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Forecasting Infant Mortality Rate in Cuba Using Artificial Neural Networks

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***Abstract* - In this research paper, the ANN approach was applied to analyze infant mortality rate (IMR) in Cuba. The employed annual data covers the period 1963-2020 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 in Cuba. The applied ANN (12, 12, 1) model predictions suggests that IMR in the country will remain under control at approximately 4/1000 live births per year in the next 10 years. The Cuban government is encouraged to continue on this commendable path.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Cuba is a small underdeveloped and poor nation (Pineo, 2019).The country has an excellent health delivery system with low child mortality rates (Gonzalez, 2015). According to WHO the country recorded under 5 mortality rate of 5.5 per 1000 live births in 2016. Universal healthcare and universal education are the main factors behind Cuba's success (Rodriguez et al, 2008; Robertshaw & Weldon, 2013). The Cuban government has massively invested in primary healthcare with more than 50 % of the doctors working in primary health care (Gonzalez & Choonara, 2019). The Cuban government implemented several measures in order to reduce infant mortality such as good antenatal care & health education, high quality neonatal care, immunization and exclusive breastfeeding for at least 6 months (Brown et al, 2019; Espinosa et al, 2018; Gorry, 2018; UNICEF, 2017; Lopez & Cloonara, 2009). Cuba has done very well in reducing child mortality and is a good example of successful health systems. In this paper we aim to model and forecast infant mortality rate in Cuba using the multilayer perceptron. The model is based on the structure and function of the human brain. It is made of 3 layers of neurons namely input, hidden and output layers connected by weights (Zhao et al, 2020, Nyoni et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018 ; Scavuzzo et al,2018; Gambhir et al, 2018; Laurean-Rosario et al, 2018; Weng et al, 2017; Guo et al, 2017;Althouse et al, 2011; Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995).

II. LITERATURE REVIEW

Beluzo et al (2020) proposed a new approach to classify newborns that may be susceptible to neonatal mortality by applying supervised machine learning methods on public health features. The approach was evaluated in a sample of 15,858 records extracted from SPNeoDeath dataset, which were created from SINASC and SIM databases from Sao Paulo city ˜ (Brazil). As a result an average AUC of 0.96 was achieved in classifying samples as susceptible to death or not with SVM, XGBoost, Logistic Regression and Random-Forests machine learning algorithms. Furthermore the SHAP method was used to understand the features that mostly influenced the algorithms output. 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 applied model projected 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, 3) (2, 0, 0)12 model and its predictions indicate slow but steady decrease in neonatal deaths at CCH. Khan et al (2019) modelled and forecasted infant mortality rates of Asian countries in the perspective of GDP. Secondary data of IMR and GDP (PPP) from 1980 to 2015 was analyzed and forecast was done from 2016 to 2025. AR (1) was found to be suitable for all the countries except Japan and Nepal for which ARIMA (1, 1, 1) model was appropriate based on FMSE and FRMSE. Kohut (2018) investigate the primary and reproductive care paradoxes presented to Cuban women today, specifically in rural Mayajigua, Cuba. A Mixed Methods approach that synthesizes information from a 2015 independent research quantitative survey alongside a 2016 independent research ethnographic project were used to assess the Cuban Medical Paradox in a holistic

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manner. Analysis showed that the Cuba Paradox exists due to a series of recent international developments, notably the 2016 Cuban Special Period.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this paper; 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 Cuba.

Data Issues

This study is based on annual infant mortality rates in Cuba for the period 1963 – 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	C
Observations	46 (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	0.018081
MSE	0.186575
MAE	0.352512

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Residual Analysis for the Applied Model

