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Modeling and forecasting of COVID-19 from the context of Ghana

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Abstract

Developing countries have had their share regarding the spread and effect of Coronavirus (COVID-19) and Ghana is no exception. We have used the data on new deaths, total deaths, total cases, new cases, collected on a daily basis from 13th March 2020 to 30th September 2020, obtained from the Ghana Health Services. We then considered appropriate time series models. This has provided robust results to help make an informed decision towards the future. The forecasted results (from the best fitted models) reveals adecrease in an amount of 174-88 in the daily new cases by flowing a linear trend, which also leads to decrease in total cases by following the same trend (from 46600 to 44942 in numbers) during the period 1-10-2020 to 10-10-2020. The government of Ghana should strictly enforce protocols established to curb COVID-19 in Ghana, encourage social distancing and other COVID-19 prevention protocols to reduce the spread of COVID-19 new cases and deaths.

Keywords: Forecasting; Modeling; ARIMA; SARIMA; Covid-19; Ghana.

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1. Introduction

Living conditions, behavioural tendencies, and humanity social systems have been disrupted by the existence of Coronavirus worldwide. Governments throughout the world have countered the spread of this Coronavirus with many domestic policies while working according to the World Health Organisation's guidelines to safeguard citizens. This has limited people's movements, affected trade, and businesses negatively, and affected growth projection negatively (Economic Commission for Africa, 2020; Yu and Aviso, 2020).

In Africa, leaders have taken decisions to enforce lockdown to curtail the rapid spread of the Coronavirus, yet the disease is spreading very fast. Economic Commission for Africa (2020) has projected that a total lockdown of Africa may cost $65 billion, which is about 2.5% of its annual GDP. This available information has given some Africa countries a thought on complete lockdown and thus, allows a partial human activity.

In Ghana, the first record of the coronavirus was endorsed on 12th March 2020 (Ministry of Health, Ghana, 2020). This was the initial two cases recorded in the Ghanaian territory and of which the government undertook a proactive action. The case counts in Ghana subsequently saw an increasing trend (WHO, 2020), and increasing recovery rates (Ministry of Health, Ghana, 2020). The coronavirus is not leaving anytime soon as there has not been a confirmed vaccine to cure this terrible disease. The existence and spread of the virus have brought about uncertainty regarding normal life and have disrupted work and perhaps, contributed to unemployment.This ultimately makes it prudent to model and forecast the case counts, new deaths, and so on.

Empirically, statistical models have been used to forecast situations like pandemics and as the coronavirus is acknowledged by the World Health Organization as a pandemic, it falls within this category. Mostafa (2020), predicted COVID-19 cases based on confirmed cases in China, Italy, and USA by the help of statistical models. The study was to identify a model to help reported daily cases as well as to advise these countries regarding their preparedness level. The study made use of Auto-Regressive Integrated Moving Average (ARIMA) and exponential growth model as to which model was good for the situation. Their result confirmed exponential growth model as best to suit the situation underhand than ARIMA.

Again, Yu and Aviso (2020) in their study modeling the economic impact and ripple effects of disease outbreaks made an account on how the Coronavirus has impacted negatively on the lives of human beings and the economic growth of many countries. Their paper looked at the supply chain interactions which could be affected due to the coronavirus and the expectations of countries at all levels to help deal with this virus based on combined effects of models.

Furthermore, Degraft-Amoah (2020) looked at the economic ramification of Covid-19 on Ghana. The study opined that adjustment in policy rate alone by the Central Bank of Ghana may not help business owners in Ghana to sustain their business. Therefore, urgent steps which are combinations of many stimulus packages are necessary to salvage the economy.

Also, at the macroeconomic level, Warwick and Roshen (2020) considered the global macroeconomic impacts of COVID-19 based on seven scenarios. They looked at how this pandemic disrupted China and engulfed the world in uncertain terms. Following an extension made by McKibbin and Sidorenko (2006) on the initial technique modeled by Lee and McKibbin (2003), they considered scenarios based on macroeconomic outcomes and financial markets. The study revealed how these scenarios resulted in a reduction in public health expenditure in developed countries.

Lastly, empirical forecasting based on time series is seen in the work of Jamal *et al.*, (2018) regarding demand forecasting based on ARIMA for a food company. They used ARIMA (1, 0, 1) based on-demand information and the result showed that the model was appropriate and useful.

Based on the foregoing, this current study is motivated by the fact that the Covid-19 virus has been identified to transmit in a certain pattern. This pattern of transmission makes it difficult especially issues about behavior among human interactions.At the same time, duty bearers and policymakers must have some scientific approximations to make decisions.

The study follows this structure: the introduction which lays the foundation of the paper, section 2 deals with the methodology, the results and discussions take the center stage in section 3, section 4 considers the conclusions derived from the study.

Therefore, this current study aims at providing a forecast for Ghana's Covid-19 situation looking at the trend of new cases as well as deaths. This is timely and useful for policymakers, duty bearers, academics, and those who might want to make informed inferences regarding Ghana's Covid-19.

