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Research Article

The Validity of Autoregressive Integrated Moving Average Approach to Forecast the Spread of COVID-19 Pandemic in Africa

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Africa's first COVID-19 case was recorded in Egypt on February 14, 2020. Although it is not as expected by the World Health Organization (WHO) and other international organizations, currently a large number of Africans are getting infected by the virus. In this work, we studied the trend of the COVID-19 outbreak generally in Africa as a continent and in the five African regions separately. The study also investigated the validity of the ARIMA approach to forecast the spread of COVID-19 in Africa. The data of daily confirmed new COVID-19 cases from February 15 to October 16, 2020, were collected from the official website of Our World in Data to construct the autoregressive integrated moving average (ARIMA) model and to predict the trend of the daily confirmed cases through STATA 13 and EViews 9 software. The model used for our ARIMA estimation and prediction was (3, 1, 4) for Africa as a continent, ARIMA (3, 1, 3) for East Africa, ARIMA (2, 1, 3) for West Africa, ARIMA (2, 1, 3) for Central Africa, ARIMA (1, 1, 4) for North Africa, and ARIMA (4, 1, 5) for Southern Africa. Finally, the forecasted values were compared with the actual number of COVID-19 cases in the region. At the African level, the ARIMA model forecasted values and the actual data have similar signs with slightly different sizes, and there were some deviations at the subregional level. However, given the uncertain nature of the current COVID-19 pandemic, it is helpful to forecast the future trend of such pandemics by employing the ARIMA model.

1. Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) caused a highly contagious disease called coronavirus disease 2019 (COVID-19). The virus was first reported in Wuhan city, People's Republic of China (PRC), in December 2019 [1–3].

Africa is the last continent to be infected by the COVID-19 pandemic. However, Africa, with the most vulnerable populations to infectious diseases, is predicted to be significantly affected by the ongoing COVID-19 outbreak [3]. As of October 30, 2021; CDC Africa reported 8,491,452 cases, 218,175 deaths, and 7,890,021 recoveries out of 76,692,988 COVID-19 tests [4].

There is no sustainable economy without a strong health sector [5]. However, the socio-economic conditions in Africa are much less developed than other countries of the world. A series of factors, i.e., the scarcity of medical supplies, low socioeconomic status, lower virus testing efficiency, and poor information and communication technology (ICT) would facilitate the spread of the pandemic [6]. Before the COVID-19 pandemic, most of the healthcare infrastructure in African countries had been deteriorating, and the situation posed unprecedented pressure on the public health systems in many African countries [7]. Currently, the COVID-19 health crisis has already transformed into an economic and labor market shock, impacting not only supply (production of goods and services) but also demand (consumption and investment). In Africa and many low- and middle-income countries, the spread of COVID-19 is translated into economic impacts that will affect the already affected most vulnerable populations [8]. Many people, especially from developing nations, are shifting their focus from the fatal effects of the pandemic to the threats it poses to their daily supply of food [9].

Table 1: African regions with their respective numbers and a list of countries.

Regions	List of countries in the region
Northern Africa (7)	Algeria, Egypt, Libya, Morocco, Sudan, and Tunisia
Central Africa (9)	Angola, Cameroon, the Central African Republic, Chad, Congo Republic—Brazzaville, the Democratic Republic of the Congo, Equatorial Guinea, Gabon, and São Tomé and Principe
Southern Africa (5)	Botswana, Lesotho, Namibia, South Africa, and Swaziland
East Africa (18)	Burundi, Comoros, Djibouti, Ethiopia, Eritrea, South Sudan, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, Tanzania, Uganda, Zambia, and Zimbabwe
Western Africa (16)	Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, MAli, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo

Source: own computation, 2021.

What will be the global socio-economic impact of the novel coronavirus (COVID-19)? Answering this question requires accurate forecasting of the spread of confirmed cases as well as analysis of the number of COVID-19-related deaths and recoveries [10]. It is essential to create a reliable and suitable predictive model that is of high importance to understand the current situation, evaluate the severity of the pandemic, and help governments and other stakeholders to control the further spread of novel coronavirus [11, 12]. Until now, several researchers have utilized the ARIMA model to forecast the spread of COVID-19 in many countries. In [13], the researchers employed the ARIMA model to forecast the spread of COVID-19 incidence in Italy, Russia, and the United States of America. In [14–19], ARIMA was used to forecast the spread of the COVID-19 pandemic in Bangladesh, Malaysia, India, Korea, Ethiopia, and Pakistan, respectively. However, the outcome of the aforementioned research depends on the validity of the ARIMA model. Therefore, the general objective of this research is to check the validity of the ARIMA model to forecast the spread of the COVID-19 pandemic in Africa under current testing capacity and public health interventions.

Once we started with this brief introduction, the whole paper was organized as follows: In the second part, the study presented the research methodology, in which the specification of the theoretical model and the data issues are included. The third part presents the empirical findings and their interpretations. Finally, in the last part, the study draws possible conclusions and policy implications based on the findings of the study.

2. Materials and Methods

2.1. Description of the Study Area. Africa is also called the "Mother Continent" due to its being the oldest inhabited continent on Earth and being the homeland for humans and their ancestors for more than five million years. The current population of Africa is 1,382,727,760 as of Tuesday, October 26, 2021, and it is equivalent to 16.72% of the total world population [20]. It can be seen from Table 1 that the UN Statistics Division, Africa, is subdivided into five regions: Northern Africa, Central or Middle Africa, Southern Africa, East Africa, and Western Africa [21].

2.2. Data Collection. The official website of Our World in Data was used to collect the daily confirmed new COVID-19 cases from February 15, 2020, to October 16, 2020 [22]. Since the collected data includes the respective daily new confirmed COVID-19 cases of the past few days, it is considered as time series data. STATA 13 and EViews 9 has been used to build and analyze the time-series data.

