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Estimating the Future Burden of Adolescent Births for EL Salvador Using Holt's 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 uses annual time series data of adolescent fertility rate for El Salvador 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 and0.2 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 El Salvador to scale up campaigns among communities, promote girl child education, strictly enforce laws that protect sexual and reproductive health rights for women and fund empowerment projects for young adults.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

In this time of sustainable development goals teenage pregnancy is among the top global health priorities (Gurung *et al.* 2020; Sukra *et al.* 2020). The 3rd sustainable development goal emphasizes on ensuring good health and promotion of well-being for all at every stage of life. Target 3.1 and 3.2 focuses on the substantial reduction of maternal and child mortality, and target 3.7.2 aims at addressing sexual and reproductive health concerns especially that of adolescent girls and women (UN, 2020; WHO, 2019; UNICEF, 2018; UN, 2016, Patton *et al.* 2016; UN, 2015). The global maternal mortality ratio should decrease to levels below 70 deaths per 100 000 live births by 2030. Neonatal mortality is expected to reach levels as low as 12 deaths per 1000 live births by 2030 (UN, 2016; UN, 2015). Several previous studies conducted in developing countries revealed that adolescent pregnancy continues to be among the top causes of maternal and child mortality around the globe (Odimegwu & Mkwananzi, 2016; WHO, 2016; Neal *et al.* 2012). Complications can occur during the antenatal, child birth and post natal periods. Maternal mortality can result from antepartum haemorrhage, postpartum haemorrhage and eclampsia (Althabe *et al.* 2015; Ganchimeg *et al.* 2014; Malabarey *et al.* 2012). Neonatal complications are as a result of hypoxia, sepsis, severe prematurity, low birth and birth trauma (Kaphagawani & Kalipeni, 2017; Sedgh *et al.* 2016). The burden of teenage pregnancy is reportedly highest in developing regions (Kassa *et al.* 2018). Among other factors poverty has been found to be a major determinant of teenage pregnancy in low and middle income countries (Wado *et al.* 2019). The gradual decline in adolescent fertility levels across the globe including developing regions is mainly attributed to improvements in educational level and use of modern methods of family planning (Birhanu*et al.* 2019). World Bank statistics revealed that adolescent fertility in El Salvador declined from 144 births per 1000 women aged 15-19 years in 1960 to 67 births per 1000 women aged 15-19 years in 2020. These figures indicate that teenage pregnancy is still a challenge in this country and more resources are required to end this problem.

The aim of this paper is to model and forecast future trends of adolescent fertility in El Salvador using the double exponential smoothing technique. Findings are expected to highlight future trends of adolescent fertility in the out of sample period. This will facilitate policymaking, planning and allocation of resources to maternal and child health program in the country with the aim of preventing teenage pregnancy and its complications.

II. METHODOLOGY

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

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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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

A_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 El Salvador 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	A
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	0.494936
Sum Square Error (SSE)	48.890025
Mean Square Error (MSE)	0.801476
Mean Percentage Error (MPE)	0.063920
Mean Absolute Percentage Error (MAPE)	0.445058

