

Adolescent Fertility Prediction for Sub-Saharan Africa Using Holt's Double Exponential Smoothing Technique

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Abstract - Adolescent pregnancy is a worldwide public health problem that requires urgent attention. Sub-Saharan Africa has the highest burden of teenage pregnancies in the world followed by South Central Asia then lastly Latin America and the Caribbean. Child marriages, poverty, peer influence, lower educational level, alcohol and substance abuse, parental absence and lack of proper guidance and single parent households have been identified as major drivers of adolescent pregnancy. This study uses annual time series data of adolescent fertility rate for Sub-Saharan Africa 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 0.1 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to drop but remain high throughout the out of sample period. In order to effectively reduce high adolescent fertility rates in Sub-Saharan Africa, authorities must continuously enforce laws that protect sexual and reproductive rights of women and girls, support girl child education, fund empowerment projects for youths and increase awareness campaigns among communities.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adolescent pregnancy is a worldwide public health problem that requires the attention it deserves (Grønvik & Fossgard, 2018; Pradhan *et al.* 2018; Sama *et al.* 2017). Every year, about 21 million girls' aged 15-19 years in developing countries become pregnant (WHO, 2019). An estimated ninety five percent of teenage pregnancies occur in low-middle income countries with 36.4 million women becoming mothers before age 18 and 5.6 million having a live birth before age 15 in 2010 (Edilberto, 2013). In 2013, sub-Saharan Africa was reported to have the highest prevalence of teenage pregnancy in the world with the least teenage age being 13 years old (UNICEF, 2008). Sub Saharan Africa has the highest burden of teenage pregnancies in the world followed by South Central Asia then lastly Latin America and the Caribbean (Woog & Kagesten, 2017). In Africa the burden of adolescence pregnancy is as follows: Niger has the highest adolescent fertility of 203.604 births per 100,000 teenage women. Mali follows with 175.4438, Angola (166.6028), Mozambique (142.5334), Guinea (141.6722), Chad (137.173), Malawi (136.972), and Cote d'Ivoire (135.464)(World Atlas, 2017). Reports indicate that there is a high prevalence of teenage pregnancy across sub-Saharan Africa regions: 16.3 percent in Eastern, 27.9 percent in Western, and 28.9 percent in Southern Africa (Odimegwu & Mkwanzani, 2016). It is well documented that adverse maternal and child health outcomes are usually linked to teenage pregnancy (Merdad & Ali, 2018; Munakampeet *et al.* 2018; Neal *et al.* 2018). Previously reported complications are maternal and perinatal deaths, anemia, preterm delivery, hypertensive disorders, antepartum hemorrhage, low birth and prematurity (Ganchimeg *et al.* 2014; Mayor, 2004). Previous studies conducted in Africa revealed that thirty five percent of pregnancies among 15-19-year-old were unintended, unwanted, or untimed and that the teenagers' relationships were unstable (Bankole & Malarcher, 2010; Mkhwanazi, 2009). It has been reported in previous studies that early marriage is the major driver of teenage pregnancies in Sub-Saharan Africa where one in every four girls has given birth by the age of 18 years (Nugent, 2006). Other risk factors for teenage pregnancy in this region are poverty, peer influence, lower educational level, alcohol and substance abuse, parental absence and lack of proper guidance, inconsistent use of condoms and single parent households (Gunawardena *et al.* 2019; Magnusson *et al.* 2019; Kassa *et al.* 2018; Yakubu & Salisu, 2018).

This paper applies the double exponential smoothing technique to model and forecast future trends of adolescent fertility in Sub-Saharan Africa. The findings are expected to depict the future burden of adolescent fertility in the region. This will guide regional policies, planning and allocation of resources to teenage pregnancy prevention programs.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Sub-Saharan Africa. 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 double exponential smoothing method is specified as follows:

Model equation

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

G_t is the actual adolescent fertility rate value 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 trend estimate at time t

b_{t-1} is the trend estimate at time period t-1

Data Issues

This study is based on annual adolescent fertility rate in Sub-Saharan Africa 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	G
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.757996
Sum Square Error (SSE)	173.071069
Mean Square Error (MSE)	2.837231
Mean Percentage Error (MPE)	-0.092379
Mean Absolute Percentage Error (MAPE)	0.520345