2.3. Description and Development of Econometric Model. The Box-Jenkins approach to modeling ARIMA (p, d, q) processes is employed in this study, and this methodology is widely regarded as the most efficient forecasting technique and is used extensively [23]. The abbreviation ARIMA stands for autoregressive integrated moving average model, and the model is divided into three components depending on the type of data. The first building block is the autoregressive (AR) models, in which the value of a variable in one period is related to its value in previous periods. AR(p) is an autoregressive model with p lag.

$\mathbf{Y_t} = \alpha + \sum_{\mathbf{i=1}}^{\mathbf{P}} \beta_{\mathbf{i}} \mathbf{y_{t-i}} + \varepsilon_{\mathbf{t}}$; where Y_t is the dependent variable, α is a constant, β_{p} is the coefficient for the lagged variable in time $t-p$ and ε_{t} is the random or white noise term that represents a shock that cannot be explained.

The second component is the moving average (MA) model, which accounts for the possibility of a relationship between a variable and the residuals from previous periods. MA(q) is a moving average model with q lags: $\mathbf{Y_t} = \alpha + \varepsilon_{\mathbf{t}} + \sum_{\mathbf{i=1}}^{\mathbf{P}} \delta_{\mathbf{i}} \varepsilon_{\mathbf{t-i}}$; where Y_t is the dependent variable, α is a constant, δ_{i} is the coefficient for the lagged variable in time t-i, and ε_{t} is the error term.

The combination of the above two models, which are AR (autoregressive) and MA (moving average), gives the ARMA model, and the ARMA model can be used if and only if the data is stationary. The ARMA models combine both p autoregressive terms and q moving average terms, also called ARMA (p, q).

$$\mathbf{Y_t} = \boldsymbol{\alpha} + \sum_{\mathbf{i=1}}^{\mathbf{P}} \boldsymbol{\beta}_{\mathbf{i}} \mathbf{y_{t-i}} + \sum_{\mathbf{i=1}}^{\mathbf{P}} \boldsymbol{\delta}_{\mathbf{i}} \boldsymbol{\varepsilon}_{\mathbf{t-i}} + \boldsymbol{\varepsilon}_{\mathbf{t}}. \quad (1)$$

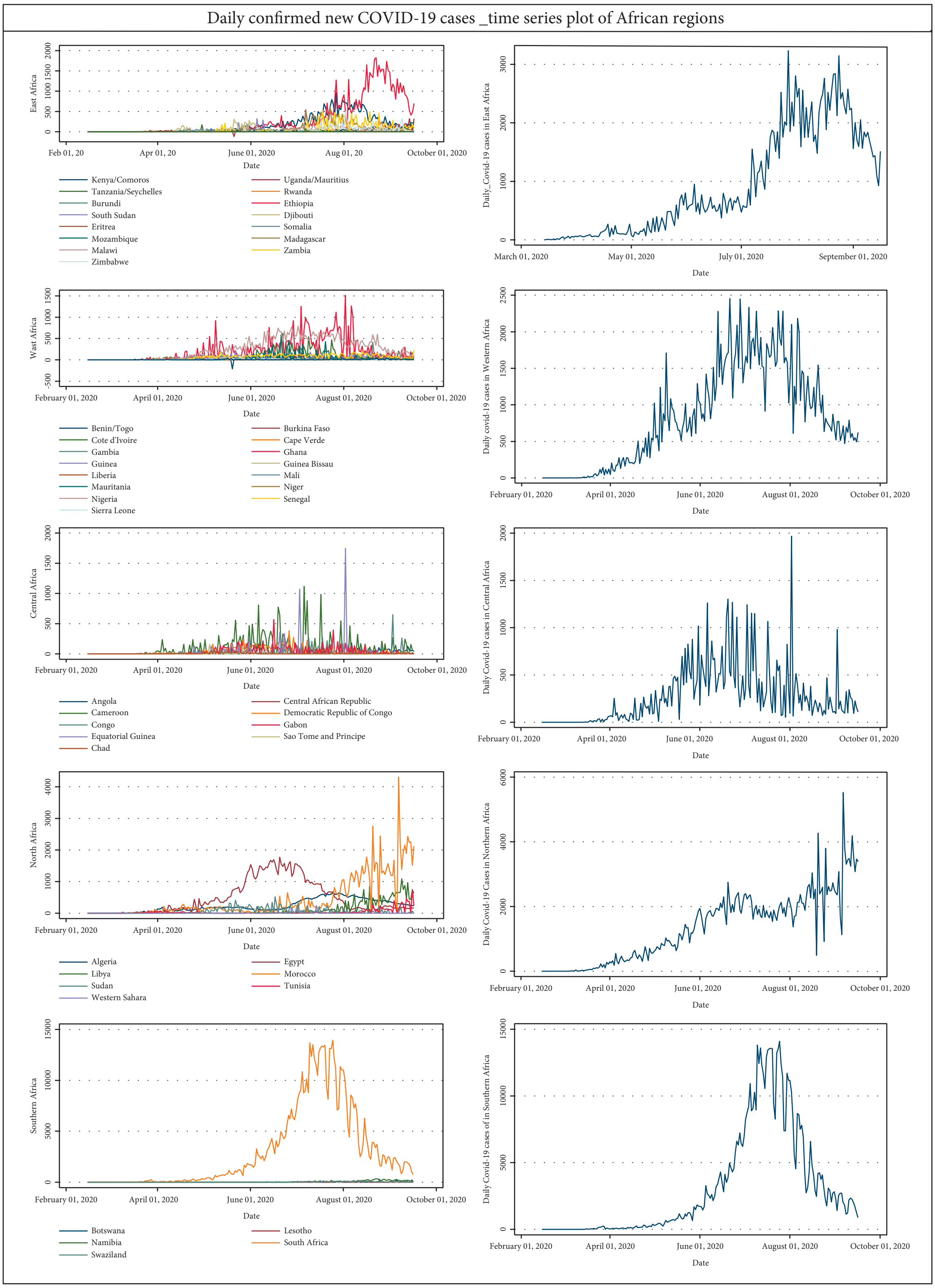

Figure 1: COVID-19 daily new cases time series plots of African countries and African regions.

