Uniport Journal of Engineering and Scientific Research (UJESR)

Vol. 6, Issue 2, 2022, Page 14-23
ISSN: 2616-1192

(www.ujesr.org)

Assessment of the Impact of The Coronavirus Pandemic on the Petroleum Industry of Nigeria Using Vector Autoregression

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Abstract
Oil and gas are primary energy sources and major drivers of the economy of Nigeria. Thus, influences on supply and demand of these fuels have been proven to disrupt the entire sectors of the nation. This paper examines the impact of the Covid-19 pandemic on the oil and gas industry in Nigeria using Vector Autoregression modelling approach. Variables such as Covid-19 infections, average daily oil production, global crude oil prices, oil and gas index of the Nigerian exchange and oil rig count from January 2018 to June 2021 were used as major indices for measuring oil and gas economy in Nigeria. The results of the analysis show that the null hypothesis of no casual effect of Covid-19 pandemic was rejected for oil production, oil prices and oil rig count but failed to be rejected for Nigerian exchange oil and gas index; indicating that Covid-19 had causal effect on Nigeria's oil production, rig count and global oil prices but no causal effect on the oil and gas index. This study also showed that the effects of the pandemic on the industry were short-lived and the forecasts showed the expected path of the indices studied over twelve (12) months.

Keywords: *Covid-19 pandemic, Vector autoregression modelling, Oil production, Crude oil prices, Oil and gas index, Nigerian exchange, Oil rig count*

Received: 12th February, 2022 *Accepted: 8th April, 2022*

1. Introduction

Covid-19 has been a crisis like no other and to tackle the health emergency, countries had to bring economic life to a standstill during the Great Lockdown thus, created the worst recession since the great depression (IMF, 2020). The first case of Covid-19 was reported in Wuhan, China on December 31, 2020. As of May 28, 2021, there have been 166,254 confirmed cases of Covid-19 in Nigeria, including 2,071 deaths (NCDC, 2021). Human health crisis is the primary but not the sole effect of the Corona virus, the damage done by this unprecedented virus has been a shock as major industries and economic sectors have also been forcefully affected.

Nigeria is heavily endowed with proven reserves of crude oil in billions of barrels, and constitutes over 80% of the GDP of Nigeria. Nigeria is the 11th largest producer of petroleum in the world with about 1.9 million barrels of daily production (Varrella, 2021). She is also a major oil exporter with crude oil sector affording approximately 90% to her export earnings. In September 2020, an average daily oil production of 1.54 million barrels was recorded in Nigeria by the Nigerian National Petroleum Corporation (NNPC) and this reflected a 6.5% fall in production from what was achieved in August 2020. The relevance of this data lies in the fact that with a nearly mono-product economy, fluctuations in production and price of sales affects the economy.

In March 2020, the Group Managing Director of Nigerian National Petroleum Corporation (NNPC), Mele Kyari warned Nigerians of tough times to come as the plummeting crude oil price was pushing Nigeria out of business (Adegboyega, 2020). Undoubtedly, Coronavirus pandemic has significantly impacted the oil and gas industry, causing a drastic drop on energy demands and disproportionately affected the transportation sector-air, land and sea. Thus, energy consumption and energy demand responded to the Covid shock. The gross reduction in oil rig count meant that manpower services heavily employed had to be cut drastically which as a result, had its toll on oil

and non-oil workers. Thus, the burden of Covid-19 on certain aspects of the petroleum industry affected the entire nation. Oil production is responsible for billions of dollar investments into Nigeria's economy as well as related sectors including infrastructure development. Jobs are created for citizens and general standard of living is improved by the growth of the oil and gas industry.

The advent of Covid-19 pandemic gave an intensive negative hit on the upstream sector of the oil and gas industry which led to gross fall in revenue that affected payment for cost of production and subsequently reduced production to the barest minimum due to lack of storage space (Praworaatmadja, 2020). Fig. 1 shows the total progressive average daily decline in crude oil and condensate production in Nigeria between December 2019 and December 2020. There was a general glut in crude oil production among producers, creating a huge scrambling for storage space, thus leading to collapse of oil prices and economic slowdown globally amid the Covid-19 pandemic (Johnston, 2021). OPEC and its allies agreed to a historic production cut to stabilise prices, but they dropped to 20-year lows. This fall in crude prices due to the pandemic negatively hammered the economy of Nigeria. For example, Afaha et al. (2020) tested the influence of the Covid-19 on the oil and gas sector in Nigeria and the implications of the resulting fall in flow of trade. After in-depth reviews of theories connected with the subject matter, they concluded that on a broad scale, the effects of the pandemic were felt.

