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

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ABSTRACT

COVID-19 has caused serious devastations to human populations across the world and Kazakhstan has been affected too. In this article, the ANN model was applied to forecast COVID-19 cases in Kazakhstan. The employed data covers the period March 13, 2020 to October 31, 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 COVID-19 cases in the country. The results of the study indicate that daily COVID-19 cases will continue to decline until an equilibrium case volume of 55 cases per day is reached, that is, around December 26, 2020. We further project that this equilibrium case volume could be reported throughout the rest of the out-of-sample period. Indeed, the pandemic will not end anytime so soon, unless there is an effective vaccine. We basically encourage the government of Kazakhstan to continue applying all World Health Organization (WHO) recommended control and preventive measures such as social distancing, sanitizing hands, washing of hands, face-mask wearing and so on. The results are important especially in resource planning for hospitalization purposes and management of COVID-19 patient volumes in Kazakhstan.

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

INTRODUCTION & BRIEF BACKGROUND

Coronaviruses are a group of viruses that cause infection ranging from a usual cold to Severe Acute Respiratory Syndrome (SARS) (Tahir *et al*., 2020). The current coronavirus disease (COVID-19) was first reported in Wuhan, China, on 31 December 2019. Its common symptoms are cold, fever, breathings problems and shortness of breath. In more critical cases, pneumonia, kidney failure, severe acute respiratory syndrome and even loss of life have also been reported (WHO, 2020). The virus may spread from bats to humans through another intermediate host and cause severe respiratory syndrome (Li *et al*., 2020), characterized by strong human-to-human transmission trough the air (Guan *et al*., 2020; Tong *et al*., 2020). What makes COVID-19 so strange and frightening is the intensity of the virus and yet unknown mechanism (Kavadi *et al*., 2020). The infectivity of COVID-19 is far much greater than of influenza, with an estimated basic reproduction number of 2.28 (Zhang *et al*., 2020). Across the globe, the current plan of action is to slow down its spread, especially via social distancing and the rush to produce state-

of-the-art expeditious diagnostic kits in addition to medications (Kavadi *et al*., 2020). The number of infections worldwide is still increasing (Wang *et al*., 2020). Kazakhstan's first COVID-19 cases were reported on March 13, 2020 (Kazinform International News Agency, 2020). The government of Kazakhstan responded by implementing aggressive intervention measures such as lockdowns of cities, social distancing, quarantines, and closure of schools (Do *et al*., 2020). Studies on modeling and forecasting COVID-19 daily cases in Kazakhstan are very important for strategizing in the fight against the pandemic and yet the government has not yet presented any official COVID-19 predictive model. Furthermore, studies on forecasting the pandemic in the country are very few, for example; Do *et al*. (2020), Semenova *et al*. (2020) and Kadyrov *et al*. (2020). The SEIR model-based study by Kadyrov *et al*. (2020) indicates that the pandemic was increasing very fast in the country with a basic reproduction number of approximately 3.622. Do *et al*. (2020), based on a SEIR model, established that any relaxation or delay of preventive and control measures would result in exponential growth of cases and deaths in the country. Using a SEIR model, Semenova *et al*. (2020) found out that the vast majority of COVID-19 patients had mild disease manifestations and that the proportion of moderate disease was 10%. The study also predicted that there will be 156 thousand hospitalized patients due to severe illness and 15.47 thousand deaths at the peak of an outbreak if no measures are implemented. This study will contribute differently to the existing body of literature in the sense that we apply the Artificial Neural Networks (ANN) model, a deep learning technique suitable for forecasting complex data sets such as COVID-19 data sets. Our results are expected to compliment government efforts in the fight against COVID-19 in Kazakhstan.

