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Projecting Future Trends of Adolescent Fertility for Mali Using Holt's Linear Method

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***Abstract* - This study employs annual time series data of adolescent fertility rate for Mali 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 0.8 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility is expected to decline but remain very high throughout the out of sample period. Therefore, we encourage authorities in Mali to strictly enforce laws that protect sexual and reproductive health rights of women and children, promote girl child education and improve on the accessibility and affordability of adolescent health services especially in the remote areas of the country and scale up campaigns among communities.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The existence of political instability in Mali has been a major setback for accelerating the implementation of sustainable development goals thereby making it hard to achieve set targets under the 3rd sustainable development goal by 2030 (Mali, 2021). According to Mali 2018 Demographic and Health Survey, the country is struggling to control high maternal mortality and its fertility remains high despite reporting fertility transition over the past decades from 7.1 in 1987 to 6.3 in 2018. Above 50 percent of Malian women are married before the age of 18 and teenage pregnancy is very high, with over 30% of Malian women being pregnant by the age of 19 (Bagayogo, 2020). Contraceptive prevalence among married women is 16%. There is a geographic variation of uptake of family planning as use is higher among married women in urban areas than those in rural areas. Unmet need for family planning is 24 percent and reportedly higher among unmarried women (INSTAT and ICF, 2019; MacQuarrie *et al.* 2020).Studies conducted in the past revealed that adolescent pregnancy carries a greater risk of pregnancy and childbirth-related adverse outcomes such as low birth weight, preeclampsia/eclampsia, preterm delivery and maternal and perinatal mortality (WHO, 2020;Kassa *et al.* 2019;Wall-Wieler*et al.* 2019; Grønvik *et al.* 2018). Pregnancy related complications are the leading causes of death among adolescents between 15 and 19 years of age in LMICs (WHO, 2020). Moreover, adolescent pregnancy is associated with low educational attainment, especially in LMICS. Children born to teenage mothers are more likely to become teenage mothers thereby creating a generational cycle of poverty. Higher school drop outs have been reported among girls than boys (Grønvik*et al.* 2018).

This paper applies Holt's double exponential smoothing to forecast future trends of adolescent fertility for Mali over the out of sample period. The findings of the study will highlight the future burden of adolescent births and stimulate timeous appropriate action to end child marriages and protect sexual and reproductive health rights of adolescent girls and women.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Mali. 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 exponential smoothing method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

Y_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 Mali 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	Y
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.800

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Forecast performance measures	
Mean Absolute Error (MAE)	0.206120
Sum Square Error (SSE)	12.951029
Mean Square Error (MSE)	0.212312
Mean Percentage Error (MPE)	-0.022929
Mean Absolute Percentage Error (MAPE)	0.107867

