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The Impact of Covid-19 and Crude Oil Price on the NGN/USD Exchange Rate Using Vector Autoregressive Coefficients

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***Abstract*—The impact of Covid-19 on economies appears global and Nigeria is not insulated from its shock. The exchange rate of a country indicates the health of that economy. In this work, the effect of the novel Covid-19 pandemic on the Nigerian Naira (NGN) and the United States Dollar (USD) exchange rate in the face of fluctuating crude oil prices were examined. Using the vector autoregressive computational model, the impact of crude oil, confirmed cases of people infected with Covid-19 and the total death due to Covid-19 on the NGNUSD exchange rate was investigated. The result shows that crude oil price contributed positively to the NGNUSD exchange rate only at the first lag while it negatively affected the exchange rate at the second and third lag. The total confirmed cases contributed positively in the first and third lag while making a negative contribution in the second lag. The total death due to covid-19 contributed negatively in the first and third lag, while contributing positively in the second lag. It was obvious that the Nigerian exchange rate was affected by the Covid-19 pandemic both positively and negatively at different stages during the covid-19 pandemic. It was suggested that the diversification of the economy is a must for the NGN/USD exchange rate stabilization in the nearest future.**

Keywords— Covid-19, Nigerian exchange rate, crude oil price, vector autoregressive (VAR) model, impulse response, Cholesky decomposition

I. INTRODUCTION

The Covid-19 pandemic took the world by storm beginning from January 2020 in Wuhan China. Things happened so fast countries locked their borders, businesses closed as governments issued stay-at-home orders. Nigeria joined in the frenzy, from the partial lockdown to the total lockdown and the gradual easing off. The airports and seaports were shut. All land borders were also shut. Nigeria as an import-dependent nation was sorely hit as there was no market for crude oil sales. There was a drastic fall in the price of crude oil as the price fell to around 11 USD/Barrel [1]. This affected the Nigerian exchange rate as the country slipped into recession.

In this work, we seek to investigate the impact of a covid-19 global pandemic on the Nigerian Naira (NGN) and the United States Dollar in the presence of crude oil price fluctuation. This work employed vector autoregressive (VAR) model.

II. LITERATURE REVIEW

Numerous works had been done on the economic impact of covid-19 on the exchange rate, stock market, crude oil. Most of the results showed that covid-19 affected the global economy negatively as well as positively. Nwosa *et al* [1] looked at how covid-19 impacted oil price, exchange rate, and oil price. He realized that the global pandemic harmed the afore-mentioned variables. The work also shows a negative effect on the flow of foreign direct investment into the country. Konstantakis in [2], investigated the impact of covid-19 on the euro to dollar exchange rate using the Markov Switching model and spectral non-causality test by comparing the performance of S&P 500 indexed stock, oil price, and gold as other determinants of the euro to the dollar exchange rate. Camb et al [3] looked at the impact of COVID-19 on the Philippine stock market, peso-dollar rate, and the retail price of diesel.
They used the vector auto-regression (VAR) model and the robust least squares regression model. Their result shows a negative impact on all the variables under consideration. In [4], Iyke et al suggested that covid-19 contains information that can enhance the prediction of exchange rate return and volatility. Syahri et al [5] focused on exchange rate, and Composite Stock Price Index (CSPI) using DCC-GARCH model. Kartal et al [6] used the multivariate adaptive regression splines model to investigate the relationship among covid-19 and USD-TRY, credit default swap spread, global uncertainty, and global volatility as control variables.

In this work, the impact of Covid-19 on the NGN/USD exchange rate is examined in light of the crude oil price

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fluctuation. Computational model involving software techniques will be employed for analysis.
This was done having in mind that Nigeria is a mono-economic nation; whose major source of revenue is crude oil export.

III. METHODOLOGY

In this Section, vector autoregressive (VAR) model is a useful tool employed for ascertaining the relationship among multiple variables. It has the capability of capturing the interaction among the variables. It is also good for forecasting.
A VAR (p) model can be represented as

$$v_t = c + Y_1 v_{t-1} + Y_2 v_{t-2} + Y_3 v_{t-3} + \cdots Y_p v_{t-p} + \varepsilon_t \quad (1)$$

Where$p$ is the lag order and $v_t = (v_{1t}, \dots, v_{nt})'$ is a random term of order $(n \times 1)$, Y_i is the coefficient matrix, $c = (c_1, \dots, c_n)'$ is a $(n \times 1)$ constant term where $E(v_t)$ can be non zero, ε_t is a vector of white noise with $E(\varepsilon_t) = 0$ and $E(\varepsilon_t, \varepsilon_t') = \xi_\varepsilon$ must satisfy non-singularity conditions.

