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

ISSN (online): 2581-3048

Volume 7, Issue 2, pp 269-273, February-2023

https://doi.org/10.47001/IRJIET/2023.702044

Forecasting Adolescent Fertility for Nigeria Using Holt's Linear Method

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Nigeria 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 fall but remain high throughout the out of sample period. Therefore, we encourage authorities in Nigeria to scale up educational campaigns, set up adolescent friendly clinics that are adequately resourced, promote girl child education and provide funds for youth empowerment projects.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The consequences of adolescent pregnancy are far reaching for the mother, baby and the society as whole (Envuladu *et al.* 2014; Atuyambe *et al.*2008; Uwaezuoke *et al.* 2004).Prevention and management of complications related to pregnancy and child birth is crucial in order to reduce morbidity and mortality among teenagers and their children. Annually about 21 million adolescent girls in low-and middle-income countries become pregnant (Mayor, 2004). Both the adolescent mother and her newborn baby have a higher risk of morbidity and mortality. The risk of health complications, such as pre-eclampsia for the mother and low birth weight for the neonate, is elevated in adolescent childbearing (Atuyambe *et al.* 2008). Previous studies conducted in Nigeria identified several factors that contribute to teenage pregnancy such as inadequate information on sexual and reproductive health (SRH), peer pressure, sexual assault and rape, social media influence, poverty, poor access to contraceptives and cultural factors such as early marriage, among others (Alabi *et al.* 2018; Ahmed *et al.* 2017; Ochiogu *et al.* 2011). In addition, pregnancy during the adolescent stage is associated with problems such as school dropouts, unsafe abortion, poverty, repeat teen pregnancies, exclusion from family and friends, and an increased tendency to be involved in criminal activities (Ayamolowo *et al.* 2019; Dare *et al.* 2016; Envuladu *et al.* 2014). Nigeria has made remarkable progress targeted at improving sexual and reproductive health, however teenage pregnancy remains a challenge due to several reasons such as unmet need for contraception, poor healthcare facilities, early childbearing, shortage of skilled health personnel, gender inequality and poor leadership (Akanbi *et al.* 2021).

In this paper we apply Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Nigeria. The findings of this research are expected to highlight the future burden of adolescent births and thus stimulate appropriate action to be taken to end child marriage and teenage pregnancy in the country.

II. METHODOLOGY

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

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

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Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

R_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 Nigeria 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	R
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	

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Mean Absolute Error (MAE)	1.057461
Sum Square Error (SSE)	324.265636
Mean Square Error (MSE)	5.315830
Mean Percentage Error (MPE)	-0.042289
Mean Absolute Percentage Error (MAPE)	0.670649

