

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

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Abstract - In this research paper, the ANN approach was applied to analyze TFR in Sri Lanka. 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 Sri Lanka. The results of the study indicate that annual total fertility rates in Sri Lanka are likely to remain around 2.3 births per woman over the out-of-sample period. Therefore, the authorities in Sri Lanka 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). Fertility transition in Sri Lanka started in the 1960s (Silva, 2001). TFR declined from 5.8 births per woman in 1960 to 2.2 births per woman in 2020 (Worldometer, 2020). Infant and under five mortality rates have also been declining over the years. IMR declined from 89.03 infant deaths per 1000 live births in 1950 to 6.44 per 1000 live births in 2020. Under five mortality rate declined from 144.1 deaths per 1000 live births in 1950 to 7.32 deaths per 1000 live births in 2020 (Worldometer, 2020). This reflects significant improvements in family planning services in Sri Lanka in order to reduce adverse maternal and child health outcomes. In this paper we shall highlight a few papers on fertility. Based on a cross sectional study, Ranatunga and Jayaratne (2020) described the proportion of unplanned pregnancies, their determinants and the health outcomes of women delivering at Colombo North Teaching Hospital-Ragama (CNTH). The study found out that the response rate was 97.8 and 17.2% of pregnancies ending at birth were unplanned, 12.7% were ambivalent and 70.1% were planned. The ARIMA model was applied by Waseem and Yasmeeen (2016) to predict total fertility rates of Pakistan. Secondary data of total fertility rates from 1984 to 2007 were obtained from Pakistan Demographic Surveys (PDS). The optimal model predicted total fertility rates (TFR) of Pakistan for the next fifteen years and revealed that the TFR of Pakistan is projected to decline and expected to be approximately 1.81 (average number of children per women) for the year 2022. Bandyopadhyay and Chattopadhyay (2008) forecasted India's population using the artificial neural network approach. The study revealed that that the model performed more efficiently in predicting female population than the male population.

The aim of the study is to forecast total fertility rate in Sri Lanka using a machine learning approach. The results of the study are expected to highlight the likely future trends of fertility in Sri Lanka. 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 Sri Lanka.

Data Issues

This study is based on annual total fertility rate (births per woman) in Sri Lanka 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	S
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	0.044396
MSE	0.006993
MAE	0.059508

