

Adolescent Fertility Forecasting for South Sudan Using Holt's Linear Method

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Abstract - This research paper uses annual time series data of adolescent fertility rate for South Sudan 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 rate will continue on a downward path to levels below 25 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage authorities in South Sudan to strictly enforce laws that safeguard sexual and reproductive rights of women and girls, promote girl child education and avail funding for youth empowerment programs.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

According to the World Health Organization (WHO), an adolescent is an individual aged 10-19 years. Adolescent pregnancy is a huge public health problem especially in low-middle income countries (UN, 2020). This challenge needs a collaborative approach in order to substantially reduce child marriage and its associated health, educational, economic and societal negative consequences. As stated in the programme of action of the 1994 International Conference on Population and development, advancing gender equality and women empowerment remains one of the top priorities in this era of sustainable development goals (SDGs) (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018, UN, 2016. UN, 2015; UN, 1995). Ending harmful practices and ending forced child marriages is key in addressing teenage pregnancy and its associated adverse sexual and reproductive health outcomes. Approximately 12 million girls aged 15– 19 years and at least 777,000 girls aged under 15 years give birth each year in developing countries (WHO, 2020). Globally, babies born to adolescent girls constitute about 11% of all births, and 95% of these are found in developing countries (Kassa *et al.* 2018). In Sub-Saharan Africa, the prevalence of adolescent pregnancy is 18.8% with the East African sub-region reporting a higher prevalence (21.5%) and North Africa recording the lowest prevalence of 9.2% (Kassa *et al.* 2018) According to the national family planning policy of South Sudan, 'by the age of 19, one out of three girls is already married or in union; and the same proportion has already started childbearing' (MOH, 2012). There are many factors which contribute to high teenage pregnancy in South Sudan and these include the need for dowries, gender based violence, respect for tradition and norms of marriage, lack of parental guidance and support. Furthermore, poor implementation or inadequate adolescent policies, weak laws prohibiting forced marriage, widespread illiteracy among adolescent girls, lack of job opportunities, poor skills, poverty and hunger (Kane *et al.* 2019; Vincent & Alemu, 2016). Several previous studies have shown that adolescent childbearing is associated with higher maternal mortality and morbidity and adverse child outcomes including a higher prevalence of low birth weight and higher perinatal and neonatal mortality as compared to older women (Kassa *et al.* 2019). Adolescent early initiation into childbearing lengthens the reproductive period and subsequently increases a woman's lifetime fertility rate, contributing to rapid population growth (Nibaruta *et al.* 2021; Palamuleni, 2017; Islam, 1999).

This paper applies Holt's double exponential smoothing model to forecast future trends of adolescent fertility in South Sudan. The findings are expected to depict future trends of adolescent fertility in the out of sample period. This will assist policy makers to review current policies and legal instruments to effectively address the problem of child marriage and protect sexual and reproductive health rights of women.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in South Sudan. 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 Represents 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 slope of the trend (Trend estimate) at time t-1

Data Issues

This study is based on annual adolescent fertility rate in South Sudan 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	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.350233
Sum Square Error (SSE)	671.315572
Mean Square Error (MSE)	11.005173
Mean Percentage Error (MPE)	-0.095279
Mean Absolute Percentage Error (MAPE)	1.065154

