

# Forecasting Total Fertility Rate (TFR) in Panama

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**Abstract - In this research article, the ANN approach was applied to analyze TFR in Panama. 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 Panama. The results of the study indicate that annual total fertility rates in the country are likely to increase from 2.46 births per woman in 2019 to 4.73 births per woman in 2025 and then decline to 2 births per woman towards the end of out-of-sample period. Therefore, we encourage the authorities in Panama 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 Panama 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 Panama.

### Data Issues

This study is based on annual total fertility rate (births per woman) in Panama 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	0.139053
MSE	0.095484
MAE	0.245217

Residual Analysis for the Applied Model

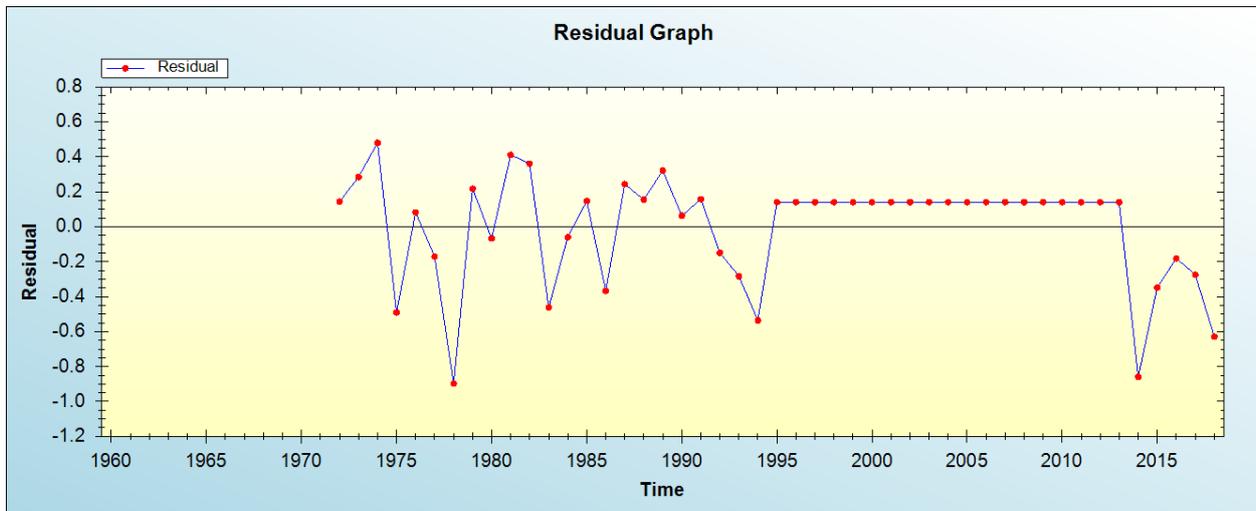


Figure 1: Residual analysis

In-sample Forecast for A

