

Forecasting Total Fertility Rate (TFR) In Paraguay Using a Machine Learning Algorithm

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Abstract - In this research paper, the ANN approach was applied to analyze TFR in Paraguay. The employed annual data covers the period 1960-2018 and the out-of-sample period ranges over the period 2019-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting TFR in Paraguay. The results of the study indicate that annual total fertility rates in the country are likely to remain around 3 or 2 births per woman over the out-of-sample period. Therefore, the authorities in Paraguay are encouraged to continue improving accessibility of family planning services to adolescents and young adults to minimize adverse SRH outcomes.

Keywords: ANN, Forecasting, Total fertility rate (TFR).

I. INTRODUCTION

Total fertility rate (TFR) is defined as the average number of children born to a woman throughout her lifetime if she were to pass through her childbearing age at the current age specific fertility rates. It is a standard measure of fertility of a population. Global fertility rates have been decreasing over the years from high to low fertility and this phenomenon is called fertility transition (Silva, 2008). The major drivers of fertility decline include improvement in human development indicators such as increased female education, female participation in labor force and use of modern contraception (Gubhaju, 2006). The aim of the study is to forecast total fertility rate in Paraguay using a machine learning approach. The results of the study are expected to highlight the likely future trends of fertility in Paraguay. This will assist in policy making, planning and in responding to the country's future health, education and employment needs.

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 annual total fertility rates in Paraguay.

Data Issues

This study is based on annual total fertility rate (births per woman) in Paraguay for the period 1960 – 2018. The out-of-sample forecast covers the period 2019 – 2030. All the data employed in this research paper was gathered from the World Bank online database.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	A
Observations	47 (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	0.112581
MSE	0.097797
MAE	0.235791