Residual Analysis for the Applied Model

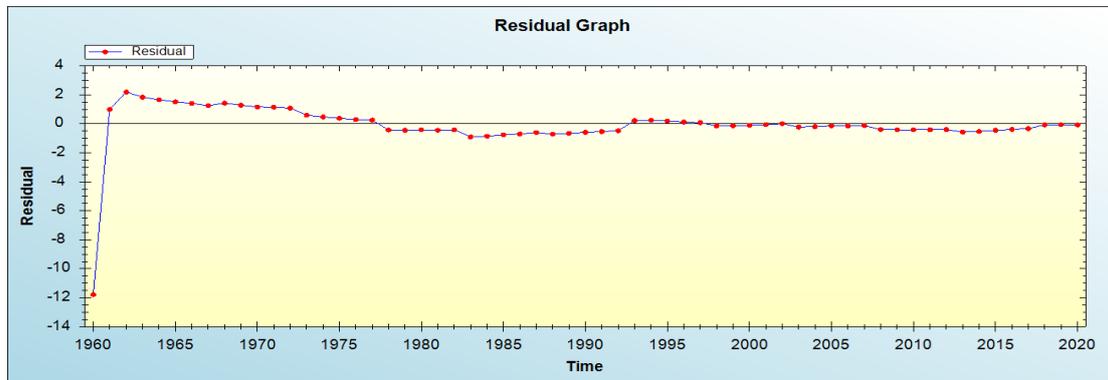


Figure 1: Residual analysis

In-sample Forecast for G

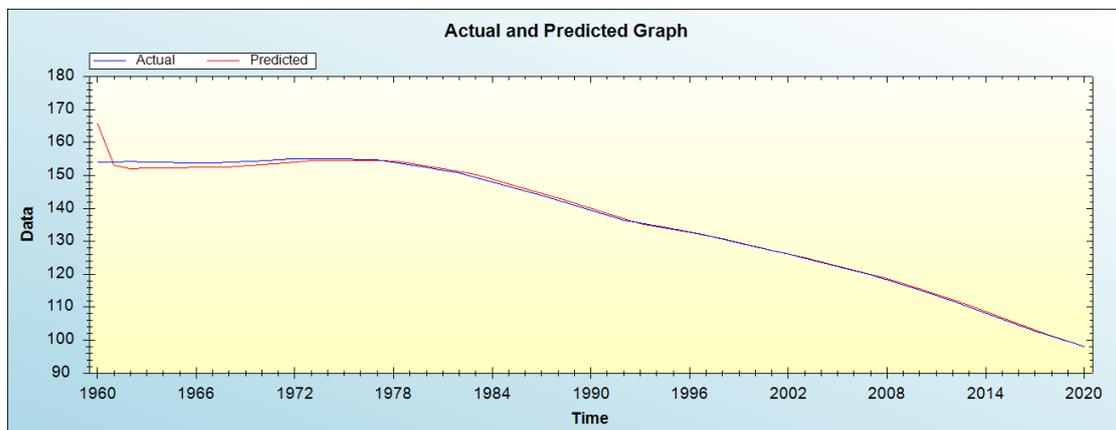


Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

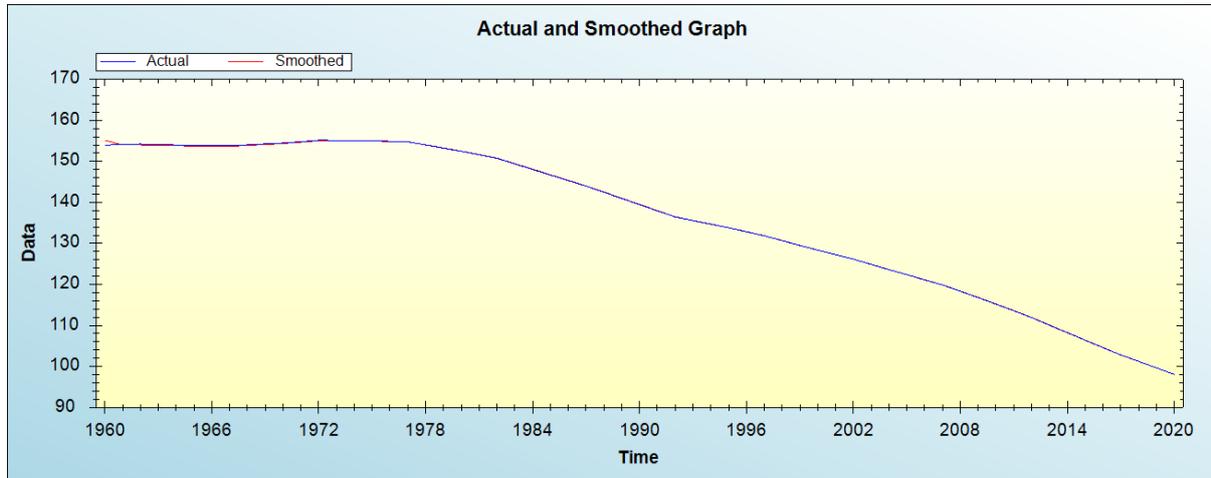


Figure 3: Actual and smoothed graph for G series

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

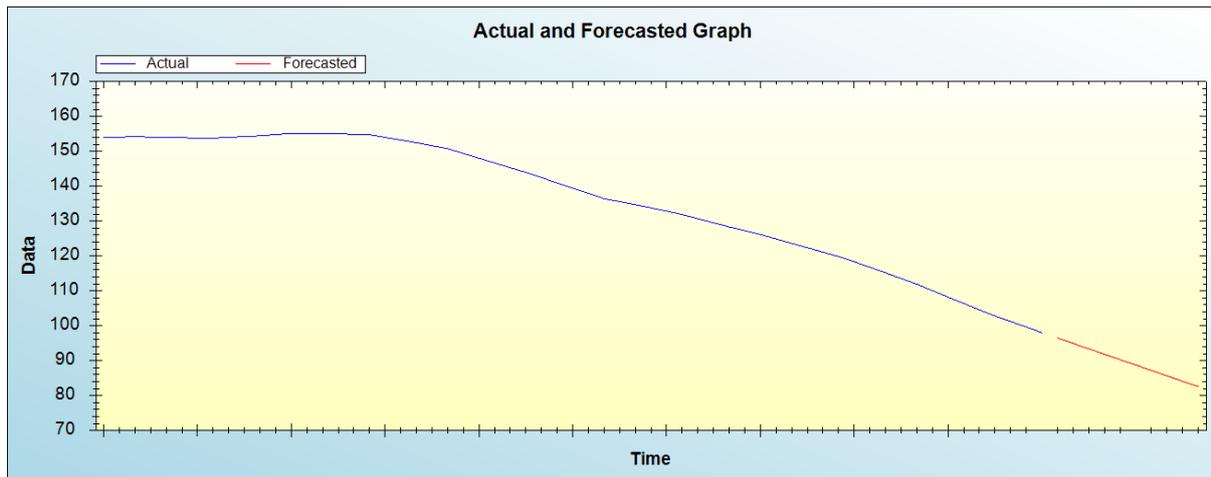


Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	96.4890
2022	94.9390
2023	93.3890
2024	91.8389
2025	90.2889
2026	88.7389
2027	87.1889
2028	85.6389
2029	84.0889
2030	82.5388

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 high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Sub-Saharan Africa has the largest burden of teenage pregnancies in the world followed by South Asia and Latin America and the Caribbean. Poverty, lack of SRH information, lower educational level, social norms, refusal to use of contraceptive methods, substance abuse and poor parental guidance are among the leading causes of pregnancy among teenagers. Teenagers have a greater risk of experiencing adverse pregnancy outcomes such as maternal and perinatal deaths, hypertensive disorders, antepartum hemorrhage, anemia, preterm labor and low birth weight. As revealed by the World Bank, adolescent fertility in Sub-Saharan Africa has been declining over the previous decades from 154 births per 1000 women aged 15-19 in 1960 to 98 births per 1000 women aged 15-19 in 2020. This decline in adolescent fertility is attributed to increase in use of contraceptive methods, improvement in girl child educational level and awareness among communities. This study proposes Holt's double exponential smoothing technique to forecast adolescent fertility for Sub-Saharan Africa. Research findings indicate that adolescent fertility will continue to drop but will remain very high throughout the out of sample period. Therefore, we encourage governments in Sub-Saharan Africa to continuously enforce laws that protect sexual and reproductive rights of women and girls, support girl child education, fund empowerment projects for youths and increase awareness campaigns among communities.

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