Modelling the impact of crude oil price on Nigerian exchange rate during COVID-19

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***Abstract*: This study examines whether the dynamics of the impact of oil prices on currency rates during a crisis are comparable throughout the many COVID-19 pandemic waves using the example of the Nigerian economy. The ARDL model was deemed the most appropriate to model the relationship between exchange rates and oil prices in the setting of this study, which is consistent with the results of our unit root testing. The study demonstrates empirically that, in the setting of exporting economies, the effect of oil prices on exchange rates is as theoretically predicted. It also shows that the average depreciation patterns of the Nigerian naira in relation to the US dollar tend to get worse when the COVID-19 pandemic outbreaks occur.**

***Keywords*: Exchange rates; Oil prices; COVID-19; Nigeria; ARDL**

***JEL Classification*: F31; O55; Q41;**

I. INTRODUCTION

Since the emerging of the theoretical paper pioneered by Krugman (1983) and Golub (1983), the debate on the exchange rate and oil prices relationship usually rests on the fact that oil price is quoted in US dollar (USD) and therefore, fluctuations in oil price may affect the exchange rate behaviour of trading nations through the USD (see Salisu & Mobolaji, 2013). Theoretically, the impact of oil price shocks on economies that export oil should be different from that on those that receive oil. According to Abed et al. (2016), an increase in oil prices results in a wealth shift from oil-importing countries to oil-exporting countries. As a result, while rise in foreign exchange earnings and the accumulation of foreign exchange reserves are anticipated to result in an appreciation of the exchange rate of a country that exports oil, it is anticipated that the currency rates of countries that import oil will decline (see Albulescu & Ajmi, 2021, for a survey of recent literature). However, it not clear whether these theoretical assumptions on the exchange rate –oil prices nexus can be generalized when the economic is in crisis compared to period of tranquility. To address this important concern, the contributions of this study to literature on exchange rate and oil price relationship are in twofold.

First, the dynamics of the impact of oil prices on exchange rates in tumultuous periods have primarily been examined in the context of the 2007–2008 global financial crisis, despite the mixed findings and inconclusive results that characterise the majority of existing studies (see, for example, Jin & An, 2016; Boamah et al., 2017; Jiang et al., 2017; Nikkinen et al., 2020; Sheikh et al., 2020; Hung, 2021). The current COVID-19 breakouts, however, seem to have had a significant impact on both the supply and demand sides of the economy, in contrast to the global financial crisis (GFC), which was brought on by loose underwriting standards and excessively leveraged financial intermediaries in the subprime mortgage finance industry. In other words, unlike the Great Financial Crisis (GFC), the COVID-19 pandemic was brought on by a significant external shock to the economic outlook, and efforts to manage it jeopardised activity and the financial market's ability to operate regularly. In reality, the fight against the epidemic caused the price of oil to fall by a record amount in March 2020. Since then, with the speculation that the COVID-19-induced oil price shocks may have changed the dynamics of their effects on exchange rates, this has reopened the discussion on the relationship between the price of oil and the exchange rate during the crisis.

However, it appears that the majority of the recently published studies connecting recent, widespread financial market instability to COVID-19 pandemic breakouts has mostly concentrated on the stock return element of financial markets (see, for example, Zhang et al., 2020; Topcu & Gulal, 2020; Baig et al., 2020; Ramelli & Wagner, 2020; Salisu & Sikiru, 2020; Al-Awadhi et al., 2020). The work by Feng et al. (2021) and, more recently, the study by Narayan are notable exceptions in this regard (2022). The former finds that the COVID-19 pandemic causes exchange rate volatility, while the latter analyses the development of spillover shocks from EUR, Yen, CAD, and GBP exchange rate returns to come to the conclusion that between 56 and 75 percent of the exchange rate volatility dynamics over the COVID-19 sample are caused by own shocks (see also Narayan et al., 2020; Iyke, 2020; Narayan, 2020a).