METHODOLOGY

This research applies the multi-layer perceptron neural network type of the ANN technique in order to predict COVID-19 cases in Kazakhstan. The research, particulary applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. The research is specifically based on newly confirmed COVID-19 daily cases (reffered to as the KX series in this study) for all age groups in the country. The data covers the period March 13, 2020 to October 31, 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this study was gathered from the online database of the Johns Hopkins University (United States of America).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
482.48	142.00	0.0000	18757.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
1361.7	2.8224	10.690	137.91
5% Perc.	95% Perc.	IQ range	Missing obs.
0.0000	1717.6	390.00	0

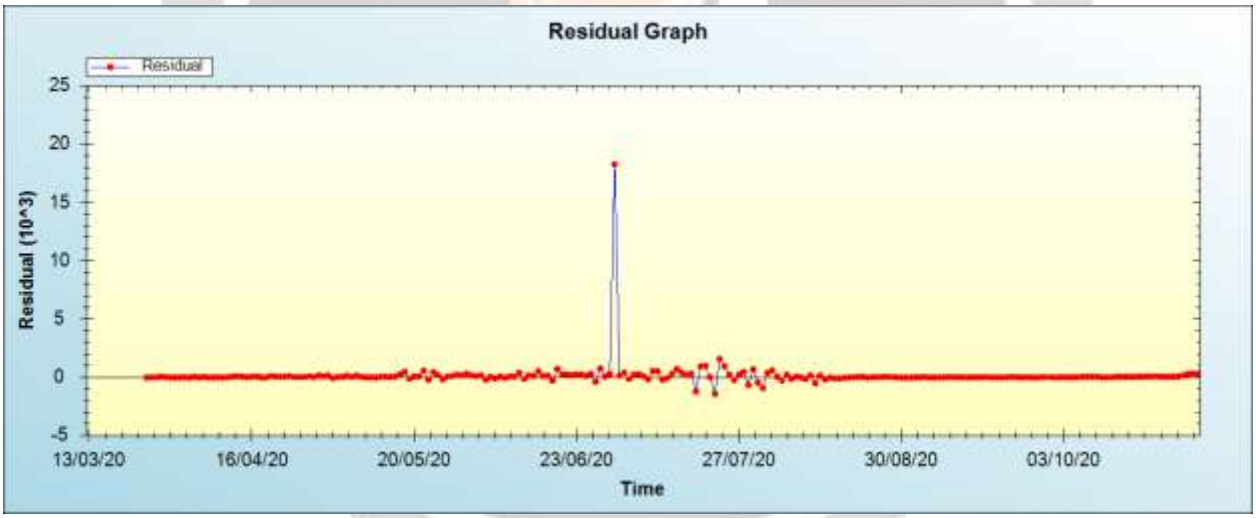
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN KAZAKHSTAN

Table 2: ANN model summary

Variable	KX
Observations	221 (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	0.121004
MSE	1589944.821434
MAE	233.205013

