Comparative Modelling of the Impact of COVID-19 Pandemic on Nigerian Economic Growth and Stability: VAR and ARDL Approaches

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Abstract

This study aimed to model the impact of the COVID-19 pandemic on economic growth and stability in Nigeria using Vector Autoregressive (VAR) Model and Autoregressive Distributive Lag (ARDL) Model, integrating four variables encompassing Nigerian COVID-19 daily confirmed cases data (CC) along with other economic metrices including the Nigerian Stock Exchange All Shares Index (ASI), Daily Nigerian Naira/United States Dollar Exchange Rate (NGNUSD), and Nigerian Crude Oil Price (OP), to discern the pandemic's trends and implications on the Nigerian Economy amid post-pandemic. Covering daily time series data for the variables from May 26, 2020, to May 25, 2022, a total of 501 days. The VAR model estimation revealed insights into short-term dynamics among key economic variables, supported by stable outcomes consistent with previous studies, emphasizing significant causal relationships among economic indicators during crises like the COVID-19 pandemic. The VAR(8) model was selected as the most appropriate model using the Akaike Information Criterion (AIC). The VAR Residual Normality Test indicates that multivariate residuals are normal, as evidenced by the Chi-square test statistics and their associated p-values being less than 0.05. Moreover, the VAR Residual Heteroscedasticity Test shows no evidence of heteroscedasticity, as the Chi-square test statistic value of 1400.368 with a corresponding probability value of 0.51341 suggests. In examining the short-term impact of the COVID-19 pandemic on Nigeria's economic growth and stability, the variance decomposition analysis conducted on the VAR(8) model offers valuable insight on significant impact of COVID-19 on economic growth and stability over a short period of time. Meanwhile, the ARDL model estimation, employing various model specifications such as ARDL(4,0,2,2), ARDL(3,1,1,0), ARDL(2,3,0,0), and ARDL(4,3,0,0) for CC, ASI, NGNUSD, and OP as dependent variables, respectively, underscored the significance of autocorrelation effects in fluctuating economic variables, providing detailed insights into only short-run impacts which corresponded to the result of VAR model and emphasizing the interconnectedness of economic indicators, particularly with oil prices. The study's findings underscore the dynamic impact of the COVID-19 pandemic on economic growth in Nigeria, revealing a short-run relationship among key variables. There were no long run effects of the pandemic on the economic stability as both VAR and ARDL suggested.

ARDL emerged as the preferred model for analyzing these relationships, offering insights into both short-term fluctuations and also investigating for a long-term trends among interacting macroeconomic indicators while VAR could only account for short-run relationship only. This highlights the nuanced nature of the pandemic's effects on Nigeria's economy, emphasising the importance of adaptable analytical frameworks like ARDL for comprehensively assessing the evolving economic landscape amidst this post pandemic era.

***Keywords**: COVID-19 Impact; Economic Growth; Vector Autoregressive (VAR) Model; Autoregressive Distributive Lag (ARDL) Model; Nigerian Economy, Time Series*

1. Introduction

With globalization, urban sprawl, and ecological transformations, contagious disease outbursts turned out to be worldwide risks demanding a joint reply (Sarbu *et al.*,, 2021). According to the International Monetary Fund (IMF), coronavirus disease 2019 (COVID-19) generated an economic crisis different from the others for the reason that it is much more multifaceted (interconnections between the economy and the health system), uncertain (the related treatment is established gradually, alongside the measures concerning how to streamline isolation and the means to restart the economy), and has a worldwide character. Both supply and demand reductions occur since individuals work and consume lower, whereas companies diminish their productivity and investment (Loayza and Pennings, 2020).

Consequently, governments globally have taken unprecedented actions, respectively fiscal measures figuring to around $8 trillion, whereas central banks injected liquidity getting up to over $6 trillion (Mishra *et al.*, 2020). The IMF has implemented exceptional measures by doubling its emergency loaning volume to $100 billion and deferring debt outflows for poor nations (Verbeek, 2020). Preparing for the economic recovery raised a number of issues such as the way to maintain fiscal stimulus and unconventional monetary policy, managing high unemployment, low interest rates, and preserving financial stability (Mishra *et al.*, 2020).

The stock market is a segment of the financial market where long term funds packaged in the form of securities, such as shares, stocks bonds, debentures, loan stocks, and derivatives, are traded. The market is information driven, thus its indicators such as price index, returns, volatility, market capitalization, etc., are believed to be potentially influenced by the availability of information in the market.

Since the outbreak of coronavirus disease (COVID-19) in China late December 2019, and the subsequent spread to other countries, up to 216 including Nigeria, no affected nation has been left the same. Ibrahim, (2020) argues COVID-19 to be one of the deadliest viruses that affect the entire humanity in all spheres of life. In that light, Ali (2020) notes that the disease is not a mere public health issue but a crisis that touches every sector. It has effects on every aspects of human life including mental and psychosocial well-being (Ibrahim, 2020; Macapagal, 2020), political and social aspect of human race (Ibrahim , 2020), as well as economic life of people (Kajo *et al.*, 2020; Ozili, 2020), to mention but a few. Expatiating the economic effects of the virus, Ibrahim, (2020) reiterated the effects of the pandemic on employment, productivity, supply chains, imports, exports and other trading activities, thus leading to a decline in gross domestic product. There are four major economic agents, among others, that facilitate economic activities in any economy; they are – the government, the apex institutions, the firm and the household, which is the central bank. The extent to which these agents can efficiently and effectively perform their roles has implication on the circular flow of income and hence the level of income in the economy. The circular flow of income describes the flows of money among the sectors of an economy. As individuals and firms buy and sell goods and services, money flows among the different sectors of an economy. The circular flow of income describes these flows of money for goods and services. On the one hand, firms require productive resources to facilitate the production of goods and services; they reward these productive resources for their contribution to the production of goods and services.

In 2020, Nigeria experienced its deepest recession in four decades, but growth resumed in the fourth quarter as pandemic restrictions were eased, oil prices recovered, and the authorities implemented policies to counter the economic shock. As a result, in 2020 the Nigerian economy experienced a smaller contraction (-1.8 percent) than had been projected when the pandemic began (-3.2 percent). As part of its response, the government carried out several long-delayed policy reforms, often against vocal opposition. Notably, the government (a) began to harmonize exchange rates; (b) began to eliminate gasoline subsidies; (c) started adjusting electricity tariffs to more cost-reflective levels; (d) cut nonessential spending and redirected resources to COVID-19 (coronavirus) responses at both the federal and the state levels; and (e) enhanced debt management and increased public-sector transparency, especially for oil and gas operations. By creating additional fiscal space and maximizing the impact of the government's limited resources, these measures were critical in protecting the economy against a much deeper recession and in laying the foundation for earlier recovery. However, several critical reforms are as yet incomplete, which threatens Nigeria's nascent recovery. In the baseline scenario, Nigeria's economy is expected to grow by 1.8 percent in 2021 (World Bank, 2021). Coronavirus Disease 2019 (COVID-19) an illness caused by novel coronavirus now called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). According to the Nigeria Centre for Disease Control (NCDC) (2020), the coronavirus disease has the origin of its outbreak in Wuhan, Hubei Province, China in late December. On 27th February, 2020. A 44-year old Italian citizen was diagnosed of COVID-19 in Lagos State, Nigeria. The case is the first to be reported in Nigeria since the first confirmed case was reported from China. According to NCDC (2020), the case arrived the Murtala Muhammed International Airport, Lagos at 10pm on 24th February 2020 aboard Turkish airline from Milan, Italy and traveled to his company site in Ogun state on 25th February 2020. From this importation, the virus has continued to spread like wildfire to different parts of Nigeria, including all the 36 states and the Federal Capital Territory (FCT). As at 25th September, 2020, all 36 states and the FCT in Nigeria, have reported a confirmed case of COVID-19. On the same date, there were 213 new confirmed cases from 17 states in Nigeria. 508 discharges were reported in ten states with only two deaths. On the same date, there was a total confirmed cases of 58,062 and total discharged cases standing at 49,606. Nigeria had a total fatal cases of 1103 which ultimately left the total active cases to be 7353. Out of the total confirmed cases, 64% (36933) are males while female gender constitutes the remaining 36% (21,129). Based on the provenance statistics, 984(1.7%) of the cases have travel history, contacts-oriented cases are 15,500 (26.7%) and the unknown exposure takes 71.6% (41, 578) share of the total confirmed cases (NCDC, 2020). Furthermore, the COVID-19 situation report shows that globally, on 25th September, 2020, 216 countries and territories of the world including Nigeria, were infected with the virus. On this date, there was a total of 32,110,656 confirmed cases in the world, with total 980,031 deaths.

