

Univariate Time Series Forecasting of Total Fertility Rate in Mozambique

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Abstract - The current civil conflict in Mozambique is likely to have serious negative impacts on the health delivery system and other key services as the nation is struggling to control the epidemics of TB, HIV and COVID-19. The country has persistently reported undesirable levels of maternal and child health indicators as well as high fertility rates. In this research paper, the ANN approach was proposed to analyze total fertility rate (TFR) in Mozambique. 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 Mozambique. The results of the study indicate that annual total fertility rates in Mozambique are likely to decline over the out-of-sample period but will still remain high. Therefore, we encourage the Mozambican government to focus on addressing sexual and reproductive health (SRH) challenges being faced by adolescents and young adults in order to reduce adverse maternal and child health outcomes, and channel more resources towards women empowerment programs.

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

I. INTRODUCTION

Mozambique is a SADC country with a high HIV and TB disease burden. The country is still struggling with high maternal and infant mortality rates. In 2020 the country recorded an infant mortality rate of 414.9 infant deaths per 1000 live births and an under five mortality rate of 61.1 deaths per 1000 live births (Worldometer, 2020). Over the years total fertility rate in Mozambique has been on a downward trend from 6.3 births per woman in 1955 to 4.9 births per woman in 2020 (Worldometer, 2020). Its population will continue to grow rapidly due to the high numbers of young women who enter the reproductive years (Mozambique, 2015).

The Mozambican government has made significant progress in ensuring access to family planning services for its population. However the contraceptive prevalence rate remains low, 25% in 2015 to 35% in 2019 (FP2020). The government is committed to tackling gender inequalities and power imbalances impacting on sexual and reproductive health and rights (MISAU, 2014) by addressing gender barriers to healthcare, increasing girls' access to education and reducing violence against girls and women. There are limited studies that have examined or forecasted fertility trends in the country and region. 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. Renzaho et al (2017) carried out a cross-sectional study to examine 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 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.

Based on a cross-sectional survey, Lafort et al (2016) did an operational research project in Tete, Mozambique, on use of, and barriers to, HIV and sexual and reproductive health (HIV/SRH) commodities and services for female sex workers (FSWs) were assessed as part of a baseline situational analysis. In a cross-sectional survey 311 FSWs were recruited using respondent driven sampling and interviewed face-to-face, and three focus group discussions were held with respectively 6 full-time Mozambican, 7 occasional Mozambican and 9 full-time Zimbabwean FSWs, to investigate use of, and barriers to, HIV/SRH care. The study concluded that the use of most HIV and SRH services is insufficient in this FSW population.

The aim of this study is to project total fertility rate in Mozambique using an artificial neural network approach. The findings of this study are envisioned to reveal likely future trends in TFR in the country to facilitate planning and allocation of resources to health, education and 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 Mozambique.

Data Issues

This study is based on annual total fertility rate (births per woman) in Mozambique 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	M
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	0.114159
MSE	0.013032
MAE	0.098044

