International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 2, pp 147-152, February-2023

https://doi.org/10.47001/IRJIET/2023.702023

Adolescent Fertility Forecasting for Kenya Using the Double Exponential Smoothing Technique

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***Abstract* -This study employs annual time series data of adolescent fertility rate for Kenya 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 rate will continue to decline throughout the out of sample period. Therefore, we encourage authorities in Kenya to scale up awareness campaigns among communities, promote girl child education and allocate funding towards youth empowerment projects to improve their labor participation.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The success of maternal and child health programs in developing and developed countries is highly dependent on government commitment and availability of resources. The call made by all 193UN member countries at the United Nations Headquarters in September 2015was for member countries to prioritize sexual and reproductive health (SRH) services. SRH is a key factor in addressing maternal morbidity and mortality. In addition, the 1994 International Conference on Population and development supported the idea of addressing gender imbalance and upholding of women's rights (UN, 1995). The Agenda 2030 for sustainable development document highlighted the importance of addressing adolescent sexual and reproductive health in light of high teenage pregnancy rates in developing countries. Furthermore, there is need to eliminate harmful practices that lead to forced child marriage and sexual abuse of women (WHO, 2019; UN, 2016; UN, 2015). Teenage conception has serious negative consequences on health and can result in premature loss of life. Complications that can rise include hypertensive disorders, anemia, premature delivery and low birth weight (Grønvik & Fossgard, 2018; Banke-Thomas *et al.* 2017; WHO, 2017; Neal *et al.* 2016; Pradhan *et al.* 2015; Kost & Lindberg, 2015; WHO, 2007). In Kenya, adolescent fertility rate has been falling gradually from 168 live births in 1977/78 to 96 live births in 2014 with the rate remaining high (Kenya DHS 2014; UN, 2013).Adolescent fertility rate in Kenya increases as adolescents advance in an age such that 3 percent of adolescents had given birth by their 15th birthday while 40 percent of the adolescent had given birth by their 19th birthday (Kenya DHS 2014). It has been revealed that in Kenya about 11 percent of adolescent girls had given birth before 20 years of age (UN, 2019).Previous studies in Kenya have revealed key factors associated with adolescent fertility such as current age, type of place of residence, education level, religion, contraceptive usage, and wealth index (Monari *et al.* 2022; Mutea *et al.* 2022; Olenja *et al.* 2019).

The objective of this paper is to model and project future trends of adolescent fertility in Kenya using the double exponential smoothing technique. The findings are expected to highlight the future burden of adolescent births in the out of sample period. This will inform 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 Kenya. 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:

<u>*Model equation*</u>

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

A_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 t-1

Data Issues

This study is based on annual adolescent fertility rate in Kenya 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	A
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100

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Forecast performance measures	
Mean Absolute Error (MAE)	1.773094
Sum Square Error (SSE)	620.753331
Mean Square Error (MSE)	10.176284
Mean Percentage Error (MPE)	0.103775
Mean Absolute Percentage Error (MAPE)	1.265956

