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Forecasting COVID-19 Daily Contraction in Sierra Leone with Implications for Policy Formulation

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ABSTRACT

When the World Health Organisation (WHO) announced COVID-19 to be a global pandemic great chaos was brought to the world economy, with institutions and economies forced to close down in a bid to save lives. While it was a well-known fact that there was no immediate cure for the disease, institutions had no option but to utilise non-traditional means of containing the alarming spread of the virus. All around the world, institutions like the health sector and central banks utilised various forecast models as a way of projecting the scale of the spread of the virus and its overall impact on economic well-being. The findings from the ARIMA (4,1,4) model indicate that there is a likelihood of the virus spreading at a rate of 13 contracted cases per day up to 28th February 2021 and beyond. The key take home from this study shows that institutions, particularly the health sector, must stay alert to ensure measures are continually set in place to curb the likelihood of the virus spreading above and beyond the projected estimate. At the same time, institutional support from the central bank, with its stimulus packages, should continue in a bid to diffuse or allay worries of a possible collapse in the economy.

Keywords: COVID-19, ARIMA Model, Forecast, Sierra Leone
Jel Code: C22, C53, C82, I12, I18

1. Introduction

The COVID-19 pandemic came as a surprise to the global economy, with its emergence during the latter part of 2019 in the city of Wahun, China (Jackson, 2020). Since then, economies all around the world have plunged into turmoil, with massive devastation and loss of lives, while at the same time, economies are being forced to close down in a bid to save lives. The impact of such decisions and the spread of the disease are revealing themselves through economic recession faced almost everywhere in the world economy. The outcome of recession, as one would interpret it, signifies a dwindling state of economic activities and potential loss of revenue to governments in executing planned budgetary activities and particularly in addressing essential services associated with education, health and protecting the well-being of those in vulnerable conditions.

The way forward for stability in global economy affairs is still bleak, even though there seems to be some level of calmness concerning the spread of COVID-19 pandemic, which is still posing a high level of uncertainty regarding the way forward. The spread of COVID-19 has come at a high risk to economies, particularly in terms of loss of revenue to key sectors, for example tourism and the travel industry, which seem to have being badly hit by the crisis (Iacus et al., 2020). Developed economies have been severely hit by the impact of COVID-19 (both in terms of infection and death rates), and the situation is proving bleak for some middle-income economies in Latin America and Sub-Saharan Africa (Jackson, 2020a; Mckibbin & Fernando, 2020).

Economies around the world have experienced the impact of the crisis differently, while those that are considered highly reliant on commodity trade to support revenue generation, have experienced severe cuts to public expenditures on account of the plummeted state of commodity market prices (Sharif, Aloui & Yarovaya, 2020; Barua, 2020; Ekinci, 2019). The impact of this means that economies perceived as being heavily reliant on revenues from commodity trade, for example Crude Oil revenue, are now seeking alternative means of addressing revenue shortfalls; some economies like Nigeria have been bold enough to request bailout support from international institutions like the IMF in a bid to remedy the impact of unexpected distress and shock to economic stability (Andam, Edeh, Victor, & James, 2020; Heigermoser & Glauben, 2020; Ozili, 2020).

Whittling down to developing economies like Sierra Leone in particular, the incidence of COVID-19 is still a concern on the way forward towards economic recovery. The economy in Sierra Leone is highly vulnerable to external shocks and the incidence of COVID-19 has proved it, with almost all the country's export earnings curtailed on account of the closure of international borders (Jackson & Jabbie, 2020; Fernandes, 2020). On a positive note, the

dwindling situation of negative shocks to Crude Oil price in the international market brought some level of respite in relation to stabilising fuel pump price across the country. The country seems to have been blessed through donor support and the relaxation of debt repayments, which if nothing else, otherwise would have made the situation worse as far as economic well-being for citizens is concerned.

The motivation for this study is to provide projection of the likely daily rate of COVID-19 infection rate in the country, with a view of making it possible for sound policy measures to be set in place as a remedy to curtailing further spread of the disease. Despite the low level of virus infection in the country, the situation is still posing a concern to well-being, and in addition, the uncertainty may constitute a threat to on-going economic stability. In this regard, it is the intention of this study to utilise a univariate ARIMA model, which assume that the future rate of infection is based on prior / past incidences of infection rate.

On the basis of the above motivation statement, this study seeks to explore the following research question: What approach can be utilised to support Sierra Leone from the continued risk of COVID-19? This question will be addressed using the following research objectives:

- To utilise an ARIMA model in forecasting out-of-sample rate of infection of COVID-19 infection in Sierra Leone.

