International Review of Applied Economics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cira20

Threshold-based asymmetric reactions of trade balances to currency devaluation: fresh insights from smooth transition regression (STR) model

Joseph Chukwudi Odionye, Augustine C Odo, Marius Ikpe & Richard O. Ojike

To cite this article: Joseph Chukwudi Odionye, Augustine C Odo, Marius Ikpe & Richard O. Ojike (2023): Threshold-based asymmetric reactions of trade balances to currency devaluation: fresh insights from smooth transition regression (STR) model, International Review of Applied Economics, DOI: 10.1080/02692171.2023.2234311

To link to this article: https://doi.org/10.1080/02692171.2023.2234311

Published online: 11 Jul 2023.

INTERNATIONAL REVIEW OF APPLIED ECONOMICS
https://doi.org/10.1080/02692171.2023.2234311

Routledge
Taylor & Francis Group

Threshold-based asymmetric reactions of trade balances to currency devaluation: fresh insights from smooth transition regression (STR) model

Joseph Chukwudi Odionye[a], Augustine C Odo[b], Marius Ikpe[c] and Richard O. Ojike[c]

[a]Department of Economics, Abia State University, Uturu, Nigeria; [b]Department of Economics, Godfrey Okoye University, Enugu, Nigeria; [c]Department of Economics and Development Studies, Alex Ekwueme Federal University Ndufu-Alike, Achoro-Ndiagu, Nigeria

ABSTRACT

This study sought to ascertain relatively the asymmetric reactions of trade balances to currency devaluation and non-devaluation regimes in sub-Saharan African (SSA) countries between 1981 and 2021 using the smooth transition regression (STR) model. The outcome indicates that, in Ghana, Malawi, and Mozambique, currency devaluation as a change in policy has a major influence on the trade balance; however, in Nigeria, Kenya, and Tanzania, this impact is negligible. Nigeria had the highest gamma coefficient but insignificant, suggesting that policy change has not significantly impacted the country's trade balance despite the high transition rate. Findings from the devaluation regime revealed that, with the exception of Ghana, all other nations' real exchange rates are inversely and significantly related to the trade balance. Additionally, it displayed an average threshold parameter of 0.147, indicating that a devaluation of more than 14.7% within a year will deteriorate the trade balance in SSA. The results indicate that the devaluation effects hinge on the structure, macroprudential policies, and infrastructural growth of the nation. The study recommended amongst other things, (i) a robust structural transformation in key sectors (ii) judicious investment in infrastructural development to address the key bottleneck in the quality and quantity of domestic production.

ARTICLE HISTORY
Received 21 February 2023
Accepted 8 May 2023

KEYWORDS
Currency devaluation; STR; trade balances; asymmetric reactions; Sub-Saharan Africa

JEL CLASSIFICATION
F14; F31; F32; F41; C22

1. Introduction

Currency devaluation (CD) is commonly seen as a key asset for regulating the external segment of an economy. This alters the conditions of trade through exchange rate alignment to determine trade balance (TB) through the export-import channel as nations seek to gain international competitive advantage. Within the framework of flexible exchange rate regimes, devaluation permits free adjustment in exchange rate. Given the lack of productive capacities that can sustain a stable exchange rate, it has made exchange rate in many developing economies very volatile, thus introducing some degrees of uncertainty in trade balance (Ikpe et al. 2021). Currently, there are growing emphasis on the link between currency devaluation/exchange rate alignments in

CONTACT Joseph Chukwudi Odionye joseph.odionye@abiastateuniversity.edu.ng

explaining TB (Aliyu and Tijjani 2015; Apamisile and Oloba 2020; Bhat and Bhat 2021; Duru et al. 2022; Iboma 2022; Keho 2021; Odionye and Chukwu 2021; Okpeku and Aras 2022). While a number of these studies examined the symmetric connection between exchange rate and TB (see Duru et al. 2022; Iboma 2022; Okpeku and Aras 2022), there is still a dearth of studies focusing on the asymmetric effect of CD on TB for selected countries with different devaluation episodes in the context of Sub-Saharan Africa (SSA) countries. A strand of view put forward by Falk (2008), posits that CD is less effective in enhancing TB in countries that are currently experiencing a current account deficit (Nusir and Leung 2021). Considering that many import-dependent countries such as SSA are pertinaciously experiencing TB deficit (World Trade Organisation 2021), can CD improve TB, or are there certain level(s) or threshold of CD that will improve it, beyond which it diminishes trade? Okere et al. (2023) and Muoneke, Okere, and Onuoha (2022) in their separate studies observed that exchange rate swings at upper quantiles worsen aggregate export of some selected African countries. Therefore, this study assesses threshold-based asymmetric reactions of TBs to CD in selected countries in SSA, using the novel Smooth Transition Regression (STR) model.

Many SSA countries have periodically weakened their currencies or used a more floating exchange rate regime since the 1980s. Anecdotal evidence indicates that many of these countries devalued their currencies multiple times between 1985 and late 1990s aimed at improving their trade balances (CBN 2021; Kamugisha and Assoua 2020; Leite et al. 2000; Maehle, Teferra, and Khachatryan 2013; Rawlins 2011; World Economic Outlook, IMF 2015). The magnitude of these devaluations are such that amounts to as much as 45% in 1986 for Ghana (Kapur et al. 1991; Leite et al. 2000; Maehle, Teferra, and Khachatryan 2013), 98% between 1990 to 2010 for Malawi; 11% per annum on average (Reserve Bank of Malawi 2003; Simwaka 2007), 88.2% for Kenya in 1992 (Maehle, Teferra, and Khachatryan 2013; O'Conell et al. 2010). Similarly, in January 1987, Mozambique devalued its currency by 80.5% (Fabrizio 1998, 2201; Maehle, Teferra, and Khachatryan 2013); on aggregate, the Tanzanian authorities devalued its currency by 95% between 1986 to mid-1990s (Maehle, Teferra, and Khachatryan 2013; Nord et al. 2009; Rawlins 2011), while Nigeria devalued the 'Naira' by as much as 347.6% in 1998 (Rawlins 2011). However, views regarding exchange rate movement and economic performance nexus are polarised (Ikpe et al. 2021). At one end of the divide lies the argument that fluctuations in exchange rate lead to undesirable effects on macroeconomic aggregates thus inducing a high degree of uncertainty in international transactions and therefore discouraging trade (Auboin and Ruta 2011; IMF 1984). At the other end is the view that associated uncertainty risk could be hedged through the forward exchange market which could leave trade flows, and by extension TBs unaffected (see Ikpe et al. 2021). So far, reliance on empirical evidence to resolve this theoretical issue is yet to yield much-needed result as findings remained mixed, thus leaving the empirical question open for further investigation.

Furthermore, many countries in SSA have consistently recorded trade deficits, especially in recent years (World Trade Statistical Review 2021). The sustained trade imbalance in the region as a whole is reflected in the ongoing worsening of the trade balance (Figure 1). Consequently, this may undermine the process of these economies' advancement and growth and thus questions the potency of currency devaluation's expansionary roles on trade balances in the region. Sub-Saharan Africa's trade balances have gotten

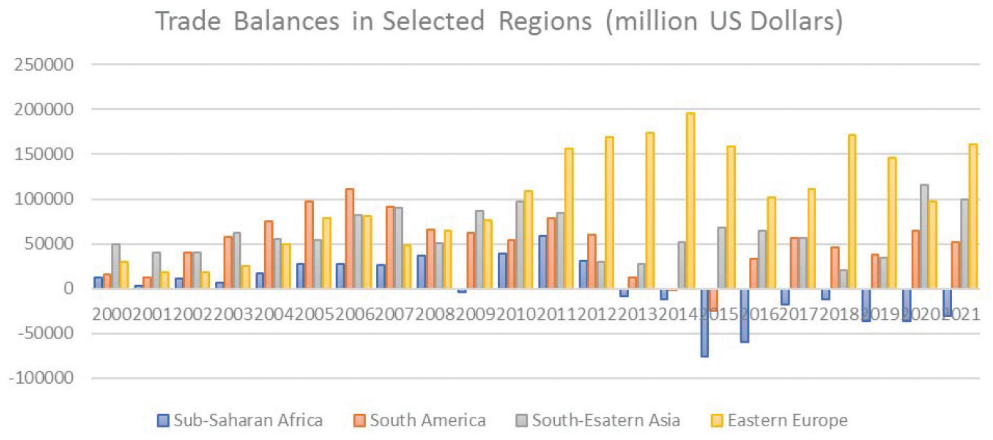

Figure 1. Trade Balances Based on Regions. *Source: United Nations Conference on Trade and Development (2021)*

worse recently, which casts doubt on the competitiveness of the region. The region's contribution to global trade is negligible in comparison to other regions (World Trade Organisation 2021); in 2000, the SSA contributed 1.5% to global trade, which was dominated by industrialised nations, who accounted for 65% of global trade. Only 2.3% of global trade in 2013 came from the SSA, compared to 50.1% from industrialised nations. In 2021, the region's contribution to global trade declined further to 1.9% while the industrialised nations accounted for 60.8% (World Economic Outlook, IMF 2021). Comparing the trade balance of SSA with other regions, (Figure 1) shows that the region recorded unfavourable trade balances from 2013 to 2021 with the highest deficit recorded in 2015. Regions like South America, South Eastern Asia, and Eastern Europe all recorded favourable trade balances during the same period. This solicits the interrogation of the extent to which the SSA region's trade is influenced by currency devaluation as a policy change.

