, both of which are based on the VAR framework, as follows:

3.8.1 Impulse Response Function (IRF): A shock to the *i*-th variable not only directly affects the *i*-th variable but is also transmitted to all other endogenous variables because of the dynamic (lag) structure of the VAR. An IRF traces the effect of a one-time shock to one of the innovations on the current and future values of the endogenous variables. The IRF provides the dynamic responses of the dependent variable to innovations in other variables included in the system. It is a process that traces the effect of a shock (or change in residuals, $\varepsilon_1, \varepsilon_2 \ldots$) to each endogenous variable in the system (Bashir & Ibrahim, 2022).

3.8.2 Variance Decompositions (VDCs): To provide further insight into the dynamic relationships among the variables in the system, the forecast error variance decomposition is calculated. Variance decomposition shows the proportion of the forecast error of each endogenous variable that is accounted for by each of the other variables. The forecast error variance decomposition technique is employed to account for the error variance in each of the variables in the VAR system, to innovations in its own variables as well as those of other variables in the system.

4. EMPIRICAL RESULTS

4.1 Unit Root Tests

The unit root tests are performed to determine the stationarity of the series, as non-stationary series can lead to "spurious regression" results. The results of the ADF test on the levels and first differences of the variables are presented in Table 1. The lag length was selected using AIC. Table 2 reports the results of the PP tests for unit root on both levels and the first differences of the variables.

Table 1: Unit root test: Augmented Dickey-Fuller (ADF) test

Variable Series	Level (Test Statistic)			First Difference (Test Statistic)		
	Intercept	Trend & Intercept	Lag	Intercept	Trend & Intercept	Integrated Order
TB	-2.89 (-2.92))	-2.91 (-3.50)	2	-1.11 (-2.92)	-1.01 (-3.50)	I(1)
InFY	-0.59 (-2.92)	-1.93 (-3.50)	2	-1.97 (-2.92)	-1.98 (-3.50)	I(1)
LnFM2	-0.71 (-2.92)	-2.14 (-3.50)	2	-1.91 (-2.92)	-1.85 (-3.50)	I(1)
InER	0.28 (-2.92)	-1.89 (-3.50)	2	-1.12 (-2.92)	-1.10 (-3.50)	I(1)
InDY	-0.55 (-2.92)	-2.71 (-3.50)	2	-5.31 (-2.92)	-5.25 (-3.50)	I(1)
LnDM2	-0.54 (-2.92)	-0.13 (-3.50)	2	-3.42 (-2.92)	-4.43 (-3.50)	I(1)

Notes: Figures in brackets are critical values at the 5% level.
TB, FY, FM2, ER, DY, and DM2 denote trade balance, foreign national income, foreign money supply, exchange rate, domestic national income, and domestic money supply, respectively.
Source: Computed using the Eviews package

Table 2: Unit root test: Phillips-Perron (PP) test

Variable Series	Level (Test Statistic)		First Difference (Test Statistic)		
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	Integrated Order
TB	-3.00 (-2.92)	-2.93 (-3.50)	-1.19 (-2.92)	-1.11 (-3.50)	I(0)
InDY	-0.57 (-2.92)	-2.22 (-3.50)	-5.79 (-2.92)	-5.19 (-3.50)	I(1)
InER	0.17 (-2.92)	-2.20 (-3.50)	-1.15 (-2.92)	-1.14 (-3.50)	I(1)
LnFM2	-0.71 (-2.92)	-2.19 (-3.50)	-1.91 (-2.92)	-1.85 (-3.50)	I(1)
InFY	-0.10 (-2.92)	-1.93 (-3.50)	-1.97 (-2.92)	-1.98 (-3.50)	I(1)
LnDM2	0.24 (-2.92)	-1.77 (-3.50)	-5.51 (-2.92)	-5.41 (-3.50)	I(1)

Notes: Figures in brackets are critical values at the 5% level.
TB, DY, ER, FM2, FY, and DM2 denote trade balance, domestic national income, exchange rate, foreign money supply, foreign national income, and domestic money supply, respectively.
Source: Computed using the Eviews package

Both tables show that in all cases, the unit root hypothesis cannot be rejected. Therefore, It can be concluded that most variables are I(1), except for trade balance, which was stationary at level, a result confirmed by numerous other studies such as Ibrahim and Bashir 2020; Bashir and Ibrahim, 2022; Ibrahim and Bashir, 2021; Wu 2020.

