# OIL PRICE, EXCHANGE RATE AND ASYMMETRIC ADJUSTMENT OF NIGERIA'S BILATERAL TRADE*

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**Abstract**

Motivated by the persistent rise in bilateral trade imbalance in Nigeria, this paper empirically examines whether Nigeria's four trading partners (China, India, the UK and the US) respond asymmetrically to changes in the oil price and exchange rate using a nonlinear autoregressive distributed lag model over the period from January 1999 to December 2019. Interestingly, we find that oil price increase and decrease influence Nigeria's trade balance with four trading partners asymmetrically. Further evidence indicates that oil price increases predominantly exert greater influence than decreases. Furthermore, Nigeria's trade balances with India and the UK in the long run and the US in the short run significantly respond asymmetrically to changes in exchange rate. In addition the result establishes significant evidence of the J-curve pattern in the response of Nigeria's trade balance with the UK to differences in exchange rate.

**Keywords:** Trade balance, oil price, exchange rate, asymmetry, nonlinear ARDL
**JEL Classification:** F31, Q43, C22, F14, F41

## 1. Introduction

The role of external trade in job creation, income generation, market expansion and competitiveness through exports and imports of goods and services has been acknowledged by recent studies (Francois and Manchin, 2013; Gorodnichenko *et al.*, 2015; Hornok and Koren, 2015; Verma, 2018; Butkus *et al.*, 2018; Lin *et al.*, 2020). These studies have identified several factors influencing trade: common currency, trade liberalisation, domestic

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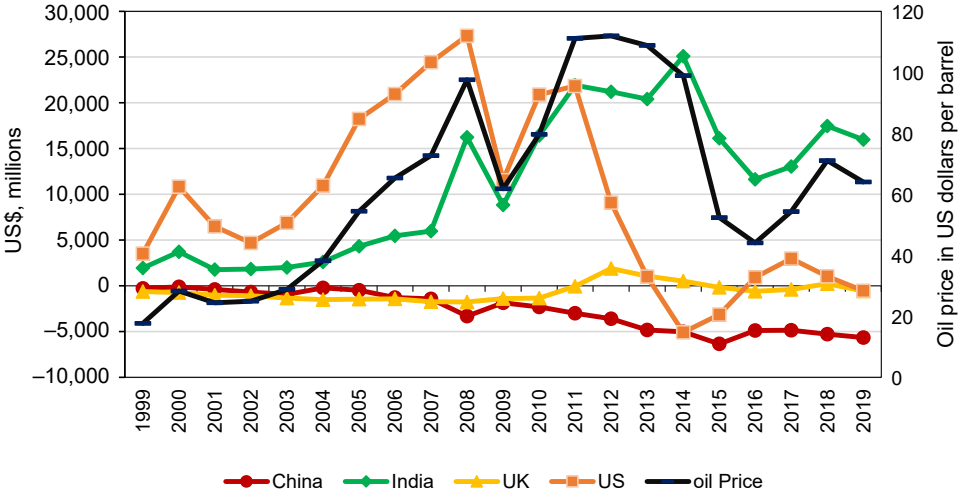
and foreign income, institutional frameworks, and tariff and non-tariff barriers. Remarkably, global crude oil price and exchange rate also play a substantial role in trade determination (Bahmani-Oskooee and Kanitpong, 2018; Baek and Choi, 2020), especially in countries exporting natural resources. Both theoretical and empirical literature have confirmed that crude oil export revenue and depreciation of a country's currency improve the trade balance of a country (Rebucci and Spatafora, 2006; Bahmani-Oskooee *et al.*, 2014; Igue and Ogunleye, 2014). Therefore, with a vastly oil-oriented economy since the 1970s, Nigeria's crude oil exports and persistent depreciation of the naira from ₦0.89 per US dollar in the 1970s to ₦306.92 per US dollar in 2019 were expected to put the economy on a path of improved external trade.

However, it has been observed that Nigeria appears not to have explored its trade potentials to turn around its economic fortunes, which may be due to fluctuations in commodity prices and unstable exchange rates. These fluctuations emanate from several global uncertainty-inducing events in recent years, thereby instigating a trade imbalance in the oil-exporting economy. Examples of events include the 2008–2009 Global Financial Crisis; the 2010–2012 Arab Spring Crisis, which ravaged many countries in the Middle East and North Africa; the US-China trade war; geopolitical factors such as the Brexit vote; the 2015–2016 commodity price shock, which threw commodity exporters like Nigeria into economic recession; the March 2020 oil price war between Russia and Saudi Arabia; and the ongoing COVID-19 pandemic, which has crippled economic activities globally. Besides, exchange rate fluctuation could follow a J-curve pattern. The J-curve phenomenon means that the policy of devaluation of a country's currency to boost trade first worsens the trade balance in the short run and then improves the real trade balance in the long run (Magee, 1973). These fluctuations are a major concern, especially for oil-exporting countries facing chronic trade deficits. For instance, Figure 1 shows how Nigeria has been registering a high incidence of trade deficits with her top trading partners except India, which accounts structurally for a trade surplus. It shows that imports overwhelmingly exceeded exports in several periods, coinciding with global oil price-inducing events, thereby revealing the influence of crude oil price on its trade balance.

The left vertical axis in Figure 1 represents the trade balance with China, India, the UK and the US, while the right vertical axis represents Brent oil price. Figure 1 shows that crude oil price shocks substantially account for trade imbalance except in the case of India. In 2012, for instance, Nigeria was a net exporter to the US and the UK. However, since 2015 it became a net importer because the influence of external demand for Nigerian goods from these partner countries was significantly weakened, while the high demand for foreign goods is significantly alarming. In 2019, Nigeria's bilateral trade with China recorded the largest deficit of US $5.6 billion.

**Figure 1: Trend of Nigeria's bilateral trade with its trade partners and crude oil price**




Source: Authors' computation from IMF Direction of Trade Statistics and International Financial Statistics, 2020

Due to these net export losses and their consequences on the economy, some studies in the extant literature have sought ways to address this challenge of rising trade imbalance. These studies suggest that the concurrent fluctuations in crude oil price and/or exchange rate could explain Nigeria's rising trade imbalance since the oil sector contributes over 90% of the country's export earnings while exchange rate adjustments influence transaction costs and trade competitiveness. In other words, changes in the oil price and exchange rate affect trade performance, but the nature of this relationship remains unknown in Nigeria. Though many empirical studies have investigated this relationship, especially in highly industrialised economies, some important gaps exist, especially in developing countries like Nigeria. For instance, there is a dearth of empirical studies on Nigeria's oil price-trade performance relationship. Besides, existing studies on Nigeria's exchange rate-trade performance relationship have anchored their analyses in the aggregate trade model (see Jibrilla and Mohammed, 2015; Onatunji, 2019). They have also assumed that the relationship is symmetric (see Ogbonna, 2011; Omojimite and Akpokodje, 2010; Igue and Ogunleye, 2014; Anoke *et al.*, 2016), thereby ignoring the potential aggregation bias and the intrinsic nonlinearity of the trade model, which could misinform inference. Even though Ogbonna and Ichoku (2022) used the nonlinear ARDL framework, their data are quarterly. However, the crude oil price and flexible exchange rate regimes are notoriously volatile. Their effects on trade balance can be short-lived; thus, higher frequency data

could be substantial in capturing these dynamics. We used higher-speed monthly data to capture the dynamics faster and better. In addition, Ogbonna and Ichoku (2022) did not account for Nigeria's bilateral trade with India, which accounts substantially for Nigeria's trade. For instance, in 2019, Nigeria's bilateral trade with India recorded the greatest chunk of Nigeria's bilateral trade, comprising about 18% of its total trade. Finally, Ogbonna and Ichoku (2022) included in the model both oil price and domestic income that are usually associated with the problem of multicollinearity in an oil dominant economy (Nyangarika, 2018). If the predictive power of a model does not substantially increase when additional regressor is introduced then the regressor ought to be removed (see Brace et al., 2000).

This study aims to examine the asymmetric effects of changes in the oil price and exchange rate on trade performance in Nigeria. The specific objectives are to: (i) ascertain whether Nigeria's bilateral trade performance adjusts asymmetrically to changes in the oil price, and (ii) establish whether there is evidence of the J-curve effect in the response of Nigeria's trade to changes in the exchange rate. Therefore, understanding the symmetric or asymmetric dynamics of oil price and the J-curve patterns on trade would provide policymakers with much-needed guidance. In addition, the relevance of studying bilateral trade is to reveal substantial trade information about a particular country since a nation's trade surplus with some trade partners, such as India in Nigeria's case, could dominate the trade deficit with other economies. Therefore, lumping all trading partners in the same analysis could lead to aggregation bias and unfair representation of the trade effect. Thus, the outcome would be fundamental in helping to design policies that best suits each trading partner instead of generalising to the rest of the world.

## 2. Literature Review

Several empirical studies have investigated the effect of the crude petroleum price on the external trade in different economies with different methodologies outside the nonlinear approach. Still, the findings are widely divided on the nature of their relationships. For example, some studies believe that a rise in the crude petroleum price benefits oil-exporting countries; others believe that the uncertainties embedded in rising prices could also exert a negative influence. Another analytical tradition has concluded that crude petroleum price increases cannot improve external trade in oil-importing countries. Such studies include Le and Chang (2013) for three distinguishable Asian economies – Malaysia as a petroleum-exporting economy, Japan as a petroleum-importing economy, and Singapore as a petroleum-refining economy. Allegret *et al.* (2015) investigated 18 oil-importing economies and 12 oil-exporting economies. Rafiq *et al.* (2009) made a similar analysis for Thailand, Arouri *et al.* (2014) for India, and Hassan and Zaman (2012) for Pakistan.

