

# Detecting Future Trends of Adolescent Fertility for Belize Using the Double Exponential Smoothing Technique

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**Abstract** - This study uses annual time series data of adolescent fertility rate for Belize 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  $\alpha$  and  $\beta$  are 0.9 and 0.3 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 encourage authorities in Belize to channel more resources towards improving the quality and accessibility of SRH services among adolescents, promote girl child education and protect women's rights.

**Keywords:** Exponential smoothing, Forecasting, adolescent fertility rate.

## I. INTRODUCTION

Teenage pregnancy is a global health problem which is associated with undesirable maternal and child health outcomes (Wado *et al.* 2019; WHO, 2017; Haddad, 2009; Glasier *et al.* 2006; Eczati *et al.* 2002). Many adolescents in low-middle income countries engage in unprotected sexual intercourse resulting in unintended pregnancies, sexually transmitted infections, and unsafe abortions (UNICEF, 2013). Several previous studies have shown that teenage pregnancies are as a result of socio-economic and demographic factors among other factors (Dejong *et al.* 2007). Many adolescents lack adequate knowledge on sexual and reproductive health information ((Newton-Levinson *et al.* 2016; Elkak, 2013; Aquaiz *et al.* 2012; Kahhalch, 2009; Dejong *et al.* 2007). Drug and substance is common among adolescents and increases the risk of acquiring STIs and unwanted pregnancies. In September 1994, UNFPA organized an International Conference in Egypt attended by 179 country representatives. The signatories declared and upheld women's rights. They agreed on several strategies to address adolescent pregnancies and gender inequalities to improve the quality of life for women (UN, 1995). Governments are expected to offer accessible quality and affordable adolescent health services including sexual and reproductive health services. Ensuring availability of adequate resources at all levels of healthcare will enable patients to get appropriate care timeously in order to prevent adverse maternal and child health outcomes. It is also important for authorities in every country to revisit existing policies and legal instruments to identify gaps or weaknesses to curb child marriages and end gender based violence. In line with the 3<sup>rd</sup> sustainable development goal, this paper applies Holt's exponential smoothing technique to project future trends of adolescent fertility in Belize and the forecast results will become a basis for the review of existing policies and legal instruments with the aim of ending teenage pregnancy and empowering women.

## II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Belize. 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 expressed as follows:

Model equation

$$Y_t = \mu_t + \rho_t t + \varepsilon_t$$

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

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

$Y_t$  is the actual value of adolescent fertility rate at time t

$\varepsilon_t$  is the time varying **error term**

$\mu_t$  is the time varying mean (**level**) term

$\rho_t$  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

$\alpha$  is the exponential smoothing constant for the data

$\beta$  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 Belize 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 ( $\alpha$ ) for data	0.900
Beta ( $\beta$ ) for trend	0.300
Forecast performance measures	

Mean Absolute Error (MAE)	1.123721
Sum Square Error (SSE)	358.903453
Mean Square Error (MSE)	5.883663
Mean Percentage Error (MPE)	0.169500
Mean Absolute Percentage Error (MAPE)	0.787853

