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Forecasting Adolescent Fertility for Libya Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Libya 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 0.9 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will remain low throughout the out of sample period. Therefore, we encourage authorities in Libya to continue promoting girl child education and protecting sexual and reproductive health rights of women and girls.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Teenage conception is a very challenging experience for the mother and her family. The physical and mental trauma the pregnant teenager goes through is unbearable in most of the cases (Natividad, 2014). The thought of being a parent and dropping out of school will leave deep wounds in the hearts of many adolescent girls (Wado *et al.* 2019; Mathewos &Mekuria, 2018; Pradhan *et al.* 2018;Lee, 2010). Stigma and discrimination cannot go unmentioned as peers and members of the society will talk about it and making it 'breaking news'. Local media platforms have a tendency of publicizing everything about victims of sexual abuse further traumatizing survivors of rape (WHO, 2015; Raj & Boehmer, 2013). Teenage pregnancy is a medical and social problem due to its association with certain medical complications that may lead to loss of life and can cause long term psychological harm to the teenage mother and her family (Ayamolowo *et al.* 2019). Previous studies have established that pregnant teenagers can suffer from depression and end up committing suicide (Dare *et al.* 2016; Undiyaundeye *et al.* 2015). Other studies revealed that adverse sexual and reproductive health outcomes can occur such as vaginal bleeding during the antenatal period, pregnancy induced hypertension, anemia, preterm birth, low birth weight and severe prematurity (Sserwanja *et al.* 2021; Sserwanja& Kawuki, 2020; Ayanaw*et al.* 2018; Ganchimeg *et al.* 2014; Kurth *et al.* 2010; Chen *et al.* 2007). It has also been reported that teenage mothers have an increased risk of experiencing adverse SRH outcomes when compared with older women in the 20-24 year age group (Okonofua, 2013; Paton, 2009; WHO, 2007). It is important to mention that prevention of teenage pregnancy is key in the reduction of obstetric complications such as maternal morbidity and mortality (UN, 2020; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015; WHO, 2012). Improving education level has been found to increase the age at marriage, labor participation and reduce early child marriages (Mehra*et al.* 2018). The general decline in adolescent fertility across Africa has been attributed to increase in contraceptive prevalence, improved knowledge on family planning, improvements in the education sector and awareness campaigns among communities (Worku *et al.* 2021; Undie *et al.* 2015). In the case of Libya, World Bank has revealed that adolescent fertility declined gradually from around 120 births per 1000 females aged 15-19 in 1960 to levels around 5 births per 1000 females aged 15-19 in 2020.

The purpose of this study is to model and project future trends of adolescent fertility for Libya using Holt's double exponential smoothing technique. The research findings are expected to highlight the future burden of adolescent births in the out of sample period. This is expected to guide policies, planning and allocation of resources to teenage pregnancy prevention program activities with the aim of ending teenage pregnancy and child marriages in the country.

II. METHODOLOGY

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

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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 model is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

Forecasting equation

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

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 series 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 ratein Libya 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

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Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.900
Forecast performance measures	
Mean Absolute Error (MAE)	0.739000
Sum Square Error (SSE)	234.549713
Mean Square Error (MSE)	3.845077
Mean Percentage Error (MPE)	0.938333
Mean Absolute Percentage Error (MAPE)	1.648489