Although several researchers have empirically investigated the currency devaluation effects on trade balances both in advanced and developing economies focusing on the symmetric effect, only a few studies examined its asymmetric effects, especially in the context of SSA countries (Aliyu and Tijjani 2015; Apamisile and Oloba 2020; Bhat and Bhat 2021; Keho 2021; Muoneke, Okere, and Onuoha 2022; Okere et al. 2023). Theoretically, exchange rate may have a nonlinear or asymmetric relationship with trade balance due to the hysterical behaviour of economic factors (Baldwin and Krugman 1989; Dixit 1989), ratchet effects, and the attributes of price rigidity (Bussiere 2013; Karoro, Aziakpono, and Cattaneo 2009). This prompted a study of asymmetric reactions of the trade balance to exchange rate changes (see Keho (2021) for Cote d'ivoire, Bhat and Bhat (2021) for India, Aliyu and Tijjani (2015), andApamisile and Oloba (2020) for Nigeria, Okere et al. (2023), as well as Odionye and Chukwu (2021) for asymmetric impacts of currency devaluation on the output of selected SSA countries.

Besides Bhat and Bhat (2021), Apamisile and Oloba (2020), and Aliyu and Tijjani (2015), most previous studies focused on the influence of exchange rate depreciation/appreciation on trade balance without taking currency devaluation into account as a policy change.

Currency weakening as a change in policy alters the demand composition in the local economy (Dong 2007; Rana 2015; World Economic Outlook, IMF 2015, 2019). To capture the regime-changing behaviour in exchange rate movements-trade balance nexus which prior studies did not consider, we utilised the STR model to decompose the exchange rate regime into currency devaluation and non-currency devaluation regimes, and examined how trade balance responds distinctly to these two regimes (Odionye and Chukwu 2021; Terasvirta 1998, 2004). The STR model, because of its multiple advantages, has been frequently utilised in studies on exchange rate markets (Odionye and Chukwu 2021) and energy and environmental research (Khaskheli et al. 2021; Ullah et al. 2021). Some of the benefits of the STR model include: (i) it calculates a threshold value that splits the explanatory variable(s) into different regimes based on regime-changing series; (ii) as a regime-switching model, it permits the estimation of the influence of variables at different regimes; and (iii) it offers robust results in the presence of structural breaks (Odionye and Chukwu 2021; Odionye, Ojiaku, and Uba 2023; Terasvirta 1998, 2004; Ullah et al. 2021). Evidence suggested that practically all SSA nations had at some stage weakened their currencies. The structural break of the unit root test was not taken into account in the earlier studies. Perron (1989, 1997) asserts that failing to take into consideration structural breaks in the series leads to bias and makes it more difficult to completely rule out the possibility of a dishonest stationarity hypothesis. Therefore, to explain the effects of structural discontinuities in time series properties, a regime-switching model must be applied.

This work differs fundamentally from the previous studies and thus contributes to the strand of economic literature by exploring relatively the threshold-based asymmetric reactions of trade balances to currency devaluation and non-currency devaluation regimes in selected SSA countries.

2. Literature review

Hypothetically, a devaluation of the currency (in a fixed exchange rate regime) or exchange rate depreciation (in a market-determined system) is anticipated to boost the BOP and therefore increase economic production. However, whether devaluation is expansionary or contractionary has been the subject of several substantial theoretical discussions, particularly in developing nations. The literature contains a wide range of perspectives. These opinions can be broadly divided into the traditionalists and structuralists theoretical perspectives. According to the structuralists, devaluation could have a contractionary influence due to the current economic structure, in contrast to the traditionalists who believe it has expansionary effects (Cooper 1971; Edwards 1986; Krugman and Tailor 1978). Keynesian, monetarist and elasticity theories are the main focus of traditionalists' viewpoints. The demand and supply sides channels are two ways that devaluation may adversely affect the health of the economy, according to structuralists (Acar 2000). They outlined the mechanisms by which devaluation may have negative impacts on cumulative demand, which in turn causes a decline in productivity and jobs.

2.1. Empirical review

Numerous empirical studies have been carried out to investigate the various theoretical hypotheses regarding the influence of currency devaluation/depreciation on

transnational trade. While some studies concentrated on cross-country studies of Asian nations, others focused on country-specific studies, but only a small number examined cross-country analyses of SSA nations. Except, for the works of Keho (2021) for Cote d'ivoire, Bhat and Bhat (2021) for India, Apamisile and Oloba (2020) for Nigeria and Okere et al. (2023) for selected African nations, the majority of the recent studies carried out in SSA focused on symmetric exchange rate-trade balance connectivity (see Duru et al. 2022; Iboma 2022; Okpeku and Aras 2022). Theoretically, exchange rate may have a nonlinear relationship with trade balance due to the hysterical behaviour of economic factors (Baldwin and Krugman 1989; Dixit 1989), rachet effects, and the attributes of price rigidity (Bussiere 2013; Karoro, Aziakpono, and Cattaneo 2009). This prompted a study of the asymmetric response of trade balance to currency changes.

In the context of Nigeria, the asymmetric influence of exchange rate movements on international trade was investigated by Apamisile and Oloba (2020). The study, being motivated by the possibility of the asymmetric reaction of transnational trade to changes in currency value, utilised the nonlinear ARDL estimation technique in its data analysis. The study's result indicates, among others that the gain in currency value inversely influenced the investigated country's transnational trade. Also observed in the study is that an asymmetric link exists between the investigated variables. A similar result was found by Aliyu and Tijjani (2015) in Nigeria. Their study utilised the threshold auto-regressive estimation technique to ascertain the adjustment to the long-run link between the factors. Evidence that devaluation has no influence on transnational trade was observed in the study. Similarly related to the work of Aliyu and Tijjani (2015) in the approach adopted, was the work of Buba, Al-Jadi, and Guza (2018) in Thailand. Though the study adopted the same method, it arrived at a different result for Thailand as it found a meaningful influence of exchange rate on the trade balance.

Bhat and Bhat (2021) investigated the exchange rate movements-trade balance connectivity in India. The study observed limited studies on asymmetric connection amid the factors and thus adopted nonlinear ARDL to inquire about the asymmetric reaction of trade balance position to Indian currency changes. The study's result indicates that currency weakening has a stronger influence on transnational trade in the investigated country than appreciation does. Equally found in the work is that, while weak currency enhances trade balance, appreciation worsens it. In another related study in the case of Cote d'ivoire, Keho (2021) employed a similar approach and arrive at a similar result. The study adopted a threshold-based approach in a nonlinear ARDL model framework to explore the trade balance-exchange rate nexus between 1975 and 2017. Conclusively, it observed exchange rate appreciation to be contractionary while depreciation was expansionary in affecting transnational trade in the study country.

In another related study, Akinwale et al. (2018) evaluated the Nigerian exchange rate devaluation effect on the trade balance. The study's focus was on the symmetric link between the variables, employing the error correction method of data analysis. The study's result showed evidence that transnational trade is insignificantly influenced by the exchange rate of the investigated country. The study did not consider currency devaluation as a change in policy. Most recently, Iboma (2022) and Duru et al. (2022) carried out related research to inquire about the exchange rate-trade balance link and to investigate the validity or otherwise of J-curve influence in Nigeria. Although both studies adopted different approaches, they arrived at similar conclusions. Both studies

observed long-run exchange rate changes-trade balance connectivity. Similarly, Onakoya, Johnson, and Ajibola (2018) examined the J-curve reaction of the trade balance to the Nigerian exchange rate employing VECM in its analysis and found that exchange rate weakening enhances the country's trade balance position.

Relatedly, Okpeku and Aras (2022) examined the exchange rate changes' effects on trade deficits in some selected African countries between 1996 and 2020. The research adopted dynamic regression within a panel model framework in its data analysis. The findings, amongst others, are that exchange rate weakening deteriorates the 10 selected African countries' trade balance. Also, the study invalidated the J-curve shape of exchange rate influence in the investigated African countries. Similarly, Anoke, Odo, and Ogbonna (2016) and Thahara, Rinosha, and Shifaniya, (2021) in their separate studies for different countries arrived at the same conclusion using different methods; that exchange rate weakening inversely influences trade balances in Nigeria and Sri Lanka respectively. While the former adopted the VECM approach, the latter utilised the ARDL technique in data analysis. Interesting to note is that both studies investigated the symmetric link of the variables using different techniques but arrive at the same conclusions.

Muoneke, Okere, and Onuoha (2022) investigated the impact of exchange rates on export in six countries with different exchange rate regimes via the lens of Multiple asymmetric thresholds nonlinear ARDL. The study revealed that for Nigeria and Ghana with the flexible exchange rate regimes, both extreme appreciation and depreciation have consistently positive impacts across low, middle and high quantiles in the long run, but a mixture of positive and negative impacts in the short run depending on the quantile. While Gabon and DR Congo (pegging exchange rate regime) in the long run show lower export in the first and second quantiles, their export rises in the third quantile due to large exchange rate appreciation, but depreciation raises export across all quantiles. The short-run evidence of varying effects across quantiles for both large appreciation and depreciation was found. In the case of Algeria and Morocco (managed exchange rate regime), both small and large depreciation and appreciation exert no significant impact on export in the long run in Algeria; however, they have positive and significant effects in Morocco. In the short run, both small and large appreciation impacts export significantly in the second and third quantile, but depreciation reduces export across all quantiles, proving the existence of the J-curve in Algeria. A similar study was conducted by Okere et al. (2023) in selected African nations. The study utilised a multiple threshold-based asymmetric NARDL estimation approach to examine the moderating role of oil price in the foreign trade-exchange rate connection. The study's estimation outcome indicates, among others, that exchange rate depreciation worsens the selected countries' export, particularly Nigeria. The study further noted that given the exchange rate arrangement in the investigated countries, especially Nigeria and Ghana, high percentile swings in the country's currency largely reduces their exports.

