Analyzing Future Trends of Adolescent Fertility for Sao Tome and Principe Using Holt's Linear Method

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Abstract - **This study uses annual time series data of adolescent fertility rate for Sao Tome and Principe 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 are 0.9 and 0.1 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline but still remain high throughout the out of sample period. Therefore, we encourage authorities in Sao Tome and Principe to continuously enforce laws that safeguard sexual and reproductive health rights of women and girls, promote girl child education and provide accessible and affordable adolescent health services.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The stage of adolescence is a very challenging phase due to multiple physiological and psychological changes that occur during this period (Azzopardi *et al.* 2019). These changes have a huge bearing on life decisions and choices adolescents make (Blackmore & Mills, 2014; Resnick *et al.* 2012). If not properly handled, teenagers end up being involved in risky behaviors such as unprotected sexual activity, drug and substance abuse and watching pornographic material on social media platforms which then increases their interest to explore sexual activity (Sychareun*et al.* 2018; Gibbs *et al.* 2012). Parents and legal guardians play a very important role at this stage of life as they provide guidance and support. Literature has revealed that lack or absence of this support, peer pressure, poverty and inadequate sexual and reproductive health knowledge are well documented risk factors for adolescent pregnancy (Wado *et al.* 2019; Kaphagawani & Kalipeni, 2017). Pregnancy among adolescents contributes 11% of global births of which 95% occur in low- and middle-income countries (LMICs) (WHO, 2016;UNFPA, 2013). Approximately 10 percent of global annual maternal deaths occur in adolescents, and maternal deaths are ranked as the second leading cause of death in this age group worldwide (UNFPA, 2013). It was established by previous authors that reducing the impacts of teenage pregnancy is critical due to the higher risk of adverse sexual and reproductive health outcomes such as maternal deaths, anemia in pregnancy, pregnancy induced hypertension, malnutrition, neonatal mortality, preterm birth, and low birth weight (Mekonnen *et al*. 2019; Althabe*et al.* 2015; Jeha *et al.* 2015; Ngowa *et al.* 2015; Ganchimeg *et al.* 2014; Kamini & Avvaru, 2014). Sao Tome and Principe (STP) is the second smallest sub-Saharan country but has one of the highest prevalence of adolescent pregnancies in the region which is estimated to be around 27% (UNICEF, 2014).The country´s maternal mortality ratio has steadily declined from 158.3 maternal deaths per 100,000 live births to 74 per 100,000 live births in 2014 (Sao Tome and Principe, 2018; UNDP, 2018; WHO, 2015). STP level of poverty is high, with 66.2 percent of the population living on less than two euros per day, which is a major obstacle to achieve universal coverage and also increases the risk of adolescent pregnancies (Sao Tome and Principe, 2018; UNICEF, 2014).

This paper applies the double exponential smoothing to model and forecast adolescent fertility for Sao Tome and Principe. The findings of this study are expected to highlight the future burden of adolescent births in the country. This will inform policy, planning and allocation of resources to teenage pregnancy prevention programs in the country.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Sao Tome and Principe. 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 method is specified as follows:

Model equations

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

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

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

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 t-1

Data Issues

This study is based on annual adolescent fertility rate in Sao Tome and Principe 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	
Mean Absolute Error (MAE)	0.806113
Sum Square Error (SSE)	227.307288
Mean Square Error (MSE)	3.726349
Mean Percentage Error (MPE)	-0.062222
Mean Absolute Percentage Error (MAPE)	0.621154

