

Tracking the Future Path of Adolescent Fertility for Papua New Guinea Using Holt's Linear Method

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Abstract - This research article uses annual time series data of adolescent fertility rate for Papua New Guinea 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 rate will continue to decline throughout the out of sample period. Therefore, we encourage authorities in Papua New Guinea to relentlessly enforce laws that protect sexual and reproductive health rights of women and girls, scale up educational campaigns among communities and promote girl child education.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Papua New Guinea (PNG) is one of the countries in the world with very high maternal mortality ratio and the major causes of these deaths are obstetric hemorrhage, sepsis, embolism, eclampsia and unsafe abortion (Robbers *et al.* 2019; Williams, 2014). Evidence shows that this country continuously reported high MMR between 500 and 1000, between 1990 and 2013 (Kassebaum *et al.* 2013). According to the United Nations, the prevalence of unmet need for FP among women of childbearing age who were married or in union did not improve in PNG in the two decades from 1990 to 2010, making it one of 42 countries globally with an unmet need greater than 25 percent. In 2015, an estimated 317,000 women of childbearing age in PNG had an unmet need for FP, and this is projected to increase to 337,000 by 2030 (Alkema *et al.* 2020). Unintended pregnancies are common among teenagers as they usually have unprotected sexual activities which also exposes them to STIs and HIV (Chae *et al.* 2017). Unplanned pregnancies expose women to obstetric risks arising from undesired fertility, unsafe abortions, inadequate birth spacing, and pregnancies in high risk groups (Canning & Schultz, 2020; Sedgh *et al.* 2014; Singh & Darroch, 2012). Family planning (FP) using modern contraceptives has reduced the number of maternal deaths across the globe by forty percent over the past decades (Cleland *et al.* 2020). Literature shows that Adolescent pregnancy in PNG, just like other developing regions is due to peer pressure, poverty, exposure to pornographic material in various social media platforms, lack of parental guidance and adherence to social norms (Magnusson *et al.* 2019; Wado *et al.* 2019; Kaphagawani & Kalipeni, 2017; UNFPA, 2017; Gibbs *et al.* 2012; Peltzer, 2010).

This paper applies Holt's double exponential smoothing technique to model and forecast future trends of adolescent fertility in PNG. The findings are expected to depict the likely future burden of adolescent births in the country. This will trigger an appropriate policy response and allocation of resources to teen pregnancy prevention programs.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Papua New Guinea. 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 specified as follows:

Model equation

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

G_t is the actual 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 Papua New Guinea 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	G
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	

Mean Absolute Error (MAE)	0.688511
Sum Square Error (SSE)	119.683866
Mean Square Error (MSE)	1.962031
Mean Percentage Error (MPE)	0.022774
Mean Absolute Percentage Error (MAPE)	0.796893