4. 2 Lag Length Criteria

Determining lag length in a VAR model is one of the most important requirements. The determination of an optimal lag length can require the use of several criteria, such as the methods of the sequential modified likelihood ratio (LR) test, the final prediction error (FPE) statistic, the AIC, SIC, and the Hanan-Quinn Criteria (HQC). As shown in Table 3, it appears that based on the criteria of AIC and SC, the optimal lag length is 2 for AIC.

Table 3: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-710.8573	NA	205305.5	29.25948	29.49113	29.34737
1	-425.1851	489.7229*	7.793930*	19.01880*	20.19031*	19.18402*
2	-407.2188	21.32177	17.42048	19.80189	22.81831	20.94944

*Notes: * indicates the lag order selected by the criterion.*
LR: sequential modified LR test statistic (each test at a 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion.
Source: Computed using the Eviews package

4.3 ARDL Bounds for Cointegration

To empirically analyze the long-run relationships and short-run dynamic interactions among the variables of interest, we apply the ARDL cointegration technique. ARDL testing is performed by Wald statistics in the form of the F-test. If the calculated value of the F statistic is significant (higher than the upper bound), one rejects H_0 in favor of H_1, thus showing that the long-run equilibrium relationship between trade balance (TB), DY, FY, DM2, FM2, and ER exists.

Table 4: F-Bounds test

Test Statistic	Value	Sig.	I(0)	I(1)
F-statistic	2.433197	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.01	4.15

Note: Null Hypothesis: No levels relationship
Source: Computed using the Eviews package

Since f(TB, DY, FY, DM2, FM2, and ER) = 2.43 exceeds the upper bound of the critical value band at the 5% level, which is given by 2.39 and 3.38 that represent the lower and upper bounds, respectively, we can reject the null hypothesis that says there is no long-run relationship between variables, irrespective of the order of their integration, I(0) or I(1). The test results are above the upper-bound critical value, indicating a rejection of the null hypothesis of no cointegration and thereby suggesting that there exists a long-run relationship between the variables; therefore, DY, FY, DM2, FM2, and ER can be treated as the “ long-run forcing ” variables to explain the trade balance (TR). This means that all the variables move together in the long-run.

4.4 Error Correction Model

Once a cointegration relationship is established, an ECM can be estimated to determine the dynamic behavior of trade balance determinants. We apply the Wald test to measure how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis.

As shown in Table 5, domestic income (DY) has a significant positive impact on Sudan's trade balance. In the first lag, both the real exchange rate (ER) and foreign income (FD) have a negative and significant impact on trade balance. This implies that a depreciation of the Sudanese pond has a negative impact on trade balance in the short-run.

Table 5: ARDL error correction regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LONLNDY)	-5193.947	2927.208	-1.774319	0.0847
D(LONLNDY(-1))	1450.975	2901.552	2.219410	0.0330
D(LONLNFY)	-52.18987	308.3010	-0.170904	0.8153
D(LONLNFY(-1))	-184.5133	329.3429	-2.078573	0.0451
D(LONLNER)	-118.9414	492.7155	-1.357173	0.1833
D(LONLNER(-1))	-2400.131	495.5797	-4.843087	0.0000
CointEq(-1)*	-0.273923	0.011324	-4.411791	0.0001

Note: DY, FY, and ER denote domestic national income, foreign national income, and exchange rate, respectively.