2. Methodology

Coronavirus (Covid-19) has permeated the fabrics of the society and ravaged projected growth and businesses' proposed plans world over. Ghana is among several countries that have witnessed the devastating effects of this Coronavirus. Ghana had a confirmation from the Noguchi Memorial Institute for Medical Research on the 12th March, 2020 with two confirmed cases (Ministry of Health, Ghana, 2020). The Government of Ghana then issued a major policy direction after the case counts continue to increase with some number of deaths. This trend of daily official confirmation of those tested positive of this Coronavirus has continued and thus present a worrying situation.

The data for this study was based on confirmed sources provided by the Ministry of Health of Ghana and the World Health Organization. The data was for the period of 13th March, 2020 to 30th September, 2020. The data comprised new cases, new deaths, total new cases as well as total recoveries. This invariably has shown a trend in the confirmed overall cases of the Coronavirus.

The descriptive analysis on forecasting which is hinged on an ordered series provided grounding for this particular study. The study has opted for the use of ARIMA models as considered appropriate owing to the data under consideration. These classes of models are often seen to be generally within the time series fraternity and are widely used because of its safety and easy to handle. The intuition behind building an ARIMA model follows the processes: (1) Model Identification, (2) Parameter Estimation and Selection, (3) Diagnostic Checking (or Model Validation); and (4) Model's use (Kumar and Anand, 2014).

The ARIMA model is premised on autoregressive (AR), moving average (MA), or both (ARMA), and its orders (Mishra *et al.*, 2015). We, therefore, provide an equation to aid the forecasting by first making y represents the dth difference of Y, which means:

$$\text{If } d = 0\text{: } y_t = Y_t \tag{1}$$

$$\text{If } d = 1\text{: } y_t = Y_t - Y_{t-1} \tag{2}$$

$$\text{If } d = 2\text{: } y_t = (Y_t - Y_{t-1}) - (Y_{t-1} - Y_{t-2}) = Y_t - 2Y_{t-1} + Y_{t-2} \tag{3}$$

Then, we state the general forecasting equation in relation to y as follows:

$$.\hat{y}_t = \mu + \theta_1 y_{t-1} + \cdots + \theta_p y_{t-p} - \theta_1 e_{t-1} - \cdots - \theta_q e_{t-q} \tag{4}$$

As originally formulated by Box and Jenkins the moving average parameters (θ's) have negative signs (Robert, 2014).

Following Robert (2014) the ARIMA construction duels on making sure that the series is stationary by considering the autocorrelation and partial autocorrelation patterns to find out the lags of the error lags or the series under stationarity, we then fit the model and check for residuals diagnostics like ACF AND PACF plots and look out for as to the existence of ACF and PACF which may point to the need for AR or MA terms. Again, Following Mishra *et al.*, (2015) the basic accuracy diagnosis of the model is presented in Table 1.

Table 1: Basic Accuracy Diagnosis of the Model

Criteria	**Formula**
Mean Absolute Error (MAE)	$\frac{1}{n}\sum_{i=1}^{n} \lvert X_i - \hat{X}_i \rvert$
Mean Absolute Percentage Error (MAPE)	$\frac{1}{n}\sum_{i=1}^{n} \left\lvert \frac{X_i - \hat{X}_i}{X_i} \right\rvert \times 100$
Akaike information criterion (AIC)	2k-2 $_{\log}$ (L (θ)) . . L (θ) is the maximized value of the likelihood function of the model.

It is required that the diagnostic process is inherent in the entire robustness of the modeling process since such ultimately determine under which a model is fit for forecasting.

When there is seasonality in a time series, instead of decomposing it to fit an ARIMA model using the Box Jenkins method, another very common option is to use the seasonal autoregressive integrated moving average (SARIMA) model which is a generalization of an ARIMA Model. The SARIMA model involves 1- Autoregression, 2- Difference. And 3- Moving average. SARIMA Model is represented as *SARIMA* $(p,d,q)(P,D,Q)s$ in which p, d, q represent the degree of no seasonal linear autoregressive model (AR), non-seasonal difference, and degree of no seasonal moving average (MA) Model, respectively, whereas P, D, Q represent the degree of seasonal AR, seasonal difference, and the degree of seasonal MA, respectively. Furthermore, the seasonality length is represented by S. which defines the number of observations that make up a seasonal cycle. For example, s = 12 for monthly series, s = 4 for quarterly series, if we have daily data and the seasonal period is the length of the month, s will be approximately 30, There may be more than one type of seasonality. For example, with daily data, we can have weekly seasonality, with s = 7, monthly, with s = 30, and yearly, with s = 365. The d and D parameters are considered when the series is not stationary. The non-seasonal ARIMA model (p,d,q) is essential in building

SARIMA $(p,d,q)(P,D,Q)s$ model, so the term (p,d,q) represents the nonseasonal part of the model and $(P,D,Q)s$ presents the seasonal part of the model. The mathematical description of the model is presented as shown in Equation:

$$\phi_p(B)\Phi_P(B^s)W_t = \theta_q(B)\Theta_Q(B^s)\omega_t \tag{5}$$

P: is the order of seasonal AR model, D: is the number of seasonal differencing, Q: is the order of seasonal MA, and s: represents the length of the season (periodicity). In addition, the ωt: is the white noise value at period t, and B: is the lag operator.