In spite of the fact that Qin et al. (2020) show that the pandemic has a negative impact on oil prices (see also Narayan, 2020b; Gharib et al., 2021; and Wang et al., 2022), as of the time of writing, Devpura (2021) appears to be the only significant study to have looked at the effects of COVID-19 on the relationship between oil price and exchange rate. The first contribution of this study is to test whether the dynamics of the impact of oil price on exchange rate during COVID-19 can be generalized for the various characteristics of the various waves of COVID-19 outbreaks, given the dearth of literature on the dynamics of the impact of oil price on literature.

Second, the idiosyncrasies of the economy under investigation may have an impact on whether or not the previously established theoretical assumptions about the relationship between exchange rates and oil prices are still relevant. For instance, Nigeria has a rather paradoxical situation in that it is both a significant exporter of crude oil and a significant importer of refined petroleum products. Because Nigeria exports crude oil and imports items related to the petroleum industry, the country's unique circumstance exerts pressure on the exchange rate whenever the price of crude oil changes. In order to achieve this, the study's second contribution is to revisit the relationship between the exchange rate and oil prices, not just in the context of an economic crisis but also in an economy that exhibits the odd paradox of both oil-exporting and oil-importing characteristics.

II. THEORETICAL CHANNELS OF TRANSMISSION BETWEEN EXCHANGE RATE AND OIL PRICE

Three channels, namely the balance of payments channel, the terms of trade channel, and the elasticity channel, can be used to understand how changes in the price of oil affect the exchange rate (see Krugman, 1983; Beutzer et al., 2012; Abed et al., 2016). The wealth transmission channel, also known as the balance of payments channel, proposed that as oil prices rose, money would move from economies that rely on oil imports to those that do not. In this regard, it is anticipated that a rise in oil prices will lead to a depreciation of the currencies of oil-importing countries in comparison to those of oil-exporting countries. In terms of the term "trade channel," the economy is divided into two sectors: tradable and non-tradable (Abed et al., 2016; Amano and Van Norden, 1988). The assumption here is that both the non-tradable and tradable sectors use a tradable input, oil, as well as a non-tradable input, labour; additionally, because the prices of outputs in the tradable sector are fixed internationally, the prices of output from the non-tradable sector influence a country's real exchange rate.

According to Benessy-Quere et al. (2007), in particular, the amount of oil used as an input in both the tradable and non-tradable sectors determines how the real exchange rate reacts to shocks in the price of oil. If a positive oil shock happens and the non-tradable sector uses less energy (oil) than the tradable sector, the price of its products decreases, which causes the currency to depreciate. But when the non-tradable sector uses more oil than the tradable sector does, the non-tradable sector's output prices rise in response to higher oil prices, which causes the currency to appreciate. Moving on to the elasticity channel, the claim is that the elasticity of a country's demand for oil imports determines how variations in the price of oil are transmitted to exchange rates (Nkomo, 2006; Abed et al., 2016). A country can reduce its oil demand, which has a propensity to cause its currency to appreciate, or at the very least neutralize the effect of an increase in oil prices if its demand for oil imports is elastic and oil prices rise. The currency of the oil-importing country depreciates when the price of oil rises, however, if the demand for imports is inelastic.

The preceding theoretical illustrations show that a positive oil price shock is projected to have a favourable impact on the currencies of oil exporting countries. However, it is unclear whether this position can be generalized when the economy is in crisis vs when things are calm. More importantly, if the premise holds true for an oil-exporting economy with an oil-importing component. To address these concerns, we examined the impact of the oil price on the exchange rate over the four COVID-19 waves using the case of Nigeria, an economy with paradoxical qualities of oil exporting and oil importing.