When a variable Y_t is not stationary, a common solution is to use a differenced variable: $\Delta Y_t = Y_t - Y_{t-1}$, for first-order differences, and by differencing (integrating (I)) the original series before using them will remove any linear time trend. If we include the third component, which is integrated into our ARMA model, it will become ARIMA.

The emphasis of these methods is not on constructing single-equation or simultaneous equation models but on

Table 2: ARIMA model for forecasting the number of daily confirmed cases according to AIC.

Region	ARIMA (p, d, q)	AIC	BIC	Remark
Africa	ARIMA (3, 1, 3)	3639.944	3666.872	
	ARIMA (3, 1, 4)	3595.321	3625.615	Selected
	ARIMA (3, 1, 5)	3595.333	3625.626	
	ARIMA (4, 1, 1)	3672.747	3696.309	
	ARIMA (4, 1, 3)	3619.915	3650.209	
East Africa	ARIMA (1, 1, 1)	2601.405	2614.308	
	ARIMA (3, 1, 1)	2598.818	2618.173	
	ARIMA (3, 1, 2)	2599.356	2621.936	
	ARIMA (3, 1, 3)	2585.117	2610.923	Selected
	ARIMA (3, 1, 4)	2586.625	2615.657	
West Africa	ARIMA (3, 1, 3)	3023.064	3049.991	
	ARIMA (2, 1, 1)	3022.722	3039.552	
	ARIMA (2, 1, 2)	3021.737	3041.933	
	ARIMA (2, 1, 3)	3020.539	3044.1	Selected
	ARIMA (1, 1, 3)	3021.737	3041.933	
Central Africa	ARIMA (3, 1, 1)	2965.526	2985.721	
	ARIMA (3, 1, 2)	2967.526	2991.087	
	ARIMA (3, 1, 3)	2964.29	2991.218	
	ARIMA (3, 1, 4)	2963.011	2989.939	
	ARIMA (2, 1, 3)	2962.982	2986.544	Selected
North Africa	ARIMA (4, 1, 1)	3195.541	3219.103	
	ARIMA (4, 1, 2)	3195.762	3222.69	
	ARIMA (2, 1, 4)	3199.014	3225.942	
	ARIMA (3, 1, 4)	3196.937	3227.23	
	ARIMA (1, 1, 4)	3193.648	3217.21	Selected
Southern Africa	ARIMA (3, 1, 3)	3482.738	3509.666	
	ARIMA (4, 1, 3)	3485.755	3516.049	
	ARIMA (3, 1, 4)	3490.28	3520.574	
	ARIMA (4, 1, 4)	3448.189	3481.849	
	ARIMA (4, 1, 5)	3446.152	3483.178	Selected

Source: own computation, 2021.

Table 3: The prediction epidemic results of the new COVID-19 in Africa for the next month as predicted by the ARIMA (3, 1, 4) model.

Date	Expected cases	Date	Expected cases
17/9/20	7256	2/10/2020	5800
18/9/20	7382	3/10/2020	5804
19/9/20	7127	4/10/2020	5478
20/9/20	648	5/10/2020	5070
21/9/20	5779	6/10/2020	4884
22/9/20	5382	7/10/2020	5051
23/9/20	5460	8/10/2020	5438
24/9/20	5838	9/10/2020	5758
25/9/20	6142	10/10/2020	5783
26/9/20	6082	11/10/2020	5513
27/9/20	5658	12/10/2020	5167
28/9/20	5151	13/10/2020	5015
29/9/20	4901	14/10/2020	5173
30/9/20	5057	15/10/2020	5526
01/10/20	5465	16/10/2020	5819

Source: own computation, 2021.

analyzing the probabilistic or stochastic properties of economic time series according to their philosophy. Let the data speak for themselves as it allows Y_t to be explained by the past, or lagged, values of Y and the stochastic error terms. For this reason, ARIMA models are not derived from any economic theory [24–26].

2.4. Model Selection Criteria. Out-of-sample forecasting is concerned with determining how a fitted model forecasts future regress values and given the values of the regressors. To select the best ARIMA (p, d, q) type of model fitted for Africa and the five African regions, their goodness-of-fit has been compared using the Akaike information criteria (AIC)

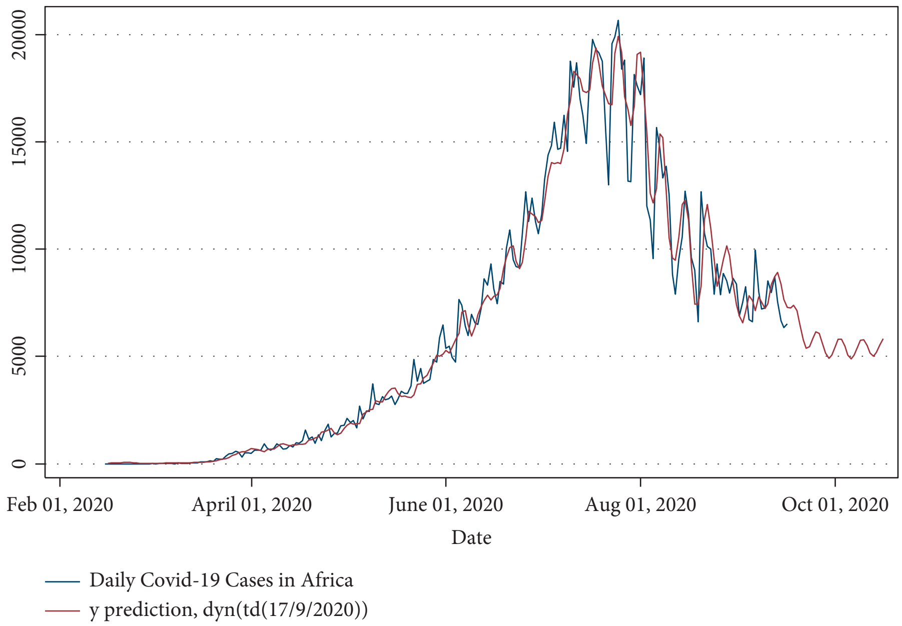

Figure 2: The plot of actual confirmed cases with the prediction result of the ARIMA model for Africa.

