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

ISSN (online): 2581-3048

Volume 5, Issue 8, pp 379-383, August-2021

https://doi.org/10.47001/IRJIET/2021.508084

Projecting Total Fertility Rates for Oman Using Artificial Neural Networks

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***Abstract* - This study projected future total fertility rates (TFRs) for Oman from 2019 to 2030 using Artificial Neural Networks by employing TFRs for Oman from 1960 to 2018 obtained from the World Bank Online database. The study results show that projected TFRs for Oman are expected to be almost constant at 2.8.**

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

I. INTRODUCTION

The importance of fertility rates cannot be overemphasized since it is used for determining economic growth opportunities and as a yardstick to anticipate future challenges such as population ageing (Gubhaju, B, Jongstra,E, and Raikoti M, 2013). These predictions on future fertility rates are used by policy makers to aid policy formulation. TFR are determined by a number of factors which include level of education, income levels, gender equality, urbanisation, modern contraception, economic uncertainties and cultural differences among other factors (Basten. S., Sobtka, T., and Zeman, K 2013). Oman is a high-income monarchy located in West Asia with a population of 4.1 million and a 3% population growth rate (Ismail and Hussein, 2018). Oman has experienced a dramatic decline in its TFR. In 1988, it had a TFR of 8.6, which fell to 3.3 by 2008 (Islam, 2017). These changes have direct impact on economic growth and development as well as the social structure, allocation of resources hence the standard of living of the citizens of Oman. This therefore calls for a precise prediction of future TFR for Oman such that informed policies can be implemented to serve the best interests of Oman citizens which is the gist of this study.

II. LITERATURE REVIEW

A summary of literature on TFRs is given below:

Table 1: Literature review

Author/s (Year)	Study period	Method	Topic	Key results
Islam, Dorvio and Al-Quasmi (2013)	2000 census data	-logistic regression analysis -univariate, bivariate and multivariate statistical methods	Pattern of female nuptiality in Oman	-high prevalence of consanguineous marriage -11% of marriages are polygamous -high prevalence of early and universal marriages
Al-Riyami and Afifi (2003)	2000	-multi stage stratified probability design -multiple linear regression model	Determinants of women fertility in Oman	-women with higher freedom of movement were more likely to have less children in the first 20 years -women with high score of decision making are more likely to have longer closed birth interval than those with lower score
Islam (2017)	1988, 1995, 2000, 2008	-Bongaarts Aggregate Model	Rapid fertility decline in Oman: understanding the role of proximate	Decline of fertility due to spacing and delaying of birth, prolonged

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			determinants	postpartum infecund ability, increased modernisation, education and labour force participation of women in Oman
Ismail and Hussein (2018)	1995-2014,2015,	-comparative statistical analysis -finite mixture clustering model	Population ageing and long-term care policies in the Gulf region: a case study of Oman	-Oman had average life expectancy of 77 -Oman's TFR was relatively lower than other Arab countries
Islam, Dorvio and Al-Quasmi (2011)	1995, 2000	-Bongaarts framework	Proximate determinants of declining fertility in Oman in the 1990s	-decrease in the age-specific proportions of married women and increased in contraceptive use led to fertility decline in Oman -women education and employment are likely factors delaying marriage hence caused fertility decline in Oman in the 1990s
Eickelman (1993)	1979, 1988	-qualitative analysis -questionnaires	Fertility and social change in Oman: women's perspectives	-natural factors such as decreasing resource base do not motivate individuals to make personal choices with regards to reduction of family size. -Omanis perceive children as signs of social strengths
Rowland (2005)	1989 to 2000	-general trends analysis	National and Regional Population Trends in Tajikistan: Results from the recent census	-The Tajik total population increased due to high fertility
Allman (1982)	1971 to 1977	-world fertility survey approach	Fertility and family planning in Haiti	-more urban women use contraceptives than rural women -women with more education have lower fertility compared to those with lower education -direct relationship between age and fertility
Lincoln, Mohammednezhad & Khan (2018)	15 March to 28 April 2017	-quantitative cross-sectional analysis	- Knowledge, attitudes and practices of family planning among women of reproductive age in Suva, Fiji 2017	- 45.5% had good knowledge of family planning, 53.5% had moderate knowledge. - 54.2% had high level of attitude whilst 3% had poor attitude level -24.6% had poor level of practice of family planning whilst 9.5% had good level of practice

III. 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

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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 Oman.

