

PREDICTION OF COVID-19 CASES IN ECUADOR USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Ecuador is one the most affected Latin American countries by the COVID-19 pandemic. The virus has caused devastating consequences throughout the country. In this paper, the ANN technique was applied to analyze daily COVID-19 case volumes in Ecuador. The employed data covers the period March 1, 2020 to October 31, 2020 and the out-of-sample period ranges over the period November 2020 April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model suggest that the model is stable for forecasting COVID-19 cases in Ecuador. The forecasts of this research suggest that COVID-19 daily cases in Ecuador will briefly continue on a downward trend from the estimated 956 cases on November 1, 2020 until an equilibrium case volume of approximately 619 cases per day is reached around January 8, 2021. This equilibrium case volume is likely to be recorded for the remaining part of the out-of-sample period. Finally, we encourage the government of Ecuador to continue enforcing and implementing control and preventive measures in order to avoid a possibility of a second wave of infections.

Keywords: - ANN, COVID-19, Forecasting

INTRODUCTION & BRIEF BACKGROUND

COVID-19 has wrecked havoc on a global scale (Pacheco *et al.*, 2020). Its first outbreak occurred in in the city of Wuhan, China, in the tail end of 2019 (Wang *et al.*, 2020; Wu *et al.*, 2020). COVID-19 is mainly transmitted by person-to-person contact (Coccia, 2020; Ma *et al.*, 2020). In order to mitigate the spread of the virus, affected countries around the world have been enforcing and implementing social distancing and lockdown measures (Lau *et al.*, 2020; Wilder-Smith & Freedman, 2020). Ecuador's first COVID-19 case was officially recorded on March 1, 2020. The infected person was a 70 years old woman coming from Spain, who landed on Ecuador on February 14, 2020. Since then, there has been a dramatic increase in the number of confirmed cases in the country (Bustamante-Orellana *et al.*, 2020). Almost 2 weeks later, the country declared a state of emergency, which entailed a suspension of school activities and a ban on gatherings of people more than 250. From March 17, 2020, the government of Ecuador increased social distancing measures by progressively restricting in-country mobility. Later on, local governments were given the authority to decide when and how to move from more restrictive to less restrictive (Government of Ecuador, 2020). Despite the fact that there is vast

literature on COVID-19, few studies have been done focusing on Ecuador, for example, Ortiz & Sharma (2020), Bustamante-Orellana *et al.* (2020) as well as Bajana *et al.* (2020). Ortiz & Sharma (2020), using SIR models, predicted that over 50000 COVID-19 cases could be recorded by July 25, 2020 and that hospital and bed needs for COVID-19 will definitely exceed the capacity in Ecuador. Based on SEAIR type epidemic models, Bustamante-Orellana *et al.* (2020) found out that provinces with high population density can avoid a large disease burden if they initiate early and stricter quarantine measures even under low isolation rate. Bajana *et al.* (2020) established that the SIR and SEIRD models are good at predicting the behavior of the virus. The authors suggest that the pandemic would remain highly prevalent in the country especially if strict measures are not properly undertaken. In order to reduce uncertainty and increase efficiency in decision making by the government of Ecuador, this study seeks to model and forecast daily COVID-19 cases in the country from March 1, 2020 to October 31, 2020.

METHODOLOGY

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Ecuador. The study particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. This piece of work is specifically based on daily new Covid19 cases (referred to series in this study) for all age groups in Ecuador. The data covers the period 1 March 2020 to 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this paper was gathered from the COVID-19 data repository prepared by the CSSE at JH University.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
776.83	661.00	0.00000	11536.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
998.38	1.2852	6.7084	63.739
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	1823.2	808.00	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN ECUADOR

