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Predicting Total Fertility Rates for Turkmenistan Using Artificial Neural Networks

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***Abstract* - This study predicted total fertility rates (TFRs) for Turkmenistan from 2019 to 2030 using Artificial Neural Networks employing data on TFRs for Turkmenistan from 1960 to 2018. The results of the projected TFRs oscillated, slightly increasing and decreasing, declining from 3.1 in 2019 to 3 in 2030.**

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

I. INTRODUCTION

The total fertility rates (TFR) in all countries in Central Asia has either been stalling or increasing following the collapse of the Soviet Union in the 1990s with Turkmenistan stagnating since the mid-2000s (Spoorenberg, 2015). Demographers have been interested in factors affecting fertility as well as the demographic transition stages of different countries however little or no interest has been channeled towards predicting future TFR for Turkmenistan. This is the aim of this study such that proper policies can be put in place to influence future economic growth and population dynamics in Turkmenistan.

II. LITERATURE REVIEW

Literature on prediction of TFRs is sporadic, below are some researches undertaken on total fertility rates:

Table 1: Literature review

Author/s (Year)	Study period	Method	Topic	Key results
Gurbansoltan Eje clinical Medical Centre for Maternal and Child Health (2001)	2000	-one child method -quantitative analysis	Turkmenistan: demographic and health survey 2000	-TFR was 2.9 children -TRF for rural areas of 3.5 is higher by one than that for urban areas which is 2.5
Hortacsu et al (2001)	2000	-ANOVA -Instrumental Variable approach	Desire for children in Turkmenistan and Azerbaijan: son preference and perceived instrumentality for value satisfaction	-Turkmens desire to have more children and ascribe greater importance to having children than Azeris. -Turkmen and Azeri men desire more sons than daughters whilst Azeri women prefer sons only
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.
Islam (2020)	Past trends 1950-2019 Future projections 2020-2070	-algebraic identity by Mason and Lee	Demographic transition in Sultanate of Oman: Emerging demographic dividend and challenges	-Oman population grew from less than half million in 1950 to more than 4 million in 2015 and is expected to reach 7 million in 2055 -TFR has declined from 8.6 in

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				1988 to 3.3 in 2008
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
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
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
De Broe &Hinde (2006)	1987, 1996, 1999 & 2002	-Ordinary Least Squares	Diversity in fertility patterns in Guatemala	-ethnic diversity and proportion of indigenous people are significant in explaining fertility
McMurray (1988)	1970 to 1986	-quantitative analysis	Population growth in Solomon Islands: signs of slowing	-Fertility slowing was due to the deferment of marriage -family planning also caused stalling of fertility

III. METHODOLOGY

In this study, the Artificial Neural Network (ANN) approach, which is compatible with nonlinear data will be used. 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 Turkmenistan.

Data Issues

This study is based on annual total fertility rate (births per woman) in Turkmenistan 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	0.093195
MSE	0.061763
MAE	0.217935

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Residual Analysis for the Applied Model