Residual Analysis for the Applied Model

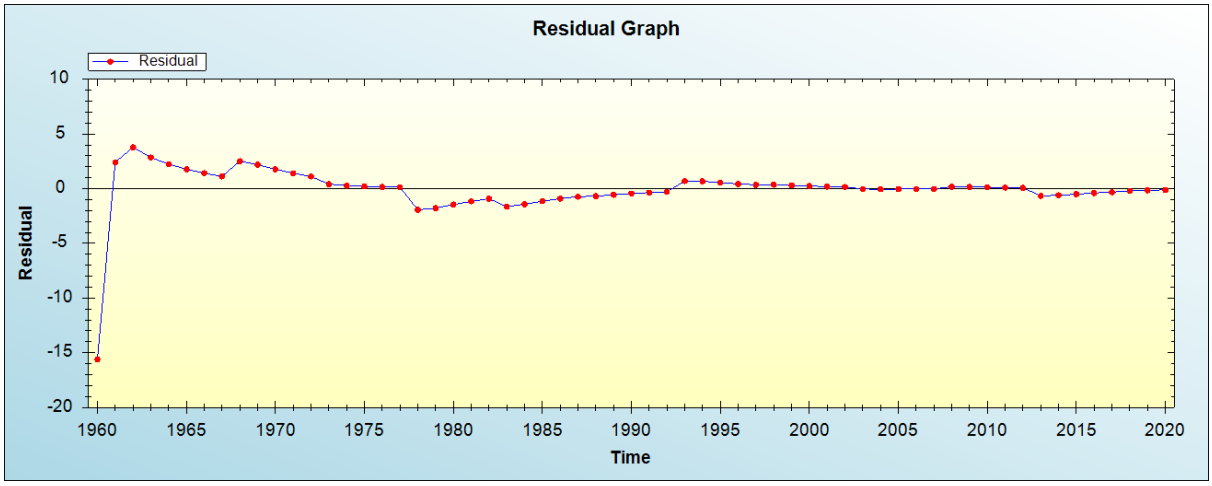

Figure 1: Residual analysis

In-sample Forecast for R

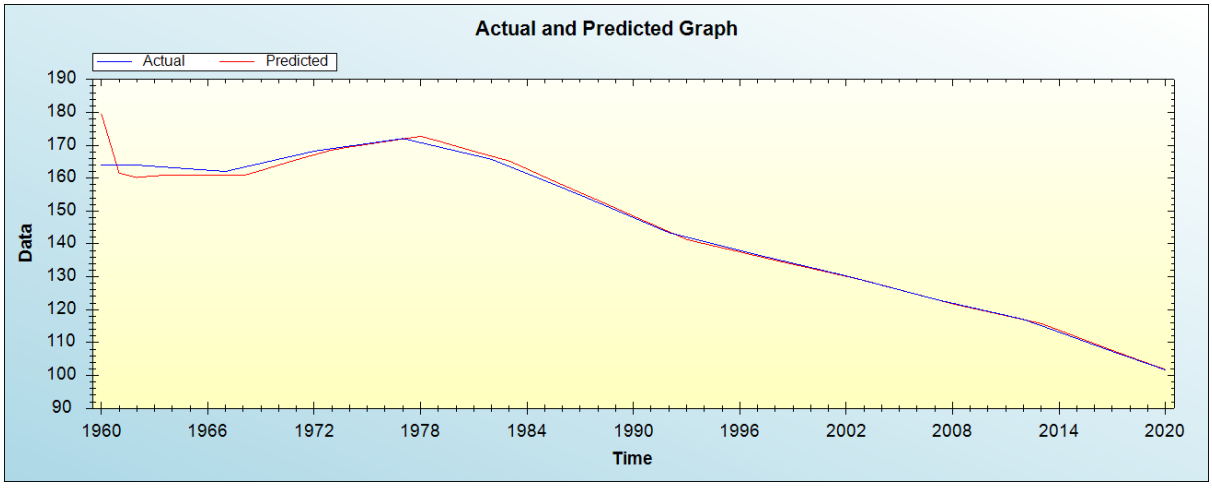

Figure 2: In-sample forecast for the R series

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Actual and Smoothed graph for R series