3. Results and discussions

From Table 2, we find that in Ghana, since 13th March, 2020, to 30th September, 2020, the new cases have increased during the period from (0) to (1513). Average daily new cases are (230.11). Ex.Kurtosis value is (2.9119) indicates the data follows a Leptokurtic distribution which shows heavy tails on either side, which means there are large outliers in the data. Followed by a positive value of skewness (1.6899) which indicates there is some probability of increasing in the new cases. The new deaths have increased from (0) to (15) during the same period, with average daily new deaths about (1.4901). Ex.Kurtosis value is (3.6150) indicates the data follows a Leptokurtic distribution which shows heavy tails on either side, which means there are large outliers in the data. The positive value of skewness (2.0150) which indicates there is some probability of increasing in the new deaths. The total cases have increased from (1) to (46482). The average daily total cases are (19844). Ex.Kurtosis value is (-1.5418) indicates the data follows a platykurtic distribution which shows tail that's thinner than a normal distribution,followed by positive value of skewness (0.33677) which indicates there is some probability of increasing in the total cases. The total deaths have increased from (0) to (301) during the same period, with average daily total deaths about (115.51). Ex.Kurtosis value is (-1.2966) indicates the data follows a platykurtic distribution which shows tail that is thinner than a normal distribution. The positive value of skewness (0.50481) which indicates there is some probability of increasing in the total deaths.Figure -3 explained the pattern of COVID 19 in Ghana. In summary, the results reveal evidence that there has been an increase in Ghana COVID 19 total cases. This is attributed to the fact that the virus easily spreads, the least contact with an infected person spreads the virus. In Ghana due to the inadequate quarantiningand testing kits, quarantining and testing was below the optimum level and the virus spiraled as a result. The attitude of Ghanaian also played an important role in increasing the cases of COVID-19 in Ghana. Observing simple COVID-19 protocols including wearing nose mask, regular washing and sanitizing of hands and practicing social distancing is difficult to most Ghanaians. Results of the current study were given credence to by Yu and Aviso (2020) in their study modeling the economic impact and ripple effects of COVID-19 where they accounted the high incidence of COVID 19 outburst.

TABLE 2: SUMMARY STATISTICS OF TOTAL CASES, NEW CASES, TOTAL DEATH AND NEW DEATH IN GHANA

	New Cases	**New Deaths**	**Total Cases**	**Total Deaths**
Mean	230.11	1.4901	19844	115.51
Standard deviation	288.79	2.7504	17835	107.91
Excess Kurtosis	2.9119	3.6150	-1.5418	-1.2966
Skewness	1.6899	2.0150	0.33677	0.50481
Minimum	0.00	0.00	1.0000	0.00
Maximum	1513.0	15.000	46482	301.00

In Table 3, the best-fitted models are based on, lowest values of AIC, SC, RMSE, MAE, MAPE, and Theil's U along with the highest significant coefficients. Among the particular models, these are the best-fitted models. We use Simple Moving Average Filter for the series (New deaths) and (Total cases) and (New cases), and Exponential moving average Filter for the series (Total deaths). For the series (Total Deaths) and the series (New Deaths), and the series (Total cases) we use SARIMA Model considering the seasonality in these series. After the assessment of every trend series, we forecast the series for the coming Days. For purpose of forecasting ARIMA (p, d, q) Model and SARIMA (p, d, q) Model, as discussed in the methodology. Data for the period 13th March 2020, to 30th September, 2020 was used for model building. And the model validation data used was for the period 29th March, 2020 to 30th September, 2020. Best models are utilized to predict the series for the coming days. Different series are seen as fitted with various SARIMA (4,1,2)(2,0,1).

Table 3: Selecting the Best Model for Forecasting

	New Deaths	**Total Deaths**	**Total Cases**	**New Cases**
MODEL SARIMA(P,D,Q)	SARIMA(4,1,2) (2,0,1)	SARIMA(5,2,5) (2,2,3)	SARIMA(4,2,7) (0,0,1)	ARIMA(2,2,10)
AIC	188.7019	365.6305	2182.452	891.4825
SC	224.7049	420.4682	2225.199	932.7651
RMSE	0.35251	0.4772	53.167	5.0982
MAE	0.24687	0.3331	36.124	3.8564
MAPE	-	0.67181	1.1009	1.4266
THEIL'S U	-	0.36561	0.27303	0.69235
error is normally distributed	No	No	No	Yes
no arch effect is present	Yes	Yes	Yes	Yes
no autocorrelation in the residual	Yes	Yes	Yes	Yes

