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

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***Abstract* - This research article uses annual time series data of adolescent fertility rate for Malawi 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 0.3 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility is anticipated to decline but remain very high throughout the out of sample period. Therefore, we encourage policy makers in Malawi to strictly enforce laws that protect sexual and reproductive health rights of women and girls, promote girl child education and improve on the accessibility and affordability of adolescent health services especially in the rural areas.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The estimated number of adolescents for the entire world is around 1.2 billion, and 50% are in the 10-14 years age group (Woog and Kagesten, 2017). In 2016, 545 million very young adolescents were from low-middle countries with 63% from Asia, 26% from Africa, 10% from Latin America, and the Caribbean (Woog and Kagesten, 2017).Getting pregnant during the adolescencest age usually brings serious negative health, economic and social consequences to the mother and the fetus (WHO, 2018; Woog *et al*. 2017;UNFPA, 2016; Chalasani *et al.* 2013; Muula*et al.* 2008). Previous research papers established that there are greater risks of mortality and morbidity among adolescents. The list of problems linked to teenage pregnancy include preterm delivery, eclampsia, anemia, malnutrition, repeat pregnancy and mental stress (Michaels-Igbokwe *et al*. 2015; Ickovics *et al*. 2011; WHO, 2007). Pregnant adolescents encounter complex psychosocial problems compared to older pregnant women because of the low self-esteem and stigma associated with adolescent pregnancy (Daley *et al.* 2013; Gross *et al*. 2012). Furthermore, stress and rejection may lead to unhealthy behaviors such as substance abuse and poor nutritional intake resulting in adverse perinatal outcomes (Ganchimeg *et al*. 2014; Novick *et al.* 2012; WHO, 2007). Several issues are known to cause teenage pregnancy which include early sexual debut, peer pressure, lack of parental guidance, poverty and lack of education (Magnusson *et al*. 2019; Bankole*et al.* 2008). A noticeable worrying trend is the exposure of teenagers to pornographic material in various social media platforms which triggers their desire to engage in early sexual activity (Magnusson *et al*. 2019; Peltzer & Pengpid, 2015; Peltzer, 2010; Pettifor*et al*. 2009). Unprotected sex exposes them to unintended pregnancies, STIs and HIV (Peltzer & Pengpid, 2015).According to Malawi Demographic Health Survey, 2015-2016, 29% of pregnant women were adolescents, and a substantial number of them reported to have given birth before the age of 18 years of age. Seven percent of adolescent girls aged 15–19 years old get pregnant before 15 years (National statistics office, 2017).

Forced child marriages in developing countries contribute significantly to adolescent pregnancies. The government of Malawi has a legal and policy framework to address this problem. This country is a party to various global and regional commitments that prohibit child marriage. These include the CRC adopted in 1989 and the Convention on Elimination of All Forms of Discrimination against Women (CEDAW), adopted in 1979 (UNICEF, 2019). Despite the current government interventions, child marriage remains a challenge. Therefore this paper focuses on forecasting adolescent fertility over the out of sample period. Findings are expected to highlight future trends of adolescent births and this will guide policies so that the practice of child marriage is eliminated by strictly enforcing effective laws which protect sexual and reproductive 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 Malawi. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having

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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 expressed as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

W_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 Malawi 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

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Table 1: ES model summary

Variable	W
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	1.866211
Sum Square Error (SSE)	858.191533
Mean Square Error (MSE)	14.068714
Mean Percentage Error (MPE)	0.023628
Mean Absolute Percentage Error (MAPE)	1.066064

