

Projection of Total Fertility Rates in Guatemala Using Artificial Neural Networks

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Abstract - The aim of this study was to project total fertility rates (TFRs) in Guatemala from 2019 to 2030. Artificial Neural Networks were employed using Guatemala TFRs data from 1960 to 2018 obtained from the World Bank Online database. The results show that TFRs are expected to slightly decline from 2.9 in 2019 to 2.8 in 2030.

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

I. INTRODUCTION

Total Fertility Rates (TFR) in Guatemala have been high at least until the turn of the 21st century as compared to other Latin American countries (De Broe and Hinde, 2006). In 1968 TRF in Guatemala was 6.1 and 1999 it was around 5.1, the highest rate in Latin America (Population Reference Bureau, 1999). High fertility rates in Guatemala leads to human underdevelopment given that it is highly populated and its one of the poorest countries in Latin America (Agency for International Development, 1982). Low acceptance and use of contraceptives (Guzman, 1996), high female illiteracy rates, low female labour participation rate and an underdeveloped health care systems (Tuiran et al, 2003) can be attributed to these high fertility rates. Few studies have been undertaken to determine transition in fertility trends in Guatemala over time regardless of the importance of understanding these dynamics (De Broe and Hinde, 2006). Therefore, there is need to determine the transition of Guatemala’s total fertility rates as well as to predict its possible future path such that sound population policies can be formulated in order to turnaround the economy of Guatemala.

II. LITERATURE REVIEW

Below is a summary of literature on total fertility rates.

Table 1: Literature on TFRs

Author/s Year	Study Period	Method	Topic	Key Results
Sutherland, Carr & Curtis (2004)	1998-1999	-Ordinary Least Squares	Fertility and the environment in a natural resource dependent economy: Evidence from Peten, Guatemala	-increasing maternal age and rural residence are positively related to fertility -improvement in living standards and maternal education is negatively related to fertility
Anderson et al (1980)	1978	-Ordinary Least Squares	Determinants of fertility in Guatemala	-Ladinos and Indian women had on average the same fertility rates -overall fertility levels from 1978 survey were consistent with what was known previously
De Broe & Hinde	1987, 1996, 1999 &	-Ordinary Least	Diversity in fertility	-ethnic diversity and

(2006)	2002	Squares	patterns in Guatemala	proportion of indigenous people are significant in explaining fertility
Sorchik et al (2019)	1999, 2007 and 2009	-quantitative and trend analysis	Fertility trends in Pacific Island countries and territories	-TFR for Solomon Islands declined over a 10-year period from 6 in 1989 to 4.7 in 1999 -fertility was highest in Solomon Islands among women aged 25 to 29
Buckley (1998)	1990	Narrative review	Rural/urban differentials in demographic processes: the Central Asian states	-differentials in fertility and mortality rates in rural areas of Central Asian states indicate the need for future policy interventions and data collection to incorporate a specific focus for rural areas.
Rowland (2005)	1989 to 2000	Narrative review Questionnaires	National and regional population trends in Tajikistan: results from recent census	-population increased rapidly due to high fertility -rural population grew rapidly but urban population fell
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
Agadjanian, Dommaraju & Nedoluzhko (2013)	Multiple Indicators Clusters Survey of 2005 and 2006	-Discrete-time logistic model -Probabilities	Economic fortunes, ethnic divides, marriage & fertility in Central Asia: Kazakhstan and Kyrgyzstan compared	-rates of entry into marriage continue to fall in both countries post- crisis years -on the other hand, fertility fell -there are ethnic variations in fertility trends
Berggren et al (1974)	1970	-questionnaires -quantitative analysis	Rural Haitian women: an analysis of fertility rates	-a TFR of 5.9 was found - modal number of liveborn children for women who completed their reproductive years in a stable union was 11 and those with more than one union was 3 children

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 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 Guatemala.

Data Issues

This study is based on annual total fertility rate (births per woman) in Guatemala 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	0.080637
MSE	0.032110
MAE	0.140765

