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Projecting Adolescent Fertility for Bangladesh Using the Double Exponential Smoothing Technique

[1]Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - This study employs annual time series data of adolescent fertility rate for Bangladesh 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 are0.9 and0.1 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline throughout the out of sample period. Therefore, we implore authorities in Bangladesh to promptly attend to the socio-cultural, economic and geographic factors that result in high absolute numbers of unwanted pregnancies among adolescents.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Many low and middle income countries have made significant progress towards achieving set targets under the 3rd sustainable development goal especially improving the quality and access to maternal and child health services, however maternal mortality ratio remains high in Sub-Saharan Africa with approximately 550 maternal deaths per 100 000 live births in 2015 (WHO, 2015). High absolute numbers of adolescent pregnancies are among the major drivers of adverse sexual and reproductive health outcomes. Lack of quality care, unsafe abortions and poor health infrastructure are among the causes of adverse sexual and reproductive health outcomes (WHO, 2017; Haddad, 2009). The 1994 International conference on Population and development (ICPD) and WHO advocated for women's sexual and reproductive health rights and needs such as health education, access to information on family planning, improved quality of prenatal, antenatal and postnatal care (Sullivan *et al.*2020). Worldwide approximately 40 % of all pregnancies are unintended and half of them end up in abortion (Sedgh *et al.* 2006). Research has shown that commercial sex-work is rampant in developing countries and there is lack of comprehensive knowledge on family planning services among adolescent girls and young women (Workie *et al.* 2019). In addition, bad cultural and religious practices which promote child marriages and abuse of women poses a threat to the eradication of teenage pregnancies in low-middle income countries and this calls for governments to enforce laws to protect sexual and reproductive health rights of adolescent girls and women (Ameyaw *et al.* 2020; Darroch *et al.*2011).

Therefore, this paper applies the double exponential smoothing technique to forecast adolescent birth rates (adolescent fertility rate) for Bangladesh and the findings are expected to highlight future trends of adolescent births. This will assist policy makers to assess the effectiveness of various strategies that are employed to curb teenage pregnancy in the country and facilitate allocation of resources to different programs designed to eradicate this public health problem.

II. METHODOLOGY

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

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

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Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

X_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 period t-1

Data Issues

This study is based on annual adolescent fertility rate in Bangladesh 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	X
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	

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Mean Absolute Error (MAE)	1.983579
Sum Square Error (SSE)	945.268390
Mean Square Error (MSE)	15.496203
Mean Percentage Error (MPE)	0.306453
Mean Absolute Percentage Error (MAPE)	1.291742