Residual Analysis for the Applied Model

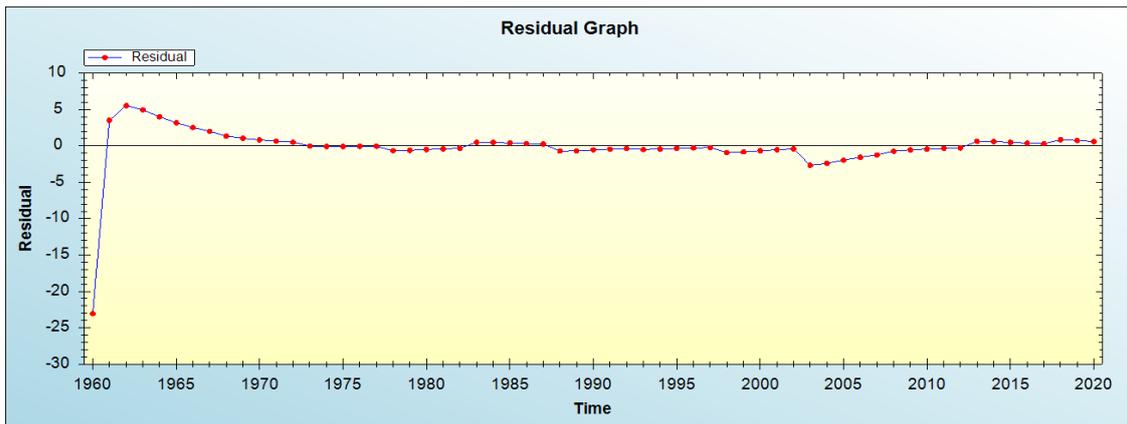


Figure 1: Residual analysis

In-sample Forecast for G

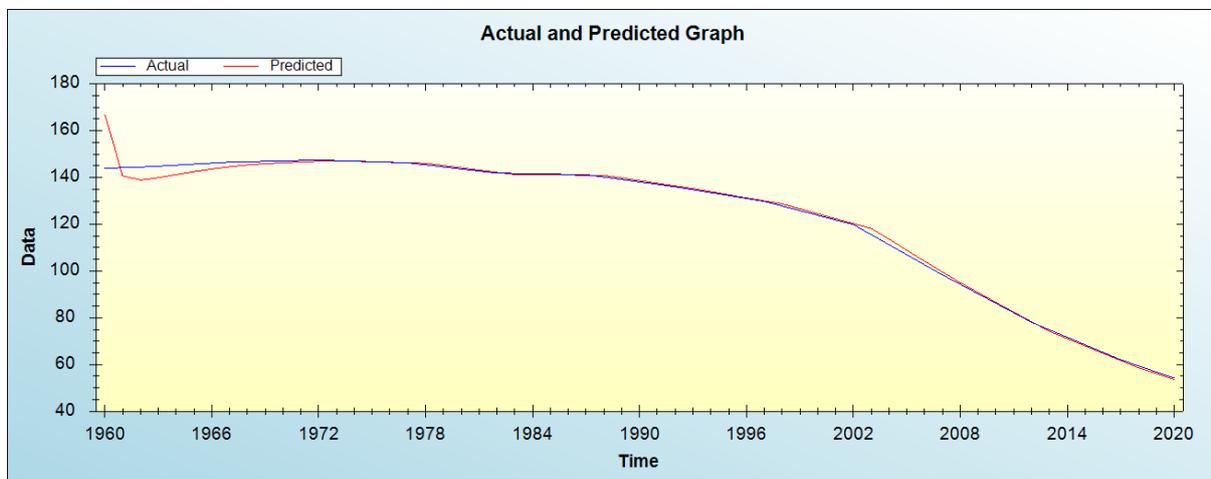


Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

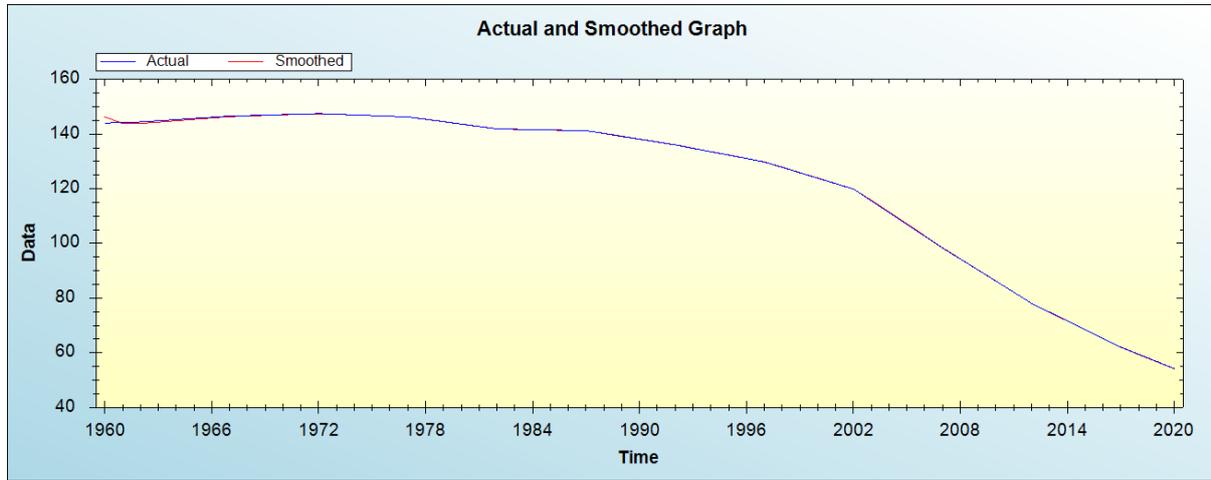


Figure 3: Actual and smoothed graph for G series

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

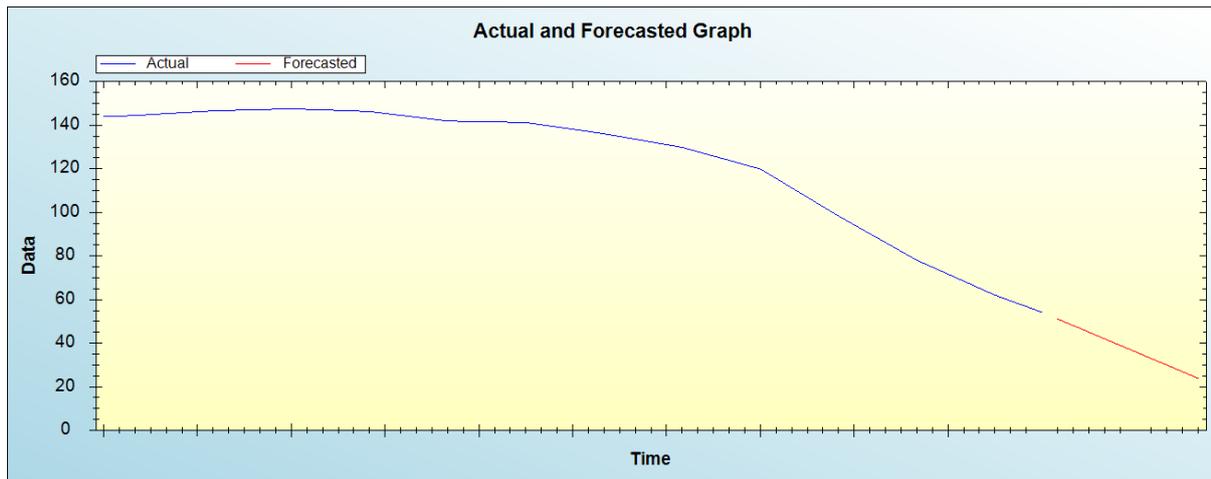


Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	51.1306
2022	48.1022
2023	45.0737
2024	42.0453
2025	39.0169
2026	35.9884
2027	32.9600
2028	29.9316
2029	26.9031
2030	23.8747

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 drop down to levels below 25 births per 1000 women aged 15-19 years by the end of 2030.

IV. POLICY IMPLICATION & CONCLUSION

Adolescent pregnancy is a huge public health challenge in many African countries. Addressing challenges faced by adolescents will help to reduce teenage conception and associated adverse pregnancy outcomes. In South Sudan teenage pregnancy can occur as result of the need for dowries, gender based violence, respect for tradition and norms of marriage, lack of parental guidance and support. In addition, poor implementation or inadequate adolescent policies, weak laws prohibiting forced marriage, widespread illiteracy among adolescent girls, lack of job opportunities, poor skills, poverty and hunger are well documented risk factors for teenage pregnancy. This study applies Holt's double exponential smoothing technique to forecast future trends of adolescent fertility in South Sudan. The results of this study indicate that adolescent fertility will continue to drop down to levels below 25 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage the South Sudanese government to strictly enforce laws that safeguard sexual and reproductive rights of women and girls, promote girl child education and avail funding for youth empowerment programs.

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