III. METHODOLOGY AND DATA

3.1 Econometric Model

To capture the dynamics of the impact of oil prices on exchange rate, the Auto-regressive Distributed Lag (ARDL) modeling procedure, which allow us to account for both the short run and long run dynamics of the nexus is considered the most appropriate in this study. The preference for ARDL compared to other alternative methods in the literature hinge on the flexibility of its application regardless of whether the variables are stationary or become stationary through the first difference. Also, and according to Pesaran, Shin and Smith (2001), the selection of the optimum ARDL model involves automatic correction of the residual serial correlation and of the endogeneity problem. Thus, the ARDL representation of the nexus between exchange rate and oil prices is as given below.

$$\Delta er_t = \phi + \alpha_1 er_{t-1} + \alpha_1 op_{t-1} + \alpha_2 \operatorname{int}_{t-1} + \sum_{j=1}^{p} \beta_{1j} \Delta er_{t-j} + \sum_{i=0}^{q1} \beta_{2i} \Delta op_{t-i} + \sum_{i=0}^{q2} \beta_{3i} \Delta \operatorname{int}_{t-i} + \sum_{n=1}^{k} \lambda_n D_{nt} + \varepsilon_t \qquad (1)$$

Equation (1) is the ARDL representation of the exchange rate–oil price relationship, where *er* represents the exchange rate and *op* is the oil price; the term *int* denoting interest rate controls for the role of monetary policy in the model; and *D* is a matrix representing a dummy variable for the different four waves of COVID-19 experienced. All the variables are captured in their natural logarithm thus explained while they are expressed in their lower case. The intercept and slope coefficients' long run parameters are calculated as follows: $-\frac{\phi}{\alpha_1}$, $-\frac{\alpha_2}{\alpha_1}$ and $-\frac{\alpha_3}{\alpha_1}$. However, since in the long run it is assumed that $\Delta er_{t-j} = 0$ and $\Delta(op, \operatorname{int})_{t-i} = 0,$ respectively, then the short run estimates are obtained as β_{1j}, β_{2i} *and* β_{3i}.

Because the variables in the first differences can accept more than one lag, it is required to determine the best lag combination for the ARDL. The Schwartz Information Criterion was used to determine the ideal lag length (SIC). The optimal lag is the lag combination with the lowest value of the given criterion among the competing lag orders. As a result, the preferred ARDL model is utilized to test the model for long-run correlations. This method of testing for cointegration, as previously mentioned, is known as "bounds testing" since it involves the upper and lower bounds. If the estimated *F*-statistic is more than the upper bound, there is cointegration and if it is less than the lower bound, then there is no cointegration. Equation (2) can be re-specified to include an error correction term as follows:

$$\Delta er_t = \phi + \delta ECT_{t-1} + \sum_{j=1}^{p} \beta_{1j} \Delta er_{t-j} + \sum_{i=0}^{q1} \beta_{2i} \Delta op_{t-i} + \sum_{i=0}^{q2} \beta_{3i} \Delta \text{int}_{t-i} + \sum_{n=1}^{k} \lambda_n D_{nt} + \varepsilon_t \quad (2)$$

Equation (2) is the error correction variant of the ARDL specification in equation (1), where the ECT_{t-1} is the error correction term while the coefficient δ represent the speed of adjustment to equilibrium level. It is instructive that the term *D* in both equations (1 & 2) is a matrix of dummy variables for the first, second, and third waves of COVID-19 captured as fixed regressors with the first wave (i.e. First_Wave) suppressed from the estimation to avoid perfect collinearity problem and instead expressed as the reference dummy.

