NIGERIA IS NOW ON TOP OF COVID-19: MESSAGE FROM ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

The tail end of 2019 cannot be forgotten due to the coming-in of the novel coronavirus in Wuhan, China; which has continued to threaten our lives and livelihoods. On 28 February, Nigeria officially confirmed her first case of COVID-19 in Lagos State, an Italian citizen who works in Nigeria, had returned on 25 February from Milan, Italy. Just like any other country affected, Nigeria is scrambling to halt the spread of the COVID-19 pandemic. In this paper, the ANN approach was applied to analyze COVID-19 case volumes in Nigeria. The employed data covers the period 28 February 2020 to 31 October 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting COVID-19 cases in Nigeria. The results of the study indicate that daily new COVID-19 cases are likely to fall to zero cases per day somewhere between 25 and 27 November 2020 and onwards, suggesting that Nigeria is now "on top" of the COVID-19 pandemic. There is need for the Nigerian authorities to continue ensuring that preventive and control guidelines are being followed, strictly. This will go a long in avoiding a second wave of COVID-19 infections.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

Since the confirmation of the first case of coronavirus disease 2019 (COVID-19) in Nigeria in February this year, the spread of the virus has been increasing exponentially, precisely due to community-based human-to-human transmission (Odukoya *et al*., 2020). In fact, the this first case was officially confirmed in Lagos on 28 February 2020; unfortunately Lagos has remained the epicenter of the pandemic, accounting for 36% of the cases and 22% of deaths by July 26, 2020. By August 12, official statistics indicated that Nigeria had 47743 confirmed cumulative cases. To control the spread of COVID-19 in Nigeria, policy makers launched a campaign themed, "Take Responsibility", quarantined all COVID-19 confirmed cases, tested and tracked confirmed cases contacts; banned non-essential international and inter-state travel; implemented curfews to reduce social interactions and restricted gathering to 20 people per work to encourage physical distancing (NCDC, 2020). Developing a predictive model for the COVID-19 pandemic in Nigeria is important for policy formulation purposes, especially given the way the pandemic is

ravaging the lives of Nigerians. The main aim of this paper is to model and forecast daily new COVID-19 cases for all age groups in Nigeria in order to inform policy.

LITERATURE REVIEW

A number of studies have been carried out in an attempt to model and forecast COVID-19 in the country. Below is a summary of the reviewed relevant papers:

Table 1: Summary of the Reviewed Literature

Author/s (Year)	Study Period	Method	Major Findings
Ayinde *et al*. (2020)	February – April	QLRM	COVID-19 is spreading at an alarming rate in the country
Abdulmajeed *et al*. (2020)	February – April	GAMS, ARIMA, GARCH and ESM models	There is a progressive rise in COVID-19 cases in Nigeria
Okuonghae & Omame (2020)	February – April	SEIR model	If people comply with control and preventive measures, the disease will eventually die out
Ogundokun *et al*. (2020)	February – July	General Linear Regression Model	The model fits the data well. Travelling increased the spread of the virus
Ibrahim & Oladipo (2020)	February – April	ARIMA models	The ARIMA (1, 1, 0) model was the best fit model. The 10 day forecast from this model showed a steep upward trend of the spread of the COVID-19 pandemic in Nigeria
Adekunle *et al*. (2020)	February – April	Bayesian Framework	Existing control measures are not enough to end the pandemic
Nurudeen *et al*. (2020)	February – May	ARIMA	The best model is the ARIMA (1, 2, 1) model
Agbata *et al*. (2020)	February – September	SEIR model	Isolation, quarantine, social distancing and other measures are the best approaches to control the pandemic
Egwuche *et al*. (2020)	February – June	SEIR model	The proposed model shows an accuracy of 72%. The COVID-19 pandemic is spreading very fast