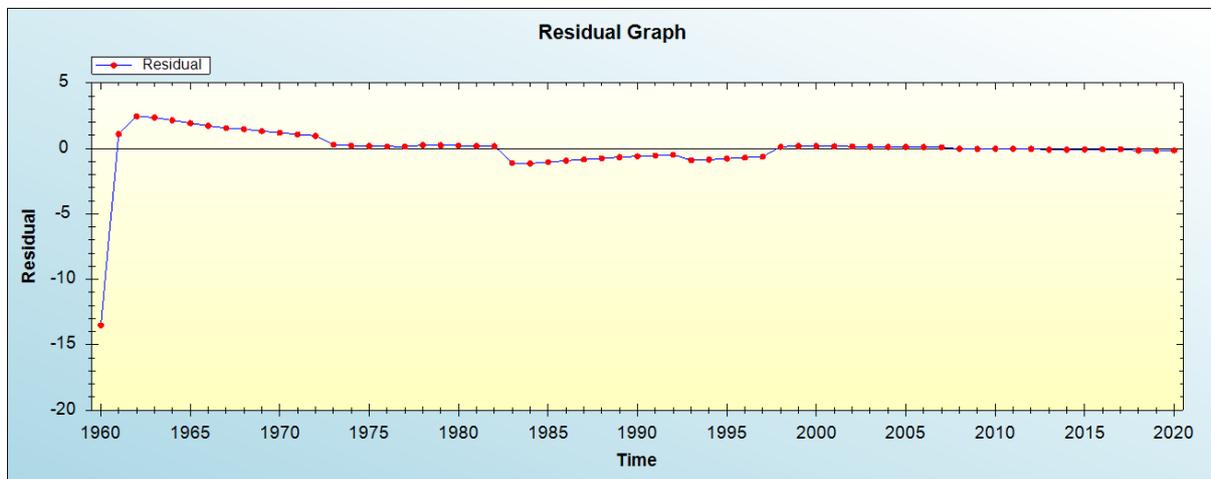Residual Analysis for the Applied Model

Figure 1: Residual analysis
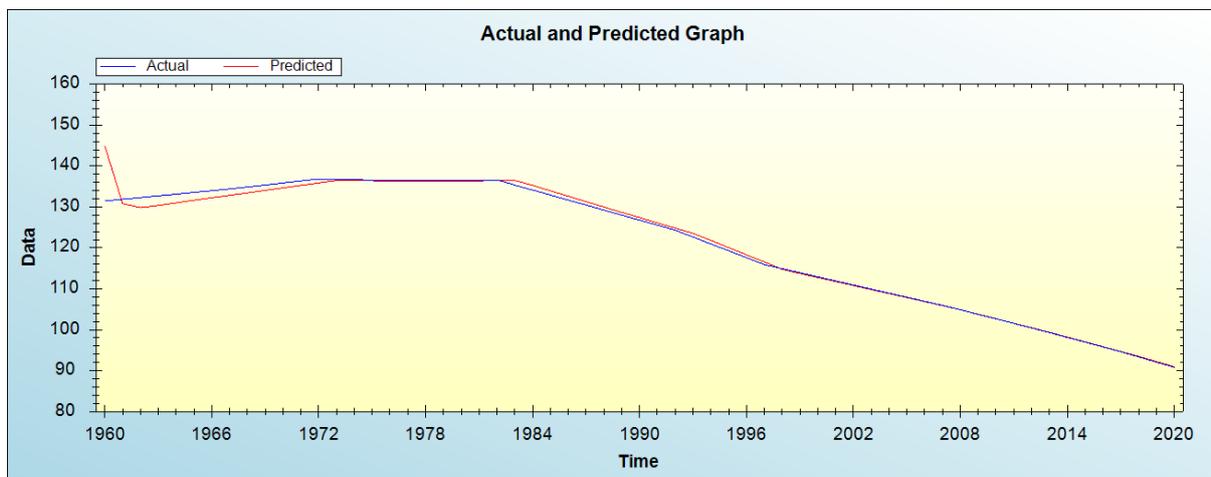
In-sample Forecast for X

Figure 2: In-sample forecast for the X series
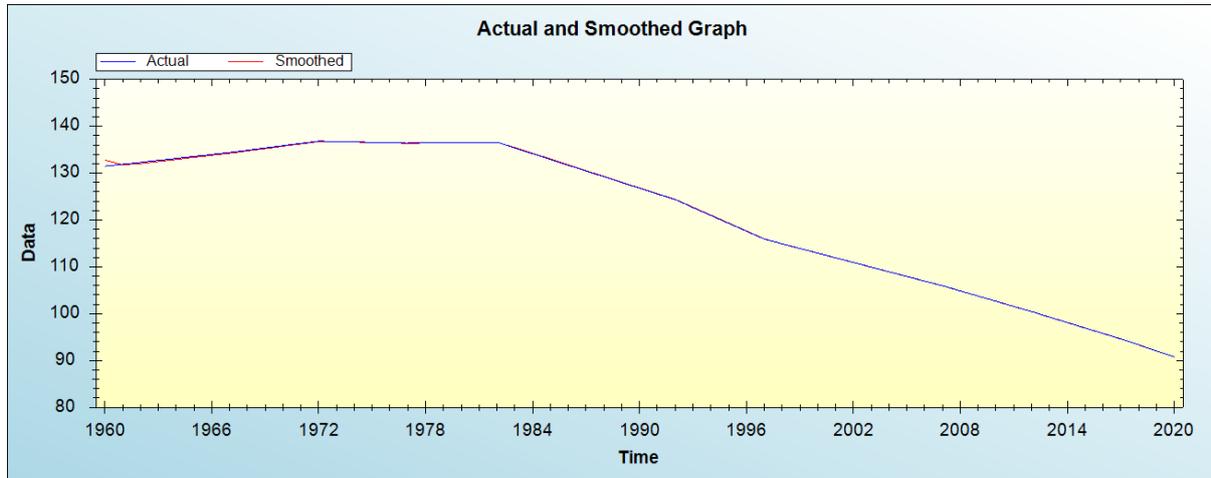
Actual and Smoothed graph for X series