- To proffer policy recommendations that will help address relevant health curative in minimising risks to the spread of COVID-19.

In view of the above introduction, the rest of the paper is detailed as follows: Section two provides a summary of facts connected with health pandemics in Sierra Leone, while section three addresses a literature review pertaining to recent use of ARIMA model to forecast incidences of pandemics. Section four provides a description of the model and empirical estimation. Finally, section five concludes by highlighting certain proffered recommendations for policy implementation across sectors associated with health and economic policy implementation.

2. Facts about Health Pandemics in Sierra Leone

In recent times, health pandemics seem to be something that is not strange to Sierra Leone, given the bitter experience of Ebola outbreak around 2014-2016. The incidence of Ebola left a lasting economic distress on the state of economic stability in the economy, with more people considered to have died when compared to the present global calamity of COVID-19 (Markwell, Mitchell, Wright, & Brown, 2020).

Figure 1 below provides pictorial representation of the state of the spread of COVID-19 infection in Sierra Leone, with death rates averaging around 10-20 in a month. The highest and most notable death alert was reported around the month of June 2020 (up to 100 cases), but this is still low when compared to other economies in the West African sub-region. Given the state of its impact, COVID-19 is still posing great concern in terms of how best to contain the spread of it, while the focus of health authorities is to make sure awareness is raised in terms of precautionary measures people should take in a bid to save lives.

Since the announcement of the first case of COVID-19 was pronounced in Sierra Leone, the government, backed by support from international organisations, instituted measures to increase contact tracing and other test trials necessary to combat its escalation in the country. Given the heightened state of alertness of the disease by the World Health Organisation (WHO), the country seems to have been blessed with a plethora of donor support, while debt payments have been rescheduled for deferral in a bid to allow the slow pace of economic activities to be addressed (IMF, April 2020).

Figure 1. COVID-19 Daily Contraction in Sierra Leone
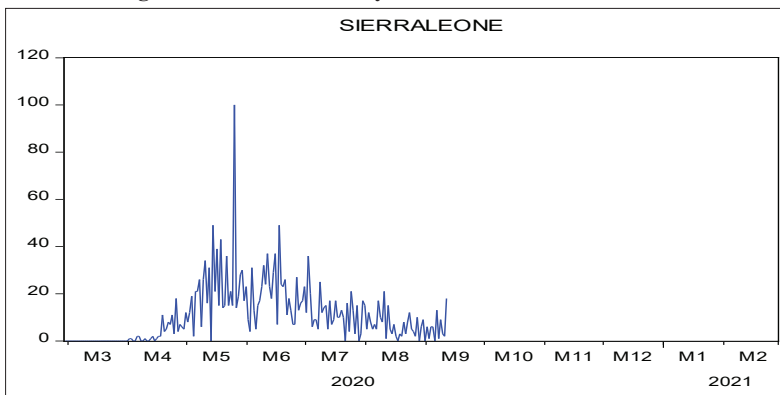
Source: EVIEWS Output

3. Literature Review (Theoretical and Empirical)

The COVID-19 pandemic has been a topic of concern in the global economy; with the continued risk of the virus spreading, it was almost impossible for economies that rely only and solely on historical data to provide an accurate picture of economic trends. While the virus continues to ravage economies, researchers all around the world have been deeply involved in utilising both statistical and econometric tools to provide projections of the incidence, with implications aimed at curtailing the rate of infection, while also providing a remedy in stabilising battered economies. This section provides a summary of the literatures

surrounding forecast outcomes and policy intervention as the incidence of COVID-19 reveals itself in the global economy.

Theoretically, the use of univariate time series methodology, which this study is going to use, can be traced to the effort of Box and Jenkins in their study of Autoregressive Moving Average (ARMA) to address univariate movement of a variable by using its past occurrences to determine future events (Asteriou & Hall, 2011). More so in Econometrics, the Autoregressive Integrated Moving Average (ARIMA) can be the most commonly used feature where the series exhibits signs of non-stationarity, which means that the differencing technique can be applied once or twice to eliminate non-stationary behaviour (Jackson, 2018). In this regard, where the series is to be integrated to satisfy a stationarity condition, we will expect three parts of the ARIMA component to be utilized. The first of these is the AR component, which shows that the variable of interest can be regressed on its lagged / prior values. The second is the 'I', which indicates integration and signifies that the variable can be integrated at first, and in extreme cases, second difference to ensure stationarity is maintained. The third component is the MA, which is the moving average and it indicates that the regression error can be a linear combination of error terms, with contemporaneous features at different points in the past (Mills, 1990). As would be applied in this study, the non-stationary ARIMA model would normally be symbolized as ARIMA(p,d,q), with the small letters in the parenthesis indicating non-negative integer; 'p', 'd' and 'q' indicate the order of the autoregressive model, degree of differencing, and order of moving average model respectively. The simplified seasonal ARIMA models of the above would be denoted similarly, but with the letters in parenthesis changed to capital letters [ARIMA(P,D,Q)$_m$]. The small letter 'm' indicates the number of seasons utilised in the model (Asteriou & Hall, 2011).