The COVID-19 contagion triggered a failure in worldwide stock markets resulting in an unpredictable setting with critical liquidity levels (Nicola *et al.,* 2020.). Therewith, substantial contagion between nations was noticed by Hafner (2020) attributable to noteworthy serial and spatial autocorrelations. Giudice *et al.,* (2020) noticed that current pandemic affected housing values, whereas Babuna, *et al.,* (2020) emphasized that insurance industry registered losses.
Nwuju and Lekara-bayo (2020) carried out a study on modelling and forecasting daily confirmed cases of COVID-19 in Africa, considering ECOWAS as a case study area. In their work they discovered that a critical investigation into the rate of spread of Coronavirus Disease 2019 (COVID-19) pandemic has shown that, the daily confirmed cases of the disease tend to follow an upward trend. This paper aimed to develop a suitable Autoregressive Integrated Moving Average (ARIMA) model which can be used to statistically forecast the actual number of confirmed cases of COVID-19 recorded in ECOWAS as a whole. An adequate subset ARIMA (5, 1, 1) model is fitted and discussed. A forecast of 235 days from 11th May 2020 to 31st December 2020, was carried out using the fitted model, and we discovered that the COVID-19 daily confirmed cases may most likely incline over the next six months.

In another study, Nwuju *et al.,* (2021), ARIMA model was fitted to daily confirmed/fatality cases of COVID-19 in Nigeria. they discovered that critical investigation into the rate of spread of COVID-19 pandemic has shown that, that the daily confirmed cases as well as death cases of the disease tends to follow an upward trend. This work aimed at developing a suitable ARIMA models which can be used to fit a most appropriate subsets to statistically forecast the actual number of confirmed cases as well as death cases of COVID-19 recorded in Nigeria for a period of 8 months. Data on total daily cases for both confirmed cases and death cases in Nigeria was obtained from the Nigerian Centre for Disease Control (NDCD) online data base on COVID-19, this was used as a secondary data for the work. The data ranged from 21 March, 2020 to 5 May, 2020 covering a total of 51 data points. An adequate subset ARIMA (2, 2, 1) and AR (1) models were fitted to the confirmed cases as well as death cases data respectively. A forecast of 239 days (8 months) from 6th May, 2020 to 31th December, 2020, was carried out and we discovered that, the COVID-19 daily confirmed cases may likely incline over the next eight months.

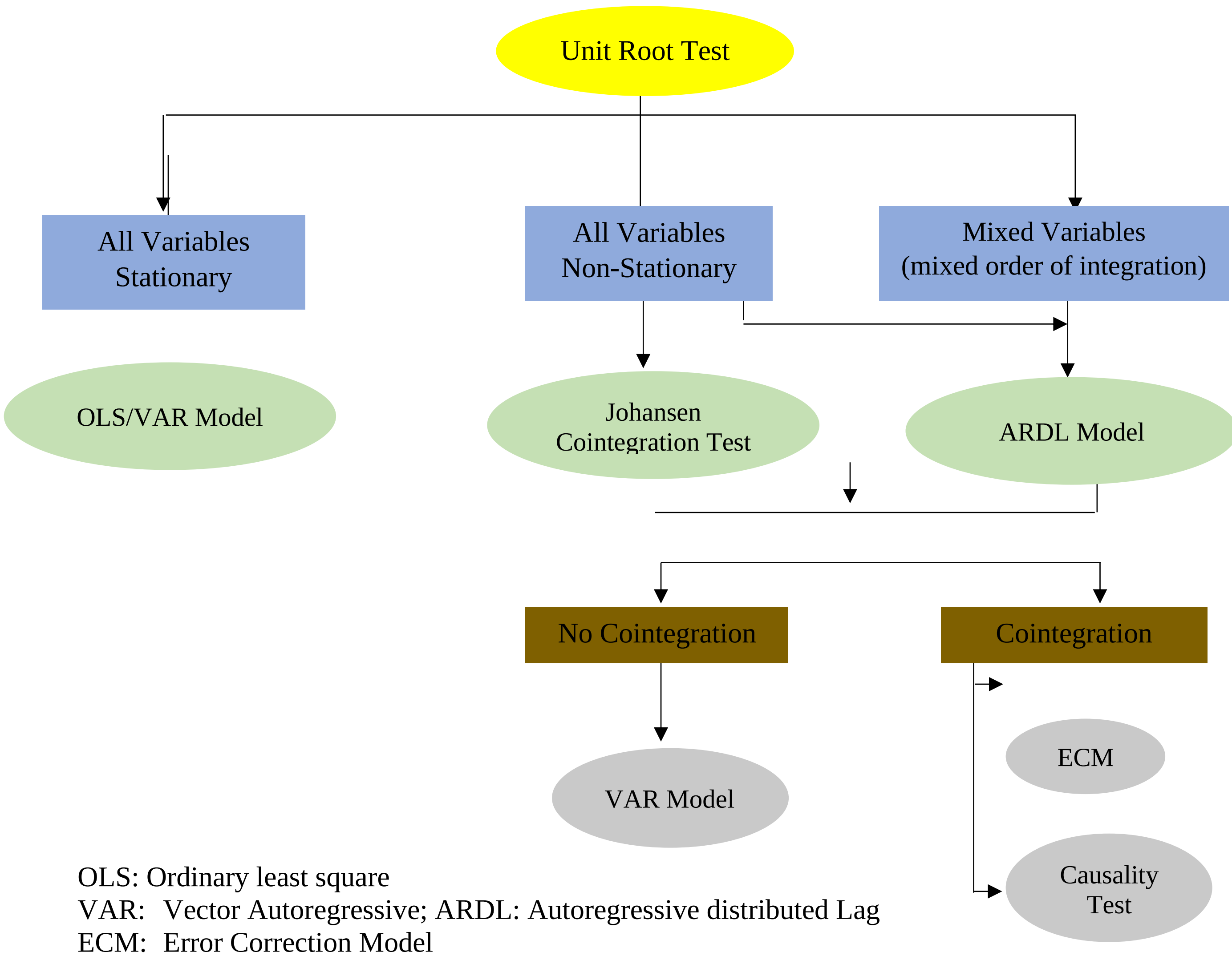
Ejukwa *et al.,* (2023) conducted a comprehensive analysis of the relationship between gross domestic product (GDP), motor vehicle assembly, and oil refining in Nigeria from 1981 to 2022. Employing the Autoregressive Distributed Lag Error Correction Model (ARDL-ECM), the study explored the interplay among these variables using annual data extracted from the National Bureau of Statistics Bulletin 2021. Their pre-estimation tests including time plots and unit root tests were conducted to ascertain the presence of unit roots in the series. Results revealed a mixed order of integration, with motor vehicle assembly stationary at a level while oil refining and GDP were integrated at first difference. Subsequently, the ARDL bounds test of cointegration indicated the existence of a long-run relationship among the variables, with lag 3 selected using Akaike Information Criteria. The error correction model analysis suggested a significant impact of oil refining on GDP, and the combined lags of oil refining and motor vehicle assembly were found to cause own shocks in the short run. Stability tests, including the CUSUM test and serial correlation test, confirmed the model's stability, with the residuals demonstrating serially uncorrelated behavior. The study concluded with recommendations aimed at reducing macroeconomic instability in Nigeria based on the findings.

In another study by Abonazel *et al.*, (2021), they investigated the dynamic causal relationship between inflation rate (measured by consumer price index), exchange rate, gross domestic product (GDP), money growth, and oil exports in Nigeria from 2005: Q1 to 2019: Q4. The study employs the ARDL bounds testing approach and error correction model to examine the long-term relationship between inflation rate and its determinants. The findings reveal that the current inflation rate, exchange rate, GDP, and money growth have a significant impact on the inflation rate in the subsequent quarter in Nigeria. However, oil exports do not exhibit a significant effect on inflation. Furthermore, the study identifies a long-run cointegration relationship between inflation rate, exchange rate, and money. This cointegration relationship is achieved relatively quickly, within the next two quarters of the year. This research contributes to understanding the determinants of inflation in Nigeria and highlights the importance of factors such as exchange rate and money growth in shaping inflation dynamics.

