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Projection of Total Fertility Rate in New Zealand

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Abstract - In this research article, the ANN approach was applied to analyze TFR in New Zealand. 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 New Zealand. The results of the study indicate that annual total fertility rates in New Zealand are likely to be around 2 births per woman over the out-of-sample period. Therefore, the New Zealand government is encouraged to continue with its current population control policy.

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

I. INTRODUCTION

Universal access to sexual and reproductive health services is a fundamental human right for every individual or couple. The 1994 international conference on population and development focused on the sexual and reproductive health rights of both sexes. However, having observed the violations of women rights in many countries, the signatories agreed to recognize SRH rights of adolescent girls and women who are usually the victims of physical and sexual abuse (Anand et al, 2017). It is estimated that 213 million pregnancies occur annually of these 40% are unplanned (Sedgh et al, 2014).

Fertility is the major determinant of size and composition of a population hence total fertility rate is used as an indicator fertility. Total fertility rate (TFR) is the average number of children born to a woman during her reproductive lifetime if she were to experience the exact current age specific fertility rates. New Zealand's TFR dropped from 4.1 births per woman in 1960 to 1.9 births per woman in 2020 (Worldometer, 2020). The country's life expectancy is 82.8 years according to worldometer. IMR and under five mortality have been on a downward trend over the past decades. IMR dropped from 26.56 infant deaths per 1000 live births in 1950 to 3.35 infant deaths per 1000 live births in 2020 (Worldometer, 2020). There are few empirical studies that have investigated fertility trends. Batyra et al (2021) used four Brazilian censuses to forecast the CTFR for the total population and by educational level using rates reconstructed with indirect techniques. The results of four forecasting methods indicated that the CTFR is likely to decline to 2.1 for the 1980 cohort, and to 1.9 for the 1984 cohort. An indirect way of calculating fertility was demonstrated by Gunawan et al (2019). The results of the research showed that the higher the effectiveness of the use of contraceptives, the higher the number of preventable births resulting in the least possible birth rate, and this calculation can be determined by total fertility rate based on the effectiveness of the use of contraceptives. In another study, Evans & Gray (2018) used birth registration and Census data to explore the spatial variation of fertility in Australia and how it relates to compositional and contextual characteristics of places. Geographically weighted regression was applied to analyze the spatial relationships and identify the geographical variability in the fertility experience of Australian women. The study found substantial variation with some areas having a total fertility rate well above or below the national average.

The aim of this study is to project TFR in New Zealand using the multilayer perceptron neural network. The findings of this paper will reveal the likely future trends of TFR in the out of sample period. This will facilitate resource mobilization for the future health, education and employment needs of the New Zealand 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 New Zealand.



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Data Issues

This study is based on annual total fertility rate (births per woman) in New Zealand for the period 1960 - 2018. The outof-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	Z
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	0.240816
MSE	0.014843
MAE	0.094769

Residual Analysis for the Applied Model



Figure 1: Residual analysis



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In-sample Forecast for Z



Figure 2: In-sample forecast for the Z series

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



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

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	2.0246
2020	2.0249
2021	2.0246
2022	2.0252
2023	2.0250
2024	2.0250
2025	2.0249
2026	2.0246
2027	2.0246
2028	2.0245
2029	2.0244
2030	2.0244

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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 New Zealand are likely to be around 2.0 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Total fertility rate in New Zealand has decline over the years to below replacement level. The country's low infant and child mortality rates reflect improvements in the health status of the population. In this study we proposed an artificial intelligence approach to project TFR in New Zealand. The model projections revealed that annual total fertility rates in New Zealand are likely to be around 2.0 births per woman over the out-of-sample period. Therefore, the New Zealand government is encouraged to continue with its current population control policy.

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