Forecasting Covid-19 Deaths in Portugal

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Abstract - **In this research article, the ANN approach was applied to analyze daily COVID-19 related deaths in Portugal. This study is based on daily COVID-19 deaths in Portugal for the period 1 January 2020 – 20 April 2021. The out-of-sample forecast covers the period 21 April – 31 August 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model show that the model is stable in forecasting daily COVID-19 related deaths in the country. The results of the study indicate that daily COVID-19 deaths in Portugal are likely to decrease at an increasing rate, characterized by two peaks over the out-of-sample period. In the out-of-sample period, the first peak for COVID-19 related deaths is likely to occur around 20 June 2021 while the second peak may be experienced around 23 August 2021. We recommend that the government of Portugal should ensure adherence to lock-down measures while creating massive awareness about the COVID-19 pandemic as well as scaling up vaccinations.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

Since the first emergence of the Coronavirus Disease 2019 (COVID-19) in Wuhan, Hubei Province, China, in December 2019 (Wu *et al*., 2020), the scourge has proliferated globally and has affected literally all nations till date (Worldometers, 2020). The global outbreak and severity of this contagious disease (Li *et al*., 2020) prompted the World Health Organization (WHO) to declare it as a Public Health Emergency of International Concern (PHEIC) on January 30, 2020, and then subsequently, to classify it as a pandemic on March 11, 2020 (WHO, 2020). As of August 2020, COVID-19 has infected approximately 20 million people across the globe with 90 countries in community transmission stage (WHO, 2020), leading to significant efforts towards control (Rawaf *et al*., 2020) and search for a cure (Le *et al*., 2020) for COVID-19 across the world. Definitely, the spread of this virus outbreak has seriously disrupted life, economy and health of citizens and this has become a great concern for everyone, as to how long will this scenario last and when the disease could be controlled (Sardar *et al*., 2020).Modeling and forecasting of the COVID-19 pandemic in Portugal, just like in any other affected country; remains paramount.

II. 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 COVID-19 deaths in Portugal.

Data Issues

This study is based on daily COVID-19 deaths in Portugal for the period 1 January 2020 – 20 April 2021.The out-of-sample forecast covers the period 21 April – 31 August 2021.All the data employed in this research paper was gathered from the Johns Hopkins University (USA).

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	P

Observations	464 (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	0.044396
MSE	55.850903
MAE	5.165495

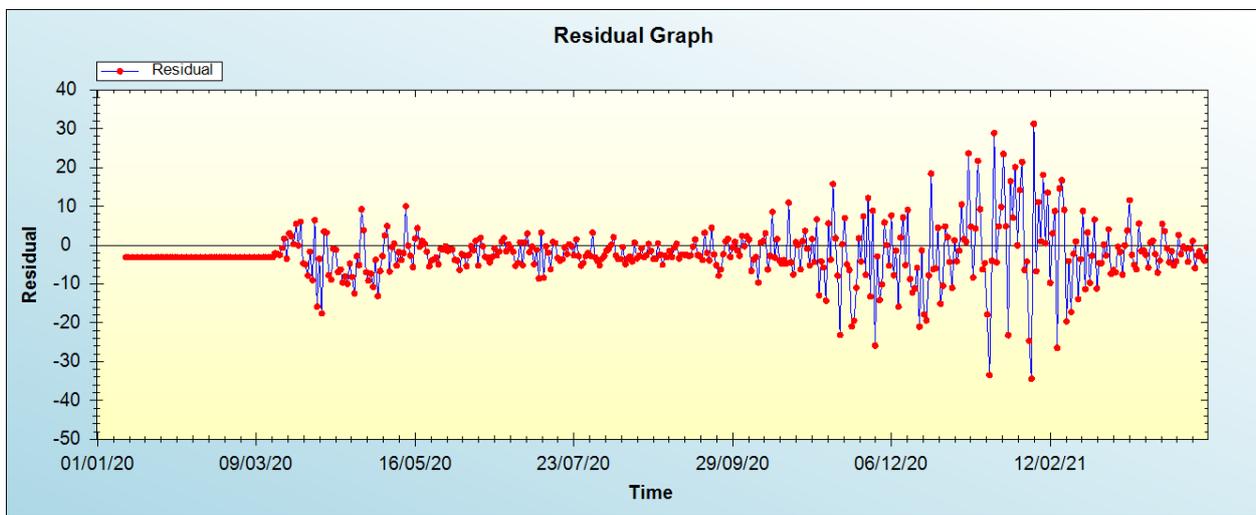*Residual Analysis for the Applied Model*