Residual Analysis for the Applied Model

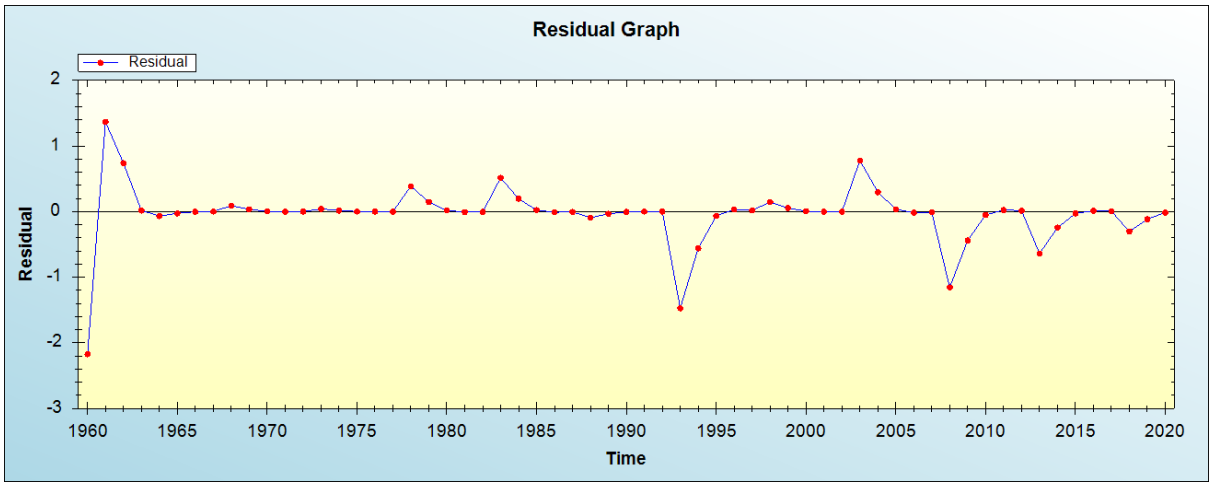

Figure 1: Residual analysis

In-sample Forecast for Y

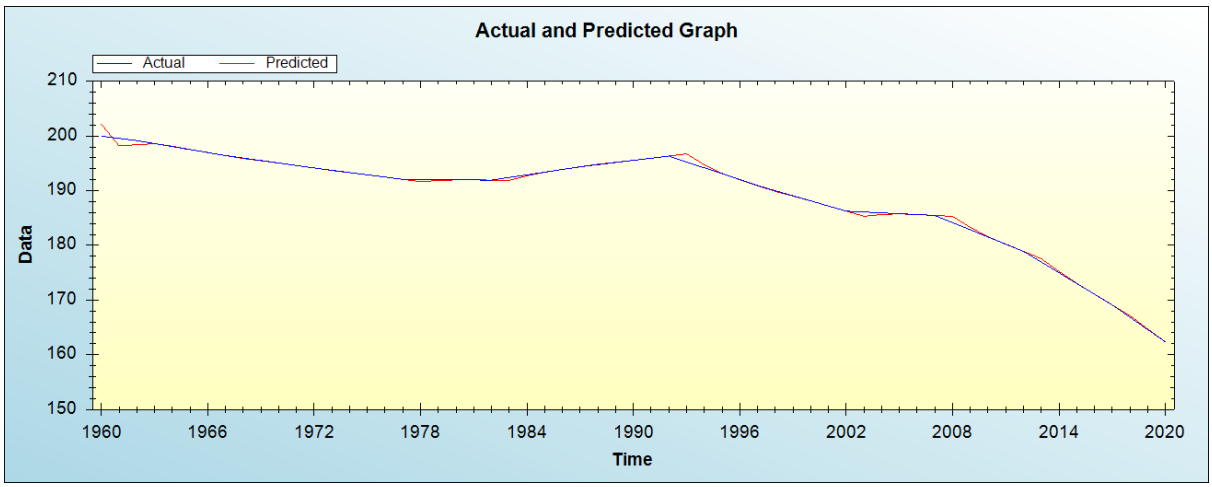

Figure 2: In-sample forecast for the Y series

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Actual and Smoothed graph for Y series