Residual Analysis for the Applied Model

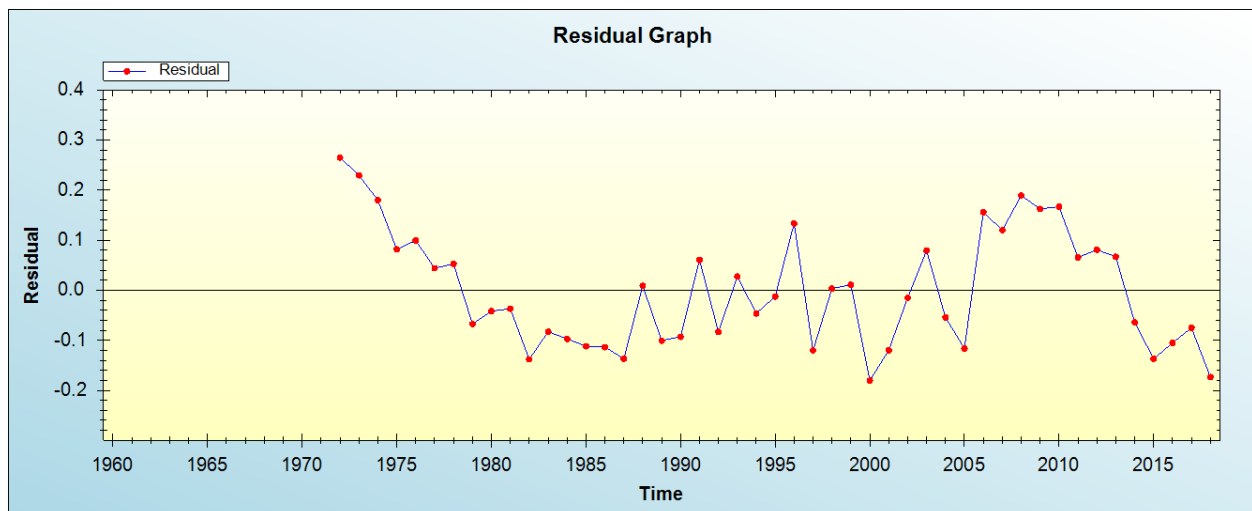


Figure 1: Residual analysis

In-sample Forecast for M

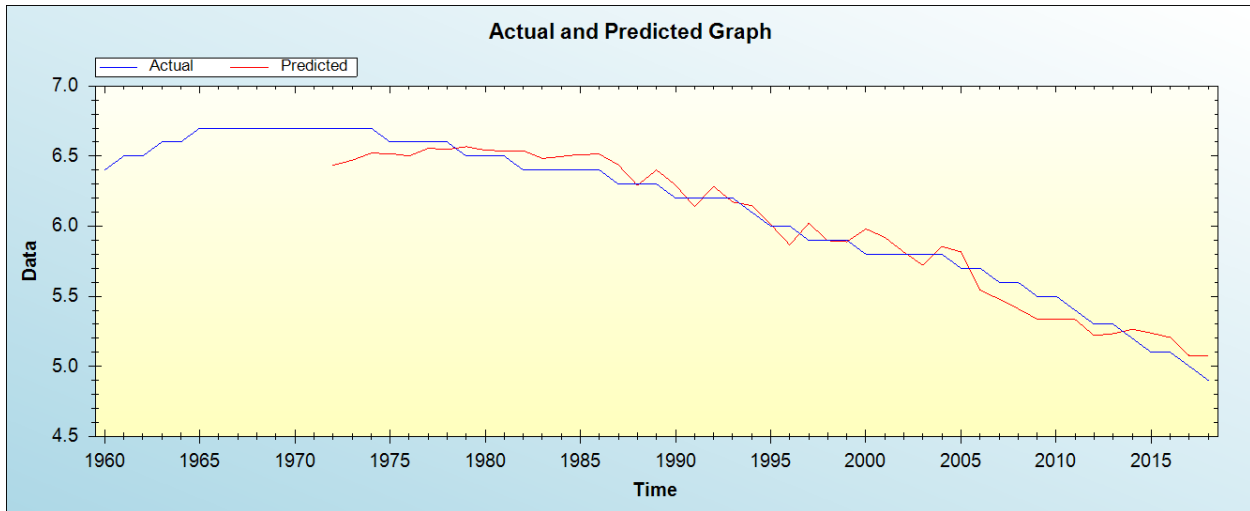


Figure 2: In-sample forecast for the M series

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

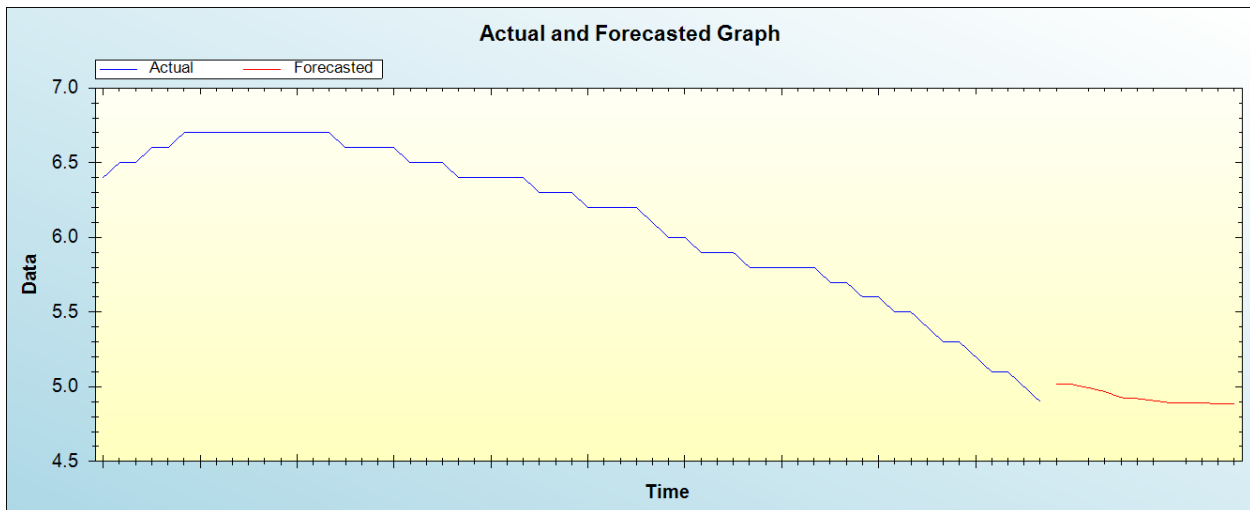


Figure 3: Out-of-sample forecast for M: actual and forecasted graph

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	5.0194
2020	5.0152
2021	4.9932
2022	4.9675
2023	4.9280
2024	4.9208
2025	4.9075
2026	4.8930
2027	4.8896
2028	4.8906
2029	4.8882
2030	4.8874

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 Mozambique are likely to decline over the out-of-sample period but will still remain high.

IV. CONCLUSION & RECOMMENDATIONS

Mozambique is a developing country which is currently in the midst of a civil conflict and battling the epidemics of TB, HIV and COVID19. The country is characterized by high maternal, infant and child mortality rates as well as high adolescent fertility rates. In this study we proposed a machine learning approach to predict TFR in Mozambique. The results of the study indicated that annual total fertility rates in Mozambique are likely to decline over the out-of-sample period but will still remain high. Therefore, the Mozambican government is encouraged to focus on addressing sexual and reproductive health (SRH) challenges being faced by adolescents and young adults to avert undesirable SRH outcomes. We also recommend that the government should channel more resources towards women empowerment programs.

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