Table 4: The prediction results of daily confirmed COVID-19 cases in East Africa for the next month as predicted by the ARIMA (3, 1, 3) model.

Date	Expected cases	Date	Expected cases
17/9/20	1286	2/10/2020	1454
18/9/20	1476	3/10/2020	1438
19/9/20	1166	4/10/2020	1408
20/9/20	1323	5/10/2020	1442
21/9/20	1443	6/10/2020	1474
22/9/20	1359	7/10/2020	1454
23/9/20	1267	8/10/2020	1447
24/9/20	1383	9/10/2020	1479
25/9/20	1440	10/10/2020	1492
26/9/20	1351	11/10/2020	1477
27/9/20	1337	12/10/2020	1485
28/9/20	1427	13/10/2020	1509
29/9/20	1434	14/10/2020	1513
30/9/20	1373	15/10/2020	1506
01/10/20	1396	16/10/2020	1519

Source: own computation, 2021.

and Bayesian information criterion (BIC). AIC is an important and leading statistic by which we can determine the order of an autoregressive model. The AIC considers both how well the model fits the observed series and the number of parameters to be used in the fit. The BIC can help in deciding the order of autoregression. $\mathbf{AIC} = \mathbf{e}^{2k/n}\mathbf{RSS/n}$, where k is the number of regressors (including the intercept), n is the number of observations, and RSS stands for the residual sum of the square. In comparing two or more models, the model with the lowest value of AIC is preferred. One advantage of the AIC is that it is useful for not only in-sample but also out-of-sample forecasting of the performance of a regression model. $\mathbf{BIC} = -2\,\mathbf{ln}\,\mathbf{L} + \mathbf{k}\,\mathbf{ln}\,\mathbf{N}$; where $\mathbf{L}$ is the value of the likelihood function evaluated at the parameter estimates, $\mathbf{N}$ is the number of observations, and $\mathbf{K}$ is the number of estimated parameters. A lower AIC or BIC value indicates a better fit (a more parsimonious model).

3. Data Presentation and Analysis

3.1. Descriptive Statistics. The daily confirmed new COVID-19 case time series plots of African countries initially depict an increasing trend and later a declining trend, but there is a variation in the daily confirmed new COVID-19 case time series plots among African countries and between the five African regions, as shown in Figure 1.

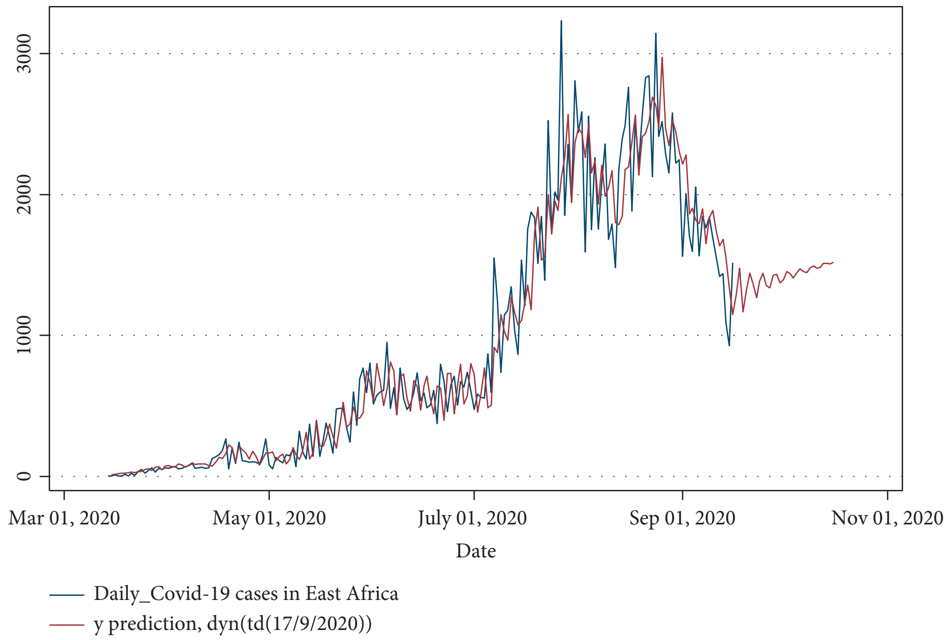

FIGURE 3: The plot of actual confirmed cases with the prediction result of the ARIMA model for East Africa.

TABLE 5: The prediction results of daily confirmed new COVID-19 cases in North Africa for the next month as predicted by the ARIMA (1, 1, 4) model.

Date	Expected cases	Date	Expected cases
17/9/20	3588	2/10/2020	3749
18/9/20	3504	3/10/2020	3783
19/9/20	3571	4/10/2020	3783
20/9/20	3533	5/10/2020	3815
21/9/20	3600	6/10/2020	3818
22/9/20	3570	7/10/2020	3847
23/9/20	3629	8/10/2020	3851
24/9/20	3607	9/10/2020	3879
25/9/20	3659	10/10/2020	3887
26/9/20	3643	11/10/2020	3911
27/9/20	3690	12/10/2020	3920
28/9/20	3678	13/10/2020	3944
29/9/20	3720	14/10/2020	3953
30/9/20	3714	15/10/2020	3976
01/10/20	3752	16/10/2020	3987

Source: own computation, 2021.

Source: own computation, 2021.

3.2. Econometric Result and Interpretation

3.2.1. Parameter Estimation and Validation. Five models are chosen and tested to find a model with a good fit for Africa and the five African regions, and the model with the lowest AIC is selected for estimation and forecasting. As we can see from Table 2, that the ARIMA (3, 1, 4), ARIMA (3, 1, 3), ARIMA (2, 1, 3), ARIMA (2, 1, 3), ARIMA (4, 1, 2), and ARIMA (4, 1, 5) models are selected to estimate the parameters of Africa, East Africa, West Africa, Central Africa, North Africa, and Southern Africa, respectively.