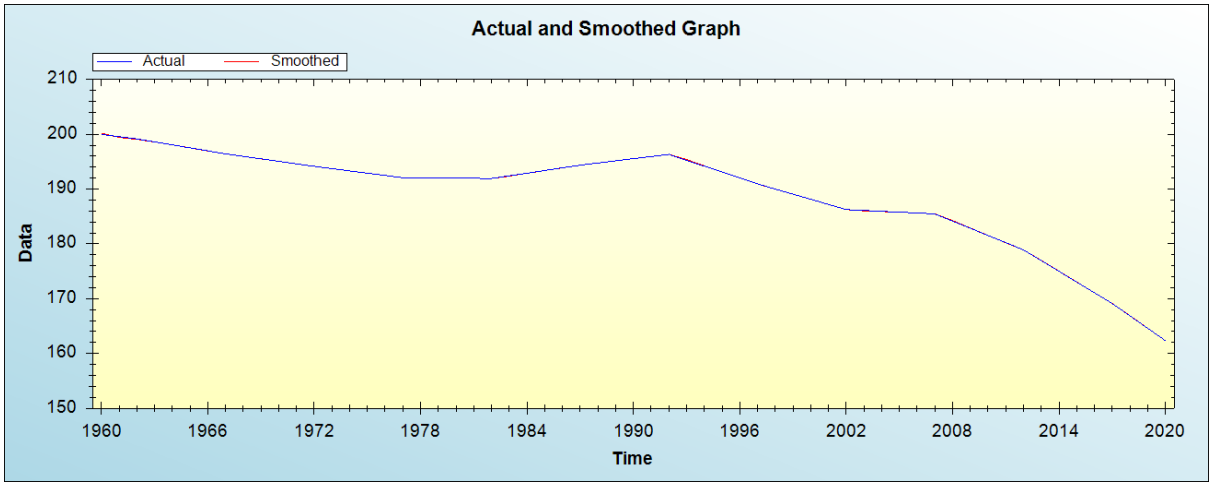

Figure 3: Actual and smoothed graph for Y series

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

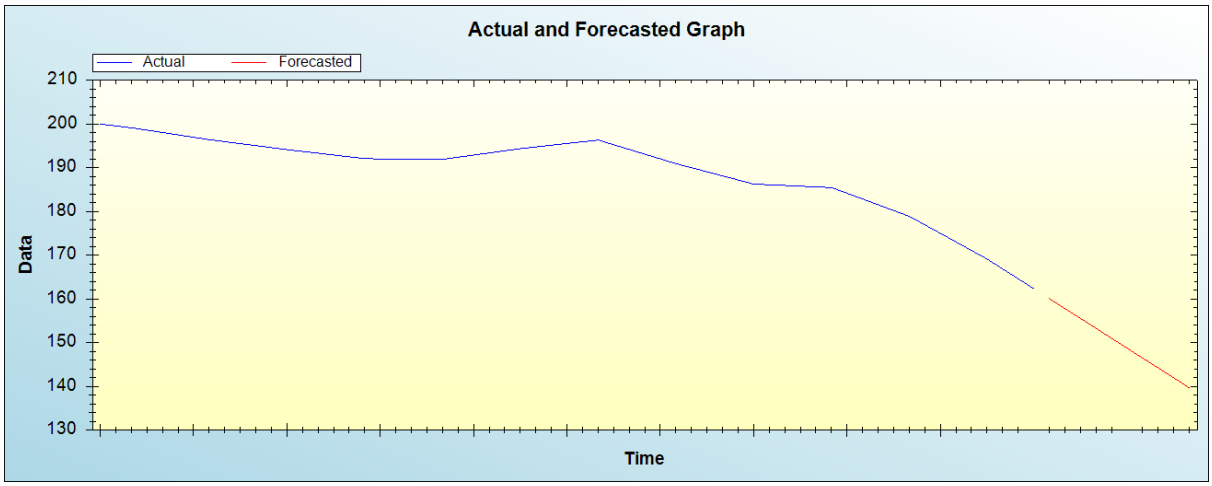

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	160.0798
2022	157.8119
2023	155.5440
2024	153.2760
2025	151.0081
2026	148.7401
2027	146.4722
2028	144.2043
2029	141.9363
2030	139.6684

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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 is expected to decline but will remain very high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

The Malian government has invested a lot of resources into the National family planning program which has triggered a gradual decline of adolescent fertility during the period 1960 to 2020. Despite all the efforts, teenage pregnancy remains a very huge challenge which requires urgent attention. Multiple factors have been found to influence adolescent fertility such as poverty, lower educational level, lack of parental guidance, sexual abuse of women, substance abuse and inadequate SRH information among teenagers. This study applied the double exponential smoothing technique to predict future trends of adolescent fertility for Mali. We established that adolescent fertility will continue to decline but still remain very high throughout the out of sample period. We, therefore implore the government to strictly enforce laws that protect sexual and reproductive health rights of women and children, promote girl child education and improve on the accessibility and affordability of adolescent health services especially in the remote areas of the country and scale up campaigns among communities.

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