On the exchange rate and trade balance relationship, some findings based on linear models confirm no significant relationship between exchange rate and trade balance. In contrast, others argue that exchange rate fluctuation contributes significantly to changes in the trade balance. Some studies that find no evidence of an association between exchange rate and trade balance include Laffer (1976), Salant (1976), Miles (1979), Liew *et al.* (2003), Wilson and Tat (2001), Hatemi and Irandoust (2005), and Anoke *et al.* (2016). Even though many previous studies have identified exchange rate as an insignificant factor in the trade balance, the empirical evidence is not uniformly one-sided regarding the relationship between the variables. Some studies find robust evidence of the association between exchange rate and trade balance, including Ogbonna (2011), Omojimite and Akpokodje (2010), and Bahmani-Oskooee *et al.* (2014).

The main pitfall in the linear approach emanates from the fact that the association between the oil price and trade balance and between exchange rate and trade balance could be nonlinear. Thus, the linear model will become highly misleading and problematic in terms of presentation and interpretation, thereby obscuring the real association between the variables. Following the recent doubt on the credibility of linear models in analysing the effect of oil price and exchange rate changes on trade balance, the numbers of studies on the oil price, exchange rate and trade balance relationship based on a nonlinear approach are surging, especially the debate regarding the asymmetric effects. This new line of enquiry has generated a comprehensive understanding of the link between the oil price and trade balance and between exchange rate and trade balance. For example, Rafiq *et al.* (2016) argued that a nonlinear approach could capture the asymmetric market information by decomposing the positive shock from the negative shock. Their study confirms that a rise in the crude petroleum price is positively associated with the oil trade balance in oil-exporting countries. At the same time, oil-importing economies are substantially insulated from positive crude petroleum price shocks. Jibril *et al.* (2020) extended the work of Rafiq *et al.* (2016) by accounting for the sources of crude petroleum price shocks. The study finds evidence of asymmetric effects of crude petroleum price shocks on the trade balance and that the asymmetric association hinges on the source of the shock.

Raheem (2017) was the first to apply the nonlinear approach of Shin *et al.* (2013) to analysing oil price shocks on components of external trade. The study found an asymmetric association on export in the long term in high-trading countries. In contrast, an asymmetric association exists on import in the short term in oil-importers but in the long term in oil-exporters. In a similar study, Ahad and Anwer (2019) found an asymmetric effect of crude petroleum price shocks on the deficit balance of trade in the economy of Pakistan. Baek and Choi (2020) find an asymmetric impact of the crude petroleum price on most bilateral commodity trade between Korea and its four major trading partners at a bilateral level. A similar study by Baek (2020) at a bilateral trade level found

an asymmetric impact of oil prices on the bilateral trade balance of some of Korea's 14 trading partners studied.

On the exchange rate and trade balance viewpoint, Jibrilla and Mohammed (2015) found the existence of an asymmetry in the link between exchange rate and trade balance. In a similar study, Onatunji (2019) argued that a devaluation policy could not correct the trade imbalance in Nigeria. As for the contrary opinion about the insignificant effect of a country's currency devaluation, Bahmani-Oskooee and Fariditavana (2015) established that currency devaluation substantially affects trade balance while appreciation may be negligible for the US, Japan, China and Canada using a nonlinear ARDL approach. Arize *et al.* (2017) revealed evidence that exchange rate adjustment is asymmetric for most of the economies studied in the long term, while half of the economies studied exhibited an asymmetric effect in the short term. The study further found that depreciation has a more substantial impact than appreciation in the long run.

By employing bilateral trade, Bahmani-Oskooee and Kanitpong (2018) found that the long-run asymmetric effects are present in seven economies. Bahmani-Oskooee and Baek (2016) found that 44 out of 79 industries responded differently and strongly to currency devaluation than to appreciation. These findings suggest that a nonlinear approach that permits an asymmetric effect is more substantial in investigating the true nature of the effect between exchange rate and trade balance.

## 3. Methodology

### 3.1 Data

The data for this study consist of monthly time series that span from January 1999 to December 2019. The choice of high-frequency data is in order to gain clear knowledge of the dynamic adjustment, while the time scope in this study accounts for the flexible exchange rate regime reintroduced in 1999. The paper is limited to Nigeria's bilateral trade with its four major trading partners, namely China, India, the UK and the US. A selected country-specific share of the total trade in Nigeria is reported in the Appendix. These selected economies accounted for the larger chunk of Nigeria's bilateral trade, responsible for about 42% of the total trade.

Consequently, the external trade performance of Nigeria is influenced by these economies. The dependent variable is the bilateral trade balance between Nigeria and its trading partners (*TB*), defined in this study as the ratio of Nigeria's value of exports to its trading partners to the value of imports from its trading partners. The advantages of the trade ratio include: (i) whether the trading partner's currency or domestic currency is applied for the measurement of imports and export, the trade ratio is indifferent

to the currency units; (ii) the trade ratio is indifferent to the price index year used and also indifferent whether nominal or real exchange rate is used, thereby overcoming the measurement challenge; (iii) the trade ratio allows the trade balance equation to be estimated in the natural logarithm form. The bilateral trade balance data were obtained from the Direction of the Trade Statistics of the International Monetary Fund (IMF). For independent variables, oil price (*OP*) denotes Brent crude oil price, and the data were obtained from the International Financial Statistics of the International Monetary Fund (IMF). Real exchange rate (*RER*) denotes real exchange rate of the Nigerian naira to the US dollar. This definition of *RER* holds for the US bilateral trade equations. It will be the naira to the respective national currency for the other bilateral trade equations. *RER* is defined in that a rise in  implies a real depreciation of the Nigerian naira against the trading partner's currency. Conversely, a fall in  implies that Nigeria's currency is overvalued and, as such, its goods are overpriced, leading to high imports and depressed exports. *RER* data were obtained from the International Financial Statistics of the International Monetary Fund (IMF). The world industrial production (*Y*) denotes the index of world industrial production as a proxy for global export demand, and the data were obtained from the Federal Reserve Bank of Dallas.

The descriptive statistics indicate that the data exhibited some variability. Quandt-Andrews test result established the presence of a structural break in the series. Hence, we conducted a Zivot-Andrews unit root test that accounts for the structural break to examine whether the time series contain a unit root. The results indicate that all the variables are either integrated of order one or stationary at level, which is consistent with the underlying requirements of the nonlinear ARDL framework. To conserve space, we do not explicitly report the results of these tests, but they are available on request.

## 3.2 Empirical model

The empirical model of this paper emanates from the "two-country" model of trade. The model is derived from the equilibrium market environment, where domestic export supply should correspond with foreign import demand, while domestic import demand should also correspond with foreign export supply. Consequently, the two-country model of trade, as first proposed by Lindert (1986), is defined as:

$$TB = EX\left(EXR, Y^{a}\right) - IM\left(EXR, Y^{b}\right), \tag{1}$$

where *a* denotes a domestic economy while *b* denotes a trading partner; *EX*(*IM*) denotes the volume of products exported (imported) from the country *a* (*b*) to the country *b* (*a*); *RER* denotes the real effective exchange rate for the products measured in the country

*a*'s currency. The standard specification described in Equation 1 is modified to capture the crude oil price. In an oil-dependent economy like Nigeria, we argue that national income changes as the oil price fluctuates following extant literature (Rafiq *et al.,* 2016; Ahad and Anwar, 2020). Thus, real exchange rate of the economy is hugely determined by the total value of export earnings, which in turn depends not only on the volume of oil exports sold abroad but primarily on prices paid for them. Hence, we incorporate the crude oil price in the model following Rafiq *et al.* (2016) and Baek and Choi (2020) and the trade balance model between Nigeria and its trading partners as a reduced-form equation as follows:

$$TB_{i,t} = \gamma + \theta OP_t + \lambda RER_{i,t} + \omega Y_t + \varepsilon_t \,, \tag{2}$$

where $i$ represents Nigeria's bilateral trading partner (*i.e.*, $i$ = China, India, the UK or the US). To test for a cointegrating relationship, we employ the NARDL model since most macroeconomic variables can react differently to crude petroleum price fluctuations and exchange rate adjustment behaviour. By decomposing the regressors in Equation 2 into partial sum processes of positive and negative changes in the regressors to capture the respective increases and decreases in these regressors, we can express Equation 2 as an asymmetric cointegrating relationship of the form:

$$TB_t = \gamma + \theta^{+} OP_t^{+} + \theta^{-} OP_t^{-} + \lambda^{+} RER_t^{+} + \lambda^{-} RER_t^{-} + \omega Y_t + \varepsilon_t \,, \tag{3}$$

where $OP_t^{+} = \sum_{j=1}^{t} \Delta OP_j^{+} = \sum_{j=1}^{t} \max(\Delta OP_{j,} 0)$ and $OP_t^{-} = \sum_{j=1}^{t} \Delta OP_j^{-} = \sum_{j=1}^{t} \min(\Delta OP_{j,} 0)$ are the partial sum processes of positive and negative changes in $OP_t$;

$RER_{i,t}^{+} = \sum_{j=1}^{t} \Delta RER_j^{+} = \sum_{j=1}^{t} \max(\Delta RER_{j,} 0)$ and $RER_{i,t}^{-} = \sum_{j=1}^{t} \Delta RER_j^{-} = \sum_{j=1}^{t} \min(\Delta RER_{j,} 0)$ are the partial sum processes of positive and negative changes in $EXR_t$; and $\Delta$ is the first difference operator. Here, the decomposition of each regressor into partial sum processes assumes an initial threshold value of zero, following Greenwood-Nimmo and Shin (2013). This decomposition splits the crude oil price and the exchange rate regressors in the ratios of 55:45 and 53:47 in favour of the positive regime, respectively. Thus, we do not worry about any bias favouring either the positive or the negative regime.

