Demonstrating The Use of Holt's Double Exponential Smoothing Technique to Detect Future Trends of Adolescent Fertility for the Dominican Republic

[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 the Dominican Republic 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 but remain high throughout the out of sample period. In order to substantially reduce adolescent fertility by 2030, the government must set up adolescent friendly clinics especially in marginalized areas, scale up awareness campaigns, strictly enforce laws that protect women's rights and promote girl child education.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Globally, teenage pregnancy (15–19 years) has declined from around 90 births per 1,000 women aged 15-19 in 1960 to levels below 45 per 1,000 women aged 15-19 years in 2015 (World Bank, 2016).The rates of teenage pregnancy range from as high as 143 per 1,000 women in some sub-Saharan countries to 2.9 per 1,000 women in South Korea (Mazaba, 2017). Previous studies revealed that Low and middle income countries continue to report high rates of adolescent pregnancies with Sub-Saharan Africa being ranked at the top followed by South East Asia then lastly Latin America and the Caribbean (Mezmur *et al.* 2021; Gunawardena *et al.* 2019; Shibanuma *et al.* 2018; Ayanaw*et al.* 2017;Sedgh*et al.* 2015; Treffers, 2003;). In addition, existing challenges like poverty, lack of education, social norms, and absence of parental guidance have been identified as causes of adolescent pregnancy and early sexual intercourse (Chung *et al.* 2018). Pregnancies among adolescent girls under 18 years of age can be associated with adverse sexual and reproductive health outcomes that will affect the mother and baby (UNFPA, 2013). Adolescent fertility in the DominicanRepublic declined from 167 births per 1000 women aged 15-19 years in 1960 to 91 births per 1000 women aged 15-19 in 2020 (World Bank, 2020). This shows that teenage pregnancy is still a huge public health challenge in this country, hence urgent action is required to address this problem so as to reduce adverse pregnancy outcomes. The aim of this paper is to model and forecast future trends of adolescent fertility in the Dominican Republic using the double exponential smoothing technique. Results from this study re expected to depict likely future trends of adolescent fertility in the out of sample period. This will stimulate an early response to the challenge of teenage pregnancy and child marriages in the country.

II. METHODOLOGY

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

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

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

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

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 slope of the trend at time t-1

Data Issues

This study is based on annual adolescent fertility rate in the Dominican Republic 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	A
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	

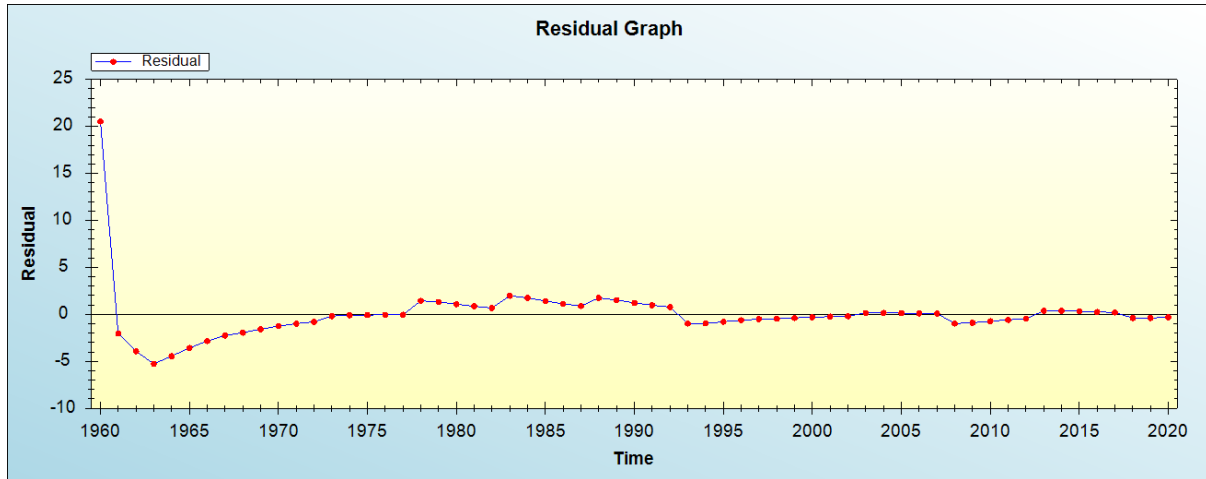|	
Mean Absolute Error (MAE)	1.360696
Sum Square Error (SSE)	557.471646
Mean Square Error (MSE)	9.138879
Mean Percentage Error (MPE)	0.022410
Mean Absolute Percentage Error (MAPE)	1.012656