SARIMA(5,2,5)(2,2,3), SARIMA(4,2,7)(0,0,1), ARIMA(2,2,10) models individually. These models are seen as best fitted models for forecasting during the period 1st October, 2020 to 10th October, 2020. In Table 4, we find that in Ghana: the new deaths will increase from 0 to 3 during the period 1-10-2020 to 10-10-2020. The total Deaths will increase from 299 to 308 during the period 1-10-2020 to 10-10-2020. The total Cases will decrease from 46600 to 44942during the period 1-10-2020 to 10-10-2020. The new Cases will decrease from 174 to 88 during the period 1-10-2020 to 10-10-2020. The evidence from the results subsist that even though there are high incidence of COVID-19 cases in Ghana, the new deathsemanting from COVID-19 cases are not many. According to the (Ghana Health Service, 2020) only people with pre-existing health conditions like health diseases, respiratory disorders have hightened risk of death. Healthy people with no pre-existing health condtion later develop immunity to fight the virus. This clearly explains the reasons for low deaths of COVID-19 cases in Ghana. Notwithstanding this, there has been limited movement of people and goods resulting from the fears contracting the virus which affected trade, businesses and economic performance. The findings of the study were coroborated in a similar study conducted by Mostafa (2020), who predicted COVID-19 cases based on confirmed cases in China, Italy, and USA by the help of statistical models. The incidence of COVID-19 cases were predicted and low deaths per cases on the contrary were also predicted.

Table 4: Forecasting for New Deaths, Total Deaths, Total Cases and New Cases in Parenthesis (standard errors) with 95% Intervals

	New Deaths	Total Deaths	Total Cases	New Cases
2020-10-1	0.420989 0.352510 (-0.269917, 1.11190)	299.362 0.477196 (298.427, 300.297)	46600.5 169.551 (46268.2, 46932.8)	174.523 5.09823 (164.531, 184.516)
2020-10-2	0.453943 0.483570 (-0.493837, 1.40172)	299.645 0.936180 (297.810, 301.480)	46719.6 284.692 (46161.6, 47277.6)	168.015 7.40115 (153.509, 182.521)
2020-10-3	0.632236 0.569548 (-0.484058, 1.74853)	299.879 1.38538 (297.164, 302.595)	46833.7 388.918 (46071.4, 47595.9)	158.995 9.75165 (139.882, 178.108)
2020-10-4	0.784169 0.699428 (-0.586685, 2.15502)	299.750 1.90754 (296.011, 303.488)	46924.5 501.586 (45941.5, 47907.6)	148.284 12.4282 (123.925, 172.643)
2020-10-5	0.929677 0.802363 (-0.642926, 2.50228)	299.719 2.40926 (294.997, 304.441)	46975.2 625.725 (45748.8, 48201.6)	136.977 14.9435 (107.689, 166.266)
2020-10-6	0.798439 0.911258 (-0.987594, 2.58447)	299.619 2.91445 (293.907, 305.331)	47021.0 753.225 (45544.7, 48497.3)	126.367 17.7774 (91.5236, 161.210)
2020-10-7	0.928425 1.02266 (-1.07596, 2.93281)	299.196 3.44910 (292.436, 305.957)	47090.1 875.738 (45373.7, 48806.5)	115.985 20.2563 (76.2832, 155.686)
2020-10-8	1.00906 1.03313 (-1.01583, 3.03396)	298.855 4.01630 (290.983, 306.727)	47173.9 993.946 (45225.8, 49122.0)	106.444 22.6645 (62.0228, 150.866)
2020-10-9	1.02359 1.05168 (-1.03766, 3.08485)	298.168 4.58923 (289.173, 307.163)	47273.8 1111.87 (45094.6, 49453.0)	97.8249 25.3177 (48.2031, 147.447)
2020-10-10	1.07757 1.08016 (-1.03951, 3.19465)	297.679 5.15119 (287.582, 307.775)	47363.0 1235.40 (44941.7, 49784.3)	88.1349 28.2749 (32.7172, 143.553)

4. Conclusions

The present study reveals that though an effective approach is taken by the government of Ghana to minimize the spread of COVID-19 to human explore, but this pandemic disease shows some probability of a decrease in new cases, which leads to a decrease in a total number of cases. The forecasted results (from the best-fitted models) tell a decrease of 174 to 88 in the daily new cases by flowing a linear trend, which also leads to a decrease in total cases by following the same trend (from 46600 to 44942 in numbers) during the period 1-10-2020 to 10-10-2020. But the forecasted graph (Fig-6) shows a wider confidence interval may lead to a sudden increase to 50,000 in numbers (may decrease also to 45,000 in numbers) of total cases. Simultaneously, on the other hand, the study reveals a small amount of increase in daily new death (i.e. 0-3 in numbers). The forecast amount of increase in total death is from 298-308 in numbers during that period. Based on our findings, we recommend that the government should be strong towards the lockdown to some extent, and the republic of Ghana should be conscious about it and maintain the social distancing to minimize the severity of the situation. There is the need for future introduction to new vaccine, new technological improvement and international cooperation between the countries to reduce the current pandemic situation in Ghana. Our results could help the government of Ghana to monitor the current situation and use our forecast findings to aid in reducing further transmission.