Since the nonlinear autoregressive distributed lag (NARDL) is an extension of the linear autoregressive distributed lag (ARDL) developed by Pesaran *et al.* (2001), we first specify Equation 2 as ARDL, where the long-run information is integrated with short-run dynamic information in an error-correction format as follows:

$$\Delta TB_t = \gamma + \rho TB_{t-1} + \theta OP_{t-1} + \lambda RER_{t-1} + \omega Y_{t-1} + \\ + \sum_{j=1}^{p-1} \phi_j \Delta TB_{t-j} + \sum_{j=0}^{q-1} (\pi_j \Delta OP_{t-1}) + \sum_{j=0}^{q-1} (\psi_j \Delta RER_{t-1}) + \sum_{j=0}^{q-1} (\varpi_j \Delta Y_{t-1}) + e_t \,. \quad (4)$$

To be able to compute both short-run and long-run asymmetries, we express Equation 3 as a nonlinear ARDL(p,q) model in its error correction form, where we assume that trade performance is explained by its past values, by current and past values of positive and negative oil price and exchange rate, and by current and past values of the index of industrial production as follows:

$$\Delta TB_t = \gamma + \rho TB_{t-1} + \theta^+ OP^+_{t-1} + \theta^- OP^-_{t-1} + \lambda^+ RER^+_{t-1} + \lambda^- RER^-_{t-1} + \omega Y_{t-1} + \\ + \sum_{j=1}^{p-1} \phi_j \Delta TB_{t-j} + \sum_{j=0}^{q-1} (\pi^+_j \Delta OP^+_{t-j} + \pi^-_j \Delta OP^-_{t-j}) + \sum_{j=0}^{q-1} ((\psi^+_j \Delta RER^+_{t-jj+} \psi^-_j \Delta RER^-_{t-j}) + \\ + \sum_{j=0}^{p-1} \varpi_j \Delta Y_{t-j} + e_t \,, \quad (5)$$

where $\rho$ is the speed of adjustment; while $\beta^+ = -\frac{\theta^+}{\rho}$, $\beta^- = -\frac{\theta^-}{\rho}$, $\alpha^+ = -\frac{\lambda^+}{\rho}$, $\alpha^- = -\frac{\lambda^-}{\rho} and\ \eta = -\frac{\omega}{\rho}$ are the asymmetric long-run parameters. $\Phi_j$ embeds the autoregressive parameters; while $\varepsilon_t$ is the white noise process. To ensure that the dynamics of the cointegrating relationship in Equation 5 is not arbitrarily misspecified, we used the general-to-specific lag selection procedure starting with an initial maximum lag length of 6 with a unidirectional 5% decision rule. The specification in Equation 5 is consistent with some recent studies, such as Gulay (2019), Ongan *et al.* (2018), and Kocaarslan *et al.* (2020), among others.

We examined the prevalence of long-run symmetry and short-run additive symmetry using the standard Wald coefficient restriction test. In the case of long-run symmetry, the null hypotheses evaluated are $H_0$: $\beta^+ = \beta^-$ and $H_0$: $\alpha^+ = \alpha^-$. In the case of short-run additive symmetry, the null hypotheses evaluated were $H_0 : \sum_{j=1}^{q-1} \pi^+_j = \sum_{j=1}^{q-1} \pi^-_j$ and $H_0 : \sum_{j=1}^{q-1} \psi^+_j = \sum_{j=1}^{q-1} \psi^-_j$. Basically, this model reveals two significant kinds of asymmetries which we seek to ascertain, namely long-run and short-run asymmetry.

## 4. Results and Discussions

The results of the asymmetric regression are reported in Table 1 using the logged data indexed with the base year 2010 = 100 representation. Moreover, there are three panels in Table 1. Panel A shows short-run and long-run coefficient estimates. Panel B shows whether Nigeria's bilateral trade performance in response to positive and negative changes in the oil price and exchange rate is symmetric or asymmetric. Finally, Panel C presents diagnostic statistics.

The major focus of the results presented in Table 1 is the sign and size of the coefficients for the increases and decreases in the oil price. The results reveal that an increase in the crude oil price has a positive and significant impact on trade performance in all cases. In contrast, the impact of an oil price decline is positive and significant for India and the UK and negative and negligible for China and the US. This implies that a positive shock in the global crude oil price is associated with an improvement in trade performance in Nigeria's bilateral trade with her four major partners. This result is similar to the study of Baek and Kwon (2019) for the oil-exporting country of Algeria, while Ahad and Anwer (2020) also found a similar result for Pakistan. As expected for an oil-dependent economy, the possible reason could be the basis of revenue effect from oil export.

On the other hand, negative shocks in the global crude oil price increase the trade balance for India and the UK. These effects of a decrease in the oil price are not surprising due to quantity effects, and as such, the negative revenue effect due to the decline in the oil price could be quite offset by the high demand for crude oil from oil-importing countries. The unexpected result is in line with some previous studies that found a decline in the oil price to be negatively related to trade balance (Baek *et al*., 2019). For China and the US, the oil price fall decreases Nigeria's trade balance with these partners, though not significantly different from zero. This result is consistent with Baek *et al.* (2019) for the case of Iran and Saudi Arabia.

Obviously, since a positive change in the oil price has a significant positive impact, a negative change in the oil price has, in contrast, a positive and negligible negative effect. There seems to be evidence of asymmetry in oil price fluctuation. To further validate this claim of asymmetric effects, we performed the Wald test on these coefficients to establish whether they are different significantly enough to support asymmetric effects. Table 1 reports that the Wald tests are statistically significant except for China in the short run and India in the long run, affirming the asymmetric effect between positive and negative changes in the oil price on trade performance for India, the UK and the US in the short run and China, UK and the US in the long run. In fact, this is a clear departure from the one-size-fits-all adjustment in the case under symmetric impact analysis.

**Table 1: Nonlinear ARDL estimation results**

| | China | India | UK | US |
|---|---|---|---|---|
| **Panel A** | | | | |
| **Long-term coefficients** | | | | |
| $\rho$ | −0.6985*** | −0.3446*** | −0.6265*** | −0.1584*** |
| $\beta^+$ | 1.6953** | 0.6673*** | 0.9497*** | 2.9323** |
| $\beta^-$ | −0.4880 | 0.9993** | 2.5550*** | −0.0697 |
| $\alpha^+$ | −2.9730 | 0.0758 | 3.6696** | −1.4455 |
| $\alpha^-$ | 1.2835 | −1.6013** | −4.9923*** | 9.3382 |
| $\eta$ | −28.5769 | −1.4360 | −7.7685 | −52.6167** |
| **Short-term coefficients** | | | | |
| $\pi^+$ | 4.8544** | 1.1637** | −1.2293 | 0.7719 |
| $\pi^-$ | 0.0063 | −0.2523 | 0.4567 | −1.2333** |
| $\psi^+$ | −5.4339 | −0.4189 | 2.4041 | −0.9715 |
| $\psi^-$ | 1.7367 | 2.9006 | −2.1044 | −5.9307 |
| **Panel B** | | | | |
| **Long-run symmetry tests** | | | | |
| $H_0 : \beta^+ = \beta^-$ | 6.6784*** | 1.6229 | 3.9352** | 4.8928** |
| $H_0 : \alpha^+ = \alpha^-$ | 2.3432 | 2.7126* | 9.4146*** | 1.1563 |
| **Short-run symmetry tests** | | | | |
| $H_0 : \sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ | 1.1441 | 7.7218*** | 4.3248** | 10.2041*** |
| $H_0 : H_0 : \sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$ | 0.5731 | 2.0443 | 0.0793 | 4.5795** |
| **Panel C** | | | | |
| **Diagnostics** | | | | |
| $F_{PSS}$ | 75.1550*** | 25.9528*** | 71.5859*** | 23.9304*** |
| $t_{BDM}$ | −8.5831*** | −4.7724*** | −8.1702*** | −3.6404*** |
| **BG Test ($NR^2$)** | 11.9599 | 8.6558 | 19.3011* | 15.4849 |
| **ARCH test** | 161.6982 | 1.0274 | 1.5161 | 0.2086 |

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Parenthesis denotes t-statistic. The notation for the estimated coefficients relates to the NARDL model of Equation 5, where $\beta$, $\alpha$, and $\eta$ are the long-run coefficients of oil price, bilateral exchange rate and index of industrial production, respectively, while $\pi$, $\psi$, and $\omega$ are the short-run coefficients of oil price, bilateral exchange rate and index of industrial production, respectively. $\beta^+ = \beta^-$ and $\alpha^+ = \alpha^-$ are the Wald tests of long-run symmetry for the oil price and exchange rate respectively. $\sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ and $\sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$ are the Wald tests of short-run symmetry for the oil price and exchange rate, respectively; $F_{PSS}$ denotes the statistics of the bound test of Pesaran *et al.* (2001), and $t_{BDM}$ denotes the statistics of Banerjee *et al.* (1998). The BG test is the Breusch-Godfrey serial correlation test. The ARCH test is an autoregressive conditional heteroskedasticity test for the equal spread of the error variance.