Source: own computation, 2021.
Source: own computation, 2021.
Source: own computation, 2021.
Source: own computation, 2021.
Source: own computation, 2021.
Source: own computation, 2021.

3.2.2. Forecasting Using the Selected ARIMA Models. Candidate models were obtained based on the respective spikes observed from the autocorrelation function (ACF) and the partial autocorrelation function (PACF). Table 3 presents the prediction results of daily confirmed new

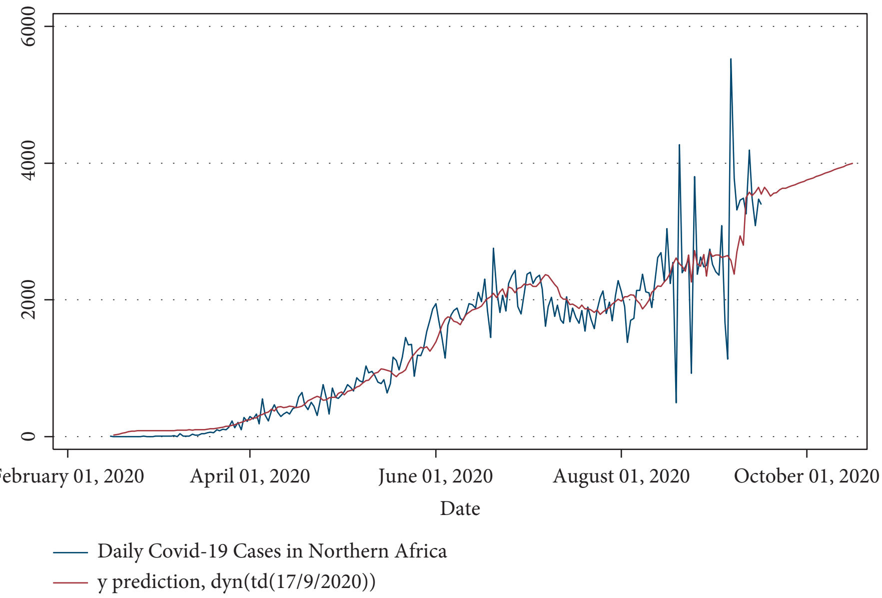

Figure 4: The plot of actual confirmed cases with the prediction results of the ARIMA model for North Africa.

Table 6: The prediction results of daily confirmed COVID-19 cases in West Africa for the next month as predicted by the ARIMA (2,1,3) model.

Date	Expected cases	Date	Expected cases
17/9/20	589	2/10/2020	644
18/9/20	643	3/10/2020	607
19/9/20	619	4/10/2020	632
20/9/20	566	5/10/2020	677
21/9/20	584	6/10/2020	667
22/9/20	644	7/10/2020	626
23/9/20	643	8/10/2020	632
24/9/20	590	9/10/2020	678
25/9/20	585	10/10/2020	686
26/9/20	640	11/10/2020	649
27/9/20	661	12/10/2020	638
28/9/20	617	13/10/2020	677
29/9/20	593	14/10/2020	700
30/9/20	635	15/10/2020	672
01/10/20	672	16/10/2020	649

Source: own computation, 2021.

Table 7: The prediction results of daily confirmed COVID-19 cases in Central Africa for the next month as predicted by the ARIMA (2,1,3) model.

Date	Expected cases	Date	Expected cases
17/9/20	184	2/10/2020	220
18/9/20	206	3/10/2020	214
19/9/20	209	4/10/2020	207
20/9/20	189	5/10/2020	218
21/9/20	199	6/10/2020	221
22/9/20	2145	7/10/2020	212
23/9/20	200	8/10/2020	216
24/9/20	195	9/10/2020	225
25/9/20	214	10/10/2020	218
26/9/20	211	11/10/2020	216
27/9/20	198	12/10/2020	225
28/9/20	210	13/10/2020	225
29/9/20	218	14/10/2020	219
30/9/20	205	15/10/2020	225
01/10/20	206	16/10/2020	230

Source: own computation, 2021.

COVID-19 cases in Africa for the period between 17/9/2020 and 16/10/2020 as predicted by the ARIMA (3,1,4) model, and the result demonstrates that the daily confirmed new cases trend in Africa as the continent may become stable or it will become stagnant (see Figure 2). However, this is the weighted average of the five African regions, and there is significant variation in the spread and trend of COVID-19 among African regions.

Unlike the cases in Africa, the prediction results of daily confirmed COVID-19 cases in East Africa as predicted by the ARIMA (3, 1, 3) model show an increasing trend in the spread of daily cases of the COVID-19 pandemic (as shown in Table 4 and Figure 3). Similarly, Table 5 presents the prediction results of daily confirmed COVID-19 cases in Northern Africa for the period between 17/9/2020 and 16/10/2020 as predicted by the ARIMA (1,1,4) model. The prediction results on the plot of actual confirmed cases with the prediction result of the ARIMA model depict the increasing trend and spread of COVID-19 in Northern Africa (see Figure 4).

