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

ISSN (online): 2581-3048

Volume 5, Issue 8, pp 478-481, August-2021

https://doi.org/10.47001/IRJIET/2021.508108

Time Series Forecasting Of Total Fertility Rate in Zimbabwe

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***Abstract* - Zimbabwe's family planning program is considered as one of the success stories in Sub-Saharan Africa. In this research paper, the ANN approach was proposed to analyze total fertility rate (TFR) in Zimbabwe. 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 Zimbabwe. The results of the study indicate that annual total fertility rates in Zimbabwe are likely to remain around 4.0 births per woman over the out-of-sample period. Therefore, we encourage the Zimbabwean government to focus on creating more demand for family planning services, address adolescent and youths' challenges faced when seeking sexual and reproductive health (SRH) services and channel more resources towards women empowerment program activities.**

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

I. INTRODUCTION

Total fertility rate (TFR) is the average number of children born to a woman throughout her lifetime or childbearing age (15-49 years of age) if she were to pass through her child bearing years and have children according to the current age specific rates (Hamad, 2020; Eslami, 2016). A TFR of 2.1 is called the replacement level fertility. It is the number of children born to a woman in order for the generation to replace itself without requiring international migration.

Zimbabwe is a developing country in the SADC region with a current estimated population of approximately 15,080,149 inhabitants as of 5 July 2021 and 38% of its population is urban (Worldometer, 2021). Its 2019 population density was 38 people per square kilometer. In the year 2020 the country recorded a TFR of 3.6 live births per woman. Infant mortality rate for the same year was 34.1 infant deaths per 1000 live births and under five mortality of 45.1 deaths per 1000 live births (Worldometer, 2020). Zimbabwe's TFR declined from 4.3 births per woman in 1990 to 4.0 births per woman in 2015 (ZNFPCIP 2016-2020). This drop in TFR is as a result of increase in age of marriage, improvements in the level of education of women and contraceptive use among other factors. The contraceptive prevalence rate (CPR) in Zimbabwe over the years has been on an upward trajectory. The 2005/06 ZDHS indicated that CPR had increased to 60.2 percent. CPR is the proportion of women in the reproductive age group (15-49 years) using family planning methods. Family planning use varies by province with CPR ranging from 57% in Manicaland to 71% in Mash west and Bulawayo due to religious, sociocultural and health infrastructure variations in various provinces (ZNFPCIP 2016-2020). Zimbabwe is regarded globally as one of the family planning successes in Africa with one of the highest CPR of about 65.6 % (ZDHS, 2012).

There are limited forecasting studies in the country and region including those that have examined fertility rates. 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. Based on an explorative qualitative study conducted by Dessalegn (2020) in five districts in Ethiopia. Sixteen key informants and eight focus group discussions were conducted among adult women and men of young adolescents and youth. The study revealed that younger and older women are the most disadvantaged groups of the society. Yaya & Ghose (2018) explored the prevalence of unmet need for contraception and unintended pregnancy as well as their relationship among married women in Angola. The authors utilized cross-sectional data from Angola Demographic and Health Survey (DHS) conducted in 2015–16. Participants were 7,808 married women aged 15–49 years. Unwanted pregnancy was measured in terms of the mistimed and unintended conception for the last-born child. Unmet need for contraception included those who reported unmet need for spacing and limiting. Data were analyzed using bivariate and multivariable techniques. The results indicated that the combined prevalence of mistimed and unwanted pregnancy was 38.3% (95%CI = 35.9–40.7), and that of unmet need for contraception for spacing and limiting was 51.7% (49.9–53.5). Based on a cross-sectional study, Renzaho et al (2017) examined factors associated with comprehensive categories of sexual and reproductive health, including sexual behaviors; sexual education and access to contraceptive services; family planning; prevention of STDs; sexual consent as a right; gender based violence; as well as HIV testing, counseling, disclosure and support. The study concluded

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that there is need to address barriers and ensure a comprehensive and harmonized sexual and reproductive health system that is youth friendly and takes into account local socio-cultural issues.