Source: Authors' computation

Thus, one of the most significant findings that emerge from the empirical results is that the global crude oil price has an asymmetric effect on bilateral trade performance in Nigeria. This is consistent with the findings of Baek (2020), who found asymmetric effects in Korea's trade balance with Malaysia, Indonesia, Singapore and the US. The varying effects indicate that an oil price increase has a more prominent impact on Nigeria's bilateral trade with China and the US. In contrast, an oil price decrease has a greater impact on Nigeria's bilateral trade with India and the UK in the long run. In the short run, an oil price increase predominantly has a more prominent impact.

Next, Table 1 also reports the asymmetric adjustment of Nigeria's bilateral trade performance to changes in the exchange rate in the short and long term. Critical observations on the coefficients' estimate of positive and negative exchange rate adjustment support asymmetric exchange rate change since the coefficients show different signs, magnitude and level of significance across all of Nigeria's trading partners. To validate the claim, we conducted empirical tests on the coefficients to be convinced of the asymmetric status in the models using the Wald test for the short and long term. In the case of the long term, the Wald statistics in Panel B of Table 1 detects an asymmetric effect of exchange rate on Nigeria's bilateral trade with India and the UK. Conversely, in the short term, the Wald statistics detect an asymmetric effect of exchange rate on Nigeria's bilateral trade with the US. This means that Nigeria's bilateral trade response with India and the UK is asymmetric in the long run and with the US in the short run. This finding supports the empirical work of Bahmani-Oskooee and Fariditavana (2016), who argued that the long-term impact of positive and negative exchange rate on US bilateral trade with Canada is asymmetric. Surprisingly, the effect of positive changes in exchange rate, which reflect depreciation of the naira against the foreign currency, is predominantly negligible. Still, the result is not in accordance with the theoretical prediction. The possible reason for this unexpected finding is not unconnected with Nigeria's import demand being inelastic. This finding also aligns with the study of Bahmani-Oskooee and Kanitpong (2017), who found that the depreciation of the yen impedes the trade balance in Japan, whose import demand is also inelastic.

Furthermore, Nigeria's bilateral trade with India, the UK and the US is more responsive to appreciation than to depreciation of exchange rate. It is quite similar to the findings of Mathur and Shekhawat (2018) for India's bilateral trade with the US. On the other hand, Nigeria's bilateral trade with China and the US in the long run and China, India and the UK in the short run are symmetric. This result agrees with Bahmani-Oskooee and Fariditavana's (2016) findings, revealing that the exchange rate has a symmetric effect on US-France bilateral trade. Bahmani-Oskooee and Kanitpong (2018) also found that Thailand's trade balance with her seven (eight) trading partners

responds asymmetrically (symmetrically) to positive and negative exchange rate adjustment.

The J-curve effect is observed only for the Nigeria-UK trade balance. More precisely, it is clear from Panel A of Table 1 that the short-run coefficient of positive exchange rate change is positive but insignificant. However, the long-run coefficient of positive exchange rate change is positive and significant, supporting the J-curve effects in Nigeria's bilateral trade with the UK. This finding is consistent with the work of Bahmani-Oskooee and Kanitpong (2018), who also found the J-curve effect for Thailand's trade balance with at least eight out of 16 trading partners.

A post-diagnostic test was performed to assure the robustness of the model. Panel C of Table 1 presents the results of the test. The test suggests that the model results are suitable for policy inference.

## 4.1 Robustness test

We conducted a robustness test to confirm that the findings do not depend on assumptions concerning the data-generating process. If the findings rely upon data-generating processes, it suggests that the findings could likely create policy uncertainty. Therefore, we used the Western Texas Intermediate (WTI) crude oil price as an alternative proxy for the crude oil price and Nigeria's trade with the European Union as an alternative to Nigeria's trade with the United Kingdom to ascertain the asymmetric effects of changes in the oil price and exchange rate on trade performance in Nigeria. Interestingly, the patterns in the results predominantly remained the same in all cases and did not qualitatively alter our overall findings, showing that the findings were not just happenstance. The estimation results are reported in Table 2.

# 5. Concluding Remarks

Despite the inherent asymmetric effect of oil prices and exchange rate changes, empirical evidence on the effects of the oil price on trade performance in Nigeria remains limited. Besides, existing studies on the exchange rate-trade balance relationship in Nigeria anchored their analyses in the aggregate trade model. Based on low-frequency data, ignoring the potential aggregation bias and the highly volatile nature of the exchange rate, this could misinform inference. The study became necessary following numerous uncertainty-inducing events in recent years, which have usually resulted in a collapse of oil prices and frequent exchange rate fluctuations, thereby stimulating trade imbalances in oil-exporting countries.

**Table 2: Nonlinear ARDL estimation results – bilateral level**

| | China | India | EU | US |
|---|---|---|---|---|
| **Panel A** | | | | |
| **Long-term coefficients** | | | | |
| $\rho$ | −0.8359*** | −0.3296*** | −0.5429*** | −0.1395*** |
| $\beta^+$ | 2.8628*** | 0.6958*** | 0.3896** | 2.9597* |
| $\beta^-$ | 0.1388 | 1.2039*** | 0.3221* | 0.3311 |
| $\alpha^+$ | −4.0604 | 0.2508 | −1.0239** | −1.1945 |
| $\alpha^-$ | 1.6100 | −2.0650*** | −0.8732 | 7.0919 |
| $\eta$ | −22.9690 | −1.1754 | 1.5953 | −47.7162** |
| **Short-term coefficients** | | | | |
| $\pi^+$ | 1.5904 | 1.4409*** | −0.3832 | 1.2869 |
| $\pi^-$ | 1.1145 | −0.2621 | 0.1250 | −1.5328 |
| $\psi^+$ | −2.3185 | −0.6895 | −0.4289 | −1.2141 |
| $\psi^-$ | 4.0072 | 3.5558* | 1.3917 | −6.4509 |
| **Panel B** | | | | |
| **Long-run symmetry tests** | | | | |
| $H_0 : \beta^+ = \beta^-$ | 12.4243*** | 2.2080 | 4.1578** | 3.2655* |
| $H_0 : \alpha^+ = \alpha^-$ | 4.3561** | 3.1079* | 3.1084* | 0.5658 |
| **Short-run symmetry tests** | | | | |
| $H_0 : \sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ | 0.0203 | 9.6724*** | 0.5137 | 13.7508*** |
| $H_0 : H_0 : \sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$ | 0.4713 | 3.5528* | 0.8291 | 4.5616** |
| **Panel C** | | | | |
| **Diagnostics** | | | | |
| $F_{PSS}$ | 28.4749*** | 27.3710*** | 19.3513*** | 20.8435*** |
| $t_{BDM}$ | −13.0387*** | −4.7076*** | −9.5041*** | −3.2204*** |
| **BG Test ($NR^2$)** | 1.4105 | 1.9670 | 3.6860 | 1.2229 |
| **ARCH test** | 27.5801*** | 1.0057 | 0.2764 | 0.7004 |

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The notation for the estimated coefficients relates to the NARDL model in Equation 5.

Source: Authors' computation

Our findings are summarised as follows. Firstly, we find that oil price rises and falls asymmetrically influence Nigeria's trade with China, India, the UK and the US, but the evidence for India appears to be in the short run only while for China in the long run only. Further evidence indicates that oil price rises exert a greater influence than falls for China and the US in the long run while in the short run, oil price falls exert a greater influence than rises for the US. Furthermore, the results indicate that Nigeria's trade balance with India and the UK in the long run and with the US in the short run significantly responds asymmetrically to changes in the exchange rate. In the case of China, there is no evidence of asymmetry either in the short run or in the long-run. Finally, the results indicate significant evidence of a J-curve pattern in the response of Nigeria's trade balance with the UK to changes in exchange rate only. In sum, the identification of symmetric or asymmetric effects is substantial for explaining shocks in global oil price movements and understanding the response of Nigeria's bilateral trade to oil price shocks for policy inference. We also demonstrated that these results are consistent with the dynamics of the economy under investigation, which mainly suggests adverse effects of the devaluation of the naira. Therefore, policymakers should mainly focus on domestic production of imported goods rather than devaluation.