If the VAR process is of order 1, then equation (1) becomes

$$V_t = C + Y\ V_{t-1} + \epsilon_t \quad (2)$$

Where

$$V_t = \begin{bmatrix} v_t \\ v y_{t-1} \\ \vdots \\ v_{t-p+1} \end{bmatrix}, \qquad C = \begin{bmatrix} c \\ 0 \\ \vdots \\ 0 \end{bmatrix},$$

$$Y = \begin{bmatrix} Y_1 & Y_2 & \cdots & Y_{p-1} & Y_p \\ I & 0 & \dots & 0 & 0 \\ 0 & I & \dots & 0 & 0 \\ \vdots & \ddots & \dots & \vdots & \vdots \\ 0 & 0 & 0 & I & 0 \end{bmatrix} \text{ and } \epsilon_t = \begin{bmatrix} \varepsilon_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

Equ (2) can be resolved using the method of ordinary least square.

A. *Condition for Stability:*

The condition for the convergence of the VAR *(p)* model is that it must be stable. For the VAR *(p)* model to be stable, it suffices that all the roots of $Det\left(I_n - Y_1 z - \cdots - Y_p z^p\right) = 0$ lie within the unit root circle.

B. *Optimal Lag Length:*

The optimal lag length p for the VAR (p) model is the value of p that minimizes the information criteria. Any of Hannan-Quinn information criterion (HQ), Akaike information criterion (AIC), Schwarz information criterion (SC) can be used.

The information criteria for a VAR (p) process is

$$IC(p) = In\left|\bar{\xi}(p)\right| + g_T \,.\, \varphi(n,p) \quad (3)$$

Given that $\bar{\xi}(p) = T^{-1} \sum_{t=1}^{T} \hat{\varepsilon}_1 \hat{\varepsilon}_T'$ is the residual covariance matrix without a degree of freedom correction from a VAR (p) model. g_T is a sequence indexed by the sample size T and $\varphi(k,p)$ is a penalty function that penalizes large VAR(p) models.

$$HQ(p) = In\left|\bar{\xi}(p)\right| + \frac{2 \ln T}{T} pn^2 \quad (4)$$

$$AIC(p) = In\left|\bar{\xi}(p)\right| + \frac{2}{T} pn^2 \quad (5)$$

$$SC(p) = In\left|\bar{\xi}(p)\right| + \frac{\ln T}{T} pn^2 \quad (6)$$

C. *Impulse Response*

An impulse response function traces the effect of a one-time shock to one of the innovations on the current and future values of the endogenous variables. Recall the Wold representation,

$$y_t = \mu + \varepsilon_t + \eta_1 \varepsilon_{t-1} + \eta_2 \varepsilon_{t-2} + \cdots + \cdots \quad (7)$$

Where

$$\eta_{ij}^{s} = \frac{\partial y_{i,t+1}}{\partial \varepsilon_{j,t}} = \frac{\partial y_{i,t}}{\partial \varepsilon_{j,t-s}} i, j = 1, \dots, T \quad (8)$$

is the response of y in period $t + s$ to shock in period s.
η_s is the Impulse Response Function of s.
The $k \times k$ moving average matrices η_s are determined recursively using

$$\eta_1 = \sum_{j=1}^{p-1} \eta_{s-j} A_j \,, s = 1,2, \dots \quad (9)$$

IV. MODEL SPECIFICATION

The exchange rate serves as our dependent variable. As a result of the heterogeneity of the variables' sizes, we take the natural log of the variables in other to homogenize the variables as well as make the model more robust.
We specify our Vector Autoregressive model as

$$Y_t = C + \sum_{i=1}^{p} A_i Y_{t-1} + \epsilon_t \quad (10)$$

Where
Y_t is a (4×1) random vector of endogenous variables being considered as exchange rate, crude oil price, total confirmed cases, and total deaths due to covid-19.
A_i are fixed coefficient matrix,

C is a fixed (4×1) vector of intercept terms.
ε_t is a 4-dimensional white noise and p is the lag order.
The structural unrestricted VAR model for this study is specified as.