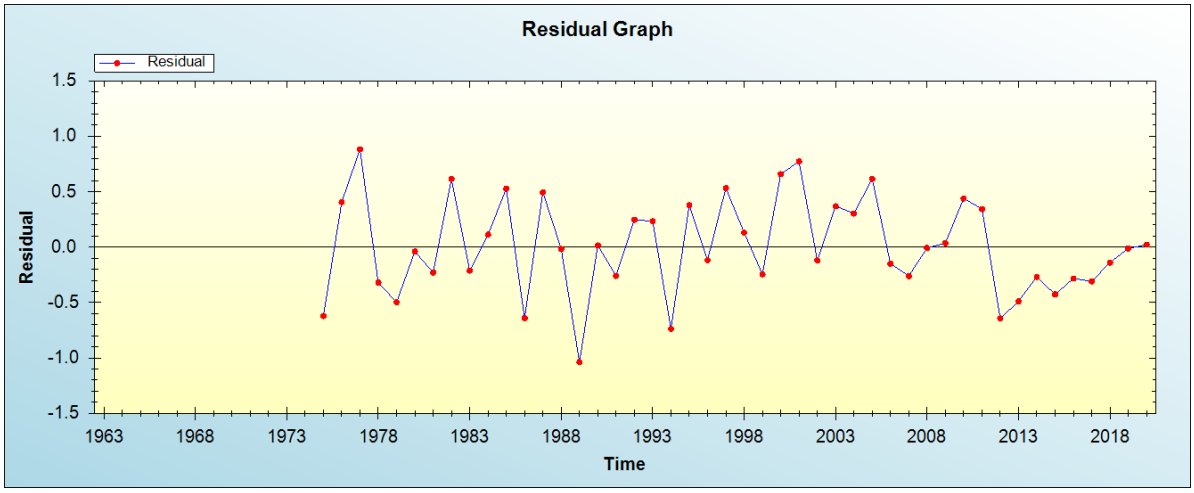

Figure 1: Residual analysis

In-sample Forecast for C

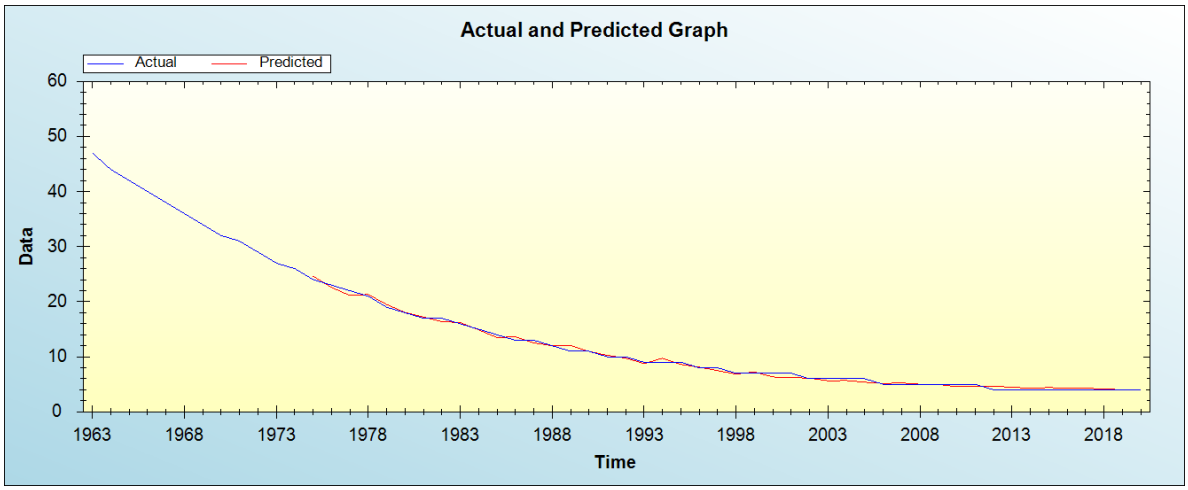

Figure 2: In-sample forecast for the C series

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

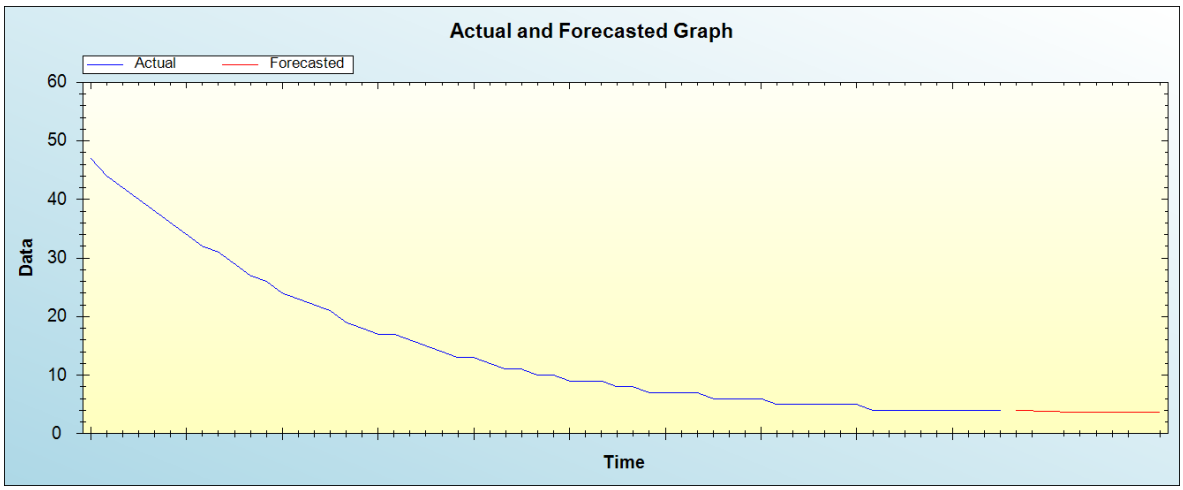

Figure 3: Out-of-sample forecast for C: actual and forecasted graph

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Out-of-Sample Forecast for C: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Predictions
2021	3.9772
2022	3.9156
2023	3.8696
2024	3.7016
2025	3.7176
2026	3.7265
2027	3.7476
2028	3.7388
2029	3.7433
2030	3.7399

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 Cuba is likely to remain around 4/1000 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 Cuba. The Cuban government remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Cuba. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Cuba 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 to educate, especially, mothers on the importance of creating a safe infant sleep environment in the country.

iii. Healthcare providers in Cuba need to use newborn screening activities in order to detect hidden conditions.

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