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Estimating Future Trends of Adolescent Fertility for Ethiopia Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Ethiopia 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 0.2 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage authorities in Ethiopia to attend to the various socio-economic, cultural, geographic and political factors that drive high adolescent birth rates in the country.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adolescent pregnancy is a global public health problem that affects both developed and developing countries (Klein, 2005). Approximately 25% of adolescent women get pregnant worldwide (Kassa *et al.*2018;Kaphagawani&Kalipeni, 2017). The prevalence of adolescent pregnancy in Sub-Saharan Africa is 19.3 % and 21.5% in eastern Africa (Kassa *et al.* 2018). Worldwide approximately 3.9 million adolescents experience unsafe abortions, which contribute to high maternal mortality and morbidity (Darroch*et al.* 2016;Frankli*et al.* 2000). Adverse maternal and child health outcomes are frequently as a result of teen pregnancy (Ochen *et al.* 2019; Ayele *et al.* 2018; Odimegwu *et al.* 2016; WHO, 2016; Neal *et al.* 2012). In addition, teen pregnancies usually occur in poor populations which are characterized by poverty, lack of education, and employment opportunities (UNICEF, 2014). Adolescents are usually exposed to unwanted pregnancy, casual sexual practices; rape; childbearing at an early age, high-risk abortion, HIV/AIDS and other STIs (UNICEF, 2011; UNICEF, 2008). In sub-Saharan Africa, the magnitude of teenage pregnancy accounts for 28%; which is higher compared with the world average of 6.5% (UNFP, 2013). Many adolescents lack adequate SRH knowledge and end up getting pregnant and experiencing adverse SRH outcomes (WHO, 2011).As reported by the Ethiopian Demographic and Health Survey (EDHS) 2016, 13% of women aged 10–19 years have begun childbearing before age 18years.The proportion of women aged 10– 19 years who have begun childbearing rises rapidly with age, from 2% among women at age of 15 years to 28% among those aged 19 years. Teenage childbearing is more common in rural than in urban areas. Many previous studies revealed that being sexually active at an early age, early marriage, older teenage, married women, educational attainment, age at 1st sex, household wealth, family structure, exposure to media, community poverty level, and contraceptive use are significantly associated with adolescent pregnancy (Birhanu *et al.* 2019;Okigbo&Speizer, 2015). This study uses Holt's double exponential smoothing technique to forecast future trends of adolescent fertility in Ethiopia in the out of sample period. The findings of the study are expected to depict the future burden of adolescent births in the country. This will guide policy making, planning and allocation of resources to the SRH program in the country in order to control teenage pregnancies and child marriages.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Ethiopia. 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 is specified as follows:

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Model equation

$E_t = \mu_t + \rho_t \mathbf{t} + \varepsilon_t$

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

Forecasting equation

$f_{t+h} = L_t + \mathrm{h} b_t$

E_t is the actual value of 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 trend estimate at time t

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

Data Issues

This study is based on annual adolescent fertility rate in Ethiopia 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	E
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900

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Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.096606
Sum Square Error (SSE)	355.126243
Mean Square Error (MSE)	5.821742
Mean Percentage Error (MPE)	-0.068381
Mean Absolute Percentage Error (MAPE)	1.024046