## Appendix

**Nigeria's top 4 trading partners in terms of origin of imports (2019)**

| Rank | Country | Exports (million USD) | Export share | Imports (million USD) | Import share | Total trade (million USD) | Trade share |
|---|---|---|---|---|---|---|---|
| **1** | China | 4,424.05 | 6.69 | 10,071.05 | 23.05 | 14,495.10 | 13.20 |
| **2** | US | 3,908.92 | 5.91 | 4,440.91 | 10.17 | 8,349.83 | 7.61 |
| **3** | India | 18,127.28 | 27.42 | 2,156.55 | 4.94 | 20,283.83 | 18.48 |
| **4** | UK | 1,257.14 | 1.90 | 1,834.05 | 4.20 | 3,091.19 | 2.82 |
| | **Sub-total** | **27,717.39** | **41.92** | **18,502.56** | **42.36** | **46,219.95** | **42.11** |
| | **Total** | **66,101.39** | **100.00** | **43,687.31** | **100.00** | **109,788.70** | **100.00** |

Note: The export, import and trade shares are the percentages of shares of total export, import and trade.

Source: Direction of Trade Statistics (DOTS) by the IMF, 2020

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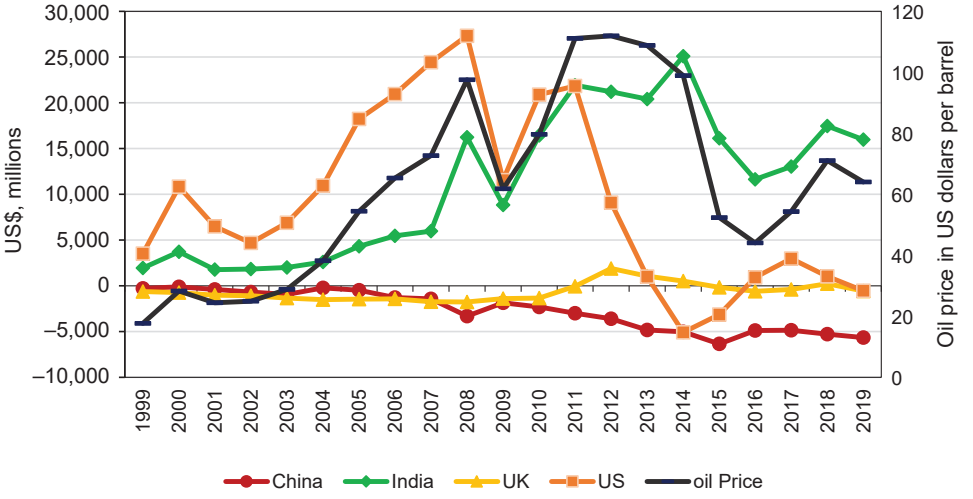
and foreign income, institutional frameworks, and tariff and non-tariff barriers. Remarkably, global crude oil price and exchange rate also play a substantial role in trade determination (Bahmani-Oskooee and Kanitpong, 2018; Baek and Choi, 2020), especially in countries exporting natural resources. Both theoretical and empirical literature have confirmed that crude oil export revenue and depreciation of a country's currency improve the trade balance of a country (Rebucci and Spatafora, 2006; Bahmani-Oskooee *et al.*, 2014; Igue and Ogunleye, 2014). Therefore, with a vastly oil-oriented economy since the 1970s, Nigeria's crude oil exports and persistent depreciation of the naira from ₦0.89 per US dollar in the 1970s to ₦306.92 per US dollar in 2019 were expected to put the economy on a path of improved external trade.

However, it has been observed that Nigeria appears not to have explored its trade potentials to turn around its economic fortunes, which may be due to fluctuations in commodity prices and unstable exchange rates. These fluctuations emanate from several global uncertainty-inducing events in recent years, thereby instigating a trade imbalance in the oil-exporting economy. Examples of events include the 2008–2009 Global Financial Crisis; the 2010–2012 Arab Spring Crisis, which ravaged many countries in the Middle East and North Africa; the US-China trade war; geopolitical factors such as the Brexit vote; the 2015–2016 commodity price shock, which threw commodity exporters like Nigeria into economic recession; the March 2020 oil price war between Russia and Saudi Arabia; and the ongoing COVID-19 pandemic, which has crippled economic activities globally. Besides, exchange rate fluctuation could follow a J-curve pattern. The J-curve phenomenon means that the policy of devaluation of a country's currency to boost trade first worsens the trade balance in the short run and then improves the real trade balance in the long run (Magee, 1973). These fluctuations are a major concern, especially for oil-exporting countries facing chronic trade deficits. For instance, Figure 1 shows how Nigeria has been registering a high incidence of trade deficits with her top trading partners except India, which accounts structurally for a trade surplus. It shows that imports overwhelmingly exceeded exports in several periods, coinciding with global oil price-inducing events, thereby revealing the influence of crude oil price on its trade balance.

The left vertical axis in Figure 1 represents the trade balance with China, India, the UK and the US, while the right vertical axis represents Brent oil price. Figure 1 shows that crude oil price shocks substantially account for trade imbalance except in the case of India. In 2012, for instance, Nigeria was a net exporter to the US and the UK. However, since 2015 it became a net importer because the influence of external demand for Nigerian goods from these partner countries was significantly weakened, while the high demand for foreign goods is significantly alarming. In 2019, Nigeria's bilateral trade with China recorded the largest deficit of US $5.6 billion.

**Figure 1: Trend of Nigeria's bilateral trade with its trade partners and crude oil price**




Source: Authors' computation from IMF Direction of Trade Statistics and International Financial Statistics, 2020

Due to these net export losses and their consequences on the economy, some studies in the extant literature have sought ways to address this challenge of rising trade imbalance. These studies suggest that the concurrent fluctuations in crude oil price and/or exchange rate could explain Nigeria's rising trade imbalance since the oil sector contributes over 90% of the country's export earnings while exchange rate adjustments influence transaction costs and trade competitiveness. In other words, changes in the oil price and exchange rate affect trade performance, but the nature of this relationship remains unknown in Nigeria. Though many empirical studies have investigated this relationship, especially in highly industrialised economies, some important gaps exist, especially in developing countries like Nigeria. For instance, there is a dearth of empirical studies on Nigeria's oil price-trade performance relationship. Besides, existing studies on Nigeria's exchange rate-trade performance relationship have anchored their analyses in the aggregate trade model (see Jibrilla and Mohammed, 2015; Onatunji, 2019). They have also assumed that the relationship is symmetric (see Ogbonna, 2011; Omojimite and Akpokodje, 2010; Igue and Ogunleye, 2014; Anoke *et al.*, 2016), thereby ignoring the potential aggregation bias and the intrinsic nonlinearity of the trade model, which could misinform inference. Even though Ogbonna and Ichoku (2022) used the nonlinear ARDL framework, their data are quarterly. However, the crude oil price and flexible exchange rate regimes are notoriously volatile. Their effects on trade balance can be short-lived; thus, higher frequency data

could be substantial in capturing these dynamics. We used higher-speed monthly data to capture the dynamics faster and better. In addition, Ogbonna and Ichoku (2022) did not account for Nigeria's bilateral trade with India, which accounts substantially for Nigeria's trade. For instance, in 2019, Nigeria's bilateral trade with India recorded the greatest chunk of Nigeria's bilateral trade, comprising about 18% of its total trade. Finally, Ogbonna and Ichoku (2022) included in the model both oil price and domestic income that are usually associated with the problem of multicollinearity in an oil dominant economy (Nyangarika, 2018). If the predictive power of a model does not substantially increase when additional regressor is introduced then the regressor ought to be removed (see Brace et al., 2000).

This study aims to examine the asymmetric effects of changes in the oil price and exchange rate on trade performance in Nigeria. The specific objectives are to: (i) ascertain whether Nigeria's bilateral trade performance adjusts asymmetrically to changes in the oil price, and (ii) establish whether there is evidence of the J-curve effect in the response of Nigeria's trade to changes in the exchange rate. Therefore, understanding the symmetric or asymmetric dynamics of oil price and the J-curve patterns on trade would provide policymakers with much-needed guidance. In addition, the relevance of studying bilateral trade is to reveal substantial trade information about a particular country since a nation's trade surplus with some trade partners, such as India in Nigeria's case, could dominate the trade deficit with other economies. Therefore, lumping all trading partners in the same analysis could lead to aggregation bias and unfair representation of the trade effect. Thus, the outcome would be fundamental in helping to design policies that best suits each trading partner instead of generalising to the rest of the world.

## 2. Literature Review

Several empirical studies have investigated the effect of the crude petroleum price on the external trade in different economies with different methodologies outside the nonlinear approach. Still, the findings are widely divided on the nature of their relationships. For example, some studies believe that a rise in the crude petroleum price benefits oil-exporting countries; others believe that the uncertainties embedded in rising prices could also exert a negative influence. Another analytical tradition has concluded that crude petroleum price increases cannot improve external trade in oil-importing countries. Such studies include Le and Chang (2013) for three distinguishable Asian economies – Malaysia as a petroleum-exporting economy, Japan as a petroleum-importing economy, and Singapore as a petroleum-refining economy. Allegret *et al.* (2015) investigated 18 oil-importing economies and 12 oil-exporting economies. Rafiq *et al.* (2009) made a similar analysis for Thailand, Arouri *et al.* (2014) for India, and Hassan and Zaman (2012) for Pakistan.