3.2 Data Description and Source

Data used in this study are monthly frequency spanning January, 2010 to October, 2022. The choice of 2010 as our start date was necessary to avoid including the period of GFC in the dataset. Given that the oil price is traded in the US dollar, the exchange rate in this study is measured as the log of Nigerian currency (Naira) relative to the US dollar. Also, the oil price is measured as the log of monthly Brent crude oil prices, while the control for monetary policy in the model is measured as log of short-term interest rate. Both the exchange rate and interest rate variables were sourced from the Central Bank of Nigeria (CBN) online database. Finally, three periods of increased transmission, for instance, waves of COVID-19 have been globally acknowledged, there have been varying definitions of what constitutes the start and end dates of the different waves of COVID-19 for different countries. Recognizing that this may cause inconsistencies in comparison, particularly when investigating the cases of countries with different start and end dates of COVID-19 waves, we opted for a unified start and end date of the different waves of COVID-19 from a global perspective. According to Ilesanmi et al. (2022), the first wave of COVID-19 globally commenced in October 2020 and peaked in January 2021, followed by a steady decline between January and March 2021. The second wave commenced in April 2021 and peaked in May 2021, and thereafter there was a subsequent decline in COVID-19 cases (see Ilesanmi et al., 2021), while the third wave of the pandemic commenced in June 2021. A dummy variable method as earlier established was used to capture each of these waves of COVID-19.

IV. RESULT PRESENTATION

4.1 Preliminary Analysis

Presented in Table 1 are descriptive statistics and unit root testing results. Starting with the former, the mean statistic shows that about N254 was required on average in exchange for just a unit of USD (i.e., $1) between the periods of January, 2010, and October, 2022. This indication of Nigerian currency depreciation relative to the US dollar is a common scenario in a number of developing African economies; however, the extent to which such depreciation is influenced by changes in oil prices is unclear at this time. Also portraying Nigeria as a typical developing economy is the fact that the mean statistic further reveals the country's average interest rates to be as high as 15%. With respect to the global variable under consideration in this case, the mean statistic puts the average monthly international crude oil price at $77 for the period under consideration. With respect to the standard deviation statistic, which measures the dispersion of a variable from its mean level, the value is particularly large for the exchange rate compared to oil prices, thus portraying the former as having the most volatility compared to the latter. This, however, may be sensitive to the period under consideration in the context of this study. Using the information from skewness and kurtosis statistics, the Jarque-Bera (JB) test for normality consistently shows evidence of non-normality for all the variables.

Table 1: Preliminary Results

Variable/Statistic	**Descriptive statistics**					**ADF test**		
	Mean	*Std. Dev.*	*Skewness*	*Kurtosis*	*J-B test*	**Level**	**First_Df**	**I(d)**
EXR_t	254.65	95.92	0.36	1.66	14.89*	-2.755^{b}	-5.632^{b}*	I(1)
OPR_t	77.86	26.05	0.12	1.72	10.81*	-1.767^{a}	-8.677^{b}*	I(1)
INT_t	15.68	2.15	-1.01	2.66	26.95*	-1.867*	-	I(0)

Source: Computed by the author(s) with * denoting the rejection of the null hypothesis of normal distribution as well as the hypothesis of unit at 5% level of significance, respectively. The term Std. Dev. denotes standard deviation while ADF represents Augmented Dickey-Fuller unit root test. The subscripts a & b implies that the ADF test was performed with model with constant only or with constant and trends while the I(d) is the order of integration.

Regarding the unit root test, a look at Table 1 shows that the null hypothesis of unit root holds in the cases of the exchange rate and oil prices but is rejected in the case of the interest rate. On the whole, the order of integration hovers around I(0) and I(1), thus suggesting the order of integration is mixed for the variables. This, among other things, strengthens our preference for the ARDL model as the appropriate technique, as it allows for the integration of variables in a mixed order in a single framework. Thus, presented and discussed in the following immediate section are empirical estimates obtained from the estimated ARDL (1,1) model.

4.2 Empirical Result and Discussion of Findings

The empirical estimates generated by the ARDL model on the relationship between exchange rates and oil prices are presented in Table 2. The goal of this research is to see if the impact of oil prices on the exchange rate during COVID-19 differs across the different waves of the epidemic. Beginning with the results of the bound cointegration tests, the null hypothesis of no cointegration was significantly rejected at 10%, indicating the possibility of a long-run link between the exchange rate and oil prices. In line with the bound cointegration testing results, the coefficients on the error correction term (ECT) were notably significant at the 1% level of significance, confirming the evidence of cointegration. Building on this background, we then proceed to analyse and discuss the elasticities of the coefficients, where we find both the short-run and long-run coefficients on oil prices to be statistically significant with negative signs. This appears to be consistent with the theoretical prediction of positive changes in oil prices promoting exchange rate appreciation in oil exporting economies.

