Assessing the Feasibility of Achieving Substantial Reduction of Adolescent Fertility for Uganda Using Holt's Linear Method

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Abstract - **This research article uses annual time series data of adolescent fertility rate for Uganda 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 decline but still remain high throughout the out of sample period. Therefore, we encourage authorities in Uganda to strictly enforce laws that safeguard sexual and reproductive health rights of women and girls, support girl child education, scale up campaigns against sexual abuse of women and girls, and provide affordable and accessible adolescent health services.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The negative health consequences of teenage pregnancy can affect both the mother and the baby (Atuyambe *et al.* 2008; Khalil, 2006). Teenage pregnancy is associated with adverse SRH outcomes such as higher rates of maternal, neonatal and infant mortality. According to the World Health Organization (WHO), teenage pregnancy and subsequent child birth at an early age accounts for 23% of the global burden of ill health as identified through disability adjusted life years. Teenage pregnancy in Uganda is a public health issue of paramount importance due to the country's low social economic status and population structure. Fifty two percent of the population is below 18 years of age and approximately 25 percent of teenage girls become pregnant before 18 years of age, a proportion that ranks Uganda higher than the other East African countries (UNFPA, 2021; Neal *et al.* 2015). According to UNFPA fact sheet on teenage pregnancy in Uganda, the number of teenage pregnancies increased by 6.4% between 2017 and 2018, then reduced by 2.1% from 2018 to 2019 and then by about 0.9% between 2019 and 2020. Although there was no marked increase in teenage pregnancy between 2019 and 2020, however it is important to highlight that there was marked increase in teenage pregnancy within districts in 2020. The COVID-19 pandemic led to an upsurge of teenage pregnancies with 67 districts registering an increase in teenage pregnancies from 2019 to 2020 (UNFPA, 2021).Literature shows that adolescent girls living in the rural areas are highly affected by poverty, which then increases the disparities that exist between social classes. The school dropout rate for girls is higher than that of boys and this is attributed to teenage pregnancy (Perper *et al.* 2010; Sekiwunga *et al.* 2009). According to Uganda's Demographic and Health Survey teenage pregnancy rates rose from 2006 to 2011 but there was regional variation. Marriage was the most significant factor associated with teenage pregnancy in both 2006 and 2011 which tallies with findings reported by several studies conducted in Uganda (Ochen *et al.* 2019; Rutaremwa, 2013).

The Ugandan government has national strategies to combat child marriage and other forms of sexual violence against women. The Constitution prohibits marriage of adolescent girls aged below 18 years of age. Furthermore, Uganda has laws and policies on rape, defilement and other forms of sexual violence; however, there is inadequate enforcement of these laws. The Penal Code Act (2007) for instance, criminalizes sex with girls below 18 years as a capital offense which is punishable by death sentence. Most importantly, there is a National strategy on Ending Child Marriage and Teenage Pregnancy (UNICEF, 2019), however the implementation part is a challenge that needs urgent attention from the highest office in the land. This strategy is line with sustainable development goal number five which seeks to advance gender equality and empowerment. It was designed to improve the policy and legal environment to protect teenagers, improve access to sexual reproductive health services, changing sociocultural norms which increase risky behaviors among the communities and empowering boys and girls with information for the purpose of ending child marriage and teenage pregnancy. If this strategy is implemented adequately the country will progress significantly towards achieving the set targets under the 3rd sustainable development goal of reducing maternal deaths to less than

70 deaths per 100 000 live births and under five mortality to as low as 25 deaths per 1000 live births(UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 1995).

In line with Uganda's National strategy on ending child marriage and teenage pregnancy, this paper utilizes Holt's double exponential smoothing technique to forecast future trends of adolescent (15-19yrs) fertility over the out of sample period. The findings are expected to trigger an urgent review of current policies and laws with the aim of curbing child marriage, teen pregnancy, and protecting sexual and reproductive rights of adolescent girls. This in turn will have a significant impact on the reduction of adverse maternal and child health outcomes in the country.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Uganda. 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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

U_t is the actual 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**

$\mathbf{t}$ 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 t-1

Data Issues

This study is based on annual adolescent fertility rate in Uganda 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	U
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.113676
Sum Square Error (SSE)	381.324872
Mean Square Error (MSE)	6.251227
Mean Percentage Error (MPE)	-0.107955
Mean Absolute Percentage Error (MAPE)	0.671914