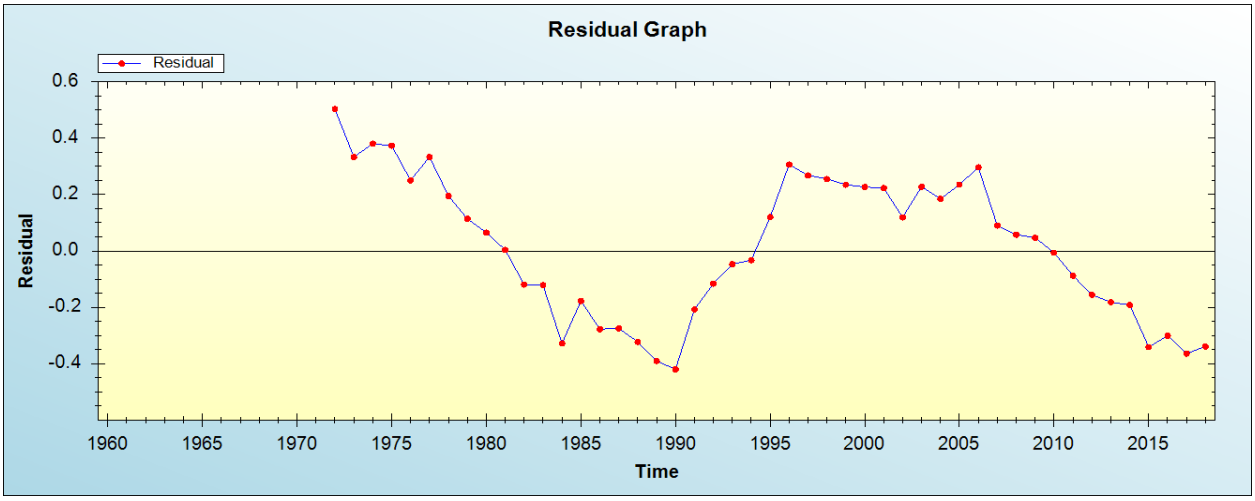

Figure 1: Residual analysis

In-sample Forecast for TRF

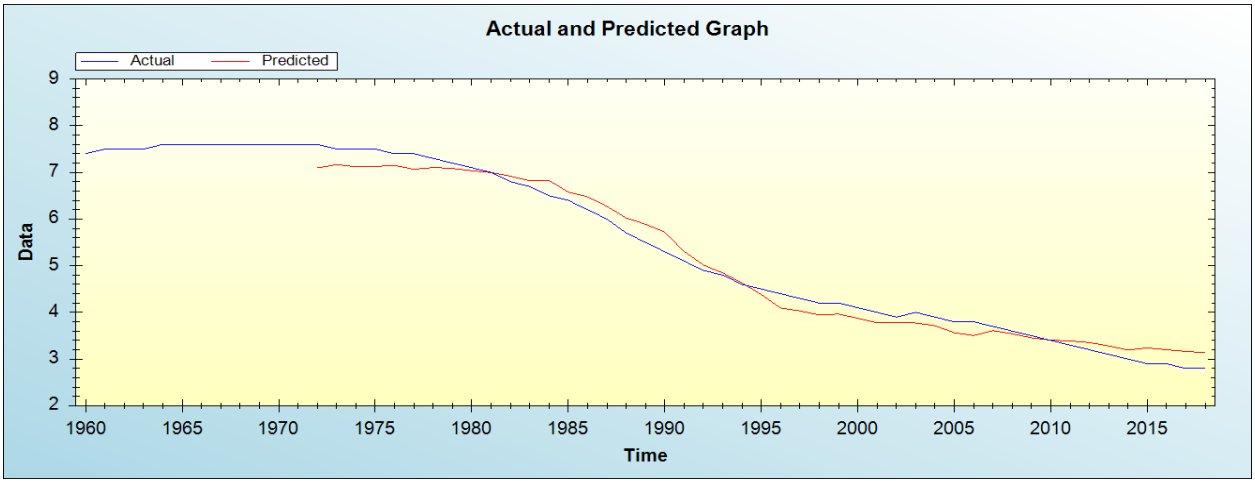

Figure 2: In-sample forecast for the TRF series

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

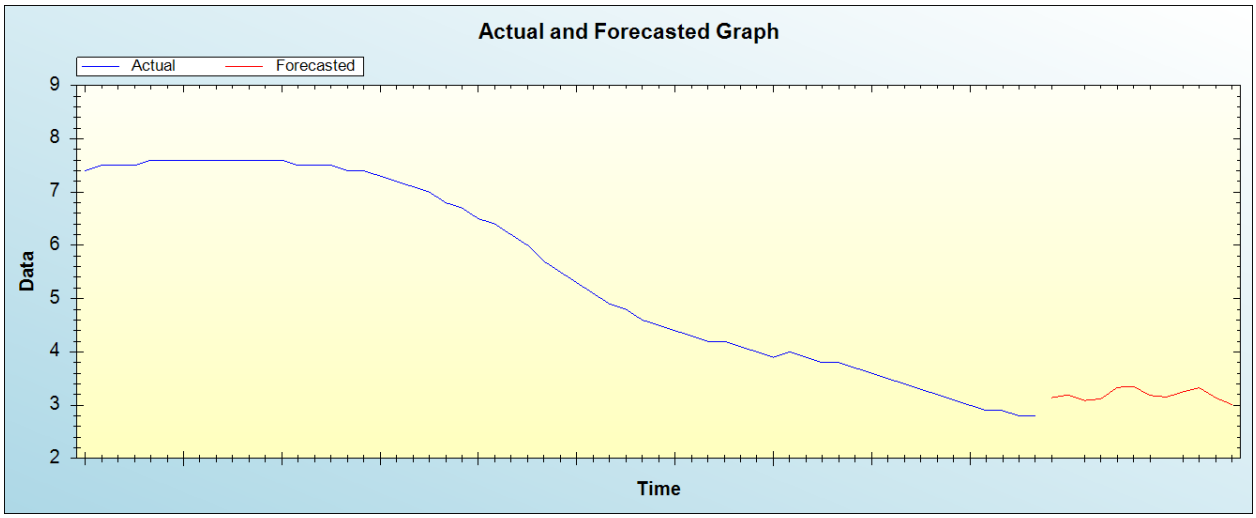

Figure 3: Out-of-sample forecast for TRF: actual and forecasted graph

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Out-of-Sample Forecast for TRF: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted
2019	3.1435
2020	3.1951
2021	3.0877
2022	3.1197
2023	3.3363
2024	3.3484
2025	3.1837
2026	3.1551
2027	3.2503
2028	3.3285
2029	3.1410
2030	3.0131

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 Turkmenistan are oscillating slightly increasing and decreasing over the out-of-sample period.

V. CONCLUSION AND RECOMMENDATIONS

The predicted TFRs for the period under review is at between 3 and 3.2. This implies that population for Turkmenistan is likely to grow ceteris paribus since the projected rates are greater than the replacement level of 2.1. Policies aimed at increasing resources and curtailing population growth should be implemented.

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