In view of the above theoretical summary, the next few paragraphs focus attention on the empirical outcomes of utilising ARIMA model in forecasting events, which is based on past occurrences of a univariate series. Kufel (2020) utilised ARIMA to address the dynamics of confirmed cases of COVID-19 in selected economies around the world, particularly in the western hemisphere. The outcome of his study shows that with ARIMA(1,2,0) as the best model for forecasting the dynamics of COVID-19 , there is an indication of its trend being revealed, which has implications for non-pharmaceutical countermeasures.

Over the past couple of months, various means or methodologies of forecasting the incidence of COVID-19 seem to have dominated empirical research. A plethora of these has been carried out more recently as cited here and these include: ARIMA, SutteARIMA, Wavelet, ARIMA-WBF (wavelet-based forecasting), ARIMA-with machine learning, long short term memory (LSTM) (Ahmar & del Val, 2020; Azad & Poonina, 2020; Benvenuto et al. 2020; Ceylan, 2020; Chintalapudi, Battineni & Amenta, 2020; Dehesh, Mardani-Fard &

Dehesh, 2020; Ding, Li, Shen & Fan, 2020; Li et al. 2020; Kufel, 2020; Kumar et al. 2020; Patwardhan, 2020; Perone, 2020; Ribeiro, da Silva, Mariani, & dos Santos Coelho, 2020; Tandon, Ranjan, Chakraborty, & Suhag, 2020; Yonar, Yonar, Tekindal, & Tekindal, 2020).

ARIMA is still viewed as one of the most reliable models for forecasting short and medium-term occurrences, and this has been proved to be the case over this period of the COVID-19 pandemic. A notable highlight of this is the case of wavelet neural network or the support vector machine models as exemplified in the   study. Equally, Singh et al. (2020), also proved the ARIMA model and the hybrid model of discrete wavelet decomposition to be very effective in producing accurate forecast outcome during the past few months of the COVID-19 spread in the global economy. Similarly, in Chakraborty and Ghosh (2020), the modified ARIMAWBF model was used. The predictability of the incidence of COVID-19 contraction and its impact on market developments has been made easier through real-time model forecasts carried out by various researchers in the global economy (Ilie et al. 2020; Perone, 2020; Singh et al, 2020).

As cited by Kufel (2020), the intensity of the COVID-19 pandemic resulted in a radical shift on behalf of researchers in pursuing wide scale empirical work aimed at addressing the impact of the disease (p. 184). Notable among these include Radio and Berret's (2020) research, who developed three types of model; amongst them, the Bayes approach was utilised for selected US counties.

In a nutshell, the use of the above-mentioned models has highlighted something typical in the stride made to pursue vigorous research in pursuit of addressing concerns pertaining to minimising health risks, and also in formulating policy measures to curb its adverse effect on the global economy. ARIMA, which up to date is considered one of the most accurate models to forecast short term incidences, seems to have proven its worth in terms of providing a reliable indication of the spread of COVID-19 pandemic in the global economy. On an equal note, the use of ARIMA model in this study is considered relevant in providing evidence of the likely direction of the virus spread, while also serving as a way of inducing critical thoughts around policy measures that can be utilised by health and institutional authorities like the government and central banks in allaying citizens' concerns about the direction of COVID-19 spread and the global economy.

4. Methodology, Model Estimation and Data Description

4.1. The Model

4.1.1. Autoregressive (AR) Models

$$COVID19_t = \emptyset_1 COVID19_{t-1} + \emptyset_2 COVID19_{t-2} + \cdots + \emptyset_p COVID19_{t-p} + \uparrow \varepsilon_t \quad (1)$$

The above series ($COVID19_t$) as expressed in equation 3, epitomize as the incidence of COVID19 pandemic in Sierra Leone, which is assumed to be an autoregressive process of the order p, expressively denoted as AR(p) (See Jackson, 2020b).

Equation 2 can be re-written as shown for ε_t to be utilised as the subject in equation 2.

$$COVID19_t \left(1 - \emptyset_1 B - \emptyset_2 B^2 - \cdots - \emptyset_p B^p\right) = \varepsilon_t \qquad (2)$$

Where:

· B in equation 2 is a backshift operator;

· $\emptyset_1 \ldots \emptyset_p$ are the parameters of the model;

· ε_t is a normally distributed random process with mean 0 and a constant variance σ_ε^2 which is assumed to be independent of all process values;

· $COVID19_{t-1}$, $COVID19_{t-2}$, are AR models, with stationary data.

