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Forecasting Covid-19 New Cases in Montenegro

[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* - In this study, the ANN approach was applied to analyze COVID-19 new cases in Montenegro. The employed data covers the period 1 January 2020 – 25 March 2021 and the out-of-sample period ranges over the period 26 March – 31 July 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is quite stable. The results of the study indicate that daily COVID-19 cases in Montenegro are likely to remain high over the out-of-sample period. Amongst other suggested policy directions, there is need for the government of Montenegro to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic.**

Keywords: ANN, COVID-19, Forecasting,

I. INTRODUCTION

In late December 2019, a deadly novel corona virus (SARS-COV2) was detected in Wuhan, China after reports of unexplained pneumonia cases (Djurovic et al, 2020; CDC, 2020; Wang et al, 2020). The virus was then known to cause corona virus disease 2019 (COVID-19) (He et al, 2020). The virus rapidly spread to all the parts of the world with many people falling sick and dying from the disease. Elderly people, people with preexisting medical conditions were among the people who had severe disease and at high risk of dying from the deadly virus. The pandemic has disrupted many economic activities around the globe as the pandemic led to the closure of businesses, schools, temporary ban on public gatherings and sporting activities. Montenegro is a small European country which heavily relies on the tourism industry (Djurovic et al, 2020). The tourism industry was severely affected by the pandemic. There was a decline in imports and investment due to COVID-19 related disruptions. Public finances are under pressure due to the huge costs to finance the government's response to the pandemic. Montenegro reported the first case of COVID-19 on the 17th of March 2020 (ILO, 2020). The government responded to the COVID-19 pandemic by imposing lockdown and enforcement of WHO protocols on prevention and control of COVID-19.The purpose of this study is to model and predict daily COVID-19 cases in Montenegro using the artificial neural network approach. This machine learning technique is now popular in time series forecasting of emerging infectious diseases and other health related problems (Maradze etal, 2021; Nyoni et al, 2021, Nyoni & Nyoni, 2021; Nyoni et al, 2020; Zhao et al, 2020). The findings of this study are envisioned to reveal future trends of COVID-19 and stimulate an evidence based response to the epidemic.

II. LITERATURE REVIEW

Djurovic et al (2020) y examined, diagnosed, and assessed appropriate macroeconomic policy responses of the Montenegrin Government to the outbreak of COVID-19. The model econometrically measured the macroeconomic costs using a Bayesian VARX Litterman/ Minessota prior to the pandemic disease in terms of demand and supply loss due to illness and closed activities and their effects on GDP growth in various pandemic scenarios. The study explored five economic scenarios—shocks—using the available data from January 2006 to December 2019, following real out-of-sample forecasts generated from January 2020 to December 2020. The results of the study revealed that there was a toll on the GDP, tourism, unemployment, capital stock, and especially human capital for 2020. On the other hand, Kriston et al (2020) modelled cumulative coronavirus disease 2019 (COVID-19) case growth in various regions. Publicly available time series data of cumulative COVID-19 cases form the John Hopkins University were used including reports up to 29 March 2020. A Bayesian hierarchical five parameter logistic model was fit to observed data to estimate and project the cumulative number of cases in all regions and countries listed in the John Hopkins University dataset with at least one case. The proposed model approximated the observed numbers of COVID19 cases very well and could be used to derive predictions. Pais & Taveira (2020) in Portugal predicted the evolution of the COVID-19 epidemic. The authors developed a mathematical model to estimate the strength of Government-Imposed Measures (GIM) and predict the impact of the degree of compliance on the number of infected cases and peak of infection. The estimated peak was expected to be around 650 thousand infected cases with 53 thousand requiring hospital care by the beginning of May if no measures were taken.

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The SIR model was applied by Silva (2020) to model COVID-19 in Cape Verde Islands. Observations made after the date of the simulations were carried out corroborated the model projections.

III. 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 Montenegro.

Data Issues

This study is based on daily new cases of COVID-19 in Montenegro 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).

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	M
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	0.152399
MSE	5475.727126
MAE	45.863560

