PREDICTION OF DAILY NEW COVID-19 CASES IN SWEDEN USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In this research article, the ANN approach was applied to analyze daily new COVID-19 cases in Sweden. The employed data covers the period 1 February 2020 to 31 October 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting daily new coronavirus cases in Sweden. The results of the study indicate that the projected number of daily new COVID-19 cases will generally increase from about 770 cases around November1, 2020 up to a plateau point around 8 December 2020, where daily new cases are expected to remain constant at around 5250 cases until 30 April, 2021.The Swedish government must strictly enforce adherence to WHO guidelines on prevention and control of COVID-19 pandemic. However, if an effective vaccine is availed during the out of sample period the daily new cases are expected to fall drastically.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

The Coronavirus disease (SARS-CoV-2) has put the entire world into a state of confusion and panic. The novel virus which was detected in Wuhan, China in December 2019 spread very fast to many parts of the globe (Kahn et al, 2020; Chan et al, 2020; Guo et al, 2020). All nations have seen the negative effects of the deadly virus which has killed millions of people the world over. Every sector in the global village has suffered from negative impacts of the pandemic. The response to the pandemic across the world has been characterized by national lockdowns, social distancing, wearing of masks, hygiene practices, and temporary ban of public gatherings. As the pandemic progressed over time most countries have failed to maintain total lockdown because of the scorching effects of economic meltdown triggered by the novel virus which has been defined by retrenchment of workers, shutdown of business operations and salary cuts. The health systems of several countries have proven to be incapable of handling pandemics of such magnitude and severity. The sudden high demand of critical care resources and the already crippled economies has worsened the situation. Even the first world countries who are usually well resourced have been thrown down to their knees by the pandemic which is yet to be fully understood. Vaccine development is ongoing but there are many questions to be asked than answered as many countries are concerned with its safety and effectiveness. In the case of Sweden, the authorities chose not to implement a national lockdown trusting people would voluntarily do their part to

stay safe. High schools switched to distance learning, elementary schools and pre-schools remained open , many non-essential businesses continued to operate and public gatherings of up to 50 people were allowed (Cho, 2020). Deaths from COVID-19 are rising and many studies are on going to understand the risk factors for dying from the disease .Available evidence suggests that men,the elderly and COVID-19 patients with pre-existing medical conditions, ethnic and racial minorities, low socio-economic status persons are most likely to die from the disease (Jin et al, 2020; Onder et al, 2020; Lusignan et al,2020; Lippi et al, 2020; Williamson et al, 2020; Aldridge et al, 2020; Dowd et al, 2020; Du et al,2020; Ruan et al, 2020; Zhang et al, 2020; Cook et al, 2020, WHO, 2020). Sweden has relatively high levels of COVID-19 mortality per capita and its experience may provide critical information for other countries to prepare for upcoming developments (Roser et al, 2020). Sweden has few empirical studies on the COVID-19 epidemic. Qi et al (2020) studied the dynamics of the disease in Sweden using the SI, SIR and SID models. The findings indicate that all models reproduced well the number of infected cases and gave similar predictions. The SI and SID models predicted large number of deaths which is quite worrisome. Britton (2020) applied the basic estimation –prediction technique for COVID-19 and did a prediction for Stockholm. The predictions showed that the peak of infections would be in Mid -April, 2020 and the infections will start to settle in May 2020. In this study we applied the ANN model (multilayer Perceptron) to model and forecast daily new COVID-19 cases in Sweden from November 2020 to April 2021. The findings of this study will assist the Swedish government to formulate policies and initiate an appropriate, timeous and evidence -based National health response to the epidemic.

METHOD

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Sweden. In this article, the ANN (12, 12, 1) model and the more efficient hyperbolic tangent function are applied. This paper is based on daily new Covid-19 cases (referred to as SC series in this study) for all age groups in Sweden. The data covers the period 1 February 2020 to 31October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this research paper was gathered from Johns Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
453.85	314.00	0.00000	5191.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
579.94	1.2778	3.5860	20.265
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	1442.0	599.75	0

