

Time Series Forecasting of Total Fertility Rate (TFR) in Zambia

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Abstract - Zambia's population pyramid is broad based indicating high fertility rates and lower life expectancy which is characteristic of developing countries. In this research article, the ANN approach was applied to analyze TFR in Zambia. 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 Zambia. The results of the study indicate that annual total fertility rates in Zambia are likely to hover around 5.0 births per woman (ranging from 4.5 to 4.7) over the out-of-sample period. Therefore, we encourage the Zambian government to focus on addressing adolescent and young adult challenges encountered when seeking sexual and reproductive health services in health care facilities and channel more resources towards women empowerment program activities.

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

I. INTRODUCTION

Zambia is a SADC country with an estimated population size of approximately 18 million inhabitants with 44.8% living in urban areas. (Worldometer, 2020). The country's TFR has been dropping over the years from 6.7 births per woman in 1955 to 4.7 births per woman in 2020. During the same year, the country recorded an infant mortality rate of 39.4 infant deaths per 1000 live births and under five mortality rate of 52.4 deaths per 1000 live births (Worldometer, 2020). Zambia has an estimated 13.3 % of the population aged 15-49 years who are living with HIV (Central statistics office, 2014). The country has a high maternal mortality ratio of 278 deaths per 100 000 live births (Central statistics office, 2019). Provision of Sexual and reproductive health services has been seen to help improve maternal and child health outcomes. The Zambian government is fully committed to fulfilling SRH services and rights by ratifying eleven international instruments of law and also committed to achieving the sustainable development goals (SDGs) including those which relate to sexual and reproductive health and rights (Zambia Policy Brief, 2017). In Zambia family planning and education have contributed significantly to the decline in fertility levels, however the uptake of family planning still remains low when compared to other countries in the region. The contraceptive prevalence rate is at 41 % for all methods (ZFP, 2012). There are limited studies in the SADC region that have examined or predicted fertility rates. In this study we shall mention some of them. Genus (2020) examined the determinants of trends wanted and unwanted fertility in SSA using fixed-effects regressions of country-level data. Data came from 103 DHS surveys in 25 countries in SSA with at least two DHS surveys between 1989 and 2019. The study revealed that Women's education and family planning programs are found to be the dominant determinants of fertility decline and their effects operate by reducing both wanted and unwanted fertility. Machira et al (2020) examined the determinants of risky sexual behavioral practices among teen women in Malawi. The study found the existence of differential determinants to influence women's conduct in having both multiple sexual partners and inability to use condom during subsequent sexual intercourses with partners other than spouses. A secondary analysis of the Global School-based Student Health Surveys (GSHS) datasets pooled from five SSA countries Benin, Mozambique, Namibia, Seychelles, and Tanzania were done by Shayo and Kalomo (2019). Logistic regression was applied and the results indicated that Adolescents sexual intercourse and more especially sex with multiple partners was prevalent and strongly correlated with substance use.

The aim of this study is to project TFR in Zambia using a machine learning algorithm. The results of the study are envisioned to reveal the likely future trends of TFR in the country to facilitate resource mobilization and allocation to the health sector, education and for employment creation.

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 Zambia.

Data Issues

This study is based on annual total fertility rate (births per woman) in Zambia 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	Z
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	0.149226
MSE	0.053884
MAE	0.191372

