International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 5, Issue 8, pp 285-288, August-2021

https://doi.org/10.47001/IRJIET/2021.508062

Projection of Total Fertility Rate (TFR) in Iraq Using a Machine Learning Technique

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***Abstract* - In this research article, the ANN approach was applied to analyze TFR in Iraq. 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 Iraq. The results of the study indicate that annual total fertility rates in Iraq are likely to be around 4.5 births per woman over the out-of-sample period. Therefore, the Iraq government is encouraged to address barriers to accessing sexual and reproductive health (SRH) services, create more demand for family planning services and scale up women empowerment program activities.**

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

I. INTRODUCTION

Demography refers to the study of human population characteristics namely size, composition, density and its processes (Demena, 2005). Births, deaths (mortality) and migration are the major determinants of the size of the population and they influence the economic and social development of a country (Fathi, 2009). Fertility is one of the factors that affect the characteristics of a population and is measured by a list of indicators such as crude birth rate (CBR), general fertility rate (GFR), Child woman ratio, gross reproduction rate, and total fertility rate. Total fertility rate (TFR) is the average number of children that would be born to a woman during her lifetime (Pourreza et al, 2021). A total fertility rate of 2.1 births per woman is called replacement fertility level. It is the average number of children born to a woman for a generation to replace itself without requiring international migration (Reshadat et al, 2014).

The global fertility rate has declined from 4.97 births per woman in 1950 to 2.31 births per woman in 1990 (Wang, 2020). Iraq's total fertility rate dropped from 7.4 births per woman in 1970 to 3.7 births per woman in 2020 (Worldometer, 2020). In 2020 the country recorded an infant mortality rate of 21.1 infant deaths per 1000 live births and under five mortality rate of 24.9 deaths per 1000 live births. This indicates significant progress that has been made to reduce adverse maternal and child health outcomes. There are few empirical studies that have been done at regional level to investigate fertility trends. Pourreza et al (2021) did a systematic review between the years 2000 and 2016. The different databases like Cochrane, PubMed, Scopus, and Science Direct and the Google Scholar search engine were used. At first, 270 articles and then 18 articles were selected and meticulously read for the final analysis. The results indicated a declining trend in the TFR in the Middle East and North Africa, as in other parts of the world. Regarding the causes of this declining trend, several factors were identified and categorized into five main factors of health care-related, cultural, economic, social, and political. Based on a cross sectional study, Ghaem et al (2019) investigated the trend of changes in Age-Specific Fertility Rate (ASFR), Total Fertility Rate (TFR), and Cohort Fertility Rate (CFR) in rural areas of Fars province, southern Iran during 1988-2012. The study revealed that fertility followed a negative slope during 1992-2012, indicating their descending trend during these years. The OLS method was applied by Karakaya (2016) to investigate the relations and the patterns of socio-economic determinants on total fertility rate in Turkey. Durbin-Watson statistics showed non-existence of autocorrelation, Variance Inflation Factor examination showed no multicollinearity, and Breush-Pagan Test and Koenker Test proved homoscedasticity. The results of the hypothesis test showed the inverse relation of total fertility rate with literacy, female workforce in non-agricultural sectors and proportion of urban population.

The aim of this paper is to project total fertility rate in Iraq using an artificial neural network approach. The results of the study are expected to highlight the likely fertility trends in the out of sample period. This will guide policy making and facilitate resource mobilization for future health, education and employment requirements of the people in Iraq.

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

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activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual total fertility rates in Iraq.

Data Issues

This study is based on annual total fertility rate (births per woman) in Iraq 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	Q
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	0.393605
MSE	0.092482
MAE	0.163119