4.1.2. Moving Average (MA) Models

White noise series properties with mean 0 and variance σ_ε^2 are moving averages, with order q, expressed as MA(q). The weighted linear sum of previous forecast errors is in Eq. 3:

$$COVID19_t = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \qquad (3)$$

Equation 3 implies that COVID19 can be explained in terms of current and past period perturbed incidences (see Jackson, 2018).

· $\theta_1, \theta_2, \ldots \theta_q$, are coefficients, with lagged error terms;

· ε_t is a normally distributed random process.

4.2. Autoregressive Moving Average (ARMA) Models

This is a combination of both the AR and MA models, which is also expressed as [ARMA(p,q)]. It is expressed thus:

$$COVID19_t = \emptyset_1 COVID19_{t-1} + \emptyset_2 COVID19_{t-2} + .. + \emptyset_p COVID19_{t-p} + \varepsilon_t + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad (4)$$

Rearranging equation 4 results in a new expression as shown in equation 5 below:

$$COVID19_t - \emptyset_1 COVID19_{t-1} + \emptyset_2 COVID19_{t-2} + .. + \emptyset_p COVID19_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad (5)$$

This is a simple case of parsimony ARMA (p,q).

4.3. Autoregressive Integrated Moving Average (ARIMA) Models

This is applicable to stationary series, which can be differenced data utilised as fit-for-purpose. Therefore, series can be differenced once or twice, depending on the properties of the series as shown in the equation below.

$$(1 - B)^d COVID19_t \tag{6}$$

Where d = is the number of times the process is differenced to bring about stationarity.

With reference to equation 6, the expression on account of differencing can be expressed as shown in equation 7 below:

$$COVID19_t\left(1 - \emptyset_1 B^1 - \emptyset_2 B^2 - \cdots - \emptyset_p B^p\right)(1 - B)^d = \varepsilon_t(1 + \emptyset_1 B^1 + \emptyset_2 B^2 + \cdots + \emptyset_q B^q) \tag{7}$$

This can now be simplified to form equation 13 as indicated below:

$$\emptyset(B)(1 - B)^d COVID19_t = \emptyset(B)\varepsilon_t \tag{8}$$

Equation 8 is the ARIMA process, with the following characteristics:

- White noise [ARIMA(0,0,0)]

- Random walk [ARIMA(0,1,0)]

- Autoregressive process [ARIMA(0,0,q)]

- Autoregressive moving average [ARIMA(p,0,q)] (See Jackson, 2020)

Random Walk process as mentioned above is hereby shown as:

$$_-COVID19_t = COVID19_{t-1} + \varepsilon_t \tag{9}$$

- The first difference of the expression in equation 9 can now activated stationary series as shown here: $COVID19_t - COVID19_{t-1}$ \hfill (10)

4.4. Data Source, Summary and Unit Root Test

Data for this study originated from the World-meter index, where data regarding the COVID-19 infection from all countries are stored on a daily basis. This is real time data and information concerning the virus infection, and death rates and other necessary data can be extracted from this site. As seen, the data captures the daily infection rate for Sierra Leone from 1st April 2020 to 30th November 2020.

Figure 2. Statistical Summary of COVID-19 Daily Infection Rate in Sierra Leone
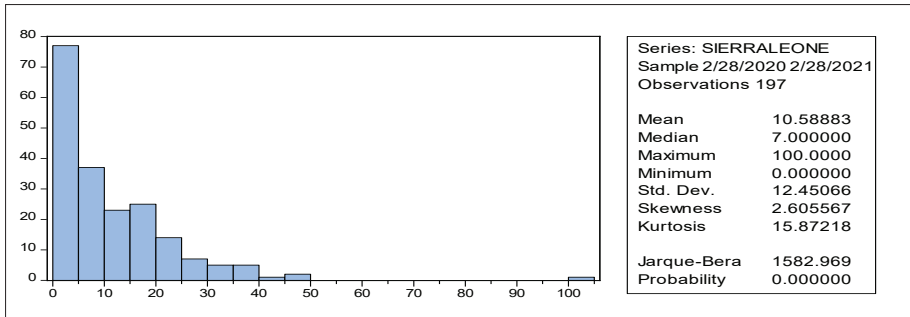
Figure 2 above provides a standard descriptive statistical summary of the daily COVID-19 infection rate in Sierra Leone. In this, the mean summarizes an average of the observed series. The median expresses the middle value of the series when the values are placed in order of magnitude. The minimum and maximum values provide information about the lowest and highest COVID-19 infection rate during the observed period (1st April 2020 – 11th September 2020). The Standard Deviation provides information about the dispersion or spread in the series, while the Skewness provides an indication of the measure of symmetry of the distribution of the series around its mean. The Kurtosis measures the peak of the distribution of the series and the standard value is expected to be 3. In the above distribution as shown in Figure 2, the Kurtosis is 15, which means that the distribution is peaked (leptokurtic) relative to the normal distribution. For the above distribution of the COVID-19 infection in Sierra Leone, we reject the hypothesis of normal distribution at both 1% and 5% significant level thereby indicating that the graph is not normal distribution.