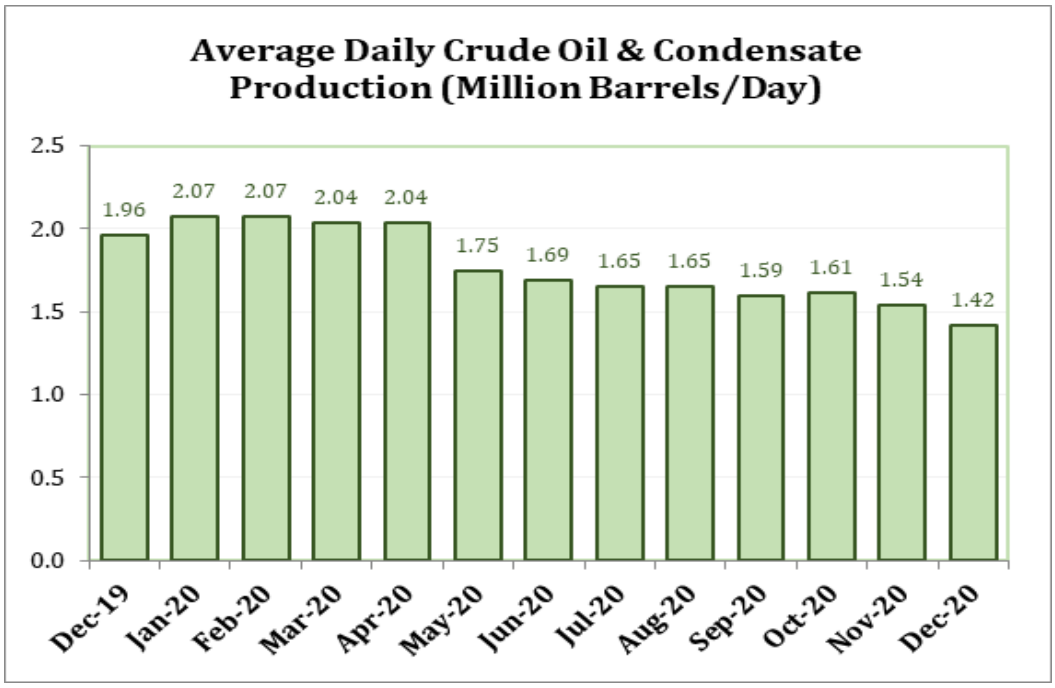

Fig. 1*:* NPDC average daily crude oil & condensate production (NNPC Monthly Operations and Financial Report, January 2021)

An empirical analysis using an unrestricted Vector Autoregression (VAR) to explain the effect of Covid-19 on oil prices, CO_2 emissions and the stock market also showed that a shock to the price of crude oil occurred (Mzoughi, et al 2020). From the analysis, a negative correlation was found to exist between the number of Covid infections and oil prices, implying that as infection cases rise, oil price fell. This negative response of the petroleum market was found however to be short-lived.

Albulescu, (2020) used the Autoregressive distributed lag (ARDL) model and documented a negative and significant impact of the coronavirus crisis leading to oil price crash, but relatively small as compared to the effect of financial volatility and economic policy uncertainty in oil prices. From their investigation, it was observed that there is an indirect impact of Covid-19 on oil prices, howbeit, it will be shot lived.

Over the years, oil and gas companies (and generally companies in the energy sector) have

remained some of the most heavily traded public entities in the Stock market. The effect of discharged, fatal and confirmed Covid-19 cases on stock prices in Nigeria was studied (Babarinde, 2020). Multivariate time series data analysis was used to confirm that discharged and fatal Covid-19 cases have positive effect on Nigerian stock prices while confirmed cases have negative effect. Corona virus however, does not determine significant movement of stock prices in Nigeria generally. Aloui et al. (2020), also confirmed that natural gas and crude oil responded to Covid-19 shock. Fig. 2 shows some major areas in the oil and gas industry where the impact of Covid-19 pandemic could have negative influence. In this study, these variables as shown in Fig. 2 are studied using Vector Autoregression modelling approach to determine their impact on the oil and gas business on the economy of Nigeria.