2. Methodology

This study adopted event study approach. This approach is considered suitable because specific event, in this case, the coronavirus outbreak, is examined in line with its effect on subject of interest, such as the Nigerian Stock Exchange All Shares Index (NSE-ASI) and daily Naira/Dollar exchange rate. In the same vein, past data on coronavirus, which cannot be manipulated, were examined vis-a-vis historical data NSE-ASI in order to establish relationship and causality between coronavirus and general price movement in the Nigerian stock market. In this study, five variables shall be used. These includes data relating to the Nigerian COVID-19 daily Confirmed Cases (CC), in collaboration with Data of Some macroeconomic indicators including Nigerian Stock Exchange All Shares Index (ASI), Daily Nigerian Naira/United State Dollar Exchange Rate (NGNUSD) and Nigerian Crude Oil Price (OP), in other to understand the trends as well as impact of COVID-19 on the Nigerian Economy in this post pandemic era.

The data used in this study was obtained from three verified sources. The COVID-19 total cases were obtained from Our World in Data Online Database (https://ourworldindata.org/covid-cases). The Nigerian Stock Exchange All Shares Index as well as Nigerian Crude Oil Price, were obtained from the Central Bank of Nigeria (CBN) official website (www.cbn.gov.ng). USD to NGN exchange rate data was extracted from Exchange Rates (www.exchangerates.org.uk/USD-NGN-exchange-rate-history.html). All Data were collection using daily frequency to confirm with the COVID-19 Daily Data. This study covered daily time series data for the four variables between 26th May, 2020 – 25th May, 2022, a total time period of 501 days.



OLS: Ordinary least square
VAR: Vector Autoregressive; ARDL: Autoregressive distributed Lag
ECM: Error Correction Model

Figure 1: Methodology Selection Flow Chart for Time Series Data

Source: Ejukwa *et al.*, (2023).

2.1 Vector Autoregressive (VAR) Modelling

This study employed firstly the Vector Autoregression (VAR) model as the estimation technique. VAR is a flexible and simple model for multivariate time series data with autoregressive characteristics that can be used for data description, estimation, and forecasting. The model treats all variables as endogenous and expresses each variable as dependent on its lag value and the lagged value of other variables in the model (. Stationarity of data is crucial for VAR modeling, and if the time series is non-stationary, the order of integration is determined, and the stationary form of the variable is added to the VAR model. The error terms in VAR modeling are required to be normal and independent (Suharsono, 2017).

Following the model of Ahmed (2020), This study specifies the functional relationship between COVID-19 (measured as confirmed cases) and economic variables (Daily NSE All-share index, Crude Oil Price, and Daily NGN/USD exchange rate). The general Vector Autoregressive Model of order k that is *VAR(k)* model for this study are specified in Equations (2.1) to Equation (2.4) as shown below.

$$CC_t = \alpha_1 + \sum_{i=1}^{k} \beta_i CC_{t-i} + \sum_{m=1}^{k} \varphi_m ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n OP_{t-n} + \sum_{p=1}^{k} \varsigma_p NGNUSD_{t-p} + u_{1t} \quad (2.1)$$

$$ASI_t = \alpha_2 + \sum_{i=1}^{k} \beta_i CC_{t-i} + \sum_{m=1}^{k} \varphi_m ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n OP_{t-n} + \sum_{p=1}^{k} \varsigma_p NGNUSD_{t-p} + u_{2t} \quad (2.2)$$

$$OP_t = \alpha_3 + \sum_{i=1}^{k} \beta_i CC_{t-i} + \sum_{m=1}^{k} \varphi_m ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n OP_{t-n} + \sum_{p=1}^{k} \varsigma_p NGNUSD_{t-p} + u_{3t} \quad (2.3)$$

$$NGNUSD_t = \alpha_4 + \sum_{i=1}^{k} \beta_i CC_{t-i} + \sum_{m=1}^{k} \varphi_m ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n OP_{t-n} + \sum_{p=1}^{k} \varsigma_p NGNUSD_{t-p} + u_{1t} \quad (2.4)$$

Where:

CC_t	-	Daily confirmed cases of COVID-19
ASI_t	-	Nigerian stock market all-shares index
OPt	-	Nigerian crude oil price
$NGNUSD_t$	-	Nigerian Naira/United State Dollar daily exchange rate
$\alpha_1 - \alpha_4$	-	The constant terms for the four variables respectively
u_t	-	the stochastic error

2.2 **Autoregressive Distributive Lag (ARDL) Modelling**

In line with the objectives, the study also applied the autoregressive distributed lag model (ARDL) in modelling both short term and long term relationship between interacting variables. The unit root test and autoregressive distributed lag (ARDL) bounds test were conducted as a pre-test to determine whether the mean and variance of the series vary systematically with time and long term equilibrium among the exogenous and endogenous variables under investigation.

3.5.1 Model Specification

The ARDL model with the four variables is prescribed as;

$$CC_t = \alpha_1 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m \Delta ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{t,1} \quad (2.5)$$

$$ASI_t = \alpha_2 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m \Delta ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{t,2} \quad (2.6)$$

$$OP_t = \alpha_3 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m \Delta ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{t,3} \quad (2.7)$$

$$NGNUSD_t = \alpha_4 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{1t} \quad (2.8)$$

Where:

CC_t	-	Daily confirmed cases of COVID-19
ASI_t	-	Nigerian stock market all-shares index
OP_t	-	Nigerian crude oil price
$NGNUSD_t$	-	Nigerian Naira/United State Dollar daily exchange rate
μ_t	-	Impulse
P	-	Maximum Lag Length
Δ	-	Difference Operator
$\beta, \varphi, \vartheta, \varsigma$	-	Short run coefficients

2.2 Autoregressive Distributive Lag (ARDL) Modelling

In line with the objectives, the study also applied the autoregressive distributed lag model (ARDL) in modelling both short term and long-term relationship between interacting variables. The unit root test and autoregressive distributed lag (ARDL) bounds test were conducted as a pre-test to determine whether the mean and variance of the series vary systematically with time and long term equilibrium among the exogenous and endogenous variables under investigation.

The ARDL model with the four variables is prescribed as;

$$CC_t = \alpha_1 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m \Delta ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{t,1} \quad (2.5)$$

$$ASI_t = \alpha_2 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m \Delta ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{t,2} \quad (2.6)$$

$$OP_t = \alpha_3 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m \Delta ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{t,3} \quad (2.7)$$

$$NGNUSD_t = \alpha_4 + \sum_{i=1}^{k} \beta_i \Delta CC_{t-i} + \sum_{m=1}^{k} \varphi_m ASI_{t-m} + \sum_{n=1}^{k} \vartheta_n \Delta OP_{t-n} + \sum_{p=1}^{k} \varsigma_p \Delta NGNUSD_{t-p} + u_{1t} \quad (2.8)$$

Where:

CC_t	-	Daily confirmed cases of COVID-19
ASI_t	-	Nigerian stock market all-shares index
OP_t	-	Nigerian crude oil price
$NGNUSD_t$	-	Nigerian Naira/United State Dollar daily exchange rate
μ_t	-	Impulse
P	-	Maximum Lag Length
Δ	-	Difference Operator
$\beta, \varphi, \vartheta, \varsigma$	-	Short run coefficients

3. Results

Table 1: Descriptive Statistics of Variables

	CC	**ASI**	**OP**	**NGNUSD**
Mean	397.8603	37.97757	69.26204	397.0115
Median	281.0000	39.19875	68.61000	390.0000
Maximum	2464.000	54.08530	139.4100	418.1700
Minimum	0.000000	24.09808	26.27000	375.4653
Std. Dev.	402.8271	7.682307	23.58714	15.05985
Skewness	1.749421	-0.426152	0.569067	0.001437
Kurtosis	6.407982	2.369564	2.656824	1.109366
Jarque-Bera	497.9989	23.46085	29.49884	74.61779
Probability	0.061421	0.210510	0.3150.2	0.210547
Sum	199328.0	19026.76	34700.28	198902.8
Sum Sq. Dev.	81134844	29508.92	278176.5	113399.5
Observations	501	501	501	501

4. Source: EViews 10 Output

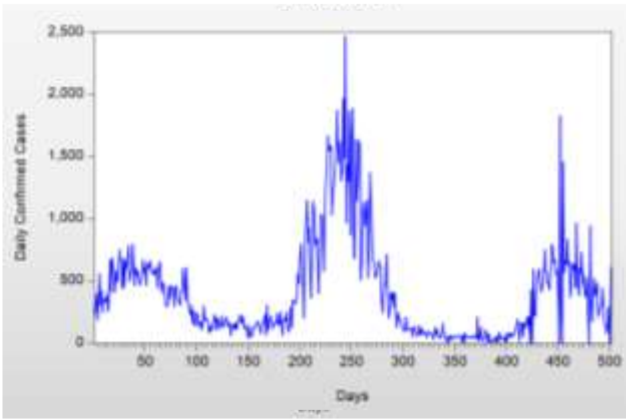


Figure 2: Time Plot of Variables including: COVID-19 daily confirmed cases, All Shares Index, Crude oil Price and USD/NGN Exchange Rate.