Residual Analysis for the Applied Model

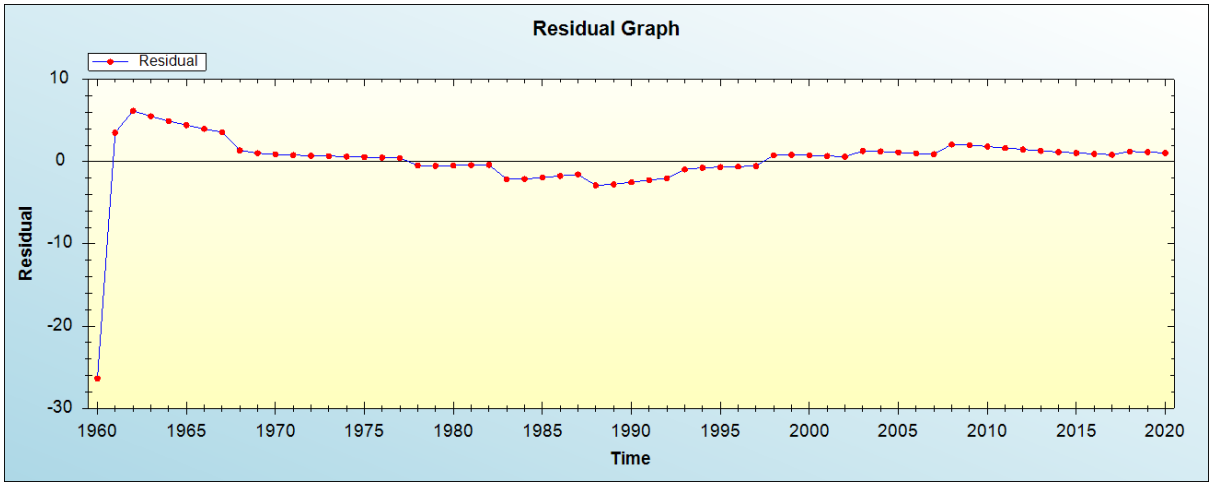

Figure 1: Residual analysis

In-sample Forecast for X

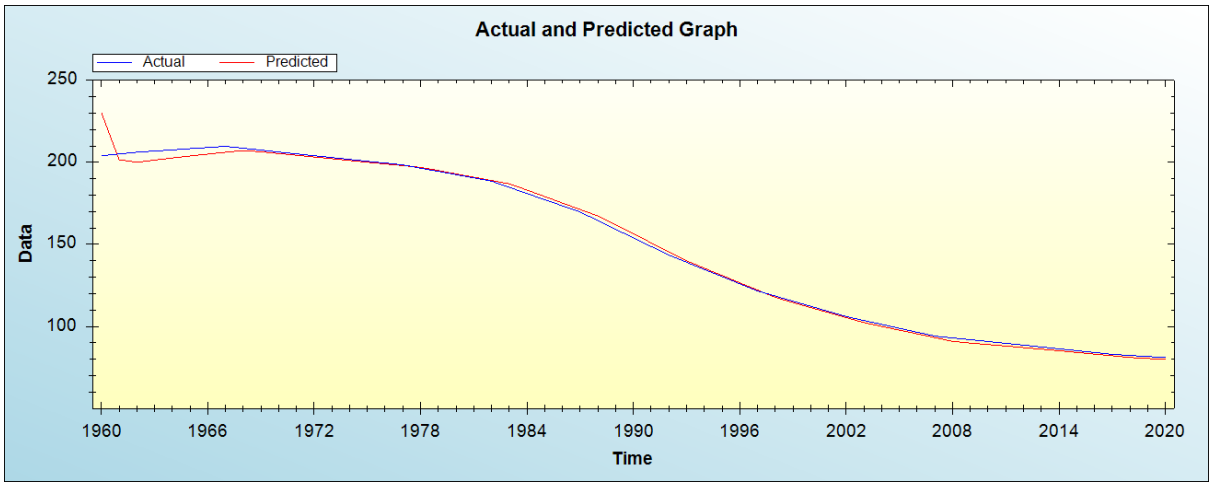

Figure 2: In-sample forecast for the X series

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Actual and Smoothed graph for X series