Residual Analysis for the Applied Model

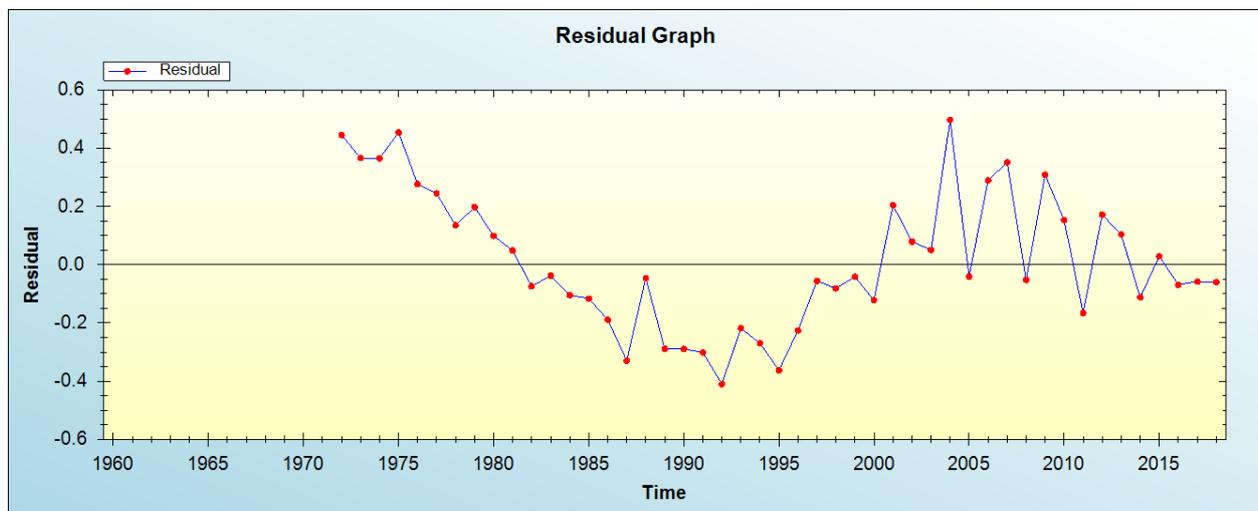


Figure 1: Residual analysis

In-sample Forecast for Z

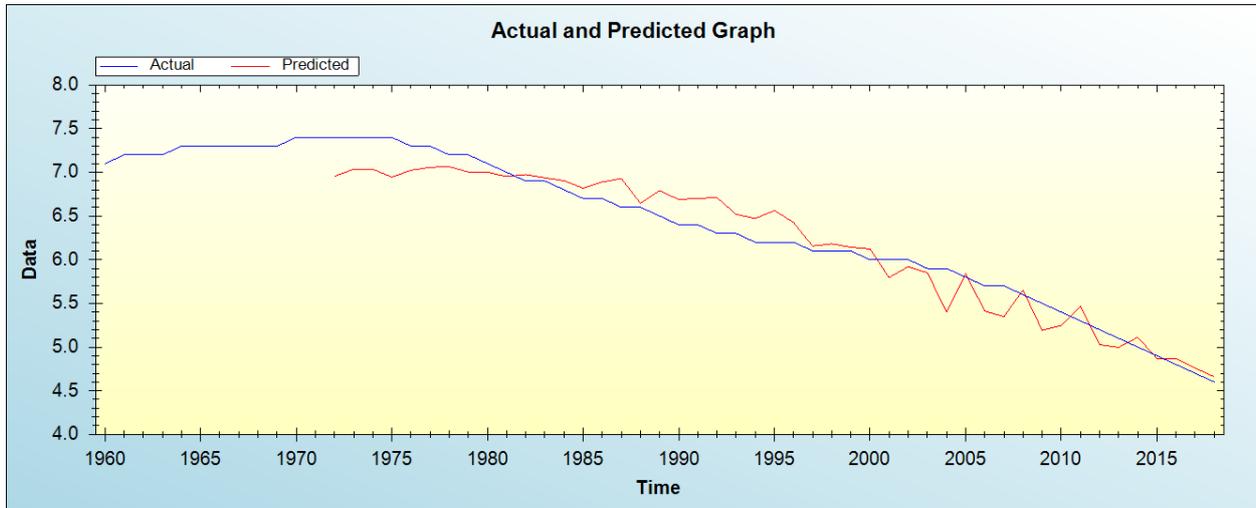


Figure 2: In-sample forecast for the Z series

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

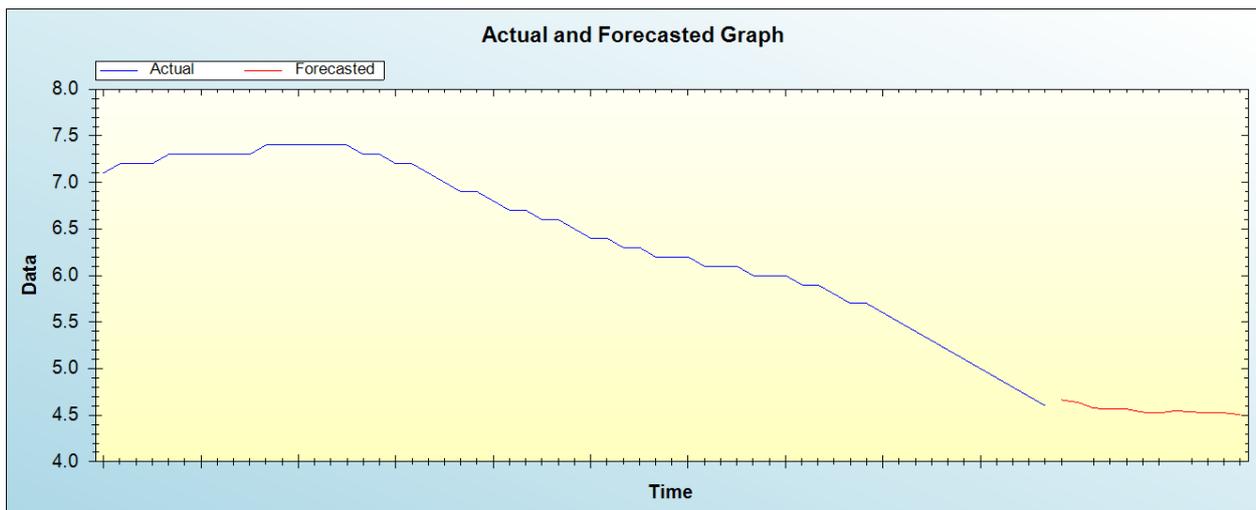


Figure 3: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	4.6634
2020	4.6377
2021	4.5733
2022	4.5704
2023	4.5644
2024	4.5326
2025	4.5220
2026	4.5474
2027	4.5361
2028	4.5219
2029	4.5247
2030	4.5056

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 Zambia are likely to hover around 5.0 births per woman (ranging from 4.5 to 4.7) over the out-of-sample period.

IV. CONCLUSIONS AND RECOMMENDATIONS

Zambia is still battling the challenge of teenage pregnancies and child marriages which are contributing factors to adverse maternal and child health outcomes. In this paper we propose the artificial neural network approach to predict TFR in Zambia. The ANN (12, 12, 1) model projections suggest that annual total fertility rates in Zambia are likely to hover around 5.0 births per woman (ranging from 4.5 to 4.7) over the out-of-sample period. Therefore, the Zambian government is advised to focus on addressing adolescent and youth challenges in accessing family planning services in health care facilities and channel more resources towards women empowerment program activities.

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