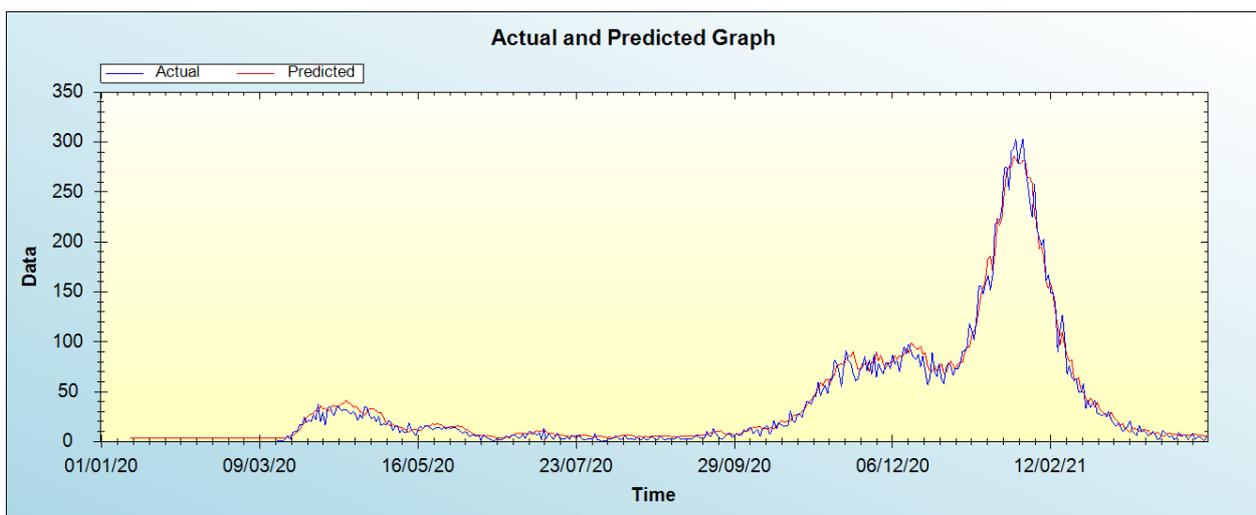**Figure 1: Residual analysis**

In-sample Forecast for P

Figure 2: In-sample forecast for the P series

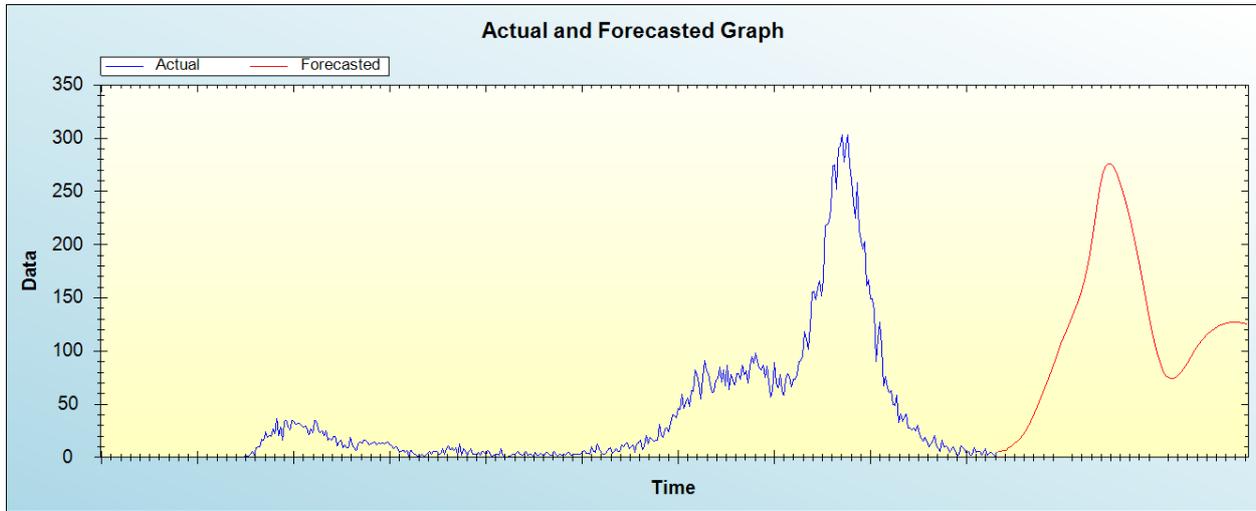*Out-of-Sample Forecast for P: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for P: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Date	Forecasts
21/04/21	5.1361
22/04/21	5.2353
23/04/21	6.1598
24/04/21	6.9040
25/04/21	6.8427
26/04/21	8.6985
27/04/21	9.7726
28/04/21	10.9631
29/04/21	12.2866
30/04/21	14.0764
01/05/21	15.0896
02/05/21	17.0488
03/05/21	19.2044
04/05/21	21.5462
05/05/21	24.0571
06/05/21	27.1034
07/05/21	30.1379
08/05/21	33.6399
09/05/21	37.4138
10/05/21	41.4193
11/05/21	45.5794
12/05/21	49.9064
13/05/21	54.1918
14/05/21	58.5493
15/05/21	62.9544
16/05/21	67.3832
17/05/21	71.8898
18/05/21	76.5322
19/05/21	81.2519
20/05/21	86.0980
21/05/21	91.0910
22/05/21	96.2361
23/05/21	101.4743
24/05/21	106.5316
25/05/21	110.8970
26/05/21	114.7308