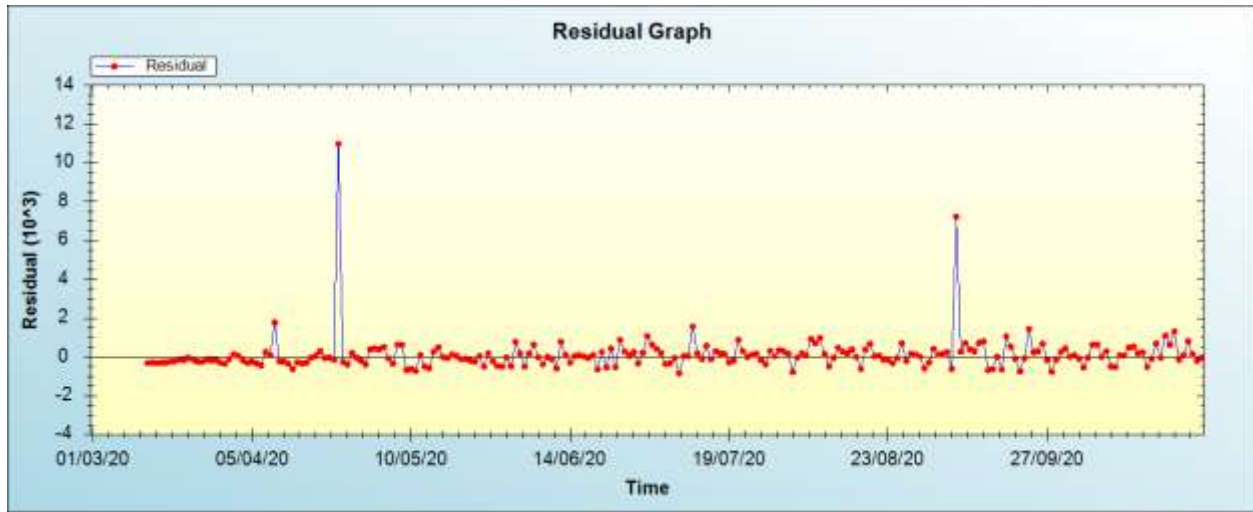
Table 2: ANN model summary

Variable	EC
Observations	233 (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	0.0151211
MSE	939142.150234
MAE	411.381428