Figure 3: Actual and smoothed graph for X series

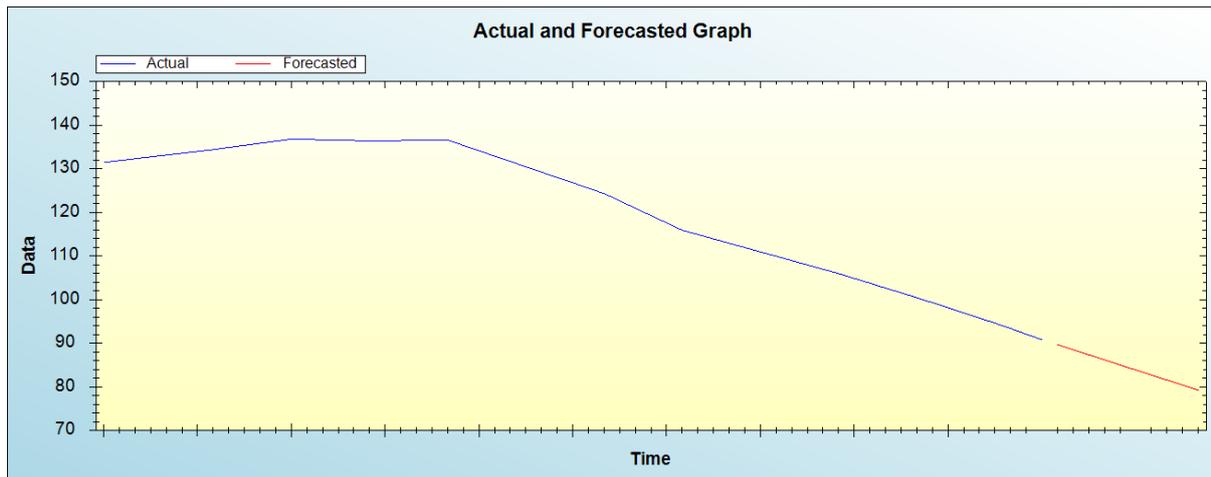Out-of-Sample Forecast for X: Actual and Forecasted Graph

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	89.6505
2022	88.4938
2023	87.3371
2024	86.1803
2025	85.0236
2026	83.8669
2027	82.7101
2028	81.5534
2029	80.3967
2030	79.2399

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 but still remain high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Sao Tome and Principe (STP) has one of the highest prevalence of adolescent pregnancies in the region which is estimated to be around 27 percent. Maternal mortality has steadily declined from 158.3 maternal deaths per 100,000 live births to 74 per 100,000 live births in 2014. According to the World Bank, adolescent fertility gradually declined from 131 births per 1000 women aged15-19 years in 1960 to 91 births per 1000 women aged 15-19 years in 2020. Multiple factors have been identified as predictors of teenage pregnancy in this country such s poverty, low educational level, lack of sexual and reproductive information and social norms. This study applied the double exponential smoothing technique to forecast future trends of adolescent fertility for Sao Tome and Principe. Our research findings suggested that adolescent fertility will continue to decline but remain high throughout the out of sample period. Therefore, we encourage authorities in this country to continuously enforce laws that safeguard sexual and reproductive health rights of women and girls, promote girl child education and provide accessible and affordable adolescent health services.

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