Modelling and Forecasting Covid-19 Mortalities in the United Kingdom Using Artificial Neural Networks (ANN)

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Abstract - **In this research article, the ANN approach was applied to analyze COVID-19 deaths in the United Kingdom (UK). The employed data covers the period January – December 2020 and the out-of-sample period ranges over the period January – May 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 thatCOVID-19 deaths will be generally between 200 and 1000 deaths per day in the UK over the out-of-sample period. The UK government ought to be cautious, particularly in the relaxation of any controls. This will ensure that the most vulnerable members of society are protected, especially those with chronic conditions.**

Keywords: Modelling, Forecasting, Artificial Neural Networks, ANN.

I. INTRODUCTION

Towards the end of 2019 in the city of Wuhan, China it was where the coronavirus started, (Song *et al*, 2019). The virus was identified as a novel coronavirus on the 7th of January 2020, (Funk *et al,* 2020). The first coronavirus death was recorded on the 9th of January 2020. Over the next days, due to contagious nature of the virus and its ability to be spread in air droplets and surfaces touched by an infected person, the virus spread from China to across the globe, (World Health Organization, 2020). This is so due to the global nature of the world and one can travel from point A to B. Severe social distancing measures were implemented by almost every government in a bid to curb the spread of the virus, (Funk *et al*, 2020).In Europe the first COVID-19 cases were recorded in Northern Italy, (Trentini*et al*, 2020). In the UK, the first cases of COVID-19 were reported on the 31st of January 2020 in York, North of England. The government started of by containing the disease and ensuring that those infected were isolated, contact tracing done and testing of suspected cases done. Despite all these strides the health system was overwhelmed and this resulted in significant number of deaths across England. These deaths were followed by the complete shutdown. Fast track to 2021, the UK has had 4.27 million confirmed coronavirus cases and 126000 deaths (5% of the world death toll), (WHO Dashboard, 2021)

Even at the peak of the COVID-19 virus, it was evident that the imposed lockdown restrictions could not continue forever and hence there was need for researches done that look at epidemiological modelling of new cases and deaths in the UK. Most studies done were on modelling and forecasting new cases from the first wave and predicting the third wave of the virus. A few studies like those done by S Jenks *et al*. (2020) have looked at Covid-19 fatalities. They used a modelling framework and they found out that age-specific Infection fatality ratio followed an approximately log-linear pattern, with a risk of death doubling every 8 years of age. West *et al* (2020), found that the Covid-19 incidence of the United Kingdom was 22.7 and around 43% of confirmed cases would pass on. Bhopal *et al*, (2020) looked at COVID-19 related deaths among children, while Holman *et al* (2020) researched on deaths in people with diabetes in England and found out that diabetes deaths more than doubled during the COVID-19 epidemic.

This paper will apply the ANN model in forecasting and modelling COVID-19 deaths, this is so as unlike conventional forecasting methods, the ANN method is based on the optimum curve fitting and forecasting for different non-linear models. Such forecasting technique can be employed in any available sets of data, in these case Covid-19 death rates in the UK. In ANN curve fitting the training data trails the trend of the given forecasted data and allows one to make forecasts of how the data series will perform in the future, in this case we will be able to determine new coronavirus death cases in the UK, especially after the

introduction of the vaccine and whether the prevalence among the population will decrease drastically. Inferences got will help policy makers and the government of the UK to be in better positions to lift restrictions and open up businesses knowing the forecasted impacted of COVID-19 in their country.

II. METHODOLOGY

The study applies the Artificial Neural Network (ANN) approach which is usually celebrated for its capability to learn from any data-set and consequently describe the nonlinear and interaction effects with great accuracy. Arguably, explicit guidelines exist for the determination of the ANN structure hence the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function.