Odunayo (2020)	February – April	Linear trend model, fish-bone diagram and Pareto analysis	Spread of the pandemic is still increasing
Adeyeri *et al*. (2020)	February – June	AR, ML, MCMC and Bayesian approaches	Highest COVID-19 incidence is recorded in days with either religious activities or market days
Adesina *et al*. (2020)	February – August	ARFIMA and ARIMA models	ARFIMA models outperform the classical ARIMA models
Yahuza *et al*. (2020)	February – July	VB, BR, MMF, MR, MG, ML, and Huang growth models	The MMF model was the best model
Musa *et al*. (2020)	February – April	Exponential growth and ARIMA models	COVID-19 spread is on the rise
Samson *et al*. (2020)	February – May	ARIMA models	The ARIMA (2, 1, 0) model was the best model. Forecasts show an upsurge in confirmed COVID-19 cases
Onyelowe & Onyelowe (2020)	March – May	MLR model	COVID-19 infections rising
Magaji (2020)	February – April	Nonlinear Regression model	COVID-19 cases rising at an alarming rate
Joseph *et al*. (2020)	February – May	OLS, QM and EM models	The OLS model was the best model
Adams *et al*. (2020)	February – May	PR, NBR and GPR models	The GPR was the best model
Udanor & Eneh (2020)	February – May	SIR model	Nigeria has entered the exponential state of the pandemic
Oyinlola *et al*. (2020)	February – April	Poisson, NB as well as Walling & Teunis modeling techniques	COVID-19 cases followed an upward sloping trajectory suggestive of huge trade-offs in respect to losses in potential GDP

Source: Literature Review (2020)

METHOD

This study applies the multi-layer perceptron (MLP) neural network type of the Artificial Neural Network (ANN) approach in order to model and forecast new daily COVID-19 cases in Nigeria. The particulary applies the generalized ANN (12, 12, 1) model and opts for the more efficient hyperbolic tangent function as the activation function.

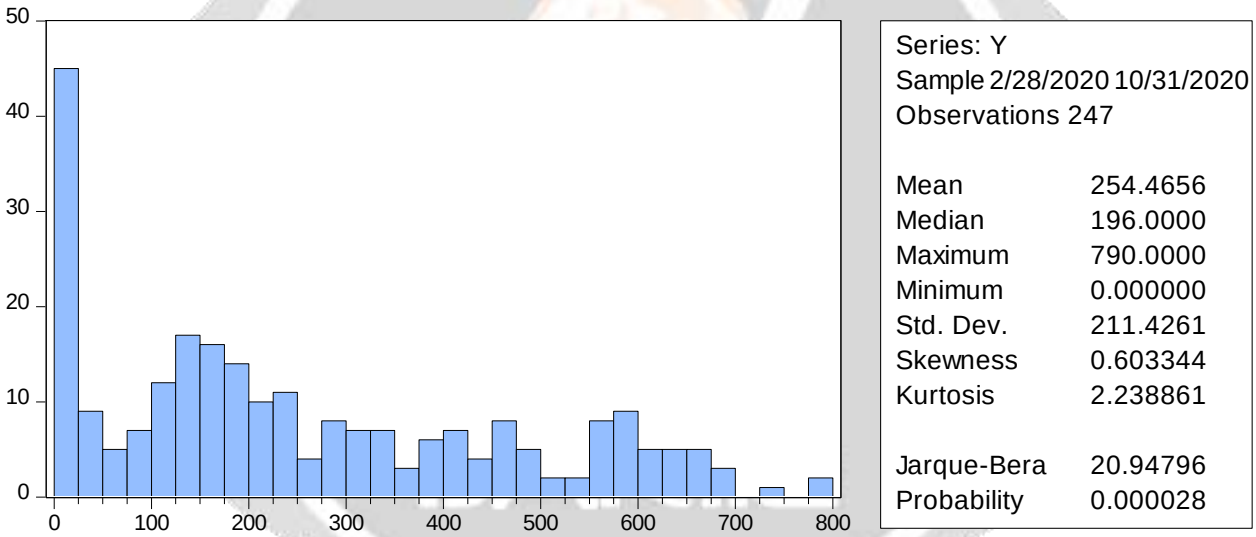
Data Issues

This study is based on new daily COVID-19 cases (reffered to as series, Y, in this study) for all age groups in Nigeria. The data covers the period 28 February 2020 to 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this research paper was gathered from the United States of America (USA)'s Johns Hopkins University online database.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Figure 1: Descriptive statistics



ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN NIGERIA

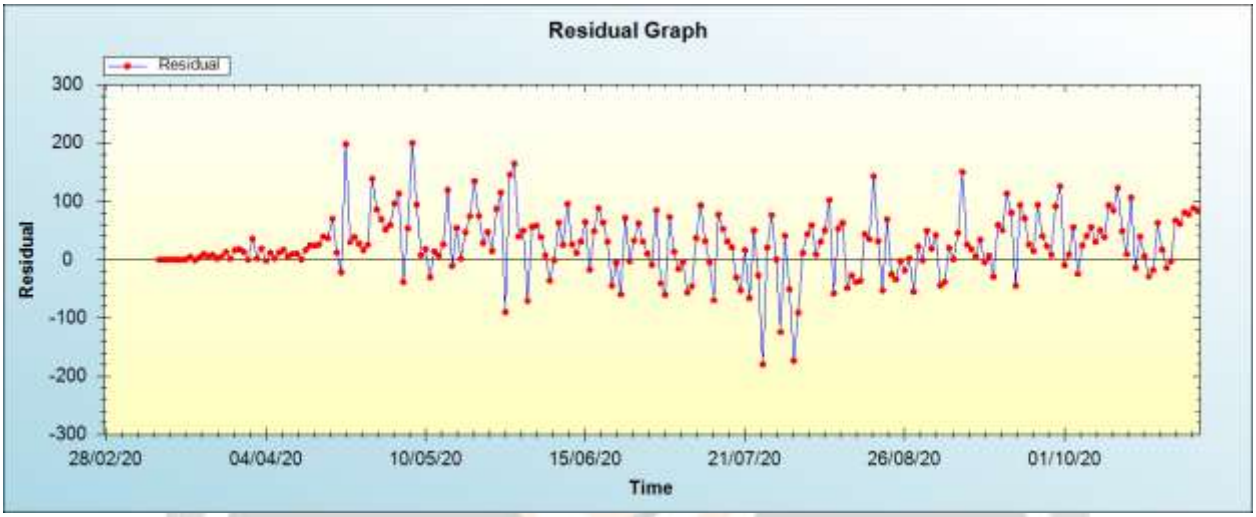
Table 2: ANN model summary

Variable	Y
Observations	235 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05