In the context of Azerbaijan exchange rate changes, Mehtiyev, Magada, and Vasa (2021) explored how foreign trade responds to it. Taking cognisance of price change influence on exchange rate devaluation, applied correlation and simple regression in its analysis. The study observed an empirically direct correlation between the factors. Kamugisha and Assoua (2020) explored the link between currency devaluation and Ugandan current account balance utilising the ARDL estimation technique. The study

observed how the Ugandan government authority weakens the country's currency in recent times with the aim of boosting its current account position. The study's finding shows that currency weakening directly affects transnational trade in the short term, invalidating the J-curve hypothesis. Adopting the same approach in the context of Pakistan, Ali, Wuhab, and Khan (2022) examined the moderating function of trade balance in illuminating the influence of currency devaluation on economic growth between 1972 and 2016. The study invalidated the traditional theory that economic growth reacts inversely to currency devaluation through trade balance in the investigated country.

Arize, Malindretos, and Igwe (2017) used an approach that considers the nonlinear relationship between exchange rates and trade balance to investigate the series connectivity in eight selected countries. The results showed that all countries under investigation had a nonlinear cointegrating equilibrium, with long-term asymmetry being observed in most countries and short-term asymmetry in only four. The study found that the trade balance is more sensitive to depreciation than appreciation over the long term. Chien, Cheng, and Setyowati (2019) examined the effects of exchange rate volatility on Taiwan-Indonesia bilateral trade using industry-level data. They discovered that increased real exchange rate volatility decreases trade while decreased real exchange rate volatility increases trade in 12 industries, out of 19 export and import industries. In a different industry-level study, BahmaniOskooee and Durmaz (2020) investigated the effect of exchange rate volatility on the trade flows of 62 industries that transact with the EU and Turkey. They discovered that more industries are impacted by exchange rate volatility in the nonlinear than in the linear model, with asymmetric effects of volatility on 38 Turkish and 49 EU exporting industries in the short run and asymmetric effects in the long run on 19 industries. For the same Turkey and her major trading partner, Germany, VuraL (2016) found that real exchange rate depreciation impacts favourably the bilateral trade balance in 54 industries. Evidence of the J-curve effect was identified in 20 out of 96 industries while 12 industries exhibit inverse J-curve. Yildirim and Saraç (2022) used a Markov Regime Switching model to analyse the asymmetric impact of exchange rate volatility on Turkey-Germany trade. The study revealed that an increase in exchange rate significantly impacts positively the trade balance of Turkey with Germany during the expansion regime but produces negative and non-significant effects during the contraction regime. Though the study was not conducted at the industry level, the finding is much similar to other industry-level studies.

A study by Hashmi, Chang, and Shahbaz (2019) between India and her trading partners using a multiple threshold nonlinear autoregressive distributed lag model estimates that short-run exchange rate volatility does not significantly impact exports, but in the long run, extreme changes in exchange rate volatility have differing effects on India's exports to its major trading partners. A study by BahmaniOskooee and Nouira (2019) of Tunisia's trade with 16 partners contradicted Hashmi, Chang, and Shahbaz (2019) results of non-existent short-run effects as the study shows that depreciation and appreciation of exchange rate have differing effects on Tunisia's trade with Italy, Algeria, Russia, the UK, Belgium, India and the Netherlands in the short run, implying the short-term asymmetric effect of the exchange rate.

In the study of selected SSA countries, Memiago and Eita (2017)examined the connection between external trade and exchange rate movement from 1995 to 2012.

The study examined how exchange rate swings affect export, import, and trade balance in a separate three-single equation model. It adopted a static panel data analysis framework for 39 designated SSA nations. The research outcome showed a negative influence of exchange rate swings on export and trade balance but a direct influence on imports, invalidating the hypothetical view. The research resolved that depreciation does not have desired influence on export in SSA. Alemu (2014) studied how currency decline could influence the export sector in designated 14 Asian countries and later narrowed it down to eight Asian countries that are relatively bigger, industrialised, and stable. He employed panel regression estimation with random effect and feasible generalised least squares. Variables included in the model were real exchange rate used as a proxy for currency devaluing, trade balance, degree of openness, and income per capita. The outcome of his findings showed that depreciation/devaluation substantially and positively affect trade balance when collective data for the chosen 14 countries was used but after narrowing it down to 8 relatively bigger, industrialised, and stable Asian countries, it was found that devaluation improved trade balance. This result suggested that the effects of devaluation are determined by the size of the economy or the country's export base. Closely related in the sample but different in objective and method, Omojimite and Akpokodje (2010) examined a comparative analysis of the effect of exchange rate volatility on exports in eight CFA countries and eight non-CFA countries between the period 1986 and 2006. The research adopted GARCH-OLS and GARCH-GMM estimation techniques. In their result, they found out that volatility inversely affects export for both groups of countries.

In a similar study, Genc and Artar (2014) studied the exchange rates-exports-imports connectivity of 22 emerging countries. Their work had two specific objectives: to estimate the influence of exchange rates on imports and exports of the selected developing countries. They employed a panel cointegration method covering 1985 and 2012. Their result showed evidence of cointegration between real exchange rate and export and import of the emerging countries. Kamal (2015) chooses 33 nations, including both emerging and wealthy nations, to explore if currency weakening has an influence on changes in some countries' primary export goods. He used the panel data estimation technique to scrutinise the influence of devaluation on the main export goods of these nations between 1987 and 2011. To assess the sensitivity of the model of choice, the study utilised OLS, 2SLS and instrumental variable (IV) in a panel estimation framework. Real exchange rate and income per capita were the explanatory factors. His research revealed that exports drop as a result of currency devaluation rather than increasing. The study, thus, endorsed that countries should adopt the appropriate policy to improve transnational trade rather than currency depreciation/devaluation. Alege and Osabuohien (2015) investigated the trade-exchange rate nexus in 40 designated SSA nations between 1980 and 2008. They employed a partial equilibrium relative price approach in the panel data with both fixed and random effects framework to explore the rate of foreign trade to exchange rate changes. The study's estimated outcomes showed that both export and import were inelastic to exchange rate swings. They explained that currency weakening in SSA may not have the expected result in view of the structure of the economies and export composition. The study further argued that depreciation would not depress imports but only aggravates the region's BOP.

Table 1. Description of Variables and Data Sources.

Names	Description and Measurement	Source
REX	The nominal exchange rate multiplied by the countries' price ratio (P*/P) yields the real exchange rate. The local CPI is signified as P, and P* is measured by the US wholesale price index (2000=100).	WDI PWT
TRB	Current account balance in all transactions other than financial and capital items measured in US billion Dollar	IMF-WEO
TOP	The ratio of total trade (export and import) to GDP at current prices	WDI
TOT	Terms of trade adjusted at constant national pricesYear on Year inflation as a percentage of average CPIGross domestic saving as a percentage of GDP	WDI
INF	Year on Year inflation as a percentage of average CPI	IMF-WEO
SAV	Gross domestic saving as a percentage of GDP	IMF-WEO

WDI = World Development Indicators (2021). PWT = Penn World Table (10.0) available on www.ggdc.net/pwt. WEO = International Monetary Fund (IMF), World Economic Outlook, IMF (2021) Source: Compiled by the Author.

3. Methodological issues and data used

This study utilised Terasvirta's Smooth Transition Regression (STR) model to assess the asymmetric reaction of trade balance to currency devaluation in some selected SSA countries; countries included in the sample for the study include Nigeria, Ghana, Kenya, Tanzania, Mozambique, and Malawi (Terasvirta 1998, 2004). The aggregation of SSA countries into three non-overlapping groups: oil exporters, other resource-intensive countries, and non-resource-intensive countries (World Economic Outlook, 2021) influenced the selection of the investigated countries. Countries were chosen in proportion to the number of countries in each group, as follows: one country (Nigeria) was chosen among the eight oil exporters, two countries (Ghana and Tanzania) were selected among the 15 other resource-intensive countries, and three countries (Kenya, Malawi and Mozambique) were selected from among the 22 non-resource-intensive countries. Furthermore, the selection reflects the World Bank income classifications, which place SSA countries predominantly in the middle and low-income categories, with Ghana, Kenya and Nigeria classified as middle-income countries and Malawi, Mozambique, and Tanzania classified as low-income countries. Several pre-estimation tests such as the BDS test of linearity, descriptive statistics, Bayesian information lag length selection, and unit root test were carried out to ascertain the appropriate model estimation. To calculate the stationarity features, the study used the Zivot and Andrews (1992) unit root test with a structural break. The sources of the data and measurements of the variables used in this work are in Table 1:

3.1. Smooth transition regression (STR) model

Contingent upon the transition variable, STR models regime change as a continuous procedure. This model presupposes a smooth transition of a factor from one regime to another, incorporating the nonlinear regime switching behaviour in both the unknown and known regime periods (Odionye and Chukwu 2021; Terasvirta 1998, 2004). Expressing the STR in its generic nature as:

$$y_t = \delta' z_t + \varphi' z_t G(S_t; \gamma, c) + \varepsilon_t \quad (1)$$

where $\varepsilon_t : iid[0, \sigma^2], z_t = \left(w_t^{'}, z_t^{'}\right)^{'}$ is an $((n+1) \times 1)$ vector of exogenous variables, as δ represents the linear coefficient and φ signifies the nonlinear coefficient. The regime-changing variable S determines the continuous transition function G, which ranges between 0 and 1, with 0 denoting the zero-policy era in this context, the non-devaluation regime, and 1 denoting the devaluation period. γ indicates the speed of change between different regimes, and c represents the threshold value. Exogenous factors, lagged of the endogenous variable or trend value, are the prospective variables for transition (t) (Terasvirta 2004). Selecting the regime-changing variable is the first stage in the estimation process. To do this, the null hypothesis for each potential regime-changing factor is tested. The next stage is the selection of a regime-changing function, selected by testing a series of hypotheses against the following auxiliary polynomial orders:

$$y_t = \alpha_0 z_t^{'} + \alpha_1\left(z_t^{'} S_t\right) + \alpha_2\left(z_t^{'} S_t^{II}\right) + b_3\left(z_t^{'} S_t^{III}\right) + \varepsilon_t \tag{2}$$

This is hypothetically stated in null form as:

$$\begin{aligned} &H_{o4} : \eta_3 = 0 \\ &H_{o3} : \eta_2 = 0 \;\; \eta_3 = 0 \\ &H_{o2} : \eta_1 = 0 \;\; \eta_2 = \eta_3 = 0 \end{aligned} \tag{3}$$

The set of F-tests (F^4, F^3, and F^2, respectively) are used to ascertain the aforementioned hypotheses. LSTR2 or the ESTR model is selected if the decline of F^3 has the minimum p-value, whereas LSTR1 is the best model if F^4 or F^2 has the least p-value (Terasvirta 2004).