Table 2: Unit Root Test using Augmented Dickey Fuller (ADF) Test

Variable (s)	Stat. level	t-Statistics 1%	5%	10%	ADFTS	Prob.	Remarks
CC	I(0)	-3.44	-2.87	-2.57	-2.50	0.1162	Not Stationary
	I(1)	-3.44	-2.87	-2.57	-3.62	0.0057	Stationary
ASI	I(0)	-3.44	-2.87	-2.57	0.26	0.9800	Not Stationary
	I(1)	-3.44	-2.87	-2.57	-12.55	0.0000	Stationary
OP	I(0)	-3.44	-2.87	-2.57	0.18	0.9700	Not Stationary
	I(1)	-3.44	-2.87	-2.57	-10.73	0.0000	Stationary
NGNUSD	I(0)	-3.44	-2.87	-2.57	-0.87	0.8000	Not Stationary
	I(1)	-3.44	-2.87	-2.57	-10.35	0.0000	Stationary

The results were tested at 1%, 5%, and 10% level of significance respectively

Table 3: Result of Johansen Cointegration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.033809	36.59352	47.85613	0.3670
At most 1	0.023098	19.67199	29.79707	0.4453
At most 2	0.016145	8.174284	15.49471	0.4470
At most 3	0.000338	0.166180	3.841466	0.6835

VAR Model Estimation

VAR Model - Substituted Coefficients:

$$\Delta CC_{t} = - 0.847657996471*\Delta CC_{t-1} - 0.693214530838*\Delta CC_{t-2} - 0.43016783404*\Delta CC_{t-3} - 0.394498829273*\Delta CC_{t-4} - 0.404452063558*\Delta CC_{t-5} - 0.162415725208*\Delta CC_{t-6} + 0.102461531696*\Delta CC_{t-7} + 0.18672968954*\Delta CC_{t-8} + 11.3177752854*\Delta ASI_{t-1} + 23.2234398021*\Delta ASI_{t-2} + 0.849200613873*\Delta ASI_{t-3} - 26.7007008718*\Delta ASI_{t-4} - 69.5531984035*\Delta ASI_{t-5} + 1.12456481052*\Delta ASI_{t-6} + 5.48553607979*\Delta ASI_{t-7} + 42.6023142463*\Delta ASI_{t-8} + 2.45760481965*\Delta OP_{t-1} - 5.63227094513*\Delta OP_{t-2} + 3.36714886314*\Delta OP_{t-3} + 2.21297081401*\Delta OP_{t-4} - 7.57520154136*\Delta OP_{t-5} - 2.39322534416*\Delta OP_{t-6} + 3.21857293201*D\Delta OP_{t-7} + 11.0921699969*\Delta OP_{t-8} + 4.25370527739*\Delta NGNUSD_{t-1} + 2.67572492244*\Delta NGNUSD_{t-2} - 3.47653409559*\Delta NGNUSD_{t-3} - 3.2528241583*\Delta NGNUSD_{t-4} - 7.36387255146*\Delta NGNUSD_{t-5} - 8.76843625387*\Delta NGNUSD_{t-6} - 10.9571641812*\Delta NGNUSD_{t-7} - 6.48403260128*\Delta NGNUSD_{t-8} + 0.382072962034 \tag{4.1}$$

$$\Delta ASI_{t} = - 8.68417874977e\text{-}05*\Delta CC_{t-1} - 0.000116082217775*\Delta CC_{t-2} - 8.34833204581e\text{-}05*\Delta CC_{t-3} - 8.47953945337e\text{-}05*\Delta CC_{t-4} - 0.000124933464708*\Delta CC_{t-5} - 1.53174717729e\text{-}05*\Delta CC_{t-6} + 1.43592628916e\text{-}05*\Delta CC_{t-7} + 3.0408380692e\text{-}05*\Delta CC_{t-8} + 0.139430914942*\Delta ASI_{t-1} + 0.114375822361*\Delta ASI_{t-2} + 4.82813596812e\text{-}05*\Delta ASI_{t-3} + 0.071368670074*\Delta ASI_{t-4} + 0.0211903951526*\Delta ASI_{t-5} + 0.0368626777587*\Delta ASI_{t-6} - 0.00168302421323*\Delta \mathrm{ASI}_{t-7} + 0.0292423604544*\Delta ASI_{t-8} + 0.00495907011895*\Delta OP_{t-1} + 0.006453759457*\Delta OP_{t-2} + 0.00496295472522*\Delta OP_{t-3} - 0.00101878610539*\Delta OP_{t-4} - 0.00329501036506*\Delta OP_{t-5} - 0.0060966970307*\Delta OP_{t-6} - 0.00312255126844*\Delta OP_{t-7} + 0.00293249024068*\Delta OP_{t-8} - 0.00204667146914*\Delta \mathrm{NGNUSD}_{t-1} + 0.00184271771789*\Delta \mathrm{NGNUSD}_{t-2} + 0.000980273023231*\Delta \mathrm{NGNUSD}_{t-3} + 0.00501494685191*\Delta \mathrm{NGNUSD}_{t-4} + 0.0191733254578*\Delta \mathrm{NGNUSD}_{t-5} + 0.00428657510353*\Delta \mathrm{NGNUSD}_{t-6} -$$

$0.0150531143079*\Delta \mathrm{NGNUSD}_{t-7}$- $0.0211120305053*\Delta \mathrm{NGNUSD}_{t-8}$ + 0.0342595850676 (4.2)

ΔOP_{t}= $0.00179824621508*\Delta CC_{t-1}$ + $0.00163100731797*\Delta CC_{t-2}$ + $0.00163244635833*\Delta CC_{t-3}$ + $0.00147140849602*\Delta CC_{t-4}$ + $0.000754106910333*\Delta CC_{t-5}$ + $0.000855842163203*\Delta CC_{t-6}$ + $0.000591645644515*\Delta CC_{t-7}$ - $0.000209928713489*\Delta CC_{t-8}$ - $0.129688628589*\Delta ASI_{t-1}$ + $0.0459006184979*\Delta ASI_{t-2}$ - $0.148135448113*\Delta NSE\_ASI_{t-3}$ + $0.652655678354*\Delta ASI_{t-4}$ - $0.246190858513*\Delta ASI_{t-5}$ + $0.644136268716*\Delta ASI_{t-6}$- $0.369607249367*\Delta ASI_{t-7}$ + $0.0960581169761*\Delta ASI_{t-8}$ - $0.122071758019*\Delta OP_{t-1}$ - $0.0494724519311*\Delta OP_{t-2}$ - $0.0190523912501*\Delta OP_{t-3}$ + $0.000441355536131*\Delta OP_{t-4}$ - $0.0709837110422*\Delta OP_{t-5}$- $0.153925295236*\Delta OP_{t-6}$ - $0.0857158712093*\Delta OP_{t-7}$ - $0.0397946403748*\Delta OP_{t-8}$ - $0.00424124324076*\Delta NGNUSD_{t-1}$ + $0.0113083026158*\Delta NGNUSD_{t-2}$ + $0.0130721311794*\Delta NGNUSD_{t-3}$ + $0.0205989484293*\Delta NGNUSD_{t-4}$ + $0.0455605723958*\Delta NGNUSD_{t-5}$ + $0.0466049031508*\Delta NGNUSD_{t-6}$ + $0.0200186168621*\Delta NGNUSD_{t-7}$ - $0.0143443272433*\Delta NGNUSD_{t-8}$ + 0.221423067123 (4.3)