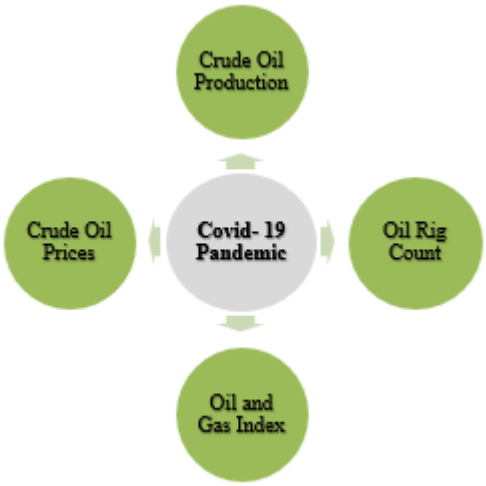

Fig. 2: Covid-19 and areas of impact relating to the petroleum industry

2. Materials and methods

2.1 Methods

Vector Autoregression (VAR) model is a multivariable linear time series model in which the variables are basically functions of the past values or lagged (time delayed) values of the other variables (Sims, 1971). The Vector Autoregression method is employed in this work because it is bi-directional and thus, at least two of the variables influence each unlike other autoregressive models that are one directional i.e. *x* influences *y* but *y* does not influence *x*. Each variable as a dependent variable has one equation and, in these equations, the right-hand side of each equation contains lags of all dependent variables in the system. There are no contemporaneous (i.e. occurring in the same period of time, synchronous) variables. Hence, the Vector Autoregression model (VAR ($_p$)) is of the form (Eloriaga, 2020):

$$Y_t = a + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t, \quad (1)$$

where Y_t is a vector of time series variable, a is a vector of intercepts, A_i is a coefficient matrix and ε_t is a vector of unobservable zero mean error term (white noise) i.e. ε contains unobserved factors. From Equation (1), a general mathematical equation/econometric model was developed in this study that incorporates Covid-19 Infections (Covid), Oil Production (PROD), Oil prices (PRICES), Rig count (RIG) and Oil and gas Index of the Nigerian Stock exchange (NGX) as:

$$COVID_t = a + \sum_{j=1}^{k} A_j COVID_{t-j} + \sum_{j=1}^{k} B_j PROD_{t-j} + \sum_{j=1}^{k} C_j PRICES_{t-j} + \sum_{j=1}^{k} D_j RIG_{t-j} + \sum_{j=1}^{k} E_j NGX_{t-j} + \varepsilon_t \quad (2)$$

where k is the number of lags, ε_t is the error term, j is the start of the series, a is a vector of intercepts. A, B, C, D, and E are coefficients attributed to each of the individual variables.

2.2 Data collection

The data were sourced from quantitative monthly time-series data from secondary sources. The oil production data was obtained from the Nigerian National Petroleum Corporation (NNPC) Monthly Financial and Operations Reports, the Crude Oil Prices were obtained from oilprice.com, while the Nigerian Exchange Oil and Gas Index data was obtained from investing.com (https://www.investing.com) and Nigerian Stock Exchange website (https://sec.gov.ng/). The Covid-19 data was obtained from the Nigerian Centre for Disease Control (NCDC) reports (https://www.ncdc.gov.ng) and the ourworldindata.com official website

(https://ourworldindata.org) while Oil rig count data was from Ycharts website (https://ycharts.com) respectively.

3. Results and discussion

3.1 Pre-estimation tests

Stationarity of the variables which tells if properties such as mean and standard deviation change over time was checked by Philips-Perron test. With p-value greater than 0.05, the null hypothesis that the unit roots failed to be rejected for all five variables implying that they are all non-stationary. Due to the non-stationarity of the data series, Johansen's cointegration test was done to confirm that the variables combined together to form a stationary one. Cointegration was found to be present at rank order of 1 ($r \leq 1$) meaning that a stable relationship can be assumed to exist within the model.

For the purpose of specifying the model, the optimal lag order p, was obtained by the lag selection criteria, Akaike (AIC), Hannah-Quinn (HQ), Schwarz (SC) as 6 while Forecast Prediction Error (FPE) selected 7. As a rule, (p-1) lags which is 5 lags is used for the calculations. Error correction using the Vector Error Correction Model (VECM) was done before transformation to the Vector Autoregression (VAR) model. This is a fallout of the non-stationarity of the individual variables. To train the model to predict unknowns, the data is split into training set for fitting of the model and testing set for assessment and prediction/forecasting. With a total of 42 data set, the series was split into 80% for the training set and 20% for the testing set.