V. COMPUTATIONAL RESULT

In this Section, the analysis as well as the graphical representations was carried out using the econometric software Eview 8. So far, the output is presented and explained below.

A. *PreCovid Era*

Before 2014, the price of oil sold for over 100 USD/barrel, between the second and fourth quarter of 2014, it fell to between 50 and 70 USD/Barrel. It fell to its lowest value in the pre-covid-19 era to around 30 USD/Barrel and back to between 50 and 80. The NGNUSD sold at about 160NGN/USD between the fourth quarter of 2014 and the first quarter of 2015.
It moves to about 200 NGNUSD and hovered at that value until the second quarter of 2016. At this point, there was a spike to about 320 NGNUSD and then it leaped to about

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360 NGNUSD in the third quarter of 2017 where it hovers until the last quarter of 2019.

B. Post Covid Era

Crude dropped from about 50 USD/Barrel to about 20 in the first quarter of 2020. From the fourth quarter of 2020, there was a steady rise to over 70 USD/Barrel. The exchange rate to about 20,000 confirmed cases. It crossed the 60,000 marks by the first quarter of 2021 and by the third quarter of 2021, it was well over 140,000 confirmed cases. The total

was at about 360 NGN/US, it then moved to about 370, and then there was a jump to about 390 NGNUSD. There was another jump in the second quarter of 2021 to around 410 NGNUSD.

Total confirmed cases of covid-19 cases started growing from the second quarter of 2020 by the third quarter it has gotten

number of death rose to about 400 in the third quarter of 2021, by the second quarter of 2021, it was over 1600.