The prediction results of daily confirmed new COVID-19 cases in West Africa and Central Africa for the next month were estimated by employing the ARIMA (2,1,3) and

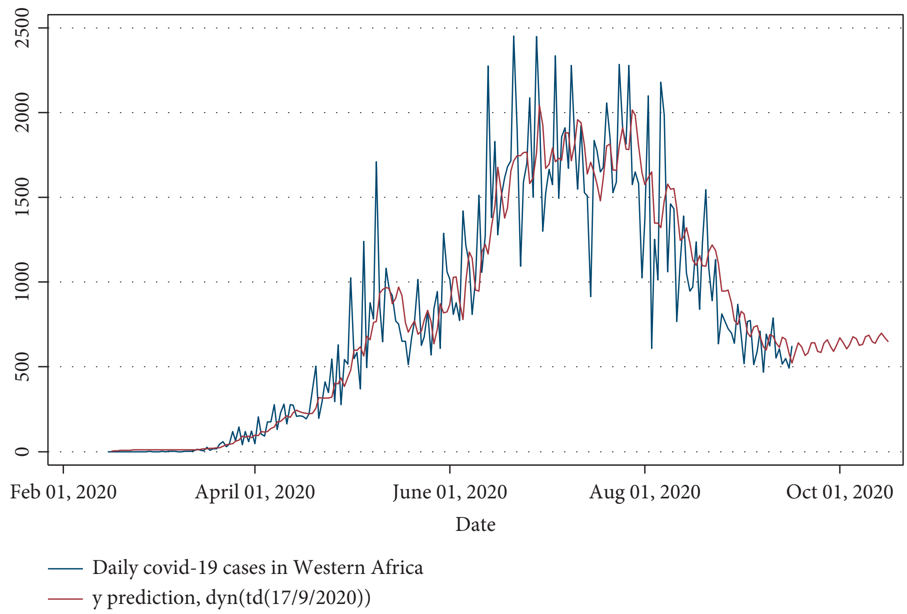

Figure 5: The plot of actual confirmed cases with the prediction result of the ARIMA model for West Africa.

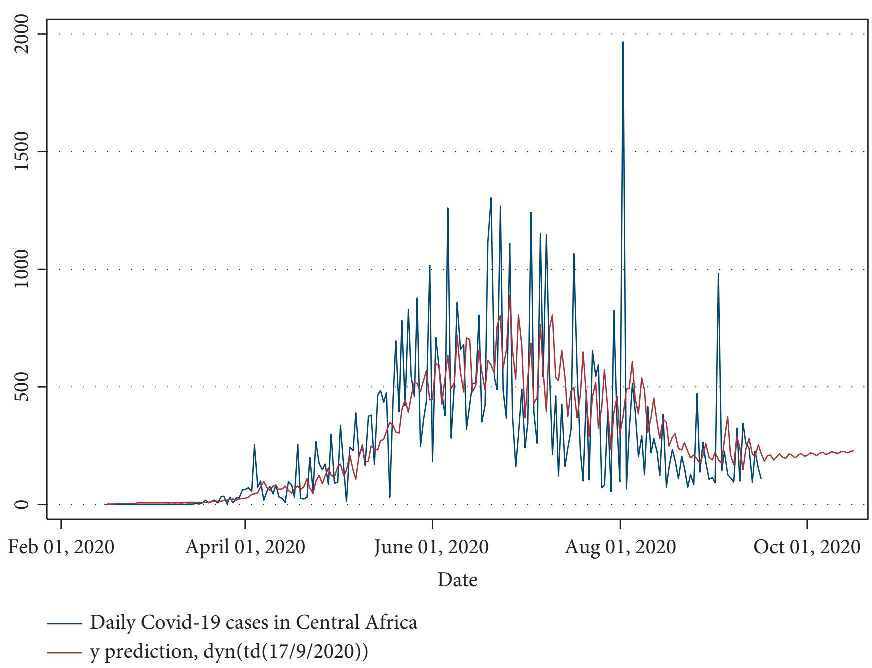

Figure 6: The plot of actual confirmed cases with the prediction result of the ARIMA model for Central Africa.

ARIMA (2,1,3) models, respectively (see Tables 6 and 7). The prediction results indicate a slight increasing trend in the number of daily new confirmed cases of COVID-19 in both West Africa and Central Africa (see Figures 5 and 6). On the other hand, Southern Africa is the most infected region in Africa, but Table 8 and Figure 7 confirmed that Southern Africa had an almost decreasing trend in the spread and daily confirmed cases of the COVID-19 pandemic, and this may be the major reason for the stable trend of the African daily confirmed COVID-19 cases as the increase in the daily confirmed cases in the North, East, West, and Central Africa is counterpoised by the decreasing trend of Southern Africa daily confirmed new COVID-19 cases.

Except for Southern Africa, all African regions show an increasing trend in the predicted daily COVID-19 new cases,

Table 8: The prediction epidemic results of the new COVID-19 in Southern Africa for the next month as predicted by the ARIMA (4,1,5) model.

Date	Expected cases	Date	Expected cases
17/9/20	1601	2/10/2020	1557
18/9/20	2063	3/10/2020	1640
19/9/20	2109	4/10/2020	1414
20/9/20	1857	5/10/2020	1047
21/9/20	1346	6/10/2020	810
22/9/20	1026	7/10/2020	865
23/9/20	1037	8/10/2020	1157
24/9/20	1381	9/10/2020	1451
25/9/20	1732	10/10/2020	1522
26/9/20	1831	11/10/2020	1319
27/9/20	1573	12/10/2020	996
28/9/20	1157	13/10/2020	795
29/9/20	872	14/10/2020	857
30/9/20	917	15/10/2020	1125
01/10/20	1230	16/10/2020	1389

Source: own computation, 2021.

Table 9: The deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in Africa for the period between 17/9/2020–16/10/2020.

Date	Expected cases	Actual cases	Gap	Date	Expected cases	Actual cases	Gap
17/9/20	7256	8603	1347	2/10/2020	5800	8853	3053
18/9/20	7382	8167	785	3/10/2020	5804	8828	3024
19/9/20	7127	8727	1600	4/10/2020	5478	8089	2611
20/9/20	648	8420	7772	5/10/2020	5070	4709	-361
21/9/20	5779	6146	367	6/10/2020	4884	6601	1717
22/9/20	5382	6839	1457	7/10/2020	5051	10546	5495
23/9/20	5460	8726	3266	8/10/2020	5438	10904	5466
24/9/20	5838	8186	2348	9/10/2020	5758	8563	2805
25/9/20	6142	7978	1836	10/10/2020	5783	13531	7748
26/9/20	6082	6412	330	11/10/2020	5513	8978	3465
27/9/20	5658	8368	2710	12/10/2020	5167	5886	719
28/9/20	5151	5667	516	13/10/2020	5015	7834	2819
29/9/20	4901	7508	2607	14/10/2020	5173	11509	6336
30/9/20	5057	8433	3376	15/10/2020	5526	9115	3589
1/10/2020	5465	7265	1800	16/10/2020	5819	10682	4863

Source: own computation, 2021.

