Forecasting Covid-19 New Cases in Kosovo

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Abstract - **In this study, the ANN approach was applied to analyze COVID-19 new cases in Kosovo. 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 Kosovo are likely to remain very high over the out-of-sample period. Amongst other suggested policy directions, there is need for the government of Kosovo to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The COVID-19 pandemic emerged at the time when most countries were ill prepared to handle any kind of natural disasters (National geographic, 2020). The disease was initially identified in the city of Wuhan in China in December 2019 when a mysterious cluster of pneumonia cases were reported (Sauer, 2020). In March 2020, WHO declared COVID-19 a global health threat due to its shocking levels of spread and associated high morbidity and mortality (WHO, 2020). By December 2020 the pandemic had claimed 1.5 million lives and infected above 67 million people (BBC, 2019).The first case of COVID-19 in Kosovo was detected on the 13th of March 2020 (Bami, 2020). By 15 December 2020, the country had reported 47952 confirmed cases, more than 1200 deaths and more than 36000 recoveries (CDC, 2020). The COVID-19 transmission rate in Kosovo reached 1.6 and medical facilities were overwhelmed because of the increased demand for ICU admissions and more medical staff were needed to deal with the situation (Avdimetaj et al, 2020). The government responded to the pandemic by imposing lockdowns and enforcing adherence to the public health mitigatory measures recommended by WHO. The purpose of this study is to predict daily COVID-19 cases in Kosovo using the artificial neural network approach. The findings of the study are expected to provide an insight of the likely future trends of COVID-19 cases in Kosovo and this will assist the authorities to plan and allocate adequate resources to fight the epidemic.

II. LITERATURE REVIEW

Gecil et al (2020) applied 4 different time series forecasting models available in the R statistical package to forecast confirmed COVID-19 cases, deaths and recoveries in USA and Italy. The autoregressive integrated moving average (ARIMA) and cubic smoothing sp line models were found to be preferable to the Holt and Trigonometric Exponential smoothing state space model with Box Cox transformation (TBATS) models. The multilayer perceptron was employed by Car et al (2020) to predict the spread of COVID-19 in Croatia. The authors used a publicly available dataset, containing information on infected, recovered, and deceased patients in 406 locations over 51 days (22nd January 2020 to 12th March 2020).The study found out that the best models achieved consists of 4 hidden layers with 4 neurons in each of those layers, and used a ReLU activation function, with R^2 scores of 0.98599 for confirmed, 0.99429 for deceased, and 0.97941 for recovered patient models. The artificial neural network technique has been widely applied in time series forecasting of COVID-19. Authors like Tamang et al (2020) employed artificial neural network-based curve fitting techniques in prediction and forecasting of the Covid-19 number of rising cases and death cases in India, USA, France, and UK, considering the progressive trends of China and South Korea. The results have shown that ANN can efficiently forecast the future cases of COVID 19 outbreak of any country. Pais et al (2020) predicted the evolution of the COVID-19 in Portugal. The authors developed a mathematical model to estimate the strength of Government-Imposed Measures (GIM) and predicted the impact of the degree of compliance on the number of infected cases and peak of infection. They estimated the peak to be around 650 thousand infected cases with 53 thousand requiring hospital care by the beginning of May if no measures were taken.

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 Kosovo.

Data Issues

This study is based on daily new cases of COVID-19 in Kosovo 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	K
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	0.121088
MSE	68022.072825
MAE	183.299332

