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Utilizing Holt's Double Exponential Smoothing Technique to Draft Effective Adolescent Health Policies to Address High Teenage Pregnancy Rates and Child Births in Niger

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Niger 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 decline but remain very high throughout the out of sample period. Therefore, we encourage authorities in Niger to strictly enforce laws that protect sexual and reproductive health rights of women and girls, promote girl child education, scale up awareness campaigns among communities and provide funding for youth empowerment projects.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

According to the World Health Organization (WHO), adolescent pregnancy is the occurrence of pregnancy among young women aged 15–19. It is a major public health problem which is associated with adverse maternal and child health outcomes. To improve on maternal and child health indicators, it is crucial to prevent pregnancy and child birth among teenagers. There is overwhelming evidence from previous studies that indicates a strong association between teenage pregnancy and adverse sexual and reproductive health outcomes (Kassa *et al*. 2018; Pradhan*et al.*2018; Mehra*et al.* 2018; Sama *et al.* 2017). The negative consequences of adolescent pregnancies to the mother and baby can be lifelong. These consequences could lead to intergenerational cycles of poverty, suboptimal health and development, poor education, and unemployment, resulting in low socio-economic status in adulthood (Mehra *et al.* 2018; Sama *et al.* 2017).Niger has the highest fertility rate in the world of 7.6 children per woman and a maternal mortality ratio of 590 deaths per 100,000live births (WHO, 2012). Adolescent pregnancy is a huge problem that needs immediate attention.The average age of first marriage is 15.7years and above 70% of adolescents are married by the age of 19. The adolescent birth rate in Niger is 207 per 1000 women ages 15–19years; and even among the youngest adolescents, 12.8% of girls have already given birth before the age of 15 (Neal *et al.* 2012; UN, 2011). In addition, a maternal death among adolescents represents 34% of all deaths in this group (INS *et al.*2013). There are several factors that are linked to pregnancy and childbirth among adolescents such as inadequate knowledge of contraceptives and partner dynamics which limit their individual ability to make decisions about preventing early pregnancy (Hindin *et al.* 2009; Williamson *et al.* 2009; Castle, 2003). Furthermore, social norms exert a huge influence over young couples' fertility choices (Cau, 2015; De Rose *et al.* 2010). Adolescents face numerous challenges in accessing sexual and reproductive health services within the formal health system, including bias of providers, stigma against contraceptive use, and lack of physical or financial access to health facilities (Chandra-Mouli*et al.* 2014; Ahanonu et al. 2014; Biddlecom et al. 2007;Mmari*et al.* 2003).

In this study we apply the double exponential smoothing technique to predict future trends of adolescent fertility in Niger. The findings are expected to highlight the future burden of adolescent births in the country. This will assist policy makers to review current laws and policies with the aim of addressing the problem of teenage pregnancy and girl child marriages.

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II. METHODOLOGY

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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

N_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 Niger 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.

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III. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	N
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.061038
Sum Square Error (SSE)	404.556253
Mean Square Error (MSE)	6.632070
Mean Percentage Error (MPE)	-0.106650
Mean Absolute Percentage Error (MAPE)	0.507187

Residual Analysis for the Applied Model

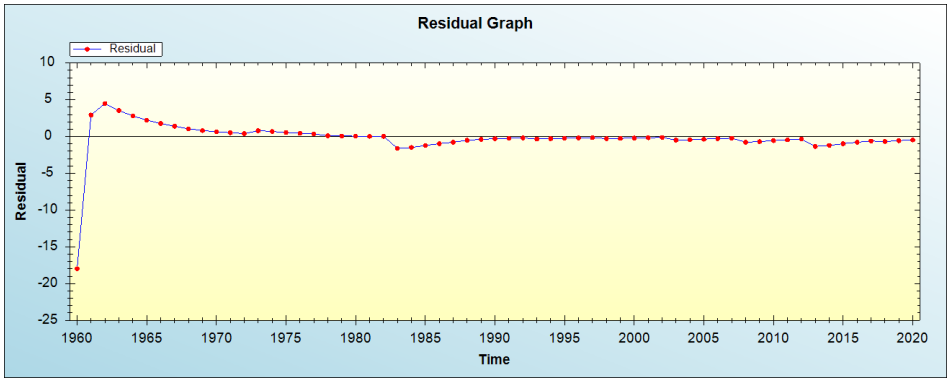

Figure 1: Residual analysis

In-sample Forecast for N

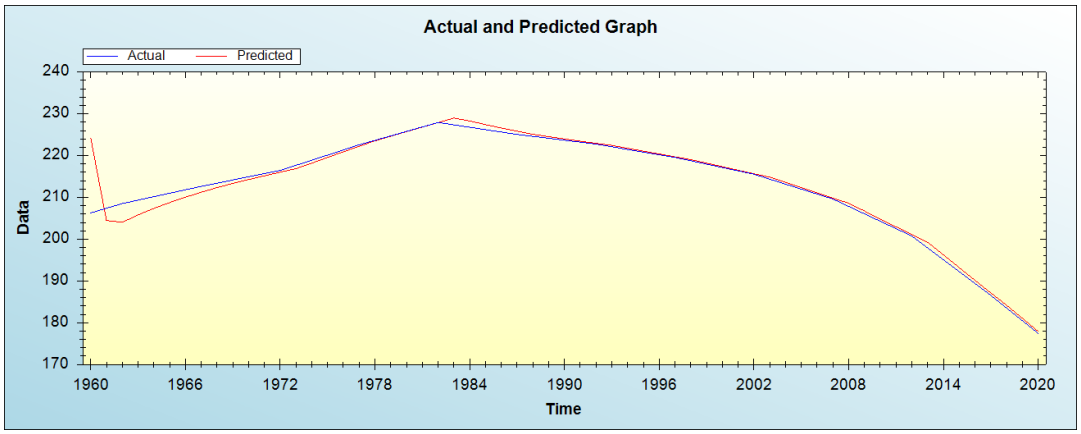

Figure 2: In-sample forecast for the N series

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Actual and Smoothed graph for N series