Residual Analysis for the Applied Model

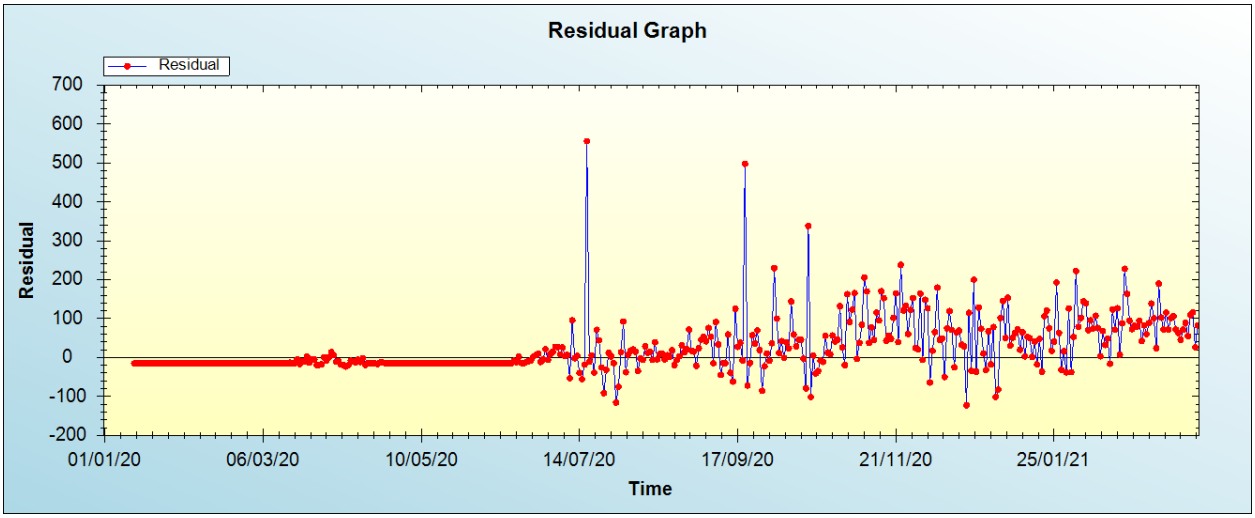

Figure 1: Residual analysis

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In-sample Forecast for M

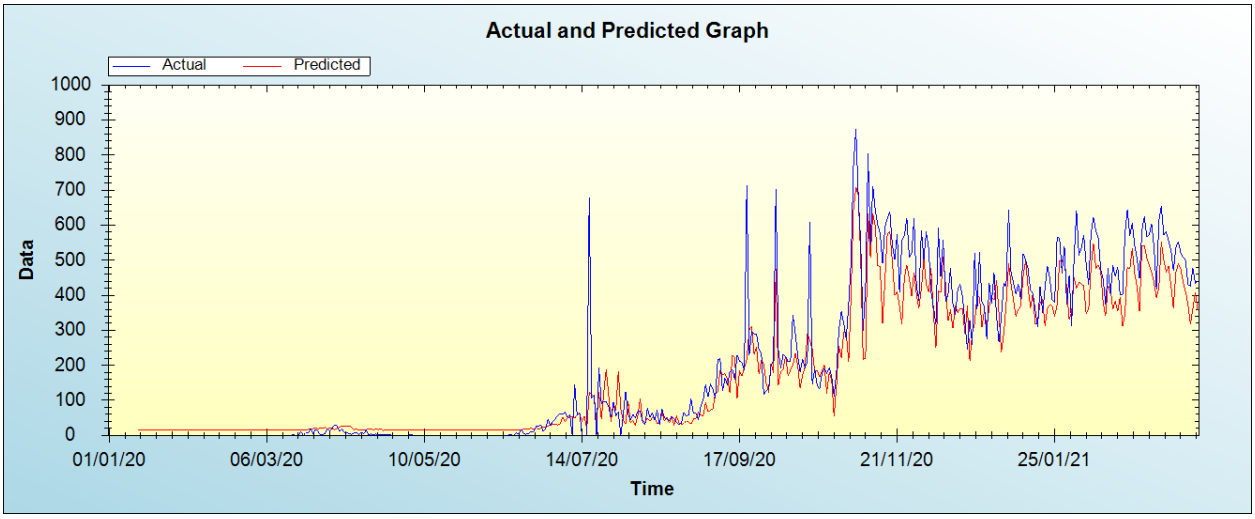

Figure 2: In-sample forecast for the M series

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

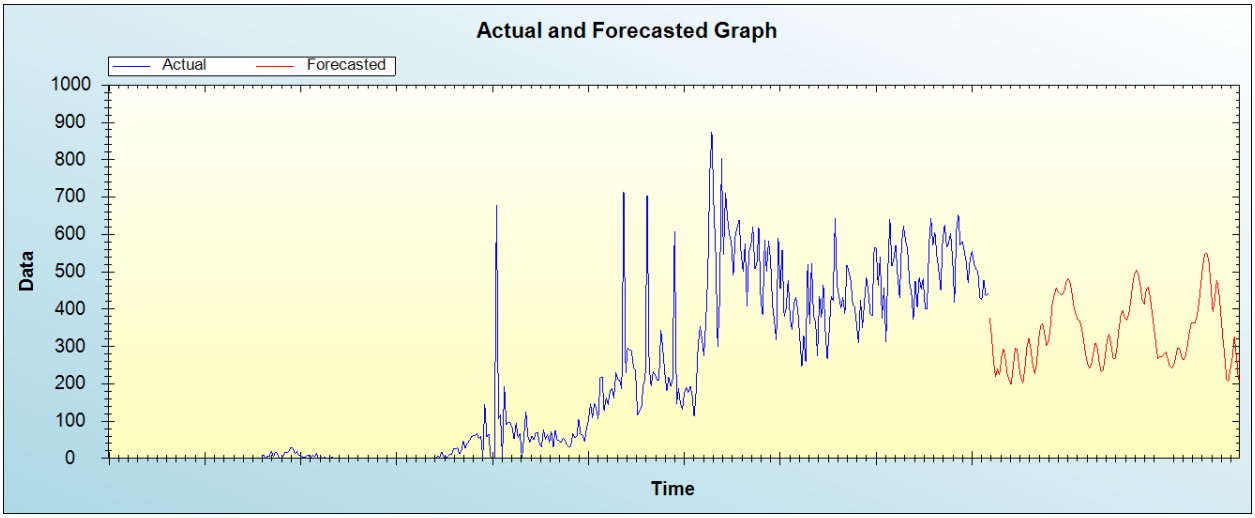

Figure 3: Out-of-sample forecast for M: actual and forecasted graph

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
26/03/21	375.1745
27/03/21	329.6326
28/03/21	261.0950
29/03/21	218.5843
30/03/21	239.8870
31/03/21	224.7048
01/04/21	270.0855
02/04/21	294.3070
03/04/21	267.7463
04/04/21	223.8723
05/04/21	211.2041
06/04/21	197.9184
07/04/21	246.2472
08/04/21	294.0012
09/04/21	292.8499

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10/04/21	243.3828
11/04/21	215.3776
12/04/21	201.5553
13/04/21	241.4610
14/04/21	299.2310
15/04/21	320.5663
16/04/21	292.0112
17/04/21	251.1183
18/04/21	226.8029
19/04/21	255.1133
20/04/21	315.0317
21/04/21	355.0121
22/04/21	361.4095
23/04/21	336.0342
24/04/21	303.0952
25/04/21	311.2684
26/04/21	351.6215
27/04/21	411.7958
28/04/21	438.4557
29/04/21	456.8169
30/04/21	445.4197
01/05/21	440.3857
02/05/21	437.5997
03/05/21	446.5643
04/05/21	469.9302
05/05/21	481.5844
06/05/21	473.1852
07/05/21	443.6407
08/05/21	407.3210
09/05/21	384.6707
10/05/21	371.1704
11/05/21	368.5213
12/05/21	348.6978
13/05/21	316.8619
14/05/21	281.3528
15/05/21	252.7504
16/05/21	241.5707
17/05/21	251.4612
18/05/21	282.8793
19/05/21	309.6336
20/05/21	297.3768
21/05/21	257.0637
22/05/21	232.3005
23/05/21	237.4485
24/05/21	274.0105
25/05/21	317.1568
26/05/21	332.6864
27/05/21	306.9192
28/05/21	269.7528
29/05/21	267.1655
30/05/21	295.2646
31/05/21	346.3773
01/06/21	383.3235
02/06/21	396.0400
03/06/21	376.1753
04/06/21	370.0254
05/06/21	384.4665
06/06/21	418.5559
07/06/21	465.0916
08/06/21	494.3508
