

Predicting Future Trends of Total Fertility Rates in Kyrgyzstan Using Artificial Neural Networks

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Abstract- The aim of this study was to predict future total fertility rates (TFRs) for Kyrgyzstan from 2019 to 2030 using Artificial Neural Networks. Kyrgyzstan TFRs from 1960 to 2018 obtained from World Bank Online database was used. Predicted results show that TFR will be almost constant at 3.1 by 2030 being 3.08 in 2019 and 3.13 in 2030.

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

I. INTRODUCTION

Total Fertility Rates (TFR) play an important role in the determination of population growth hence a positive, direct relationship between the two (Gubhaju et al 2013). For Kyrgyzstan is a post-Soviet country located in Central Asia and it had a population of about 6.5 million people in 2020, its population is growing by about 2% per year due to high TFR (Denisenko, 2020). Kyrgyzstan experienced falling TFR following the collapse of the Soviet Union in the 1990s (Kazenin and Kozlov, 2020) and increasing period TFR throughout the 2000s (Nedoluzhko, 2012). The decline in fertility in the 1990s can be regarded as the eventual stage in TRF decline that started in the early 1970s following a peak reached in the 1960s (Kazenin and Kozlov, 2020). This fall in fertility was typical for countries experiencing First Demographic Transition however it did not reach the replacement level of 2.1 which marks the final stage of the transition. It is therefore important to predict precise and reflective future TFR trends for Kyrgyzstan so that policy makers can effectively plan and allocate resources to areas where maximum social benefit is to be derived and to ensure sustainable use of resources.

II. LITERATURE REVIEW

A summary of the literature on TFRs is given below:

Table 1: Literature on TFRs

Author/s Year	Study Period	Method	Topic	Key Results
Kazenin &Kozlov (2020)	Multiple Indicators Clusters Survey of 2012 and 2014	-Cumulative Probabilities -Regression Analysis	What factors support the early age patterns of fertility in a developing country: Kyrgyzstan	-women education, labour market relations and family gender relations influence her likelihood of becoming a mother
Nedoluzhko (2012)	Multiple Indicators Clusters survey of 2005 and 2006	-Poisson Regression -logistic regression model	Achieved fertility and fertility intentions among ethnic groups in Central Asia: Kyrgyzstan, Tajikistan and Uzbekistan compared	-number of children ever born and the intention to have another child appear to be negatively correlated with minority status.
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
Spoorenberg (2015)	1990 to 2011	-simulation method -panel regression	Explaining recent fertility increase in Central Asia	-fertility changes in the region are not due to data artifacts -Population composition, economic context and the shifting fertility tempo effect are contributed to fertility changes in Central Asia
Yurtseven (2015)	2000-2013	-dynamic panel data estimation model	The socio-economic determinants of fertility rates in Muslim countries: a Dynamic Panel Data Analysis	-income, past realizations of fertility, college enrolment rate, contraceptive usage and time trends are significant as determinants of fertility in Muslim nations.
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 and May (1979)	1971 1973	-own children analysis -Brass model	Fertility, mortality, migration and family planning in Haiti	-malnutrition, longer breast-feeding period and use of contraceptives may reduce fertility -malnutrition and lack of quality healthcare services led to an increase in mortality
Gani (1999)	1982 to 1993	-panel data regression analysis	An economic analysis of factors influencing fertility in the Pacific Island countries	-high infant mortality rates are associated with high fertility rates -family planning, urbanisation, female education and high incomes are negatively correlated with 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

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 Kyrgyzstan.

Data Issues

This study is based on annual total fertility rate (births per woman) in Kyrgyzstan 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 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	0.078761
MSE	0.018399
MAE	0.106341