3.2. Asymmetric reactions of trade balance to currency devaluation in STR model

The STR model is specified following Alege and Osabuohien (2015) and Alalade, Adekunle, and Joseph (2014) and in tandem with the hypothetical view as:

$$\begin{aligned} TRB_{it} = \varpi + \sum_{j=0}^{p} \phi_{ij} LREX_{it-j} + \sum_{j=0}^{p} \psi_{ij} LTOP_{t-j} + \sum_{j=0}^{p} \delta_{ij} TOT_{it-j} + \sum_{j=0}^{p} \eta_{ij} LSAV_{it-j} \\ + \sum_{j=0}^{p} \pi_{ij} INF_{it-j} + G(S_{it}; \gamma, c)\left(\sum_{j=0}^{p} \lambda_{ij} LREX_{it-j}\right) + \varepsilon_{it} \end{aligned} \tag{4}$$

where TRB, LREX, LTOP, TOT, LSAV and INF represent trade balance, real exchange rate, trade openness, domestic saving and inflation rate respectively. L represents natural log. The choice of the control variables was based on theoretical views and past related studies (Alalade, Adekunle, and Joseph 2014; Alege and Osabuohien (2015); Nasir and Leung, 2021; Ikpe et al. (2021). The definition and measurements of these variables are contained in Table 1

4. Empirical results and discussion

4.1. Descriptive analysis

Every empirical presentation usually starts with some initial descriptive statistics that prepare the way for more robust estimates. As a result, summary statistics were applied to

the applicable series for this investigation. This analysis, amongst other things, indicates the form of the distributions as well as the series' behavioural trend. Particularly, descriptive statistics provide information that highlights whether the series are typically distrusted, thus the test results summarised in Table 2

Table 2 demonstrates the descriptive statistics which was carried out before the variables were log-transformed to enable us ascertain their true behavioural patterns. The Jarque-Bera statistics indicates the rejection of the null hypothesis of normal distribution for most of the series in all the investigated samples. This test justifies the use of a nonlinear model (Ozcelebi 2021; Ullah et al. 2022).

Table 2. Descriptive Statistics.

Series	Mean	Maximum	Std_Dev	Skewness	Kurtosis	J_B Stat.
Nigeria						
TRB	5.29	36.53	12.30	0.79	3.58	5.06**
REX	154.78	275.72	61.13	−0.25	2.04	2.05
TOP	1.14E−07	2.05E−07	4.62E−08	0.28	1.81	3.02
TOT	5.90E+11	1.84E+13	5.46E+12	2.00	6.03	44.3***
INF	18.57	72.72	16.11	1.84	5.55	35.27**
SAV	20.17	37.11	7.06	0.36	2.68	1.10
Tanzania						
TRB	−1.22	−0.09	1.31	−1.46	4.21	17.54***
REX	1142.51	1569.36	315.06	−0.82	2.78	4.78*
TOP	2.15E−08	4.17E−08	1.21E−08	0.60	1.61	5.91**
TOT	−1.56E+11	3.44E+11	2.55E+11	0.18	2.61	0.51
INF	17.36	47.70	11.03	0.70	8.69	11.6**
SAV	20.03	39.09	9.11	0.107	2.17	1.29
Kenya						
TRB	−2.18	0.13	3.11	−1.39	3.49	13.96***
REX	60.15	103.41	32.16	−0.34	1.73	3.65
TOP	1.56E−10	2.67E−10	7.41E−11	0.45	1.45	5.69**
TOT	−9.96E+10	−2.88E+10	4.43E+10	−1.01	4.16	9.48***
INF	10.89	45.98	7.95	2.52	10.77	150.2**
SAV	9.68	16.04	3.75	2.31	7.86	8.96**
Ghana						
TRB	−1.12	−0.05	1.12	−0.82	2.18	6.01**
REX	1.39	2.77	0.73	0.20	2.48	0.75
TOP	2.28E−08	5.06E−08	1.23E−08	0.70	2.19	4.59
INF	25.53	122.88	24.60	2.78	10.98	165.9**
SAV	20.18	41.53	10.36	0.03	2.33	0.79
Malawi						
TRB	−0.36	0.04	0.29	−1.82	4.92	29.77***
RXR	6760.66	31773.17	9986.29	1.56	4.01	18.83***
TOP	6.53E−10	1.05E−09	2.00E−10	0.42	1.93	3.21
TOT	1.08E+10	5.83E+10	2.09E+10	0.84	2.63	5.25*
INF	21.44	83.15	13.70	2.24	10.81	143.9**
SAV	3.15	16.21	4.98	0.06	3.89	1.41
Mozambique						
TRB	−1.92	−0.19	2.12	−0.99	2.26	6.99**
REX	36.54	56.62	11.45	−0.17	3.07	0.18
TOP	2.84E−09	5.64E−09	1.79E−09	0.36	1.47	4.41
TOT	−1.15E+08	1.58E+10	1.11E+10	−0.95	3.08	5.65**
INF	22.92	164.11	30.08	2.98	14.13	245.8**
SAV	13.78	31.54	6.90	0.55	2.80	1.97

Authors' computation. Data for terms of trade (TOT was not available for Ghana as at the time of his study. *** (**) [*] represent rejection of null hypothesis of normal distribution at 1% (5%)[10%] level of significance respectively. TRB denotes trade balance; REX denotes real exchange rate, TOP represents trade openness TOT represents terms of trade, INF is inflation rate while SAV is the domestic savings.

4.2. BDS test

The Broock et al. (1996) estimation, also known as the BDS test, was used to confirm the nonlinear feature of the data series. The null hypothesis in this test assumes independent and identically distributed (i.i.d) residuals, while the alternative presupposes that the residual series deviates from independence, indicating nonlinear dependence The outcome of the BDS test is summarised in Table 3.

As indicated in Table 3, except for Ghana ($M = 2$), Malawi ($M = 2$, 3 and 4) for model residual 1 and Malawi ($M = 6$) for model residual 2, the outcome demonstrates the rejection of the null hypothesis of the BDS in the model residuals of all the countries, and in favour of the alternative hypothesis. The estimation establishes that the model residuals exhibit nonlinear behaviour, requiring the use of a nonlinear methodology (Ozcelebi 2021; Ullah et al. 2021, 2022)

4.3. Unit root test

Since the designated nations had practiced different exchange rates regimes and devalued national currencies at one point or the other, the study employed Zivot and Andrews (1992) stationarity test with a structural break to account for policy change to evade misleading inference (Odionye and Chukwu 2021; Odionye, Ojiaku, and Uba 2023; Perron 1989, 1997), and the summary of the outcome is presented in Table 4.

As anticipated, Table 4 demonstrates that the majority of the variables were stationary at the initial difference. It also demonstrates that, with the exception of Malawi and Tanzania, all the variables were incorporated in a different order. In order to prevent giving false results, tests that were carried out thereafter were dependent on the appropriateness of their integration order.

4.4. Selection of best regime-changing variable and function

Selection of the potential regime-changing variables is a prerequisite for STR estimation, and the algorithm automatically chooses the best regime-changing variable. In this study, real exchange rate (REX) was selected as the regime-changing variable, and two (2) was

Table 3. Summary of BDS Outcomes.

Dimension	Nigeria	Ghana	Kenya	Malawi	Tanzania	Mozambique
Model Residual 1: TRB = f (cons, REX, TOP, TOT, INF, SAV)						
$M = 2$	0.059** (0.000)	0.022 (0.170)	0.088** (0.000)	0.018 (0.190)	0.066** (0.000)	0.061** (0.000)
$M = 3$	0.123** (0.000)	0.079** (0.002)	0.143** (0.000)	0.014 (0.531)	0.119** (0.000)	0.117** (0.000)
$M = 4$	0.163** (0.000)	0.196** (0.001)	0.163** (0.000)	0.047 (0.09)	0.164** (0.000)	0.156** (0.000)
$M = 5$	0.209** (0.000)	0.117** (0.000)	0.156** (0.000)	0.094** (0.002)	0.182** (0.000)	0.172** (0.000)
$M = 6$	0.241** (0.000)	0.114** (0.000)	0.138** (0.000)	0.074* (0.014)	0.161** (0.000)	0.166** (0.000)
Model Residual 2: d(TRB) = f (cons, d(REX), d(TOP), d(TOT), d(INF), d(SAV))						
$M = 2$	0.127** (0.000)	0.069** (0.000)	0.042** (0.000)	0.040* (0.020)	0.043* (0.000)	0.173** (0.000)
$M = 3$	0.199** (0.000)	0.133** (0.000)	0.082** (0.000)	0.080** (0.005)	0.076* (0.000)	0.279** (0.000)
$M = 4$	0.235** (0.000)	0.157** (0.000)	0.107** (0.000)	0.101** (0.003)	0.127** (0.000)	0.332** (0.000)
$M = 5$	0.249** (0.000)	0.154** (0.000)	0.111** (0.000)	0.075* (0.043)	0.161** (0.000)	0.349** (0.000)
$M = 6$	0.244** (0.000)	0.131** (0.000)	0.101** (0.000)	0.027 (0.459)	0.155** (0.000)	0.345**\(0.000)

Authors' computation. ** and * indicate rejection of null hypothesis of linearity at 1% and 5% level of significance. Figures in parentheses are the p-values. The distance value selected for the estimates is 0.7.