On the exchange rate and trade balance relationship, some findings based on linear models confirm no significant relationship between exchange rate and trade balance. In contrast, others argue that exchange rate fluctuation contributes significantly to changes in the trade balance. Some studies that find no evidence of an association between exchange rate and trade balance include Laffer (1976), Salant (1976), Miles (1979), Liew *et al.* (2003), Wilson and Tat (2001), Hatemi and Irandoust (2005), and Anoke *et al.* (2016). Even though many previous studies have identified exchange rate as an insignificant factor in the trade balance, the empirical evidence is not uniformly one-sided regarding the relationship between the variables. Some studies find robust evidence of the association between exchange rate and trade balance, including Ogbonna (2011), Omojimite and Akpokodje (2010), and Bahmani-Oskooee *et al.* (2014).

The main pitfall in the linear approach emanates from the fact that the association between the oil price and trade balance and between exchange rate and trade balance could be nonlinear. Thus, the linear model will become highly misleading and problematic in terms of presentation and interpretation, thereby obscuring the real association between the variables. Following the recent doubt on the credibility of linear models in analysing the effect of oil price and exchange rate changes on trade balance, the numbers of studies on the oil price, exchange rate and trade balance relationship based on a nonlinear approach are surging, especially the debate regarding the asymmetric effects. This new line of enquiry has generated a comprehensive understanding of the link between the oil price and trade balance and between exchange rate and trade balance. For example, Rafiq *et al.* (2016) argued that a nonlinear approach could capture the asymmetric market information by decomposing the positive shock from the negative shock. Their study confirms that a rise in the crude petroleum price is positively associated with the oil trade balance in oil-exporting countries. At the same time, oil-importing economies are substantially insulated from positive crude petroleum price shocks. Jibril *et al.* (2020) extended the work of Rafiq *et al.* (2016) by accounting for the sources of crude petroleum price shocks. The study finds evidence of asymmetric effects of crude petroleum price shocks on the trade balance and that the asymmetric association hinges on the source of the shock.

Raheem (2017) was the first to apply the nonlinear approach of Shin *et al.* (2013) to analysing oil price shocks on components of external trade. The study found an asymmetric association on export in the long term in high-trading countries. In contrast, an asymmetric association exists on import in the short term in oil-importers but in the long term in oil-exporters. In a similar study, Ahad and Anwer (2019) found an asymmetric effect of crude petroleum price shocks on the deficit balance of trade in the economy of Pakistan. Baek and Choi (2020) find an asymmetric impact of the crude petroleum price on most bilateral commodity trade between Korea and its four major trading partners at a bilateral level. A similar study by Baek (2020) at a bilateral trade level found

an asymmetric impact of oil prices on the bilateral trade balance of some of Korea's 14 trading partners studied.

On the exchange rate and trade balance viewpoint, Jibrilla and Mohammed (2015) found the existence of an asymmetry in the link between exchange rate and trade balance. In a similar study, Onatunji (2019) argued that a devaluation policy could not correct the trade imbalance in Nigeria. As for the contrary opinion about the insignificant effect of a country's currency devaluation, Bahmani-Oskooee and Fariditavana (2015) established that currency devaluation substantially affects trade balance while appreciation may be negligible for the US, Japan, China and Canada using a nonlinear ARDL approach. Arize *et al.* (2017) revealed evidence that exchange rate adjustment is asymmetric for most of the economies studied in the long term, while half of the economies studied exhibited an asymmetric effect in the short term. The study further found that depreciation has a more substantial impact than appreciation in the long run.

By employing bilateral trade, Bahmani-Oskooee and Kanitpong (2018) found that the long-run asymmetric effects are present in seven economies. Bahmani-Oskooee and Baek (2016) found that 44 out of 79 industries responded differently and strongly to currency devaluation than to appreciation. These findings suggest that a nonlinear approach that permits an asymmetric effect is more substantial in investigating the true nature of the effect between exchange rate and trade balance.

## 3. Methodology

### 3.1 Data

The data for this study consist of monthly time series that span from January 1999 to December 2019. The choice of high-frequency data is in order to gain clear knowledge of the dynamic adjustment, while the time scope in this study accounts for the flexible exchange rate regime reintroduced in 1999. The paper is limited to Nigeria's bilateral trade with its four major trading partners, namely China, India, the UK and the US. A selected country-specific share of the total trade in Nigeria is reported in the Appendix. These selected economies accounted for the larger chunk of Nigeria's bilateral trade, responsible for about 42% of the total trade.

Consequently, the external trade performance of Nigeria is influenced by these economies. The dependent variable is the bilateral trade balance between Nigeria and its trading partners (*TB*), defined in this study as the ratio of Nigeria's value of exports to its trading partners to the value of imports from its trading partners. The advantages of the trade ratio include: (i) whether the trading partner's currency or domestic currency is applied for the measurement of imports and export, the trade ratio is indifferent

to the currency units; (ii) the trade ratio is indifferent to the price index year used and also indifferent whether nominal or real exchange rate is used, thereby overcoming the measurement challenge; (iii) the trade ratio allows the trade balance equation to be estimated in the natural logarithm form. The bilateral trade balance data were obtained from the Direction of the Trade Statistics of the International Monetary Fund (IMF). For independent variables, oil price (*OP*) denotes Brent crude oil price, and the data were obtained from the International Financial Statistics of the International Monetary Fund (IMF). Real exchange rate (*RER*) denotes real exchange rate of the Nigerian naira to the US dollar. This definition of *RER* holds for the US bilateral trade equations. It will be the naira to the respective national currency for the other bilateral trade equations. *RER* is defined in that a rise in  implies a real depreciation of the Nigerian naira against the trading partner's currency. Conversely, a fall in  implies that Nigeria's currency is overvalued and, as such, its goods are overpriced, leading to high imports and depressed exports. *RER* data were obtained from the International Financial Statistics of the International Monetary Fund (IMF). The world industrial production (*Y*) denotes the index of world industrial production as a proxy for global export demand, and the data were obtained from the Federal Reserve Bank of Dallas.

The descriptive statistics indicate that the data exhibited some variability. Quandt-Andrews test result established the presence of a structural break in the series. Hence, we conducted a Zivot-Andrews unit root test that accounts for the structural break to examine whether the time series contain a unit root. The results indicate that all the variables are either integrated of order one or stationary at level, which is consistent with the underlying requirements of the nonlinear ARDL framework. To conserve space, we do not explicitly report the results of these tests, but they are available on request.

## 3.2 Empirical model

The empirical model of this paper emanates from the "two-country" model of trade. The model is derived from the equilibrium market environment, where domestic export supply should correspond with foreign import demand, while domestic import demand should also correspond with foreign export supply. Consequently, the two-country model of trade, as first proposed by Lindert (1986), is defined as:

$$TB = EX\left(EXR, Y^{a}\right) - IM\left(EXR, Y^{b}\right), \tag{1}$$

where *a* denotes a domestic economy while *b* denotes a trading partner; *EX*(*IM*) denotes the volume of products exported (imported) from the country *a* (*b*) to the country *b* (*a*); *RER* denotes the real effective exchange rate for the products measured in the country

*a*'s currency. The standard specification described in Equation 1 is modified to capture the crude oil price. In an oil-dependent economy like Nigeria, we argue that national income changes as the oil price fluctuates following extant literature (Rafiq *et al.,* 2016; Ahad and Anwar, 2020). Thus, real exchange rate of the economy is hugely determined by the total value of export earnings, which in turn depends not only on the volume of oil exports sold abroad but primarily on prices paid for them. Hence, we incorporate the crude oil price in the model following Rafiq *et al.* (2016) and Baek and Choi (2020) and the trade balance model between Nigeria and its trading partners as a reduced-form equation as follows:

$$TB_{i,t} = \gamma + \theta OP_t + \lambda RER_{i,t} + \omega Y_t + \varepsilon_t \,, \tag{2}$$

where $i$ represents Nigeria's bilateral trading partner (*i.e.*, $i$ = China, India, the UK or the US). To test for a cointegrating relationship, we employ the NARDL model since most macroeconomic variables can react differently to crude petroleum price fluctuations and exchange rate adjustment behaviour. By decomposing the regressors in Equation 2 into partial sum processes of positive and negative changes in the regressors to capture the respective increases and decreases in these regressors, we can express Equation 2 as an asymmetric cointegrating relationship of the form:

$$TB_t = \gamma + \theta^{+} OP_t^{+} + \theta^{-} OP_t^{-} + \lambda^{+} RER_t^{+} + \lambda^{-} RER_t^{-} + \omega Y_t + \varepsilon_t \,, \tag{3}$$

where $OP_t^{+} = \sum_{j=1}^{t} \Delta OP_j^{+} = \sum_{j=1}^{t} \max(\Delta OP_{j,} 0)$ and $OP_t^{-} = \sum_{j=1}^{t} \Delta OP_j^{-} = \sum_{j=1}^{t} \min(\Delta OP_{j,} 0)$ are the partial sum processes of positive and negative changes in $OP_t$;

$RER_{i,t}^{+} = \sum_{j=1}^{t} \Delta RER_j^{+} = \sum_{j=1}^{t} \max(\Delta RER_{j,} 0)$ and $RER_{i,t}^{-} = \sum_{j=1}^{t} \Delta RER_j^{-} = \sum_{j=1}^{t} \min(\Delta RER_{j,} 0)$ are the partial sum processes of positive and negative changes in $EXR_t$; and $\Delta$ is the first difference operator. Here, the decomposition of each regressor into partial sum processes assumes an initial threshold value of zero, following Greenwood-Nimmo and Shin (2013). This decomposition splits the crude oil price and the exchange rate regressors in the ratios of 55:45 and 53:47 in favour of the positive regime, respectively. Thus, we do not worry about any bias favouring either the positive or the negative regime.