3.2 Statistical analysis

Summary of the statistics of the variables is shown in Table 1. From Table 1, the mean, standard deviation, skewness, range, kurtosis and coefficient of variation for each variable is shown, indicating the spread of values and variation between datasets from the actual and expected. For the correlation between the variables, it was deduced that oil production and rig count showed moderate negative correlations of -0.51 and -0.54 while oil prices and the oil and gas index showed weak negative correlations of -0.31 and -0.33 respectively as shown in Table 2. This implies that as Covid infection cases increased, there is a decrease in oil production and crude oil prices, while both the oil and gas index and oil rig count reduced slightly. For the correlation between the variables, it was deduced that oil production and rig count showed moderate negative correlations of -0.51 and -0.54 while oil prices and the oil and gas index showed weak negative correlations of -0.31 and -0.33 respectively as shown in Table 2. This implies that as Covid infection cases increased, there is a decrease in oil production and crude oil prices, while both the oil and gas index and oil rig count reduced slightly.

Fig. 3 shows plots of the variation of the five variables investigated over time. Fig. 3(a) depicts a steady absence of Covid-19 cases in Nigeria from January 2018 until February 2020 from when infections began, to a peak of about 17,000 cases by July 2020. The infection rate dropped between August and November 2020 due to some proactive measures implemented by the Federal Government to mitigate Covid-19 spread. However, by January 2021, the second wave of infections led to more than 40,000 recorded cases. Vaccinations and safety measures prompted a steady decline and only about 1000 cases were recorded in June 2021 as shown in Fig. 3(a).

Table 1: Descriptive statistics of the variables

Variable	Mean	Standard Deviation	Min	Max	Range	Skewness	Kurtosis	Coeff. of Var.
Covid cases	3990.79	8681.44	0.00	43635	43635	2.82	8.61	2.18
Oil Production	1.84	0.22	1.40	2.12	0.72	- 0.60	- 1.03	0.12
Oil prices	57.83	13.04	21.04	76.73	55.69	- 0.89	0.13	0.22
Stock Index	266.37	51.67	170.34	378.54	208.20	0.31	- 0.70	0.19
Rig count	12.33	4.57	5.00	23.00	18.00	0.09	- 0.78	0.37

Table 2: Correlation matrix of the variables

	Covid Infections	Oil Production	Crude Oil Prices	NGX Oil and Index	Oil Rig Count
Covid Infections	1.00	- 0.51	- 0.31	- 0.33	- 0.54
Oil Production	- 0.51	1.00	0.16	0.14	0.85
Crude Oil Prices	- 0.31	0.16	1.00	0.72	0.15
NGX Oil and Gas Index	- 0.33	0.14	0.72	1.00	0.07
Oil Rig Count	- 0.54	0.85	0.15	0.07	1.00