Residual Analysis for the Applied Model

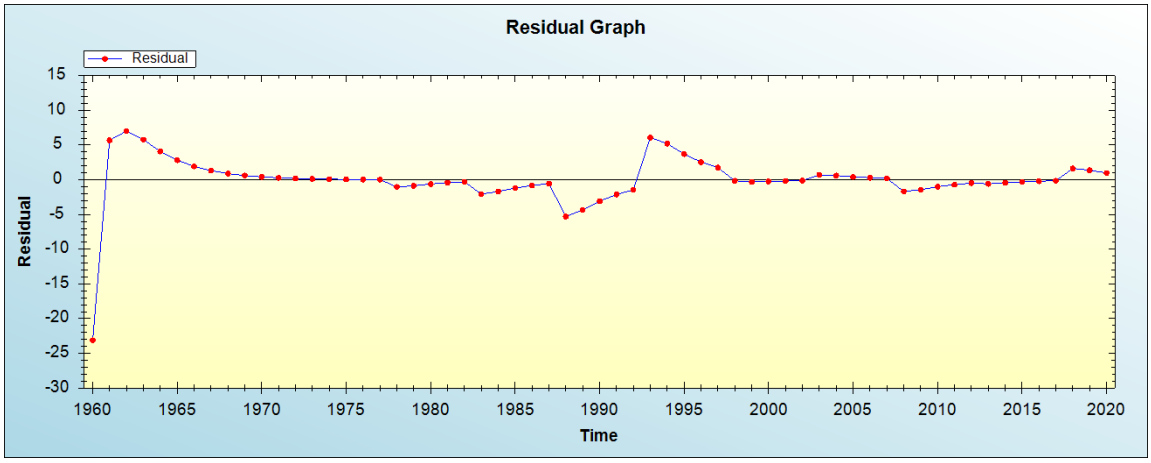

Figure 1: Residual analysis

In-sample Forecast for W

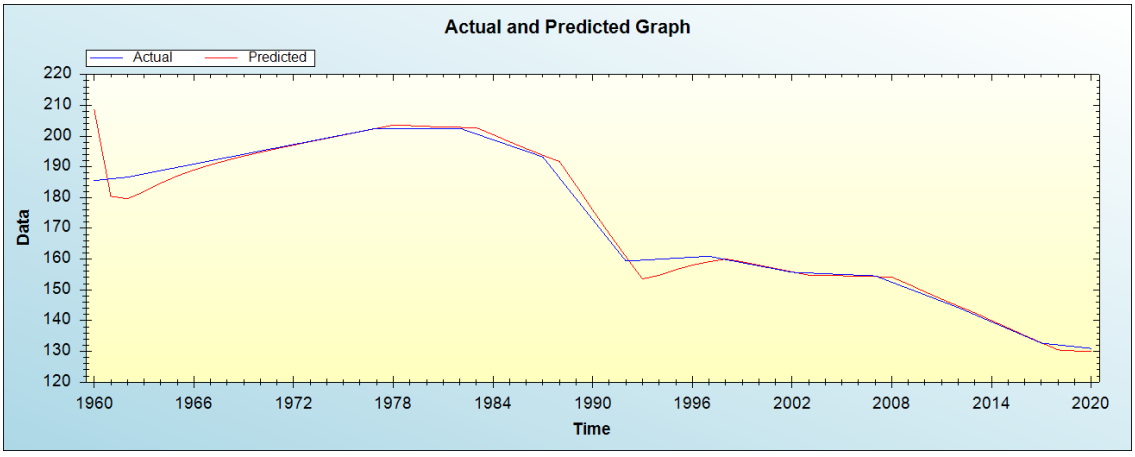

Figure 2: In-sample forecast for the W series

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Actual and Smoothed graph for W series

