

Forecasting Infant Mortality Rate in Togo Using a Machine Learning Algorithm

¹Dr. Smartson. P. NYONI, ²Thabani NYONI

¹ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

²Department of Economics, University of Zimbabwe, Harare, Zimbabwe

Abstract - In this piece of work, the ANN approach was applied to analyze infant mortality rate (IMR) in Togo. The employed data covers the period 1960-2020 and the out-of-sample period ranges over the period 2021-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting IMR rate in Togo. The applied ANN (12, 12, 1) model predictions suggest that IMR will be around 44/1000 live births per year in the coming 10 years. Therefore the government should focus on improving the quality of health care services especially primary health care and work towards developing strategies to retain its skilled health labour force.

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Artificial neural networks are artificial intelligence models or electronic models whose structure and function is based on the human brain (Niazkar & Niazkar, 2020; Patterson, 1995). The model has been applied in various fields with very good results (Niazkar, 2019; Niazkar, 2020a; Niazkar, 2020 b). The multilayer perceptron is the commonest artificial neural network framework in time series forecasting. The model is composed of 3 layers of neurons: input, hidden and output layers connected by weights (Nyoni et al, 2020; Zhao et al, 2020; Niazkar, 2019; Kaushik & Sahi, 2018; Yan et al, 2018, Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995). The support vector machine, ensembles, K-nearest neighbors and Bayesian networks are also being applied in time series forecasting and have proven to be reliable (Nyoni et al, 2020; Panch et al, 2018;Weng et al, 2017). The support vector machine (SVM) was proposed by Vapnik in the 1990s. The technique is based on the structural risk minimization principle. The objective of SVM is to construct an optimal hyperplane through nonlinear mapping of input data X into a higher dimension feature space H. For the Support vector for regression (SVR), the optimal hyperplane is closest to all the data points whereas in the support vector classifier the linear decision boundary separates the two classes with a maximum margin (Zhang, 2003). In this paper we aim to model and forecast infant mortality rate in Togo using the multilayer perceptron. The findings of this study are envisioned to facilitate health planning and decision making in order to allocate resources for maternal and child health services.

II. LITERATURE REVIEW

Nyoni & Nyoni (2020) modelled and forecasted infant deaths in Zimbabwe using ARIMA model. The study utilized annual time series data on total infant deaths in Zimbabwe from 1960 to 2018. The best model based on AIC was the ARIMA (1, 2, 5) model. The study findings indicated that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend. In a related study, Nyoni & Nyoni (2020) used monthly time series data on neonatal deaths cases at Chitungwiza Central Hospital (CCH) from January 2013 to December 2018; to forecast neonatal deaths over the period January 2019 to December 2020 using the Box-Jenkins SARIMA approach. The parsimonious model was found to be the SARIMA (0, 0, and 3) (2, 0, 0)12 model and its predictions indicate slow but steady decrease in neonatal deaths at CCH. Iriondo et al (2020) developed and validated different mortality predictive models, using Spanish data, to be applicable to centers with similar morbidity and mortality. Infants born alive, admitted in NICU, and registered in the SEN1500 database, were included. Multivariable regression models were used for the different time periods. The study concluded that using dynamic models to predict individual mortality can improve outcome estimations. Development of models in the prenatal period, first 24 hours, and during hospital admission, cover key stages of mortality prediction in preterm infants. Khan et al. (2019) compared infant mortality rate with GDP (PPP(Purchasing Power Parity)) of developed, underdeveloped and lower developing countries of Asia such as Bangladesh, China, India, Japan, Sri Lanka, Nepal, Oman, Pakistan, Philippines, Saudi Arabia, Singapore, Thailand and Turkey. The results of the study indicated that there is a strong negative correlation between infant mortality rate and GDP (PPP). The study also found out that the AR (1) model is suitable for analyzing infant mortality rates for all the countries except Japan and Nepal for which ARIMA (1, 1, 1) model is appropriate.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this study; is a data processing system consisting of a huge number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from any data-set to describe the nonlinear and interaction effects with great accuracy. No strict rules 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. This paper applies the Artificial Neural Network (ANN) approach in predicting infant mortality rates in Togo.