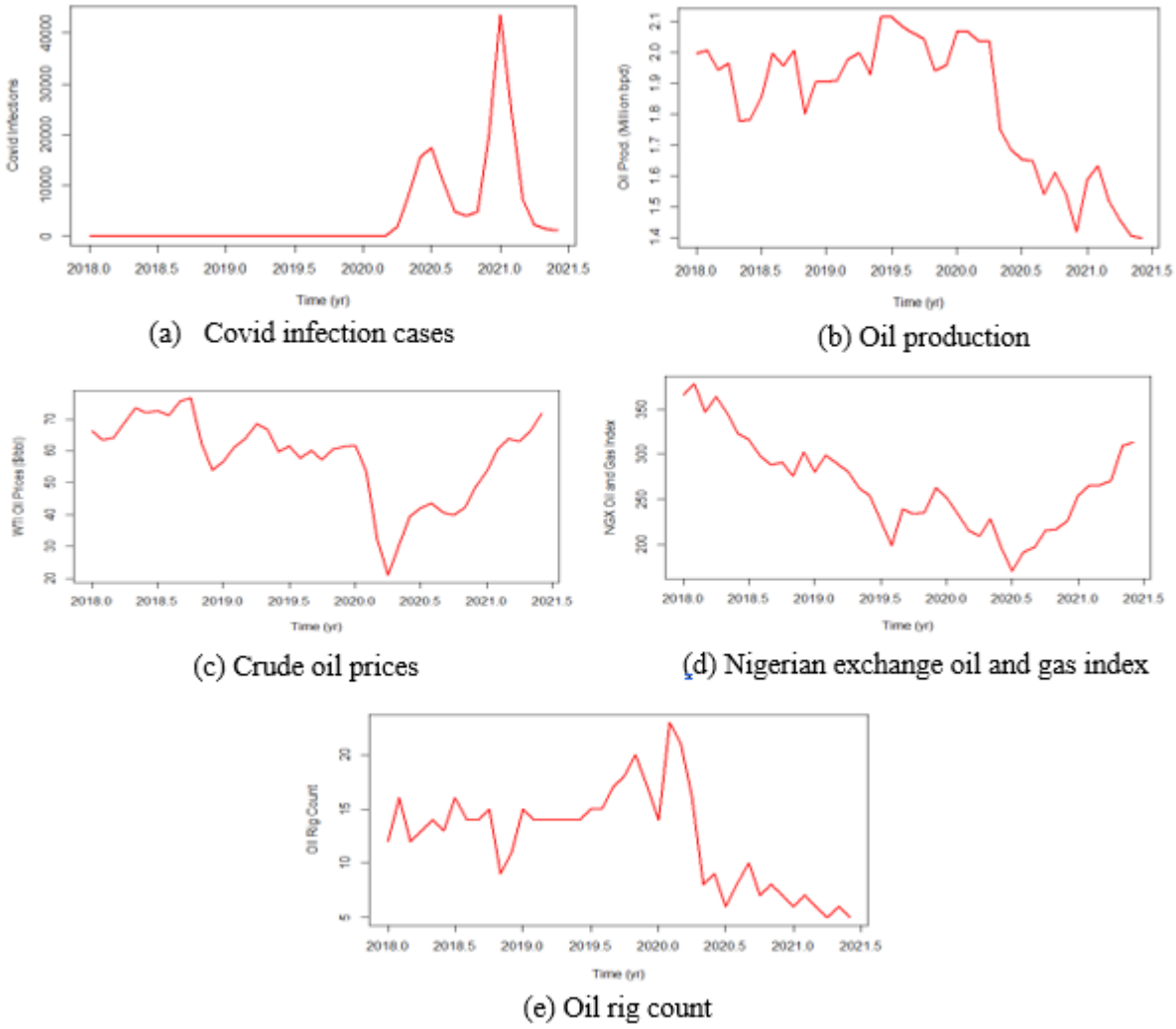

Fig. 3: Time series plots of variables from January 2018 to June 2021

Oil production dropped suddenly in the first quarter of 2020 and continued till about 1.4 million barrels per day by the end of 2020 as shown in Figure 3(b). On account of the Nigerian National Petroleum Corporation (NNPC), this drop was partly due to Covid-19 disruption and partly caused by shutdown of some flow stations for repairs due to vandalism and leaks. The movement of crude oil prices is first seen to be in an unsteady manner partly due to the price war that occurred between Russia and Saudi Arabia as shown in Figure 3(c). By the end of year 2019, oil was sold for $60 per barrel but March 2020 saw demand loss that crushed prices so negatively growing surplus in the spot market caused sellers to practically give away oil for almost no cost to create storage space (Stevens, 2020). [14]. The ease of lockdown measures led to increase in oil demand which led to a corresponding increase in the price of crude to $70 per barrel by May 2021. The Oil and Gas Index of the Nigerian Stock Exchange, which

was already on a steady decline from 2018 to August 2019 fell to a new low of about 170 in July 2020 as shown in Figure 3(d). Recovery began by June 2021, when the market share index rose to about 313. Figure 3(e) shows that after a mild uptrend in the number of operational rigs in Nigeria from 2018 to a peak in first quarter 2020, a sudden gross reduction occurred. At the inception of this study in June 2021, operational rigs in Nigeria remain at a very small number of 5.