Source: Computed using the Eviews package

The coefficient of ECT (EC_{t-1}) representing the proportion by which a long-run disequilibrium in trade balance can be corrected in each year, estimated at -0.273923, is statistically significant at the 5% level and correctly negatively signed. It suggests the validity of a long-run equilibrium relationship among the variables in the model as well as a moderate speed of convergence to equilibrium.

4.5 Tests for Serial Correlation and Granger Causality

It is advisable to compute the Breusch-Godfrey statistic and respond to any indication of autocorrelation disturbances, as it is almost certainly more dangerous to incorrectly suppose that autocorrelation is not present than to incorrectly suppose that it is. As shown in Table 6, the result indicates there was evidence of autocorrelation, as the *p*-value is greater than 5%.

Table 6: Breusch-Godfrey serial correlation LM test

F-statistic	0.054138	Prob. F(2,33)	0.9419
Obs*R-squared	0.158421	Prob. Chi-Square(2)	0.9238

Source: Computed using the Eviews package

Since trade balance and DY are stationary, we assume that their residuals are uncorrelated, which is a condition of the Granger causality test, and the optimum lag is 2, which is the lowest AIC. After this, we can proceed to test Granger causality. We test the null hypothesis using the F-test, the guidelines for which include the *P*-value and a 5% level of significance. As shown in Table (7), we cannot reject the hypothesis that neither variable Granger-causes the other. These results are in line with Ibrahim & Bashir, 2020.

Table 7: Pairwise Granger causality test

Null Hypothesis	Obs.	F-Statistic	Prob.
LONLNDY does not Granger Cause TB	48	0.17903	0.8317
TB does not Granger Cause LONLNDY		0.27411	0.7111

Note: TB, and DY, denote trade balance, and domestic national income, respectively.
Source: Computed using the Eviews package

4.6 Impulse Response Functions (IRFs)

IRFs seek the effects of a shock to endogenous variables on the other variables in the system. It is a shock to the VAR system. It is a unit shock that is applied to each variable to observe its effect on the VAR system. IRFs map out the dynamic response of Cholesky one standard deviation innovation, which is used to identify the trade balance determinants that exist in Sudan. Figure 1 shows the estimated orthogonalized IRFs for DY, FY, DM2, FM2, and ER for a standard deviation innovation in the trade balance. The impulse response result in Figure 1 shows that DM2 has a positive effect on trade balance with sustained stability over time. It also shows that FM2, DY, and ER have a negative effect on TB in the first three phases and then converge to zero. In addition, FY has a positive effect on TB in the first three phases, a negative effect after that, and almost zero thereafter. This result is similar to that reported by Haansende and Nyambe, 2020.