Residual Analysis for the Applied Model

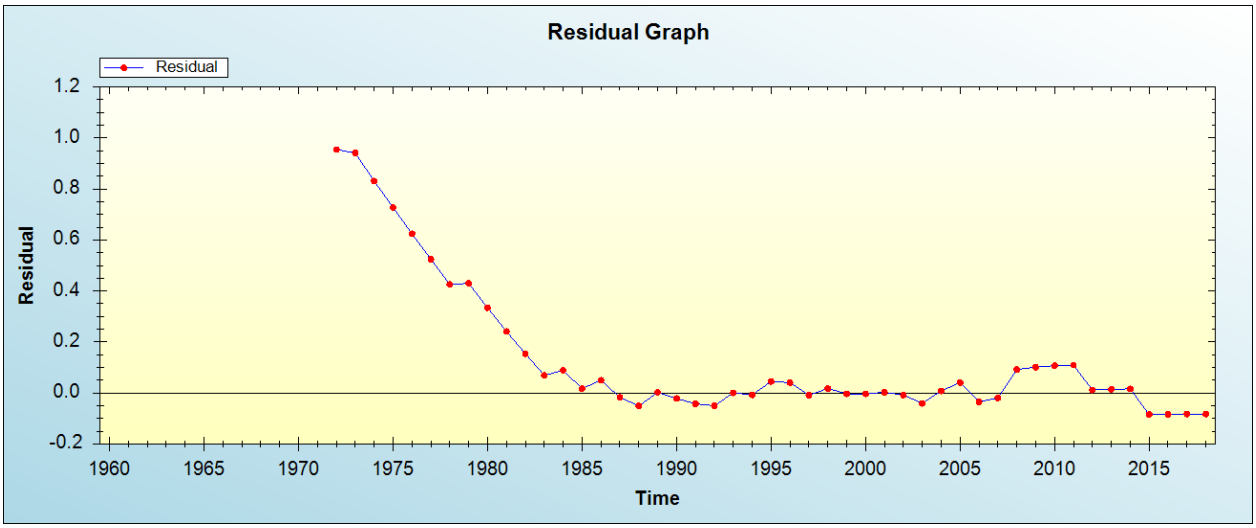

Figure 1: Residual analysis

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In-sample Forecast for Q

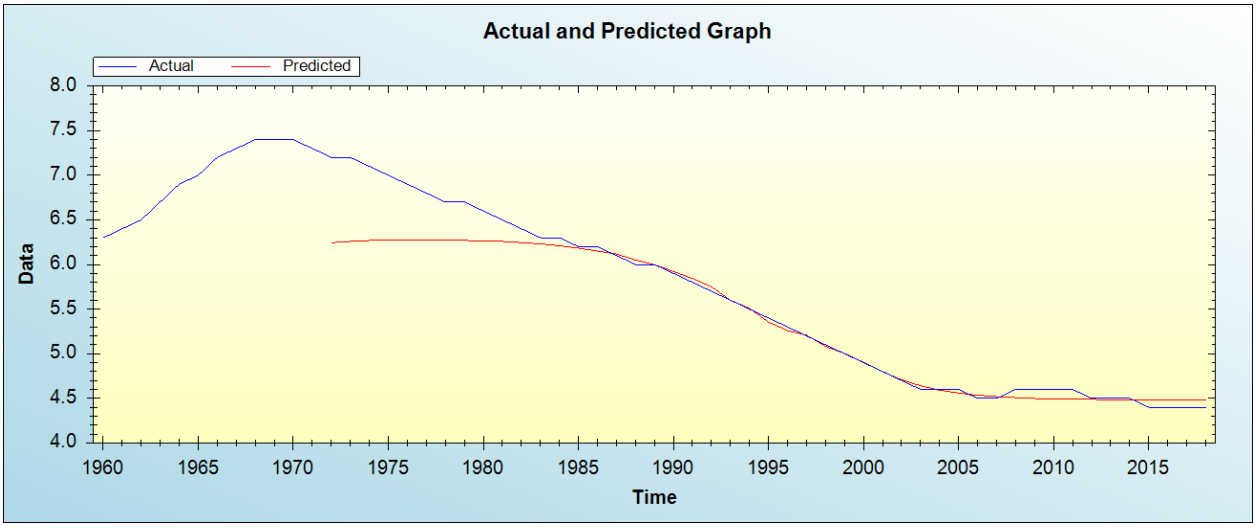

Figure 2: In-sample forecast for the Q series

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

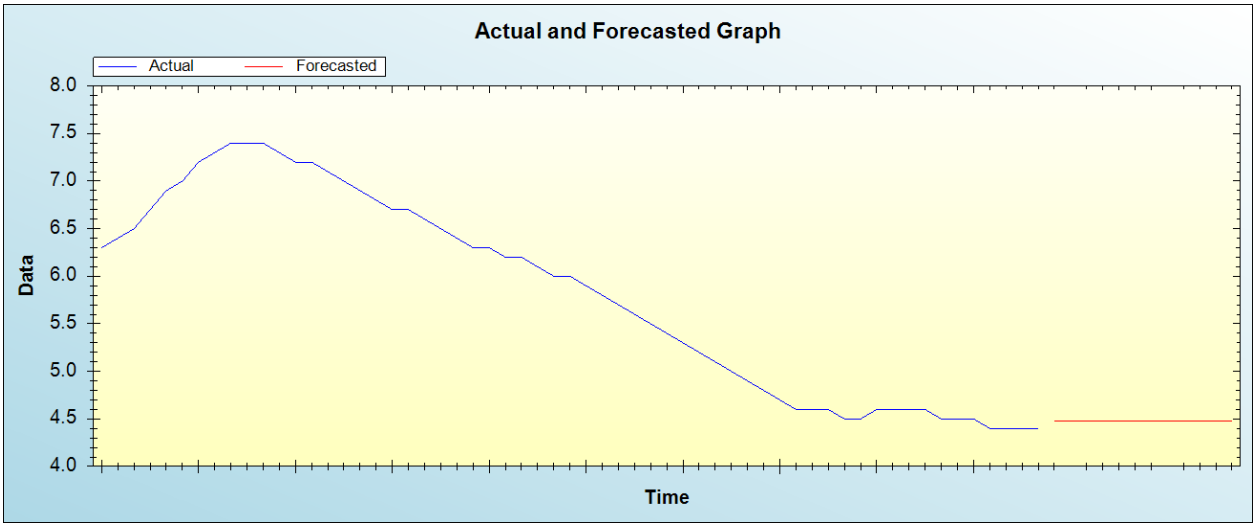

Figure 3: Out-of-sample forecast for Q: actual and forecasted graph

Out-of-Sample Forecast for Q: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	4.4821
2020	4.4811
2021	4.4813
2022	4.4802
2023	4.4789
2024	4.4794
2025	4.4788
2026	4.4789
2027	4.4796
2028	4.4793
2029	4.4800
2030	4.4804

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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 Iraq are likely to be around 4.5 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Iraq has witnessed fertility transition over the past 4 decades as well as decline in infant and child mortality rates. In this paper we employed a machine learning approach to forecast TFR in Iraq. The ANN model projections revealed that annual total fertility rates in Iraq are likely to be around 4.5 births per woman over the out-of-sample period. Therefore, the Iraq government should address barriers to accessing sexual and reproductive (SRH) services, create more demand for family planning services and channel more resources towards women empowerment program activities.

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Citation of this Article:

Dr. Smartson. P. NYONI, Tatenda. A. CHIHOHO, Thabani NYONI, "Projection of Total Fertility Rate (TFR) in Iraq Using a Machine Learning Technique" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 8, pp 285-288, August 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.508062

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