3.3 Application

3.3.1 Test for causality

In causal analysis, examination of plots is done first to check for patterns and abnormalities. The Granger Causality test was employed in this study. Granger causality is about in-sample fitting and it is significant in improving prediction and forecasting. The Granger Causality test is concerned with whether lagged x helps explain y, and vice versa. It is important to note that correlation does not mean causality and thus, x does not Granger-cause y if x cannot help predict the future value of y (Lau, et al 2019). Mathematically, where F is conditional distribution and $\Omega_t - \mathrm{x_t}$ is all the information in the universe except $\mathrm{x_t}$, x is said to Granger-cause y if for all $h > 0$,

$$F(Y_{t+h}|\Omega_t) = F(Y_{t+h}|\Omega_t - \mathrm{x}_t) \qquad (3)$$

H0: Covid cases do not have granger-causal effect on oil production, oil prices, rig count and the oil and gas index. It is rejected when the p-value is less than the 0.05 confidence level.
H1: Causal effect exists between Covid cases and the variables. It is rejected when p > 0.05.

Table 3 shows that the null hypotheses of no causality was rejected for Average daily oil production, Global oil prices and Rig count. However, Covid did not granger cause movement of the oil and gas index.

3.3.2 Impulse response function

Evaluation of how the variables react to a shock in the system for a number of periods from today was done by the Impulse response function as presented in Figure 4. In the Impulse response plots, the red dotted lines are 95% confidence bands while the black line is the response or reaction of the system to the shock. Covid-19 shock to oil production shown in Fig. 4 (a) depicts that the shock causes a positive response of production until period 5 and then the impact stabilised in the positive region. Covid shock affected the variable but as time elapsed, the effects of the shock died out. As can be seen in Fig. 4 (b), the bands went below 0, indicating that initial reduction in crude oil prices occurred between periods 5 and 10, and thereafter, stabilized in the negative region. Crude oil prices showed negative response and the negative effect was being felt till the period of the end of the study. Fig. 4 (c) showed that the Oil and Gas Index increased for a while until the regions of periods 5 and 10, where it stabilised after the effects dissipated. The Index showed little response. Oil Rig Count shown in Fig. 4 (d), shows a positive response to the shock and when the effect of the shock died out, it returned to the initial range of values. The Impulse response plots of oil production, oil prices, oil and gas index and rig count to the Covid-19 shock all show significant response even though, they were all short-lived.

Table 3: Granger causality of covid infections on oil production, crude oil prices, oil and gas index and rig count

Granger Causality X ~Y (X granger causes Y)	**F Test**	**P - value**	**Null Hypotheses of no causality**
Covid Infections ~ Oil Production	3.8105	0.008788	Rejected
Covid Infections ~ Crude Oil Prices	5.1481	0.001745	Rejected
Covid Infections ~ Oil and Gas Index	1.5553	0.2052	Not rejected
Covid Infections ~ Oil Rig Count	5.1890	0.001666	Rejected