Table 4. Summary of Zivot-Andrews URT.

Country	Nigeria		Ghana		Kenya		Malawi		Tanzania		Mozambique	
Variables	URT	O I	URT	O I	URT	O I	URT	O I	URT	O I	URT	O I
REX	−576*	1	−6.23**	0	−6.71**	0	−7.32**	1	−8.48**	1	−7.64**	0
	(−4.73)		(−5.57)		(−5.57)		(−5.57)		(−5.34)		(−5.34)	
TRB	−5.04*	0	−5.17*	0	−6.08**	1	−10.3**	1	−5.60**	1	−6.17**	0
	(−4.93)		(−5.08)		(−5.57)		(−5.14)		(−5.34)		(−5.43)	
TOP	−5.24*	1	−7.04**	1	−6.72**	0	−6.17**	1	−7.10**	1	−6.64**	2
	(−4.91)		(−5.34)		(−5.57)		(−5.34)		(−5.57)		(−5.57)	
TOT	−5.24**	1	NA	-	−4.05**	0	−5.32**	1	−6.13*	1	−6.51**	1
	(−4.93)				(−3.57)		(−4.34)		(−5.93)		(−5.57)	
INF	−3.24*	0	−4.78**	0	−6.75**	0	−3.62**	0	−3.42*	1	−4.88**	0
	(−2.94)		(−3.60)		(−3.75)		(−3.62)		(−2.94)		(−3.69)	
SAV	−5.15**	1	−9.42**	1	−10/3**	1	−9.11**	1	−5.83**	1	−4.12**	0
	(−3.61)		(−3.61)		(−3.61)		(−3.61)		(−3.61)		(−3.63)	

URT is a unit root test, figures in parenthesis are critical values. ** (*) denote statistically significant at 1% and 5% significance levels respectively. OI represents the integration order of the series.
Source: Computed by the Author using E-views 12.0.

determined to be the appropriate lag value based on information criteria. The linearity of each regime-changing variable was then tested against STR to choose the ideal regime-changing function. The table below shows the linearity's outcome:

Table 5 indicates that logistic STR (LSTR-1) is the suitable regime-changing function for Nigeria, Kenya, Mozambique, Tanzania, and Ghana while quadratic logistic STR (LSTR2) is the ideal model for Malawi. Accordingly, the nonlinear model's regimes correspond to devaluation (depreciation), with G = 1, vs non-devaluation, with G = 0. The outcome confirms that trade balances in all of the investigated nations exhibit asymmetric reactions to devaluation and non-devaluation regimes, but in Malawi, the form is a non-monotonous change from one state that is asymmetric about the threshold parameter (c). The current period of the real exchange rate (REXt) is used as the regime-changing variable for Ghana and Malawi, while the factor at lagged one is used for Nigeria, Kenya, Mozambique, and Tanzania (REXt-1). Table 6 provides the results' executive summary.

The result from Table 6 has three parts. The first part indicates the coefficients of the threshold value (c) and the speed of regime-changing (γ). The threshold values show a mixed result with Nigeria, Malawi, and Tanzania having negative threshold parameters while Ghana, Kenya, and Mozambique have positive threshold parameters. The threshold parameter of −0.0021 for Nigeria which is approximately zero suggests that some level of stability in exchange is needed for the improvement of the country's trade balance. A negative value of the threshold parameter based on the study's definition of

Table 5. Linearity tests against STR-Trade Balance model with $S_t = REX_{t-i.}$

	Nigeria	Kenya	Malawi	Mozambique	Tanzania	Ghana
Null hypothesis	REX_t	REX_t	REX_{t-1}	REX_t	REX_t	REX_{t-1}
F	5.97E−03	4.97E−03	1.64E−02	9.97E−03	5.77E−03	5.43E−02
F^4	1.13E−01	1.13E−01	6.05E−02	1.16E−01	1.13E−01	6.04E−03
F^3	2.94E−02	2.94E02	1.17E−02*	2.94E−02	2.99E−02	9.27E−01
F^2	2.67E−04*	2.67E−05*	7.88E−01	1.46E−04*	1.66E−04*	1.34E−02
Nominated model	LSTR-1	LSTR-1	LSTR-2	LSTR-1	LSTR-1	LSTR-1

The statistics are the p-values of LM linearity test. * denotes a regime-changing function with the least p-values Source: *Computed by the Author using JMulTi 4.0.*

Table 6. Summary of STR results of Asymmetric Reactions of Trade Balance to Currency Devaluation.

Country						
Variables	Nigeria	Ghana	Kenya	Malawi	Tanzania	Mozambique
Threshold	−0.0021	0.125	0.32**	−0.017	−0.009	0.493**
C1	(0.78)	(0.95)	(0.005)	(0.450)	(0.45)	(0.009)
C2				−0.015 (0.629)		
Speed of regime-changing γ	604.8	246.81**	34.21	7.236**	6.321	7.651**
	(0.16)	(0.0014)	(0.204)	(0.003)	(0.981)	(0.002)
G = 0 Non-devaluation Regime						
Constant	0.067** (0.002)	−0.23	−0.562	0.812	5.232	12.76**
		(0.99)	(0.31)	(0.110)	(0.09)	(0.009)
$lnREX_t$	3.21**	−0.016	−0.24	0.61	−28.713	−14.41**
	(0.009)	(0.62)	(0.06)	(0.312)	(0.62)	(0.0001)
$lnTOP_t$	4.26**	−0.10	−0.75	2.09*	1.95	53.91*
	(0.002)	(0.08)	(0.82)	(0.001)	(0.34)	(0.050)
TOT_t	0.0214	NA	−0.0002	0.0007	0.00006	0.021**
	(0.82)		(0.51)	(0.450)	(0.83)	(0.001)
lnREX (−1)		−0.8		35.12**		
		(0.56)		(0.001)		
lnTOP (−1)		−0.07		0.43		
		(0.23)		(0.98)		
TOT (−1)		NA		−0.00002**		
				(0.001)		
INF	0.23	−0.05*	−0.13**	−1.23	0.34*	1.2
	(0.23)	(0.04)	(0.006)	(0.09)	(0.03)	(0.16)
LnSAV	0.03**	0.018*	0.23**	−0.04	1.06**	0.04
	(0.001)	(0.04)	(0.008)	(0.06)	(0.008)	(0.14)
G = 1 Devaluation regime						
Constant	4.01*	−1.56**	12.6**	−0.13*	−14.04	−81.09**
	(0.046)	(0.001)	(0.001)	(0.04)	(0.69)	(0.007)
$lnREX_t$	−3.67** (0.01)	4.71**	−26.89*	−2.09	−31.81	−18.35**
		(0.000)	(0.047)	(0.93)	(0.39)	(0.003)
$lnTOP_t$	−6.11**	0.84	10.78	−2.48**	−2.01	−10.09
	(0.009)	(0.77)	(0.09)	(0.01)	(0.61)	(0.10)
TOT_t	−0.00042	NA	−0.0090	−0.008	−0.003	−0.045*
	(0.46)		(0.99)	(0.25)	(0.56)	(0.045)
$lnREX_{t-1}$		5.271**		−28.71**		
		(0.007)		(0.009)		
$lnTOP_{t-1}$		2.67		−0.79		
		(0.66)		(0.09)		
TOT_{t-1}		NA		0.00007**		
				(0.0009)		
INF	−0.07*	−0.10*	−0.61*	0.13	0.04*	−2.1**
	(0.03)	(0.02)	(0.050)	(0.14)	(0.02)	(0.002)
LnSAV	1.04*	0.31*	0.12**	−0.07	1.13*	−0.14**
	(0.03)	(0.02)	(0.008)	(0.09)	(0.02)	(0.001)
Robustness Checks						
R^2	0.711	0.783	0.878	0.745	0.608	0.936
Adj. R^2	0.704	0.776	0.864	0.729	0.601	0.921
Arch Test	(0.85)	(0.09)	(0.12)	(0.65)	(0.10)	(0.41
J.B Test	(0.32)	(0.09)	(0.65)	(0.98)	(0.02)	(0.001)
Auco (2)	(0.35)	(0.11)	(0.19)	(0.07)	(0.001)	(0.39)
PC	(0.15)	(0.61)	(0.09)	(0.09)	(0.001)	(0.37)

Numbers in parenthesis are *p*- values of t-statistics. ** (*) denote 1% and 5% significance level respectively. Auco signifies a test of autocorrelation. PC denotes LM test for parameter constancy. *Source: Computed by the Author using JMulTi 4.0.*

exchange rate implies appreciation and thus 0.21% appreciation of exchange rate is relatively low and stable. This can be a consequence of the fact that Nigeria, being a net importer in all sectors except the oil sector where oil export, arguably does not depend on exchange rate, and hence exchange rate depreciation/devaluation does not

improve its trade balance (see Anoke, Odo, and Ogbonna 2016). This corroborates the outcome of Onwuka and Obi (2015) who found that exchange rate stability is needful to enhance economic advancement in designated SSA as well as Okere et al. (2023). Okere et al. (2023) observed that the export is positively influenced, in the short-run, by the currency appreciation in Nigeria and Gabon. This is also applicable to Malawi and Tanzania whose threshold parameters are −0.017 and −0.009 respectively. Threshold values are positive in the cases of Ghana, Kenya, and Mozambique, meaning that currency devaluation/depreciation within 12.5%, 32%, and 49.3% of each country's threshold level will enhance trade balances, whereas depreciation high and above the threshold level will harm trade balances.

