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Forecasting Covid-19 New Cases in Luxemburg

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

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The novel coronavirus disease (COVID-19) which was first identified in Wuhan, China affected several regions of the world. It affected people's health and economic indicators all over the world (Burzynski et al, 2020). The lockdown measures have impacted severely on private consumption, private investment on Luxemburg's international trade in goods and non-financial services (OECD, 2020; Fadinger & Schymik, 2020). Luxemburg's COVID-19 epidemic was characterized by rapid spread of the virus. The government responded by imposing lockdown, border closures, schools closures, ban on public gatherings, and closure of non-essential businesses. The adherence to COVID-19 prevention and control guidelines was enforced by the state.The aim of this study is to predict daily COVID-19 cases in Luxemburg using artificial neural networks (ANNs) ANNs are widely used in medicine in many applications such as pattern recognition, function approximation, classification and time series forecasting (Zhang, 2003). Several studies have proven the forecasting accuracy of the artificial intelligence technique (Maradze et al, 2021; Nyoni et al, 2021; Nyoni & Nyoni, 2021; Nyoni et al, 2020; Zhao et al, 2020).The findings of this study are expected to provide an insight of the likely future trends of COVID-19 cases in Luxemburg and trigger an appropriate and prompt health response to the epidemic.

II. LITERATURE REVIEW

Braga et al (2021) applied artificial neural networks for the daily and cumulative forecasts of cases and deaths caused by COVID-19, and the forecast of demand for hospital beds. Six scenarios with different periods were used to identify the quality of the generated forecasting and the period in which they start to deteriorate. Results indicated that the computational model adapted capably to the training period and was able to make consistent short-term forecasts, especially for the cumulative variables and for demand hospital beds. 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 showed that ANN can efficiently forecast the future cases of COVID 19 outbreak of any country. Cabore et al (2020) applied the Markov chain model to predict the potential effects of COVID-19 in the WHO African region. The transition states and country specific probabilities derived based on currently available knowledge. A risk of exposure, and vulnerability index are used to make the probabilities country specific. The results predict a high risk of exposure in states of small size, together with Algeria, South Africa and Cameroon. Nigeria will have the largest number of infections, followed by Algeria and South Africa. Mauritania would have the fewest cases, followed by Seychelles and Eritrea. Mollalo et al (2020) predicted COVID-19 incidence rates in the continental United States using artificial neural networks. The results indicated that a single-hidden-layer MLP could explain almost 65% of the correlation with ground truth for the holdout samples.

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

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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 Luxembourg.

Data Issues

This study is based on daily new cases of COVID-19 in Luxembourg 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	L
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	0.166060
MSE	93529.944037
MAE	280.444343