Fig 1: Pre Covid Time Series Plot of Crude Price and NGNUSD Rate

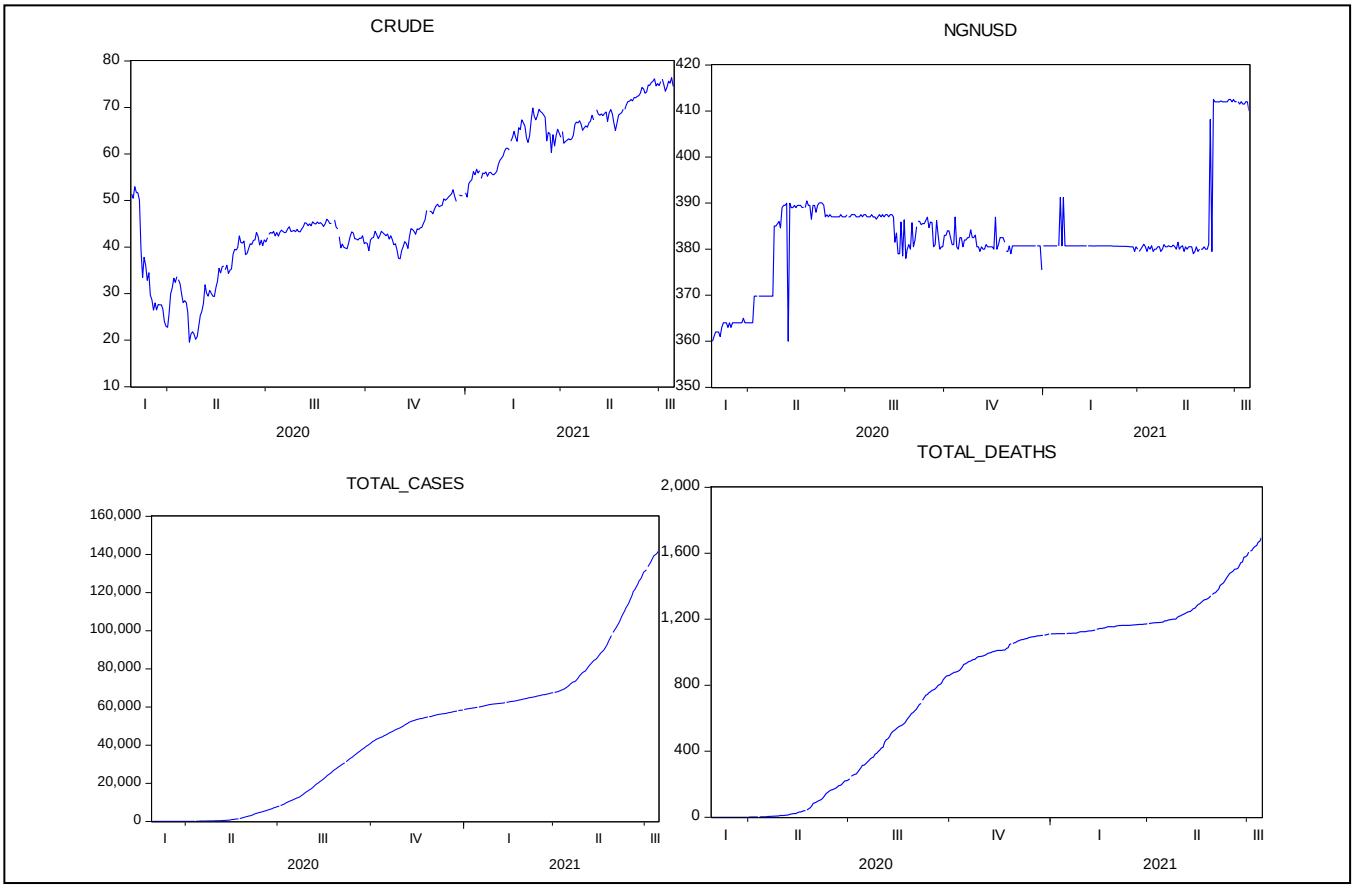

Fig 2: A Time Series Plot of the Post Covid-19 Crude Oil Price, NGN/USD Rate, Total Infected Case, and Total Death as a Result of Covid-19

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C. VAR Estimate

The vector autoregressive estimate shows the impact of each variable at different lag

$$\begin{aligned}\text{LN\_NGNUSD} = {} & 0.31026358333 * \text{LN\_NGNUSD}(-1) + 0.47462536607 * \\ & \text{LN\_CRUDE}(-3) + 0.00193357256856 * \\ & \text{LN\_TOTAL\_CASES}(-1) - 0.00592226907181 * \\ & \text{LN\_TOTAL\_CASES}(-2) + 0.00362745592335 * \\ & \text{LN\_TOTAL\_CASES}(-3) + 9.42682578515e-05 * \\ & \text{TOTAL\_DEATHS}(-1) - 0.00011492293962 * \\ & \text{TOTAL\_DEATHS}(-2) + 2.2243918109e-05 * \\ & \text{TOTAL\_DEATHS}(-3) + 0.100145026175 \end{aligned} \quad (11)$$

It is the contribution of each variable at different lag to the explanation of the exchange rate dynamics. The NGNUSD made a contribution of 0.28 on its first lag and 0.46 on its second lag and 0.181 on its third lag. Thus the impact of the previous lag of naira on itself is negative this implies that the regulatory framework for the Nigerian exchange rate is counterproductive. This can be hinged on the multiple windows for the exchange rate, hoarding of dollar thus strengthening the black market.

Crude oil made a contribution of -0.014 on its first lag, 0.035 on its second lag and 0.008 on its third lag. Thus crude price has a slightly positive impact on the NGNUSD only on its first lag, while it harms the NGNUSD rate in the second and third lag. This is surprising as Nigeria is regarded as a mono-economy where its main source of earning. It is expected that an increase in oil prices will strengthen the exchange rate. This can be attributed to corruption among top government officials. Proceeds from oil sales are diverted into private pockets, siphoned to foreign countries. Another factor is the inability of the country over the years to refine its oil but rather export them and re-import the refined products at an exorbitant price which is again subsidized and sold locally. Aside from this, the smuggling of subsidized petroleum products to other African countries is another factor.

The total number of confirmed cases of Covid-19 in Nigeria contributed -0.00015 on its first lag and 0.0014 on its second lag and -0.0012 on the third lag. This result implies that covid-19 contributed positively to the NGN/USD rate at the early and the later stage of the pandemic.

It however contributed negatively in the second lag. This can be attributed to the fact that at the early stage when other economies were locking down ours was open. When we eventually shut down the economy, businesses folded, markets were locked down, the borders were shut, and all these adversely affected the NGNUSD rate. The harsh economic impact of these measures forced many people back to the farm; others went into other productive ventures, hitherto neglected. There was also an increase in technology-based business. These led to a positive effect on the NGNUSD rate.