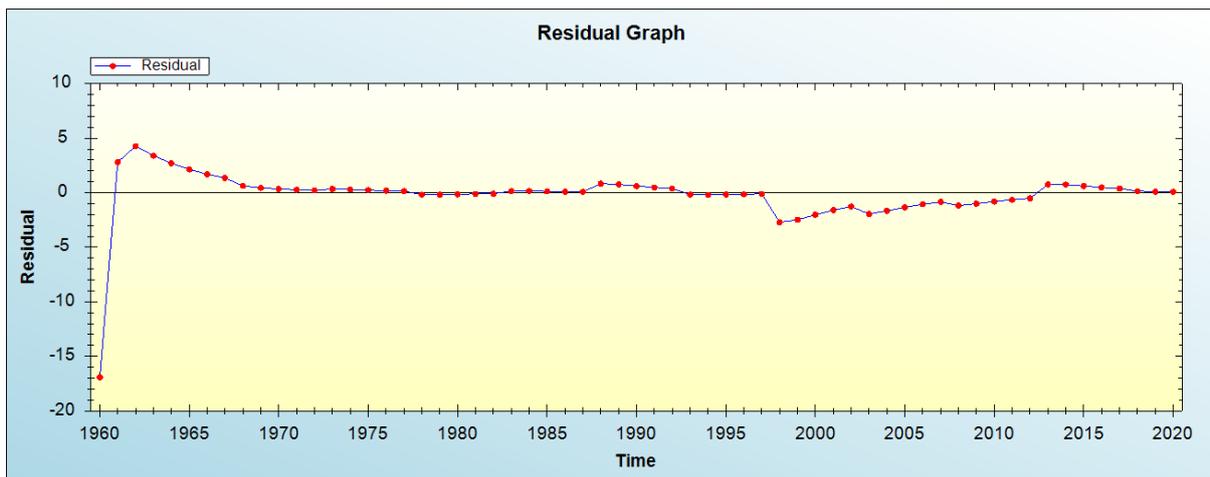Residual Analysis for the Applied Model

Figure 1: Residual analysis
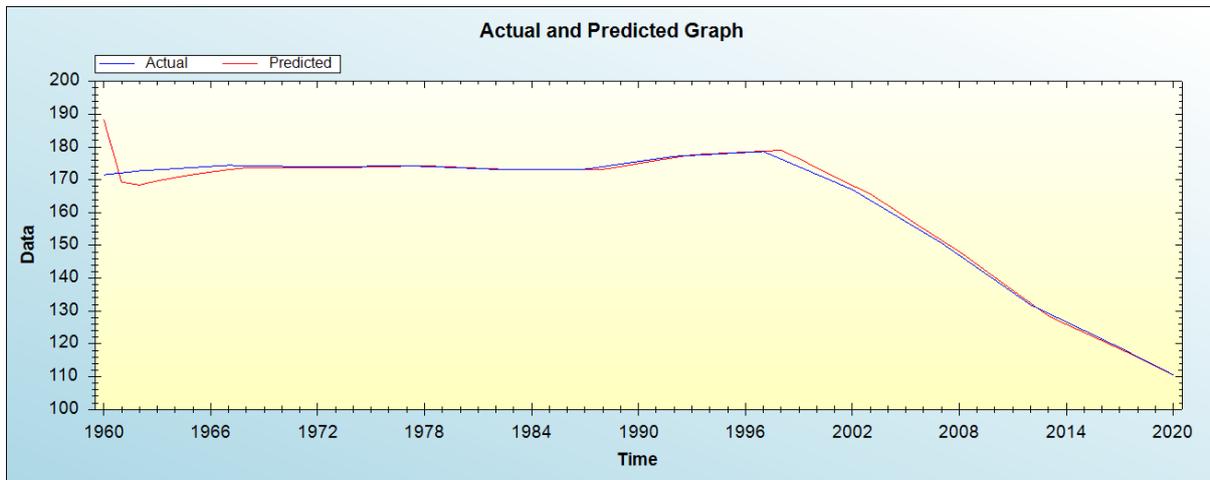
In-sample Forecast for U