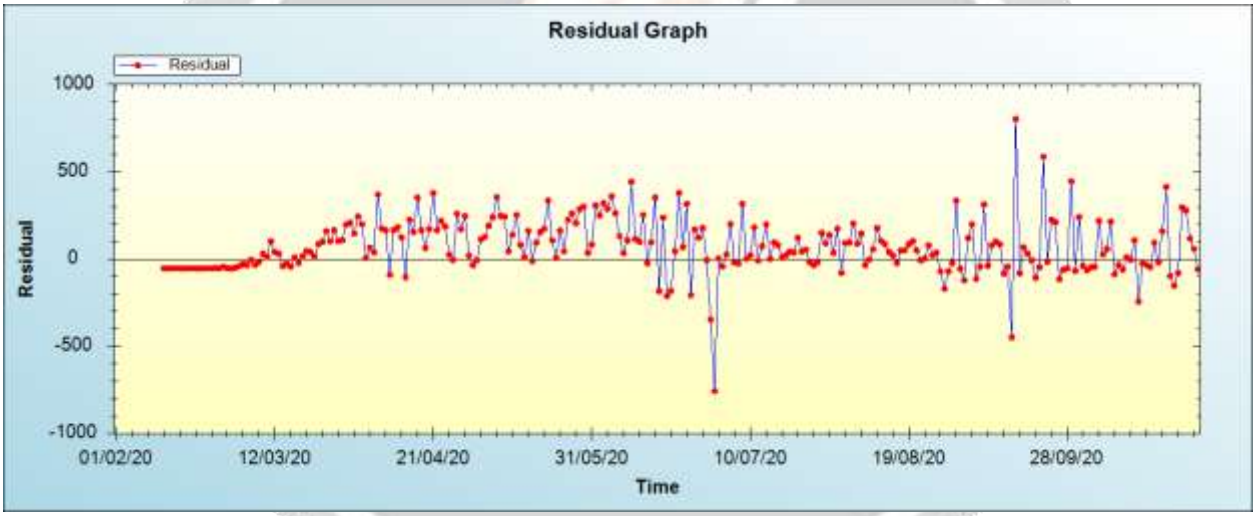
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN SWEDEN

Table 2: ANN model summary

Variable	SC
Observations	262 (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	0.059424
MSE	29368.162071
MAE	122.710623

