

# Forecasting Total Fertility Rate (TFR) in Costa Rica

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**Abstract - In this research article, the ANN approach was applied to analyze TFR in Costa Rica. 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 Costa Rica. The results of the study indicate that annual total fertility rates in the country are likely to be around 2 births per woman towards the end of out-of-sample period. Therefore, we encourage the authorities in Costa Rica to continue improving the quality of family planning services to minimize adverse maternal and child health outcomes.**

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

## I. INTRODUCTION

The future size and composition of a population are determined by fertility, mortality and migration rates (Arbu et al, 2021). Forecasting of fertility rates remains crucial in understanding the future population dynamics. TFR is the frequently used fertility measure in time series forecasting of fertility trends (Ali et al, 2001). It is the average number of children born to a woman throughout her life time if she were to pass through her child bearing years at the current age specific fertility rates. Fertility is the most determinant of population change (Caldwell, 1982; Easterlin, 1975; Becker, 1965). It does not only determine population growth but it is a major determinant for change in age composition of a population (Rabbi, 2015; Khuda & Hussain, 1996). The fertility of a population is determined by biological, social and behavioral factors (Dougall et al, 2012). Determinants of fertility can also be classified into demographic, socio-economic, cultural and spatial determinants (BBS & SID, 2015). Early age marriage, low levels of education and unemployment have been seen to be associated with higher fertility rates. Rural areas generally have higher fertility rates when compared to urban settings (BBS & SID, 2015). The aim of this study is to project TFR in Costa Rica using a machine learning approach. The findings of this piece of work are envisioned to reflect the likely fertility trends in the out of sample period. This will guide policy and initiate an early response to the future health, education and employment needs of the people in the country.

## 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 Costa Rica.

### Data Issues

This study is based on annual total fertility rate (births per woman) in Costa Rica 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	0.106802
MSE	0.088014
MAE	0.238468