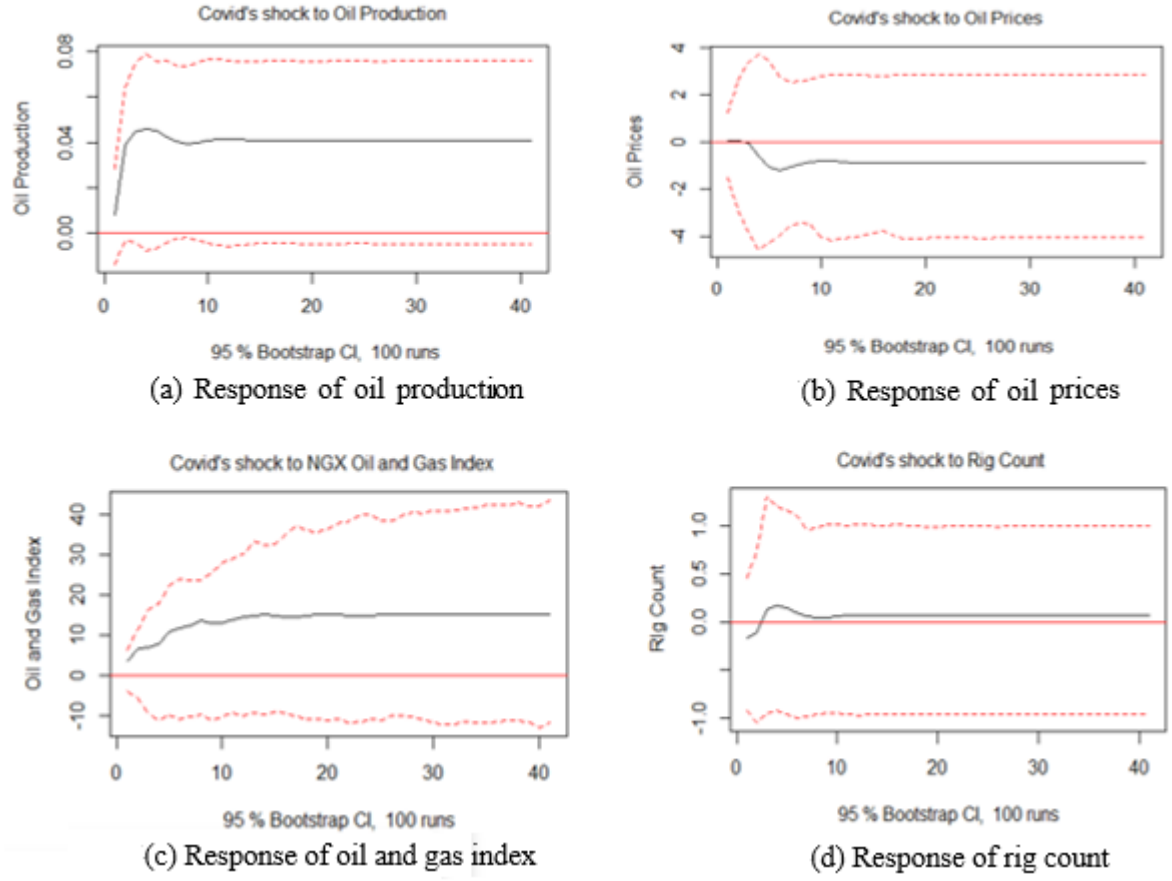

Fig. 4: Plots of impulse responses of variables to covid shock showing the red dotted confidence bands and the black response band.

3.3.3 Forecasting

The fanchart for Covid cases in Fig. 5(a) shows that the number of Covid infections will drop and increase slightly before dropping again; explaining likely new waves of the virus. The fanchart for Oil Production in Fig. 5(b) predicts that production will continue to drop but not by much. This is due to the fact that operational activities have not returned fully even though lockdown and restriction measures have started been relieved in phases. From the chart in Fig. 5(c), Crude oil prices will continue on a steady rebound. This is as global demand for crude oil rose and also due to the policies of the Organisation of Petroleum Exporting Countries (OPEC) put in place to govern the production and sales of oil. The continual rebound of the oil and gas index is also forecasted to occur as seen in Fig. 5(d). The Fanchart for Rig count in Fig. 5(e) showed that the return to the peak value of oil rig count in Nigeria is unlikely in the short term. This is because economic activities have not fully returned in the country.