D(NGNUSD) = - $0.00127092112455*\Delta CC_{t-1}$ - $0.00172408601356*\Delta CC_{t-2}$ - $0.000846562679316*\Delta CC_{t-3}$ - $0.00132389776401*\Delta CC_{t-4}$ - $0.002775241329*\Delta CC_{t-5}$ - $0.00022450556494*\Delta COVIDDATA_{t-6}$ - $0.000276705959595*\Delta CC_{t-7}$ + $0.00077659228893*\Delta CC_{t-8}$ - $0.061461164282*\Delta ASI_{t-1}$ - $0.540793384087*\Delta ASI_{t-2}$ + $0.420402987114*\Delta ASI_{t-3}$ + $0.297542315846*\mathrm{D}\Delta ASI_{t-4}$ + $0.274570792709*\Delta ASI_{t-5}$ - $0.300586005994*\Delta ASI_{t-6}$ - $0.438390224244*\Delta ASI_{t-7}$ - $0.294224605947*\Delta ASI_{t-8}$ + $0.0344216590771*\Delta OP_{t-1}$ + $0.0224264447099*\Delta OP_{t-2}$ + $0.00265817465474*\Delta OP_{t-3}$ + $0.0180165196639*\Delta OP_{t-4}$ - $0.00771051945746*\Delta OP_{t-5}$ - $0.038599881502*\Delta OP_{t-6}$ - $0.00146721448305*\Delta OP_{t-7}$ + $0.0134633173596*\Delta OP_{t-8}$ - $0.716360351492*\Delta NGNUSD_{t-1}$ - $0.0286537293994*\Delta NGNUSD_{t-2}$+ $0.270481988918*\Delta NGNUSD_{t-3}$ + $0.166497128989*\Delta NGNUSD_{t-4}$ + $0.0486785646611*\Delta NGNUSD_{t-5}$ - $0.0446925903718*\Delta NGNUSD_{t-6}$ - $0.0659197508471*\Delta NGNUSD_{t-7}$ - $0.0638323384114*\Delta NGNUSD_{t-8}$ + 0.108125428278 (4.4)

VAR Residual Diagnostic Tests

Table 4:VAR(8) Model Stability Test

Diagnostic Test	Test Statistics	df	Chi-square Test Statistic Value	Prob. Value (p-value)	Remarks
VAR Residual Normality Test	Orthogonalization:	2	972.124	0.08324	Multivariate residual are normal
		2	723.181	0.20145	
		2	10107.3	0.05105	
		2	39643.1	0.10514	
VAR Residual Heteroscedasticity Test	Chi-square	640	1400.368	0.51341	No Heteroscedastic

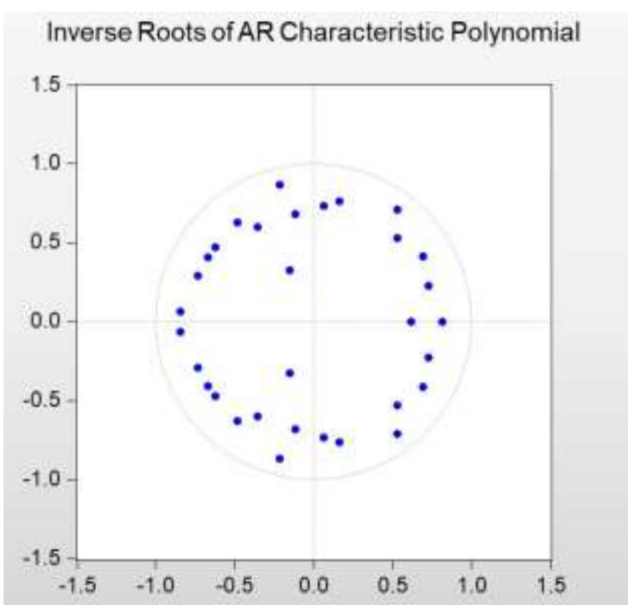


Figure 3: Inverse Roots of AR Characteristic Polynomial of the VAR(8) Model Showing Dynamic Stability.

Forecasting using the VAR (8) Model

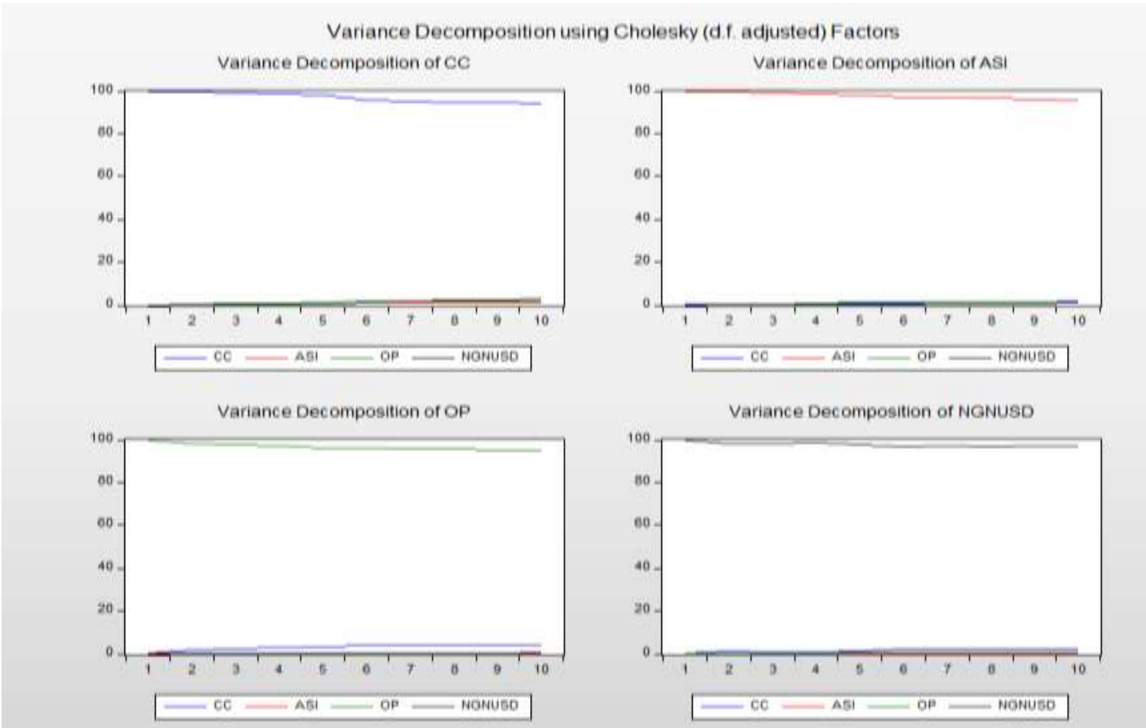


Figure 4: Variance Decomposition of the VAR(8) Model.

ARDL Model Estimation

Table 5: Summary of ARDL Bounds Test for Cointegration using (4,0,3,2), (3,0,0,0), (2,1,0,0), (2,3,0,0) models

Null Hypothesis: No Long-Run Relationship Exist

Dependent Variable	F-Statistic	K	Signif	I(0)	I(1)	Decision
CC	2.991245	3	5%	3.23	4.35	Short-Run (No cointegration)
ASI	0.906940	3	5%	3.23	4.35	Short-Run (No cointegration)
OP	2.925894	3	5%	3.23	4.35	Short-Run (No cointegration)
NGNUSD	3.131489	3	5%	3.23	4.35	Short-Run (No cointegration)

Signif – Level of significance

Estimating the Effects of ASI, OP and NGNUSD on CC

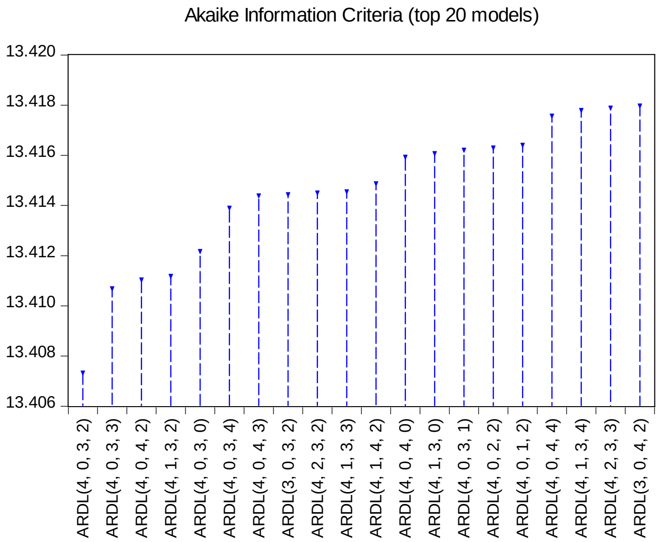


Figure 5: ARDL Model Selection (CC as dependent variable).