Table 10: The deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in East Africa for the period between 17/9/2020–16/10/2020.

Date	Expected cases	Actual cases	Gap	Date	Expected cases	Actual cases	Gap
17/9/20	1286	1408	122	2/10/2020	1454	1582	128
18/9/20	1476	1327	−149	3/10/2020	1438	1604	166
19/9/20	1166	1663	497	4/10/2020	1408	1786	378
20/9/20	1323	1526	203	5/10/2020	1442	970	−472
21/9/20	1443	1585	142	6/10/2020	1474	1076	−398
22/9/20	1359	1640	281	7/10/2020	1454	1614	160
23/9/20	1267	1351	84	8/10/2020	1447	1926	479
24/9/20	1383	1210	−173	9/10/2020	1479	1630	151
25/9/20	1440	1178	−262	10/10/2020	1492	1811	319
26/9/20	1351	1325	−26	11/10/2020	1477	1615	138
27/9/20	1337	1355	18	12/10/2020	1485	1208	−277
28/9/20	1427	1444	17	13/10/2020	1509	1258	−251
29/9/20	1434	1487	53	14/10/2020	1513	1906	393
30/9/20	1373	1320	−53	15/10/2020	1506	1646	140
01/10/20	1396	1357	−39	16/10/2020	1519	1456	−63

Source: own Computation, 2021.

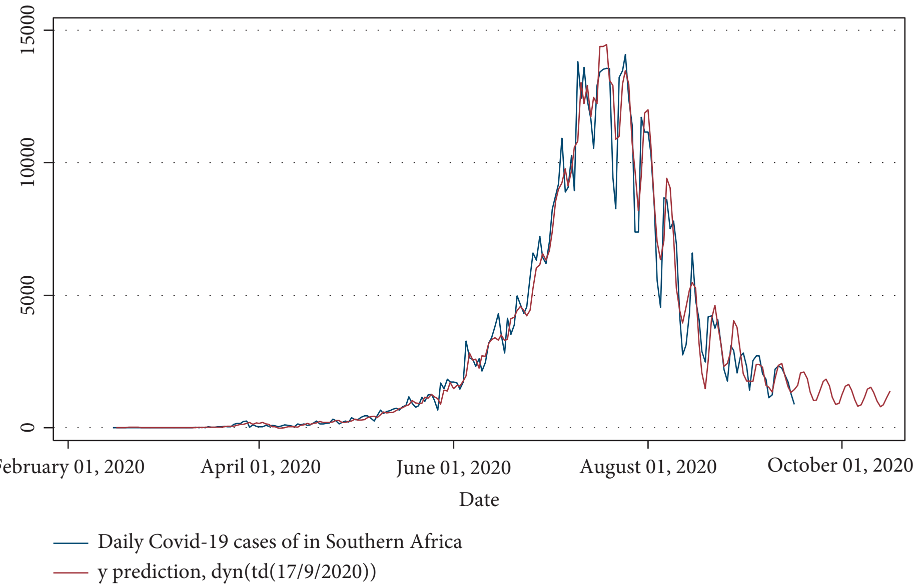

FIGURE 7: The plot of actual confirmed cases with the prediction results of the ARIMA model for Southern Africa.

TABLE 11: The deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in West Africa for the period between 17/9/2020–16/10/2020.

Date	Expected cases	Actual cases	Gap	Date	Expected cases	Actual cases	Gap
17/9/20	589	428	−161	2/10/2020	644	525	−119
18/9/20	643	649	6	3/10/2020	607	520	−87
19/9/20	619	601	−18	4/10/2020	632	288	−344
20/9/20	566	495	−71	5/10/2020	677	329	−348
21/9/20	584	423	−161	6/10/2020	667	378	−289
22/9/20	644	407	−237	7/10/2020	626	453	−173
23/9/20	643	555	−88	8/10/2020	632	484	−148
24/9/20	590	412	−178	9/10/2020	678	473	−205
25/9/20	585	573	−12	10/10/2020	686	468	−218
26/9/20	640	372	−268	11/10/2020	649	429	−220
27/9/20	661	586	−75	12/10/2020	638	399	−239
28/9/20	617	320	−297	13/10/2020	677	585	−92
29/9/20	593	454	−139	14/10/2020	700	564	−136
30/9/20	635	686	51	15/10/2020	672	494	−178
1/10/2020	672	442	−230	16/10/2020	649	515	−134

Source: own computation, 2021.

and specifically East and Northern Africa show a significant increasing trend in the spread of the COVID-19 pandemic.

3.2.3. The Deviation between the Forecasted and Actual Data on the Spread of Covid-19. As shown in Table 9, the sign of the forecasted values of COVID-19 cases in Africa and the actual values of the daily confirmed COVID-19-19 cases are similar, which is a positive or an increasing trend. Both values portray the increasing trends of the COVID-19-19 pandemic. However, in all cases, the forecasted values are lower than the actual values, or the ARIMA model prediction results underestimate the spread of COVID-19-19 in Africa.

At the subregional level, there is a deviation between the actual and the ARIMA model forecasted values of the daily COVID-19 cases, and the deviation is both on the sign and the size of the actual and forecasted values of the daily COVID-19 cases. Tables 10–14 present the deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in East Africa, West Africa, Central Africa, North Africa, and Southern Africa for the period between 17/9/2020–16/10/2020, respectively.

However, we can tolerate the minor difference between the actual and the ARIMA model forecasted values of COVID-19 daily confirmed cases, given the uncertain nature

Table 12: The deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in Central Africa for the period between 17/9/2020–16/10/2020.

