

Forecasting Under Five Mortality Rate for Portugal Using Artificial Neural Networks

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Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Portugal from 1960 to 2020 to predict future trends of Portugal over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied ANN (12, 12, 1) model is stable in forecasting under five mortality rate in Portugal. The ANN model projections revealed that annual U5MR will hover around 3 deaths per 1000 live births throughout the out of sample period. Therefore, the Portuguese government must continue supporting the maternal and child health program in order to keep under five mortality under control.

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The third sustainable development goal (SDG3) prioritizes global population health. It seeks to identify all the health challenges affecting different regions and come up with appropriate country specific strategies that will ensure good health and promote well-being for all at all stages of life (UN, 2016; UN, 2015). The strategies should be able to deal with communicable and non-communicable diseases, neglected tropical diseases, access to adequate, clean and safe water, substance abuse, deaths from road traffic accidents and hazardous chemicals (UN, 2020; WHO, 2019; UNICEF, 2019; UNICEF, 2018). Maternal, newborn and under five mortality remain a global health concern which requires all stakeholders and political leaders to design policies that will effectively control these preventable deaths. Portugal has witnessed a significant decrease in infant and neonatal mortality in recent years (Bandeira *et al.* 2016). This was achieved through the government's commitment to universal health coverage. Several strategies were implemented such as the national vaccination program, improved nutrition, reorganization of hospital care, implementation of a network of health care facilities and training of medical staff. In line with the Agenda 2030, this study applies the artificial neural network approach to forecast future trends of under-five mortality for Portugal with the aim of ending all preventable under five deaths.

II. LITERATURE REVIEW

Weiland *et al.* (2021), in Portugal, examined the effects of the 2006 National Program of Maternal and Neonatal Health policy on spatial inequalities in access to care and consequently avoidable infant mortality. A thematic analysis of qualitative data including interviews and surveys and a quantitative spatial analysis using Geographic Information Systems was applied. Spatial inequalities were found which may lead to avoidable infant mortality. Inequalities exist in freedom of choice and autonomy in care, within a medicalized system. A systematic review conducted by Masaba and Phetoe (2020) found out that in 2018, the neonatal mortality rate for Kenya was 19.6 deaths per 1000 live births. The neonatal mortality rate had fallen gradually from 35.4 deaths per 1000 live births in 1975. On the other hand, South Africa had its neonatal mortality rate fall from 27.9 deaths per 1000 live births in 1975 to 10.7 deaths per 1000 live births in 2018. Damian *et al.* (2019) demonstrated that estimates from both global metrics and institutional reporting, although widely divergent, indicate South Africa has not achieved MDG 4a and 5a goals but made a significant progress in reducing maternal and neonatal mortality. Bandeira *et al.* (2016) described Portugal's achievements in the maternal and child health program. The study highlighted that the joint venture of pediatricians and obstetricians with adequate top-down government commissions for maternal and child health for the decision making by health administrators and a well-defined schedule of preventive and managerial measures in the community and in hospitals, registry of special diseases and training of medical personnel are the most likely explanations for this success.

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 annual under five mortality rate for Portugal.

Data Issues

This study is based on annual under five mortality rate in Portugal for the period 1960 – 2020. The out-of-sample forecast covers the period 2021– 2030. All the data employed in this research paper was gathered from the World Bank online database.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	P
Observations	49 (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	0.000693
MSE	0.101650
MAE	0.271878