Residual Analysis for the Applied Model

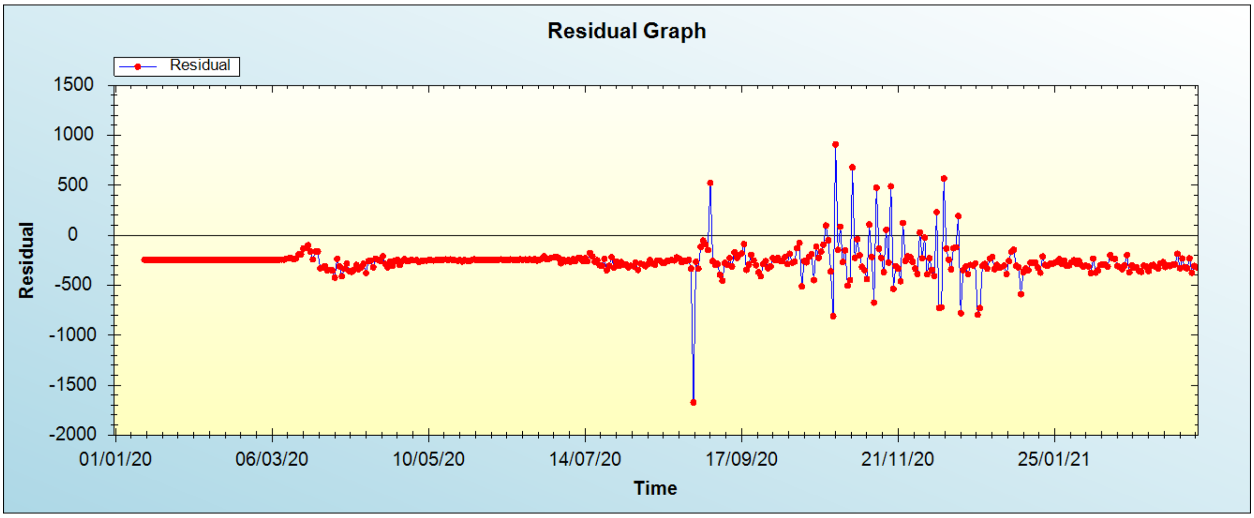

Figure 1: Residual analysis

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In-sample Forecast for L

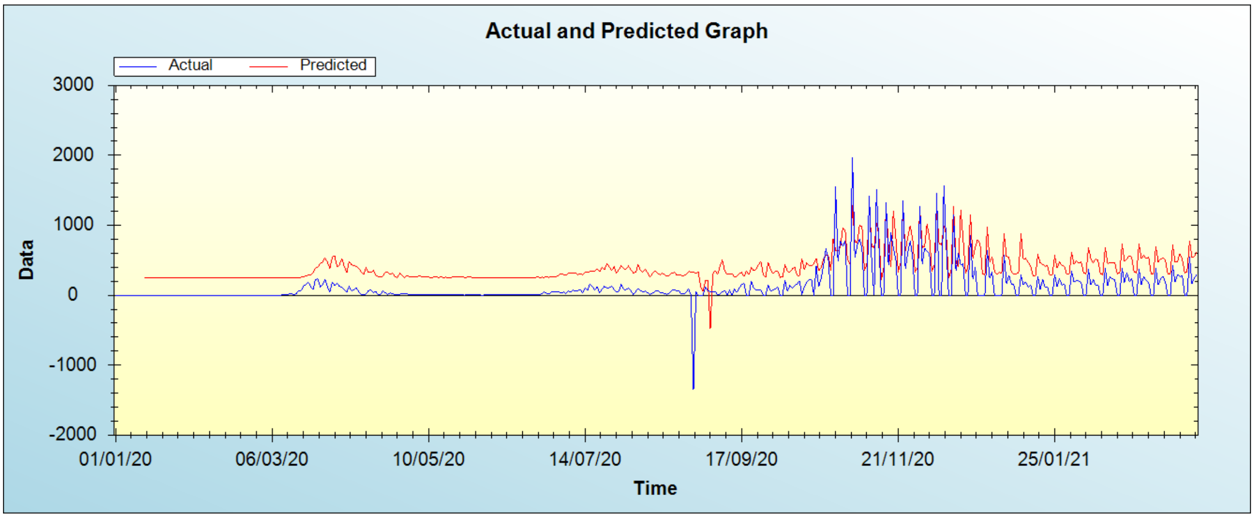

Figure 2: In-sample forecast for the L series

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

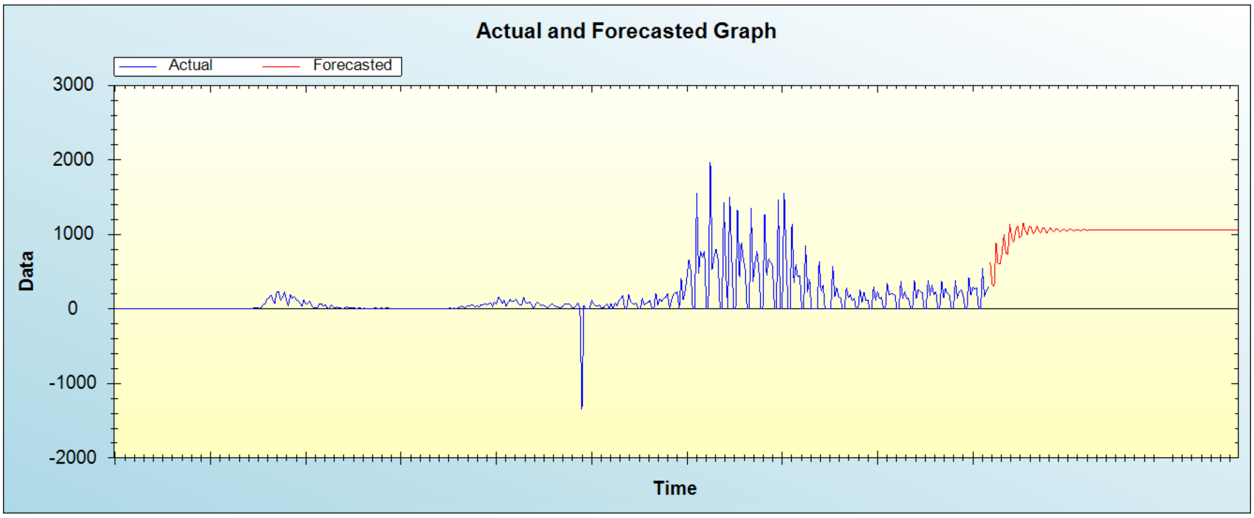

Figure 3: Out-of-sample forecast for L: actual and forecasted graph

Out-of-Sample Forecast for L: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
26/03/21	627.8371
27/03/21	320.7631
28/03/21	304.4790
29/03/21	888.0331
30/03/21	615.3273
31/03/21	607.2419
01/04/21	749.4631
02/04/21	998.0527
03/04/21	748.3460
04/04/21	737.3289
05/04/21	1136.3173
06/04/21	958.6732
07/04/21	897.6894
08/04/21	1051.0624
09/04/21	1121.3531