Table 1: Unit Root

Null Hypothesis: D (SIERRA LEONE) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 2 (Automatic - based on SIC, maxlag=14)				
		t-Statistic		Prob.
		I(0)	I(1)	
Augmented Dickey-Fuller test statistic		-2.313446	-15.29534	0.0000
Test critical values	1% level	-3.469993	-4.006311	
	5% level	-2.878829	-3.433278	
	10% level	-2.576067	-3.140478	
Critical Value: *significant at 1%, **significant at 5% and ***significant at 10%				

*MacKinnon (1996) one-sided p-values.
Note: As indicated in Table 2 above, the test was carried out with trend and no intercept at 1st difference, with the overall evidence showing no evidence of unit root, and a probability value of 0.0000

### 4.5. Model Results and Discursive Evaluation

Table 2: Summary of Best Model Selection based on Dynamic Out-of-Forecast to 2/28/2021

Component	Best Model	AIC	Durbin-Watson stat	MAE	RMSE	Out-of-Forecast	Stability Condition
	(2,1,2)	7.35	2.03	8.59	14.28	13	AR <1 MA<1
	(3,1,4)	7.65	2.01	8.56	14.24	13	AR <1 MA<1
COVID-19 $_{SL}$	(2,1,4)	7.52	1.99	8.20	13.68	18	AR <1 MA<1
	(4,1,4)	7.32	1.99	6.66	14.36	13	AR <1 MA<1

Source: *EVIEWS Output*

In this study, Sierra Leone was used as a case study, with the first confirmed case dated on 1st April, 2020. As shown in Table 2 above, there are four models utilised for comparative evaluation in this study, with the best model coming up as (4,1,4). This implies four AR roots and four MA roots, which are integrated to the first order to ascertain stationarity in the model. In comparison, the model also revealed a reasonably low AIC and Durbin-Watson stat. value (see Appendix 1), low Mean Absolute Error value and an out-of-sample forecast value of 13 possible confirmed cases per day. In other words, this implies that, based on the past trend of confirmed cases in Sierra Leone, there is a likelihood that projected confirmed cases per day will reach 13 by 28th February, 2021. The model robustness was revealed to be stable as indicated in the stability condition on Table 3 and Appendix 2 respectively. In evaluating the accuracy of the model forecast, there are specific points worth taking note of, particularly when it comes to the authority's action in setting measures to combat the spread of the pandemic beyond the projected rate of 13 cases per day. It is also worth noting that the increase projection of likely confirmed cases up to 28th February 2020 is an indication that the virus is not over as yet, despite the slow pace of contraction as recorded during latter periods leading up to 11th September 2020.

Figure 3. Out-of-Sample Forecast of likely confirmed cases between 9/12/2020 – 22/28/2021
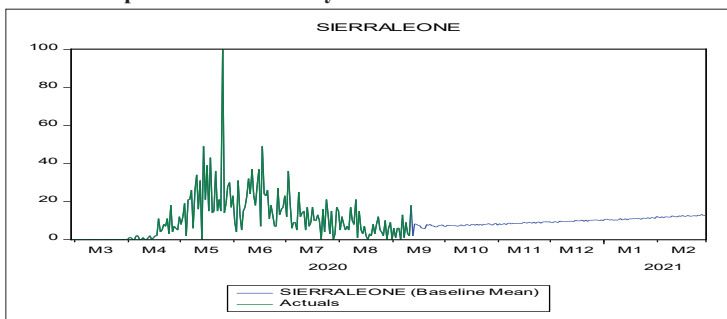
Source: EVIEWS Output

Despite the incidence of COVID-19 being perceived as a health concern to the global community, its mere presence is viewed as one of the greatest challenges the world has ever experienced in modern times. It has brought about changes in the way people do things, with lockdowns being imposed in almost every country in the world. In this regard, outcome of the projected forecast, with likely increased cases of infection in Sierra Leone is of paramount concern to economic institutions like the Bank of Sierra Leone, the Ministry of Finance and a host of others.