Residual Analysis for the ANN model

Figure 1: Residual analysis



In-sample Forecast for KX

Figure 2: In-sample forecast for the KX series

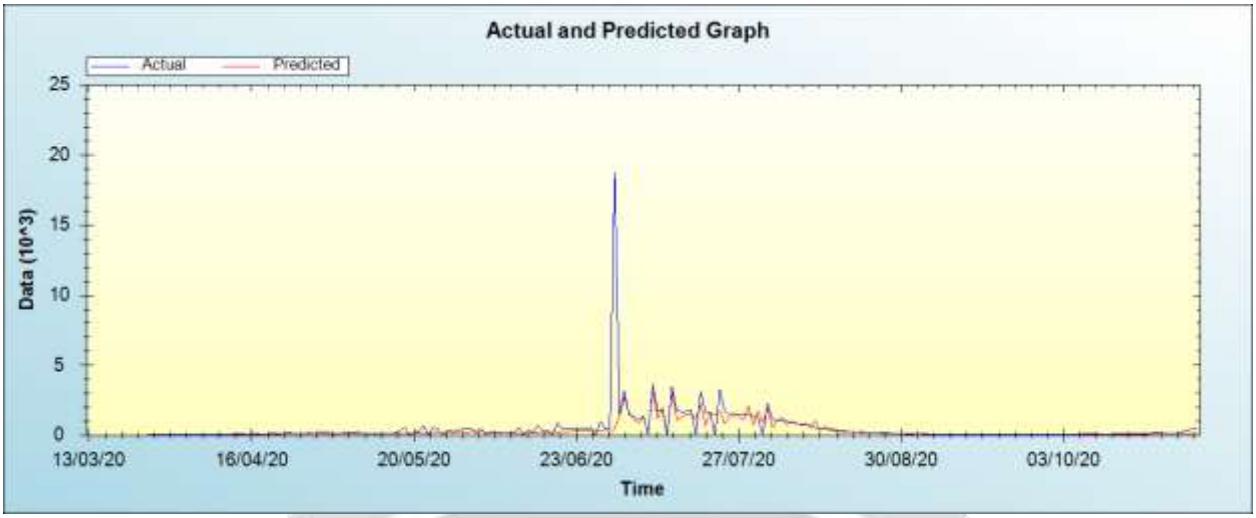
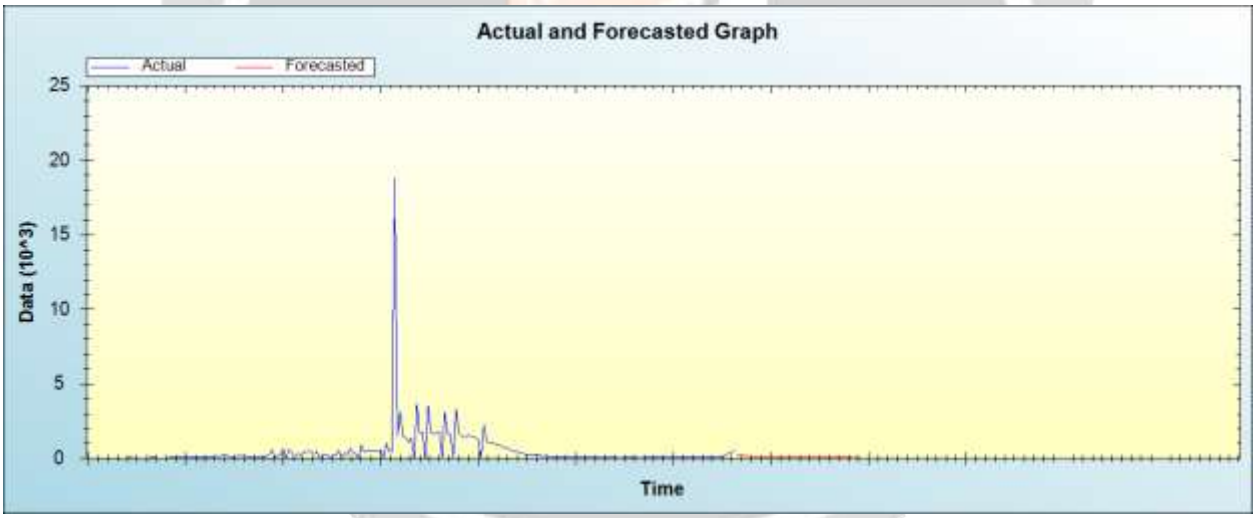


Figure 3 shows the in-sample forecast for KX series.

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

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



Out-of-Sample Forecast for KX: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	203.8945
02/11/20	212.4187
03/11/20	208.9664
04/11/20	177.9207

05/11/20	192.9230
06/11/20	163.8172
07/11/20	166.3734
08/11/20	147.8287
09/11/20	124.0887
10/11/20	129.5339
11/11/20	104.5866
12/11/20	125.0939
13/11/20	104.0163
14/11/20	94.4559
15/11/20	99.3836
16/11/20	84.3362
17/11/20	87.9508
18/11/20	81.1795
19/11/20	77.3327
20/11/20	79.4212
21/11/20	70.6236
22/11/20	74.1408
23/11/20	67.9016
24/11/20	67.8215
25/11/20	68.0398
26/11/20	63.3223
27/11/20	65.4007
28/11/20	62.3912
29/11/20	61.8840
30/11/20	62.0223