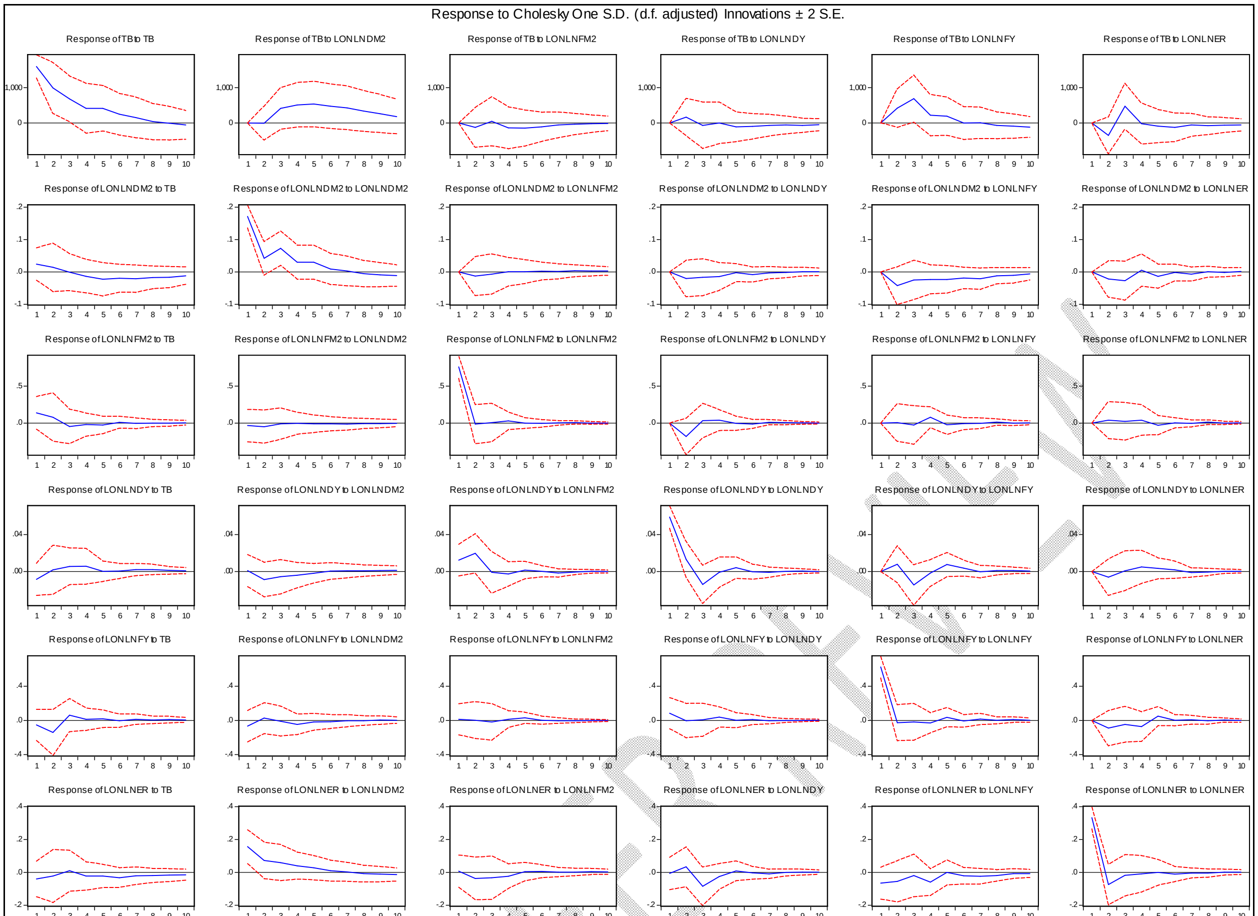

Fig. 1. Impulse Response Functions

4.7 Variance Decompositions (VDCs)

Decomposing variation in an endogenous variable into its component shocks provides information about the relative importance (of each shock to the variable) of a random innovation. The VDCs are sensitive to the ordering of the variables. As all the variables are stationary in nature, the VAR needs stationary variables, and the lag selection criteria advise us to use 2 lags as the optimum.

Table 8: Variance Decompositions

Variance Decomposition of TB							
Period	S. E.	**TB**	LONLN**DM2**	LONLN**FM2**	LONLN**DY**	LONLN**FY**	LONLN**ER**
3	2279.110	71.590740	3.270531	0.318392	0.103354	12.558210	12.158773
10	2154.190	12.179120	19.100450	1.005198	0.931212	10.841190	55.942830
Variance Decomposition of LONLNDM2							
Period	S. E.	**TB**	LONLN**DM2**	LONLN**FM2**	LONLN**DY**	LONLN**FY**	LONLN**ER**
3	0.204101	1.905120	87.411190	0.481411	1.123791	5.729093	3.349395
10	0.221132	1.158580	79.189180	0.499781	1.970052	9.221408	7.960999
Variance Decomposition of LONLNFM2							
Period	S. E.	**TB**	LONLN**DM2**	LONLN**FM2**	LONLN**DY**	LONLN**FY**	LONLN**ER**
3	0.803917	4.174812	0.599718	89.411190	5.311581	0.123419	0.379280
10	0.812101	4.290211	0.189718	87.710710	5.457551	1.144915	1.206895
Variance Decomposition of LONLNDY							
Period	S. E.	**TB**	LONLN**DM2**	LONLN**FM2**	LONLN**DY**	LONLN**FY**	LONLN**ER**
3	0.070137	2.177237	2.305334	11.001370	78.139510	5.514211	0.862338
10	0.071111	2.894171	2.177012	10.821280	75.311740	1.749718	7.046079
Variance Decomposition of LONLNFY							
Period	S. E.	**TB**	LONLN**DM2**	LONLN**FM2**	LONLN**DY**	LONLN**FY**	LONLN**ER**
3	0.114795	5.934318	1.202129	0.121133	1.119128	88.712310	2.910985
10	0.177371	5.927351	1.711459	0.382911	1.991410	81.010710	8.976159
Variance Decomposition of LONLNER							
Period	S. E.	**TB**	LONLN**DM2**	LONLN**FM2**	LONLN**DY**	LONLN**FY**	LONLN**ER**
3	0.413712	1.300717	19.590270	1.484118	4.880410	4.475839	68.268646
10	0.428979	2.989898	19.820890	1.739503	4.971791	1.854411	68.623507