In a bid to diffuse or allay fears about the devastating impact of the spread of COVID-19 contraction, the central bank was very quick to respond with a stimulus package to soften uncertainties and expectation of economic crash on key sectors in the country's system. Given Sierra Leone's high dependence on imports to support lives and on basic inelastic goods and services, the effort of the central bank made it less cumbersome for importers of essential items to gain access to foreign exchange in settling outstanding bills on imports. Going forward, the outcome as seen with the forecast also indicates that the central bank will need to set itself on the alert in softening worries that continue to permeate in people's mindset about the likelihood of a deteriorating state of well-being in the country. As announced by the Governor of the Bank of Sierra Leone in an interview with Abubakarr Hashim, the palliative measure of a Le500 billion to support the supply of essential goods and services is welcome news (News Nigeria, Saturday 9th September, 2020). Such a package will address ongoing worries about the likelihood of COVID-19's long-term impact on the well-being of people in the country, while at the same time, health authorities also should endeavour to monitor those in receipt of health packages to make sure funds are utilised in the best possible way to minimise abuse of the central bank's generosity in achievement of its price stability mandate.

5. Conclusion and Policy Recommendation

The outcome from this study has presented a case for (4,1,4) as the best model choice, with a moderate contraction of 13 daily cases projected up to the period 28th February 2021. While this is the case, it should be noted that the number of projected cases could rise or fall, which indicates that the virus is not over as yet. Hence, complacency should be thrown out of the window, with all hands-on-deck to make sure measures are adequately set in place by health authorities to continue its contact tracing and testing, with the hope of reducing the possibility of a likely surge in the number of cases.

The likelihood of continuous daily projected cases means that the model (4,1,4) can always be re-estimated to provide updated outcomes of the future state of the disease. While it is seen that the above model is considered the best, efforts should also be made to re-

estimate with other models, which could produce better results of the future state of COVID-19 threats to well-being and economic stability in the Sierra Leone economy.

In view of addressing the second objective of the study, state agencies like the Ministry of Health should continue to increase media awareness about the threat of the COVID-19 epidemic to human health in the country. With this in mind, there is also the added threat of economic stagnation or recession, given restriction to services and economic activities in the country. While the situation stands as it is, there is an onus on state actors to ensure proactive efforts are stepped up in a bid to ensure the country's current state of high dependence on the importation of basic essential items like inelastic goods and services is well catered for through efforts to capacitate independent real sector operational activities in the domestic economy.

References

Ahmar, A. S., & del Val, E. B. (2020). SutteARIMA: Short-term forecasting method, a case: Covid-19 and stock market in Spain. *Science of The Total Environment, 138883*. https://dx.doi.org/10.1016/j.scitotenv.2020.138883.

Andam, K.S., Edeh, H.O., Victor, P.K. & James. I.T. (2020). Estimating the Economic Costs of COVID-19 in Nigeria. Strategy Support Program, Working Paper 63. Nigeria.

Asteriou, D., & Hall, S.G. (2011). ARIMA models and the Box-Jenkins methodology. *Applied Econometrics, 2(2):265–286*.

Azad, S., & Poonia, N. (2020). Short-term forecasts of COVID-19 spread across Indian states until 1 May 2020. https://dx.doi.org/10.20944/preprints202004.0491.v1.

Fernandes, N. (2020). Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy. IESE Business School *Working Paper No. WP-1240-E*. http://dx.doi.org/10.2139/ssrn.3557504.

Barua, S. (2020). Understanding Coronanomics: The Economic Implications of the Coronavirus (COVID-19) Pandemic. https://dx.doi.org/10.2139/ssrn.3566477.

Benvenuto, D., Giovanetti, M., Vassallo, L., Angeletti, S., & Ciccozzi, M. (2020). Application of the ARIMA model on the COVID-2019 epidemic dataset. https://dx.doi.org/10.1016/j.dib.2020.105340.

Ceylan, Z. (2020). Estimation of COVID-19 prevalence in Italy, Spain, and France. Science of The Total Environment. https://dx.doi.org/10.1016/j.scitotenv.2020.138817.

Chintalapudi, N., Battineni, G., & Amenta, F. (2020). COVID-19 disease outbreak forecasting of registered and recovered cases after sixty-day lockdown in Italy: a data driven model approach. *Journal of Microbiology, Immunology and Infection, 53(3), 396-403*. https://dx.doi.org/10.1016/j.jmii.2020.04.004.