Data Issues

This study is based on annual total fertility rate (births per woman) in Oman 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.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 2: ANN model summary

Variable	TFR
Included Observation	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	0.043143
MSE	0.017378
MAE	0.103629

Residual Analysis for the Applied Model

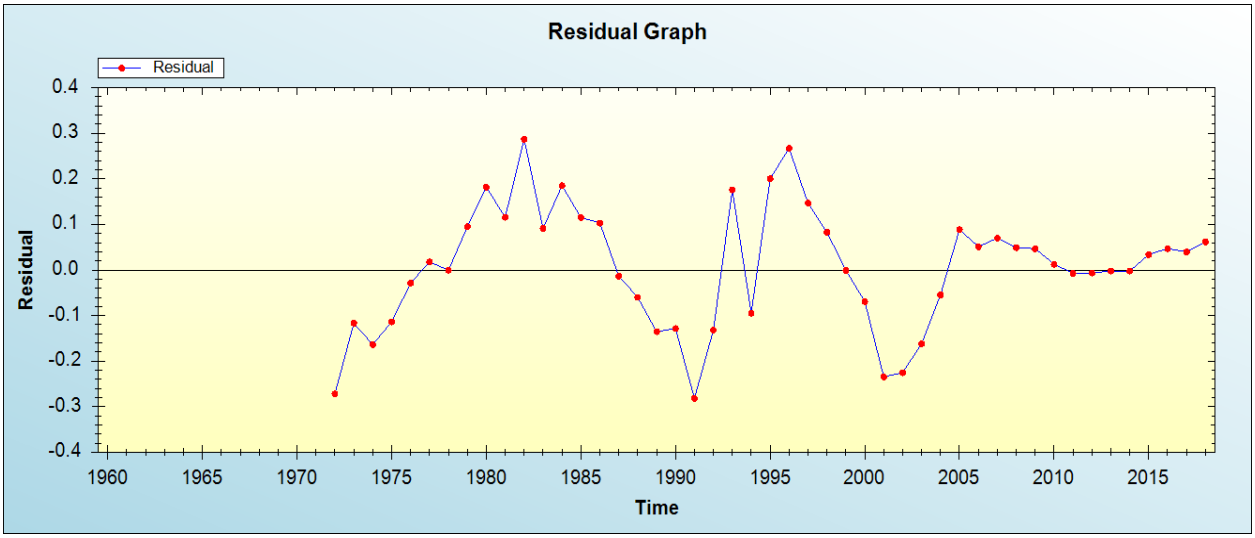

Figure 1: Residual analysis

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In-sample Forecast for TFR

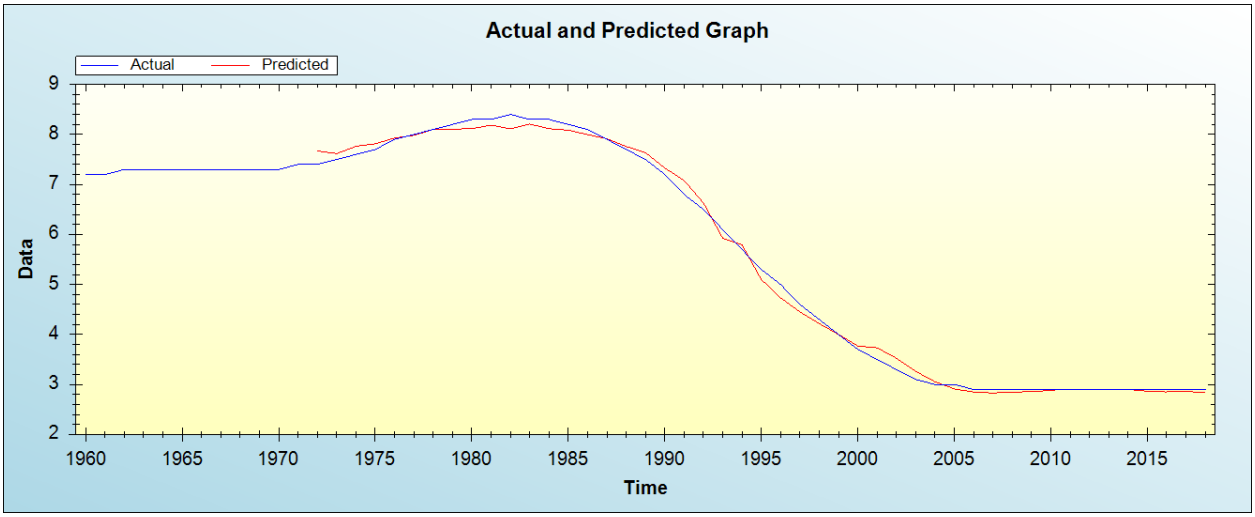

Figure 2: In-sample forecast for the TFR series

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

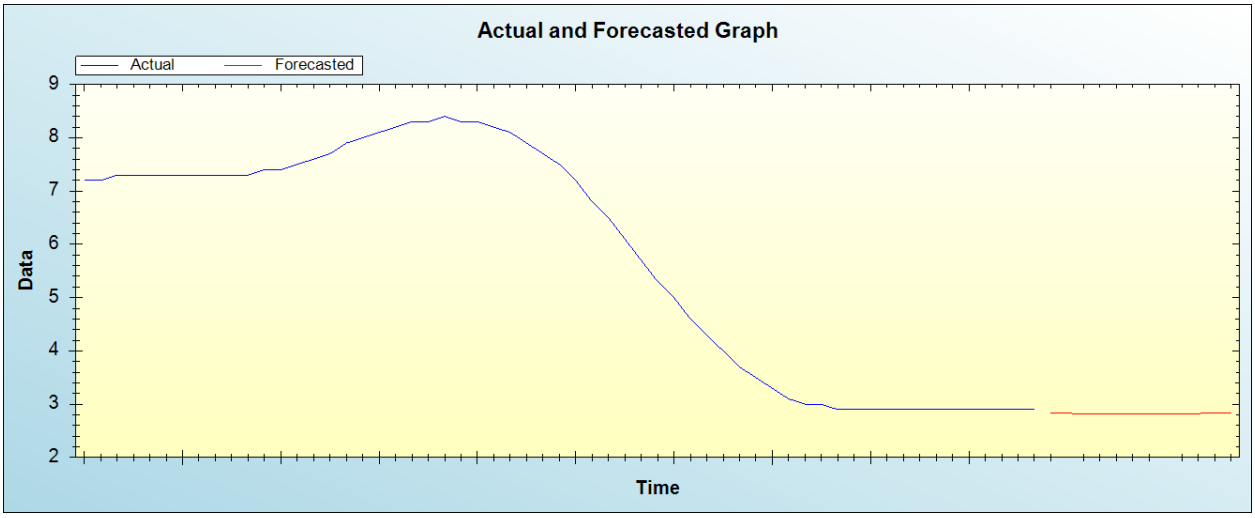

Figure 3: Out-of-sample forecast for TFR: actual and forecasted graph

Out-of-Sample Forecast for TFR: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted
2019	2.8381
2020	2.8307
2021	2.8216
2022	2.8183
2023	2.8148
2024	2.8111
2025	2.8101
2026	2.8104
2027	2.8208
2028	2.8260
2029	2.8355
2030	2.8438

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The main results of the study are shown in table 2. 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 Oman are likely to be almost constant over the out-of-sample period.

V. CONCLUSIONS AND RECOMMENDATIONS

Study results show that future TFRs are expected to be constant at 2.8 throughout the out of sample period. This is clearly more than the replacement level of 2.1 hence Oman population is likely to increase throughout the period. Therefore, Oman authorities may need to put policies to stall growth in population.

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Citation of this Article:

Dr. Smartson. P. NYONI, Tatenda. A. CHIHOHO, Thabani NYONI, "Projecting Total Fertility Rates for Oman Using Artificial Neural Networks" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 8, pp 379-383, August 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.508084

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