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Forecasting Covid-19 New Cases in Bolivia

[1]Dr. Smartson. P. NYONI, [2]Mr. Thabani NYONI, [3]Mr. Tatenda. A. CHIHOHO

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]SAGIT Innovation Center, Harare, Zimbabwe
[3]Independent Health Economist, Harare, Zimbabwe

***Abstract* - The outbreak of COVID-19 is a public health emergency of international concern. Healthcare professionals of various disciplines are addressing the problem of controlling the spread of the virus while reducing the negative effect on the economy and society. In this research article, the ANN approach was applied to analyze COVID-19 cases in Bolivia. This study is based on daily new cases of COVID-19 in Bolivia for the period 1 January 2020 – 25 March 2021. The out-of-sample forecast covers the period 26 March 2021 – 31 July 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied basic ANN model indicate that the model is stable. Our findings show that daily COVID-19 cases will remain significantly high in the out-of-sample period. We encourage the government of Bolivia to continue enforcing control and preventive measures suggested by WHO, for example, face-mask wearing, social distancing, isolations, and quarantine as well as vaccinations.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

COVID-19, known to have originated from Wuhan city in Hubei Province in China, is caused by a novel coronavirus, widely recognized as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Ng *et al*., 2020). Being declared by WHO as a pandemic, the novel coronavirus is now a major emergency worldwide (Haghanifar *et al*., 2020). The virus is transmitted from one person to another by respiratory droplets or close contact with a contaminated surface (WHO, 2020). The most common symptoms are fever, cough, and dyspnea, which may appear 2 – 14 days after exposure to virus (Kanne *et al*., 2020). Optimal decision making in the context of COVID-19 pandemic is a complex process (Alamo *et al*., 2020) that requires the use of reliable predictive models such as Artificial Neural Network (ANN) models. In fact, in a state of pandemic, the ability to accurate forecast caseload is extremely important to help inform policy makers on how to allocate limited healthcare resources, rapidly control the outbreak and ensure the safety of the general public (Kapoor *et al*., 2020; Li *et al*., 2020). For decision makers in Uruguay, one of the biggest challenges posed by the virus is how the pandemic will behave in the coming months. This study seeks to model and forecast COVID-19 cases in Bolivia using a basic ANN model.

II. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting new COVID-19 cases Bolivia.

Data Issues

This study is based on daily new cases of COVID-19 in Bolivia for the period 1 January 2020 – 25 March 2021.The out-of-sample forecast covers the period 26 March 2021 – 31 July 2021.All the data employed in this research paper was gathered from the Johns Hopkins University (USA).

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III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	B
Observations	438 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.113609
MSE	32721.701284
MAE	139.058990