Residual Analysis for the Applied Model

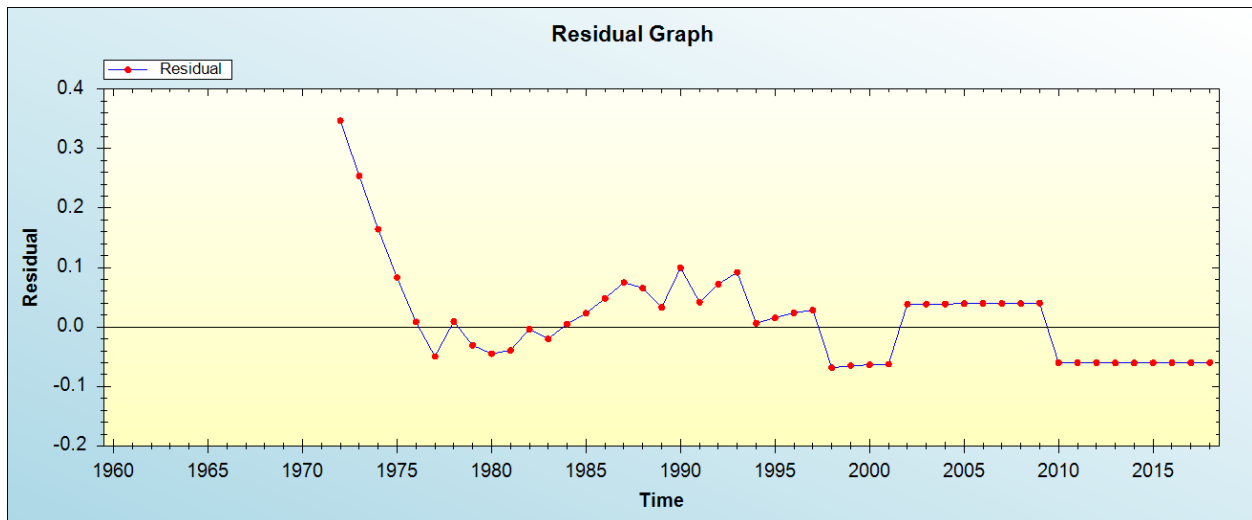


Figure 1: Residual analysis

In-sample Forecast for S

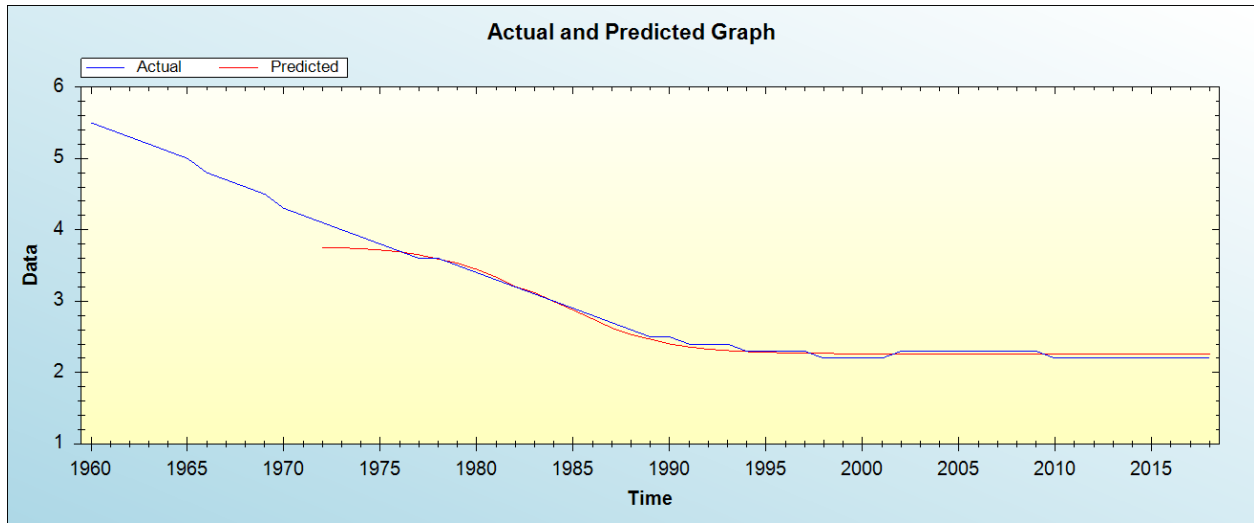


Figure 2: In-sample forecast for the S series

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

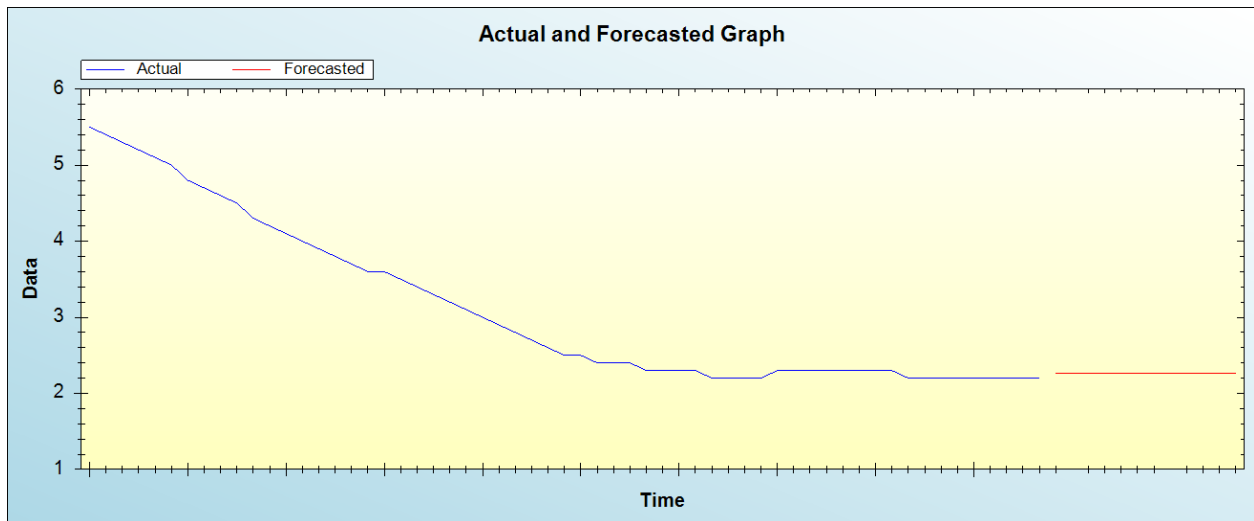


Figure 3: Out-of-sample forecast for S: actual and forecasted graph

Out-of-Sample Forecast for S: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	2.2597
2020	2.2596
2021	2.2592
2022	2.2593
2023	2.2592
2024	2.2594
2025	2.2594
2026	2.2595
2027	2.2595
2028	2.2596
2029	2.2598
2030	2.2601

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 Sri Lanka are likely to remain around 2.3 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Total fertility rates in Sri Lanka 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 Sri Lanka. The results indicated that annual total fertility rates in Sri Lanka are likely to remain around 2.3 births per woman over the out-of-sample period. Therefore, the authorities in Sri Lanka 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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