Residual Analysis for the Applied Model

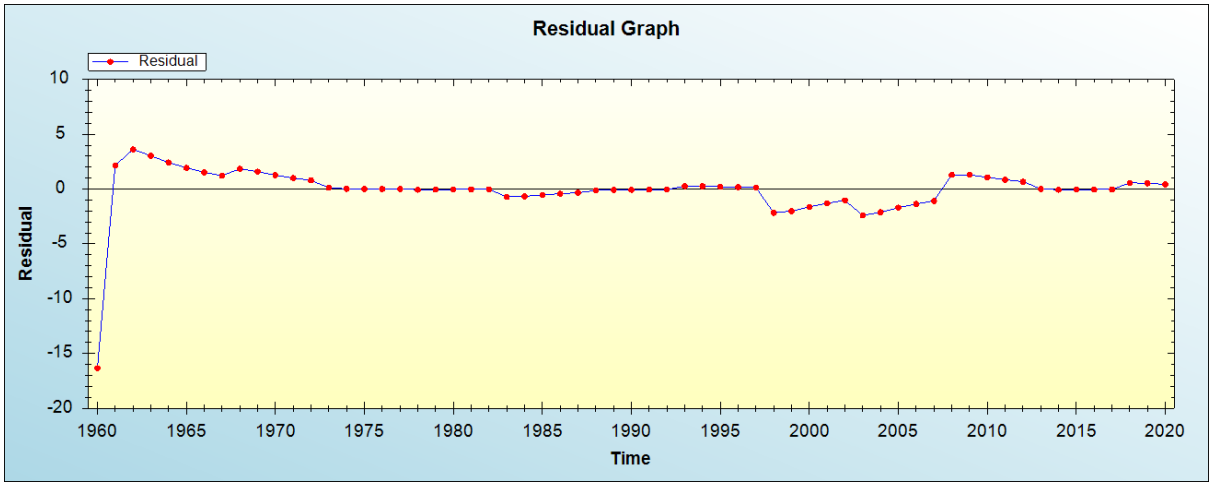

Figure 1: Residual analysis

In-sample Forecast for E

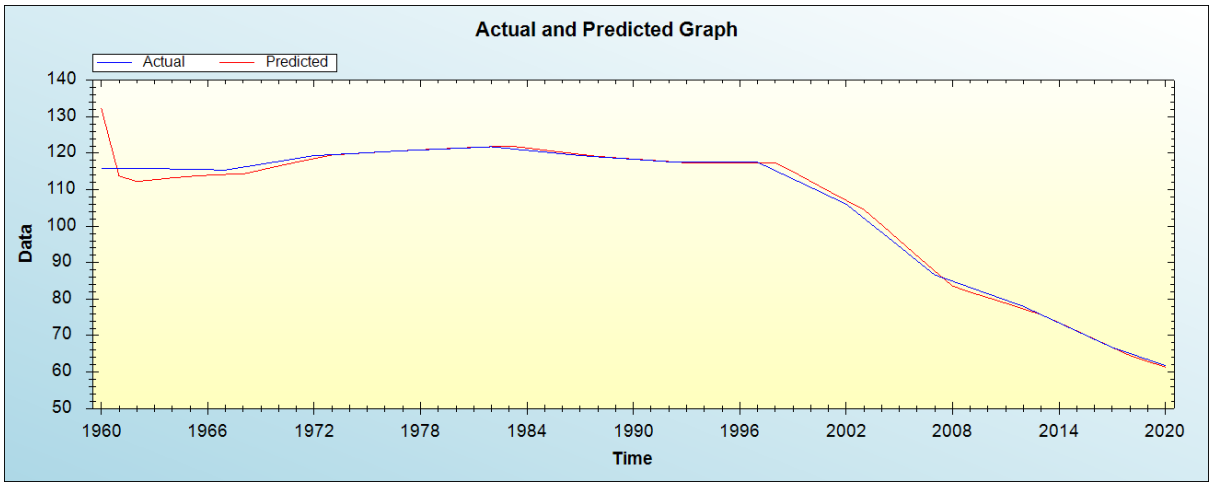

Figure 2: In-sample forecast for the E series

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Actual and Smoothed graph for E series