Residual Analysis for the Applied Model

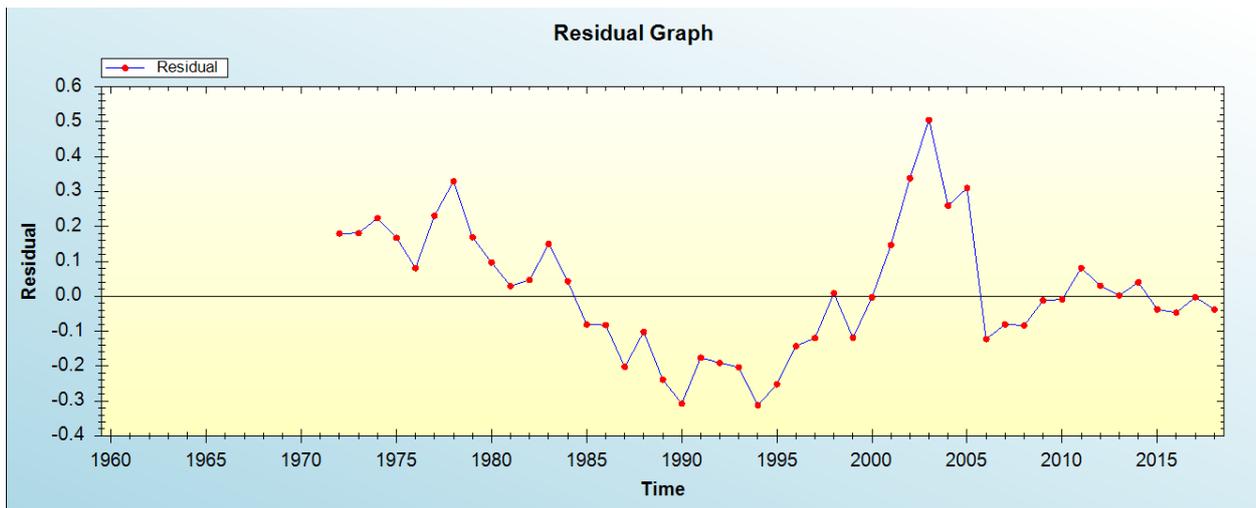


Figure 1: Residual analysis

In-sample Forecast for TFR

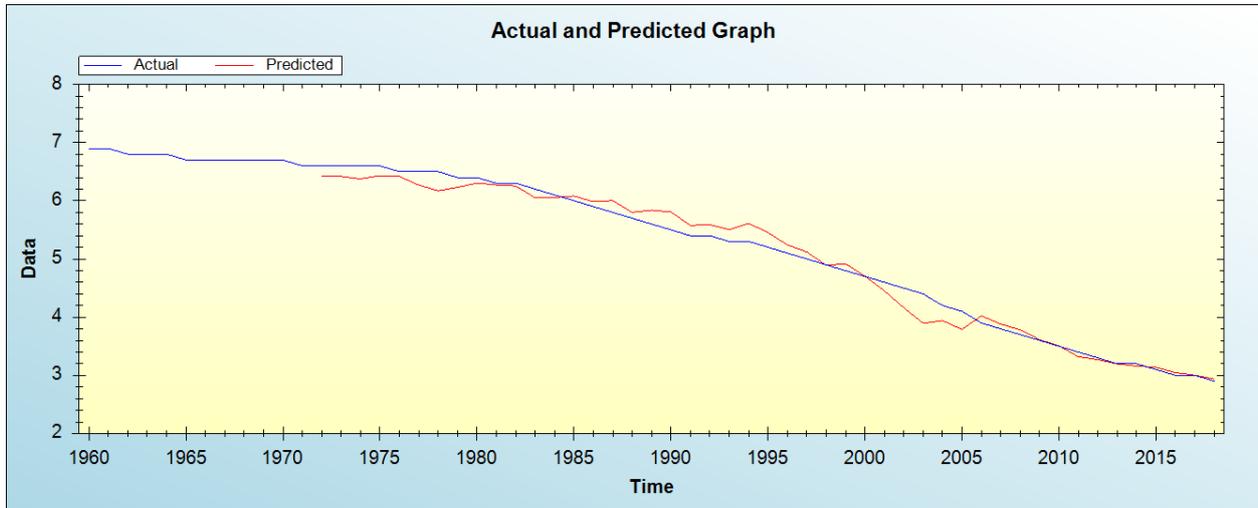


Figure 2: In-sample forecast for the TFR series

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

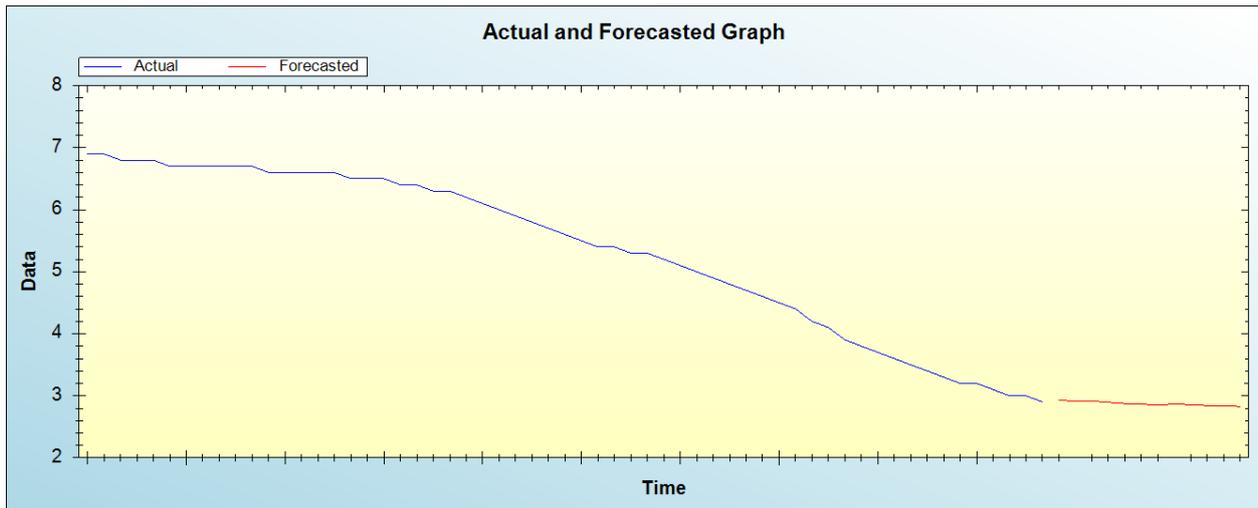


Figure 3: Out-of-sample forecast for TFR: actual and forecasted graph

Out-of-Sample Forecast for TFR: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted
2019	2.9313
2020	2.9111
2021	2.9150
2022	2.8944
2023	2.8729
2024	2.8665
2025	2.8497
2026	2.8662
2027	2.8562
2028	2.8431
2029	2.8450
2030	2.8269

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 Guatemala are likely to slightly decline over the out-of-sample period.

IV. CONCLUSIONS AND RECOMMENDATIONS

Results reveal that TFRs for Guatemala is expected to slightly fall from 2.9 in 2019 to 2.8 in 2030. These projections are still higher than the replacement level of 2.1 implying that though the fertility rates are falling in Guatemala, its population will continue to grow holding other factors constant. Her authorities might consider policies aimed at further slackening these TFRs since overpopulation might end up putting pressures on the country's resources.

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