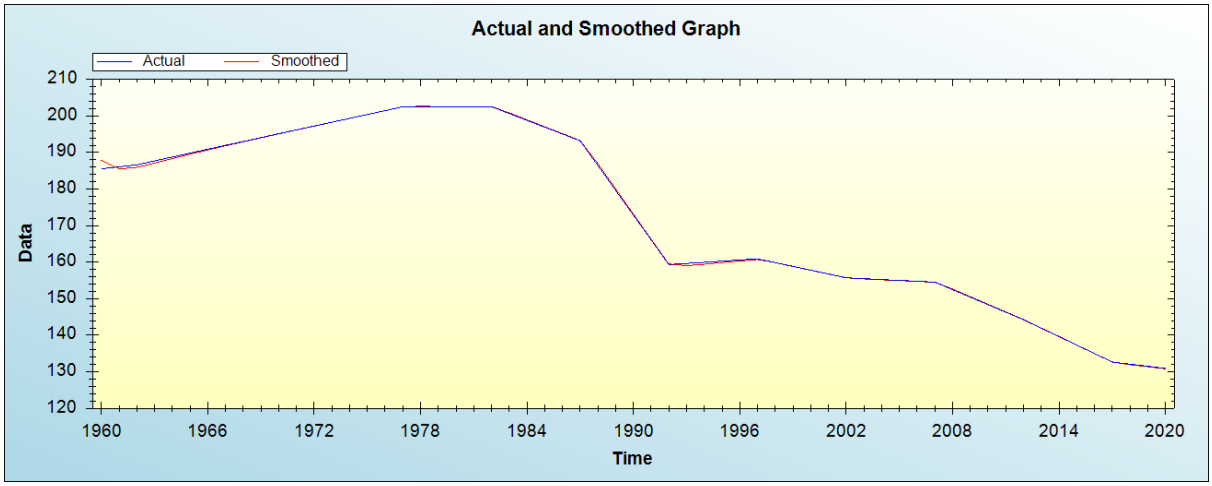

Figure 3: Actual and smoothed graph for W series

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

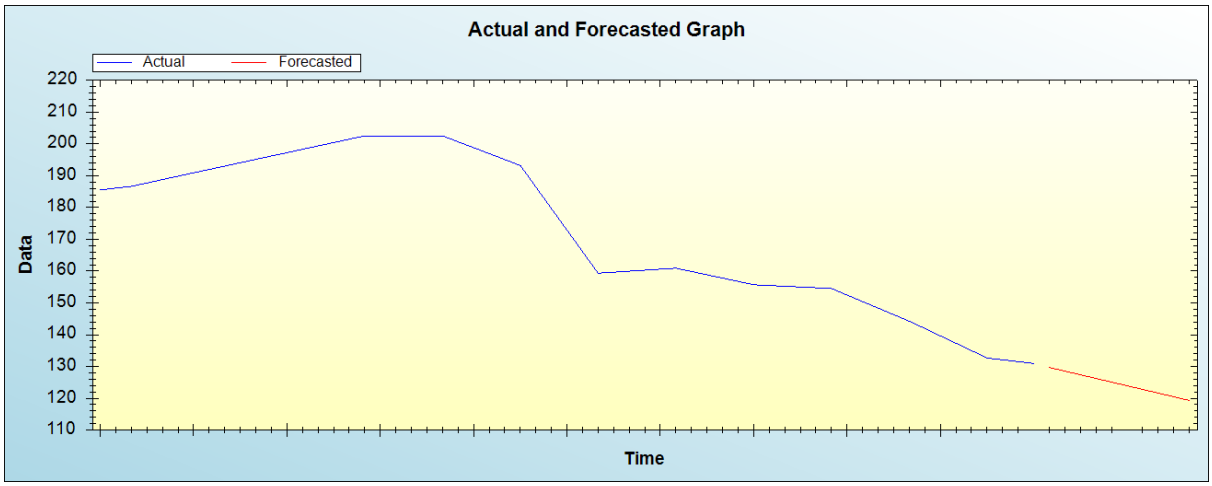

Figure 4: Out-of-sample forecast for W: actual and forecasted graph

Out-of-Sample Forecast for W: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	129.6920
2022	128.5395
2023	127.3869
2024	126.2343
2025	125.0817
2026	123.9292
2027	122.7766
2028	121.6240
2029	120.4715
2030	119.3189

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

IV. POLICY IMPLICATION & CONCLUSION

Developing countries are currently facing numerous challenges which hinder progress towards achieving set targets of sustainable development goals by 2030. High rates of teenage pregnancies in Malawi are a clear indication that huge investments towards the national family planning program are required. Adolescent birth rates during the period 1960-2020 have been declining but are still unacceptably very high. Identified risk factors for teenage pregnancy include poverty, low educational level, peer pressure, social norms, substance abuse and inadequate sexual and reproductive health knowledge. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Malawi. Forecast results revealed that adolescent fertility will continue to drop but remain very high throughout the out of sample period. Therefore, we implore the government to strictly enforce laws that protect sexual and reproductive health rights of women and girls, promote girl child education and improve on the accessibility and affordability of adolescent health services especially in the rural areas.

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