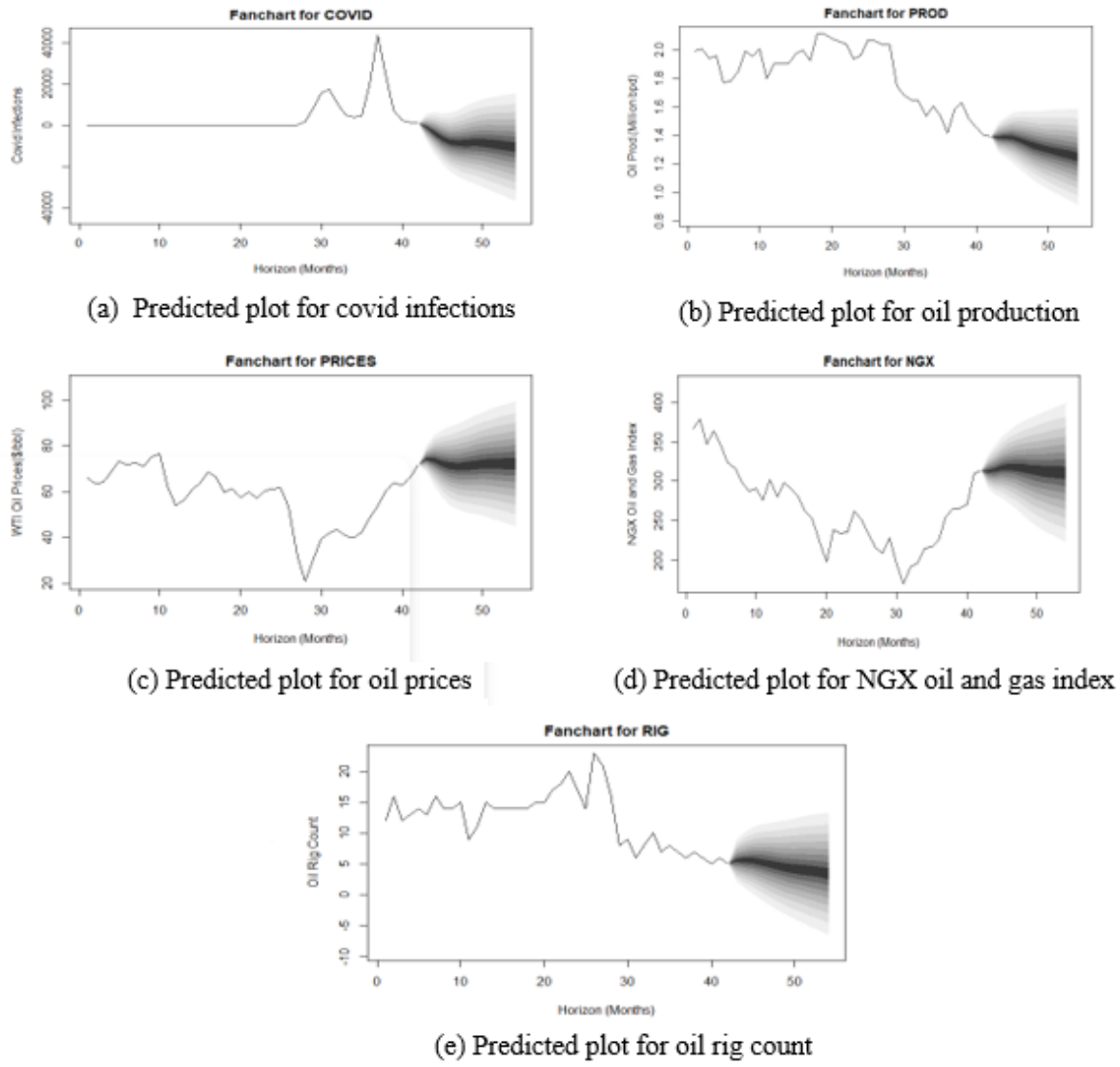

Fig. 5: Predicted path of variables over time

3.4 Validation of analysis

Serial correlation of the residuals was checked for all variables. The Portmanteau test (asymptotic) with lag value of 10 gave p-value of 0.8457, thereby failing to reject the null hypothesis of no serial correlation. The presence of serial correlation does not mean the model is bias, it simply means that variance is not minimum. Autoregressive Conditional Heteroscedasticity (ARCH) tests to deny the presence of periods of unusual volatility was done producing p-value of 1 strongly favouring the null hypothesis of no heteroscedasticity. This implies that the results obtained from the analysis shows credibility. The Jarque-Bera test for measuring goodness of fit and normality of the distribution of residuals was done. The null hypothesis is that there is presence of normality. The test produced a p-value of 2.65e-^{08} which is less than the 0.05 confidence level rejecting the null hypothesis. This means the residuals are not normally distributed. This absence of normality potentially demeans the accuracy of forecasts and predictions.

4. Conclusion

Based on the analysis of data and results obtained, it is concluded that a rise in Covid-19 cases had granger causal effect of reduction in average daily oil production, reduction in global crude oil prices and decline in oil rig count but did not have causal effect on the oil and gas index of the Nigerian Exchange. The results obtained show a degree of accuracy as they aligned with

the findings from similar studies previously done. The analysis confirms the negative correlation found between Covid-19 infections and oil prices by Mzoughi et al. (2020) and the Impulse response functions confirmed that no long-run significant effect was felt by the variables to the Covid shock in agreement with the work of Albulescu (2020). The forecasting done is generally not reliable as the data did not show normal distribution. Finally, the findings obtained can be employed by the government, research bodies and academics as a tool for explaining the effect of Covid-19 on different oil and gas indices. Further studies can be carried out using other determinant variables such as oil demand/oil consumption, oil exports, net profits and by the application of different analytical procedures like Autoregressive Distributed Lag (ARDL) and the Autoregressive Moving Average (ARMA) model respectively.

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