Note: TB, DM2, FM2, DY, FY, and ER denote trade balance, domestic money supply, foreign money supply, domestic national income, foreign national income, and exchange rate, respectively.

Source: Computed using the Eviews package

We divide the period into short and long runs. In the short-run, or in year 3, the impulse (or innovation or shock) to trade balance (TB) accounts for 71.59% of the variation in the trade balance fluctuation, or its own shock, which is considered to be the largest contribution to the fluctuations. The second shock is the shock to the domestic money supply (DM2), which can cause a 3.27% fluctuation in the trade balance. However, a shock to the foreign money supply (FM2) can contribute to a 0.32% fluctuation in the trade balance. A shock to domestic national income (DY) can contribute to 0.1% of the fluctuation in the trade balance. A shock to foreign national income (FY) can contribute to 12.56% of the fluctuation in the trade balance. A shock to the exchange rate (ER) can contribute to a 12.16% fluctuation in the trade balance. As a result, total fluctuations amounted to 100%.

In the long-run, that is, in year 10, the impulse to trade balance (TB) can contribute to a 12.18% variation of fluctuation in the trade balance or its own shock. The second shock is the shock to DM2, which can cause a 19.1% fluctuation in the variance of the trade balance. A shock to FM2, however

r, can contribute to a 1.01% fluctuation in the trade balance. A shock to DY can contribute to a 0.93% of fluctuation in the trade balance. But a shock to foreign national income can contribute to a 10.84% fluctuation in the trade balance. A shock to the exchange rate can contribute to a 55.94% fluctuation in the trade balance. As a result, total fluctuations reach 100%.

In the short-run, that is, in year 3, impulse to domestic money supply (DM2) accounts for a 1.9% variation of the fluctuation in the trade balance. The second shock is the shock to DM2, which can cause an 87.42% fluctuation in DM2 or its own shock. A shock to FM2, however, can contribute to a 0.48% fluctuation in DM2. A shock to DY can contribute to a 1.12% fluctuation in DM2. Further, a shock to FY can contribute to a 5.73% fluctuation in DM2. A shock to the exchange rate can contribute to a 3.35% fluctuation in DM2. As a result, total fluctuations amounted to 100%.

In the long-run, that is, in year 10, impulse to domestic money supply (DM2) can contribute to a 1.11% variation of fluctuation in the trade balance. The second shock is the shock to DM2, which can cause a 79.19% fluctuation in the variance of DM2 or its own shock. A shock to FM2, however, can contribute to a 0.50% fluctuation in DM2. A shock to DY can contribute to a 1.97% fluctuation in DM2. A shock to FY can contribute to a 9.22% fluctuation in DM2. A shock to the exchange rate can contribute to a 7.96% fluctuation in DM2. As a result, total fluctuations amounted to 100%.

