Projection of Total Fertility Rate (TFR) in China Using an Artificial Intelligence Technique

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Abstract - **China is the most populous country in the world and continues to record an annual population growth of approximately 6-7 million. In this research article, the ANN approach was proposed to analyze TFR in China. 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 China. The results of the study indicate that annual total fertility rates in China are likely to be around 1.7 births per woman over the out-of-sample period. Therefore, the Chinese government is encouraged to continue with its strict population control policy.**

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

I. INTRODUCTION

China is the most populous country in the world with an estimated population size of approximately 1.39 billion in 2017 and has an annual population growth of about 6-7 million (Wang, 2019). The population size continues to increase annually despite its growing economy, increased social competition improved gender equality and women's participation in labour force (Adsera, 2004; Boon et al, 1999; Becker et al, 1988).China's life expectancy at birth increased from 43.4 to 76years from 1960 to 2015 (Li et al, 2018). The nation's family planning policy is one the strictest in the world allowing one child per couple since 1980 (Hesketh et al, 2005; Greenhalgh, 20003).It has been revealed that China's population control policy contributed significantly to the country's economic development (Wang & Mason, 2007). Total fertility rate in China declined from 6.1 births per woman in 1955 to 1.7 births per woman in 2020 (Worildometer, 2020).The country has also recorded a decline in infant and under five mortality rates. In 2020, infant mortality was 8.4 infant deaths per 1000 live births and under five mortality was 9.8 deaths per 1000 live births. This reflects the country's commendable progress in reducing adverse maternal and child health outcomes. There are limited studies on forecasting TFR in China. However in this paper we will highlight some of them and other related studies. Based on the short term and long term prediction models, Liu et al (2020) forecasted China's population growth. The study revealed that the results were in line with China's development. Wang (2019) conducted a time-series predictive study based on the Holt's Exponential Smoothing models to restore the deleted fertility data for 2016 and beyond, allowing a comprehensive analysis of fertility rates in China from 2003 to 2018. It was noted that the population structure was aging fast, fertility rates continued to decrease to a substantially low level, and three Northeastern provinces displayed notable socioeconomic issues associated with low-fertility trap. The study concluded that it is critical for China to urgently remove its current birth limit and implement social policies to reverse the downtrend of fertility rate. Prediction of China's total population and the trends of population structural change in 2015-2050, based on the fifth and sixth national census data was carried out by Liu et al (2016). The results show that since implementation of the two-child family planning policy, the aging trend of the population structure will be significantly improved, and after 2030 that is the population structure will be gradually younger.

The aim of this study is to forecast total fertility rate in China using an artificial intelligence technique. The results of this piece of work are expected to reveal the likely fertility trends in the out of sample period. This will help in making policies and stimulate an evidence based response to the future health, education and employment needs of the Chinese population.

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 China.

Data Issues

This study is based on annual total fertility rate (births per woman) in China 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	C
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	0.188576
MSE	0.055414
MAE	0.167456

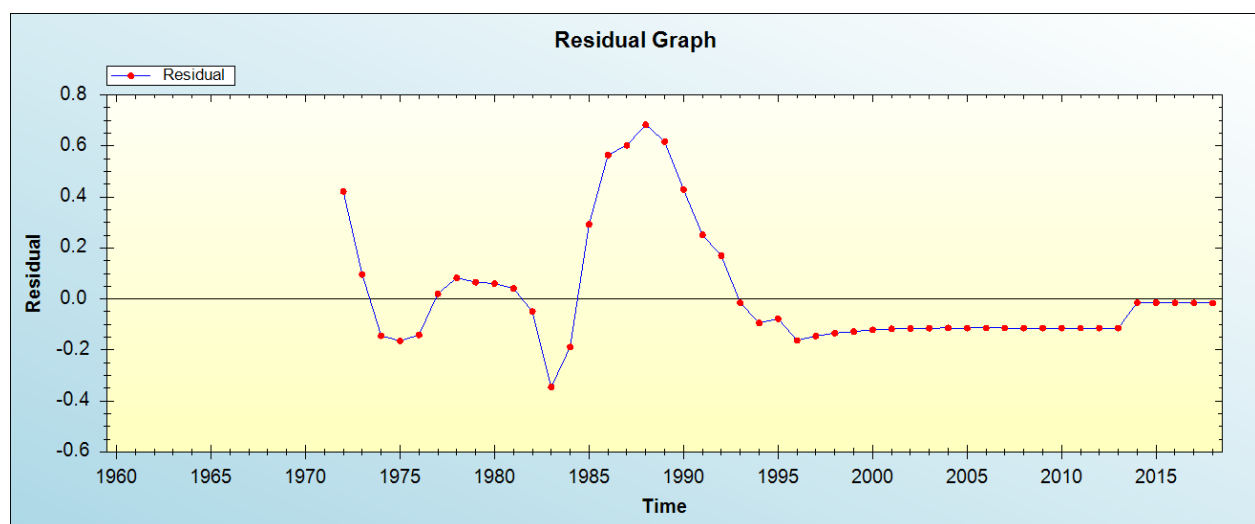*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
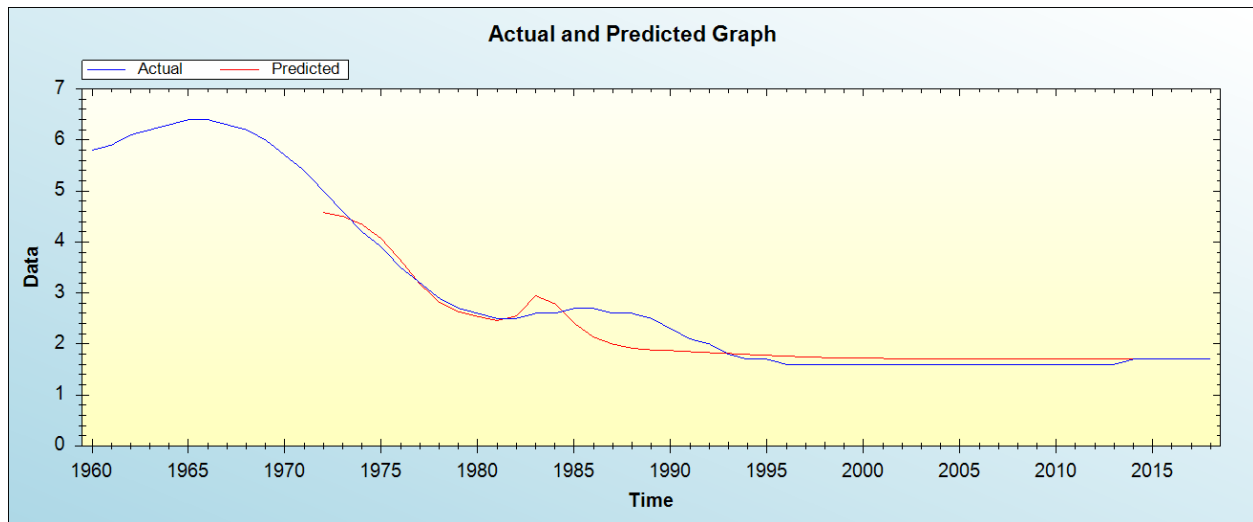
In-sample Forecast for C