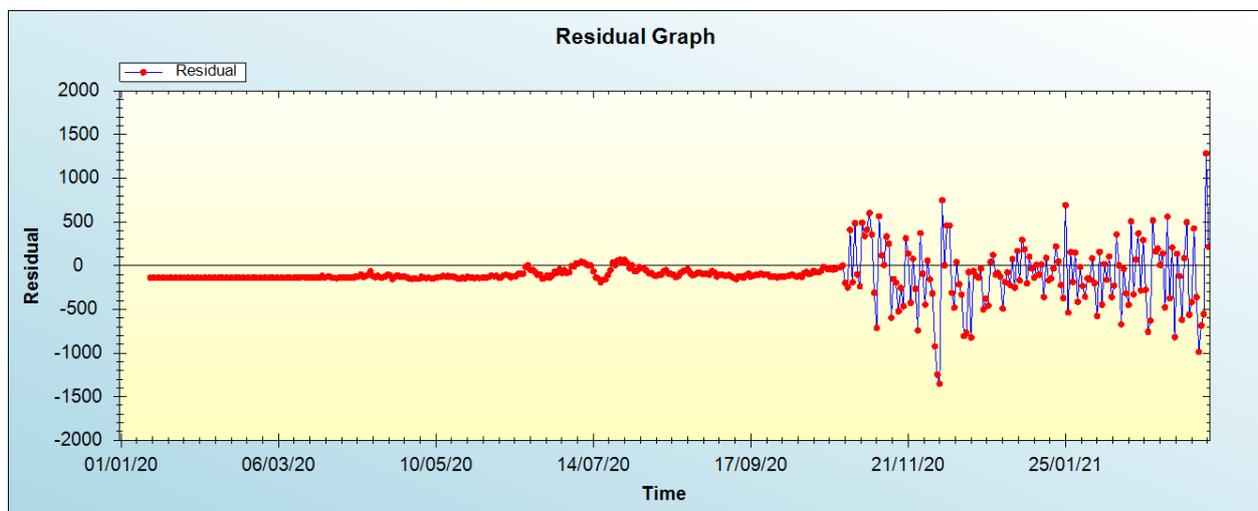*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
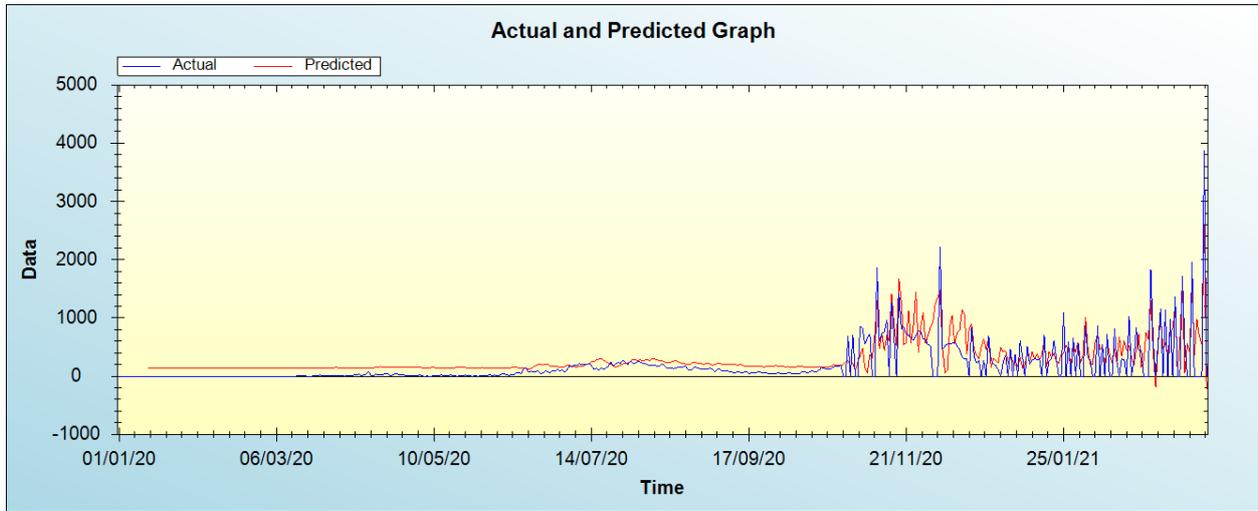
In-sample Forecast for K

Figure 2: In-sample forecast for the K series

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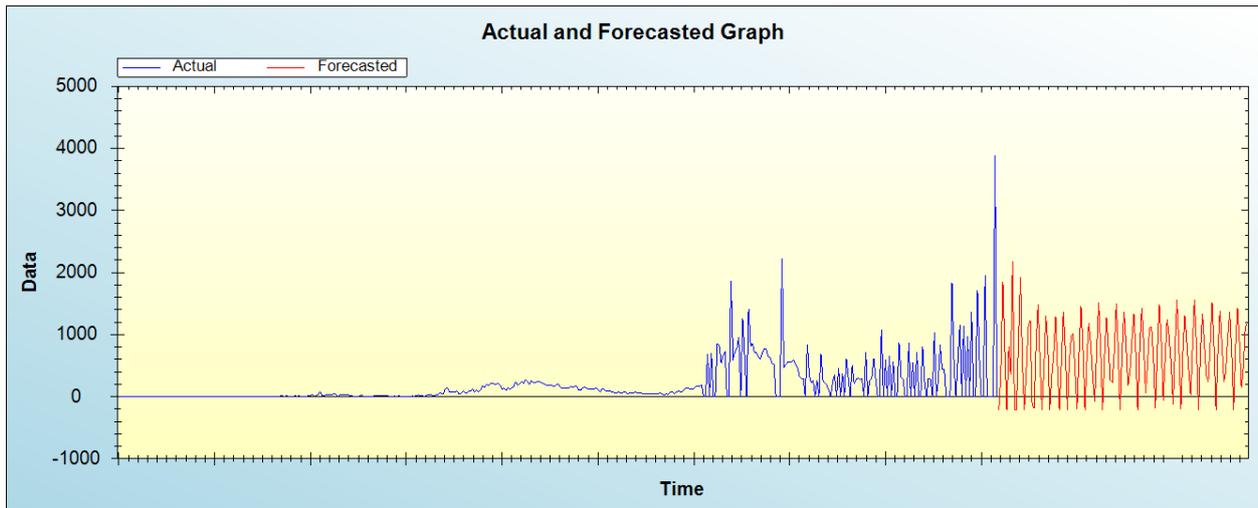