In the short-run, that is, in year 3, impulse to foreign money supply (FM2) accounts for a 4.17% variation of the fluctuation in the trade balance. The second shock is the shock to DM2, which can cause a 0.59% fluctuation in FM2. A shock to FM2, however, can contribute to an 89.47% fluctuation in FM2 or its own shock. A shock to DY can contribute to a 5.31% fluctuation in FM2. Further, a shock to FY can result in a 0.12% fluctuation in FM2. A shock to the exchange rate can contribute to a 0.38% fluctuation in DM2. As a result, the total fluctuations in the trade balance amounted to 100%.

In the long-run, that is, in year 10, impulse to foreign money supply (FM2) can contribute to a 4.29% variation of fluctuation in FM2. The second shock is the shock to DM2, which can cause a 0.19% fluctuation in the variance of FM2. A shock to FM2 can contribute to an 87.71% fluctuation in FM2 or its own shock. A shock to DY can contribute to a 5.41% fluctuation in FM2. A shock to FY can contribute to a 1.14% fluctuation in FM2. A shock to the exchange rate can contribute to a 1.21% fluctuation in FM2. As a result, the total fluctuation amounted to 100%.

In the short-run, that is, in year 3, impulse to domestic national income (DY) accounts for a 2.18% variation of fluctuation in the trade balance. The second shock is the shock to DM2, which can result in a 2.31%

fluctuation in DY. A shock to FM2, however, can contribute to an 11% fluctuation in DY. Further, a shock to DY can contribute to a 78.14% fluctuation in DY or its own shock. A shock to FY can contribute 5.51% to DY. A shock to the exchange rate can contribute to a 0.86% fluctuation in DY. As a result, total fluctuations amounted to 100%.

In the long-run, that is, in year 10, impulse to domestic national income (DY) can contribute to a 2.89% variation of the fluctuation in the trade balance. The second shock is the shock to DM2, which can cause a 2.18% fluctuation in the variance of DY. However, a shock to FM2 can contribute to a 10.82% fluctuation in DY. Furthermore, a shock to DY can contribute to a 75.31% fluctuation in DY or its own shock. A shock to FY can contribute to a 1.75% fluctuation in DY or its own shock. A shock to the exchange rate can contribute to a 7.05% fluctuation in DY. As a result, total fluctuations amounted to 100%.

In the short-run, that is, in year 3, impulse to foreign national income (FY) accounts for a 5.93% variation of fluctuation in the trade balance. The second shock is the shock to DM2, which can result in a 1.20% fluctuation in FY. A shock to FM2, however, can contribute to a 0.12% fluctuation in FY. Further, a shock to DY can contribute to a 1.12% fluctuation in FY. A shock to FY can contribute to 88.71% of FY or its own shock. A shock to the exchange rate can contribute to a 2.91% fluctuation in FY. As a result, total fluctuations amounted to 100%.

In the long-run, that is, in year 10, impulse to foreign national income (FY) can contribute to a 5.92% variation of the fluctuation in the trade balance. The second shock is the shock to DM2, which can cause a 1.71% fluctuation in the variance of FY. However, a shock to FM2 can contribute to a 0.38% fluctuation in FY. Furthermore, a shock to DY can contribute to a 1.99%

fluctuation in FY. A shock to FY can contribute to an 81.01% fluctuation in FY or its own shock. A shock to the exchange rate can contribute to an 8.98% fluctuation in FY. As a result, total fluctuations amounted to 100%.

In the short-run, that is, in year 3, impulse to the exchange rate (ER) accounts for a 1.30% variation of fluctuation in the trade balance. The second shock is the shock to DM2, which can cause a 19.59% fluctuation in ER. However, a shock to FM2 can contribute to a 1.48% fluctuation in ER. A shock to DY can contribute to a 4.88% fluctuation in the exchange rate. A shock to FY can contribute to 1.85% of ER. A shock to ER can contribute to a 68.27% fluctuation in ER or its own shock. As a result, the total fluctuations add up to 100%.