Residual Analysis for the Applied Model

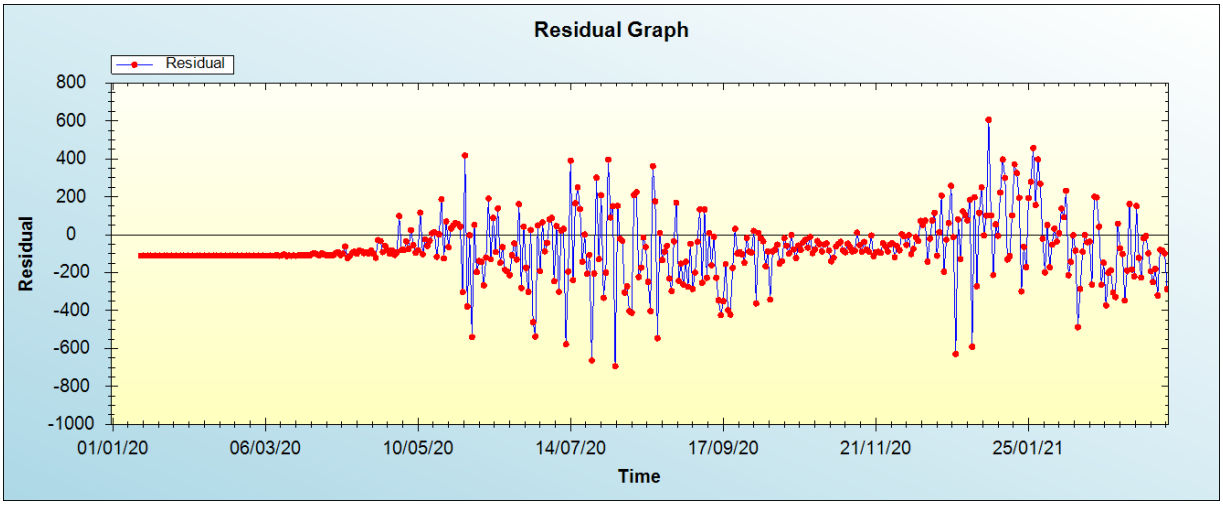

Figure 1: Residual analysis

In-sample Forecast for B

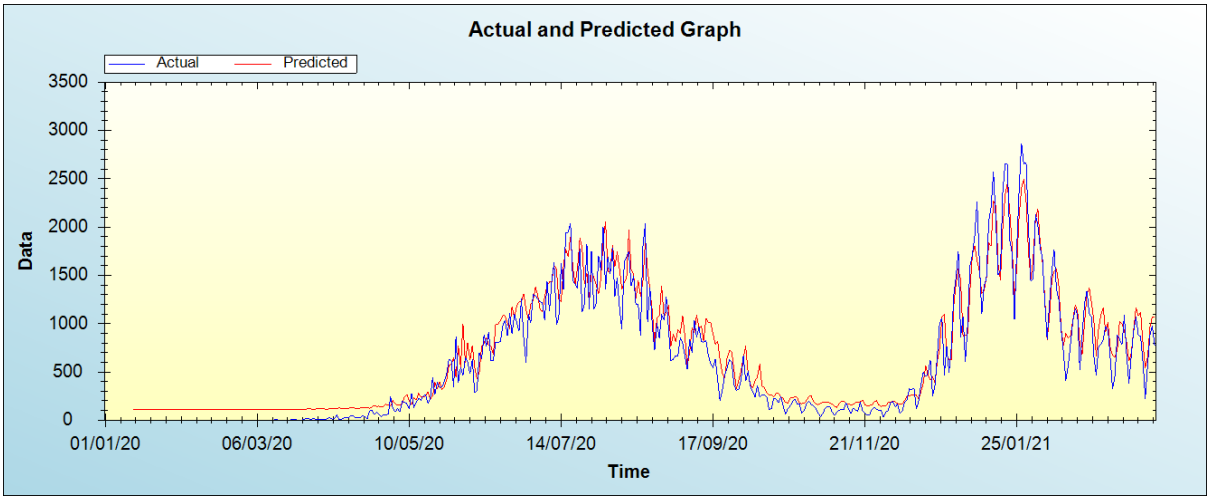

Figure 2: In-sample forecast for the B series

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

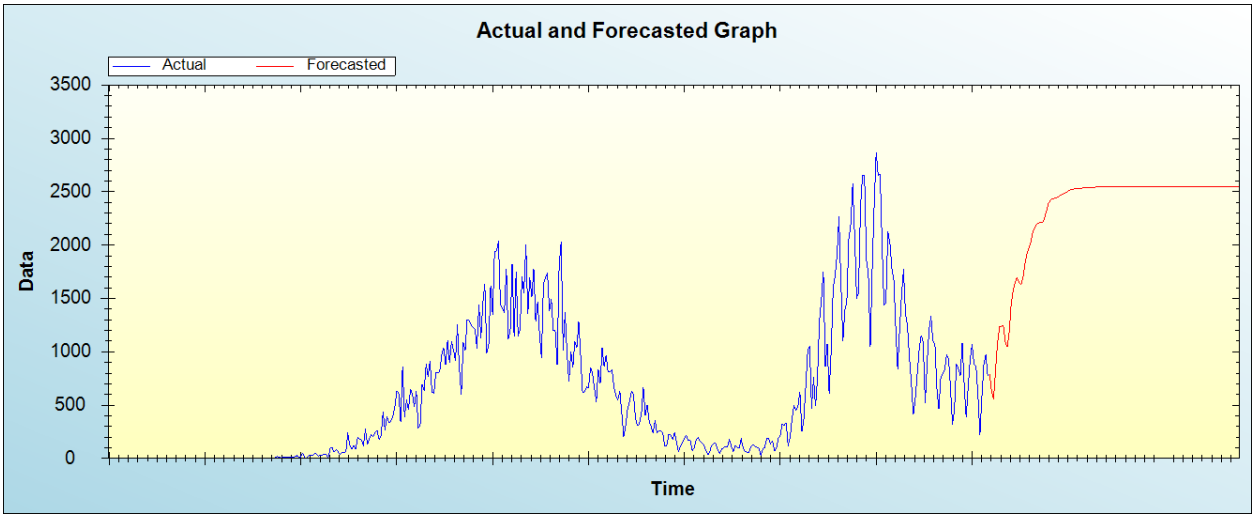

Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
26/03/21	792.2399
27/03/21	624.3051
28/03/21	561.4640
29/03/21	829.0409
30/03/21	1078.6937
31/03/21	1234.6507
01/04/21	1237.3868
02/04/21	1245.9517
03/04/21	1088.5099
04/04/21	1049.8032
05/04/21	1191.7122
06/04/21	1452.1328
07/04/21	1576.3531
08/04/21	1650.5908
09/04/21	1696.8506
10/04/21	1646.7029
11/04/21	1631.6024
12/04/21	1687.7901
13/04/21	1827.5408
14/04/21	1915.2397
15/04/21	1967.0715
16/04/21	2029.6202
17/04/21	2120.5756
18/04/21	2162.0752
19/04/21	2198.7548
20/04/21	2207.3397
21/04/21	2214.9629
22/04/21	2210.8833
23/04/21	2251.4583
24/04/21	2317.3935
25/04/21	2389.8944
26/04/21	2419.1244
27/04/21	2434.2101
28/04/21	2436.5488
29/04/21	2442.0152
30/04/21	2449.6837
01/05/21	2463.8595

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02/05/21	2473.4962
03/05/21	2482.4584
04/05/21	2491.2100
05/05/21	2505.4034
06/05/21	2517.0688
07/05/21	2522.5156
08/05/21	2524.6420
09/05/21	2525.6790
10/05/21	2527.2731
11/05/21	2529.8409
12/05/21	2533.2421
13/05/21	2535.9844
14/05/21	2537.6964
15/05/21	2538.4885
16/05/21	2539.8403
17/05/21	2541.0948
18/05/21	2541.9968
19/05/21	2542.5579
20/05/21	2542.9622
21/05/21	2543.2705
22/05/21	2543.6238
23/05/21	2544.0410
24/05/21	2544.4488
25/05/21	2544.7008
26/05/21	2544.7907
27/05/21	2544.9244
28/05/21	2545.0582
29/05/21	2545.1857
30/05/21	2545.2828
31/05/21	2545.3607
01/06/21	2545.4091
02/06/21	2545.4487
03/06/21	2545.4883
04/06/21	2545.5409
05/06/21	2545.5773
06/06/21	2545.5941
07/06/21	2545.6107
08/06/21	2545.6257
09/06/21	2545.6410
10/06/21	2545.6540
11/06/21	2545.6657
12/06/21	2545.6737
13/06/21	2545.6788
14/06/21	2545.6824
15/06/21	2545.6887
16/06/21	2545.6935