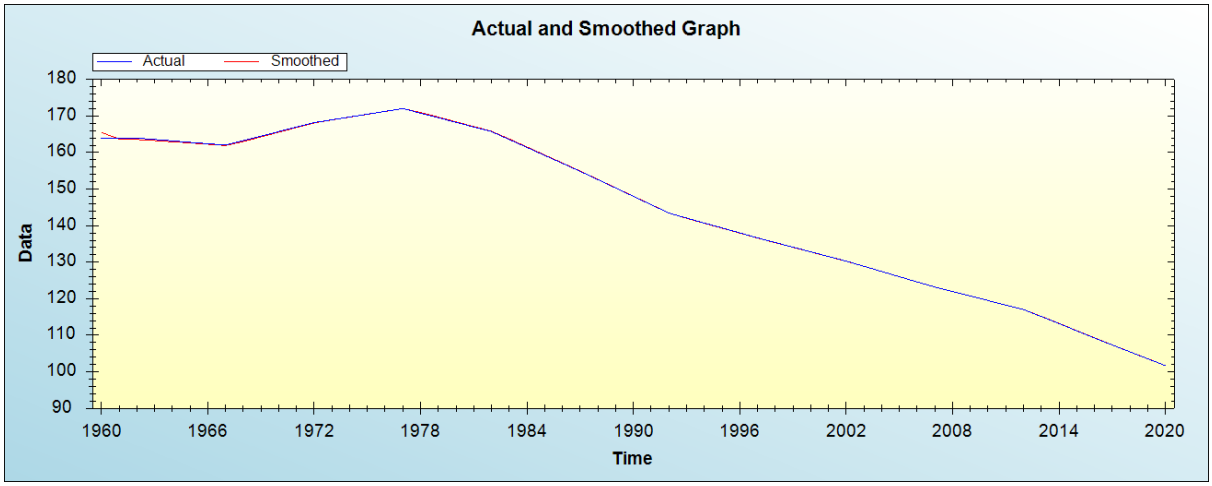

Figure 3: Actual and smoothed graph for R series

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

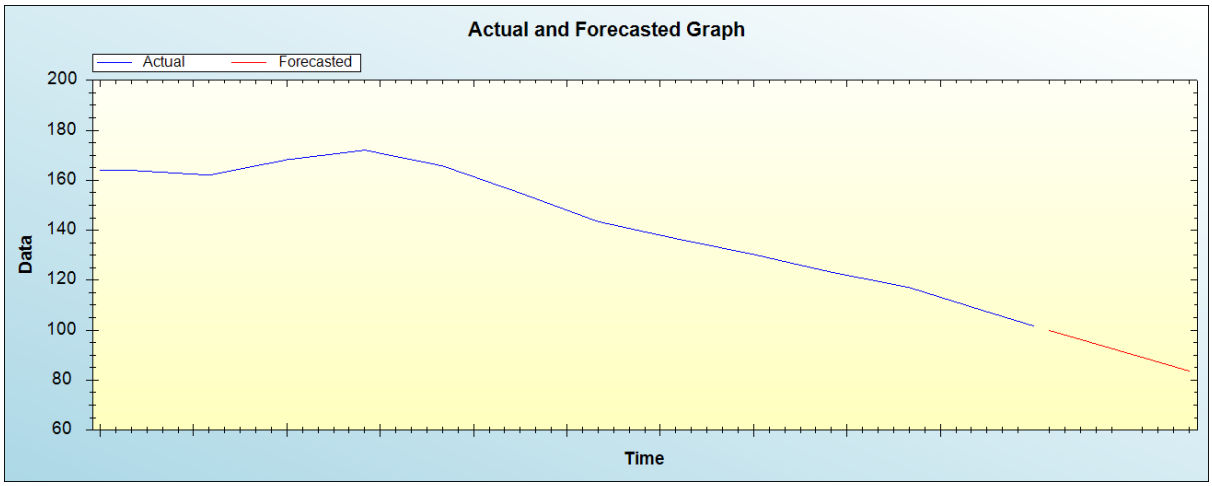

Figure 4: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	99.8860
2022	98.0800
2023	96.2739
2024	94.4679
2025	92.6618
2026	90.8558
2027	89.0497
2028	87.2437
2029	85.4376
2030	83.6316

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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 but remain high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Nigeria has made tremendous progress towards improving sexual and reproductive health including that of adolescents, however teenage pregnancy remains a complex challenge due to several reasons such as unmet need for contraception, poor healthcare facilities, early childbearing, shortage of skilled health personnel, gender inequality and poor leadership. As revealed by the World Bank, adolescent fertility declined gradually from164 to 102 births per 1000 women aged 15-19 years during the period 1960-2020. Among other factors, family planning services have significantly contributed to this fertility decline. This study applied Holt's double exponential smoothing technique to predict adolescent fertility for Nigeria. Our study findings showed that adolescent fertility will continue to decline but remain high throughout the out of sample period. Therefore, we encourage the Nigerian government to scale up educational campaigns, set up adolescent friendly clinics that are adequately resourced, promote girl child education and provide funds for youth empowerment projects.

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Citation of this Article:

Smartson. P. NYONI, Thabani NYONI, "Forecasting Adolescent Fertility for Nigeria Using Holt's Linear Method" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 2, pp 269-273, February 2023. Article DOI https://doi.org/10.47001/IRJIET/2022.702044

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