Residual Analysis for the Applied Model

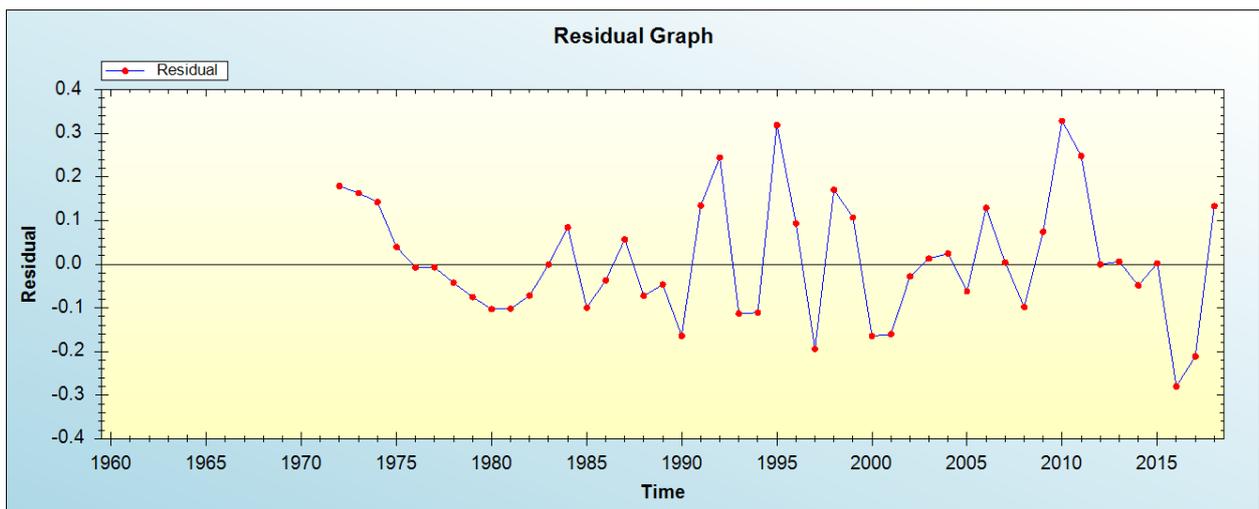


Figure 1: Residual analysis

In-sample Forecast for TFR

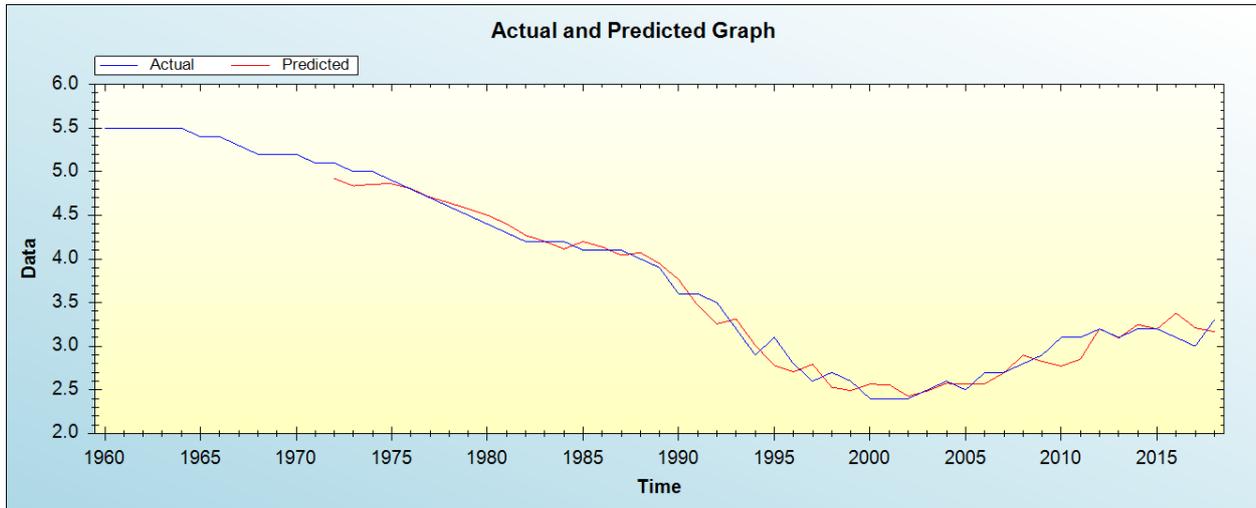


Figure 2: In-sample forecast for the TFR series

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

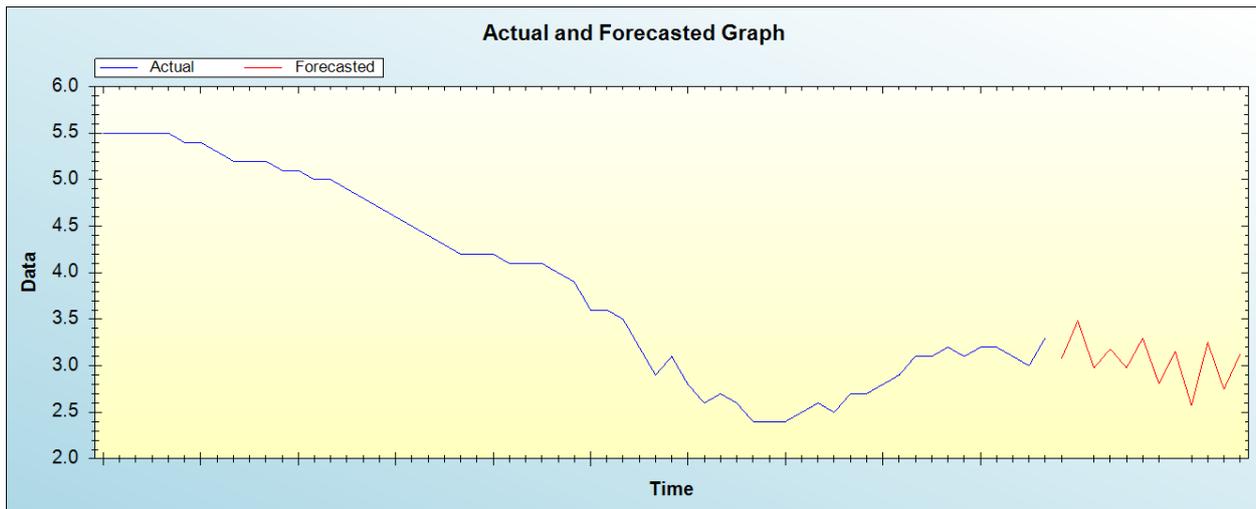


Figure 3: Out-of-sample forecast for TFR: actual and forecasted graph

Out-of-Sample Forecast for TFR: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted
2019	3.0751
2020	3.4817
2021	2.9760
2022	3.1823
2023	2.9787
2024	3.2959
2025	2.8056
2026	3.1525
2027	2.5699
2028	3.2517
2029	2.7467
2030	3.1298

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 Kyrgyzstan are oscillating slightly increasing and decreasing, it slightly increased from 3.08 in 2019 to 3.13 by 2030.

IV. CONCLUSIONS AND RECOMMENDATIONS

The results of Kyrgyzstan's predicted TFRs show them oscillating, slightly increasing or decreasing throughout the out of sample period though it remained constant at 3.1 in 2019 and by 2030. However, these rates are all above the replacement level of 2.1 hence population is expected to grow, ceteris paribus, throughout these years. The authorities may need to put measures and policies to control population growth and to boost the productive capacity of the country so that resources may not fall short of population growth.

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