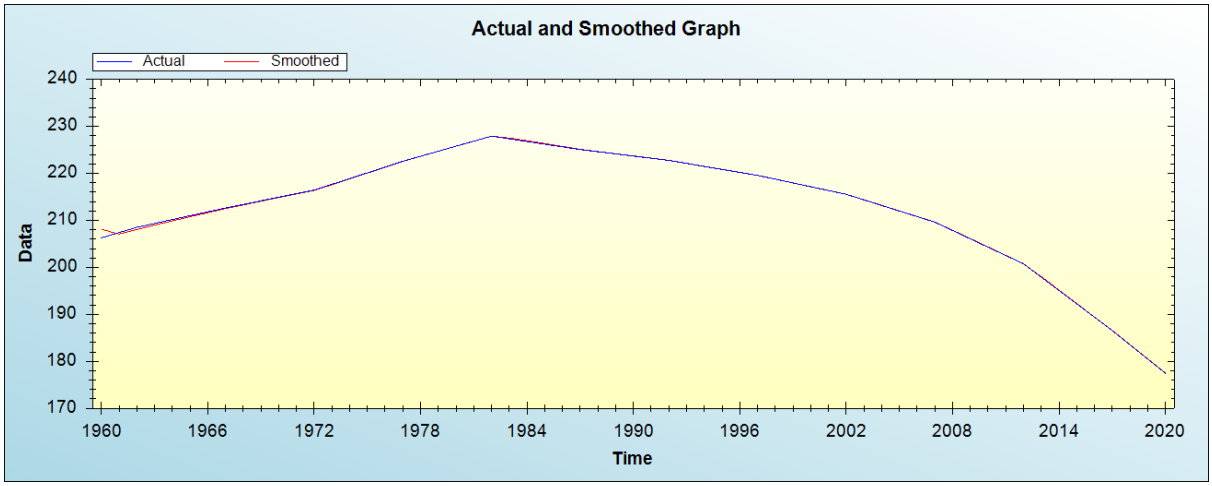

Figure 3: Actual and smoothed graph for N series

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

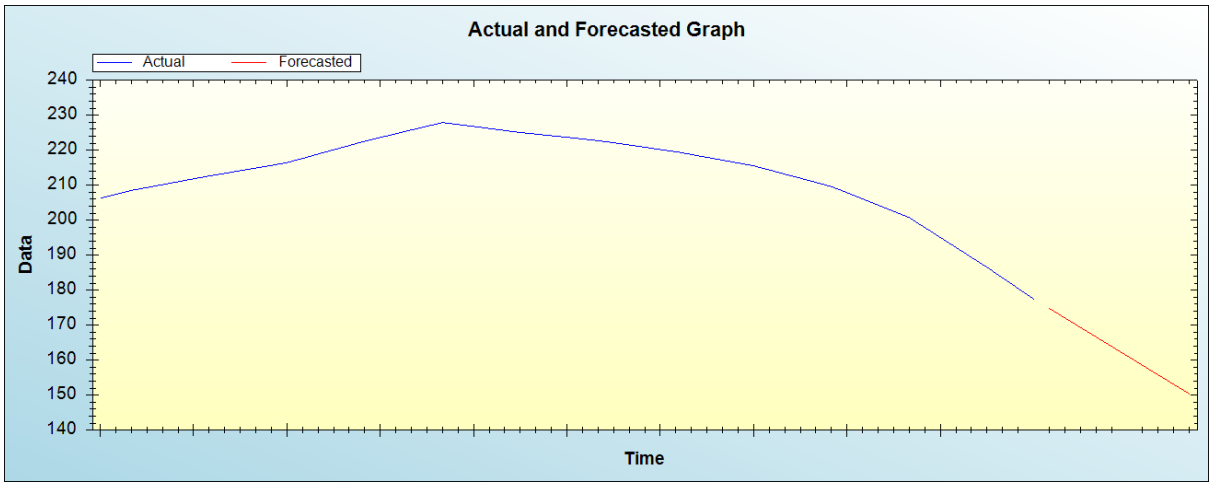

Figure 4: Out-of-sample forecast for N: actual and forecasted graph

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	174.7927
2022	172.0767
2023	169.3607
2024	166.6448
2025	163.9288
2026	161.2129
2027	158.4969
2028	155.7809
2029	153.0650
2030	150.3490

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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 decline but remain very high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Niger has the highest fertility rate in the world and a high maternal mortality ratio of 590 deaths per 100,000 live births. Maternal deaths among adolescents represents 34 percent of all deaths in this group. Major drivers of teen pregnancy and childbirth among adolescents include social norms, inadequate knowledge of contraceptives and partner dynamics which limit their individual ability to make decisions about preventing early pregnancy. Adolescent fertility in Niger has been declining over years from 228 births per 1000 women aged 15-19 in 1982 to 177 births per 1000 women aged 15-19 years in 2020. This decline of fertility is partly due to use of modern methods of contraception. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Niger. Our study results indicated that adolescent fertility will continue to decline but remain very high in the out of sample period. Therefore, we encourage the government of Niger to strictly enforce laws that protect sexual and reproductive health rights of women and girls, promote girl child education, scale up awareness campaigns among communities and provide funding for youth empowerment projects.

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