Data Issues

This study is based on daily deaths of COVID-19 in the United Kingdom (UK) for the period 1 January – 31 December 2020. The out-of-sample forecast covers the period January 2021 – May 2021. All the data employed in this paper was gathered from the World Bank.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	B
Observations	354 (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	0.089677
MSE	3718.610944
MAE	42.496618

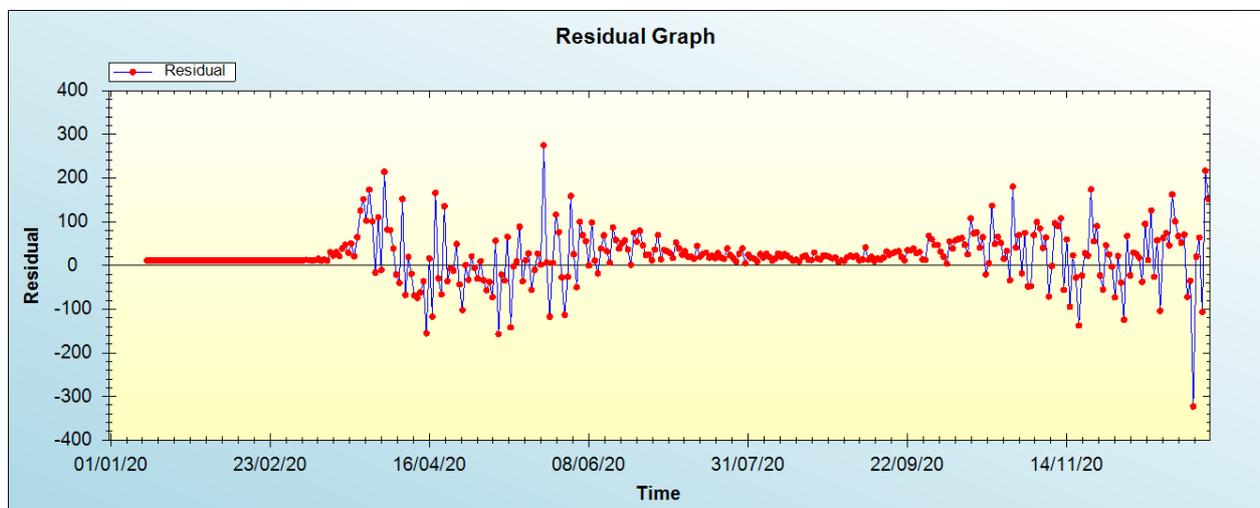*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
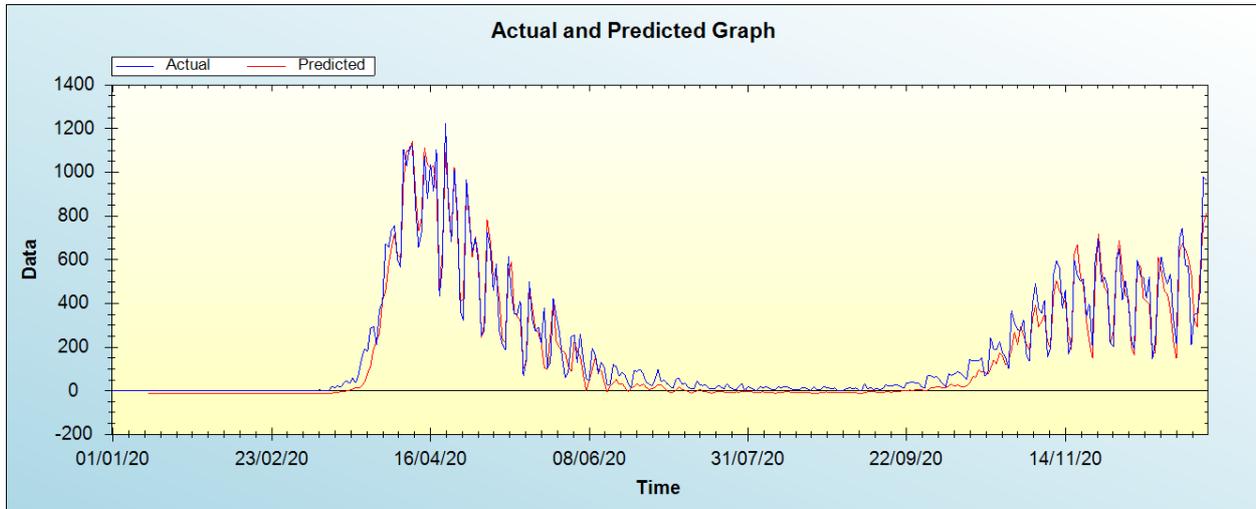
In-sample Forecast for B

