

How to Utilize the Double Exponential Smoothing Technique to Develop Effective Adolescent Health Policies to Address Teenage Pregnancy and Child Births in Jamaica

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Abstract - This research article uses annual time series data of adolescent fertility rate for Jamaica 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 throughout the out of sample period. Therefore, we encourage policy makers in Jamaica to set up more adolescent friendly clinics, continuously promote empowerment of women and girls and enforce laws that protect the rights of women and girls.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Addressing challenges faced by adolescents will have a positive impact on maternal and child health in any country. The adolescence stage is a complex stage in life which is characterized by multiple physiological, emotional and psychological changes (Noori *et al.* 2022; UNICEF, 2020). During this stage adolescents require proper parental guidance to enable them to make sound life decisions including the choice of sexual partners. Education on sexual and reproductive health in schools, colleges and in the community is very critical to prevent unintended pregnancies and other adverse SRH outcomes. Traditional leaders, City health promoters (CHPs), village health workers (VHWs), community health promoters and other stakeholders in the society should be given adequate information on family planning and educated on early identification of sexual abuse and domestic violence cases and prevention of unintended pregnancies especially among teenagers. Regular awareness campaigns should focus on addressing adolescent issues such as teenage pregnancy, alcohol and substance abuse, HIV and STI prevention, education, gender imbalances and respect of human rights especially women's rights. Studies conducted in low and middle income countries revealed that adolescent girls living in limited resource settings and in war zones have challenges in accessing sexual and reproductive health services. Low educational level, peer influence, lack of parental guidance are additional risk factors for teenage pregnancy (Lianget *et al.* 2019; Ochen *et al.* 2019; Galvão *et al.* 2018; Grønvik & Fossgard, 2018; Martínez *et al.* 2017; UNFPA, 2017; Woog & Kagesten, 2017; Neal *et al.* 2016; Blum & Gates, 2015; Araujo *et al.* 2013; Williamson, 2012; Tebeu *et al.* 2012). Previous studies have revealed that teenage pregnancy is associated with adverse pregnancy outcomes that can lead to maternal and perinatal mortality (Amjad *et al.* 2019; Margret Greene, 2015; WHO, 2014; Ganchimeg *et al.* 2014; Chandra-Mouli *et al.* 2013). In Jamaica adolescent fertility gradually declined from 150 births per 1000 women aged 15-19 years in 1960 to 48 births per 1000 women aged 15-19 years in 2020 (World Bank, 2020). This reflects significant progress made towards the reduction of teenage pregnancy and which then translates to the reduction of poor pregnancy outcomes in the country.

This paper aims to model and predict future trends of adolescent fertility in Jamaica using the double exponential smoothing technique. The findings of this paper will highlight likely future trends of adolescent fertility in the out of sample period. This will inform family planning policy, decisions 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 Jamaica. 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 equation

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

J_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 slope of the trend at time t

b_{t-1} is the slope of the trend at time period t-1

Data Issues

This study is based on annual adolescent fertility rate in Jamaica 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	J
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.774378
Sum Square Error (SSE)	750.417313
Mean Square Error (MSE)	12.301923
Mean Percentage Error (MPE)	0.090718
Mean Absolute Percentage Error (MAPE)	1.372261