Residual Analysis for the Applied Model

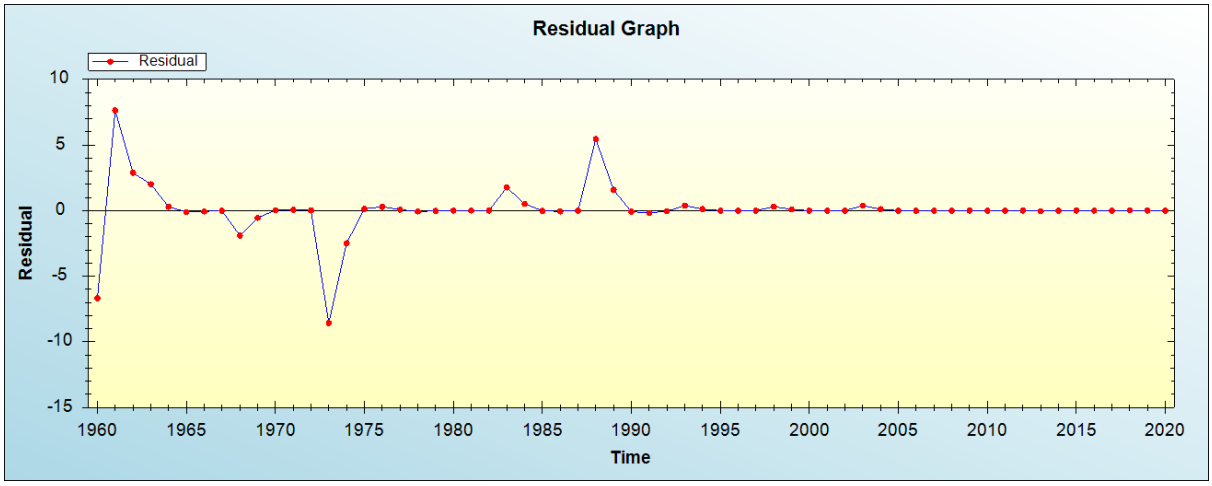

Figure 1: Residual analysis

In-sample Forecast for Y

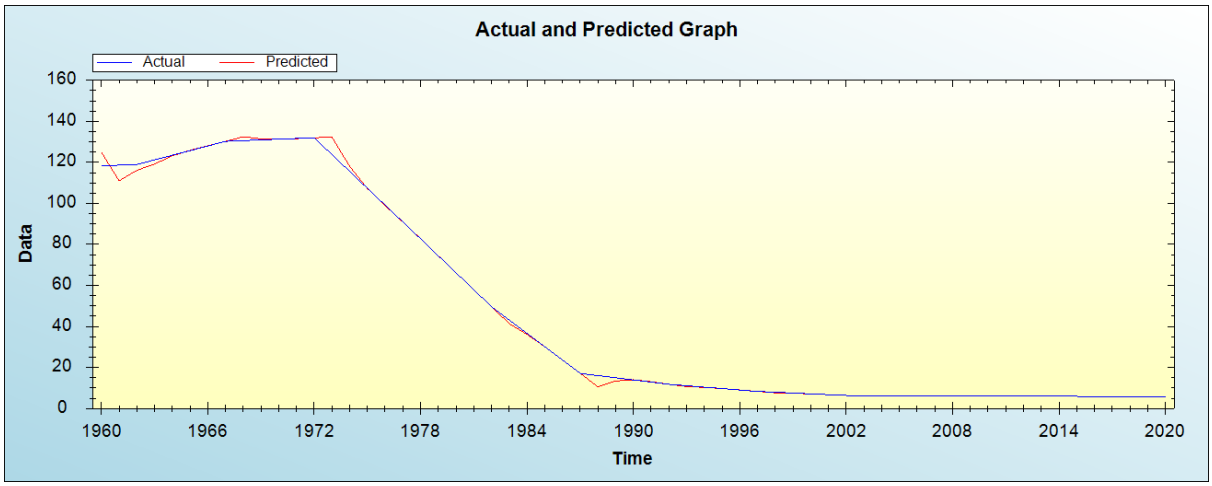

Figure 2: In-sample forecast for the Y series

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Actual and Smoothed graph for Y series