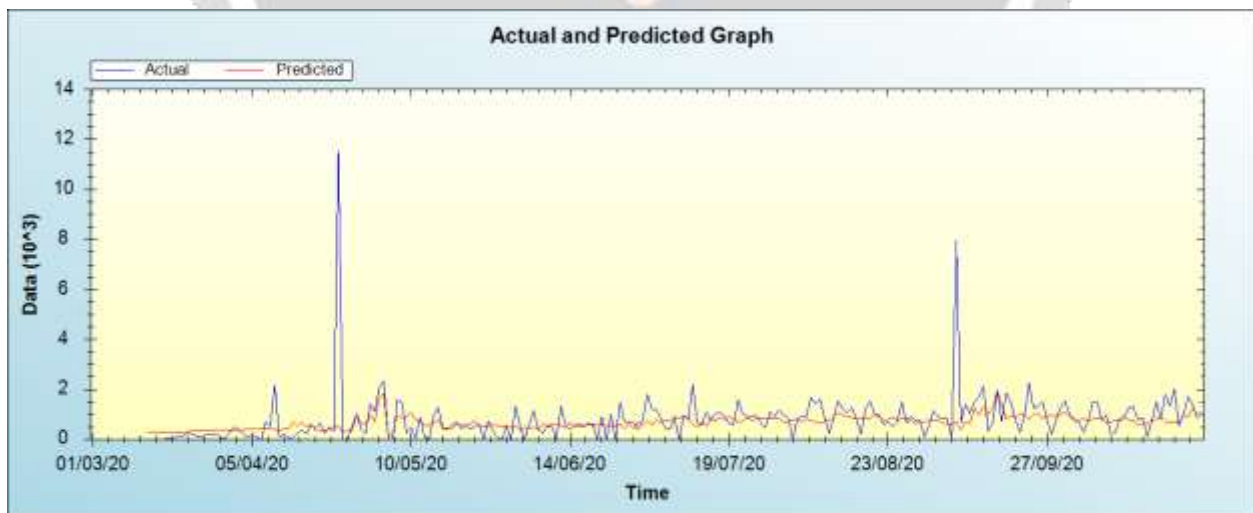
Residual Analysis for the ANN model

Figure 1: Residual analysis



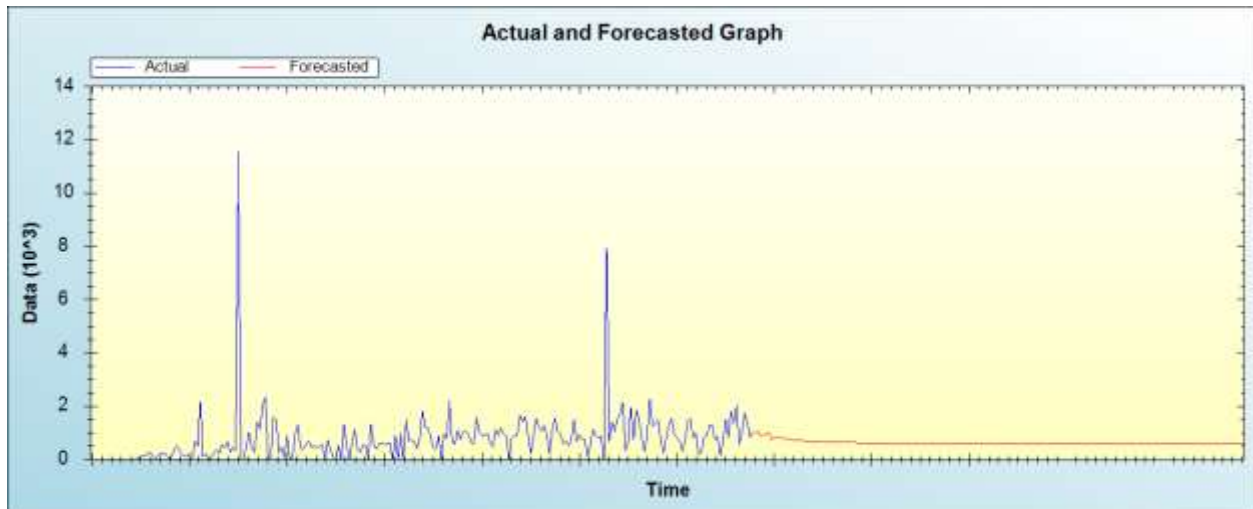
In-sample Forecast for EC

Figure 2: In-sample forecast for the EC series



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

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



Out-of-Sample Forecast for EC: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	955.7212
02/11/20	1077.3028
03/11/20	870.5423
04/11/20	943.3788
05/11/20	956.3499
06/11/20	1028.1331
07/11/20	755.8063
08/11/20	808.1718
09/11/20	836.9921
10/11/20	860.0354
11/11/20	773.2550
12/11/20	794.4123
13/11/20	760.0220
14/11/20	780.0427

15/11/20	723.2335
16/11/20	726.7244
17/11/20	723.8342
18/11/20	737.8769
19/11/20	698.0562
20/11/20	698.9284
21/11/20	688.9806
22/11/20	692.5425
23/11/20	676.2577
24/11/20	676.5127
25/11/20	668.8763
26/11/20	671.3010
27/11/20	659.5100
28/11/20	657.3684
29/11/20	653.1664
30/11/20	654.1218
01/12/20	647.6856
02/12/20	646.5655
03/12/20	642.9534
04/12/20	642.5794
05/12/20	638.8165
06/12/20	637.7105
07/12/20	635.4742
08/12/20	635.2288
09/12/20	632.8286
10/12/20	631.8690

11/12/20	630.3139
12/12/20	629.8627
13/12/20	628.4138
14/12/20	627.7915
15/12/20	626.7490
16/12/20	626.3452
17/12/20	625.4081
18/12/20	624.9012
19/12/20	624.2025
20/12/20	623.8887
21/12/20	623.2897
22/12/20	622.9355
23/12/20	622.4652
24/12/20	622.2047
25/12/20	621.8083
26/12/20	621.5546
27/12/20	621.2396
28/12/20	621.0494
29/12/20	620.7881
30/12/20	620.6047
31/12/20	620.3906
01/01/21	620.2489
02/01/21	620.0735
03/01/21	619.9454
04/01/21	619.8014
05/01/21	619.6987



06/01/21	619.5801
07/01/21	619.4890
08/01/21	619.3909
09/01/21	619.3176
10/01/21	619.2374
11/01/21	619.1736
12/01/21	619.1068
13/01/21	619.0545
14/01/21	618.9997
15/01/21	618.9549
16/01/21	618.9094
17/01/21	618.8726
18/01/21	618.8351
19/01/21	618.8038
20/01/21	618.7726
21/01/21	618.7467
22/01/21	618.7210
23/01/21	618.6991
24/01/21	618.6777
25/01/21	618.6596
26/01/21	618.6420
27/01/21	618.6267
28/01/21	618.6120
29/01/21	618.5994
30/01/21	618.5872
31/01/21	618.5766