Biographical Notes

Jamal Mohammed is a Senior Lecturer in Economics in the Department of General/Liberal Studies with the Koforidua Technical University, Ghana. He is currently the Director of Research for the University. Dr Mohammed also serves as the Executive Director of the Africa Development Resources Research Institute (ADRRI), a research policy think tank based in Koforidua. His research specializations are: Environmental and Natural Resources Economics, Development Economics, Economics of Education, Economic Policy and Economic Modelling. Dr. Mohammed has published research articles in peer review journals. His research has span into: fuel wood commercialization, charcoal trade, climate change, Small and Medium Enterprises, Poverty, economics of education, entrepreneurship, and energy. He is also an entrepreneur and works on Network Marketing Techniques for entrepreneurial growth.

Abdullah Mohammad Ghazi Al Khatib currently works at the Department of Banking and Insurance, Faculty of Economics, Damascus University, Syria. Abdullah does research in Financial Economics, Econometrics and Development Economics. He is Member of International Association of Scientific Researcher.

His Ph.D degree entitled: The relationship between Financial Development and Economic Growth (Study the experience of Egypt and how to benefit from it in Syria) completed from Damascus University. His research area interest is financial economics, financial market, economic growth and econometrics. He has worked as a reviewer for different journals.He has published many papers in peer-review journals.

Pradeep Mishra completed his PhD in Agriculture Statistics in 2014 in Modeling and forecasting of foods crops in India and their yield sustainability. He has specialized in the field of time series, design of experiment and Agriculture Statistics. Presently, he is working as a assistant professor at college of agriculture, Powarkheda under JNKVV University, India. His area of specialization is agriculture statistics, time series and design of experiment. He has published more than 93 research article in different international and national journals. Also he got award like young scientists in 2017 in international conference (GRISAAS-2017), second best paper from Society of economics & development in PAU, 2018 and other different societies. Dr Mishra has published 4 books with a reputed publisher.

Prince Adjei is an Economist by training and Lecturer by profession. He is a product of the University of Ghana, holding a PhD in Development Economics, Master of Philosophy in Economics and Bachelor's degree major in Economics (first class honors). His research interest lies in the area of Economics of Education, Labor Market Analysis and Development Economics. He is currently a Lecturer in Economics and Research Methods at the Koforidua Technical University and doubles as the Acting Coordinator of Grants and Research Proposals for the University. Dr Prince also serves as the Deputy Executive Director of the Africa Development Resources Research Institute (ADRRI), a research policy think tank based in Koforidua.

Pankaj Kumar Singh holds a PhD in Civil Engineering and currently working as Director Research in R D Enguneering College, Ghaziabad. His research area of interest is in waste water treatment and Plant medicine. His fabulous work in the field of Patent and research paper and till now published 9 Patent and currently working on Biological Treatment (with combined effect of Micro algae and fungai) of Industrial and MSW waste water. He also presented and published many research papers in diffent countries like Las Vegas, New Jersey, Bali, Geneva, George Town (Australia). His works are all related to social and nation causes.

S. R Krishna Priya holds a Ph D in Statistics (Bharathiar University, Coimbatore). Her areas of interest and research experience are in Statistical Modeling and Forecasting. She currently works as an Assistant Professor at PSG College of Arts & Science, Coimbatore. completed from Department of Statistics, Bharathiar University, Coimbatore. Her PhD degree entitled Certain Results of Pre-harvest Yield Forecasting for Sugarcane Crop in Coimbatore District completed from Department of Statistics, Bharathiar University, Coimbatore. She has published 10 research article in different reputed journals. She is teaching time series and forecasting subject for post graduation students.

Soumitra Sankar Das completed his PhD from Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal in Agricultural Statistics. He was awarded Rajiv Gandhi National Fellowship (RGNF) by UGC, New Delhi. Dr. Das fas worked as a Junior Research Fellow (JRF) under the project of SAC (Space Application Center) - ISRO (Indian Space Research Organization). He is a author of a book entitled "Question Bank on Agricultural Statistics and Computer Application". He was also awarded for "Young Scientist Award" organized by Academy for Environment and Life Sciences, Agra and Department of Botany, St. John's College, Agra in 2020. Presently, he is working as an Assistant Professor-cum-Junior Scientist at Birsa Agricultural University, Ranchi, Jharkhand. He has a number of research articles in various reputed journals.

References

Degraft-Amoah, E. (2020). The Economic Ramifications of COVID-19 for Ghana. https://www.researchgate.net/publication/340066293

Economic Commission for Africa (2020). COVID-19: Lockdown Exit Strategies for Africa, 4 May, 2020, Addis Ababa, Ethiopia.

https://ghanahealthservice.org/covid19/archive.php

https://www.who.int/data/gho Retrieved on 12th July, 2020

Kumar Manoj and Anand Madhu (2014). An Application of Time Series ARIMA Forecasting Model for Predicting Sugarcane Production in India. *Studies in Business and Economics* 9(1):81 – 94.

Ministry of Health of Ghana (2020). Provisional Standard Treatment Guidelines for Novel Coronavirus Infection. COVID - 19 Guidelines for Ghana.

Mostafa, S. A. A. (2020). Predicting COVID-19 Cases using Some Statistical Models: An Application to the Cases Reported in China Italy and USA. *Academic Journal of Applied Mathematical Sciences*, ISSN (e): 2415-2188, ISSN (p): 2415-5225; 6(4), pp.: 32-40, DOI: https://doi.org/10.32861/ajams.64.32.40.