Figure 3: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
26/03/21	-215.3882
27/03/21	382.9549
28/03/21	1855.0348
29/03/21	740.8465
30/03/21	-215.3873
31/03/21	807.4360
01/04/21	356.8189
02/04/21	2184.8707
03/04/21	-215.3664
04/04/21	-215.3885
05/04/21	897.4796
06/04/21	1926.1744
07/04/21	500.5198
08/04/21	-215.3880
09/04/21	398.5799

10/04/21	1121.5953
11/04/21	1233.7352
12/04/21	-122.1793
13/04/21	-190.5596
14/04/21	859.6376
15/04/21	1486.0247
16/04/21	548.4423
17/04/21	-215.3884
18/04/21	404.8068
19/04/21	1299.7120
20/04/21	842.6753
21/04/21	-210.0864
22/04/21	335.1879
23/04/21	688.7304
24/04/21	1289.6535
25/04/21	478.4059
26/04/21	-215.3779
27/04/21	550.0162
28/04/21	1363.5758
29/04/21	723.1957
30/04/21	-215.3872
01/05/21	566.9673
02/05/21	975.2127
03/05/21	1017.0662
04/05/21	395.0318
05/05/21	-194.5331
06/05/21	645.7561
07/05/21	1454.7458
08/05/21	770.2556
09/05/21	-215.3865
10/05/21	628.7237
11/05/21	1184.8062
12/05/21	850.6133
13/05/21	319.1640
14/05/21	-66.2512
15/05/21	750.6081
16/05/21	1518.0564
17/05/21	787.1511
18/05/21	-215.3873
19/05/21	631.0010
20/05/21	1278.2242
21/05/21	815.3457
22/05/21	269.4206
23/05/21	229.3174
24/05/21	749.6565
25/05/21	1497.9436
26/05/21	754.8768
27/05/21	-215.3738
28/05/21	721.1719
29/05/21	1368.2883
30/05/21	813.0787
31/05/21	175.3771
01/06/21	419.0424
02/06/21	906.1084
03/06/21	1335.9105
04/06/21	705.9394
05/06/21	-213.6375
06/06/21	772.6999
07/06/21	1423.0666
08/06/21	843.2245
09/06/21	68.4477
10/06/21	517.0207
11/06/21	1110.6254
12/06/21	1127.4274

13/06/21	638.0081
14/06/21	-185.1724
15/06/21	788.6255
16/06/21	1486.2326
17/06/21	878.9942
18/06/21	-56.9127
19/06/21	601.5506
20/06/21	1243.1400
21/06/21	967.3656
22/06/21	530.6266
23/06/21	-115.6433
24/06/21	815.7597
25/06/21	1551.2211
26/06/21	875.3795
27/06/21	-199.9715
28/06/21	680.8882
29/06/21	1305.6877
30/06/21	878.9899
01/07/21	425.9738
02/07/21	26.8820
03/07/21	819.4794
04/07/21	1565.0029
05/07/21	838.0426
06/07/21	-215.3753
07/07/21	722.4576
08/07/21	1335.5506
09/07/21	855.2310
10/07/21	337.3225
11/07/21	244.6102
12/07/21	827.0177
13/07/21	1511.7421
14/07/21	793.2258
15/07/21	-215.3243
16/07/21	781.0173
17/07/21	1385.9919
18/07/21	849.9655
19/07/21	242.9543
20/07/21	392.6237
21/07/21	954.2688
22/07/21	1357.5014
23/07/21	745.2291
24/07/21	-211.7518
25/07/21	810.1616
26/07/21	1424.4054
27/07/21	871.4974
28/07/21	142.8508
29/07/21	477.0210
30/07/21	1114.9853
31/07/21	1173.2451

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

V. CONCLUSION AND POLICY RECOMMENDATIONS

The length of the COVID-19 pandemic still remains unknown and this has put the entire world in a difficult situation. The emergence of new strains has triggered new waves of infections which are associated with high levels of community transmission and in some cases with higher mortality. Containment measures such as restrictions on movement of people and services, travel ban, suspension of education process, shutdown of non-essential businesses and later on imposition of a national partial-lockdown has a negative economic impact in Kosovo. Prediction of COVID-19 case volume is important to understand the future evolution of the epidemic in Kosovo to facilitate planning and resource mobilization to curb the spread of the virus. In this

study we applied the ANN (12, 12, 1) model to predict daily COVID-19 cases in Kosovo and the results indicate that daily COVID-19 cases in Kosovo are likely to remain very high over the out-of-sample period. Therefore the country needs to adhere to the COVID-19 public health measures including vaccination.

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