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10/04/21	956.8974
11/04/21	979.1318
12/04/21	1158.6324
13/04/21	1045.7795
14/04/21	997.5421
15/04/21	1104.8214
16/04/21	1103.9205
17/04/21	1005.9797
18/04/21	1040.9877
19/04/21	1116.5681
20/04/21	1047.4084
21/04/21	1024.4507
22/04/21	1091.9828
23/04/21	1076.8584
24/04/21	1021.9122
25/04/21	1055.3175
26/04/21	1087.5385
27/04/21	1045.0580
28/04/21	1039.5244
29/04/21	1079.4277
30/04/21	1064.0031
01/05/21	1035.3177
02/05/21	1060.7745
03/05/21	1073.4316
04/05/21	1047.5386
05/05/21	1049.8017
06/05/21	1071.8927
07/05/21	1059.2713
08/05/21	1045.4249
09/05/21	1062.5366
10/05/21	1066.2653
11/05/21	1050.9160
12/05/21	1055.3882
13/05/21	1066.8851
14/05/21	1057.5975
15/05/21	1051.6032
16/05/21	1062.2906
17/05/21	1062.3031
18/05/21	1053.5896
19/05/21	1057.8857
20/05/21	1063.4911
21/05/21	1057.1636
22/05/21	1055.0478
23/05/21	1061.3950
24/05/21	1060.1694
25/05/21	1055.4782
26/05/21	1058.8402
27/05/21	1061.3393
28/05/21	1057.2834
29/05/21	1056.9056
30/05/21	1060.5130
31/05/21	1059.1216
01/06/21	1056.7496
02/06/21	1059.1137
03/06/21	1060.0639
04/06/21	1057.5936
05/06/21	1057.8747
06/06/21	1059.8330
07/06/21	1058.6671
08/06/21	1057.5618
09/06/21	1059.1099
10/06/21	1059.3455
11/06/21	1057.9094
12/06/21	1058.3527

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13/06/21	1059.3606
14/06/21	1058.5065
15/06/21	1058.0534
16/06/21	1059.0128
17/06/21	1058.9594
18/06/21	1058.1624
19/06/21	1058.5691
20/06/21	1059.0534
21/06/21	1058.4774
22/06/21	1058.3363
23/06/21	1058.9031
24/06/21	1058.7629
25/06/21	1058.3427
26/06/21	1058.6540
27/06/21	1058.8642
28/06/21	1058.4986
29/06/21	1058.4913
30/06/21	1058.8113
01/07/21	1058.6701
02/07/21	1058.4619
03/07/21	1058.6778
04/07/21	1058.7531
05/07/21	1058.5326
06/07/21	1058.5719
07/07/21	1058.7440
08/07/21	1058.6310
09/07/21	1058.5364
10/07/21	1058.6763
11/07/21	1058.6909
12/07/21	1058.5640
13/07/21	1058.6111
14/07/21	1058.6986
15/07/21	1058.6180
16/07/21	1058.5807
17/07/21	1058.6666
18/07/21	1058.6579
19/07/21	1058.5883
20/07/21	1058.6284
21/07/21	1058.6697
22/07/21	1058.6163
23/07/21	1058.6059
24/07/21	1058.6562
25/07/21	1058.6414
26/07/21	1058.6052
27/07/21	1058.6348
28/07/21	1058.6522
29/07/21	1058.6188
30/07/21	1058.6196
31/07/21	1058.6477

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

V. CONCLUSION AND POLICY RECOMMENDATIONS

The COVID-19 pandemic attacked the whole world at a time many countries were ill prepared to handle a public health crisis of such magnitude. Many governments have channeled their resources towards fighting the pandemic. Emergency preparedness has proven to be very crucial in public health programming in order to minimize loss of lives. Strengthening public health surveillance mechanisms should not be over emphasized as this is the backbone of the emergency preparedness plan. As a surveillance mechanism, we predicted the daily COVID-19 cases in Luxemburg using the artificial neural network approach. The

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results of the study indicate that daily COVID-19 cases in Luxembourg are likely to remain very high over the out-of-sample period. Therefore the government is encouraged to continue implementing COVID-19 public health mitigation measures.

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