17/06/21	2545.6965
18/06/21	2545.6988
19/06/21	2545.7007
20/06/21	2545.7025
21/06/21	2545.7040
22/06/21	2545.7055
23/06/21	2545.7068
24/06/21	2545.7076
25/06/21	2545.7079
26/06/21	2545.7087
27/06/21	2545.7092
28/06/21	2545.7097
29/06/21	2545.7100
30/06/21	2545.7103
01/07/21	2545.7105
02/07/21	2545.7107
03/07/21	2545.7109
04/07/21	2545.7111

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05/07/21	2545.7112
06/07/21	2545.7112
07/07/21	2545.7113
08/07/21	2545.7114
09/07/21	2545.7114
10/07/21	2545.7115
11/07/21	2545.7115
12/07/21	2545.7116
13/07/21	2545.7116
14/07/21	2545.7116
15/07/21	2545.7116
16/07/21	2545.7116
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25/07/21	2545.7117
26/07/21	2545.7117
27/07/21	2545.7117
28/07/21	2545.7117
29/07/21	2545.7117
30/07/21	2545.7117
31/07/21	2545.7117

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that daily COVID-19 cases in Bolivia are likely to remain very high over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Access to accurate outbreak prediction models is important to obtain insights into the likely spread and consequences of infectious diseases. Governments and other legislative bodies rely on insights from prediction models to suggest new policies and to assess the effectiveness of the enforced policies (Remuzzi & Remuzzi, 2020). Therefore, in order to prepare, understand and control the spread of the disease, researchers globally have come together in a collaborative effort to model and forecast COVID-19 (Kapoor *et al*., 2020). Consistently, in this work, we use a generalized ANN (12, 12, 1) model to analyze daily COVID-19 cases in Bolivia. Our findings show that daily COVID-19 cases will remain significantly high in the out-of-sample period. We encourage the government of Bolivia to continue enforcing control and preventive measures suggested by WHO, for example, face-mask wearing, social distancing, isolations, and quarantine as well as vaccinations.

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