Dehesh, T., Mardani-Fard, H. A., & Dehesh, P. (2020). Forecasting of covid-19 confirmed cases in different countries with ARIMA models. https://dx.doi.org/10.1101/2020.03.13.20035345.

Ding, G., Li, X., Shen, Y., & Fan, J. (2020). Brief Analysis of the ARIMA model on the COVID-19 in Italy. https://dx.doi.org/10.1101/2020.04.08. 20058636.

Ekinci, C., Akyildirim, E., & Corbet, S. (2019). Analysing the dynamic influence of us macroeconomic news releases on Turkish stock markets. *Finance Res. Lett., 31, 155-164*. https://dx.doi.org/10.1016/j.frl.2019.04.021.

Heigermoser, M., & Glauben, T. (2020). COVID-19, the oil price slump and food security in low-income countries, IAMO Policy Brief, No. 37e. Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale).

Iacus, S.M., Natale, F., Santamaria, C., Spyratos, S., & Vespe, M. (2020). Estimating and projecting air passenger traffic during the COVID-19 coronavirus outbreak and its socio-economic impact. *Safety Science, 129, 1-11*. https://dx.doi.org/10.1016/j.ssci.2020.104791.

Ilie, O., Cojocariu, R., Ciobica, A., Timofte, S., Mavroudis, I., & Doroftei, B. (2020). Forecasting the Spreading of COVID-19 across Nine Countries from Europe, Asia, and the American Continents Using the ARIMA Models. *Microorganisms, 8(8), 1-18*. https://dx.doi.org/10.3390/microorganisms8081158.

IMF. (2020). IMF Executive Board Approves Immediate Debt Relief for 25 Countries. Retrieved from https://www.imf.org/eng/News/Articles/2020/04/13/pr20151-imf-executive-board-approves-immediate-debt-relief-for-25-countries.

Jackson, E.A. (2020). Emerging innovative thoughts on globalization amidst the contagion of COVID-19. In: Leal Filho W., Azul A., Brandli L., Ozuyar, P.G. (ed.) Industry, Innovation and Infrastructure. *Encyclopedia of the UN Sustainable Development Goals*. Springer, Cham. https://dx.doi.org/10.1007/978-3-319-71059-4_131-1.

Jackson, E.A. (2020b). Understanding SLL/US$ exchange rate dynamics in Sierra Leone using Box-Jenkins ARIMA approach. *Theoretical and Practical Research in the Economic Fields, 11(1), 5-20*. https://dx.doi.org/10.14505/tpref.v11.1(21).01.

Jackson, E.A. (2018). Comparison between Static and Dynamic Forecast in Autoregressive Integrated Moving Average for Seasonally Adjusted Headline Consumer Price Index. https://dx.doi.org/10.2139/ssrn.3162606.

Jackson, E.A. & Jabbie, M. (2020). Twin Deficits hypothesis as an indication of government failure in Sierra Leone: An empirical investigation (2007 to 2018). *Journal of Economic Policy Researches, 7(1), 43-68*. https://dx.doi.org/10.26650/JEPR658440.

Kufel, T. (2020). ARIMA-based forecasting of the dynamics of confirmed Covid-19 cases for selected European countries. Equilibrium. *Quarterly Journal of Economics and Economic Policy, 15(2), 181–204*. https://dx.doi.org/10.24136/eq.2020.009.

Kumar, P., Kalita, H., Patairiya, S., Sharma, Y. D., Nanda, C., Rani, M., Rahmani, J., & Bhagavathula, A. S. (2020). Forecasting the dynamics of COVID-19 pandemic in top 15 countries in April 2020: ARIMA model with machine learning approach. https://dx.doi.org/10.1101/2020.03.30.20046227.

Li Y, Wang B, Peng R, Zhou C, Zhan Y, & Liu Z. (2020). Mathematical Modeling and Epidemic Prediction of COVID-19 and Its Significance to Epidemic Prevention and Control Measures. *Ann Infect Dis Epidemiol. 5(1): 1052*. Retrieved from http://www.remedypublications.com/open-access/mathematical-modeling-and-epidemic-prediction-of-covid-19-and-its-significance-5755.pdf.

Markwell, A., Mitchell, R., Wright, A.L. & Brown, A.F. (2020). Clinical and ethical challenges for emergency departments during communicable disease outbreaks: Can lessons from Ebola Virus Disease be applied to the COVID-19 pandemic? *Emergency Medicine Australasia, 32, 520-524*. https://dx.doi.org/10.1111/1742-6723.13514.

McKibbin, W.J., & Fernando, R, (2020). The Global Macroeconomic Impacts of COVID-19: Seven Scenarios. *CAMA Working Paper No. 19/2020*. https://dx.doi.org/10.2139/ssrn.3547729.