Table 6: ARDL(4,0,3,2) Model Estimation, using CC as Dependent Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DCC(-1)	-0.729995	0.045473	-16.05348	0.0000
DCC(-2)	-0.566623	0.055229	-10.25955	0.0000
DCC(-3)	-0.247385	0.055204	-4.481259	0.0000
DCC(-4)	-0.105690	0.045436	-2.326143	0.0204
DASI	6.795228	29.87746	0.227437	0.8202
DNGNUSD	9.786622	4.144417	2.361399	0.0186
DNGNUSD(-1)	10.65855	5.030785	2.118666	0.0346
DNGNUSD(-2)	-1.594449	5.020313	-0.317600	0.7509
DNGNUSD(-3)	-10.38625	4.131720	-2.513785	0.0123
DOP	-0.208412	3.627199	-0.057458	0.9542
DOP(-1)	-0.862324	3.636653	-0.237120	0.8127
DOP(-2)	-9.065045	3.618522	-2.505179	0.0126
C	0.827265	9.003574	0.091882	0.9268
OP(-3)	10.35697	3.615061	2.864951	0.0044
C	1423.997	472.0764	3.016454	0.0027
R-squared	0.778404	Mean dependent var		398.8974
Adjusted R-squared	0.771968	S.D. dependent var		404.2224
S.E. of regression	193.0272	Akaike info criterion		13.39326
Sum squared resid	17959074	Schwarz criterion		13.52028
Log likelihood	-3313.224	Hannan-Quinn criter.		13.44311
F-statistic	120.9379	Durbin-Watson stat		2.010092
Prob(F-statistic)	0.000000			

Table 7: ARDL(4,0,3,2) Serial Correlation and Heteroscedasticity

Test	F-statistic	P-Value	Decision
Breusch-Godfrey Serial Correlation LM Test	1.020391	0.3722	No Serial Correlation
Breusch-Pagan-Godfrey for Heteroskedasticity	2.327334	0.0553	No Heteroscedasticity

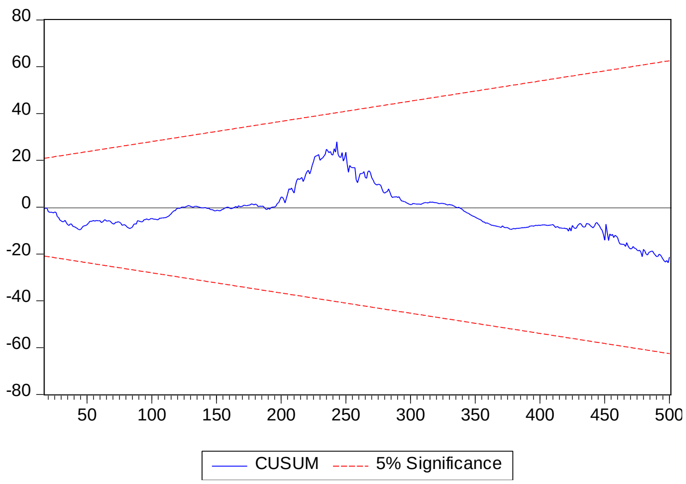


Figure 6: CUSUM Stability Test for ARDL (4,0,4,3), using CC as Dependent Variable.

Estimating the Short Run Effects of CC, OP and NGNUSD on ASI

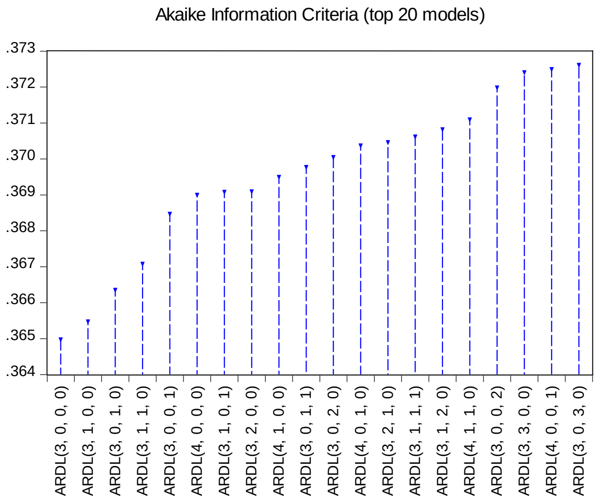


Figure 7: ARDL Model Selection (ASI as dependent variable).

Table 8: ARDL(3,0,0,0) Model Estimation, using ASI as Dependent Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DASI(-1)	1.138889	0.045111	25.24624	0.0000
DASI(-2)	-0.025309	0.068431	-0.369850	0.0217
DASI(-3)	-0.115274	0.045367	-2.540898	0.0114
DCC	-7.03E-05	3.67E-05	-1.918873	0.0456
DNGNUSD	-0.000806	0.001667	-0.483504	0.6290
DOP	0.001059	0.001709	0.619841	0.5357
C	0.382366	0.637312	0.599967	0.5488
R-squared	0.998593	Mean dependent var	38.05693	
Adjusted R-squared	0.998576	S.D. dependent var	7.636742	
S.E. of regression	0.288157	Akaike info criterion	0.363336	
Sum squared resid	40.77002	Schwarz criterion	0.422522	
Log likelihood	-83.47079	Hannan-Quinn criter.	0.386565	
F-statistic	58096.59	Durbin-Watson stat	1.992125	
Prob(F-statistic)	0.000000			

Table 9: ARDL(3,0,0,0) Serial Correlation and Heteroscedasticity

Test	F-statistic	P-Value	Decision
Breusch-Godfrey Serial Correlation LM Test	0.539378	0.5835	No Serial Correlation
Breusch-Pagan-Godfrey for Heteroskedasticity	5.637724	0.3124	No Heteroscedasticity

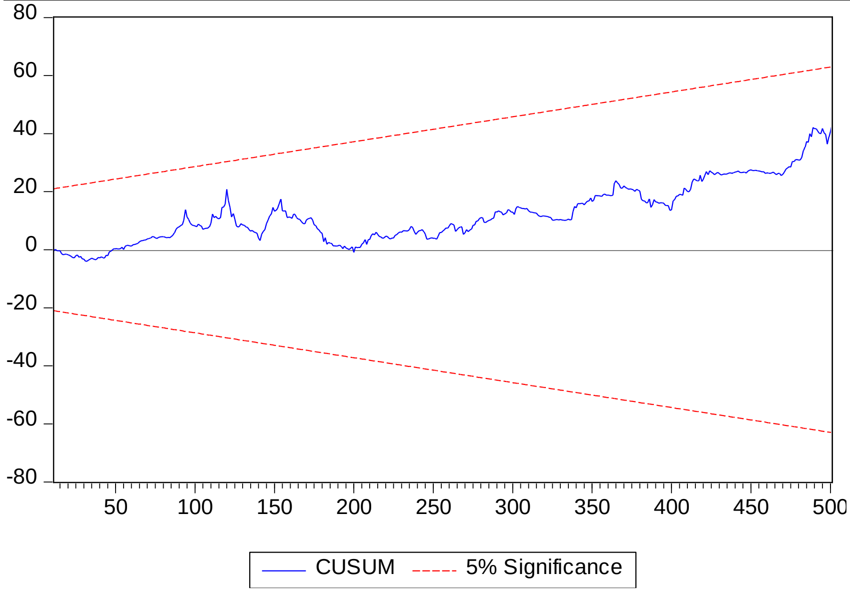


Figure 8: CUSUM Stability Test for ARDL (3,0,0,0), Using ASI as Dependent Variable.