In the long-run, that is, in year 10, impulse to the exchange rate (ER) can contribute to a 2.99% variation of fluctuation in the trade balance. The second shock is the shock to DM2, which can cause a 19.82% fluctuation in variance in the ER. A shock to FM2, however, can contribute to a 1.74% fluctuation in the ER. A shock to DY can contribute to a 4.98% fluctuation in ER. A shock to ER can contribute to a 68.62% fluctuation in ER or its own shock. As a result, total fluctuations amounted to 100%.

In terms of explanatory power, we conclude that shocks to domestic money supply and domestic national income explain very little of the forecast error variance of trade balance as compared to other variables. While the changes in the country's trade balance are highly attributable to shocks from foreign national income, and foreign money supply respectively. These findings are in line with Eshetu & Eshetu, 2021; Akoto & Saky, 2019.

4.8 Stability Diagnostics

We apply the well-known CUSUM and CUSUMQ tests to the residuals of the optimum model to test them for the stability of short-run and long-run coefficient estimates altogether. Since the blue lines lie inside the red lines, the model is stable. As shown in Figure 2, the CUSUM of squares test reflects that the blue trend line lies within the red lines, which confirms that the model is dynamically stable. However, the CUSUMSQ test in Figure 3 shows that the graph crosses the lower and upper red lines at critical limits from 1994 to 2019. Therefore, we can conclude there are structural breakpoints and greater instability between 1994 and 2019, when the trade balance suffered a large deficit and the exchange rate experienced huge and multiple depreciations.