Residual Analysis for the Applied Model

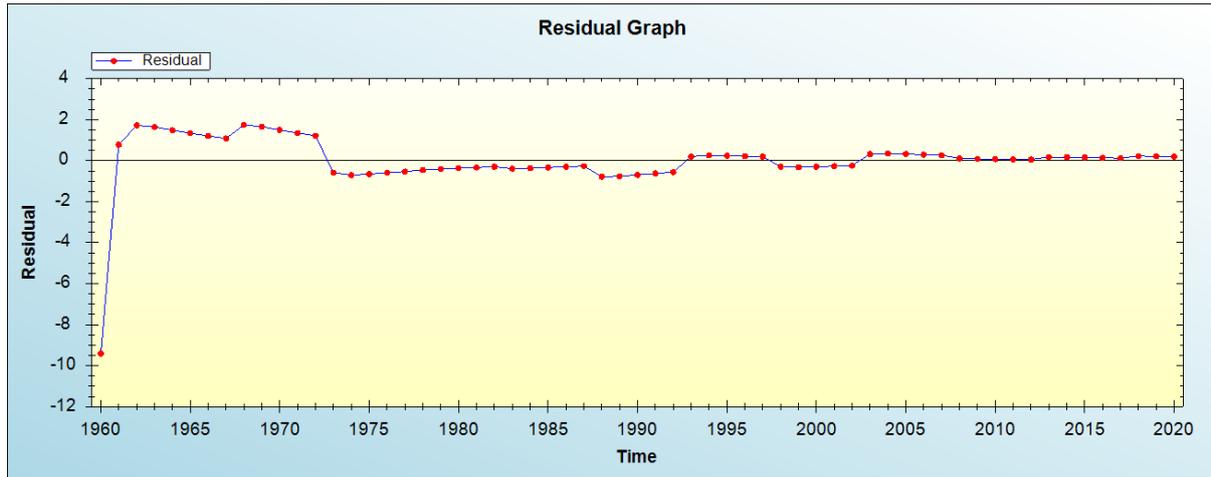


Figure 1: Residual analysis

In-sample Forecast for G

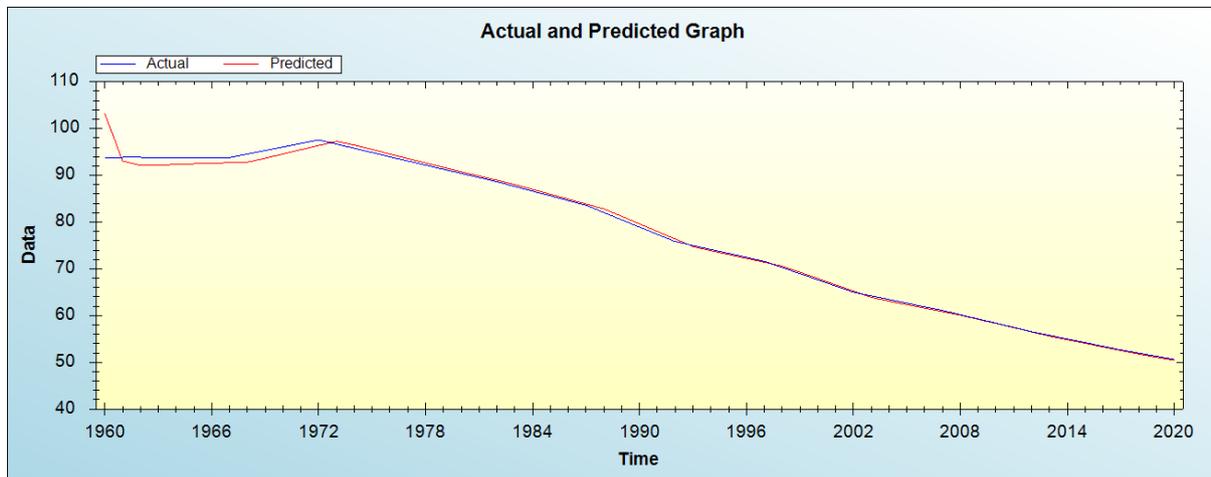


Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

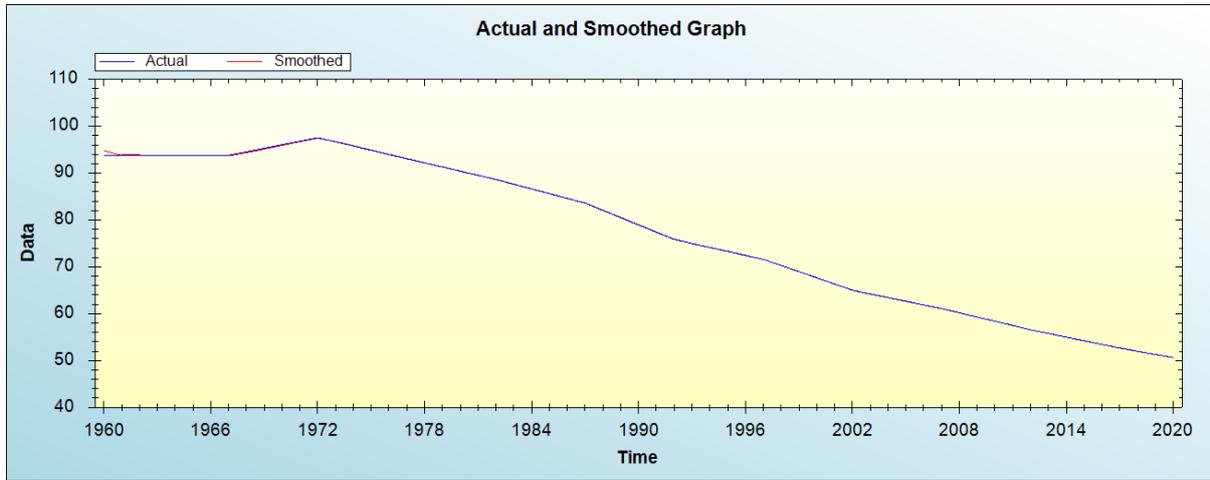


Figure 3: Actual and smoothed graph for G series

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

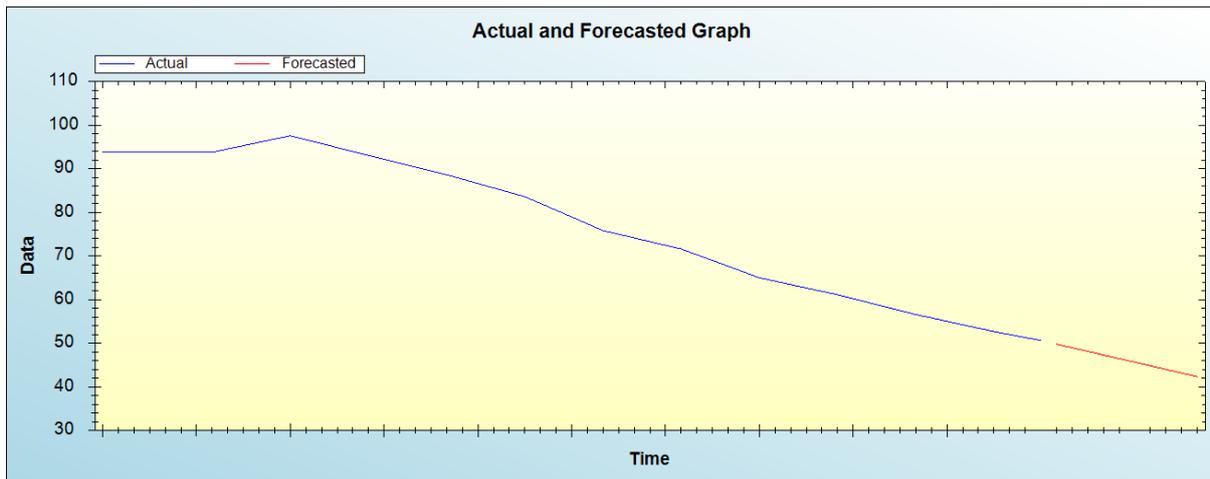


Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	49.7888
2022	48.9610
2023	48.1332
2024	47.3054
2025	46.4776
2026	45.6498
2027	44.8220
2028	43.9942
2029	43.1665
2030	42.3387

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

Papua New Guinea (PNG) is one of the countries in the world with very high maternal mortality and the major causes of these deaths are obstetric hemorrhage, sepsis, embolism, eclampsia and unsafe abortion. Literature shows that this country continuously reported high MMR between 500 and 1000, between 1990 and 2013. Teenage pregnancies in the country are attributed to peer pressure, poverty, exposure to pornographic material in various social media platforms, lack of parental guidance and adherence to social norms. As revealed by the World Bank, adolescent fertility declined from 94 births per 1000 women aged 15-19 years in 1960 to 50.6 births per 1000 women aged 15-19 years in 2020. This study applied Holt's double exponential smoothing technique to predict future trends of adolescent fertility for Papua New Guinea. Study findings showed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage authorities in PNG to relentlessly enforce laws that protect sexual and reproductive health rights of women and girls, scale up educational campaigns among communities and promote girl child education.

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