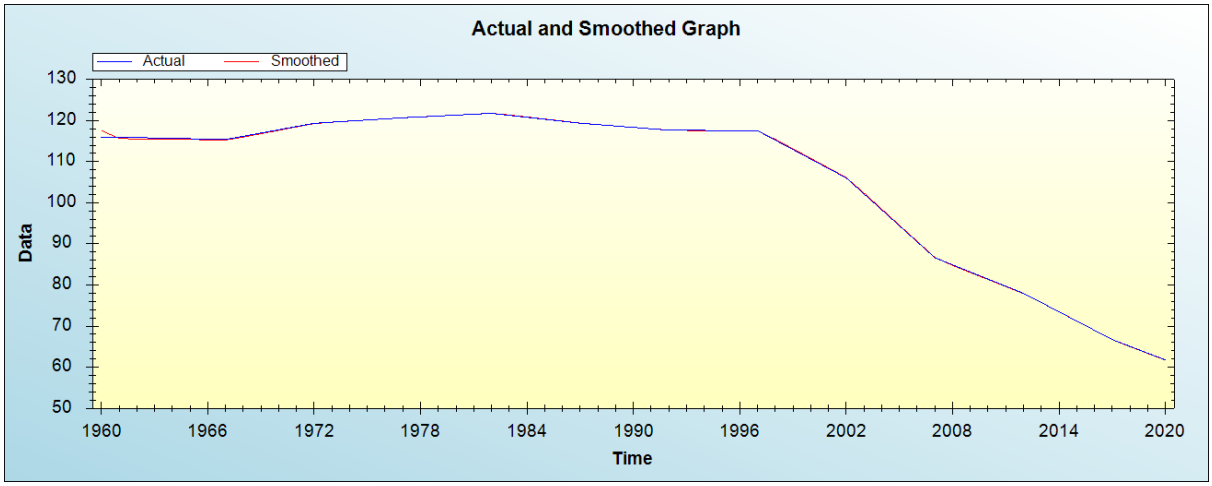

Figure 3: Actual and smoothed graph for E series

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

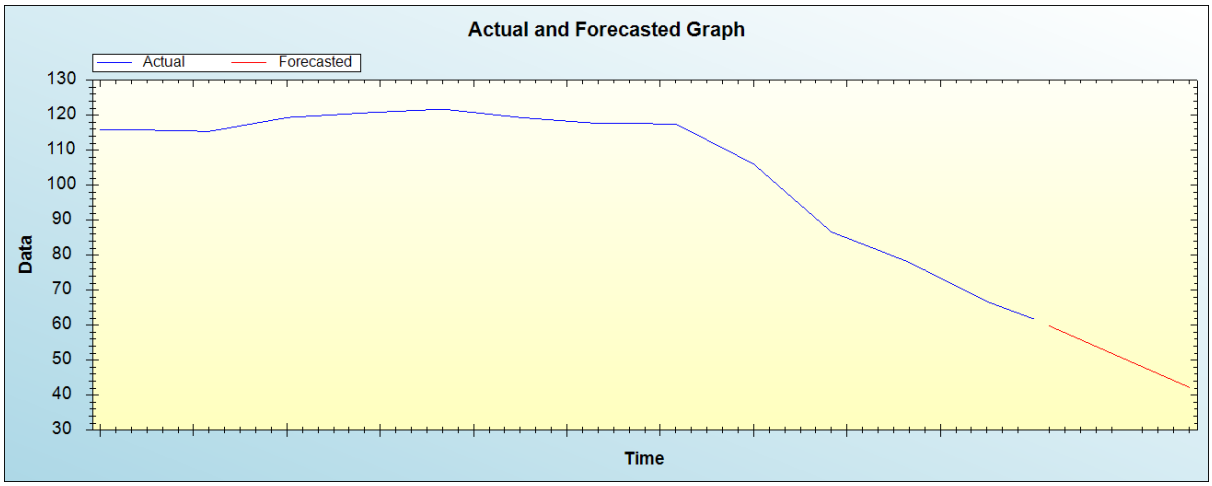

Figure 4: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	59.7752
2022	57.8231
2023	55.8710
2024	53.9188
2025	51.9667
2026	50.0146
2027	48.0624
2028	46.1103
2029	44.1582
2030	42.2061

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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 adolescent fertility rate will continue to decline throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Adolescent pregnancy is a global public health problem that affects both developed and developing countries. Teen pregnancies usually occur in poor populations which are characterized by poverty, lack of education, and employment opportunities. Being sexually active at an early age, early marriage, older teenage, married women, educational attainment, age at 1st sex, household wealth, family structure, exposure to media, community poverty level, and contraceptive use are significantly associated with adolescent pregnancy. During the period 1997-2020 adolescent fertility declined gradually to levels around 60 births per 1000 women aged 15-19 years partly as a result of family planning services. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Ethiopia. We established that adolescent fertility will continue to drop throughout the out of sample period. Therefore, we encourage the government to attend to the various socio-economic, cultural, geographic and political factors that drive high adolescent birth rates in the country.

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