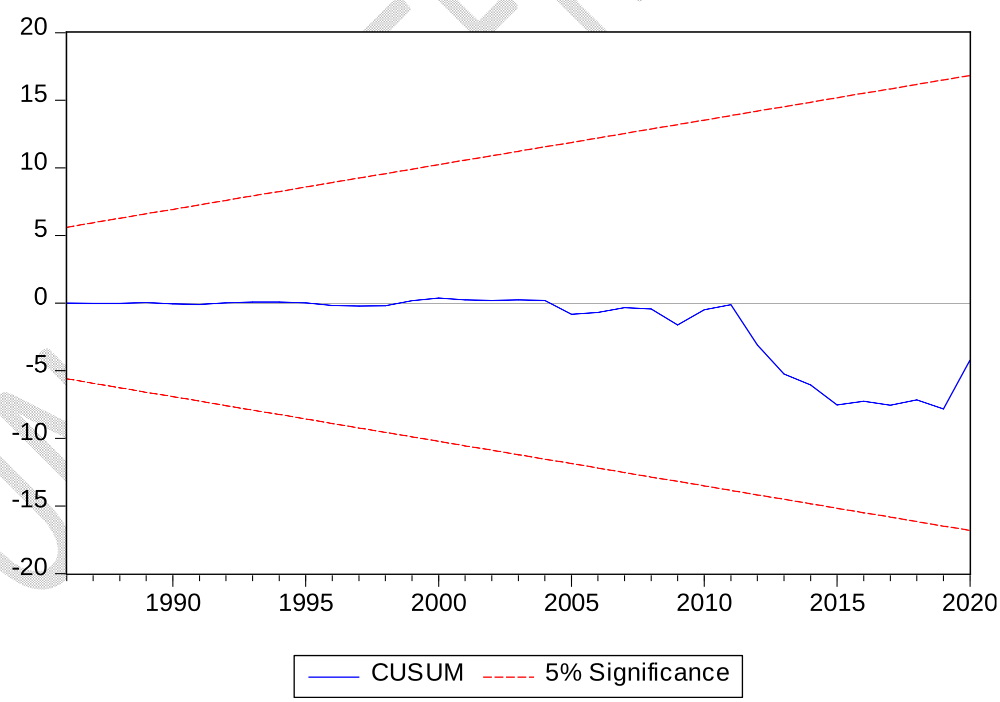

Fig. 2. CUSUM of Squares test
Source: Computed using the Eviews package

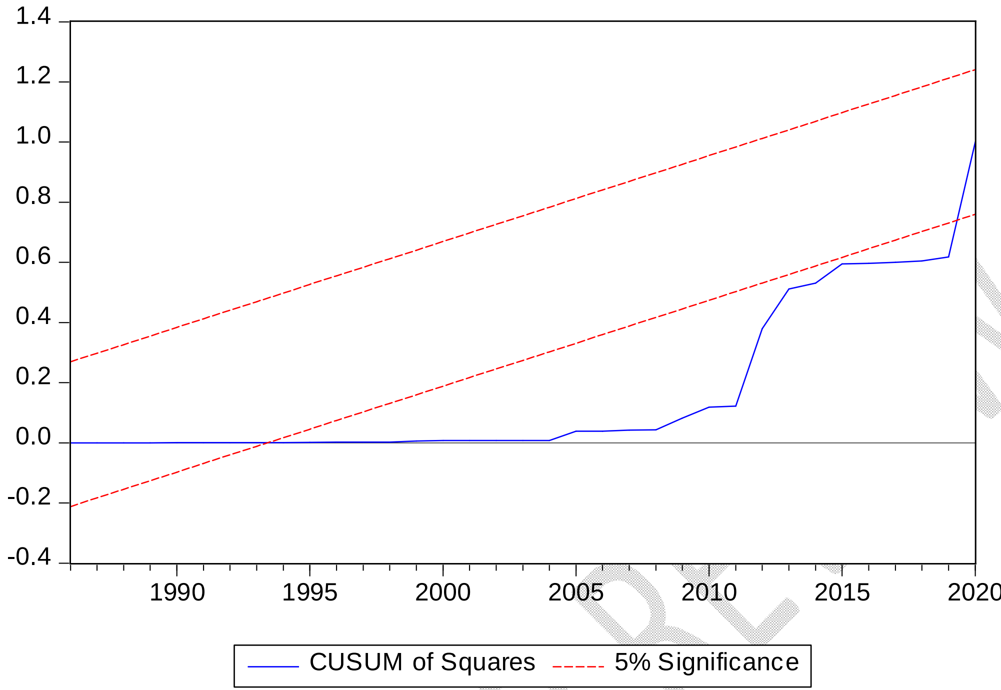

Fig. 3. CUSUMQ of Squares test
Source: Computed using the Eviews package

5. CONCLUSION AND POLICY RECOMMENDATIONS

The objective of this paper was to shed light on the effect of devaluation on the trade balance of Sudan over the period 1970 – 2020. The empirical model for this investigation is developed using the absorption, elasticity, and monetary approaches to the trade balance. Before estimating the model, each series is tested for stationarity. The estimated results indicate that devaluations do improve the trade balance in the long-run.

The study uses cointegration and error correction techniques to identify the variables that explain the effects of the exchange rate, income and money supply on the trade balance in Sudan. The ARDL cointegration test analysis was used to create a long-run equilibrium relationship among these variables. The methodology of an ECM was applied to estimate the short- and long-run relationships. The selected cointegrated vector provided the appropriate ECT, which proved to be negative and statistically significant at a 5% level of significance during its inclusion in the short-run dynamic equation. The study considers the domestic national income, foreign national income, domestic money supply, foreign money supply, and exchange rate variables to see if they explain the trade balance. All the variables indicated the correct signs and were statistically significant.

The most important policy implication of our findings is that any trade balance strategy will contribute to economic growth and vice versa. Therefore, as a recommended policy implication, we should emphasize the significant effects of the determinants of the trade balance. One could argue that strategies to improve the trade balance of Sudan should put more emphasis on domestic production and manufacturing of imported goods than currency devaluation.

There are a few limitations to the data used in this study that must be underlined. The main problem with conducting empirical studies on developing countries is data availability. Many developing countries do not have adequate time series data that can be used for analysis. It is suggested that future studies on this topic should be based on high-frequency data and a larger sample size so that the results are more reliable and robust.

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