

Forecasting the Future Path of Adolescent Fertility for Tanzania Using Holt's Linear Method

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Abstract - This study uses annual time series data of adolescent fertility rate for Tanzania from 1960 to 2020 to predict future trends of adolescent fertility rate over the period 2021 to 2030. The study utilizes Holt's linear exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.3 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline but still remain very high throughout the out of sample period. Therefore, we encourage authorities in Tanzania to scale up awareness campaigns among the communities, support girl child education, fund empowerment programs for youths and strictly enforce laws that protect sexual and reproductive health rights of girls and women in order curb child marriages.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Pregnancy during the stage of adolescence is a major cause of maternal and under five morbidity and mortality (WHO, 2020; UNFPA, 2015). A second pregnancy during adolescence has been associated with an increased risk of preterm birth, low birth weight, stillbirths, perinatal and neonatal mortality above and beyond the first pregnancy (Akinbami, 2000; Galvão *et al.* 2018). It is evident that teenage pregnancy increases the risk of further economic hardships, mental stress and behavioral disorders leading to poorer health and educational outcomes (Cook & Cameron, 2020; Maravilla *et al.* 2017; Corcoran, 2016; WHO, 2004). Teenage pregnancy in Tanzania is a very big public health problem among adolescent girls. Literature has shown that teenage pregnancy in this country is associated with school dropouts among girls in Tanzania (Madeni *et al.* 2011). According to IRIN, school dropouts in Tanzania are much higher in girls than boys and the main causes are teen pregnancy and teen marriages. Differences in teenage childbearing rates exist across regions, ranging from a low of 5 percent in Mjini Magharibi Region in Zanzibar, 6 percent in Kilimanjaro Region to 45 percent in Katavi and 43 percent in Tabora Regions. Teenagers in rural areas are more likely to have started child bearing than their urban counterparts: 32 percent of rural teenagers have had a live birth or are pregnant, compared with 19 percent of urban teenagers (TDHS, 2015/16). Studies conducted in this country indicate that the main drivers of adolescent pregnancy in Tanzania are low education level, poverty, gender inequality and social norms (TDHS, 2015/16; McCleary-Sills *et al.* 2013). The government's strategy to end teenage pregnancy include offering affordable quality comprehensive sexual and reproductive health services for young people, sensitizing communities and advocating for the end of exclusion of pregnant pupils and teenage mothers from schools and providing re-entry of opportunities for young mothers of school going age.

In line with sustainable development goals 3, 4 and 5, this paper applies Holt's double exponential smoothing technique to forecast future trends of adolescent fertility in Tanzania. The findings are expected to highlight the future burden of adolescent births in the out of sample period. This will trigger implementation of appropriate policies to end child marriages in the country.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Tanzania. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more influence than those in the more distant past as more recent values are allocated more weights than those in the distant past. This study uses the Holt's linear method (Double exponential smoothing) because it is an appropriate technique for modeling linear data.

Holt's linear method is specified as follows:

Model equation

$$Z_t = \mu_t + \rho_t t + \varepsilon_t$$

Smoothing equation

$$L_t = \alpha Z_t + (1-\alpha)(L_{t-1} + b_{t-1})$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (L_t - L_{t-1}) + (1-\beta)b_{t-1}$$

Forecasting equation

$$f_{t+h} = L_t + hb_t$$

Z_t is the adolescent fertility rate at time t

ε_t is the time varying **error term**

μ_t is the time varying mean (**level**) term

ρ_t is the time varying **slope term**

t is the trend component of the time series

L_t is the exponentially smoothed value of adolescent fertility rate at time t

α is the exponential smoothing constant for the data

β is the smoothing constant for trend

f_{t+h} is the h step ahead forecast

b_t is the slope of the trend at time t

b_{t-1} is the slope the trend at time t-1

Data Issues

This study is based on annual adolescent fertility rate in Tanzania for the period 1960 – 2020. The out-of-sample forecast covers the period 2021 – 2030. All the data employed in this research paper was gathered from the World Bank online database.

III. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Z
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300

Forecast performance measures	
Mean Absolute Error (MAE)	0.538865
Sum Square Error (SSE)	66.479722
Mean Square Error (MSE)	1.089832
Mean Percentage Error (MPE)	-0.026889
Mean Absolute Percentage Error (MAPE)	0.377001

Residual Analysis for the Applied Model

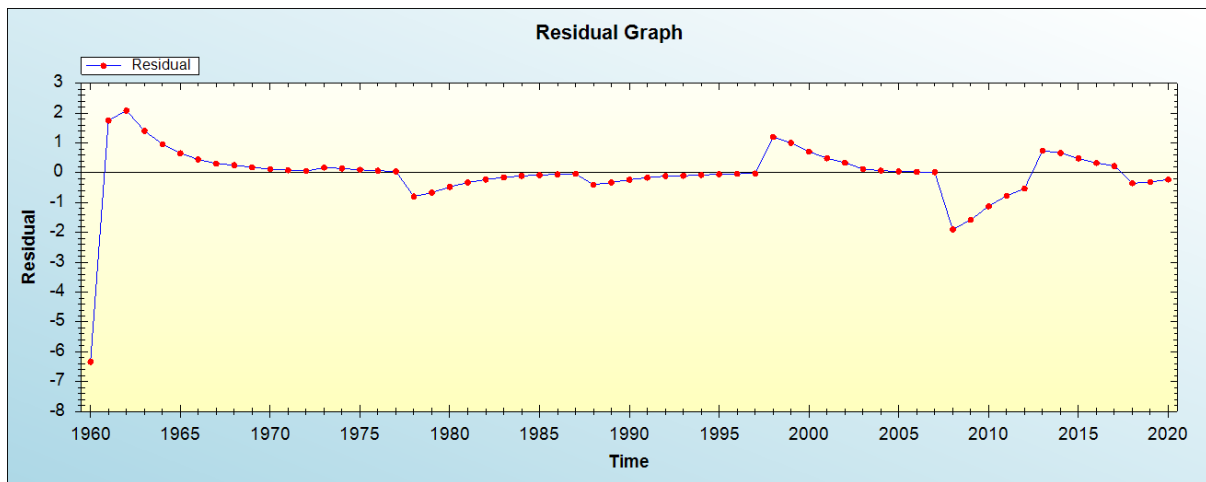


Figure 1: Residual analysis

In-sample Forecast for Z

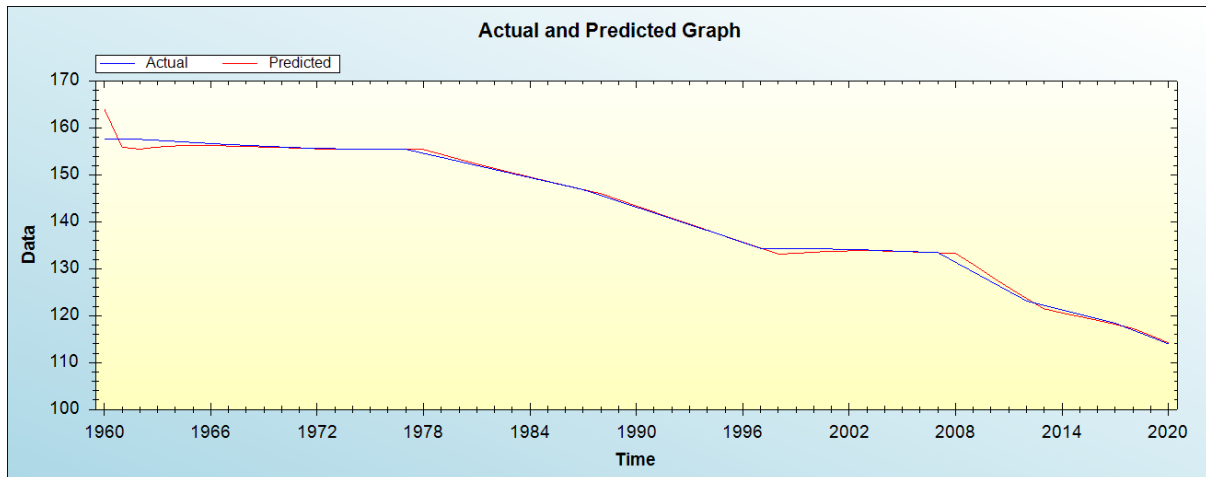


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

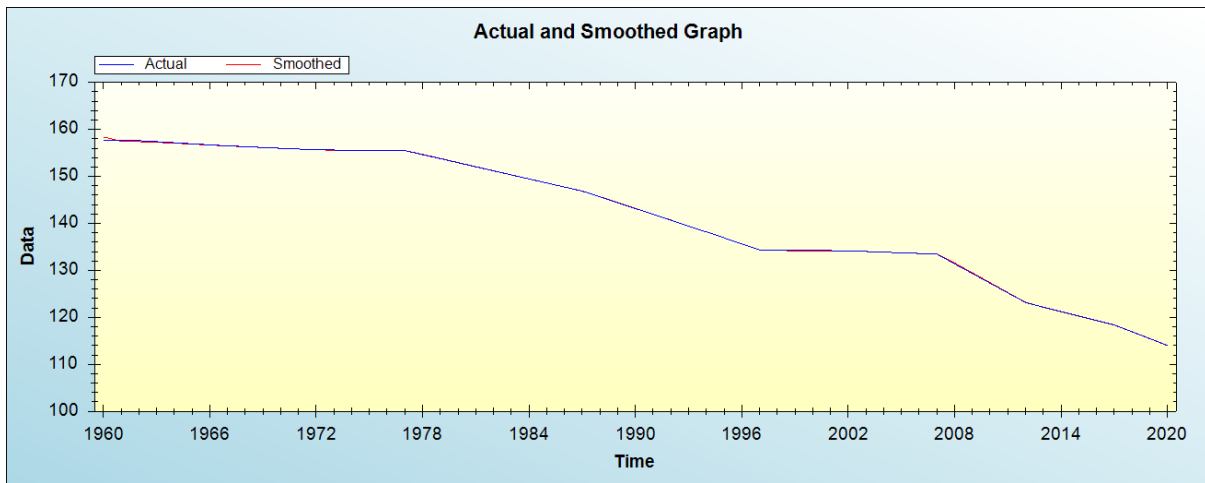


Figure 3: Actual and smoothed graph for Z series

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

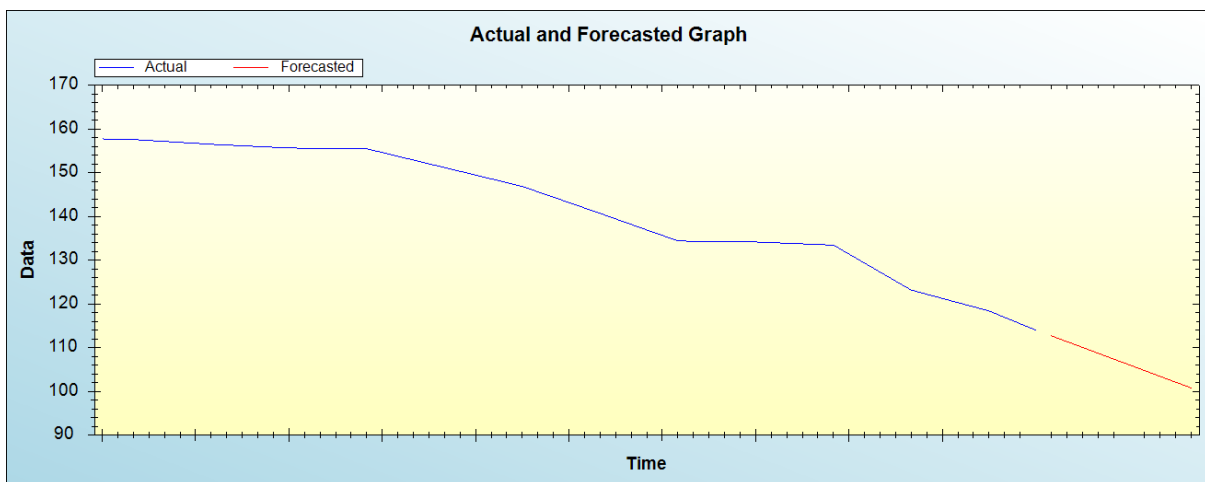


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	112.7038
2022	111.3771
2023	110.0505
2024	108.7238
2025	107.3972
2026	106.0705
2027	104.7439
2028	103.4172
2029	102.0906
2030	100.7639

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 adolescent fertility rate will continue to decline but remain very high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

World Bank reports indicate that adolescent fertility in Tanzania is very high. Adolescent fertility has been declining over the past decades but has remained above 100 births per 1000 women aged 15-19 years. Pregnancy rates among teenagers have been found to be higher in the rural areas than urban settings. The leading causes of adolescent pregnancy in Tanzania are low education level, poverty, gender inequality and social norms. The government adopted a national strategy to end teenage pregnancy. This initiative includes offering affordable quality comprehensive sexual and reproductive health services for young people, sensitizing communities and advocating for the end of exclusion of pregnant pupils and teenage mothers from schools and providing re-entry of opportunities for young mothers of school going age. This study applies the double exponential smoothing technique to forecast adolescent fertility for Tanzania. The study findings suggest that adolescent fertility will remain very high throughout the out of sample period. Therefore, we encourage the Tanzanian government to scale up awareness campaigns among the communities, support girl child education, fund empowerment programs for youths and strictly enforce laws that protect sexual and reproductive health rights of girls and women in order curb child marriages.

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