Since the nonlinear autoregressive distributed lag (NARDL) is an extension of the linear autoregressive distributed lag (ARDL) developed by Pesaran *et al.* (2001), we first specify Equation 2 as ARDL, where the long-run information is integrated with short-run dynamic information in an error-correction format as follows:

$$\Delta TB_t = \gamma + \rho TB_{t-1} + \theta OP_{t-1} + \lambda RER_{t-1} + \omega Y_{t-1} + \\ + \sum_{j=1}^{p-1} \phi_j \Delta TB_{t-j} + \sum_{j=0}^{q-1} (\pi_j \Delta OP_{t-1}) + \sum_{j=0}^{q-1} (\psi_j \Delta RER_{t-1}) + \sum_{j=0}^{q-1} (\varpi_j \Delta Y_{t-1}) + e_t \,. \quad (4)$$

To be able to compute both short-run and long-run asymmetries, we express Equation 3 as a nonlinear ARDL(p,q) model in its error correction form, where we assume that trade performance is explained by its past values, by current and past values of positive and negative oil price and exchange rate, and by current and past values of the index of industrial production as follows:

$$\Delta TB_t = \gamma + \rho TB_{t-1} + \theta^+ OP^+_{t-1} + \theta^- OP^-_{t-1} + \lambda^+ RER^+_{t-1} + \lambda^- RER^-_{t-1} + \omega Y_{t-1} + \\ + \sum_{j=1}^{p-1} \phi_j \Delta TB_{t-j} + \sum_{j=0}^{q-1} (\pi^+_j \Delta OP^+_{t-j} + \pi^-_j \Delta OP^-_{t-j}) + \sum_{j=0}^{q-1} (\psi_j^+ \Delta RER^+_{t-j+} \psi_j^- \Delta RER_{t-j}) + \\ + \sum_{j=0}^{p-1} \varpi_j \Delta Y_{t-j} + e_t \,, \quad (5)$$

where $\rho$ is the speed of adjustment; while $\beta^+ = -\frac{\theta^+}{\rho}$, $\beta^- = -\frac{\theta^-}{\rho}$, $\alpha^+ = -\frac{\lambda^+}{\rho}$, $\alpha^- = -\frac{\lambda^-}{\rho}$ *and* $\eta = -\frac{\omega}{\rho}$ are the asymmetric long-run parameters. $\Phi_j$ embeds the autoregressive parameters; while $\varepsilon_t$ is the white noise process. To ensure that the dynamics of the cointegrating relationship in Equation 5 is not arbitrarily misspecified, we used the general-to-specific lag selection procedure starting with an initial maximum lag length of 6 with a unidirectional 5% decision rule. The specification in Equation 5 is consistent with some recent studies, such as Gulay (2019), Ongan *et al.* (2018), and Kocaarslan *et al.* (2020), among others.

We examined the prevalence of long-run symmetry and short-run additive symmetry using the standard Wald coefficient restriction test. In the case of long-run symmetry, the null hypotheses evaluated are $H_0$: $\beta^+ = \beta^-$ and $H_0$: $\alpha^+ = \alpha^-$. In the case of short-run additive symmetry, the null hypotheses evaluated were $H_0 : \sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ and $H_0 : \sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$. Basically, this model reveals two significant kinds of asymmetries which we seek to ascertain, namely long-run and short-run asymmetry.

## 4. Results and Discussions

The results of the asymmetric regression are reported in Table 1 using the logged data indexed with the base year 2010 = 100 representation. Moreover, there are three panels in Table 1. Panel A shows short-run and long-run coefficient estimates. Panel B shows whether Nigeria's bilateral trade performance in response to positive and negative changes in the oil price and exchange rate is symmetric or asymmetric. Finally, Panel C presents diagnostic statistics.

The major focus of the results presented in Table 1 is the sign and size of the coefficients for the increases and decreases in the oil price. The results reveal that an increase in the crude oil price has a positive and significant impact on trade performance in all cases. In contrast, the impact of an oil price decline is positive and significant for India and the UK and negative and negligible for China and the US. This implies that a positive shock in the global crude oil price is associated with an improvement in trade performance in Nigeria's bilateral trade with her four major partners. This result is similar to the study of Baek and Kwon (2019) for the oil-exporting country of Algeria, while Ahad and Anwer (2020) also found a similar result for Pakistan. As expected for an oil-dependent economy, the possible reason could be the basis of revenue effect from oil export.

On the other hand, negative shocks in the global crude oil price increase the trade balance for India and the UK. These effects of a decrease in the oil price are not surprising due to quantity effects, and as such, the negative revenue effect due to the decline in the oil price could be quite offset by the high demand for crude oil from oil-importing countries. The unexpected result is in line with some previous studies that found a decline in the oil price to be negatively related to trade balance (Baek *et al*., 2019). For China and the US, the oil price fall decreases Nigeria's trade balance with these partners, though not significantly different from zero. This result is consistent with Baek *et al.* (2019) for the case of Iran and Saudi Arabia.

Obviously, since a positive change in the oil price has a significant positive impact, a negative change in the oil price has, in contrast, a positive and negligible negative effect. There seems to be evidence of asymmetry in oil price fluctuation. To further validate this claim of asymmetric effects, we performed the Wald test on these coefficients to establish whether they are different significantly enough to support asymmetric effects. Table 1 reports that the Wald tests are statistically significant except for China in the short run and India in the long run, affirming the asymmetric effect between positive and negative changes in the oil price on trade performance for India, the UK and the US in the short run and China, UK and the US in the long run. In fact, this is a clear departure from the one-size-fits-all adjustment in the case under symmetric impact analysis.

**Table 1: Nonlinear ARDL estimation results**

| | China | India | UK | US |
|---|---|---|---|---|
| **Panel A** | | | | |
| **Long-term coefficients** | | | | |
| $\rho$ | −0.6985*** | −0.3446*** | −0.6265*** | −0.1584*** |
| $\beta^+$ | 1.6953** | 0.6673*** | 0.9497*** | 2.9323** |
| $\beta^-$ | −0.4880 | 0.9993** | 2.5550*** | −0.0697 |
| $\alpha^+$ | −2.9730 | 0.0758 | 3.6696** | −1.4455 |
| $\alpha^-$ | 1.2835 | −1.6013** | −4.9923*** | 9.3382 |
| $\eta$ | −28.5769 | −1.4360 | −7.7685 | −52.6167** |
| **Short-term coefficients** | | | | |
| $\pi^+$ | 4.8544** | 1.1637** | −1.2293 | 0.7719 |
| $\pi^-$ | 0.0063 | −0.2523 | 0.4567 | −1.2333** |
| $\psi^+$ | −5.4339 | −0.4189 | 2.4041 | −0.9715 |
| $\psi^-$ | 1.7367 | 2.9006 | −2.1044 | −5.9307 |
| **Panel B** | | | | |
| **Long-run symmetry tests** | | | | |
| $H_0 : \beta^+ = \beta^-$ | 6.6784*** | 1.6229 | 3.9352** | 4.8928** |
| $H_0 : \alpha^+ = \alpha^-$ | 2.3432 | 2.7126* | 9.4146*** | 1.1563 |
| **Short-run symmetry tests** | | | | |
| $H_0 : \sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ | 1.1441 | 7.7218*** | 4.3248** | 10.2041*** |
| $H_0 : H_0 : \sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$ | 0.5731 | 2.0443 | 0.0793 | 4.5795** |
| **Panel C** | | | | |
| **Diagnostics** | | | | |
| $F_{PSS}$ | 75.1550*** | 25.9528*** | 71.5859*** | 23.9304*** |
| $t_{BDM}$ | −8.5831*** | −4.7724*** | −8.1702*** | −3.6404*** |
| **BG Test ($NR^2$)** | 11.9599 | 8.6558 | 19.3011* | 15.4849 |
| **ARCH test** | 161.6982 | 1.0274 | 1.5161 | 0.2086 |

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Parenthesis denotes t-statistic. The notation for the estimated coefficients relates to the NARDL model of Equation 5, where $\beta$, $\alpha$, and $\eta$ are the long-run coefficients of oil price, bilateral exchange rate and index of industrial production, respectively, while $\pi$, $\psi$, and $\omega$ are the short-run coefficients of oil price, bilateral exchange rate and index of industrial production, respectively. $\beta^+ = \beta^-$ and $\alpha^+ = \alpha^-$ are the Wald tests of long-run symmetry for the oil price and exchange rate respectively. $\sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ and $\sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$ are the Wald tests of short-run symmetry for the oil price and exchange rate, respectively; $F_{PSS}$ denotes the statistics of the bound test of Pesaran *et al.* (2001), and $t_{BDM}$ denotes the statistics of Banerjee *et al.* (1998). The BG test is the Breusch-Godfrey serial correlation test. The ARCH test is an autoregressive conditional heteroskedasticity test for the equal spread of the error variance.