The outcome of the regime-changing factor demonstrates that, for Malawi, Tanzania, and Mozambique, the regime-changing between two extreme regimes-devaluation and non-devaluation regimes is smooth, while for Nigeria, Ghana, and Kenya, it is high, indicating a transition that is rather sudden and unexpected. The coefficients of regime-changing were negligible for Nigeria, Kenya, and Tanzania, but are significant for Ghana, Malawi, and Mozambique because their p-values are less than 0.05. This implies that while the impact of devaluation as a policy change is small for Nigeria, Kenya, and Tanzania, it has a considerable influence on the trade balance for Ghana, Malawi, and Mozambique. The greatest regime-changing coefficient, though insignificant, belongs to Nigeria, which is followed in that order by Ghana and Kenya. This result implies that Nigeria recorded the highest rate of regime-changing in the exchange rate market, but interestingly, this policy change had little influence on the trade balance. This may be explained by the country's high level of policy inconsistency and the fact that Nigeria's export base is primarily comprised of oil exports, which do not entirely depend on exchange rates, leading to the trade balance reacting inconsequentially to devaluation as a policy shift.

From Table 6 (non-devaluation regime), the actual exchange rate is negative but insignificant for Ghana, Kenya, and Tanzania, but positive and substantial for Nigeria and Malawi. The findings for Nigeria and Malawi show that exchange rate depreciation improves these nations' trade balances during non-devaluation periods but worsens them during devaluation periods. This advocates that as the country's government introduces a more flexible exchange rate or devalued its currency, further depreciation in the exchange rate reduces or worsens their trade balances. This result validates the J-curve theory that states that devaluation of a country's currency will first worsen its trade balance before improving it and partly corroborates the research outcome of Gebeyehu (2014) that following currency devaluation, the trade balance first declines before it improves subsequently. This result supports the findings of BahmaniOskooee and Durmaz (2020) and Yildirim and Saraç (2022).

The findings from the third part of Table 6 (devaluation regime) indicate that Ghanaian trade balance asymmetrically reacts directly and meaningfully to exchange rate in the currency devaluation era while the trade balances of Nigeria, Kenya, Malawi, and Mozambique respond inversely and significantly to changes in the exchange rate. This outcome corroborates the findings of Okpeku and Aras (2022), Okere et al. (2023), and Muoneke, Okere, and Onuoha (2022) all for selected African countries, and Anoke, Odo, and Ogbonna (2016), Aliyu and Tijjani (2015), Thahara, Rinosha, and Shifaniya (2021), Yildirim and Saraç (2022) and Arize, Malindretos, and Igwe (2017). In Tanzania's context, the parameter of exchange rate is negative but insignificant. The negative and substantial exchange rate parameters for Nigeria, Kenya, Malawi, and Mozambique

suggest that a 1% rise (depreciation) in currency rates will deteriorate each country's trade balance by 3.7%, 26.9%, 28.7%, and 18.4%, respectively. The outcome of Bhat and Bhat (2021) in India that exchange rate loss boosts trade balance whereas gain worsens it, is supported by the positive and large asymmetric reaction of the trade balance to currency devaluation. These findings support the structural school of thinking, which holds that a depreciation/devaluation of the currency rate will cause the trade balance of emerging nations that are import-dependent to contract (worsen). This confirms the conclusions of Okere et al. (2023); Muoneke, Okere, and Onuoha (2022); Alege and Osabuohien (2015) and Kamal (2015). Kamal (2015) discovered that in several poor countries, weak currency results in a decline in exports as opposed to an upsurge in imports. Alege and Osabuohien (2015) looked at the transnational trade-exchange rates connectivity in 40 SSA countries and discovered that, given the export-heavy nature of the region, currency devaluation did not improve the trade balance and actually made the BOP imbalance worse. The conflicting outcomes of the asymmetric reaction of the trade balance to currency devaluation in these selected countries support the opinion that the devaluation effects vary with the state and structural features of an economy.

In the non-devaluation era, the parameters of trade openness (TOP) have a direct and considerable influence on the trade balance in Nigeria, Malawi, and Mozambique. According to the results, a 1% increase in trade openness will raise each country's trade balance by 4.3%, 2.1%, and 53.9%, respectively. This is in keeping with the theoretical supposition that as a nation opens its international borders, its export base should grow relative to its import base. This is in line with the finding of Ju, Wu, and Zeng (2010) that studied the trade liberalisation-trade balance connectivity in poor nations and found evidence of a direct and substantial effect of trade openness on trade balances.

On the contrary, the result from the devaluation era indicates that trade openness significantly but inversely influences trade balances in Nigeria and Malawi, but in the context of Tanzania and Mozambique, although negative, it is insignificant. These negative and significant coefficients suggest that during devaluation, imports increase relatively quickly to trade openness than export thereby leading to a worsening of the trade balance (Santos-Paulino 2004). This result equally corroborates the empirical outcome of Zakaria (2014) who studied the exchange rate-export-import connectivity in Pakistan. He observed that after Pakistan weakened its currency by 137% in 1972, imports outstripped the increase in export, and the deficit trade balance persisted for a long period. Using different techniques, the study found an inverse and significant link between openness and trade balance in Pakistan.

Pertaining to savings, the study's outcome demonstrates that during the non-devaluation era, elevated saving significantly improves the trade balances of Nigeria, Ghana, Kenya and Tanzania by 0.03, 0.018, 0.23 and 1.06% respectively, whereas in the context of Malawi and Mozambique, it indicates inconsequential influence. In the devaluation era, the saving rate largely increases the trade balances of Nigeria, Ghana, Kenya, and Tanzania. The study's outcome demonstrates that relatively, the saving rate significantly influences the trade balances of the majority of the selected countries (Nigeria, Ghana, Kenya, and Tanzania) more in the devaluation period. This outcome upholds the hypothetical view that savings rate reduces the domestic interest rate through an elevated loanable fund. The reduction in interest rate leads to an increase in indigenous investment and hence increases domestic production, thereby improving the countries' trade balances. This result supports the finding of Nusir and Leung (2021) in the case of the US.

In the case of the inflation rate, the study upholds the theoretical view only in Kenya as the series significantly reduces trade balance in the non-devaluation period. However, in the devaluation era, elevated inflation largely deteriorates the trade balances of Nigeria, Ghana, Kenya and Mozambique. This validates the theoretical preposition that a rise in the domestic price level will worsen the country's trade balance The study's outcome align with the finding of Nusir and Leung (2021) in the context of the US.

Considering the elevated R square of above 70% in all the nations with the exception of Tanzania, where the R square is 60.8%, the coefficients of multiple determination results demonstrate that the variability in predictors substantially predicts the changes in the response variable.

A number of robust tests were carried out, which include the Arch LM test, Jarque-Bera test, Auto-correlation test, and parameter constancy test, to ensure the resilience and validity of the estimated STR model. The model passed the primary diagnostic test in most of the sampled countries. The p-values for the Arch LM test all exceeded 0.05, indicating no arch effect in the model. For the Jarque-Bera estimates, the p-values indicate that the residual is normally distributed for Nigeria, Ghana, Kenya, and Malawi, but not for Tanzania and Mozambique. Furthermore, the auto-correlation estimates (with the exception of Tanzania) indicate, absence of serial autocorrelation in the STR model. Finally, with the exception of Tanzania, the results demonstrate a signal of parameter constancy, with p-values of the parameter constancy test larger than 0.05.

5. Conclusion and policy implication

The study employed the STR model to investigate the threshold-based asymmetric reaction of the trade balance to currency devaluation as a policy change in selected SSA countries. In estimation, the STR model divided the regressors into regimes with and without devaluation of exchange rates. The BDS and Jarque-Bera tests justify the use of nonlinear tests as the ideal model for the study. The model selection outcome preferred the steeply sloping, zero-centred logistic regime-changing function. The chosen model suggests that trade balance reacts asymmetrically to devaluation and non-devaluation regimes, with $G = 1$ relating to devaluation (depreciation) and $G = 0$ relating to non-devaluation. The threshold levels show a mixed result with Nigeria, Malawi, and Tanzania having negative threshold parameters while Ghana, Kenya, and Mozambique have positive threshold parameters. The threshold parameters of −0.0021, −0.017, and −0.009 for Nigeria, Malawi, and Tanzania respectively, which are approximately zero, suggest that some level of stability in the exchange rate is needed for the improvement of the country's trade balance. The negative value of the threshold parameter based on the definition of exchange rate implies appreciation; thus 0.21%, 1.7%, and 0.9% appreciation of exchange rate in the respective countries being relatively low will boost trade balance. In the case of Ghana, Kenya, and Mozambique, threshold levels are positive, implying that exchange rate depreciation within 12.5%, 32%, and 49.3% respectively will improve trade balance in these respective countries but, depreciation – high and above the threshold level will worsen their trade balances. On average, exchange rate depreciation within the threshold parameter of 14.7% improves trade balance but high and above 14.7% worsen the investigated countries' trade balance.

The outcome of the regime-changing parameter indicates that, for Tanzania, Mozambique, and Malawi, smooth change from one exchange rate regime to another took place while those of Kenya, Tanzania, and Nigeria were sudden and unexpected. It further indicates that devaluation as a policy tool significantly influences trade balances in Ghana, Malawi, and Mozambique while other countries were negligible. These inconsistent outcomes infer that currency devaluation influence hinges on the nation's structure and level of infrastructure development, and the extent of demand shifting from foreign goods to exporting items. Consequent to the observed results, the following recommendations are made: (i) a robust structural transformation in crucial sectors of these countries' economies is needed to enhance international competitiveness. (ii) To tackle major obstacles, nations should strive to prudently improve infrastructure development to lower production costs and boost domestic supply. (iii) It is important to adopt strategies that will remove structural barriers that have a detrimental impact on both the business environment and production costs. (iv) intelligent import restrictions on goods that can be produced locally are required as well as providing a business-friendly environment for the production of such goods (this includes tax holidays, soft loans, removing bottlenecks in access to credit, etc).