Mills, Terence C. (1990). Time Series Techniques for Economists. United Kingdom: Cambridge University Press.

NewsNigeria. (2020). Bank of Sierra Leone Governor: We have restored International Confidence on the economy amidst COVID. Retrieved from https://www.thenewsnigeria.com.ng/2020/09/19/bank-of-sierra-leone-governor-we-have-restored-international-confidence-on-the-economy-amidst-covid/.

Ozili, P.K. (2020). COVID-19 Pandemic and Economic Crisis: The Nigerian Experience and Structural Causes. https://dx.doi.org/10.2139/ssrn.3567419.

Patwardhan, C. (2020). SARS-COV-2 pandemic: understanding the impact of lockdown in the most affected states of India. Retrieved from https://arxiv.org/pdf/2004.13632.pdf.

Perone, G. (2020). An ARIMA model to forecast the spread and the final size of COVID-2019 epidemic in Italy. HEDG - *Health Econometrics and Data Group Working Paper Series*, University of York. https://dx.doi.org/10.2139/ssrn.3564865.

Ribeiro, M. H. D. M., da Silva, R. G., Mariani, V. C., & dos Santos Coelho, L. (2020). Short-term forecasting COVID-19 cumulative confirmed cases: perspectives for Brazil. Chaos, Solitons & Fractals, 109853. https://dx.doi.org/10.1016/ j.chaos.2020.109853.

Sharif, A., Aloui, C., & Yarovaya, L. (2020). COVID-19 Pandemic, Oil Prices, Stock Market, Geopolitical Risk and Policy Uncertainty Nexus in the US Economy: Fresh Evidence from the Wavelet-Based Approach. https://dx.doi.org/10.2139/ssrn.3574699.

Singh, R.K., Rani, M., Bhagavathula, A.S., Sah, R., Rodriguez-Morales, A.J., Kalita, H., Nanda, C., Sharma, S., Sharma, Y.D., Rabaan, A.A., Rajmani, J., and Kumar, P. (2020). Prediction of thee COVID-19 Pandemic for the Top 15 Autoregressive Integrated Moving Average (ARIMA) Model. *JMIR Public Health Surveill, 6(2), e19115*. https://dx.doi.org/10.2196/19115.

Tandon, H., Ranjan, P., Chakraborty, T., & Suhag, V. (2020). Coronavirus (COVID-19): ARIMA based time-series analysis to forecast near future. Retrieved from https://arxiv.org/ftp/arxiv/papers/2004/2004.07859.pdf.

Yonar, H, Yonar, A, Tekindal, M. A, & Tekindal. M. (2020). Modeling and forecasting for the number of cases of the COVID-19 pandemic with the curve estimation models, the Box-Jenkins and exponential smoothing methods. *Eurasian Journal of Medicine and Oncology, 4(2), 160-165*. https://doi.org/10.14744/ejmo.2020.28273.

Appendices

Appendix 1: Best Model Outcom

Dependent Variable: D(SIERRALEONE)

Method: ARMA Maximum Likelihood (OPG - BHHH)

Date: 09/15/20   Time: 16:17

Sample: 2/29/2020 9/11/2020

Included observations: 196

Convergence achieved after 80 iterations

Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.035522	0.158635	0.223923	0.8231
AR(1)	-0.118974	0.098800	-1.204191	0.2300
AR(2)	0.185203	0.081176	2.281490	0.0237
AR(3)	-0.677824	0.084516	-8.020100	0.0000
AR(4)	-0.254336	0.096340	-2.639989	0.0090
MA(1)	-0.939203	0.071790	-13.08263	0.0000
MA(2)	-0.024432	0.082967	-0.294483	0.7687
MA(3)	1.052194	0.079562	13.22486	0.0000
MA(4)	-0.748562	0.061627	-12.14664	0.0000
SIGMASQ	78.51071	5.058556	15.52038	0.0000
R-squared	0.597427	Mean dependent var		0.091837
Adjusted R-squared	0.577947	S.D. dependent var		14.00080
S.E. of regression	9.095698	Akaike info criterion		7.320218
Sum squared resid	15388.10	Schwarz criterion		7.487469
Log likelihood	-707.3814	Hannan-Quinn criter.		7.387929
F-statistic	30.66975	Durbin-Watson stat		1.996631
Prob(F-statistic)	0.000000			
Inverted AR Roots	.55-.73i	.55+.73i	-.36	-.86
Inverted MA Roots	.79	.56+.80i	.56-.80i	-.98

Appendix 2: Estimation Stability Root of AR/MA Polynomial(s)

Inverse Roots of AR/MA Polynomial(s)