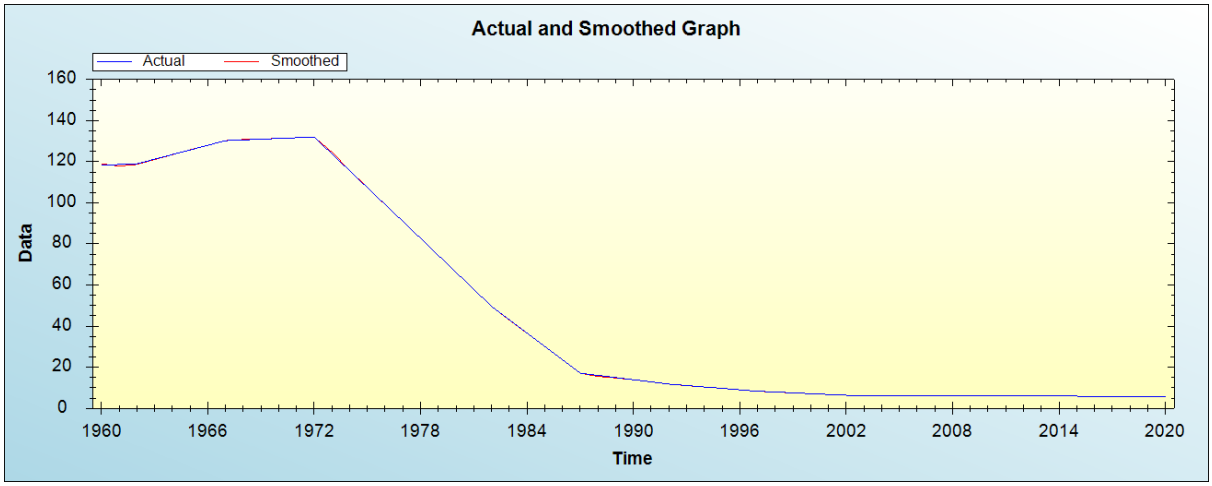

Figure 3: Actual and smoothed graph for Y series

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

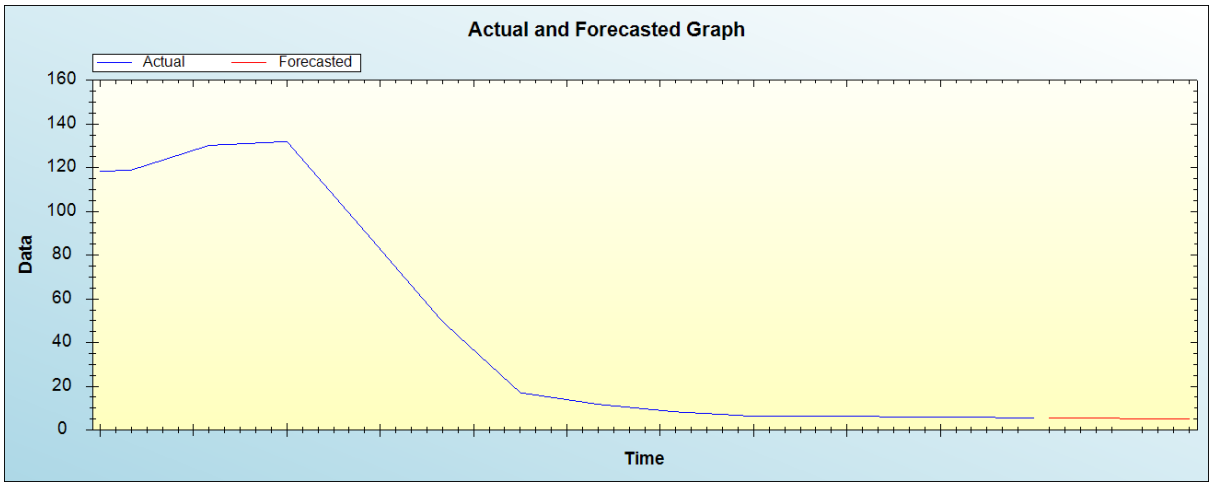

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	5.5528
2022	5.4991
2023	5.4455
2024	5.3918
2025	5.3381
2026	5.2845
2027	5.2308
2028	5.1772
2029	5.1235
2030	5.0698

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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 remain low throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

The general decline in adolescent fertility across Africa has been attributed to increase in contraceptive prevalence, improved knowledge on family planning, improvements in the education sector and awareness campaigns among communities. As revealed by the World Bank, Libya's adolescent fertility declined gradually from around 120 births per 1000 females aged 15-19 in 1960 to levels around 5 births per 1000 females aged 15-19 in 2020. This indicates the impact of government interventions on curbing teenage pregnancy and child marriages. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Libya. We established that adolescent fertility will remain low throughout the out of sample period. Therefore, we encourage the government to continue promoting girl child education and protecting sexual and reproductive health rights of women and girls.

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