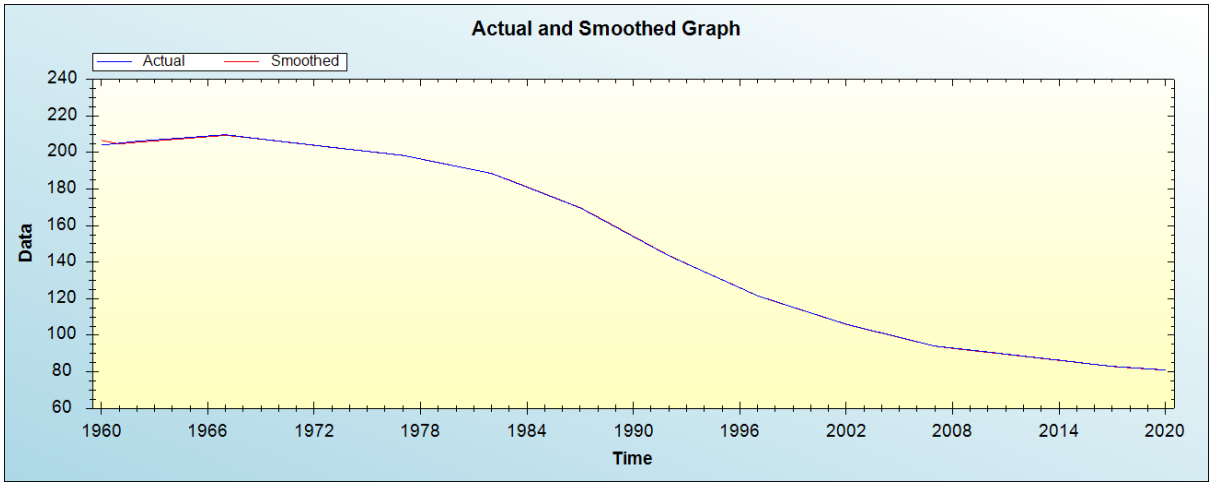

Figure 3: Actual and smoothed graph for X series

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

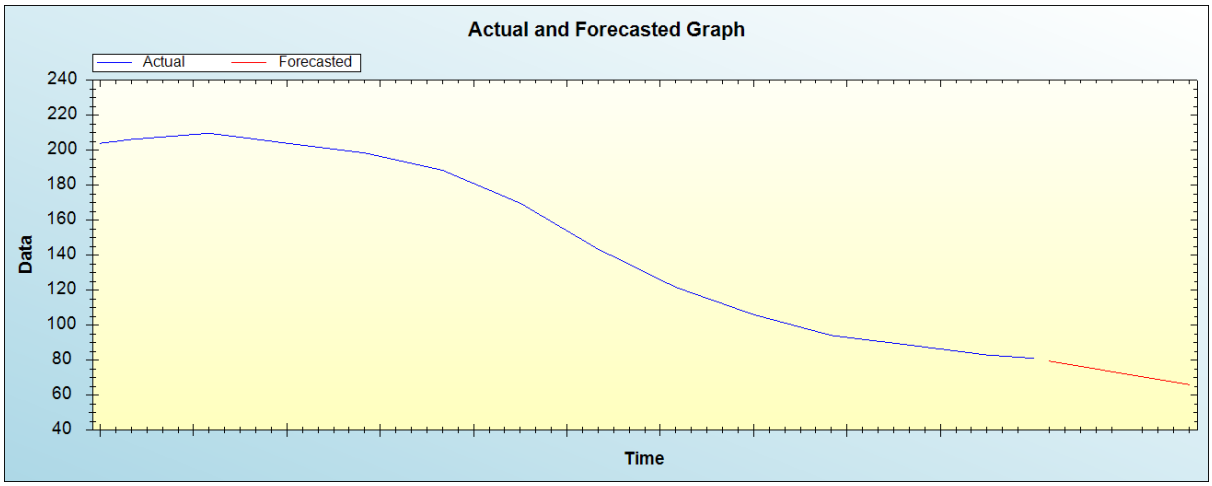

Figure 4: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	79.4119
2022	77.9154
2023	76.4189
2024	74.9224
2025	73.4260
2026	71.9295
2027	70.4330
2028	68.9365
2029	67.4400
2030	65.9435

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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 throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Adverse pregnancy outcomes are very common in developing countries as a result of poverty, inadequate SRH information, sexual abuse of women, peer pressure, substance abuse, low educational levels and low contraceptive prevalence. Pregnant adolescents have a greater risk of experiencing adverse SRH outcomes such as unintended pregnancy, STIs, HIV and unsafe abortions. Addressing adolescent sexual and reproductive health issues is expected to improve knowledge levels, increase contraceptive prevalence, reduce unmet need for family planning and manage adverse pregnancy outcomes to reduce maternal and child mortality. This study applied Holt's double exponential smoothing technique to forecast adolescent fertility for Bangladesh. Our research findings revealed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, the government must attend to the socio-cultural, economic and geographic factors that result in high absolute numbers of unwanted pregnancies among adolescents.

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