Date	Expected cases	Actual cases	Gap	Date	Expected cases	Actual cases	Gap
17/9/20	184	169	−15	2/10/2020	220	266	46
18/9/20	206	242	36	3/10/2020	214	203	−11
19/9/20	209	153	−56	4/10/2020	207	43	−164
20/9/20	189	119	−70	5/10/2020	218	163	−55
21/9/20	199	323	124	6/10/2020	221	236	15
22/9/20	2145	157	−1988	7/10/2020	212	35	−177
23/9/20	200	257	57	8/10/2020	216	559	343
24/9/20	195	163	−32	9/10/2020	225	149	−76
25/9/20	214	157	−57	10/10/2020	218	239	21
26/9/20	211	132	−79	11/10/2020	216	150	−66
27/9/20	198	69	−129	12/10/2020	225	171	−54
28/9/20	210	201	−9	13/10/2020	225	209	−16
29/9/20	218	149	−69	14/10/2020	219	525	306
30/9/20	205	220	15	15/10/2020	225	271	46
1/10/2020	206	186	−20	16/10/2020	230	216	−14

Source: own computation, 2021.

Table 13: The deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in North Africa for the period between 17/9/2020–16/10/2020.

Date	Expected cases	Actual cases	Gap	Date	Expected cases	Actual cases	Gap
17/9/20	3588	4213	625	2/10/2020	3749	4648	899
18/9/20	3504	3746	242	3/10/2020	3783	4514	731
19/9/20	3571	4226	655	4/10/2020	3783	4303	520
20/9/20	3533	4582	1049	5/10/2020	3815	2283	−1532
21/9/20	3600	3095	−505	6/10/2020	3818	3842	24
22/9/20	3570	3183	−387	7/10/2020	3847	6387	2540
23/9/20	3629	4574	945	8/10/2020	3851	6326	2475
24/9/20	3607	4048	441	9/10/2020	3879	4776	897
25/9/20	3659	4467	808	10/10/2020	3887	8391	4504
26/9/20	3643	3530	−113	11/10/2020	3911	5150	1239
27/9/20	3690	4963	1273	12/10/2020	3920	2857	−1063
28/9/20	3678	2535	−1143	13/10/2020	3944	4562	618
29/9/20	3720	4474	754	14/10/2020	3953	6776	2823
30/9/20	3714	4276	562	15/10/2020	3976	4483	507
1/10/2020	3752	3360	−392	16/10/2020	3987	5017	1030

Source: own computation, 2021.

Table 14: The deviation between the actual and forecasted values of the daily confirmed COVID-19 cases in Southern Africa for the period between 17/9/2020–16/10/2020.

Date	Expected cases	Actual cases	Gap	Date	Expected cases	Actual cases	Gap
17/9/20	1601	2382	781	2/10/2020	1557	1918	361
18/9/20	2063	2271	208	3/10/2020	1640	1984	344
19/9/20	2109	2144	35	4/10/2020	1414	1669	255
20/9/20	1857	1698	−159	5/10/2020	1047	964	−83
21/9/20	1346	887	−459	6/10/2020	810	1065	255
22/9/20	1026	1452	426	7/10/2020	865	2057	1192
23/9/20	1037	2081	1044	8/10/2020	1157	1884	727
24/9/20	1381	2371	990	9/10/2020	1451	1535	84
25/9/20	1732	1603	−129	10/10/2020	1522	2622	1100
26/9/20	1831	1072	−759	11/10/2020	1319	1634	315
27/9/20	1573	1395	−178	12/10/2020	996	1251	255
28/9/20	1157	1270	113	13/10/2020	795	1219	424
29/9/20	872	943	71	14/10/2020	857	1976	1119
30/9/20	917	1931	1014	15/10/2020	1125	2221	1096
01/10/20	1230	1915	685	16/10/2020	1389	3472	2083

Source: own computation, 2021.

of the current COVID-19 pandemic and the growing interconnected and complex world, which are ultimately demanding flexibility, robustness, and resilience to cope with unexpected future events and scenarios [27].

4. Conclusion

The pattern of daily confirmed new cases of the COVID-19 pandemic is forecasted by using the ARIMA model strategy to help the efforts of the World Health Organization, African Union, Africa Centers for Disease Control and Prevention (CDC Africa), African regional organizations (IGAD, ECOWAS, COMESA, ECCAS, SADC), and other stakeholders to control the further spread of coronavirus in Africa. The prediction of the number of infections would assist policymakers in a specific region to assess their current healthcare capacity and decide which measures need to be taken to curb and control the spread of COVID-19 [28].

Based on the available data, the study found that the best prediction models for forecasting the trend of daily new confirmed COVID-19 cases are ARIMA (3,1,4), ARIMA (3,1,3), ARIMA (2,1,3), ARIMA (2,1,3), ARIMA (1,1,4), and ARIMA (4,1,5). The prediction models are considered best for Africa as a continent, East Africa, West Africa, Central Africa, North Africa, and Southern Africa, respectively. By adopting this model, we were able to predict the daily confirmed new COVID-19 cases for the period between 17/9/2020 and 16/10/2020.

Given the uncertain nature of the current COVID-19 pandemic and the world's growing interconnectedness and complexity, the proposed method's experimental results match the actual COVID-19 daily case data to demonstrate the proposed model's realistic nature. As a result, the ARIMA model's forecasting will help in prioritizing and promoting regional cooperation in formulating policies to address the COVID-19 pandemic and employing effective strategies to control the virus by incorporating the experience of those regions that have seen a declining trend, such as Southern Africa.

Abbreviations

ARIMA:	Autoregressive integrated moving average
AIC:	Akaike information criteria
BIC:	Bayesian information criterion
IGAD:	Intergovernmental authority for development
ECOWAS:	Economic community of West African states
COMESA:	Common market for Eastern and Southern Africa
ECCAS:	Economic community of Central African states
SADC:	Southern African development community.

Data Availability

The daily confirmed COVID-19 cases were retrieved from the official website of our world in data. Retrieved from the: https://covid.ourworldindata.org/data/owid-covid-data.xlsx.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

Both authors contributed equally to this paper.

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