Residual Analysis for the Applied Model

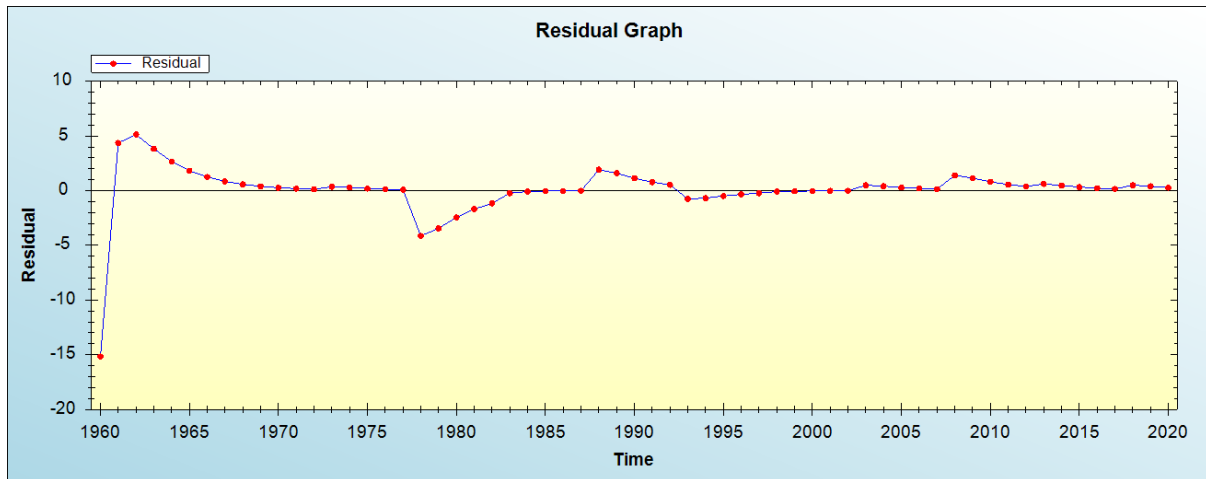


Figure 1: Residual analysis

In-sample Forecast for Y

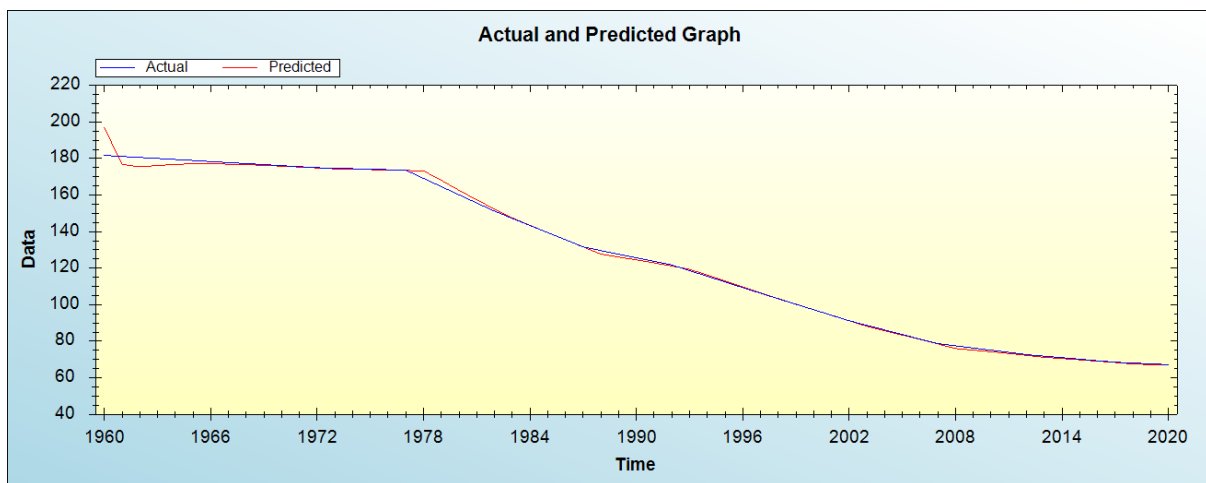


Figure 2: In-sample forecast for the Y series

Actual and Smoothed graph for Y series

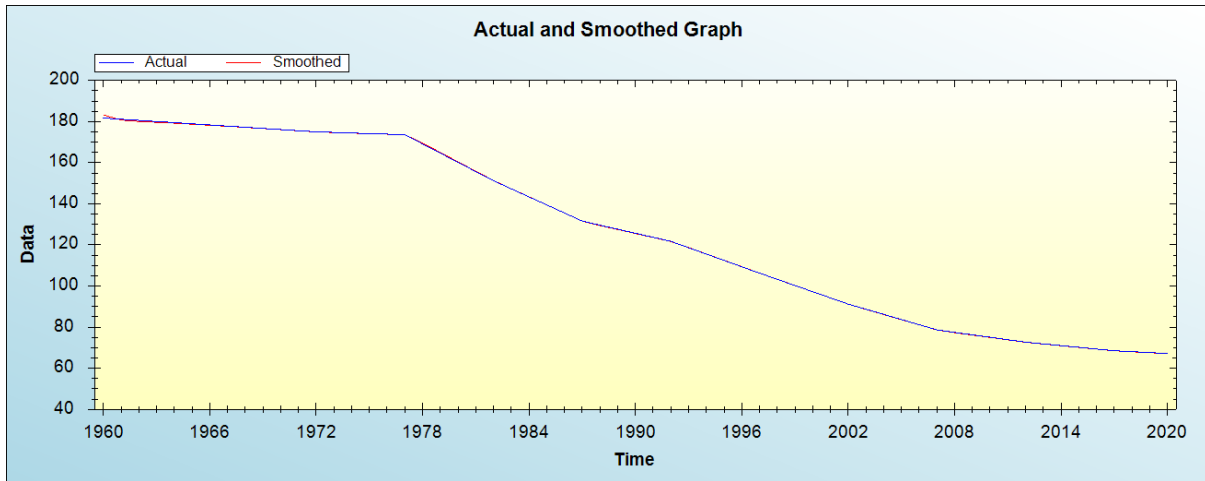


Figure 3: Actual and smoothed graph for Y series

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

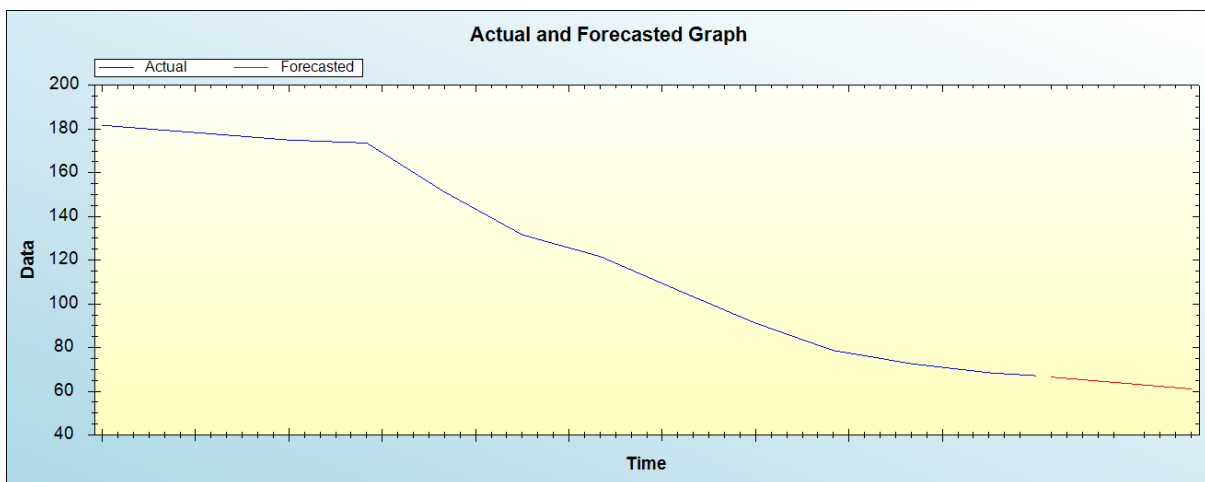


Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	66.5382
2022	65.9321
2023	65.3259
2024	64.7198
2025	64.1136
2026	63.5074
2027	62.9013
2028	62.2951
2029	61.6889
2030	61.0828

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

Teenage pregnancy is a global public health problem which is associated with undesirable maternal and child health outcomes. Teenage pregnancies are as a result of socio-economic and demographic factors among other factors. Many adolescents lack adequate knowledge on sexual and reproductive health information, experience sexual abuse, come from poor families and low educational levels which predispose them to unintended pregnancies. Adolescent fertility for Belize has been declining during the period 1960-2020. This can be attributed partly to the national family planning program. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Belize. Our study findings indicate that adolescent fertility will continue to decline throughout the out of sample period. Therefore, the government must channel more resources towards improving the quality and accessibility of SRH services among adolescents, promote girl child education and protect women's rights.

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