Residual Analysis for the Applied Model

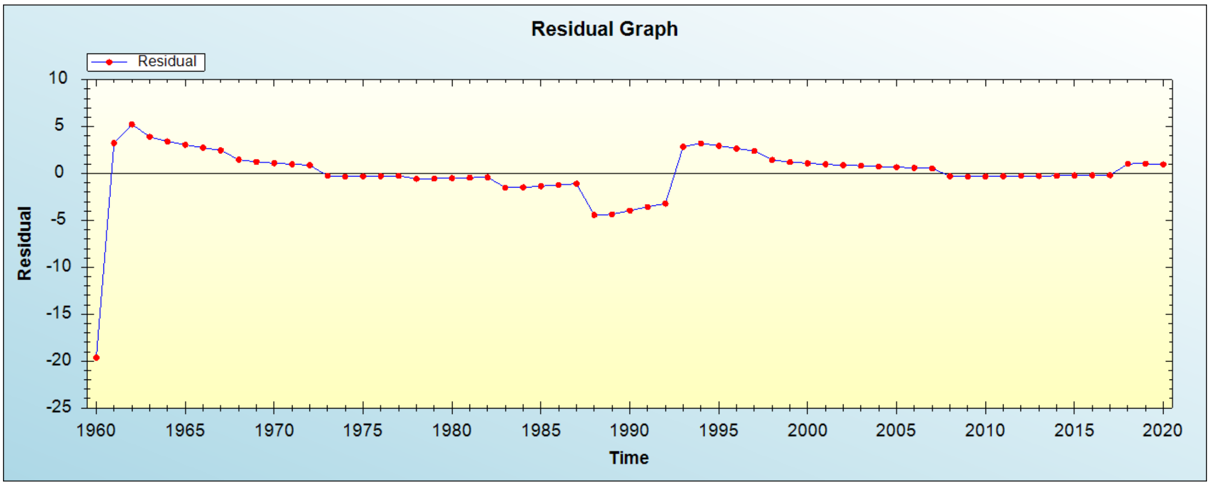

Figure 1: Residual analysis

In-sample Forecast for A

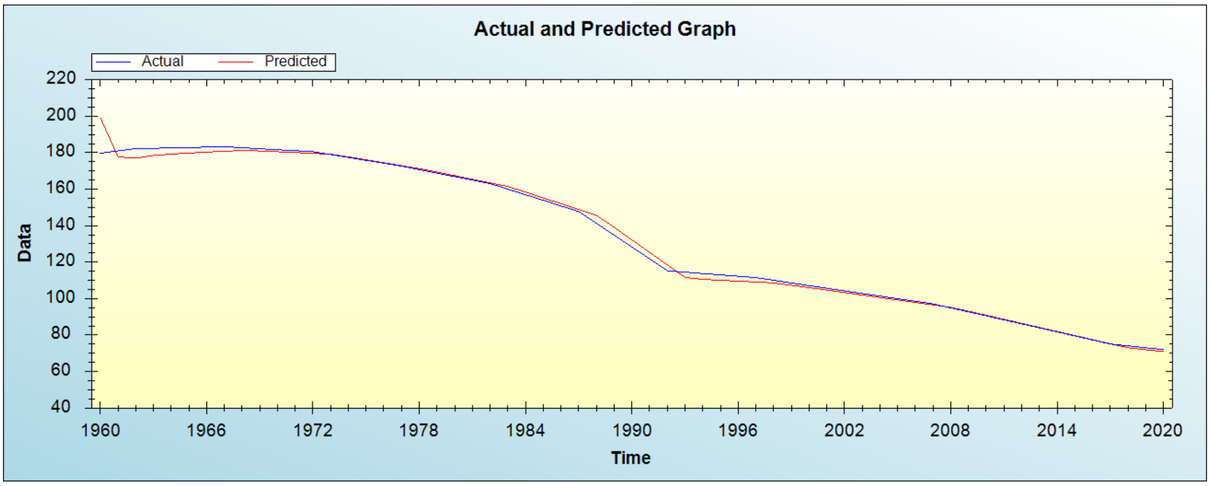

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

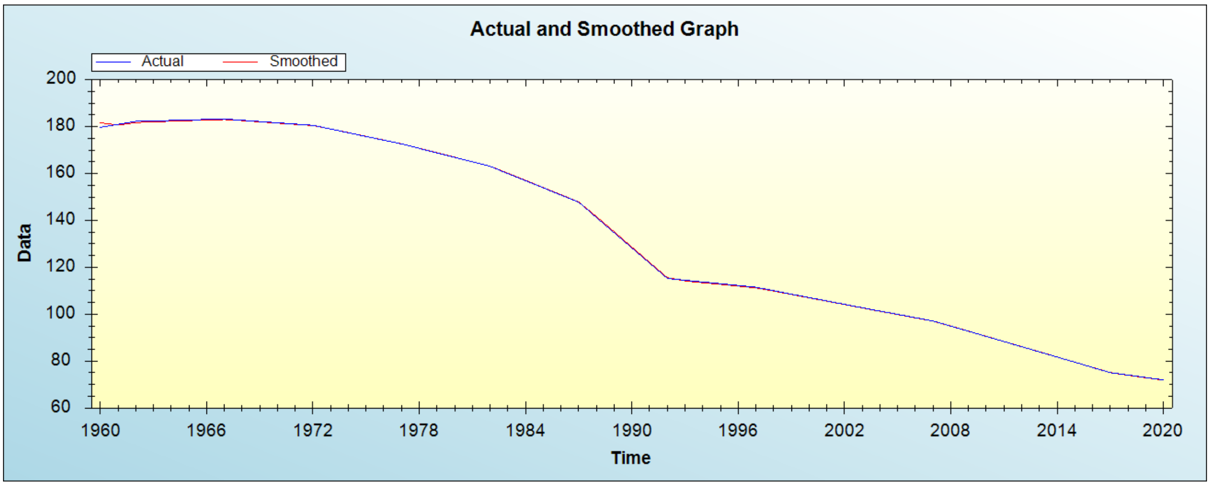

Figure 3: Actual and smoothed graph for A series

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

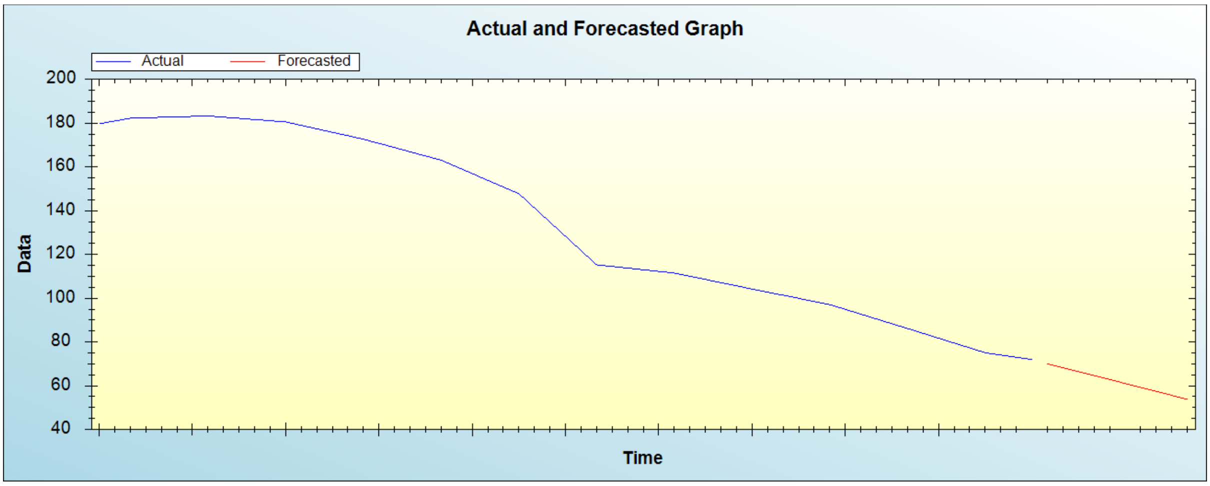

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	70.0726
2022	68.2657
2023	66.4589
2024	64.6520
2025	62.8452
2026	61.0383
2027	59.2315
2028	57.4246
2029	55.6178
2030	53.8109

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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

In Kenya, adolescent fertility rate has been falling gradually from 168 live births in 1977/78 to 96 live births in 2014 with the rate remaining high. Multiple factors have been identified as predictors of teenage pregnancy in Kenya such as current age, type of place of residence, education level, religion, contraceptive usage, and wealth index. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Kenya. Our study findings indicated that adolescent fertility will continue to drop throughout the out of sample period. Therefore, we encourage the Kenyan government to scale up awareness campaigns among communities, promote girl child education and allocate funding towards youth empowerment projects to improve their labor participation.

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Citation of this Article:

Smartson. P. NYONI, Thabani NYONI, "Adolescent Fertility Forecasting for Kenya Using the Double Exponential Smoothing Technique" Published in *International Research Journal of Innovations in Engineering and Technology* - *IRJIET*, Volume 7, Issue 2, pp 147-152, February 2023. Article DOI https://doi.org/10.47001/IRJIET/2022.702023

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