Estimating the Effects of CC, ASI, NGNUSD on OP

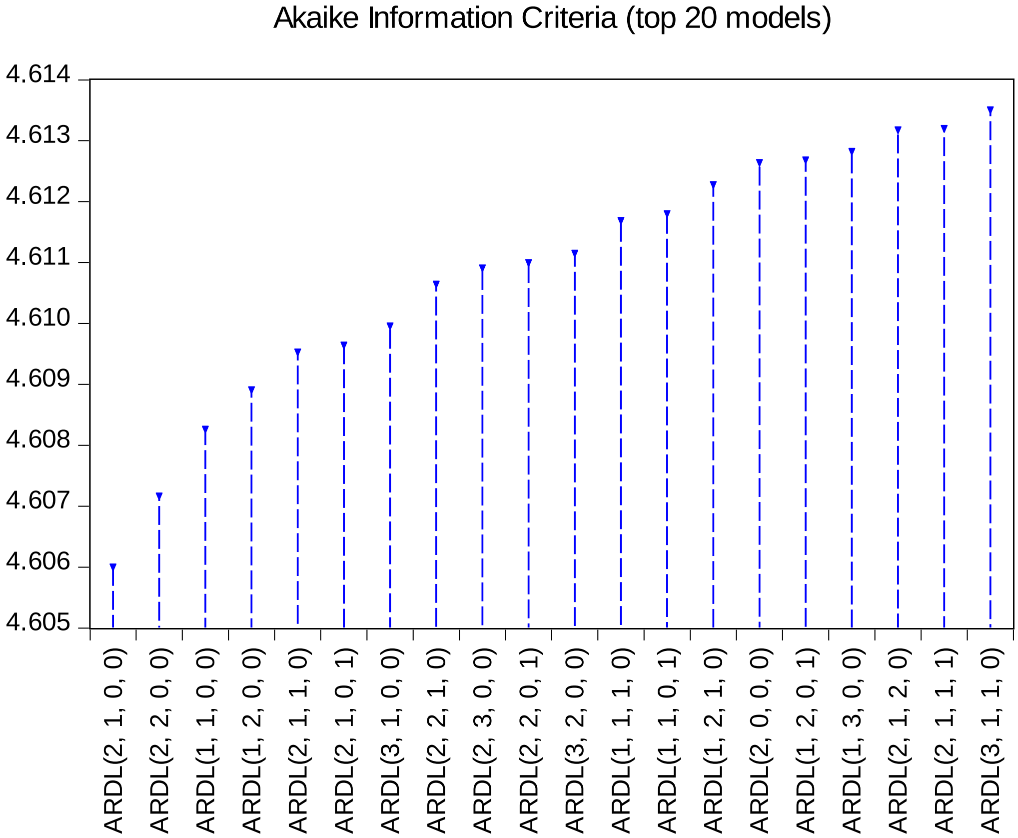


Figure 9: ARDL Model Selection (OP as dependent variable).

Table 10: ARDL(2,1,0,0) Model Estimation using OP as Dependent Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DOP(-1)	0.863904	0.044738	19.31045	0.0000
DOP(-2)	0.078400	0.044477	1.762720	0.0486
DCC	-0.000314	0.000465	-0.675464	0.0197
DCC(-1)	0.001073	0.000466	2.300463	0.0218
DASI	0.120236	0.031981	3.759564	0.0002
DNGNUSD	0.041099	0.014132	2.908250	0.0038
C	-17.00664	5.413157	-3.141723	0.0018
R-squared	0.989727	Mean dependent var	69.40476	
Adjusted R-squared	0.989601	S.D. dependent var	23.52605	
S.E. of regression	2.399053	Akaike info criterion	4.601954	

Sum squared resid	2831.683	Schwarz criterion	4.661048
Log likelihood	-1141.187	Hannan-Quinn criter.	4.625144
F-statistic	7899.723	Durbin-Watson stat	1.993257
Prob(F-statistic)	0.000000		

Table 11: ARDL(2,1,0,0) Serial Correlation and Heteroscedasticity

Test	F-statistic	P-Value	Decision
Breusch-Godfrey Serial Correlation LM Test	0.557479	0.8127	No Serial Correlation
Breusch-Pagan-Godfrey for Heteroskedasticity	8.391975	0.5418	No Heteroscedasticity

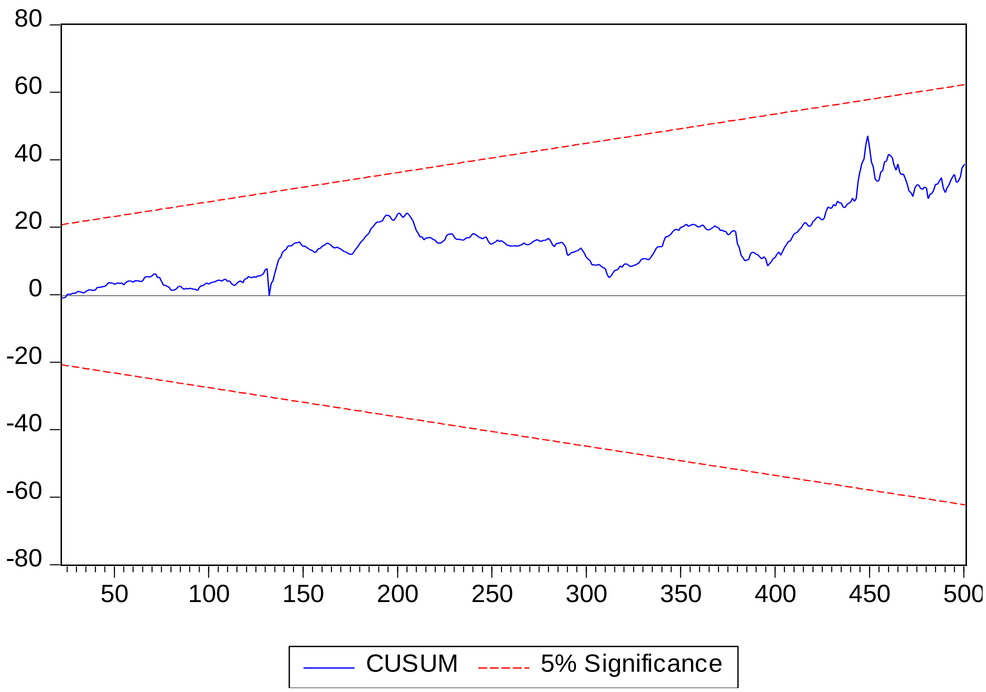


Figure 10: CUSUM Stability Test for ARDL (2,1,0,0), using OP as Dependent Variable.

Estimating the Short Run Effects of CC, ASI, OP on NGNUSD

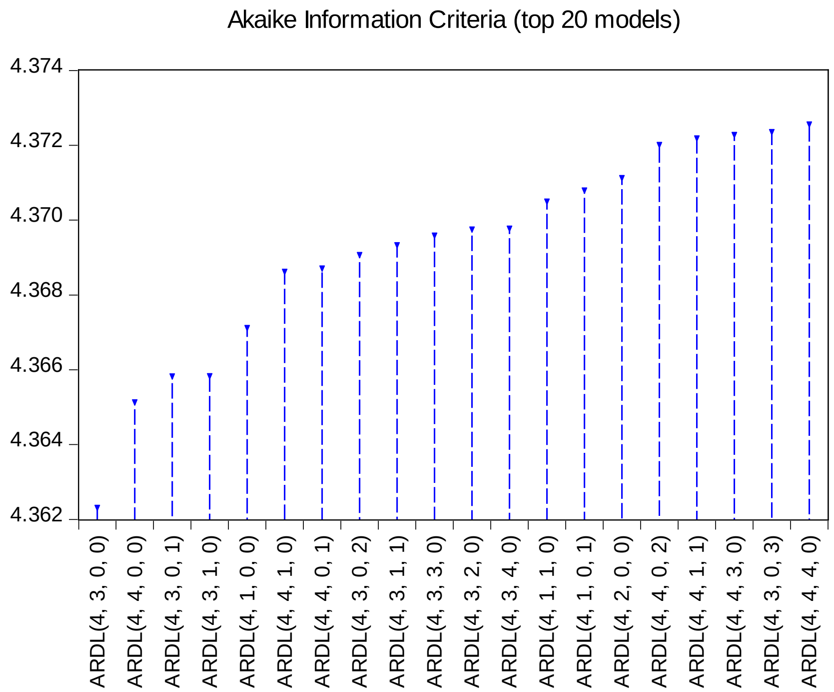


Figure 11: ARDL Model Selection (NGNUSD as dependent variable).

