

# Tracking Future Trends of Adolescent Fertility for Guatemala Using Holt's Double Exponential Smoothing Technique

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**Abstract** - This study uses annual time series data of adolescent fertility rate for Guatemala 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 rate will continue to decline throughout the out of sample period. Therefore, we encourage authorities in Guatemala to improve accessibility of sexual and reproductive health services among teenagers, improve girl child education, scale up awareness campaigns among the communities, provide financial support to youth empowerment projects and continually enforce laws to protect women's rights and end child marriages.

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

## I. INTRODUCTION

Adolescent pregnancy is a worldwide phenomenon which affects both developing and developed countries (WHO, 2017). According to Ospina, Guatemala has the highest teenage pregnancy rates in Latin America. In Guatemala, 50 percent of all women are married by the age of 20, and 44 percent become mothers by the same age. Literature has shown that teenage pregnancy rates are higher among indigenous and uneducated women. By the age of 30, many of these women have seven or eight children, only 5 percent of women in Guatemala consistently use an effective method of birth control, mainly due to cultural norms and the influence of the Catholic Church's ban on contraceptive use (Tuschman, 2012). The Ministry of Health and Social Assistance reported that there were 135,808 pregnancies in girls aged 10 to 19 between 2009 and 2011. In 2012, there were 61,000 pregnancies of which 35 were 10-year-old girls giving Guatemala the highest adolescent pregnancy rate in Latin America. Evidence shows that these unintended pregnancies are attributed to the lack of education and healthcare, widespread poverty, lack of sexual education, inadequate knowledge regarding the use of effective contraceptive methods, inappropriate use of contraceptives and sexual violence (Ticotimes, 2014; ONU, 2014). Strategies to prevent pregnancy among adolescents in Guatemala have not achieved their desired impact because annually an average of 107,664 adolescent pregnancies were reported pregnancies between 2015 and 2019 (Guatemala, 2019). The latest estimates report that there were 104,837 adolescent pregnancies in 2020 (Guatemala, 2020). World Bank data also reveals that adolescent pregnancy in Guatemala gradually declined from 160 births per 1000 woman aged 15-19 in 1960 to around 67.5 births per woman aged 15-19 in 2020.

The objective of this paper is to model and forecast future trends of adolescent fertility in Guatemala using Holt's double exponential smoothing technique. The findings are expected to highlight the future burden of adolescent fertility in the out of sample period. This will trigger an appropriate timeous response to the problem of teenage pregnancy through the allocation of adequate resources to teenage pregnancy prevention programs.

## II. METHODOLOGY

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

Model equation

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

Forecasting equation

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

$Z_t$  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 under adolescent fertility rate in Guatemala 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	$Z$
Included Observations	61
Smoothing constants	

Alpha ( $\alpha$ ) for data	0.900
Beta ( $\beta$ ) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	0.789246
Sum Square Error (SSE)	128.108454
Mean Square Error (MSE)	2.100139
Mean Percentage Error (MPE)	0.049602
Mean Absolute Percentage Error (MAPE)	0.641426