Jamal, F., Ezzine, L., Aman, Z., Moussami, H. E., and Lachhab, A. (2018). Forecasting of demand using ARIMA model. *International Journal of Engineering Business Management*, Volume 10: 1–9. DOI: 10.1177/1847979018808673.

P. Mishra, P.K. Sahu, B.S. Dhekale and Vishwajith K.P. (2015). Modeling and Forecasting of Wheat in India and their Yield Sustainability. *Indian J Econ Dev*, 11(3) (2015): 637-647. DOI: 10.5958/2322-0430.2015.00072.4.

Robert, N. (2014). Lecture notes on forecasting. Fuqua School of Business, Duke University.

Warwick, M. and Roshen, F. (2020). The Global Macroeconomic Impacts of COVID-19: Seven Scenarios. OECD.

Yu, K. D. S. and Aviso, K. B. (2020). Modelling the Economic Impact and Ripple Effects of Disease Outbreaks, Process Integration and Optimization for Sustainability. https://doi.org/10.1007/s41660-020-00113-y, #Springer Nature Singapore Pte Ltd. 2020.

Appendices

Figure 1: Regional Distribution of COVID-19 Active Cases in Ghana, March - July 2020

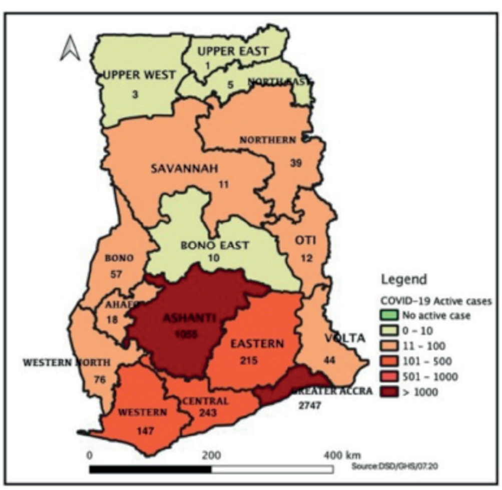

Figure 2: Regional Distribution of Cumulative COVID-19 Cases in Ghana, March - July 2020