Table 12: ARDL(4,3,0,0) Model Estimation using NGNUSD as Dependent Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
NGNUSD(-1)	0.271745	0.044636	6.088048	0.0000
NGNUSD(-2)	0.657695	0.045221	14.54386	0.0000
NGNUSD(-3)	0.220781	0.045430	4.859811	0.0000
NGNUSD(-4)	-0.157109	0.045197	-3.476071	0.0006
CC	0.001044	0.000487	2.144253	0.0325
CC(-1)	-0.001258	0.000481	-2.617349	0.0091
CC(-2)	-0.000364	0.000480	-0.758819	0.4483
CC(-3)	0.001217	0.000486	2.505723	0.0125
ASI	0.023383	0.029244	0.799579	0.4243
OP	-0.000959	0.013385	-0.071610	0.9429
C	1.738301	5.118003	0.339644	0.7343

R-squared	0.980709	Mean dependent var	397.0688
Adjusted R-squared	0.980312	S.D. dependent var	15.10681
S.E. of regression	2.119708	Akaike info criterion	4.362318
Sum squared resid	2183.677	Schwarz criterion	4.455466
Log likelihood	-1073.036	Hannan-Quinn criter.	4.398878
F-statistic	2470.672	Durbin-Watson stat	2.024687
Prob(F-statistic)	0.000000		

Table 13: ARDL(2,3,0,0) Serial Correlation and Heteroscedasticity

Test	F-statistic	P-Value	Decision
Breusch-Godfrey Serial Correlation LM Test	0.912476	0.3147	No Serial Correlation
Breusch-Pagan-Godfrey for Heteroskedasticity	12.868630	0.2147	No Heteroscedasticity

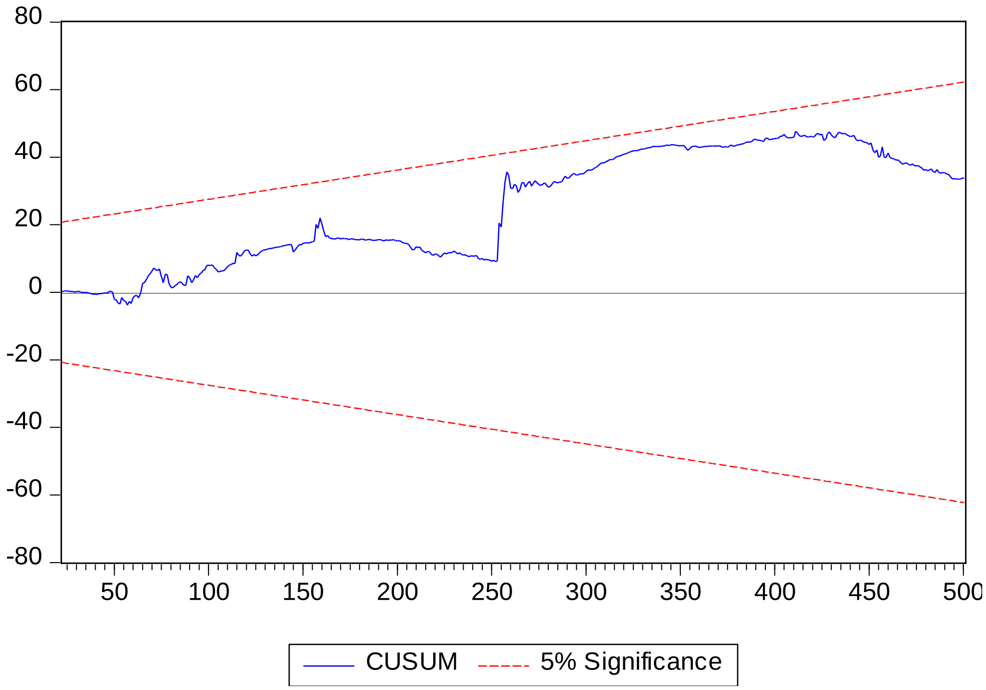


Figure 14: CUSUM Stability Test for ARDL (2,3,0,0) using NGNUSD as Dependent Variable

4. Discussion

On the short run effect of COVID-19 on economic growth and stability in Nigeria, the variance decomposition analysis of the Vector Autoregression VAR(8) model as seen in the graph in Figure 4, reveals insightful dynamics in the forecasting strength of the selected model. Across various periods, the model effectively captures the majority of the variance in the variables D(CC), D(ASI), and D(OP), indicating a robust forecasting capability. For instance, in the case of D(CC), the model captures 100% of the variance in the first period and maintains a high level of explanatory power throughout subsequent periods. Similarly, for D(ASI) and D(OP), the model consistently explains a significant portion of the variance. This finding is in line with recent studies highlighting the efficacy of VAR models in forecasting financial time series data (Lütkepohl, 2005). Interpreting the table, the Variance Decomposition analysis delineated how much of the variance in D(CC) could be ascribed to shocks originating from each of the other variables (D(ASI), D(OP), D(NGNUSD)) over the examined timeframe (Ajide, 2021). Considering the global economic context and the timeframe covered, it was reasonable to infer that the analysis encapsulated the repercussions of the COVID-19 pandemic on the Nigerian economy. Hence, it likely captured how pandemic-related shocks, such as financial market disruptions, exchange rate fluctuations, and stock market volatility, impacted credit conditions (D(CC)) in Nigeria. Additionally, the analysis underscored the interconnectedness of these variables, elucidating which factors contributed most significantly to fluctuations in credit conditions during certain periods. This insight was pivotal for policymakers and investors to comprehend how changes in one economic indicator reverberated throughout the system (Adediran *et al.*, 2020). Consequently, understanding the relative importance of different variables in driving credit conditions fluctuations could guide policymakers in formulating targeted measures to stabilize the economy or mitigate the impact of future crises. For instance, if the analysis revealed that exchange rate fluctuations exerted a substantial influence on credit conditions, policymakers could consider implementing policies to enhance currency stability, thereby bolstering overall financial stability and economic resilience (Omotosho *et al.*, 2021).

The findings from the ARDL models reveal that the COVID-19 pandemic had predominantly short-run impacts on key economic variables in Nigeria. The Bounds Test for cointegration indicated no long-run relationships across different model specifications for Confirmed Cases (CC), All Share Index (ASI), Oil Prices (OP), and the Nigerian Naira to US Dollar Exchange Rate (NGNUSD), with F-statistics failing to surpass critical values at the 5% significance level. Specific models such as the ARDL(4,0,3,2) highlighted significant lagged effects of Differenced COVID Data (DCC) on economic variables, suggesting that historical changes in COVID-19 cases influenced economic outcomes in the short term. However, the ASI did not show a direct impact on economic growth, and the influence of OP and NGNUSD was mixed. The ARDL(3,0,0,0) and ARDL(2,1,0,0) models, respectively, demonstrated strong predictive power for ASI and OP with high R-squared values and no significant autocorrelation or heteroskedasticity issues, underscoring their reliability. These results are consistent with recent literature, which emphasizes the transient nature of the pandemic's economic effects and the need for dynamic, short-term policy responses to mitigate volatility in developing economies like Nigeria (Ozili, 2021; Takyi et al., 2023; Ghosh, 2020).

The comparative analysis between Vector Autoregression (VAR) and Autoregressive Distributed Lag (ARDL) models reveals key insights into the short-run dynamics of Confirmed Cases of COVID-19 (CC), All Share Index (ASI), Oil Prices (OP), and the Nigerian Naira to US Dollar Exchange Rate (NGNUSD). Both models confirm the existence of short-run relationships, highlighting the interconnected nature of these economic variables amidst external shocks like the COVID-19 pandemic (Saleem et al., 2020). However, the forecasting strengths differ: while VAR models are advantageous in capturing dynamic interdependencies over time, ARDL models demonstrate greater robustness in handling non-stationary data and cointegration, often outperforming VAR in contexts requiring both short-run and long-run analysis (Atri et al., 2021; Charfeddine *et al.*, 2023). This distinction suggests that ARDL models are more effective in scenarios requiring a nuanced understanding of persistence and stability, whereas VAR models are suited for analyzing short-term fluctuations and immediate responses, making the choice of model contingent on specific research objectives and data attributes.

5. Conclusion

This study aimed to model the impact of the COVID-19 pandemic on economic growth and stability in Nigeria using Vector Autoregressive (VAR) Model and Autoregressive Distributive Lag (ARDL) Model, integrating four variables encompassing Nigerian COVID-19 daily data (confirmed cases) along with other economic metrics like the Nigerian Stock Exchange (NSE) All Shares Index, Daily Nigerian Naira/United States Dollar Exchange Rate, and Nigerian Crude Oil Price, to discern the pandemic's trends and implications on the Nigerian Economy post-pandemic. Covering daily time series data for the variables from May 26, 2020, to May 25, 2022, a total of 501 days. The VAR model estimation revealed insights into short-term dynamics only among key economic variables, supported by stable outcomes consistent with previous studies, emphasizing significant causal relationships among economic indicators during crises like the COVID-19 pandemic. The VAR(8) model was selected as the most appropriate model using the Akaike Information Criterion (AIC). Meanwhile, the ARDL model estimation, employing various model specifications such as ARDL(4,0,2,2), ARDL(3,1,1,0), ARDL(2,3,0,0), and ARDL(4,3,0,0) for CC, ASI, NGNUSD, and OP as dependent variables, respectively, underscored the significance of autocorrelation effects in fluctuating economic variables, providing detailed insights into short-run impacts and emphasizing the interconnectedness of economic indicators, particularly with oil prices. The study concluded that only a short-run relationship existed among the variables, with ARDL being more suitable for studying both short-run and long-run relationships among interacting macroeconomic variables.

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