Figure 2: In-sample forecast for the C series

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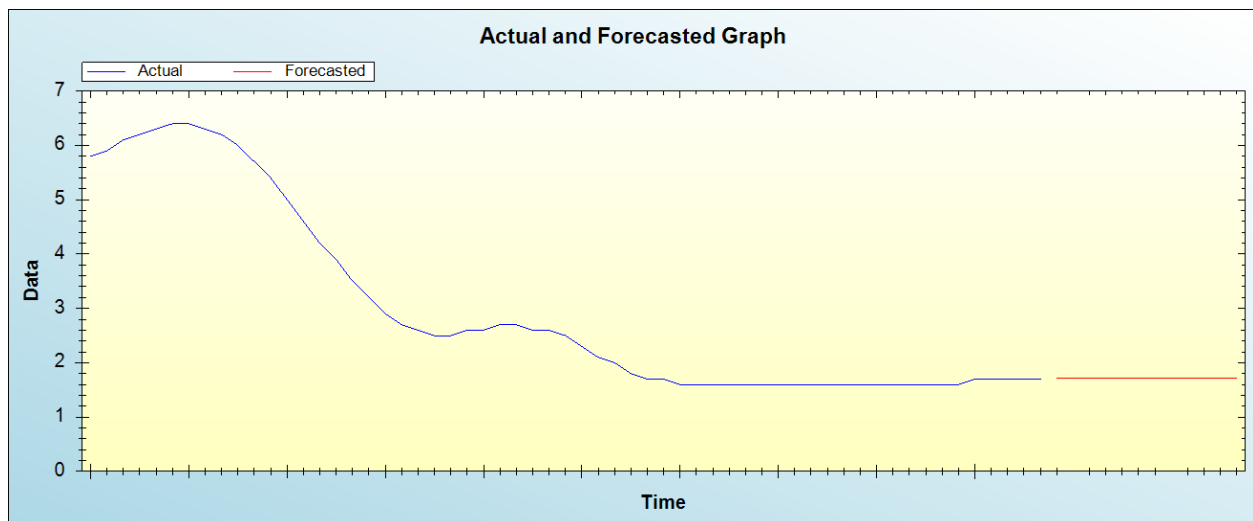

Figure 3: Out-of-sample forecast for C: actual and forecasted graph

Out-of-Sample Forecast for C: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	1.7162
2020	1.7169
2021	1.7175
2022	1.7179
2023	1.7178
2024	1.7181
2025	1.7182
2026	1.7182
2027	1.7183
2028	1.7182
2029	1.7183
2030	1.7183

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 China are likely to be 1.7 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

China is regarded as one of the countries in the world with a very strict population control policy. However its population continues to grow annually. Prediction of total fertility is vital to reveal the future population dynamics. In this study we applied a machine learning technique to project TFR in China. The model projections suggest that annual total fertility rates in China are likely to be 1.7 births per woman over the out-of-sample period.t. Therefore, China is encouraged to continue with its strict population control policy.

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