01/12/20	59.5464
02/12/20	60.8344
03/12/20	58.8582
04/12/20	59.0200
05/12/20	58.7464
06/12/20	57.5815
07/12/20	58.2691
08/12/20	57.1409
09/12/20	57.2670
10/12/20	57.1276
11/12/20	56.4893
12/12/20	56.8815
13/12/20	56.2190
14/12/20	56.3719
15/12/20	56.2123
16/12/20	55.9288
17/12/20	56.1190
18/12/20	55.7522
19/12/20	55.8604
20/12/20	55.7530
21/12/20	55.6092
22/12/20	55.7157
23/12/20	55.5058
24/12/20	55.5833
25/12/20	55.5047
26/12/20	55.4446

27/12/20	55.4932
28/12/20	55.3802
29/12/20	55.4286
30/12/20	55.3779
31/12/20	55.3521
01/01/21	55.3762
02/01/21	55.3133
03/01/21	55.3443
04/01/21	55.3112
05/01/21	55.3025
06/01/21	55.3124
07/01/21	55.2793
08/01/21	55.2974
09/01/21	55.2771
10/01/21	55.2749
11/01/21	55.2788
12/01/21	55.2611
13/01/21	55.2719
14/01/21	55.2594
15/01/21	55.2598
16/01/21	55.2608
17/01/21	55.2517
18/01/21	55.2578
19/01/21	55.2504
20/01/21	55.2514
21/01/21	55.2513

22/01/21	55.2467
23/01/21	55.2501
24/01/21	55.2457
25/01/21	55.2468
26/01/21	55.2463
27/01/21	55.2440
28/01/21	55.2459
29/01/21	55.2433
30/01/21	55.2442
31/01/21	55.2437
01/02/21	55.2426
02/02/21	55.2436
03/02/21	55.2421
04/02/21	55.2427
05/02/21	55.2423
06/02/21	55.2418
07/02/21	55.2423
08/02/21	55.2415
09/02/21	55.2419
10/02/21	55.2416
11/02/21	55.2414
12/02/21	55.2417
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17/02/21	55.2413
18/02/21	55.2411
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27/04/21	55.2409
28/04/21	55.2409
29/04/21	55.2409
30/04/21	55.2409

Table 1 tells us that on average, the number of daily COVID-19 cases was 482 cases over the period under study while the maximum was 18757 cases. These are huge and alarming numbers for a small country like Kazakhstan. The applied model has been shown to be stable as revealed by the residual diagnostics in figure 1. Our in-sample forecasts are shown in figure 2 while the out-of-sample forecasts are shown in figure 3 and table 3. The results of this research indicate that COVID-19 cases in the country will continue to decline from the estimated 204 cases on November 1, 2020 until an equilibrium case volume of 55 cases per day is reached on December 26, 2020. This equilibrium daily case volume is projected to stretch throughout the out-of-sample period.

CONCLUSION & RECOMMENDATIONS

There is no doubt, the outbreak of COVID-19 has put the entire world at risk of contracting the virus and has also caused severe economic damage. Therefore, predicting the trend of COVID-19 is an extremely vital challenge, especially for developing countries such as Kazakhstan whose health systems are fragile and could be overwhelmed by catastrophic increases in daily COVID-19 case volumes. The paper made use of an ANN technique based on the hyperbolic tangent function as the activation function. It was found out that the pandemic is slowly declining in terms of daily case volumes. However, an equilibrium level of daily cases [i.e 55 cases per day] could be reached by 26 December 2020 and be recorded for the rest of the out-of-sample period. While 55 cases per could be described as a relatively low number of cases, it is important to note the total cumulative number of cases will still be on the increase, but at a relatively decreasing rate. We encourage the government of Kazakhstan to continue applying all World Health Organization (WHO) recommended control and preventive measures such as social distancing, sanitizing hands, washing of hands, face-mask wearing and so on. While our model does not indicate a possibility of the pandemic ending soon in Kazakhstan, it does give a green light on the possibility of getting "on top" of the virus, particularly by maintaining the equilibrium case volumes, at least. This can simply be done by maintaining the current government response to virus: there is no need to "over-relax" the COVID-19 restrictive measures. In fact, intensifying the measures will go a long way in suppressing a possible second wave of infections in the country.

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