Tab 1: Vector Autoregressive (VAR) Coefficients

	NGNUSD	CRUDE	TOTAL_CASES	TOTAL_DEATHS
NGNUSD(-1)	0.274901	-0.01394	0.562652	0.097514
NGNUSD(-2)	0.459124	0.034739	-3.563059	0.076061
NGNUSD(-3)	0.181079	0.008295	2.212236	-0.024423
CRUDE(-1)	0.084444	1.026580	0.916779	-0.169419
CRUDE(-2)	-0.11079	-0.09578	-3.222195	0.071571
CRUDE(-3)	-0.00447	0.030246	3.353264	0.120189
TOTAL_CASES(-1)	-0.00015	0.000392	1.436671	0.000645
TOTAL_CASES(-2)	0.001418	-0.00078	-0.117538	0.004689
TOTAL_CASES(-3)	-0.00121	0.000386	-0.315436	-0.005446
TOTAL_DEATHS(-1)	0.060997	0.023954	9.512623	1.103411
TOTAL_DEATHS(-2)	-0.10464	-0.05876	-8.519308	0.068739
TOTAL_DEATHS(-3)	0.040357	0.035981	-1.171284	-0.168138
C	33.54707	-9.85541	273.1523	-55.18586

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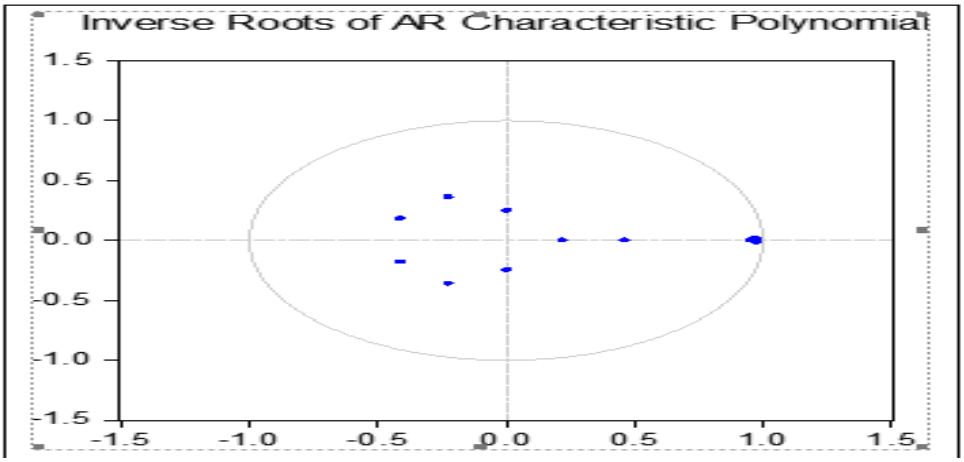

Fig 3: Unit Root Test for Stability

VI. CONCLUSION AND POLICY RECOMMENDATION

This study took a cursory look at the impact of the Covid-19 global pandemic on the Nigerian Naira (NGN) and the United States Dollars (USD) in the face of fluctuating crude oil prices. To achieve this goal, the following were used, namely: time-series data of the NGN/USD daily price, Brent crude oil price, the daily confirmed cases of people who tested positive for Covid-19, and the cumulative total of death resulting from covid-19.

Using the vector autoregressive (VAR) model we identified the contribution of each of the variables to the NGN/USD exchange dynamics. A lag of order 3 was used, so we had a first, second, and third lag for each variable. The observation from the result shows that the impact of the previous lag NGNUSD on itself was negative, crude price has a positive impact on the NGNUSD only on its first lag, while it harms the NGNUSD rate in the second and third lag.

The total confirmed cases contribute positively to the NGN/USD rate at the first and the third stage of the pandemic. It however contributed negatively to the second lag. The total death contributed negatively to the NGNUSD on its first and third lag, while contributing positively on its second lag.

As a consequence of the result, the following recommendations follow: The economy should be diversified to further strengthen the Naira. The regulatory framework for the exchange rate should be redesigned to allow for a single window for the exchange rate to avoid round-tripping. Strengthen the institutional framework to avoid proceeds from oil sales ending up in private pockets. Public health policies should be well thought out to suit our peculiar circumstances and not just copy the western nations. This will prevent such a situation as was experienced when the country was locked down without provision for palliatives.

Finally, covid-19 came with negatives but a lot of positives. As a nation, we should build on the positive and learn from the negatives.

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