Residual Analysis for the Applied Model
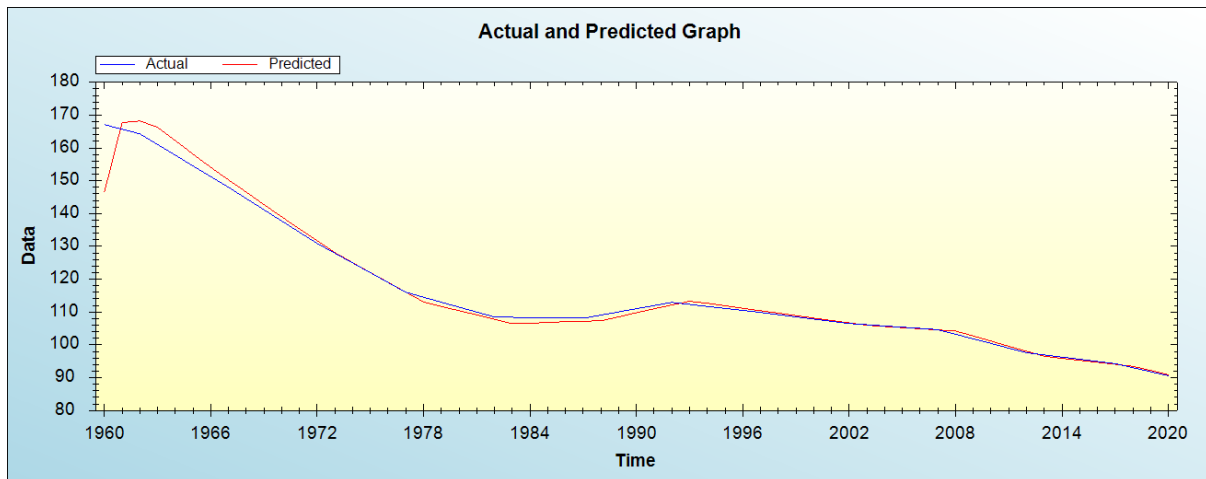

Figure 1: Residual analysis

In-sample Forecast for A

Figure 2: In-sample forecast for the A series

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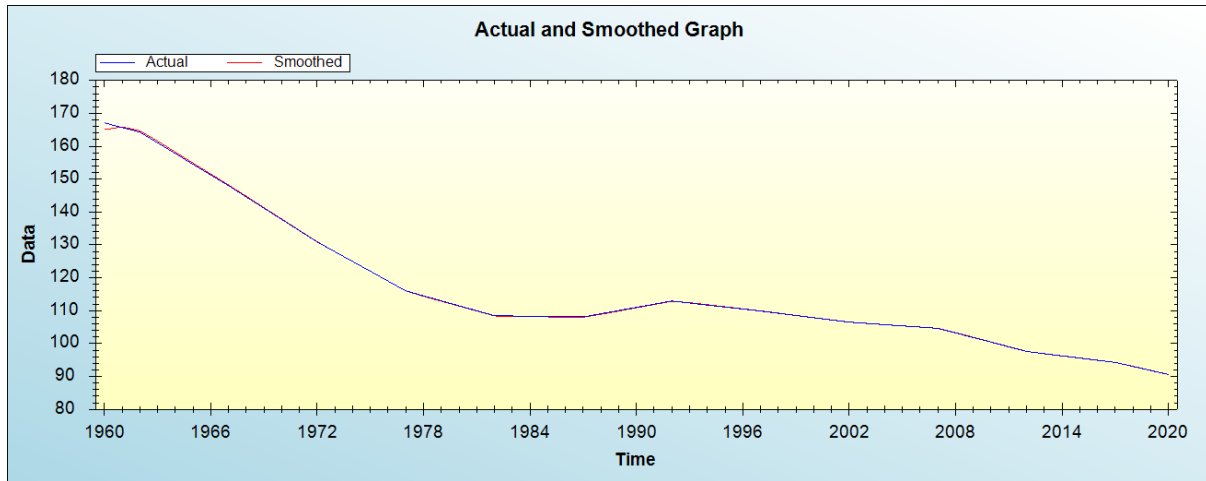
Actual and Smoothed graph for A series