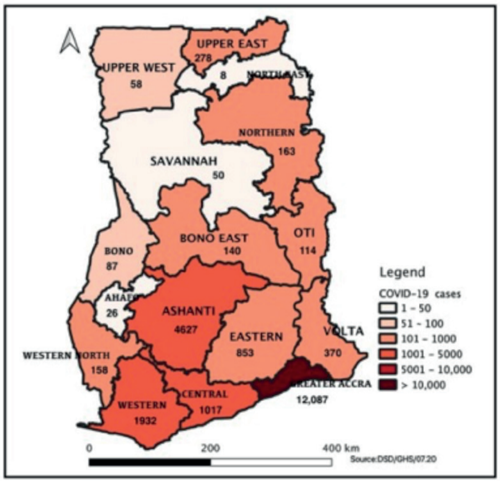

Figure 3: Pattern of Covid -19 Ghana for Total and New Cases and Deaths

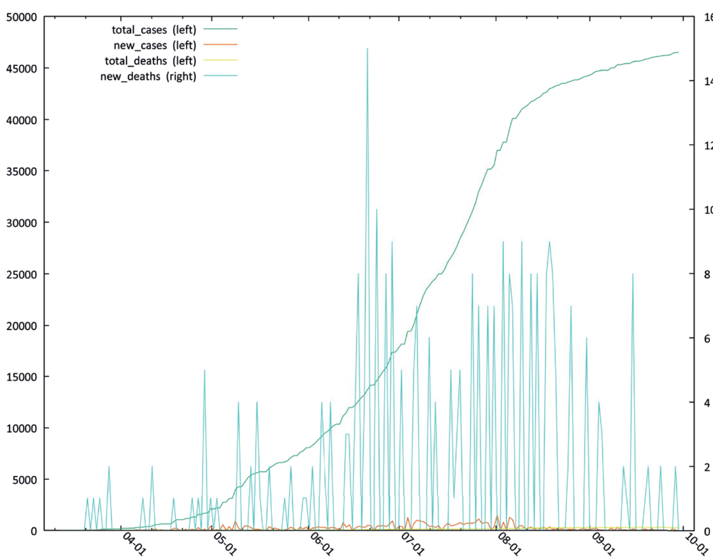

Figure 4: Forecast for COVID-19 New Deaths in Ghana

Figure 5: Forecast for COVID-19 Total Deaths in Ghana

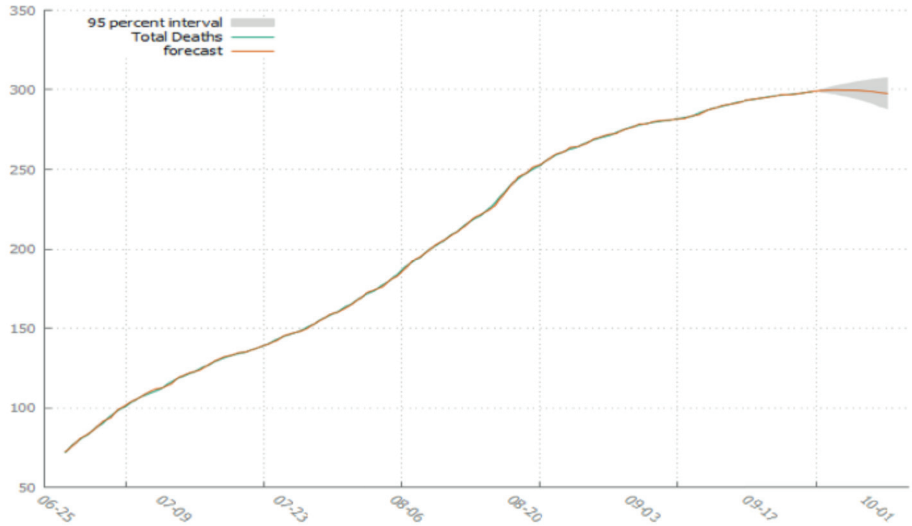

FIGURE 6: FORECAST FOR COVID-19 TOTAL CASES IN GHANA

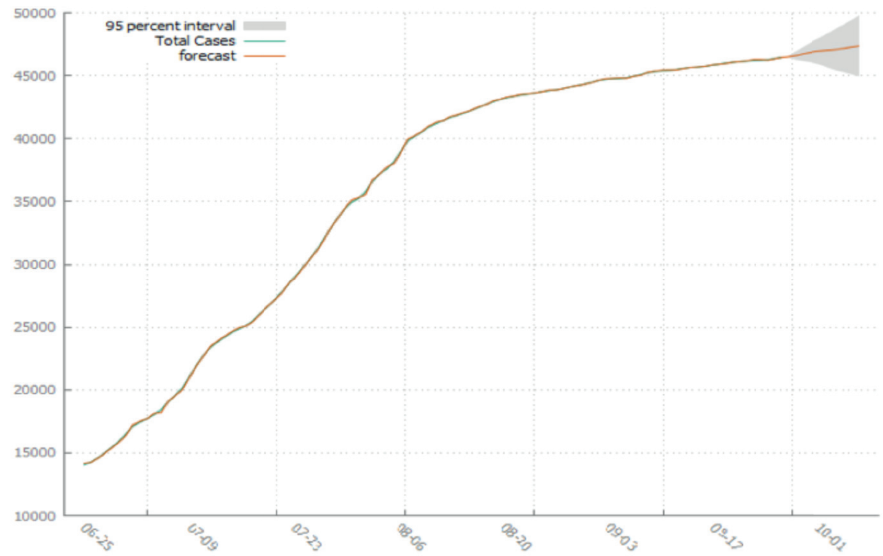

FIGURE 7: FORECAST FOR COVID-19 NEW CASES IN GHAN