01/02/21	618.5665
02/02/21	618.5577
03/02/21	618.5493
04/02/21	618.5419
05/02/21	618.5349
06/02/21	618.5288
07/02/21	618.5230
08/02/21	618.5179
09/02/21	618.5131
10/02/21	618.5088
11/02/21	618.5048
12/02/21	618.5012
13/02/21	618.4979
14/02/21	618.4950
15/02/21	618.4922
16/02/21	618.4897
17/02/21	618.4874
18/02/21	618.4854
19/02/21	618.4835
20/02/21	618.4818
21/02/21	618.4802
22/02/21	618.4788
23/02/21	618.4774
24/02/21	618.4762
25/02/21	618.4751
26/02/21	618.4742

27/02/21	618.4732
28/02/21	618.4724
01/03/21	618.4717
02/03/21	618.4710
03/03/21	618.4704
04/03/21	618.4698
05/03/21	618.4693
06/03/21	618.4688
07/03/21	618.4683
08/03/21	618.4679
09/03/21	618.4676
10/03/21	618.4673
11/03/21	618.4670
12/03/21	618.4667
13/03/21	618.4664
14/03/21	618.4662
15/03/21	618.4660
16/03/21	618.4658
17/03/21	618.4656
18/03/21	618.4655
19/03/21	618.4653
20/03/21	618.4652
21/03/21	618.4651
22/03/21	618.4650
23/03/21	618.4649
24/03/21	618.4648

25/03/21	618.4647
26/03/21	618.4646
27/03/21	618.4645
28/03/21	618.4645
29/03/21	618.4644
30/03/21	618.4644
31/03/21	618.4643
01/04/21	618.4643
02/04/21	618.4642
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26/04/21	618.4639
27/04/21	618.4639
28/04/21	618.4639
29/04/21	618.4639
30/04/21	618.4639

The average number of daily COVID-19 cases in Ecuador over the period under study is 777 cases per day while the maximum is 11536 cases. These are alarming number for the country and they warrant strict measures to be put in place. The employed model architecture is summarized in table 2 and its diagnostics are shown in figure 1; clearly the model is stable as its residuals are as small as possible. Figure 2 presents in-sample forecasts while figure 3 and table 3 show out-of-sample predictions. Our forecasts suggest that COVID-19 daily cases in Ecuador will briefly continue on a downward trend from the estimated 956 cases on November 1, 2020 until an equilibrium case volume of approximately 619 cases per day is reached around January 8, 2021. This equilibrium case volume is projected to be recorded for the remaining part of the out-of-sample period. The results of the study are generally in line with previous studies such as Ortiz & Sharma (2020) and Bajana *et al.* (2020). The results of this study are also an answer to the question asked by Ortiz & Sharma (2020), “is it the right time to lift social distancing containment measures?” – the study suggests that it’s not yet the right time to do so; given the current forecasts. If social distancing is lifted, Ecuador could experience a more devastating “second-wave” of infections and that is not a desirable public health outcome. In the interest of public health, Ecuadorians are advised to behave responsibly with regards to strictly following sanitary rules as put forward by the World Health Organization (WHO).

CONCLUSION & RECOMMENDATIONS

The COVID-19 pandemic has spread very quickly worldwide and Ecuador, just like other Latin American countries; has not been able to escape. One of the questions that have been asked by the government of Ecuador is hinged on the nature of the future trend of the pandemic. The government continues to be concerned about the future trend of the pandemic because they need to plan ahead in order to control and or prevent the virus from further devastating the country. In a bid to help the government of Ecuador in fighting against the COVID-19 pandemic, we used a basic ANN (12, 12, 1) model to analyze COVID-19 daily cases in the country based on 245 daily observations ranging over the period March 1, 2020 to 31 October 2020. Our data set is large

enough for us to derive reliable policy prescriptions from our analysis. Eventually, we encourage the government of Ecuador to continue enforcing and implementing control and preventive measures in order to avoid a possibility of a second wave of the pandemic.

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