Figure 3: Actual and smoothed graph for A series

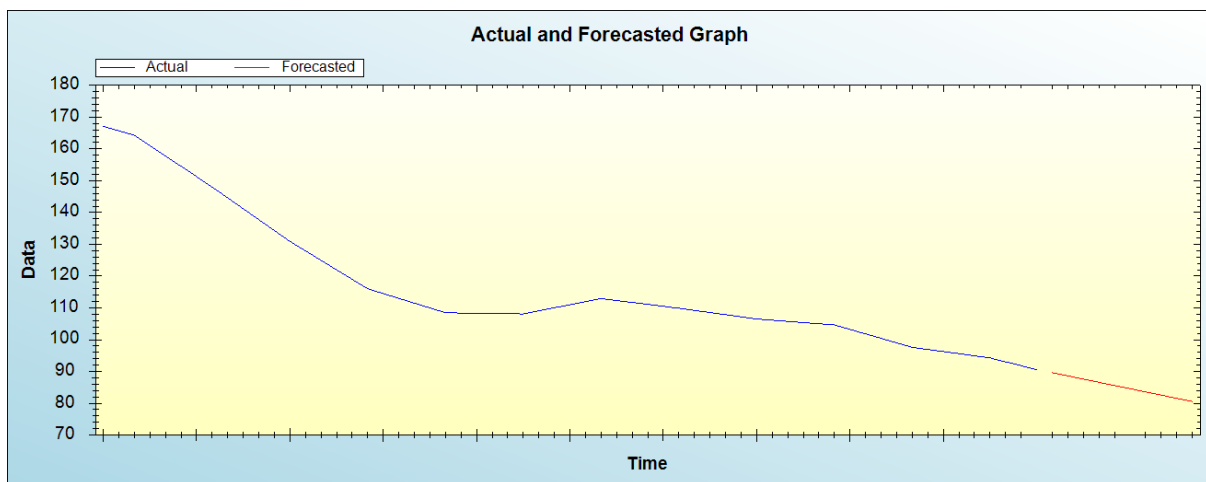Out-of-Sample Forecast for A: Actual and Forecasted Graph

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	Forecasted adolescent fertility rate
2021	89.6084
2022	88.6027
2023	87.5970
2024	86.5913
2025	85.5856
2026	84.5799
2027	83.5742
2028	82.5685
2029	81.5628
2030	80.5571

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 ratewill continue to decline and remain high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Low and middle income countries continue to report high rates of adolescent pregnancies with Sub-Saharan Africa being ranked at the top followed by South East Asia then lastly Latin America and the Caribbean. Existing challenges like poverty, lack of education, social norms, and absence of parental guidance have been identified as causes of adolescent pregnancy and early sexual intercourse. Adolescent fertility in the Dominican Republic gradually declined from 167 births per 1000 women aged 15-19 years in 1960 to 91 births per 1000 women aged 15-19 in 2020. These figures indicate that teenage pregnancy and child births is still a huge public health challenge in this country, hence urgent action is needed to address this problem so as to avert adverse pregnancy outcomes. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for the Dominican Republic. We established that adolescent fertility will continue to drop but remain high throughout the out of sample period. Therefore, the government must set up adolescent friendly clinics especially in marginalized areas, scale up awareness campaigns, strictly enforce laws that protect women's rights and promote girl child education.

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