Residual Analysis for the Applied Model

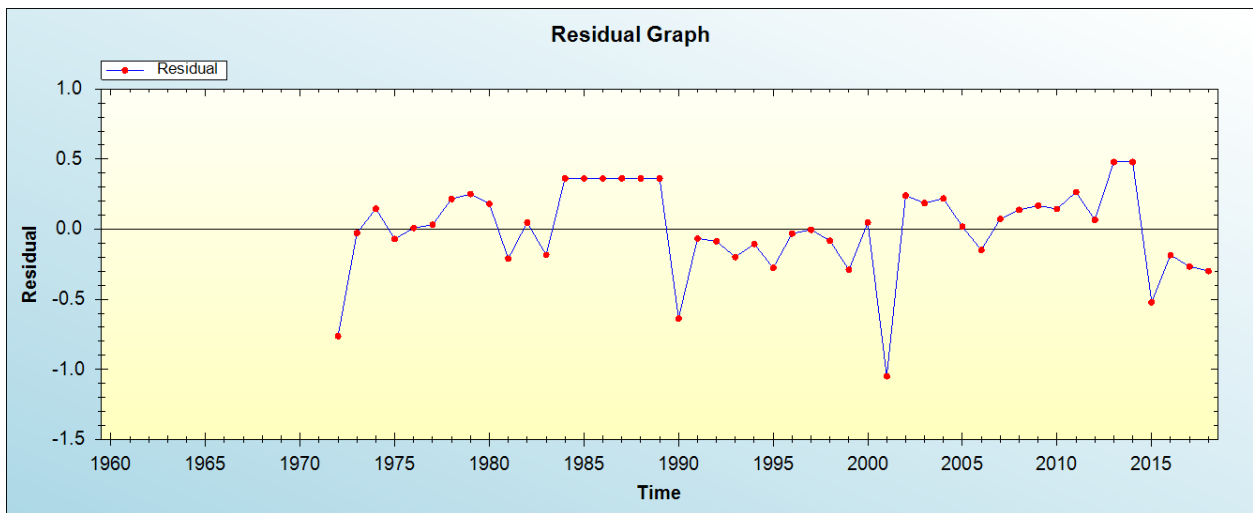


Figure 1: Residual analysis

In-sample Forecast for A

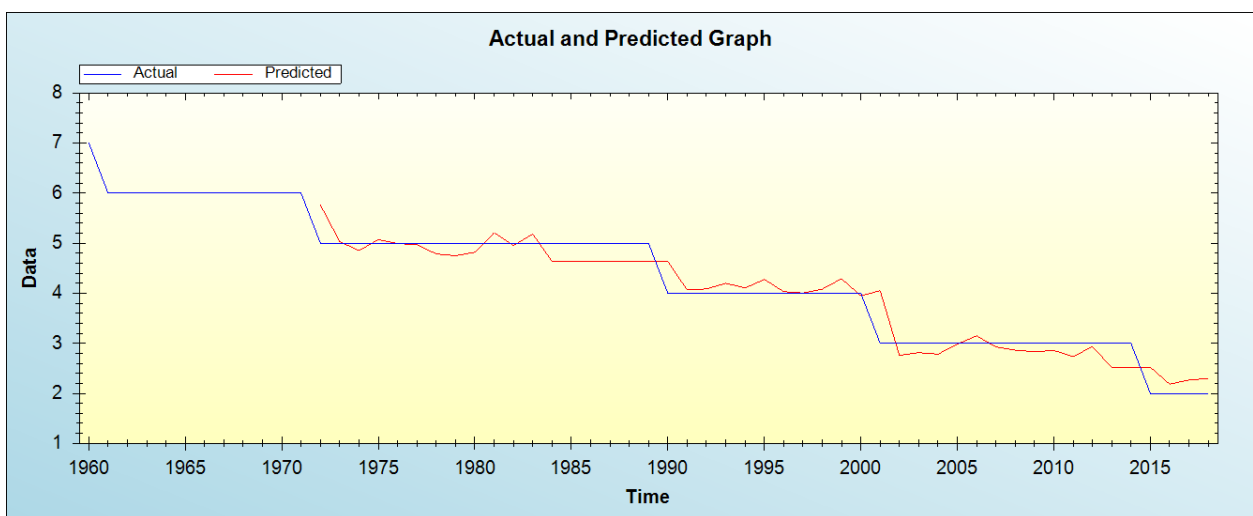


Figure 2: In-sample forecast for the A series

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

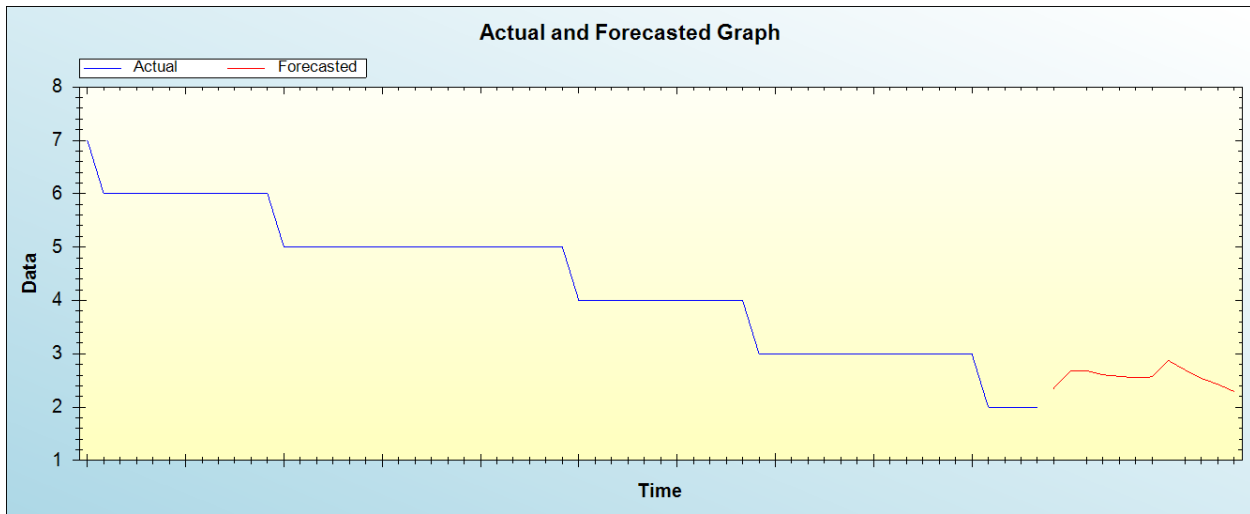


Figure 3: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	2.3530
2020	2.6762
2021	2.6829
2022	2.6035
2023	2.5780
2024	2.5473
2025	2.5671
2026	2.8713
2027	2.6980
2028	2.5396
2029	2.4289
2030	2.2921

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 total fertility rates in Paraguay are likely to hover around 3 or 2 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Total fertility rates in Paraguay have declined over the years and the country currently has low infant and child mortality rates. In this paper we proposed an artificial intelligence technique to project TFR in the country. The results indicated that annual total fertility rates in Paraguay are likely to remain around 3 or 2 births per woman over the out-of-sample period. Therefore, the authorities in the country are encouraged to continue improving accessibility of family planning services to adolescents and young adults to minimize adverse sexual and reproductive (SRH) outcomes.

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