Figure 2: In-sample forecast for the B series

Out-of-Sample Forecast for B: Actual and Forecasted Graph
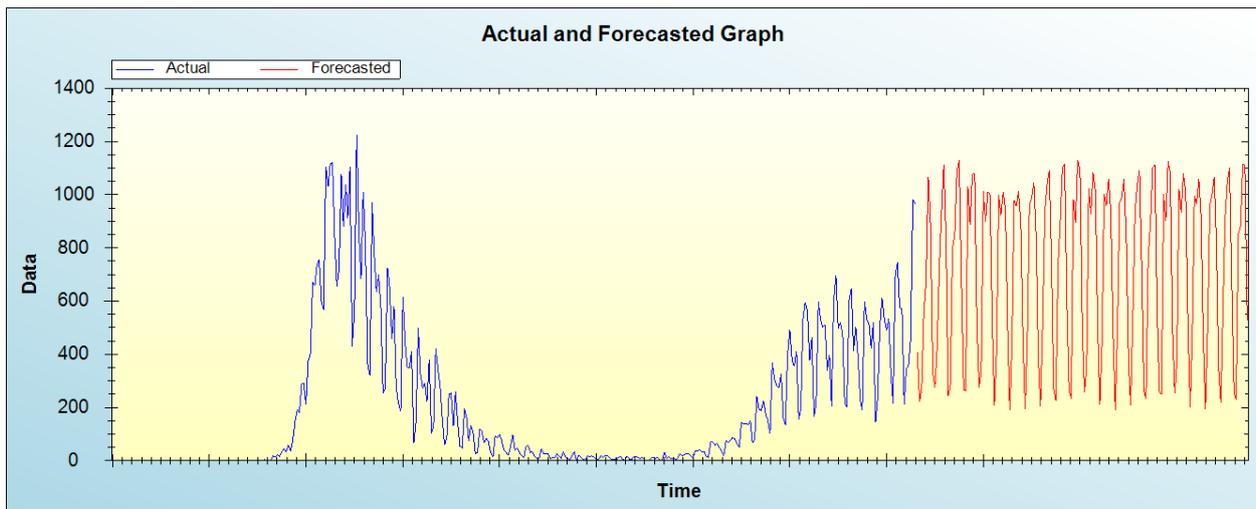
Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Forecasted

01/01/21	408.9115
02/01/21	223.5628
03/01/21	270.2409
04/01/21	557.9240
05/01/21	671.7677
06/01/21	1065.4513
07/01/21	874.1984
08/01/21	330.7505
09/01/21	275.6185
10/01/21	424.4303
11/01/21	720.1409

12/01/21	932.5644
13/01/21	1113.2597
14/01/21	834.3267
15/01/21	244.1427
16/01/21	287.6325
17/01/21	801.2228
18/01/21	849.3804
19/01/21	1088.7863
20/01/21	1127.0452
21/01/21	670.4231
22/01/21	267.3133
23/01/21	261.9509
24/01/21	1032.3671
25/01/21	886.3345
26/01/21	1075.4545
27/01/21	1080.9304
28/01/21	520.5876
29/01/21	274.9695
30/01/21	336.6806
31/01/21	1011.4159
01/02/21	899.9358
02/02/21	1010.3886
03/02/21	999.9732
04/02/21	525.9429
05/02/21	208.5696
06/02/21	411.2972
07/02/21	998.6007
08/02/21	923.6764
09/02/21	1008.4364
10/02/21	946.5558
11/02/21	506.4819
12/02/21	191.7876
13/02/21	428.8485
14/02/21	978.6383
15/02/21	956.9851
16/02/21	1011.1237
17/02/21	893.3723
18/02/21	458.8038
19/02/21	195.3635
20/02/21	444.5349
21/02/21	963.5345
22/02/21	985.8827
23/02/21	1045.3522
24/02/21	843.0561
25/02/21	382.6470
26/02/21	204.0414
27/02/21	520.7214
28/02/21	937.6073
01/03/21	1035.0390
02/03/21	1090.4639
03/03/21	750.9289
04/03/21	272.0574
05/03/21	225.6109
06/03/21	729.3906
07/03/21	893.6188
08/03/21	1099.6626
09/03/21	1116.0987
10/03/21	583.4005