Criteria:	
Error	0.134635
MSE	3491.579285
MAE	43.970744

Residual Analysis for the ANN model

Figure 2: Residual analysis



In-sample Forecast for Y

Figure 3: In-sample forecast for the Y series

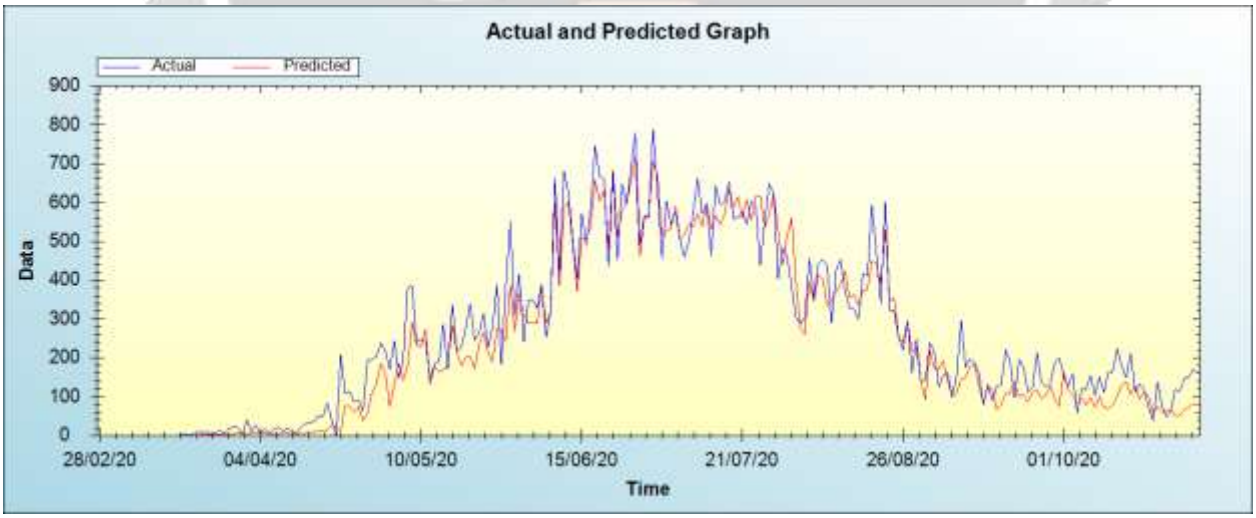
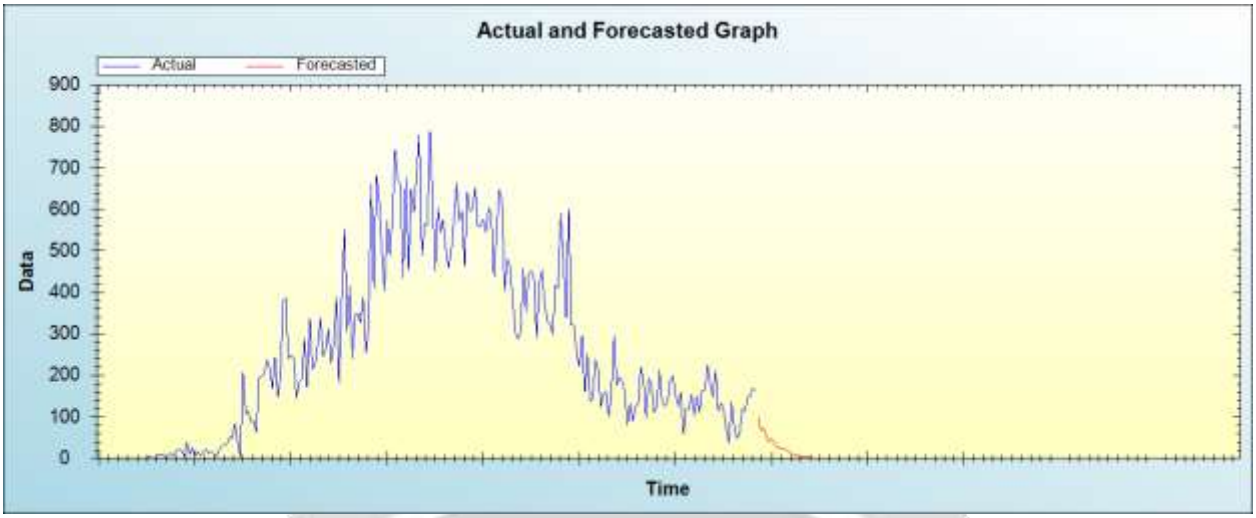


Figure 3 shows the in-sample forecast for Y series.