27/05/21	118.8007
28/05/21	123.2177
29/05/21	127.6529
30/05/21	132.0232
31/05/21	136.4430
01/06/21	140.9333
02/06/21	145.5278
03/06/21	150.4948
04/06/21	156.2263
05/06/21	162.7852
06/06/21	169.8948
07/06/21	177.6232
08/06/21	186.4916
09/06/21	196.7666
10/06/21	208.2618
11/06/21	220.6813
12/06/21	233.5178
13/06/21	245.7488
14/06/21	256.2335
15/06/21	264.3985
16/06/21	270.2605
17/06/21	274.0200
18/06/21	275.9090
19/06/21	276.2132
20/06/21	275.1922
21/06/21	272.9832
22/06/21	269.6628
23/06/21	265.4070
24/06/21	260.4957
25/06/21	255.1162
26/06/21	249.2865
27/06/21	243.0019
28/06/21	236.3131
29/06/21	229.2457
30/06/21	221.7822
01/07/21	213.9419
02/07/21	205.7807
03/07/21	197.2943
04/07/21	188.4098
05/07/21	179.1185
06/07/21	169.5406
07/07/21	159.8248
08/07/21	150.0845
09/07/21	140.4602
10/07/21	131.1317
11/07/21	122.2391
12/07/21	113.8677
13/07/21	106.1109
14/07/21	99.0688
15/07/21	92.7813
16/07/21	87.2266
17/07/21	82.4306
18/07/21	78.6654
19/07/21	76.4443
20/07/21	75.3827
21/07/21	74.6262
22/07/21	74.2302
23/07/21	74.4471
24/07/21	75.2332
25/07/21	76.4983
26/07/21	78.2649
27/07/21	80.4912
28/07/21	82.9696
29/07/21	85.4970

30/07/21	88.1373
31/07/21	91.1228
01/08/21	94.4046
02/08/21	97.6625
03/08/21	100.6933
04/08/21	103.4278
05/08/21	105.8467
06/08/21	108.0482
07/08/21	110.2059
08/08/21	112.3799
09/08/21	114.4394
10/08/21	116.2092
11/08/21	117.6816
12/08/21	119.0041
13/08/21	120.2723
14/08/21	121.4767
15/08/21	122.6031
16/08/21	123.6255
17/08/21	124.4702
18/08/21	125.1076
19/08/21	125.6224
20/08/21	126.1166
21/08/21	126.5828
22/08/21	126.9332
23/08/21	127.1257
24/08/21	127.1873
25/08/21	127.1384
26/08/21	126.9827
27/08/21	126.7494
28/08/21	126.4591
29/08/21	126.0679
30/08/21	125.5187
31/08/21	124.8231

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 deaths in Portugal are likely to decrease at an increasing rate, characterized by two peaks over the out-of-sample period. In the out-of-sample period, the first peak for COVID-19 related deaths is likely to occur around 20 June 2021 while the second peak may be experienced around 23 August 2021.

IV. CONCLUSION & RECOMMENDATIONS

The COVID-19 pandemic, declared as a pandemic by WHO, is currently the most aggressive threat in the entire world, affecting everyone in this world, in one way or the other. It has become inevitable to forecast the daily COVID-19 related deaths in Portugal as this information is important for policy makers to be in a position to properly handle the pandemic. It is projected that daily COVID-19 deaths in Portugal are likely to decrease at an increasing rate, characterized by two peaks over the out-of-sample period. In the out-of-sample period, the first peak for COVID-19 related deaths is likely to occur around 20 June 2021 while the second peak may be experienced around 23 August 2021. We recommend that the government ought to ensure adherence to lock-down measures while creating massive awareness about the COVID-19 pandemic. We also encourage the government of Portugal to scale up COVID-19 vaccinations throughout the country.

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