The aim of this study is to project TFR in Zimbabwe using a machine learning algorithm. The results of the study are envisioned to reveal likely future trends of TFR in the country. This will guide policy, planning, decision making and resource allocation towards education, health and employment creation. Resource allocation to health sector will improve the quality and access to SRH services in order to reduce maternal deaths, unintended pregnancies and improve child survival.

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 Zimbabwe.

Data Issues

This study is based on annual total fertility rate (births per woman)in Zimbabwe 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	0.143139
MSE	0.091314
MAE	232455

Residual Analysis for the Applied Model

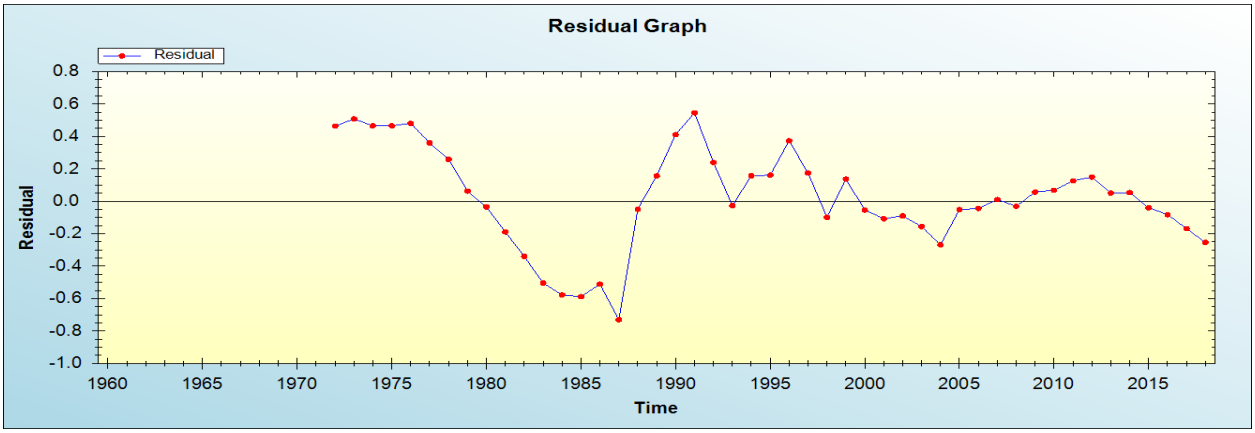

Figure 1: Residual analysis

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In-sample Forecast for Z

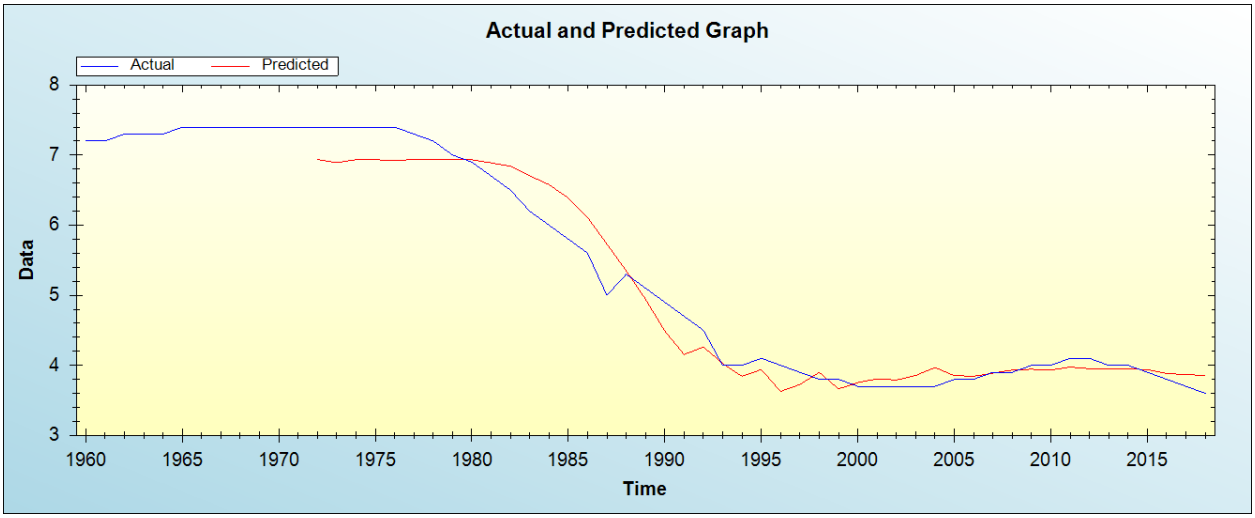

Figure 2: In-sample forecast for the Z series

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

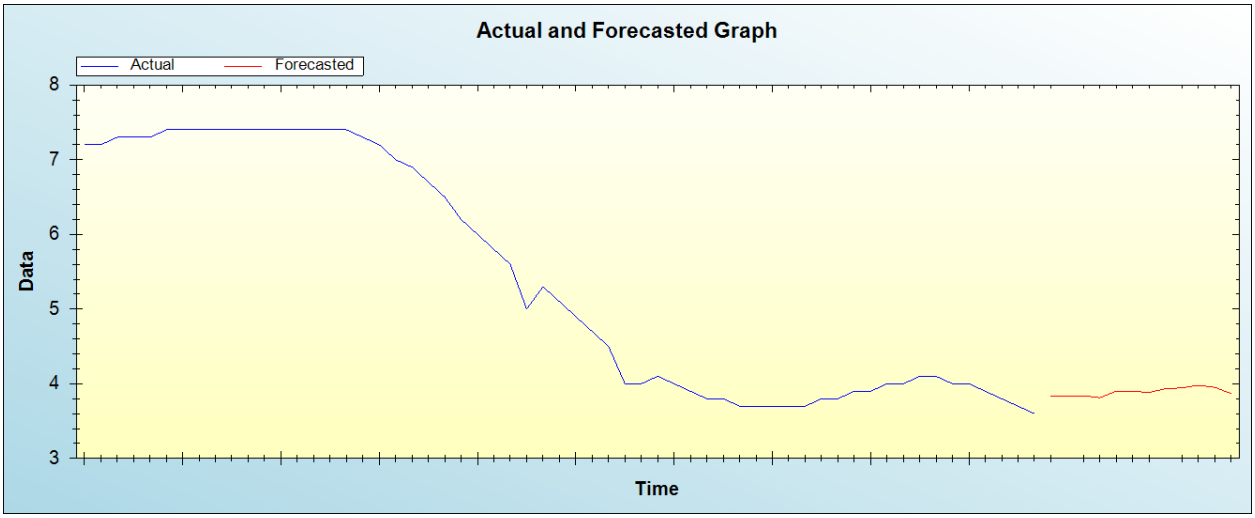

Figure 3: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	3.8353
2020	3.8366
2021	3.8404
2022	3.8143
2023	3.9031
2024	3.8991
2025	3.8846
2026	3.9332
2027	3.9458
2028	3.9790
2029	3.9533
2030	3.8683

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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 Zimbabwe are likely to remain around 4.0 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Zimbabwe is still experiencing the challenge of early child marriages and teenage pregnancies which are being driven by socio cultural and economic factors. Although the country has witnessed fertility transition over the past decades, fertility rates are still high. In this study we proposed a machine learning technique to forecast TFR in Zimbabwe. The ANN model projections revealed that annual total fertility rates in Zimbabwe are likely to remain around 4.0 births per woman over the out-of-sample period. Therefore, the Zimbabwean government is encouraged to focus on creating more demand for family planning services, address adolescent and youth challenges in accessing sexual and reproductive health (SRH) services and channel more resources towards women empowerment program activities.

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Citation of this Article:

Dr. Smartson. P. NYONI, Tatenda. A. CHIHOHO, Thabani NYONI, "Time Series Forecasting Of Total Fertility Rate in Zimbabwe" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 8, pp 478-481, August 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.508108

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