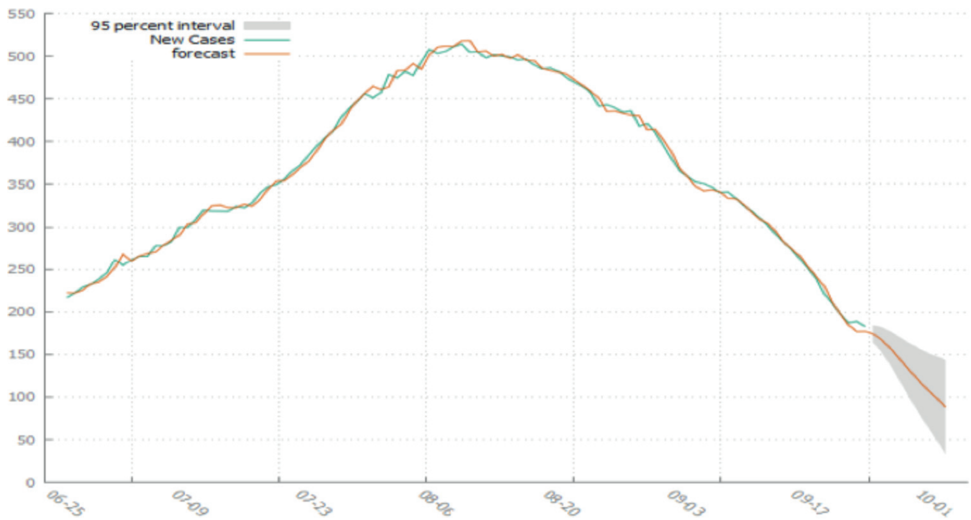

Figure 8a: Correlogram and Partial Correlogram of the Residuals: New Deaths

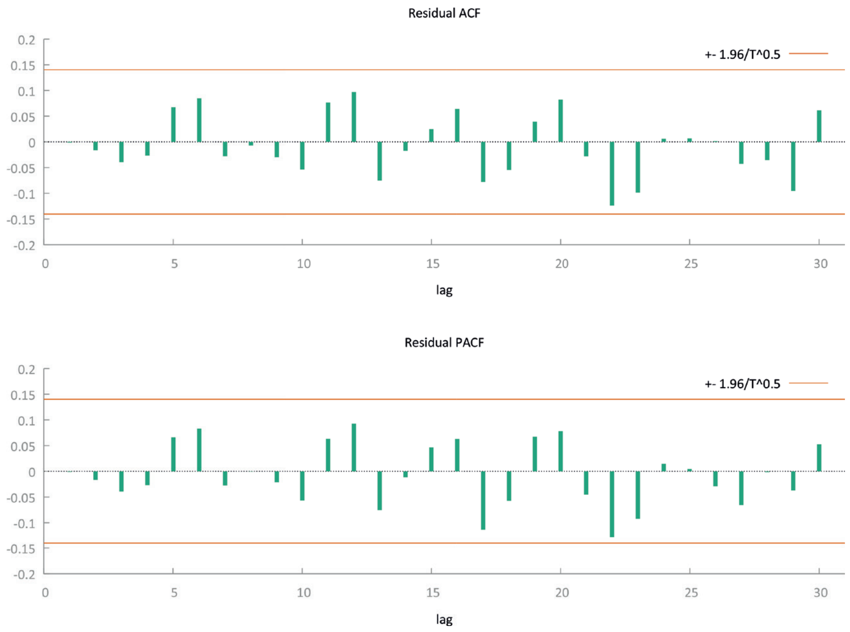

Figure 8b: Correlogram and Partial Correlogram of the Residuals: Total Deaths

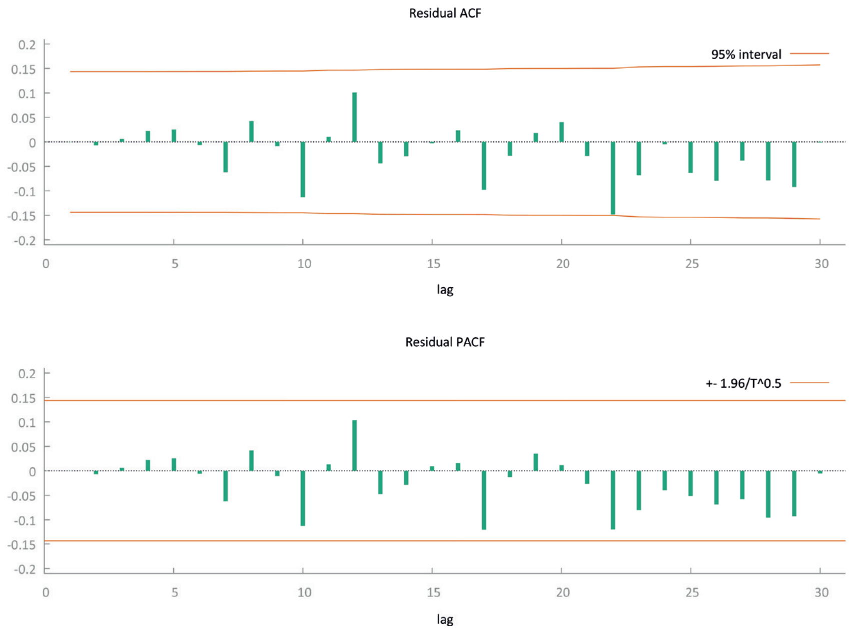

Figure 8c: Correlogram and Partial Correlogram of the Residuals: Total Cases

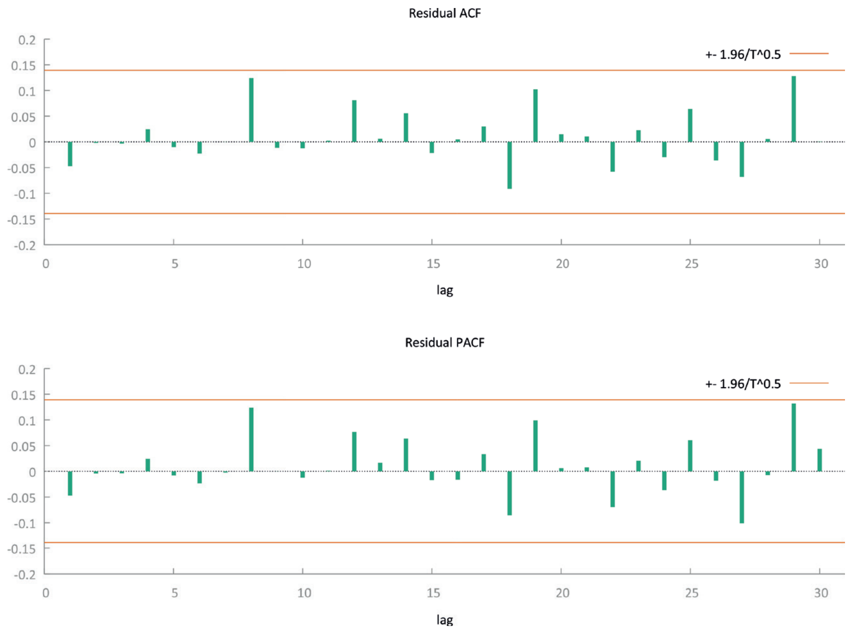

Figure 8d: Correlogram and Partial Correlogram of the Residuals: New Cases