Residual Analysis for the Applied Model

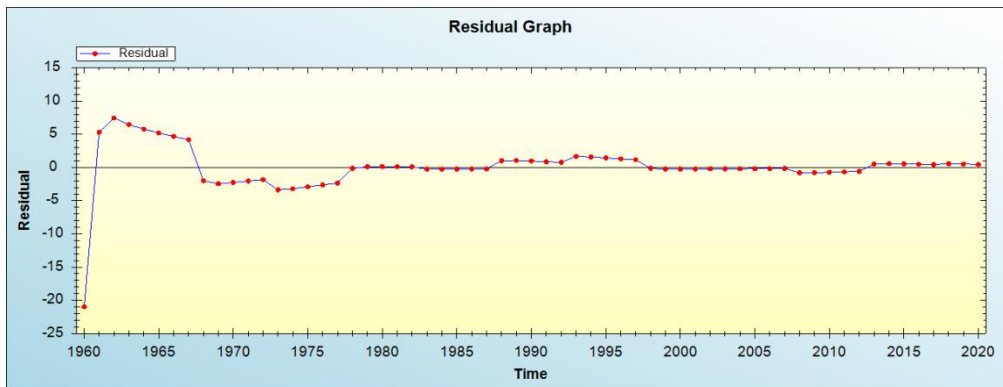


Figure 1: Residual analysis

In-sample Forecast for J

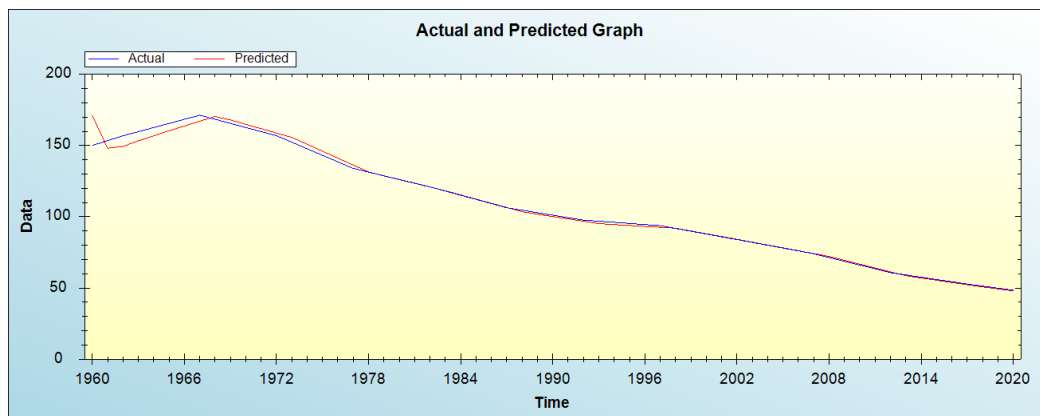


Figure 2: In-sample forecast for the J series

Actual and Smoothed graph for J series

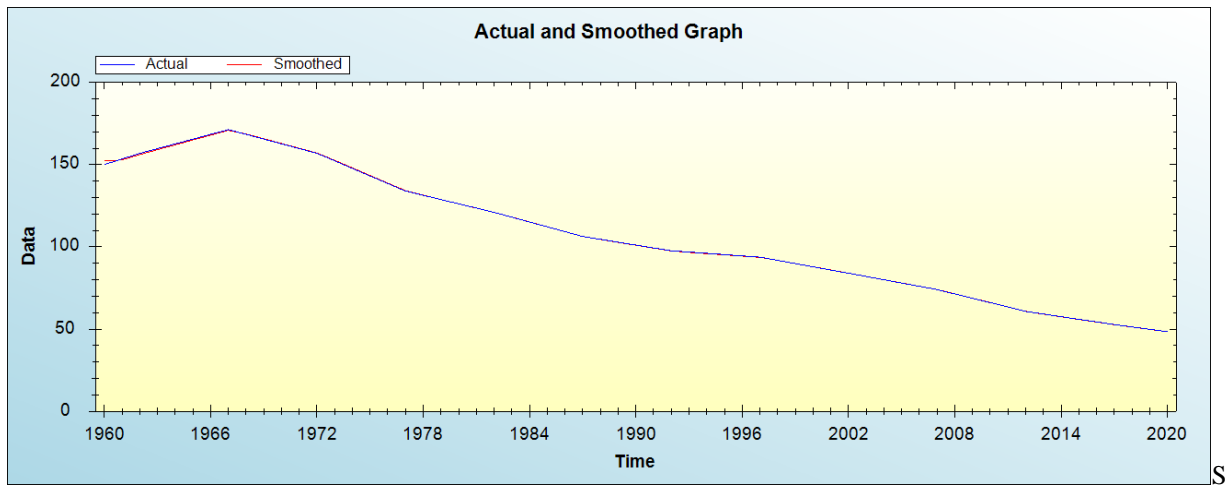


Figure 3: Actual and smoothed graph for J series

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

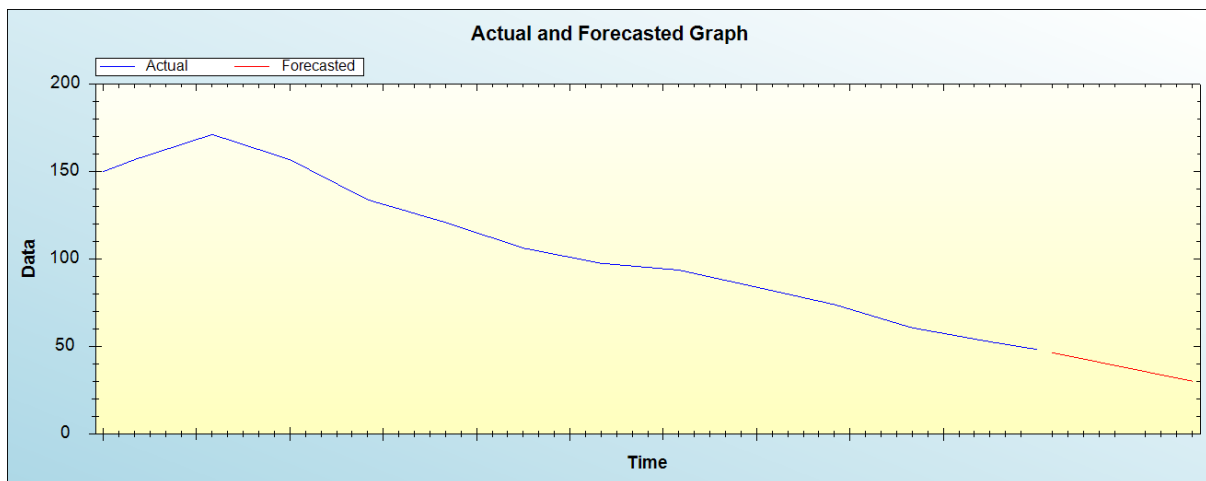


Figure 4: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Years	Predicted adolescent fertility rate
2021	46.5773
2022	44.7603
2023	42.9432
2024	41.1261
2025	39.3091
2026	37.4920
2027	35.6749
2028	33.8578
2029	32.0408
2030	30.2237

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 continues to be an important health problem in Jamaica. Adolescent fertility gradually declined from 150 births per 1000 women aged 15-19 years in 1960 to 48 births per 1000 women aged 15-19 years in 2020. This indicates significant progress made towards the reduction of teenage pregnancy and which then translates to the reduction of poor pregnancy outcomes in the country. This study applies Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Jamaica. We established that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage the government to set up more adolescent friendly clinics, continuously promote empowerment of women and girls and enforce laws that protect the rights of women and girls.

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