Residual Analysis for the Applied Model

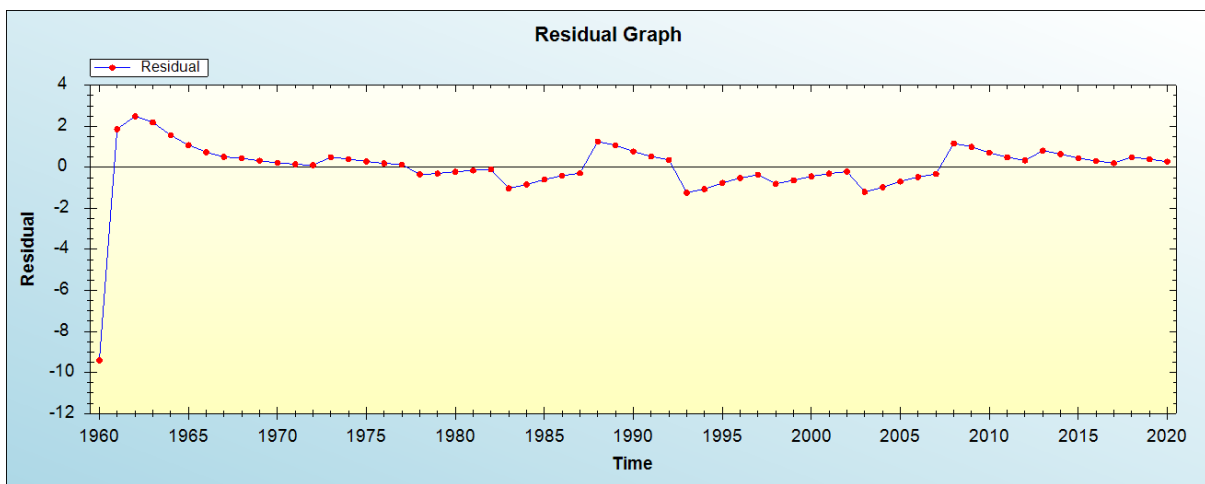


Figure 1: Residual analysis

In-sample Forecast for Z

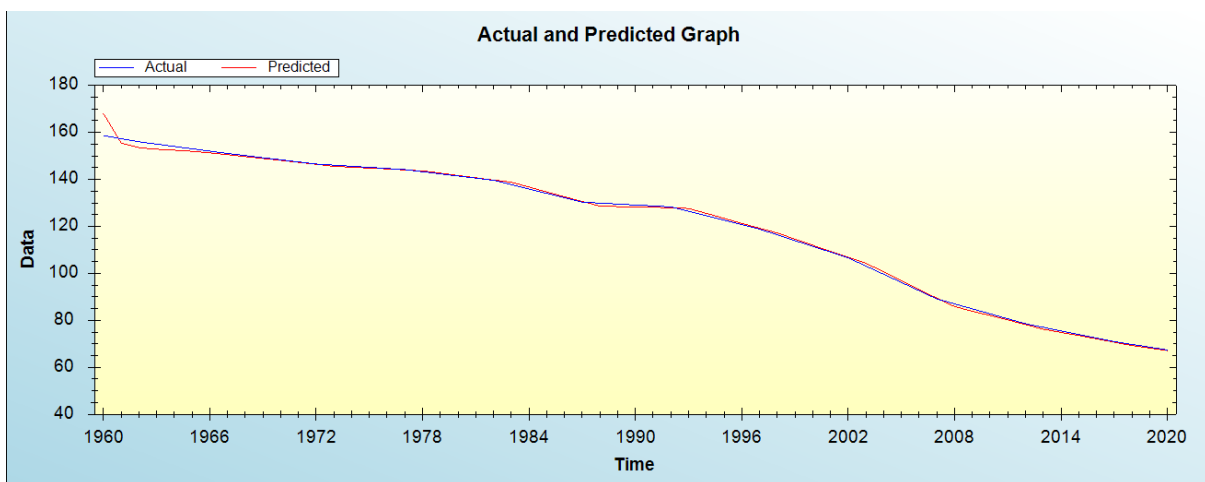


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

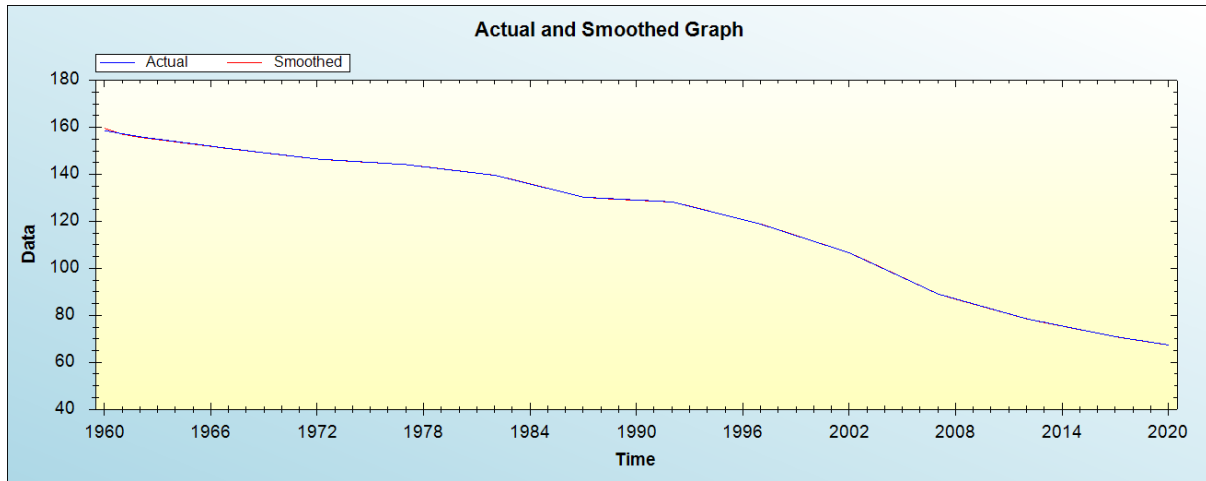


Figure 3: Actual and smoothed graph for Z series

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

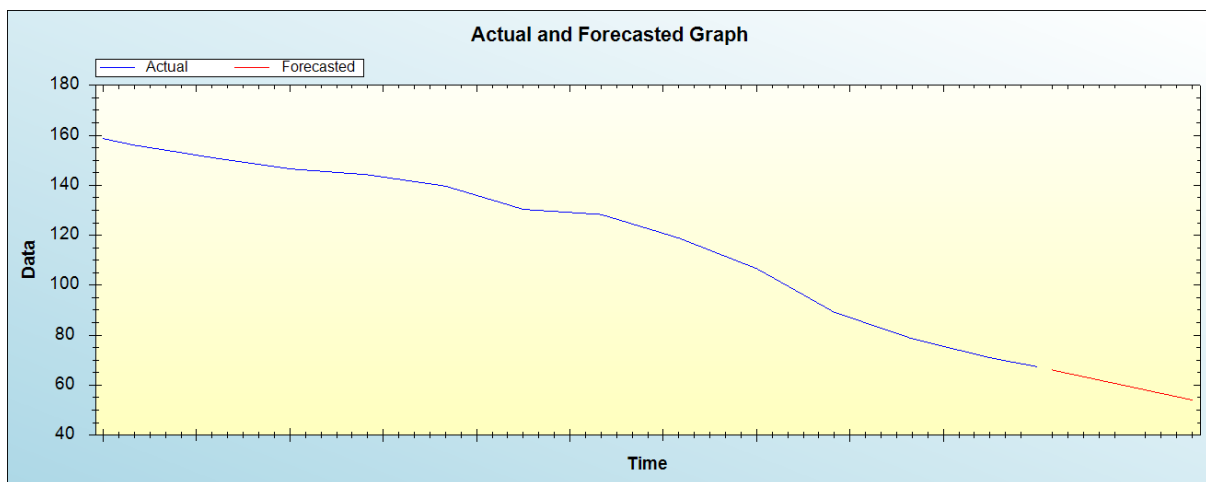


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	66.0438
2022	64.7072
2023	63.3707
2024	62.0341
2025	60.6976
2026	59.3610
2027	58.0245
2028	56.6879
2029	55.3514
2030	54.0148

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

Guatemala has the highest adolescent pregnancy rate in Latin America. Evidence shows that these unintended pregnancies are attributed to the lack of education and healthcare, widespread poverty, lack of sexual education, inadequate knowledge regarding the use of effective contraceptive methods, inappropriate use of contraceptives and sexual violence. Adolescent birth rate has been declining during the period 1960-2020 partly due to the national family planning program and improvements in education. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Guatemala. Our study findings revealed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, the government must improve accessibility of sexual and reproductive health services among teenagers, improve girl child education, scale up awareness campaigns among the communities, provide financial support to youth empowerment projects and continually enforce laws to protect women's rights and end child marriages.

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