Residual Analysis for the Applied Model

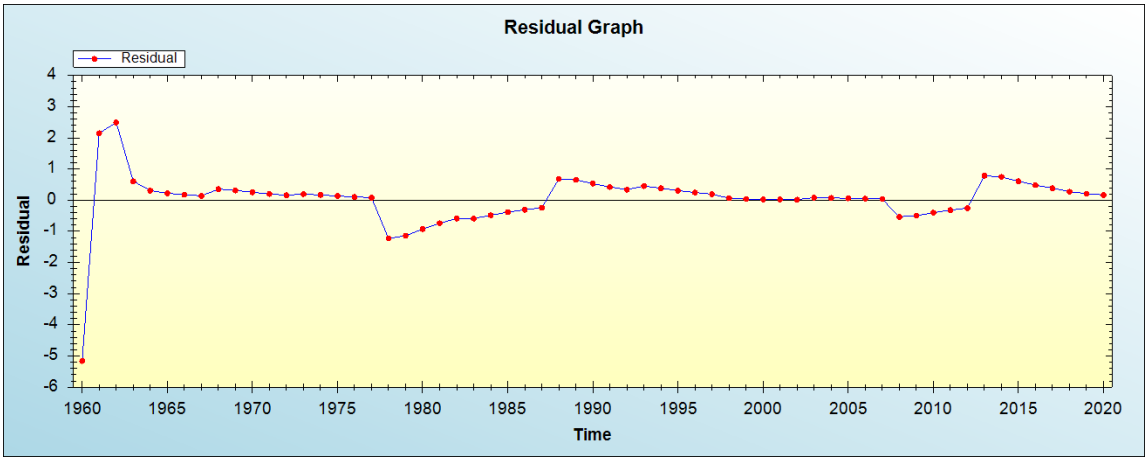

Figure 1: Residual analysis

In-sample Forecast for A

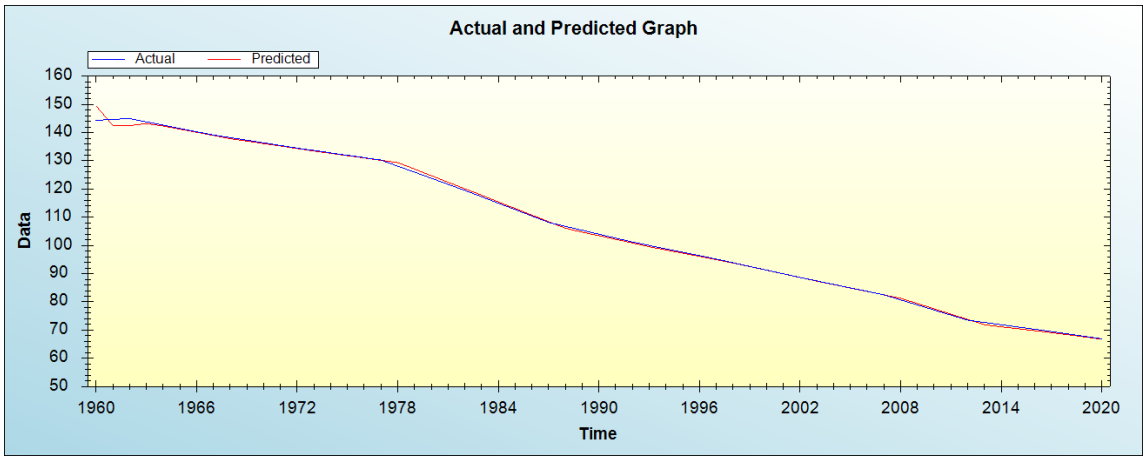

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

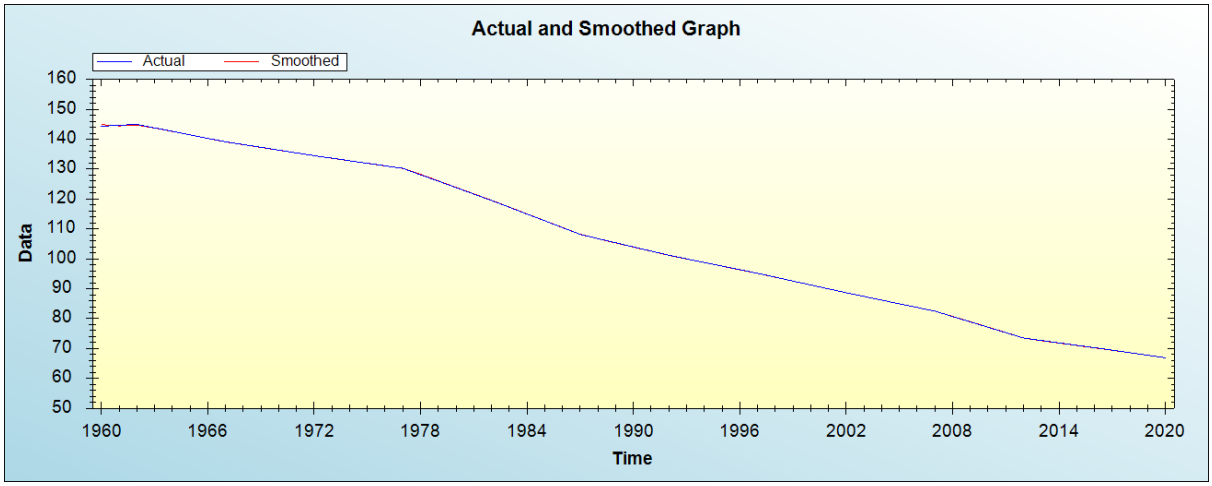

Figure 3: Actual and smoothed graph for A series

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

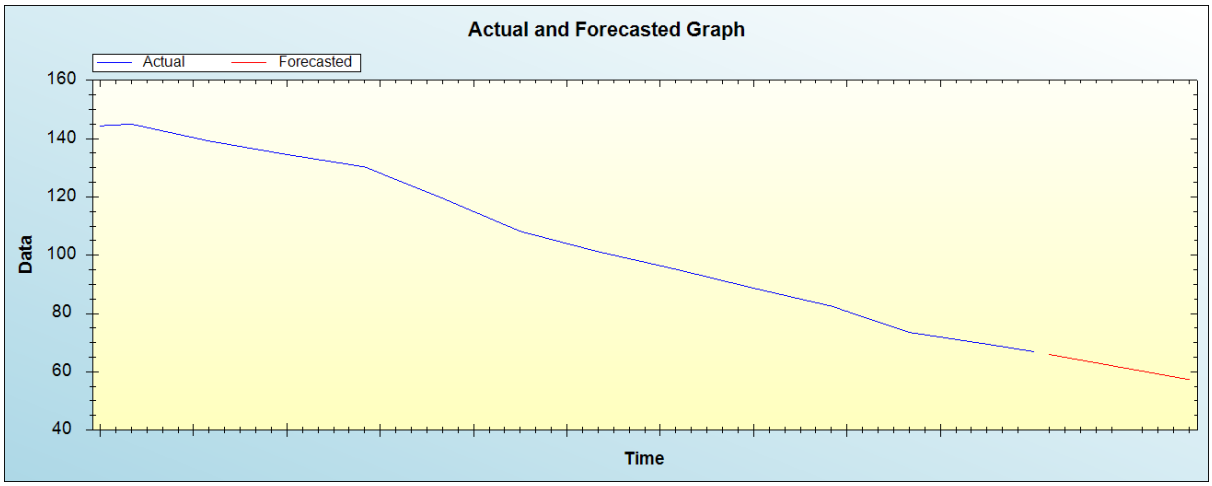

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	65.9446
2022	64.9831
2023	64.0217
2024	63.0602
2025	62.0988
2026	61.1373
2027	60.1759
2028	59.2144
2029	58.2529
2030	57.2915

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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

Among other factors, poverty has been identified as one of the major drivers of teenage pregnancy in low and middle income countries. The gradual decline in adolescent fertility levels across the globe including developing regions is mainly attributed to family planning services, improvements in educational level and better employment opportunities for women. Adolescent fertility in El Salvador declined from 144 births per 1000 women aged 15-19 years in 1960 to 67 births per 1000 women aged 15-19 years in 2020. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for El Salvador. Our study findings revealed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, the government must scale up campaigns among communities, promote girl child education, strictly enforce laws that protect sexual and reproductive health rights for women and fund empowerment projects for young adults.

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