Residual Analysis for the Applied Model

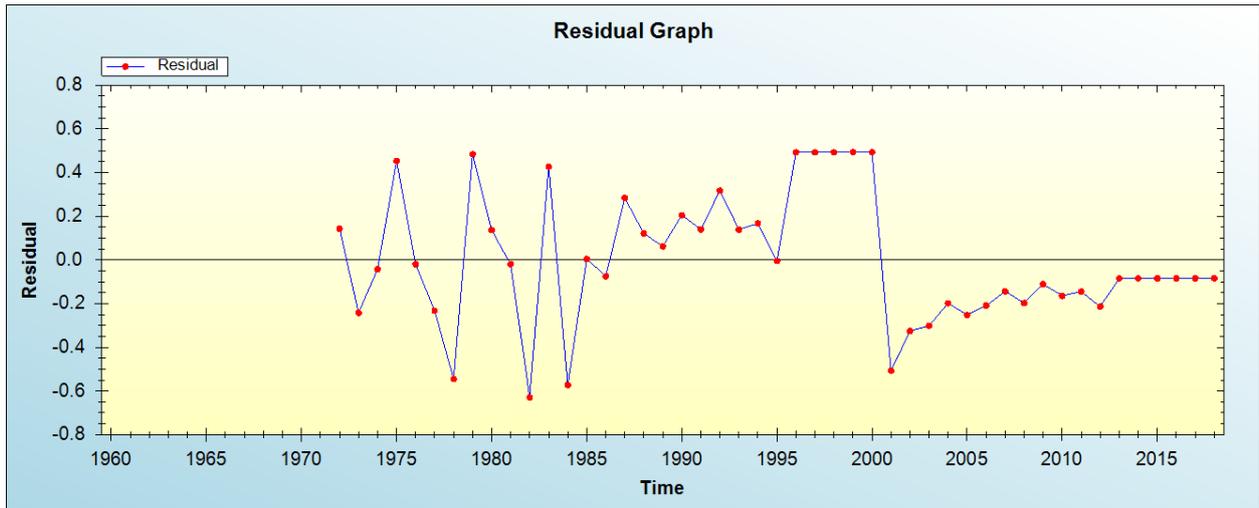


Figure 1: Residual analysis

In-sample Forecast for A

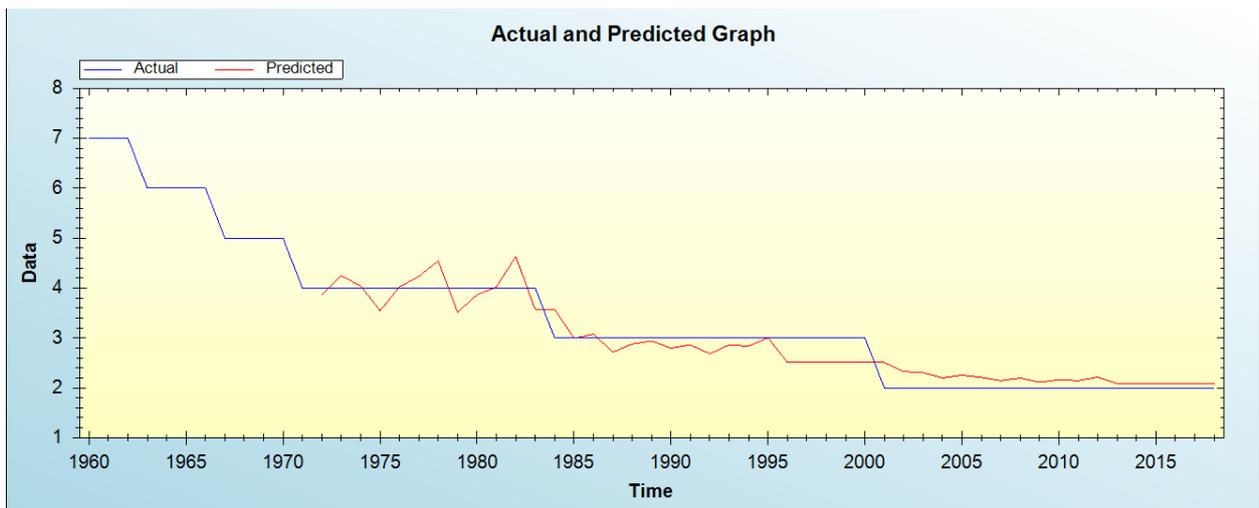


Figure 2: In-sample forecast for the A series

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

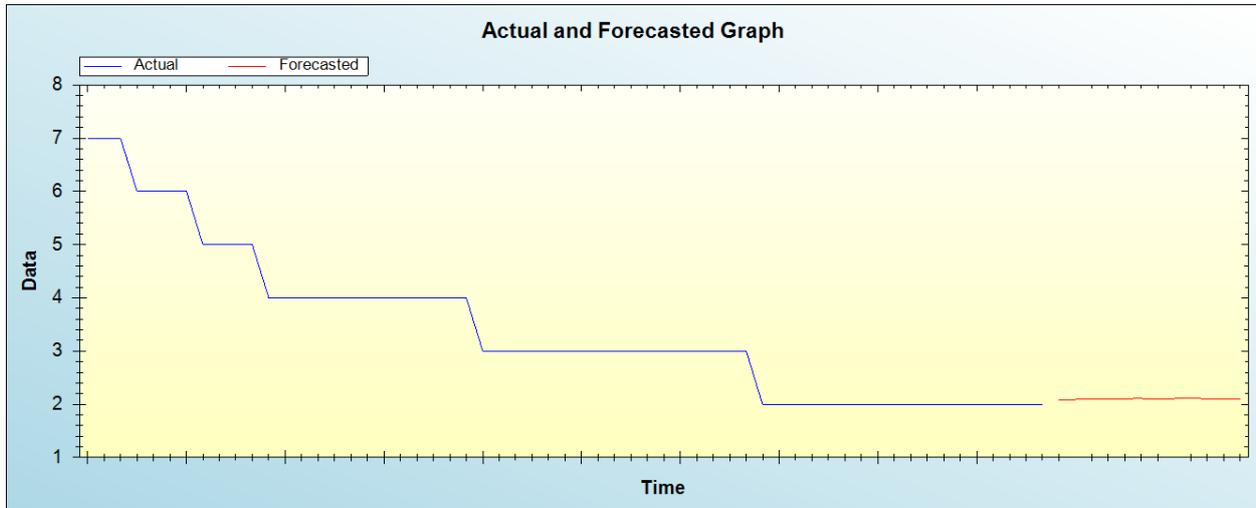


Figure 3: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	2.0843
2020	2.0892
2021	2.0960
2022	2.0997
2023	2.1056
2024	2.1077
2025	2.1067
2026	2.1063
2027	2.1114
2028	2.1056
2029	2.1060
2030	2.0979

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 Costa Rica are likely to remain around 2 births per woman over the out-of-sample period.

**IV. CONCLUSION & RECOMMENDATIONS**

Fertility forecasting is important to understand the future population dynamics especially population composition and size. It provides an insight of the future labor force and demand for housing, education and health services. In this paper we apply the artificial neural network approach to forecast total fertility rate in Costa Rica. The results of the study revealed that annual total fertility rates in Costa Rica are likely to be around 2 births per woman towards the end of the out-of-sample period. Therefore, we encourage the authorities in Costa Rica to continue improving the quality of family planning services to minimize adverse maternal and child health outcomes.

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