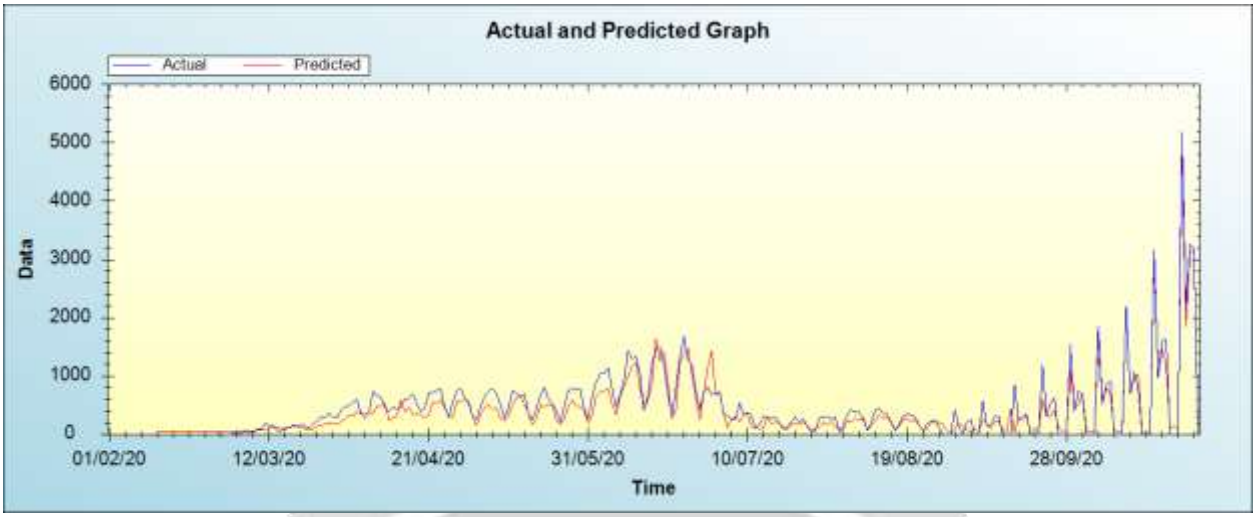
Residual Analysis for the ANN model

Figure 1: Residual analysis



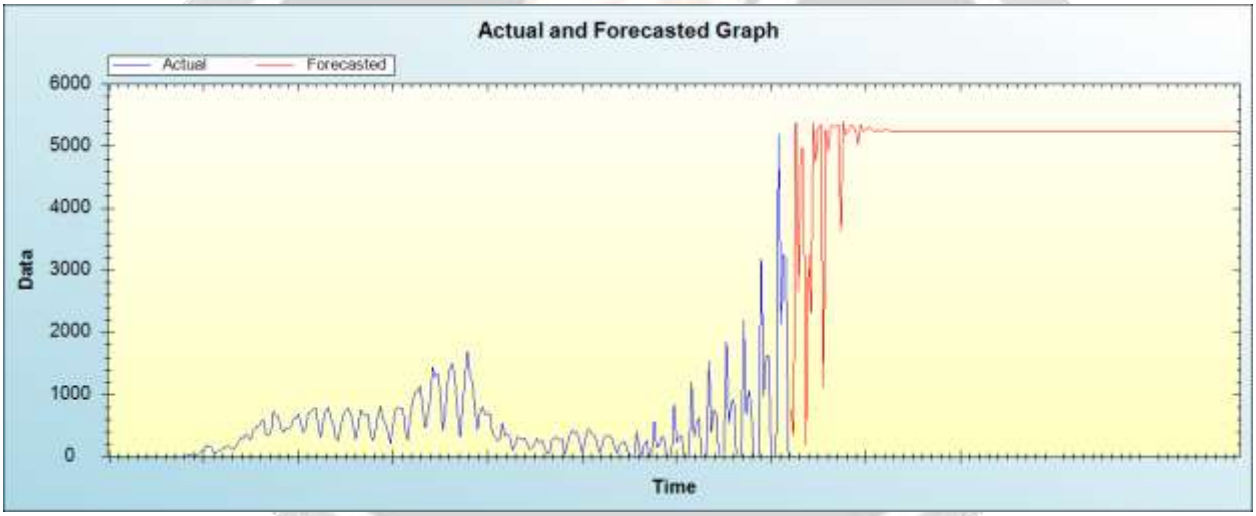
In-sample Forecast for SC

Figure 2: In-sample forecast for the SC series



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

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



Out-of-Sample Forecast for SC: Forecasts only

Table 3: Forecasts

Day/Month/Year	Forecasted daily new COVID-19 cases
01/11/20	770.2316
02/11/20	344.8044
03/11/20	5375.6949
04/11/20	2658.5147
05/11/20	4983.6147

06/11/20	4947.3994
07/11/20	188.2118
08/11/20	3261.2862
09/11/20	2328.9894
10/11/20	5382.7691
11/11/20	4745.3457
12/11/20	5278.2593
13/11/20	5357.8648
14/11/20	1124.5943
15/11/20	5270.1064
16/11/20	4917.5821
17/11/20	5318.7902
18/11/20	5338.4977
19/11/20	5313.4921
20/11/20	5355.7889
21/11/20	3625.9220
22/11/20	5397.9488
23/11/20	5186.1785
24/11/20	5246.5767
25/11/20	5333.6834
26/11/20	5328.3515
27/11/20	5263.5744
28/11/20	5017.6403
29/11/20	5348.1575
30/11/20	5243.1237
01/12/20	5270.0902

02/12/20	5294.1336
03/12/20	5299.5674
04/12/20	5245.3155
05/12/20	5227.2833
06/12/20	5274.6747
07/12/20	5242.1702
08/12/20	5253.8957
09/12/20	5258.1340
10/12/20	5256.5567
11/12/20	5242.8393
12/12/20	5246.6457
13/12/20	5251.8632
14/12/20	5245.1283
15/12/20	5249.7611
16/12/20	5251.0523
17/12/20	5250.2359
18/12/20	5248.2888
19/12/20	5250.2863
20/12/20	5250.3187
21/12/20	5249.3725
22/12/20	5250.6733
23/12/20	5250.7805
24/12/20	5250.4250
25/12/20	5250.2451
26/12/20	5250.6555
27/12/20	5250.3822

28/12/20	5250.2737
29/12/20	5250.5182
30/12/20	5250.4428
31/12/20	5250.3367
01/01/21	5250.3436
02/01/21	5250.3892
03/01/21	5250.2954
04/01/21	5250.3062
05/01/21	5250.3491
06/01/21	5250.3218
07/01/21	5250.3103
08/01/21	5250.3263
09/01/21	5250.3294
10/01/21	5250.3131
11/01/21	5250.3258
12/01/21	5250.3330
13/01/21	5250.3273
14/01/21	5250.3290
15/01/21	5250.3339
16/01/21	5250.3323
17/01/21	5250.3301
18/01/21	5250.3335
19/01/21	5250.3334
20/01/21	5250.3319
21/01/21	5250.3326
22/01/21	5250.3331