Data Issues

This study is based on annual infant mortality rates in Togo for the period 1960 – 2020. The out-of-sample forecast covers the period 2021 to 2030. Infact mortality rate, which is simply a proxy for infant deaths; for the purposes of this study, is defined as the number of infants dying before reaching one year of age, per 1000 live births in a given year. All the data employed in this paper was gathered from the World Bank.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	Q
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	0.013519
MSE	0.733126
MAE	0.703255

Residual Analysis for the Applied Model

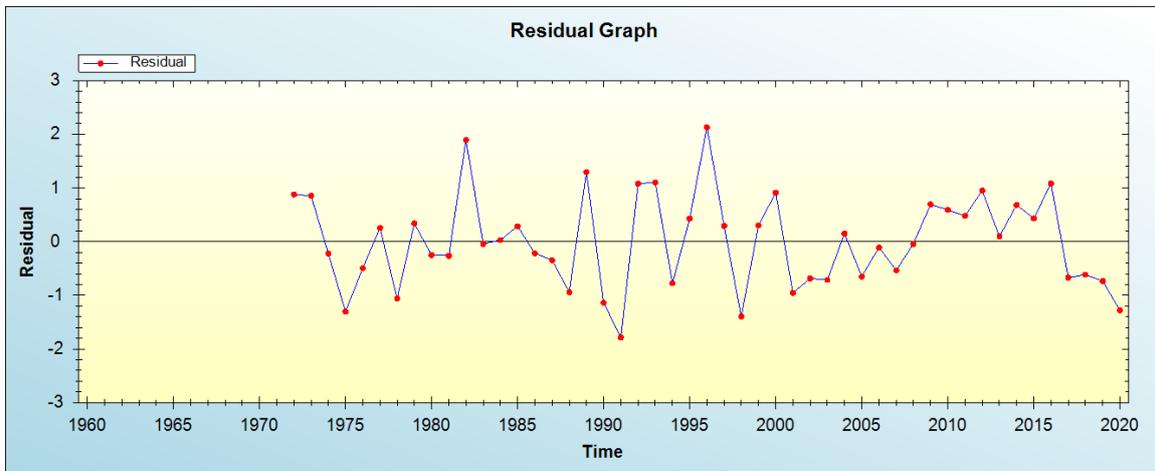


Figure 1: Residual analysis

In-sample Forecast for Q

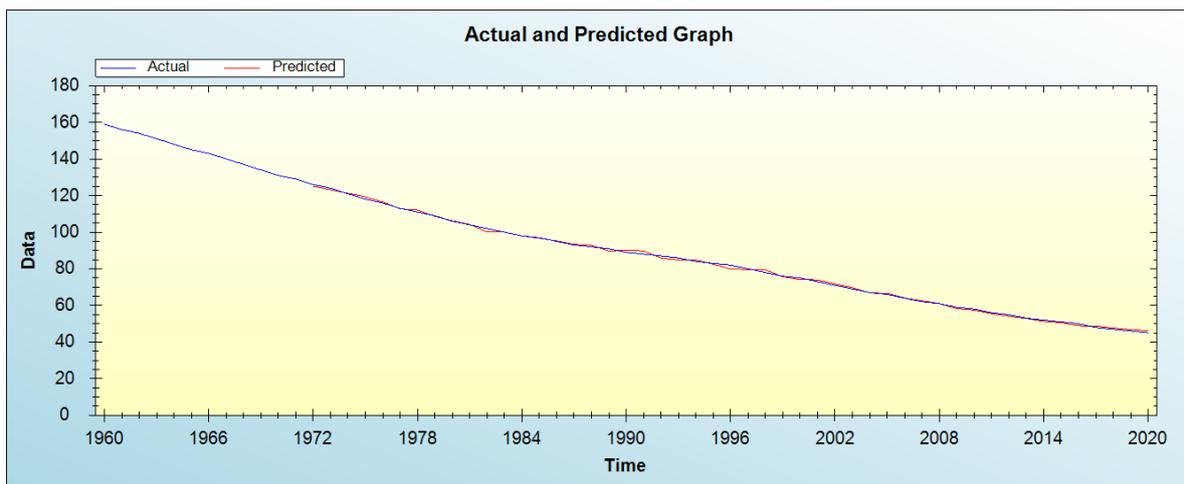


Figure 2: In-sample forecast for the Q series

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

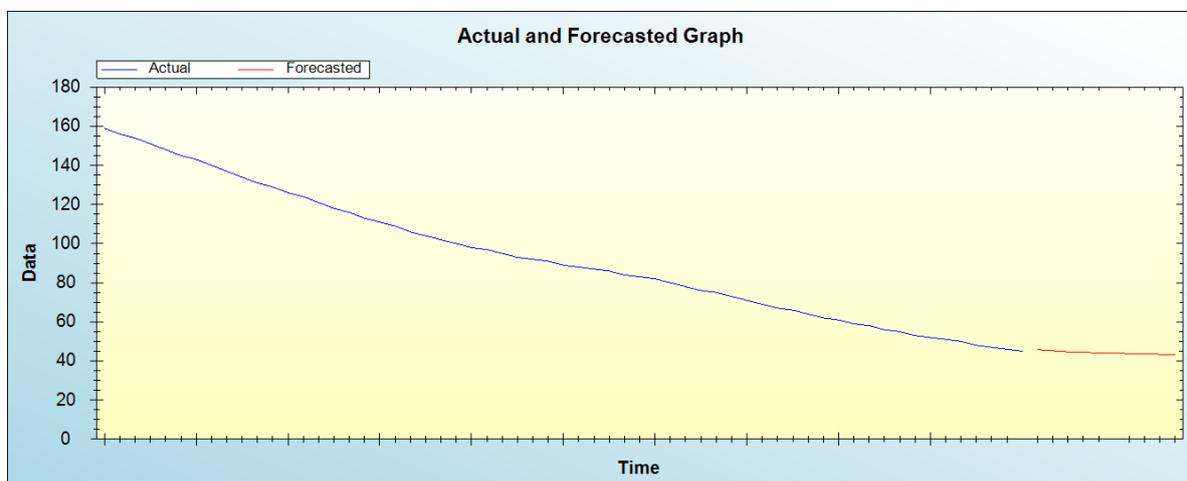


Figure 3: Out-of-sample forecast for Q: actual and forecasted graph

Out-of-Sample Forecast for Q: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	45.8558
2022	45.2478
2023	44.7001
2024	44.5827
2025	43.9625
2026	43.9811
2027	43.8309
2028	43.6364
2029	43.3820
2030	43.2085

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 infant mortality in Togo is likely to remain around 44/1000 live births per year over the next decade.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Preventing infant mortality remains one of the main objectives of the health ministry in Togo. The government remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Togo. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Togo ought to consider the following policy suggestions:

- i. The government should continue to encourage mothers to breast-feed their babies adequately.
- ii. There is need for all child-bearing women to be vaccinated against common illnesses.
- iii. There is need to prevent birth defects in Togo.
- iv. The government of Togo should address preterm birth, low birth-weight and their outcomes.
- v. The government of Togo should also ensure adequate access to pre-pregnancy and prenatal care.
- vi. There is need to educate, especially, mothers on the importance of creating a safe infant sleep environment in the country.
- vii. Healthcare providers in Togo need to use newborn screening activities in order to detect hidden conditions.

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Citation of this Article:

Dr. Smartson. P. NYONI, Thabani NYONI, “Forecasting Infant Mortality Rate in Togo Using a Machine Learning Algorithm” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 3, pp 602-606, March 2021. Article DOI <https://doi.org/10.47001/IRJIET/2021.503103>