Figure 2: In-sample forecast for the U series

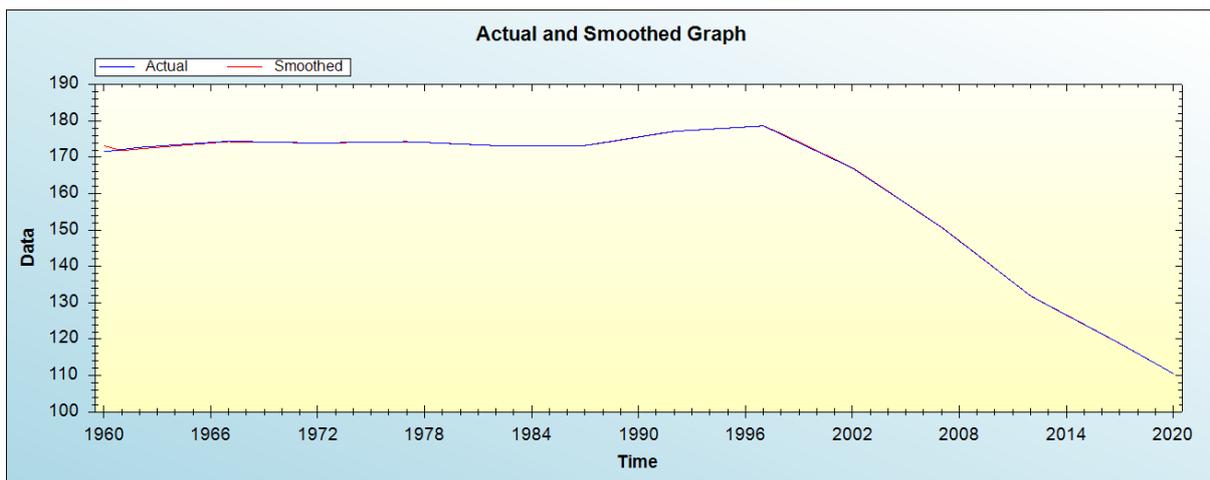Actual and Smoothed graph for U series

Figure 3: Actual and smoothed graph for U series

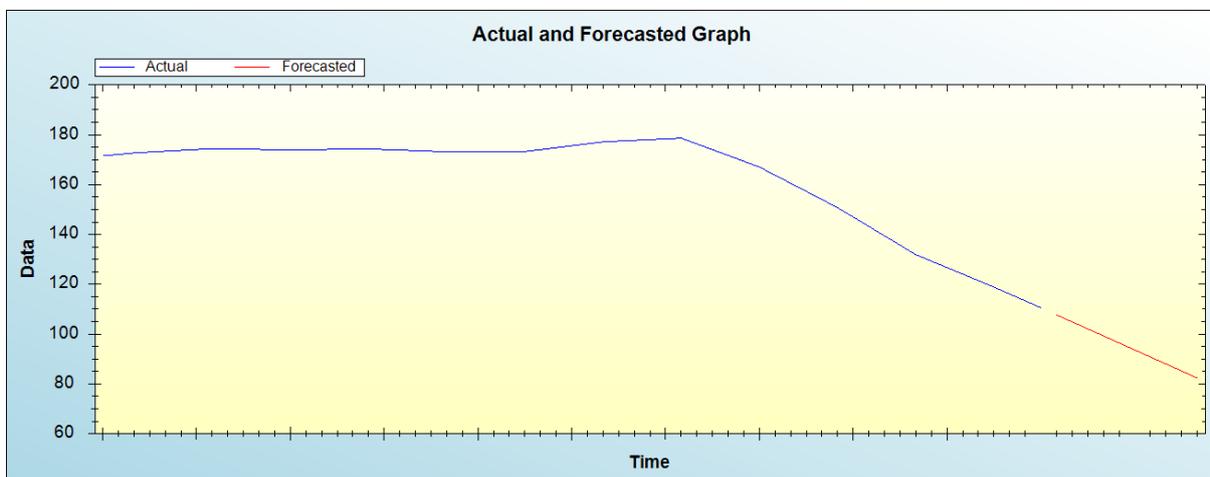Out-of-Sample Forecast for U: Actual and Forecasted Graph

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

Out-of-Sample Forecast for U: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	107.7154
2022	104.8964
2023	102.0774
2024	99.2585
2025	96.4395
2026	93.6205
2027	90.8016
2028	87.9826
2029	85.1636
2030	82.3447

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 will continue to decline but still remain high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Low and middle income countries like Uganda are currently facing numerous challenges such as poverty, hunger, political conflict and high unemployment rates. All these problems increase the risk of falling pregnant among teenagers. In addition, inadequate SRH information, low educational level, poor parental guidance, peer pressure and adherence to social norms are well documented risk factors for adolescent pregnancy. The country has made some progress in the reduction of adolescent fertility as evidenced by the gradual decline of adolescent fertility over the past decades. This study employed Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Uganda. Study findings suggested that adolescent fertility will continue to drop but will remain high throughout the out of sample period. Therefore, we encourage the Ugandan government to strictly enforce laws that safeguard sexual and reproductive health rights of women and girls, support girl child education, scale up campaigns against sexual abuse of women and girls, and provide affordable and accessible adolescent health services.

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