Source: Authors' computation

Thus, one of the most significant findings that emerge from the empirical results is that the global crude oil price has an asymmetric effect on bilateral trade performance in Nigeria. This is consistent with the findings of Baek (2020), who found asymmetric effects in Korea's trade balance with Malaysia, Indonesia, Singapore and the US. The varying effects indicate that an oil price increase has a more prominent impact on Nigeria's bilateral trade with China and the US. In contrast, an oil price decrease has a greater impact on Nigeria's bilateral trade with India and the UK in the long run. In the short run, an oil price increase predominantly has a more prominent impact.

Next, Table 1 also reports the asymmetric adjustment of Nigeria's bilateral trade performance to changes in the exchange rate in the short and long term. Critical observations on the coefficients' estimate of positive and negative exchange rate adjustment support asymmetric exchange rate change since the coefficients show different signs, magnitude and level of significance across all of Nigeria's trading partners. To validate the claim, we conducted empirical tests on the coefficients to be convinced of the asymmetric status in the models using the Wald test for the short and long term. In the case of the long term, the Wald statistics in Panel B of Table 1 detects an asymmetric effect of exchange rate on Nigeria's bilateral trade with India and the UK. Conversely, in the short term, the Wald statistics detect an asymmetric effect of exchange rate on Nigeria's bilateral trade with the US. This means that Nigeria's bilateral trade response with India and the UK is asymmetric in the long run and with the US in the short run. This finding supports the empirical work of Bahmani-Oskooee and Fariditavana (2016), who argued that the long-term impact of positive and negative exchange rate on US bilateral trade with Canada is asymmetric. Surprisingly, the effect of positive changes in exchange rate, which reflect depreciation of the naira against the foreign currency, is predominantly negligible. Still, the result is not in accordance with the theoretical prediction. The possible reason for this unexpected finding is not unconnected with Nigeria's import demand being inelastic. This finding also aligns with the study of Bahmani-Oskooee and Kanitpong (2017), who found that the depreciation of the yen impedes the trade balance in Japan, whose import demand is also inelastic.

Furthermore, Nigeria's bilateral trade with India, the UK and the US is more responsive to appreciation than to depreciation of exchange rate. It is quite similar to the findings of Mathur and Shekhawat (2018) for India's bilateral trade with the US. On the other hand, Nigeria's bilateral trade with China and the US in the long run and China, India and the UK in the short run are symmetric. This result agrees with Bahmani-Oskooee and Fariditavana's (2016) findings, revealing that the exchange rate has a symmetric effect on US-France bilateral trade. Bahmani-Oskooee and Kanitpong (2018) also found that Thailand's trade balance with her seven (eight) trading partners

responds asymmetrically (symmetrically) to positive and negative exchange rate adjustment.

The J-curve effect is observed only for the Nigeria-UK trade balance. More precisely, it is clear from Panel A of Table 1 that the short-run coefficient of positive exchange rate change is positive but insignificant. However, the long-run coefficient of positive exchange rate change is positive and significant, supporting the J-curve effects in Nigeria's bilateral trade with the UK. This finding is consistent with the work of Bahmani-Oskooee and Kanitpong (2018), who also found the J-curve effect for Thailand's trade balance with at least eight out of 16 trading partners.

A post-diagnostic test was performed to assure the robustness of the model. Panel C of Table 1 presents the results of the test. The test suggests that the model results are suitable for policy inference.

## 4.1 Robustness test

We conducted a robustness test to confirm that the findings do not depend on assumptions concerning the data-generating process. If the findings rely upon data-generating processes, it suggests that the findings could likely create policy uncertainty. Therefore, we used the Western Texas Intermediate (WTI) crude oil price as an alternative proxy for the crude oil price and Nigeria's trade with the European Union as an alternative to Nigeria's trade with the United Kingdom to ascertain the asymmetric effects of changes in the oil price and exchange rate on trade performance in Nigeria. Interestingly, the patterns in the results predominantly remained the same in all cases and did not qualitatively alter our overall findings, showing that the findings were not just happenstance. The estimation results are reported in Table 2.

# 5. Concluding Remarks

Despite the inherent asymmetric effect of oil prices and exchange rate changes, empirical evidence on the effects of the oil price on trade performance in Nigeria remains limited. Besides, existing studies on the exchange rate-trade balance relationship in Nigeria anchored their analyses in the aggregate trade model. Based on low-frequency data, ignoring the potential aggregation bias and the highly volatile nature of the exchange rate, this could misinform inference. The study became necessary following numerous uncertainty-inducing events in recent years, which have usually resulted in a collapse of oil prices and frequent exchange rate fluctuations, thereby stimulating trade imbalances in oil-exporting countries.

**Table 2: Nonlinear ARDL estimation results – bilateral level**

| | China | India | EU | US |
|---|---|---|---|---|
| **Panel A** | | | | |
| **Long-term coefficients** | | | | |
| $\rho$ | −0.8359*** | −0.3296*** | −0.5429*** | −0.1395*** |
| $\beta^+$ | 2.8628*** | 0.6958*** | 0.3896** | 2.9597* |
| $\beta^-$ | 0.1388 | 1.2039*** | 0.3221* | 0.3311 |
| $\alpha^+$ | −4.0604 | 0.2508 | −1.0239** | −1.1945 |
| $\alpha^-$ | 1.6100 | −2.0650*** | −0.8732 | 7.0919 |
| $\eta$ | −22.9690 | −1.1754 | 1.5953 | −47.7162** |
| **Short-term coefficients** | | | | |
| $\pi^+$ | 1.5904 | 1.4409*** | −0.3832 | 1.2869 |
| $\pi^-$ | 1.1145 | −0.2621 | 0.1250 | −1.5328 |
| $\psi^+$ | −2.3185 | −0.6895 | −0.4289 | −1.2141 |
| $\psi^-$ | 4.0072 | 3.5558* | 1.3917 | −6.4509 |
| **Panel B** | | | | |
| **Long-run symmetry tests** | | | | |
| $H_0 : \beta^+ = \beta^-$ | 12.4243*** | 2.2080 | 4.1578** | 3.2655* |
| $H_0 : \alpha^+ = \alpha^-$ | 4.3561** | 3.1079* | 3.1084* | 0.5658 |
| **Short-run symmetry tests** | | | | |
| $H_0 : \sum_{j=1}^{q-1} \pi_j^+ = \sum_{j=1}^{q-1} \pi_j^-$ | 0.0203 | 9.6724*** | 0.5137 | 13.7508*** |
| $H_0 : H_0 : \sum_{j=1}^{q-1} \psi_j^+ = \sum_{j=1}^{q-1} \psi_j^-$ | 0.4713 | 3.5528* | 0.8291 | 4.5616** |
| **Panel C** | | | | |
| **Diagnostics** | | | | |
| $F_{PSS}$ | 28.4749*** | 27.3710*** | 19.3513*** | 20.8435*** |
| $t_{BDM}$ | −13.0387*** | −4.7076*** | −9.5041*** | −3.2204*** |
| **BG Test ($NR^2$)** | 1.4105 | 1.9670 | 3.6860 | 1.2229 |
| **ARCH test** | 27.5801*** | 1.0057 | 0.2764 | 0.7004 |

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The notation for the estimated coefficients relates to the NARDL model in Equation 5.

Source: Authors' computation

Our findings are summarised as follows. Firstly, we find that oil price rises and falls asymmetrically influence Nigeria's trade with China, India, the UK and the US, but the evidence for India appears to be in the short run only while for China in the long run only. Further evidence indicates that oil price rises exert a greater influence than falls for China and the US in the long run while in the short run, oil price falls exert a greater influence than rises for the US. Furthermore, the results indicate that Nigeria's trade balance with India and the UK in the long run and with the US in the short run significantly responds asymmetrically to changes in the exchange rate. In the case of China, there is no evidence of asymmetry either in the short run or in the long-run. Finally, the results indicate significant evidence of a J-curve pattern in the response of Nigeria's trade balance with the UK to changes in exchange rate only. In sum, the identification of symmetric or asymmetric effects is substantial for explaining shocks in global oil price movements and understanding the response of Nigeria's bilateral trade to oil price shocks for policy inference. We also demonstrated that these results are consistent with the dynamics of the economy under investigation, which mainly suggests adverse effects of the devaluation of the naira. Therefore, policymakers should mainly focus on domestic production of imported goods rather than devaluation.

## Appendix

**Nigeria's top 4 trading partners in terms of origin of imports (2019)**

| Rank | Country | Exports (million USD) | Export share | Imports (million USD) | Import share | Total trade (million USD) | Trade share |
|---|---|---|---|---|---|---|---|
| **1** | China | 4,424.05 | 6.69 | 10,071.05 | 23.05 | 14,495.10 | 13.20 |
| **2** | US | 3,908.92 | 5.91 | 4,440.91 | 10.17 | 8,349.83 | 7.61 |
| **3** | India | 18,127.28 | 27.42 | 2,156.55 | 4.94 | 20,283.83 | 18.48 |
| **4** | UK | 1,257.14 | 1.90 | 1,834.05 | 4.20 | 3,091.19 | 2.82 |
| | **Sub-total** | **27,717.39** | **41.92** | **18,502.56** | **42.36** | **46,219.95** | **42.11** |
| | **Total** | **66,101.39** | **100.00** | **43,687.31** | **100.00** | **109,788.70** | **100.00** |

Note: The export, import and trade shares are the percentages of shares of total export, import and trade.

Source: Direction of Trade Statistics (DOTS) by the IMF, 2020

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