Residual Analysis for the Applied Model

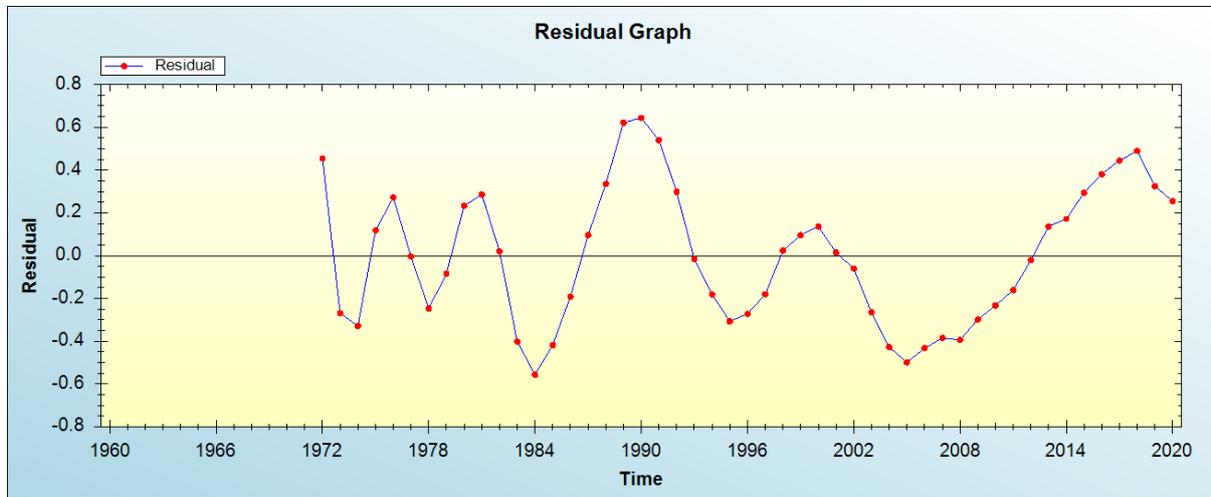


Figure 1: Residual analysis

In-sample Forecast for P

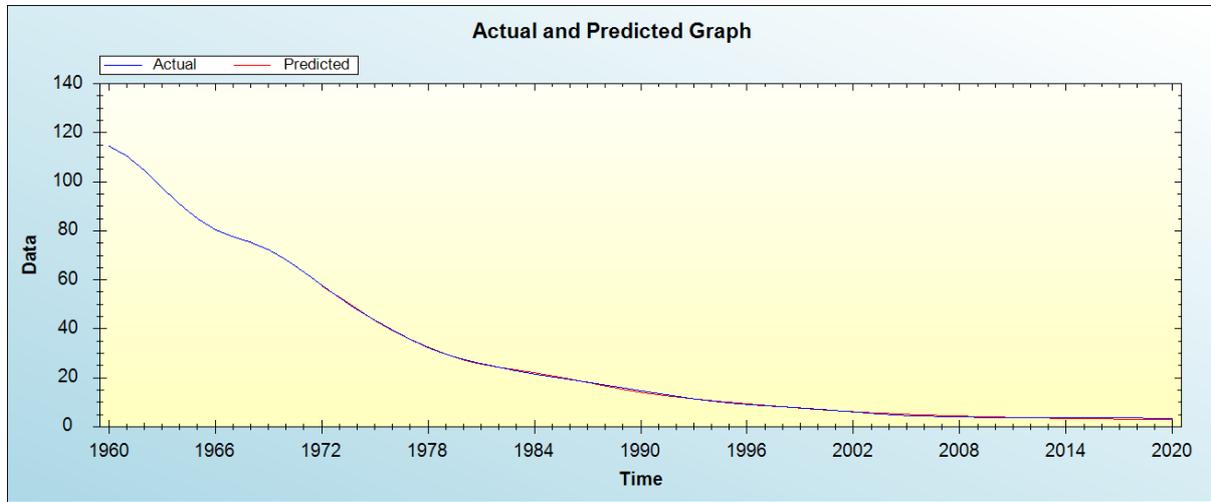


Figure 2: In-sample forecast for the P series

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

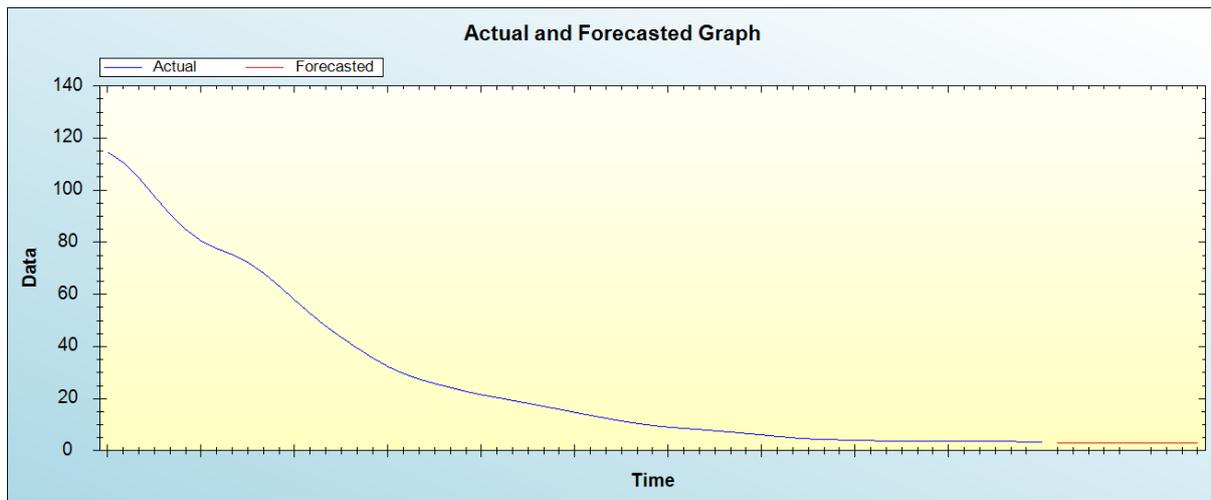


Figure 3: Out-of-sample forecast for P: actual and forecasted graph

Out-of-Sample Forecast for P: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	3.0265
2022	3.0281
2023	3.0201
2024	3.0097
2025	2.9830
2026	2.9612
2027	2.9400
2028	2.9459
2029	2.9258
2030	2.9144

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 annual U5MR will hover around 3 deaths per 1000 live births throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The Portuguese government has made significant progress towards achieving sustainable development goals (SDGs). The state has implemented strategies that promote universal health coverage and quality affordable healthcare. Under five mortality has remained low as revealed by the decline in under five mortality rates over the past decades to levels below 25 deaths per 1000 live births. This study applied the ANN model to predict under five mortality rate in Portugal and forecast results revealed that annual U5MR will hover around 3 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage the Portuguese government to continue supporting the maternal and child health program activities in order to keep under five mortality under control.

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