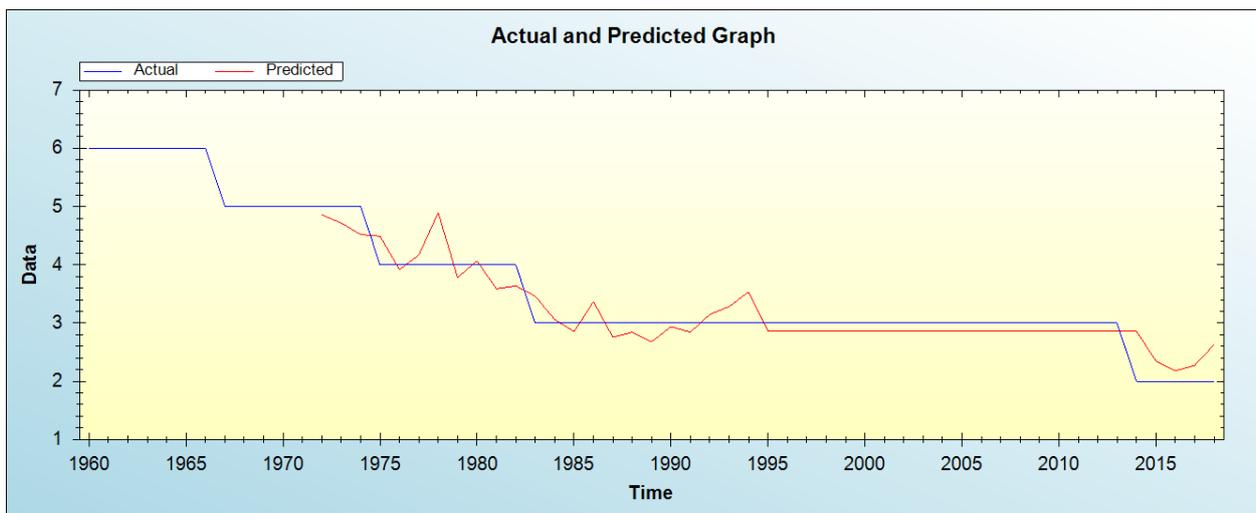


Figure 2: In-sample forecast for the A series

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

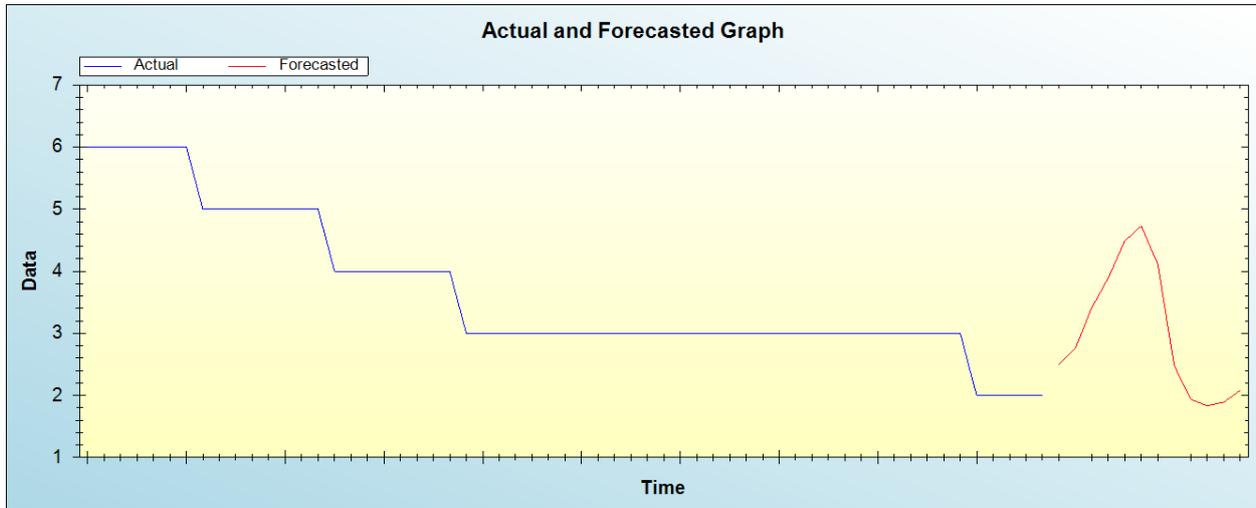


Figure 3: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	2.4950
2020	2.7603
2021	3.4132
2022	3.8916
2023	4.4877
2024	4.7278
2025	4.1147
2026	2.4807
2027	1.9361
2028	1.8330
2029	1.8890
2030	2.0775

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 Panama are likely to slightly decline 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 Panama. The results of the study revealed that annual total fertility rates in Panama are likely to increase from 2.46 births per woman in 2019 to 4.73 births per woman in 2025 and then decline to 2 births per woman towards the end of out-of-sample period. Therefore, we encourage the authorities in Panama to continue improving the quality of family planning services to minimize adverse maternal and child health outcomes.

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