Acknowledgments

Authors are grateful to two anonymous reviewers for their valuable comments and suggestions.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This study was not funded either by any agency, institution or government.

Data availability statement

The World Bank, Washington, D. C. http://data.worldbank.org/indicator.

Ethical approval

The article does not contain any studies with human participants or animal participants by any of the authors.

References

Acar, M. 2000. "Devaluation in Developing Countries: Expansion or Contraction?" *Journal of Economics and Social Science Research* 2 (1): 59–83.

Akinwale, S. O., M. D. Solawon, E. O. Adekunle, and T. O. Obagunwa. 2018. "Exchange Rate Devaluation and Balance of Trade in Nigeria: An Error Correction Model Approach." *International Journal of Innovative Research & Development* 7 (8): 137–143. https://doi.org/10.24940/ijird/2018/v7/i8/AUG18084 .

Alalade, S. Y., O. Adekunle, and O. A. Joseph. 2014. "Foreign Exchange Rate Regimes and Non-Oil Export Performance in Nigeria." *International Journal of Business and Behavioral Sciences* 4 (1): 1–22.
Alege, P. O., and E. S. Osabuohien. 2015. "Trade-Exchange Rate Nexus in Sub-Saharan African Countries: Evidence from Panel Cointegration Analysis." *Foreign Trade Review* 50 (3): 151–167. https://doi.org/10.1177/0015732515589440.
Alemu, A. M. 2014. "Examining the Effects of Currency Depreciation on Trade Balance in Selected Asian Economies." *International Journal of Global Business* 7 (1): 59–76.
Ali, N., A. Wuhab, and K. Khan. 2022. "The Effects of Devaluation of Currency on Economic Growth: The Mediating Role of Current Account Deficit." *Global Economic Review* VII (1): 145–156. https://doi.org/10.31703/ger.2022(VII-I).12 .
Aliyu, A. J., and S. M. Tijjani. 2015. "Asymmetric Cointegration Between Exchange Rate and Trade Balance in Nigeria." *Cogent Economics & Finance* 3 (1): 1–19. https://doi.org/10.1080/23322039.2015.1045213.
Anoke, C. I., S. I. Odo, and B. C. Ogbonna. 2016. "Effect of Exchange Rate Depreciation on Trade Balance in Nigeria." *IOSR Journal of Humanities and Social Sciences* 21 (3): 72–81.
Apamisile, O. T., and O. M. Oloba. 2020. "Asymmetric Effects of Exchange Rate Changes on Cross-Border Trade in Nigeria." *Future Business Journal* 6 (8): 1–9. https://doi.org/10.1186/s43093-020-00013-0.
Arize, A. C., J. Malindretos, and E. U. Igwe. 2017. "Do Exchange Rate Changes Improve the Trade Balance: An Asymmetric Nonlinear Cointegration Approach." *International Review of Economics and Finance* 45:316–326. https://doi.org/10.1016/j.iref.2017.02.007.
Auboin, M., and M. Ruta. 2011. "The Relationship Between Exchange Rates and International Trade: A Literature Review." *World Trade Review* 12 (3): 577–605. https://doi.org/10.1017/S1474745613000025.
BahmaniOskooee, M., and N. Durmaz. 2020. "Exchange Rate Volatility and Turkey–EU Commodity Trade: An Asymmetry Analysis." *Empirica* 48 (2): 429–482. https://doi.org/10.1007/s10663-020-09472-8.
BahmaniOskooee, M., and R. Nouira. 2019. "On the Impact of Exchange Rate Volatility on Tunisia's Trade with 16 Partners: An Asymmetry Analysis." *Economic Change and Restructuring* 53 (3): 357–378. https://doi.org/10.1007/s10644-019-09250-y.
Baldwin, R., and P. Krugman. 1989. "Persistent Trade Effects of Large Exchange Rate Shocks." *Quarterly Journal of Economics* 104 (4): 635–654. https://doi.org/10.2307/2937860 .
Bhat, S. A., and J. A. Bhat. 2021. "Impact of Exchange Rate Changes on the Trade Balance of India: An Asymmetric Nonlinear Cointegration Approach." *Foreign Trade Review* 56 (1): 71–88. https://doi.org/10.1177/0015732520961328.
Broock, W.A., Scheinkman, J. A., Dechert, W. D., and Lebaron, B. 1996. A test for independence based on the correlation dimension. *Economic Review* 15 (3): 197–233. https://doi.org/10.1080/07474939608800353.
Buba, S., S. M. I. Al-Jadi, and G. M. Guza. 2018. "Asymmetric Cointegration Between Exchange Rate and Trade Balance in Thailand." *World Journal of Economic and Finance* 4 (1): 75–84.
Bussiere, M. 2013. "Exchange Rate Pass-Through to Trade Prices: The Role of Nonlinearities and Asymmetries." *Oxford Bulletin of Economics and Statistics* 73 (5): 731–758. https://doi.org/10.1111/j.1468-0084.2012.00711.x .
CBN. 2021. *Central Bank of Nigeria Statistical Bulletin*. Abuja: CBN.
Chien, M., C. Cheng, and N. Setyowati. 2019 Asymmetric Effects of Exchange Rate Volatility on Bilateral Trade Between Taiwan and Indonesia. *The Singapore Economic Review*, pp 1–44
Cooper, R. N. 1971. "Currency Devaluation in Developing Countries." *Essays in International Finance* 86 (1): 1–38.
Dixit, A. K. 1989. "Hysteresis, Import Penetration and Exchange Rate Pass Through." *The Quarterly Journal of Economics* 104 (2): 205–228. https://doi.org/10.2307/2937845 .
Dong, W. 2007. *Expenditure Switching Effect and the Choice of Exchange Rate Regime*. International Department, Bank of Canada. May 9, 2007, wdong@bank-banque-canada.ca.
Duru, I. U., M. A. Eze, A. S. Saleh, A. Yusuf, and K. Uzoma. 2022. "Exchange Rate and Trade Balance in Nigeria: Testing for the Validity of J-Curve Phenomenon and Marshall-Lerner

Condition." *Asian Themes in Social Sciences Research* 6 (1): 1–11. https://doi.org/10.33094/atssr.v6i1.65.
Edwards, S. 1986. "Are Devaluations Contractionary?" *The Review of Economics and Statistics* 68 (3): 501–507. https://doi.org/10.2307/1926028 .
Fabrizio, F. 1998. "Exchange Rates and External Competitiveness in Mozambique Determinants." In *IMF, 1998*, Republic of Mozambique-Selected Issues and Statistical Appendix. Washington: SM/98/78 International Monetary Fund.
Fabrizio, F. 2201. "Equilibrium Exchange Rates and Its Determinants." IMF, 2001, *Republic of Mozambique-selected issues and statistical appendix." IMF Country Report, no. 01/25* International Monetary Fund, Washington.
Falk, M. 2008. "Determinants of the Trade Balance in the Industrialized Countries." *FIW Research Report* 13: 1–31.
Gebeyehu, A. B. 2014. "Exchange Rate and Trade Balances; J-Curve Effects in Ethiopia." *Journal of Economics & Sustainable Development* 5 (24): 185–191.
Genc, E. G., and O. K. Artar. 2014. "The Impact of Exchange Rates on Exports and Imports of Emerging Countries." *European Scientific Journal* 10 (13): 128–141.
Hashmi, S. M., B. H. Chang, and M. Shahbaz 2019. "Asymmetric Effect of Exchange Rate Volatility on India's Cross-Border Trade: Evidence from Global Financial Crisis and Multiple Threshold Nonlinear Autoregressive Distributed Lag Model." *Australian Economic Papers*. 1–34
Iboma, G. E. 2022. "Analysis of the Effects of Currency Devaluation on Trade Balance and Economic Growth in Nigeria." *Multidisciplinary Journal of Research Development* 31 (1): 1–15.
Ikpe, M., A. C. Odo, S. A. Okwor, and K. E. Uma. 2021. "Exchange Rate Volatility and Dynamics of Non-Oil Trade: Evidence from Nigeria." *The Nigerian Journal of Economic and Social Studies* 63 (1): 25–49.
IMF. 1984. Exchange Rate System: Lessons of the Past and Options for the Future. *IMF Occasional Paper* No. 30. Washington DC.
Ju, J., Y. Wu, and L. Zeng. 2010. "The Impact of Trade Liberalization on the Trade Balance in Developing Countries." *International Monetary Fund Staff Papers* 57 (2): 427–229. https://doi.org/10.1057/imfsp.2009.19.
Kamal, K. M. 2015. "A Panel Data Analysis to Evaluate the Effects of Currency Devaluation on Major Export Items." *Dhaka University Journal of Social Science* 63 (1): 53–57. https://doi.org/10.3329/dujs.v63i1.21769.
Kamugisha, G., and J. E. Assoua. 2020. "Effects of a Devaluation on Trade Balance in Uganda: An ARDL Cointegration Approach." *International Journal of Economics and Finance* 12 (7): 42–53. https://doi.org/10.5539/ijef.v12n7p42 .
Kapur, I., M. Hadjimichael, P. Hilberts, J. Schiff, and P. Szymczak. (1991). Ghana: Adjustment and Growth. *International Monetary Fund, Occasional Paper No. 86*. Washington: IMF
Karoro, T. D., M. J. Aziakpono, and N. Cattaneo. 2009. "EXCHANGE RATE PASS-THROUGH to IMPORT PRICES in SOUTH AFRICA: IS THERE ASYMMETRY? 1." *South African Journal of Economics* 77 (3): 380–398. https://doi.org/10.1111/j.1813-6982.2009.01216.x.
Keho, Y. 2021. "Effects of Real Exchange Rate on Trade Balance in Cote d'Ivoire: Evidence from Threshold Nonlinear ARDL Model." *Theoretical Economics Letters* 11 (03): 507–521. https://doi.org/10.4236/tel.2021.113034.
Khaskheli, A., Y. Jiang, S. A. Raza, K. A. Khan, and M. A. Qureshi. 2021. "Financial Development, International Trade and Environmental Degradation: A Nonlinear Threshold Model Based on Panel Smooth Transition Regression." *Environmental Science and Pollution Research* 28 (21): 26449–26460. https://doi.org/10.1007/511356-020-11912-8.
Krugman, P., and L. Tailor. 1978. "Contractionary Effects of Devaluation." *Journal of International Economics* 8 (3): 445–456. https://doi.org/10.1016/0022-1996(78)90007-7.
Leite, S., A. Pellechio, L. Zanforlin, G. Bergashaw, S. Fabrizio, and J. Harnack 2000. "Ghana: Economic Development in a Democratic Environment." *International Monetary Fund, Occasional Paper No. 199*, IMF, Washington.