Table 2: ARDL estimates on the impact of oil price on exchange rate during COVID-19

Long Run Equation	**Dependent variable: Exchange Rate (ER)**		
	Coefficient	**Standard Error**	**T-statistic**
OP_t	-0.5675**	0.2402	-2.3624
INT_t	-0.0524	0.4410	-0.1188
Short Run Equation			
Constant	0.4120***	0.1271	3.2403
ΔER_{t-1}	-0.0534***	0.0201	-2.6512
ΔOP_t	-0.0303***	0.0082	-3.6602
ΔINT_t	-0.0027	0.0234	-0.1193
ECT_{t-1}	-0.5341***	0.0126	-8.2101
Fixed Regressors			
$Second\_Wave$	0.1712**	0.0161	-3.3574
$Third\_Wave$	0.0254**	0.0027	-1.8202
Bound Test Cointegration Results			
Level of Significance	F-statistic	I(0)	I(1)
10%	5.83*	4.31	5.22
5%		5.07	6.10
1%		6.73	8.05
Diagnostic and Post-Estimation Results			
Adjusted R^2:	0.98		
F-statistics:	7859.89 (0.00)		
Autocorrelation test (Q-Statistic):	38.76 (0.071)		
Heteroscedasticity test (ARCH LM)	4.993 (0.099)		
Normality test (Jaque-Bera):	11.612 (0.703)		

Note: The value in parenthesis represent the probability values for the various post estimation tests performed, while ***, ** and * denote 1%, 5% and 10% level of significance.

However, of particular interest in this study is whether such dynamics of short- and long-term appreciative responses of the exchange rate to oil prices can still be generalized in a crisis period such as the COVID-19 outbreak and particularly across the different waves of the outbreak. First, we find the intercept coefficient, which, in the context of constant dummy regression as applicable in this study, denotes the reference dummy (i.e., First_Wave) to be statistically significant. Also, we find the coefficients on the two fixed regressors, namely, Second_Wave and Third_Wave, to be statistically significant. This evidence of the statistical significance of the coefficients on the intercept and fixed dummy regressors is an indication that the average exchange rate during COVID-19 varies across the three waves of the pandemic.

For instance, the average unit of naira required in exchange for one unit of dollar appears to be 0.17% higher in the second wave of the pandemic compared to the first wave of the pandemic. Also, the rate of depreciation of the Nigerian currency relative to the USD is higher in the third wave of the pandemic by 0.03% compared to that of the first wave. The economic intuition in this regard is that while the oil price, as theoretically predicted, tends to cause appreciation of exchange rates in Nigeria, the outbreaks of COVID-19 appear to have worsened the average depreciation trends of the Nigerian currency relative to the US dollar. More importantly, the magnitude of the depreciation during COVID-19 appears to vary for the different waves of the pandemic such that the depreciation is on average higher during the second wave of the pandemic, with the first wave being the period with the least depreciation of the exchange rate during the pandemic.

V. CONCLUSION

This study examines whether the dynamics of the impact of oil prices on currency rates during a crisis are comparable throughout the many COVID-19 pandemic waves using the example of the Nigerian economy. The ARDL model was deemed the most appropriate to model the relationship between exchange rates and oil prices in the setting of this study, which is consistent with the results of our unit root testing. But while the study's empirical findings support the theoretical predictions that oil prices have on exchange rates in the context of exporting economies, it further reveals the fact the COVID-19 pandemic outbreaks exacerbates the average trends of the Nigerian currency's depreciation relative to the US dollar.

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