23/01/21	5250.3320
24/01/21	5250.3318
25/01/21	5250.3323
26/01/21	5250.3319
27/01/21	5250.3316
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30/01/21	5250.3315
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29/04/21	5250.3317
30/04/21	5250.3317

Figure 1 shows that over the study period, the minimum and maximum number of daily new COVID-19 cases are 0 and 5191 respectively. The average daily new coronavirus cases are 453 cases. The residual graph and model evaluation criteria indicate that the applied model is stable and suitable for forecasting daily new cases of COVID-19. The in-sample forecasts show that the model simulates the observed data very well. The model projects that the number of daily new cases will generally increase from around 770 cases on November 1, 2020 up to a plateau point around 8 December, 2020 where daily new cases will be constant at around 5250 daily new COVID-19 cases until 30April,2021.

CONCLUSION & RECOMMENDATIONS

The Swedish government is facing numerous challenges as a result of COVID-19. The rising daily new cases and high mortality per capita is worrisome. The results of this piece of work indicates that the projected daily new COVID-19 cases will generally increase from about 770 cases on November 1,2020 up to a plateau point around 8December ,2020 where we expect daily new cases to remain constant at around 5250 cases until 30April 2021.The Swedish government should strictly enforce WHO guidelines on prevention and control of COVD-19 in order contain the epidemic. Daily new cases are expected to fall drastically if an effective vaccine is found.

REFERENCES

[1] Aldridge et al (2020). Black, Asian and Minority Ethnic groups in England are at increased risk of death from COVID-19: indirect standardization of NHS mortality data. Welcome Open Res. 5, 88.

[2] Chen etal (2020). Emerging coronaviruses: genome structure, replication, and pathogenesis. Journal of medical virology, 92,4, 418-423.

[3] Cho (2020) Quantifying the impact of non-pharmaceutical interventions during the COVID-19 outbreak: the case of Sweden. Econometrics Journal 23,323-344.

[4] Cook etal (2020). Exclusive: deaths of NHS staff from covid-19 analysed. Health Ser. J. https://www.hsj.co.uk/exclusive-deaths-ofnhs-staff-from-covid-19-analysed/7027471.article (2020).

[5] COVID-19 Repository By the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

[6] Dong, E., *et al*. (2020). An Interactive Web-based Dashboard to Track COVID-19 in Real Time, *Lancet Infectious Diseases*, 20 (5): 533 – 534.

[7] Dowd, J. B. et al. Demographic science aids in understanding the spread and fatality rates of COVID-19. Proc. Natl. Acad. Sci. USA 117, 9696–9698 (2020).

[8] Du, R.-H. et al. Predictors of mortality for patients with COVID-19 pneumonia caused by SARS-CoV-2: a prospective cohort study. Eur. Respir. J. 55, 2000524 (2020).

[9] Guo etal (2020). The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak–an update on the status. Military Medical Research, 7,1, 1-10.

[10] Jin et al (2020). Gender differences in patients with COVID-19: focus on severity and mortality. Front Public Health 8, 152.

[11] Jin, J.-M. et al. Gender differences in patients with COVID-19: focus on severity and mortality. Front Public Health 8, 152 (2020).

[12] Kahn etal (2005). History and recent advances in coronavirus discovery. The Pediatric infectious disease journal, 24,11, S223-S227.

[13] Lippi etal (2020) Clinical and demographic characteristics of patients dying from COVID-19 in Italy vs China. J. Med. Virol. 92, 1759–1760 (2020).

[14] Lusignan et al (2020). Risk factors for SARS-CoV-2 among patients in the Oxford Royal College of General Practitioners Research and Surveillance Centre primary care network: a cross-sectional study. Lancet Infect. Dis. 20, 1034–1042 (2020).

[15] Onder etal (2020) Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy. JAMA 323, 1775–1776 (2020).

[16] Roser etal (2020) Coronavirus (COVID-19) deaths - statistics and research. Our World in Data https://ourworldindata. org/covid-deaths.

[17] Ruan etal (2020). Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. Intensive Care Med. 46, 846–848 (2020).

[18] Williamson et al (2020). Factors associated with COVID-19-related death using Open SAFELY. Nature 584, 430–436.

[19] World Health Organization. Director-General's Opening Remarks at the Media Briefing on COVID-19 - 15 April 2020 https://www.who.int/dg/speeches/ detail/who-director-general-s-opening-remarks-at-the-media-briefing-onco

[20] Zhang, J. et al. Risk factors for disease severity, unimprovement, and mortality in COVID-19 patients in Wuhan, China. Clin. Microbiol. Infect. 26, 767–772 (2020).