Maehle, N., H. Teferra, and A. Khachatryan 2013. "Exchange Rate Liberalization in Selected Sub-Saharan African Countries: Success, Failure and Lesson." *IMF Working Paper, African department*, *No. 13/32*

Mehtiyev, J., R. Magada, and L. Vasa. 2021. "Exchange Rate Impacts on International Trade." *Economic Annals* 190 (5–6(2): 12–22. https://doi.org/10.21003/ea.V190-02.

Memiago, C., and J. H. Eita. 2017. "The Effect of Exchange Rate Changes on Sub-Saharan African Trade." *International Journal of Sustainable Economy* 9 (3): 213–230. https://doi.org/10.1504/IJSE.2017.085065.

Muoneke, O. B., K. I. Okere, and F. C. Onuoha. 2022. "Extreme Exchange Rate Dynamics and Export Trade in the Selected Oil-Exporting Countries in Africa. Multiple Asymmetric Threshold Nonlinear ARDL Approach." *The Journal of International Trade & Economic Development* 23 (3): 1–24. https://doi.org/10.1080/09638199.2022.2139405.

Nasir, M. A., and M. Leung. 2021. "US Trade Deficit, a Reality Check: New Evidence Incorporating Asymmetric and Nonlinear Effects of Exchange Rate Dynamics." *The World Economy* 2021 (44): 818–836. https://doi.org/10.1111/twec.12986.

Nord, R., Y. V. Sobolev, D. G. Dunn, A. Hajdenberg, N. Hobdari, S. Maziad, and S. Roudet. 2009. "Tanzania, the Story of an African Transition." Washington: International Monetary Fund.

O'Conell, S., B. O. Maturu, F. M. Mwega, N. S. Ndung'u, and R. W. Ngugi. 2010. *Capital Mobility, Monetary Policy, and Exchange Rate Management in Kenya*, eds Adam, Coller and Ndung U, 172–210. Kenya: Policies for Prosperity, Oxford University Press, Oxford.

Odionye, J. C., and J. O. Chukwu. 2021. "The Asymmetric Effects of Currency Devaluation in Selected Sub-Saharan Africa." *Economic Annals* LXVI (230): 135–155. https://doi.org/10.2298/EKA2130135O.

Odionye, J. C., E. U. Ojiaku, and C. N. Uba. 2023. "Impact of Interest Rate Differential, Exchange Rate Changes and Political Stability on Foreign Capital Inflow in Nigeria: Discrete Threshold Regression Model." *Cogent Economics & Finance* 11 (1): 2203590. https://doi.org/10.1080/23322039.2023.2203590.

Okere, K. I., O. B. Muoneke, G. Ogbolu, and O. P. Egbo. 2023. "The Moderating Role of Oil Price in the Export-Exchange Rate Nexus for Selected African Economics: Evidence from MATNARDL Model." *HELIYON* 9 (4): e15343. https://doi.org/10.1016/j.heliyon.2023.e,15343 .

Okpeku, L. O., and O. N. Aras. 2022. "Effects of Depreciation on Trade Balances in Selected African Countries." *Global Journal of Management and Business Research: B Economics and Commerce* 22 (1): 1–10.

Omojimite, B. U., and G. Akpokodje. 2010. "A Comparative Analysis of the Effects of Exchange Rate Volatility on Exports in the CFA and Non-CFA Countries of Africa." *Journal of Social Science* 24 (1): 23–31. https://doi.org/10.1080/09718923.2010.11892833.

Onakoya, A. B., S. B. Johnson, and O. J. Ajibola. 2018. "Exchange Rate and Trade Balance: The Case of J-Curve Effect in Nigeria." *Kampala International University Journal of Social Sciences* 4 (4): 47–63.

Onwuka, K. O., and K. O. Obi. 2015. "Exchange Rate Volatility and Growth Dynamics: Evidence from Selected Sub-Saharan African Countries." *British Journal of Economics, Management & Trade* 6 (1): 61–77. https://doi.org/10.9734/BJEMT/2015/12308.

Ozcelebi, O. 2021. "Assessing the Impacts of Global Economic Policy Uncertainty and the Long-Term Bond Yields on Oil Prices." *Applied Economic Analysis* 29 (87): 2021, 226–244. https://doi.org/10.1108/AEA-05-20200046.

Perron, P. 1989. "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis." *Econometrica* 57 (6): 1361–1401. https://doi.org/10.2307/1913712 .

Perron, P. 1997. "Further Evidence on Breaking Trend Functions in Macroeconomic Variables." *Journal of Econometrics* 80 (2): 251–270. https://doi.org/10.1016/S0304-4076(97)00049-3.

Rana, M. M. 2015. "Internal and External Balances with Expenditure Changing and Switching Policies in Bangladesh: An Empirical Analysis." *IOSR Journal of Economics and Finance* 6 (4): 44–52.

Rawlins, G. 2011. "Currency Depreciations and the Trade Balance: The Case of Sub-Saharan African Countries." *The Journal of Applied Business and Economics* 12 (6): 132–148.

Reserve Bank of Malawi. 2003. "*Evolution of Exchange Rate Determination in Malawi: Past and Present*. Reserve Bank of Malawi." http://www.rbm.mw/research_papers.aspx.
Santos-Paulino, A. U. 2004. "Trade Liberalization on the Balance of Payment in Selected Developing Countries." *Manchester School* 71 (1): 100–118. https://doi.org/10.1111/j.1467-9957.2004.00382.x.
Simwaka, K. 2007. "Modeling and Forecasting the Malawi Kwacha-US Dollar Nominal Exchange Rate." *MPRA* Paper No. 3327.
Terasvirta, T. 1998. "Modelling Economic Relationships with Smooth Regression." In *Handbook of Applied Economic Statistics*, edited by A. Ullah and D. Gills, 229–246. *New York*: *Dekker*.
Terasvirta, T. 2004. "Smooth Transition Regression Modeling." In *Applied Time Series Econometrics*, edited by H. Lutkepohl and M. Kratzig, 222–242. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511606885.007.
Thahara, A.F., Rinosha, K.F. and Shifaniya, A.J.F. 2021. "The relationship between exchange rate and trade balance: Empirical evidence from Sei Lanka." *The Journal of Asian Finance, Economics and Business* 8 (5): 37–41. https://doi.org/10.13106/jafeb.2021/vol8no5.0037.
Ullah, A., A. Mansoora, S. A. Raza, and S. Ali. 2021. "A Threshold Approach to Sustainable Development: Nonlinear Relationship Between Renewable Energy Consumption, Natural Resource Rent and Ecological Footprint." *Journal of Environmental Management* 295:1–10. https://doi.org/10.1016/j.jenvman.2021.113073.
Ullah, A., X. Zhao, A. A. Amin, A. A. Syed, and A. Riaz. 2022. "Impact of COVID-19 and Economic Policy Uncertainty on China's Stock Market Returns: Evidence from Quantile-On-Quantile and Causality-In-Quantiles Approaches." *Environmental Sciences and Pollution Research* 30 (5): 12596–12607. https://doi.org/10.1007/s11356-022-22680-y.
United Nations Conference on Trade and Development. 2021. "UNCTAD Annual Report." New York: United Nations.
VuraL, B. M. T. 2016. "Effect of Real Exchange Rate on Trade Balance: Commodity Level Evidence from Turkish Bilateral Trade Data." *Procedia Economics and Finance* 38 (pp): 499–507. https://doi.org/10.1016/S2212-5671(16)30221-0.
World Development Indicators. 2021. "The World Bank." Washington, D. C. http://data.worldbank.org/indicator.
World Economic Outlook, IMF. 2015. "International Monetary Fund." Washington. October, 2015.
World Economic Outlook, IMF. 2019. "International Monetary Fund." Washington. October, 2019.
World Economic Outlook, IMF. 2021. "International Monetary Fund." Washington. October, 2021.
World Trade Organisation. 2021. "The World Bank." December, 2021.
World Trade Statistical Review. 2021. "The World Bank." December, 2021.
Yildirim, A. E., and T. B. Saraç. 2022. "Exchange Rate Volatility and Turkey-Germany Bilateral Trade: An Asymmetry Analysis." *The Journal of International Trade & Economic Development* 31 (5): 783–797. https://doi.org/10.1080/09638199.2021.2022742.
Zakaria, M. 2014. "Effects of Trade Liberalization on Exports, Imports and Trade Balance in Pakistan: A Time Series Analysis." *Prague Economic Papers* 23 (1): 121–139. https://doi.org/10.18276/j.pep.476 .
Zivot, E., and K. Andrews. 1992. "Further Evidence on the Great Crash, the Oil Price Shock, and the Unit Root Hypothesis." *Journal of Business and Economic Statistics* 10 (10): 251–270. https://doi.org/10.1080/07350015.1992.10509904.