Date	Value
11/03/21	260.7746
12/03/21	234.7481
13/03/21	983.3316
14/03/21	894.3903
15/03/21	1128.3010
16/03/21	1093.5764
17/03/21	494.2247
18/03/21	259.6459
19/03/21	346.0695
20/03/21	1023.0644
21/03/21	926.4443
22/03/21	1082.1489
23/03/21	1016.4444
24/03/21	500.1716
25/03/21	211.1758
26/03/21	455.0834
27/03/21	1001.2709
28/03/21	956.7059
29/03/21	1058.1561
30/03/21	934.2469
31/03/21	474.6001
01/04/21	191.5904
02/04/21	489.9275
03/04/21	969.7717
04/04/21	990.4445
05/04/21	1057.5620
06/04/21	845.1656
07/04/21	374.3036
08/04/21	210.3768
09/04/21	545.5003
10/04/21	930.9469
11/04/21	1033.2939
12/04/21	1090.0791
13/04/21	714.0434
14/04/21	262.6467
15/04/21	231.4152
16/04/21	769.1814
17/04/21	884.8143
18/04/21	1099.8370
19/04/21	1111.7161
20/04/21	556.2414
21/04/21	260.0257
22/04/21	249.8161
23/04/21	1000.7104
24/04/21	902.2284
25/04/21	1124.3635
26/04/21	1081.9279
27/04/21	488.7929
28/04/21	253.1179
29/04/21	372.4858
30/04/21	1020.5114
01/05/21	934.2663
02/05/21	1079.2167
03/05/21	1001.3264
04/05/21	498.0673
05/05/21	203.4213
06/05/21	472.1690
07/05/21	994.9414

08/05/21	965.9456
09/05/21	1059.3306
10/05/21	916.1821
11/05/21	456.5188
12/05/21	193.4620
13/05/21	502.4634
14/05/21	961.3090
15/05/21	1000.6556
16/05/21	1065.7817
17/05/21	817.3897
18/05/21	339.6682
19/05/21	218.2537
20/05/21	588.2116
21/05/21	917.3818
22/05/21	1049.5493
23/05/21	1099.3313
24/05/21	665.8442
25/05/21	253.3114
26/05/21	231.3369
27/05/21	852.4794
28/05/21	880.8018
29/05/21	1115.1700
30/05/21	1109.7170
31/05/21	526.8561

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 COVID-19 deaths will be generally between 200 and 1000 deaths per day in the UK over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

In conclusion, one can see that the COVID-19 pandemic led to the introduction of multiple levels of social distancing measures in the UK. Following the strict lockdowns and complete shutdowns to mitigate the first and second wave, public-health agencies are continually analyzing how best to develop exit strategies that best balance the epidemiological consequences against impacts on mental health and income generation. Advice is for the government of the UK to be cautious, in the relaxation of any controls. This will ensure that the most vulnerable members of society are protected, especially those with chronic conditions and children. Lessons of the first wave of the corona virus must be learnt and ought to inform policy decisions for tackling any resurgence. While controlling the pandemic takes precedence, it's also imperative to take the long view as many of the risk factors for dying from covid-19, these include cardiovascular disease, diabetes, obesity, and deprivation which lead to the lack mortality improvements and widening inequalities prevailing in the UK. Such diseases have always been there and focus on dealing with such chronic conditions amid the COID-19 era should be intensified.

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Citation of this Article:

Mr. Takudzwa. C. Maradze, Dr. Smartson. P. NYONI, Mr. Thabani NYONI, "Modelling and Forecasting Covid-19 Mortalities in the United Kingdom Using Artificial Neural Networks (ANN)" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 3, pp 551-557, March 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.503093

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