09/06/21	504.6029
10/06/21	491.0705
11/06/21	463.1433
12/06/21	424.3681

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13/06/21	412.9617
14/06/21	451.7072
15/06/21	458.1004
16/06/21	432.9411
17/06/21	391.0484
18/06/21	348.2101
19/06/21	303.8558
20/06/21	267.6028
21/06/21	273.8801
22/06/21	273.2772
23/06/21	278.6595
24/06/21	285.4666
25/06/21	267.0735
26/06/21	246.5896
27/06/21	242.8490
28/06/21	249.6450
29/06/21	270.4617
30/06/21	296.0519
01/07/21	295.5821
02/07/21	272.1892
03/07/21	263.7876
04/07/21	273.6101
05/07/21	299.2679
06/07/21	336.5367
07/07/21	362.6666
08/07/21	363.7254
09/07/21	363.7751
10/07/21	383.2587
11/07/21	419.7583
12/07/21	470.5360
13/07/21	519.9526
14/07/21	548.0595
15/07/21	550.0304
16/07/21	525.9715
17/07/21	464.5097
18/07/21	392.8890
19/07/21	424.7000
20/07/21	477.6590
21/07/21	450.0159
22/07/21	394.8741
23/07/21	329.6101
24/07/21	277.6263
25/07/21	212.5367
26/07/21	205.7314
27/07/21	241.0150
28/07/21	268.8096
29/07/21	326.5962
30/07/21	280.1645
31/07/21	211.9327

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 Montenegro are likely to remain high over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

COVID-19 forecasting is increasing exponentially with many studies applying statistical and machine learning techniques. ARIMA, exponential smoothing models and machine learning methods are some of the widely applied techniques. However, hybrid models have been found to have better predictive accuracy. In this study we applied the most popular artificial neural network framework, the Multilayer perceptron (MLP) which is based on the back propagation algorithm. The results of the study indicate that daily COVID-19 cases in Montenegro are likely to remain high over the out-of-sample period. Therefore the authorities are advised to ensure adherence to COVID-19 public health mitigation measures.

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