Out-of-Sample Forecast for Y: Actual and Forecasted Graph

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph



Out-of-Sample Forecast for Y: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	98.1182
02/11/20	67.9465
03/11/20	73.1393
04/11/20	52.5142
05/11/20	39.2364
06/11/20	48.5921
07/11/20	39.0073
08/11/20	25.1057
09/11/20	25.7825
10/11/20	23.4497
11/11/20	22.8363
12/11/20	18.8697
13/11/20	13.5723
14/11/20	9.6621
15/11/20	7.4766

16/11/20	4.9534
17/11/20	3.8440
18/11/20	4.9225
19/11/20	3.7572
20/11/20	2.2420
21/11/20	1.5479
22/11/20	1.2907
23/11/20	1.2707
24/11/20	1.1073
25/11/20	1.0695
26/11/20	0.8768
27/11/20	0.6227
28/11/20	0.2582
29/11/20	0.1769
30/11/20	0.3316
01/12/20	0.3259
02/12/20	0.2602
03/12/20	0.1864
04/12/20	0.1450
05/12/20	0.0956
06/12/20	0.0802
07/12/20	0.1130
08/12/20	0.1363
09/12/20	0.1275
10/12/20	0.0845
11/12/20	0.0676

12/12/20	0.0717
13/12/20	0.0758
14/12/20	0.0799
15/12/20	0.0831
16/12/20	0.0822
17/12/20	0.0717
18/12/20	0.0650
19/12/20	0.0665
20/12/20	0.0718
21/12/20	0.0742
22/12/20	0.0724
23/12/20	0.0708
24/12/20	0.0692
25/12/20	0.0681
26/12/20	0.0682
27/12/20	0.0698
28/12/20	0.0709
29/12/20	0.0703
30/12/20	0.0692
31/12/20	0.0687
01/01/21	0.0689
02/01/21	0.0692
03/01/21	0.0694
04/01/21	0.0696
05/01/21	0.0695
06/01/21	0.0692

07/01/21	0.0690
08/01/21	0.0691
09/01/21	0.0693
10/01/21	0.0693
11/01/21	0.0693
12/01/21	0.0692
13/01/21	0.0692
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31/01/21	0.0692
01/02/21	0.0692

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28/02/21	0.0692
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27/04/21	0.0692
28/04/21	0.0692
29/04/21	0.0692
30/04/21	0.0692

Figure 1 shows the descriptive statistics of the series Y under consideration. Worthy to note is that the average number of daily new infections has been 254 cases per day over the period under study. Figure 1 also indicates that the maximum number of new infections per day is 790 for the period under consideration. Table 2 shows the summary of the ANN model applied. The residual diagnostics of the applied model, shown in figure 2, indicate that the model is stable and suitable for forecasting COVID-19 daily new case volumes in Nigeria. Figures 3 and 4 as well as table 3 are basically out-of-sample forecasts. Clearly, the daily new COVID-19 infections are going down in the country. By end of November 2020, Nigeria could be "on top" of the virus. These results are quite acceptable and relevant and also consistent with previous studies Okuonghae & Omame (2020). In fact, Okuonghae & Omame (2020) found out that if people comply with safety measures, the pandemic would eventually die out. Because people in the country have responded well to the virus, today we project a sharp decline in future cases. In fact, our model shows that, beginning 25 November 2020, Nigeria will start experiencing almost zero cases on a daily basis, which suggests that the virus will eventually die out in the country. Nigerians should be complacent about it but continue to "take responsibility" in order to avoid a second wave of infections.

CONCLUSION & RECOMMENDATIONS

The COVID-19 pandemic shocked the world. Today the scourge is regarded as a global public health emergency. Health systems, even of higher incomes countries have been and continue to be overwhelmed. Nigeria has not been spared. Health systems that are fragile such as the one in Nigeria cannot be able to handle a high incidence of COVID-19 infection. Hence, this study investigated the trends of this disease and also forecasted its future evolution in order to help policy makers control it before the health systems are overwhelmed. The study showed that the pandemic is now under control in Nigeria. The country can be regarded as being "on top" of the virus. However, there is no need for complacency this time around: control and preventive measures need to be strictly followed and observed all the time, especially the wearing of masks, regular washing of hands as well as social distancing among other things.

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