

Adolescent Fertility Prediction for Pakistan Using Holt's Linear Method

¹Smartson. P. NYONI, ²Thabani NYONI

¹ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract - This study uses annual time series data of adolescent fertility rate for Pakistan 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 0.2 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 Pakistan to continuously support girl child education and empowerment of women, and improve the quality, accessibility and affordability of adolescent health services especially in the rural areas.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Teenage pregnancy remains a global health problem which can result in undesirable maternal and child health outcomes (Sayem & Nury, 2011). The problem is more prevalent in low- and middle-income countries (LMICs) compared to high-income countries (WHO, 2014). The agenda 2030 for sustainable development through its 3rd sustainable development goal has a target to reduce adverse effects of teenage pregnancy by aiming to eliminate all harmful practices including early child marriages by 2030 (UN, 2020; UN, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). In South Asia, a bigger proportion of women become pregnant in early life because of child marriage and the social expectation to have a child soon after marriage (Raj *et al.* 2010). Pregnancy among adolescents is usually due to lack of knowledge and misconceptions regarding contraception. Previous studies carried out in South Asia have highlighted that wider socio-demographic and cultural factors, such as limited education for women, low socioeconomic status, as well as being part of an ethnic or religious minority, increase the prevalence of teenage marriages and pregnancies (Islam *et al.* 2017; Brahmhatt *et al.* 2014; Sayem& Nury, 2011; Mukhopadhyay *et al.* 2010).There are forty million adolescents in Pakistan, who represent 22.3% of the total population (UNICEF, 2012). Roughly fifty percent of teenage girls get married before the age of 18 years (Mubeen & Baig, 2016)and 7.7 percent of all women become pregnant before the age of 19 years (World Bank, 2020). In addition, there is a geographic variation in adolescent pregnancy (NIPS *et al.* 2019).Pakistan is a signatory to the agenda 2030 for Sustainable Development Goal (2015–2030) and in line with this, has developed a monitoring and evaluation mechanism for the National Health Vision 2016–2025. There is evident coordination of activities designed to address maternal and child health issues in the country (NIPS *et al.* 2019). The 3rd SDG aims to ensure healthy lives and promote well-being at all ages—includes bringing the global NMR to as low as 12 deaths per 1000 live births and the MMR to less than 70 deaths per 100,000 live births by 2030 (UNICEF, 2018). SDG3 target 3.7 focuses on ensuring availability of affordable and quality sexual and reproductive health services including that of adolescents. In line with Vision 2030, this paper applies Holt's double exponential smoothing technique to forecast future trends of adolescent fertility in Pakistan. The findings are envisioned to depict the future burden of adolescent births in the country and facilitate planning, and allocation of resources to programs designed to end child marriage and protection of women's rights.

II. METHODOLOGY

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

P_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 Pakistan 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	P
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900

Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.005030
Sum Square Error (SSE)	301.006163
Mean Square Error (MSE)	4.934527
Mean Percentage Error (MPE)	0.309497
Mean Absolute Percentage Error (MAPE)	1.232911

Residual Analysis for the Applied Model

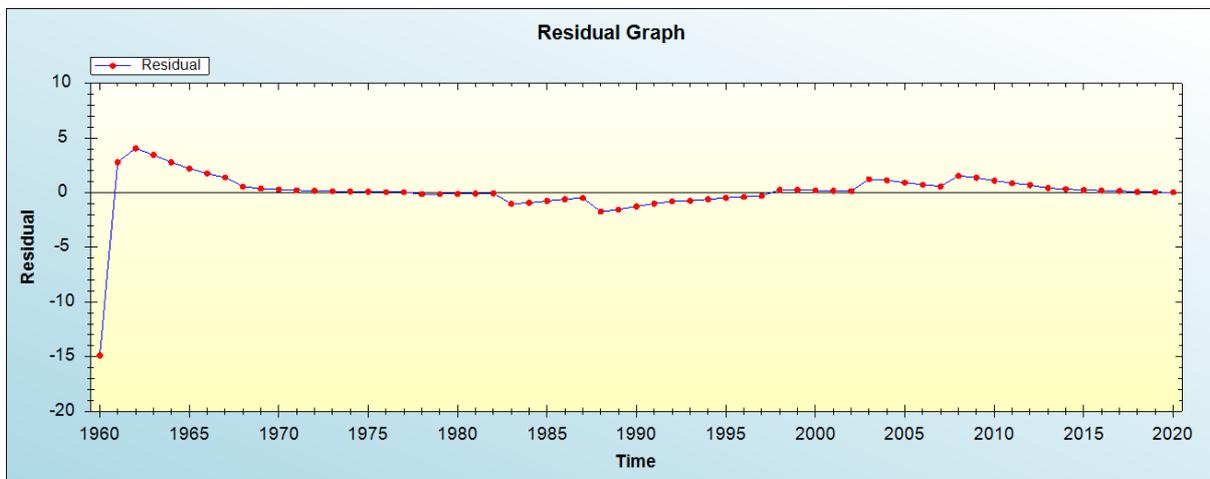


Figure 1: Residual analysis

In-sample Forecast for

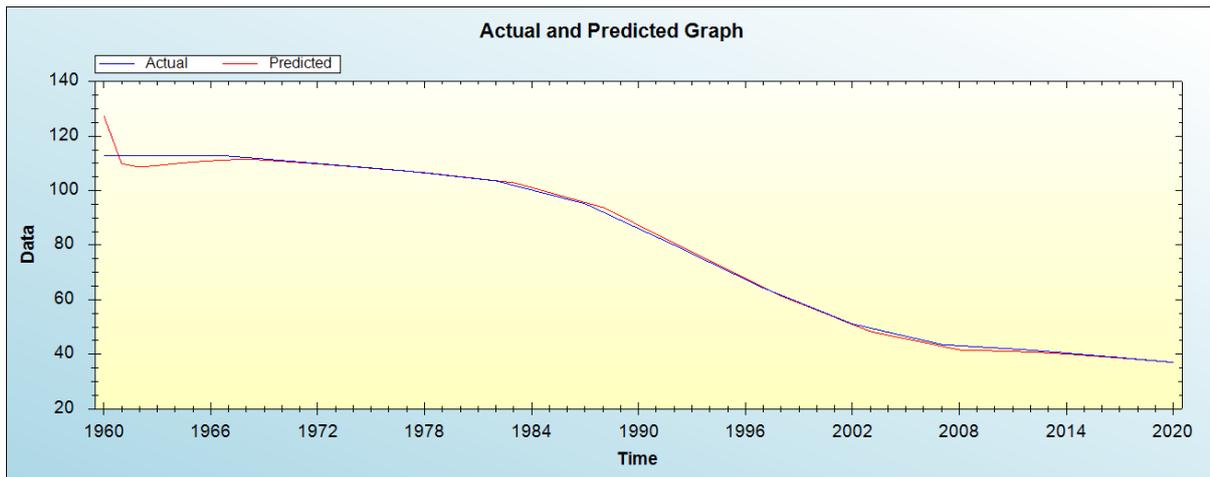


Figure 2: In-sample forecast for the P series

Actual and Smoothed graph for P series

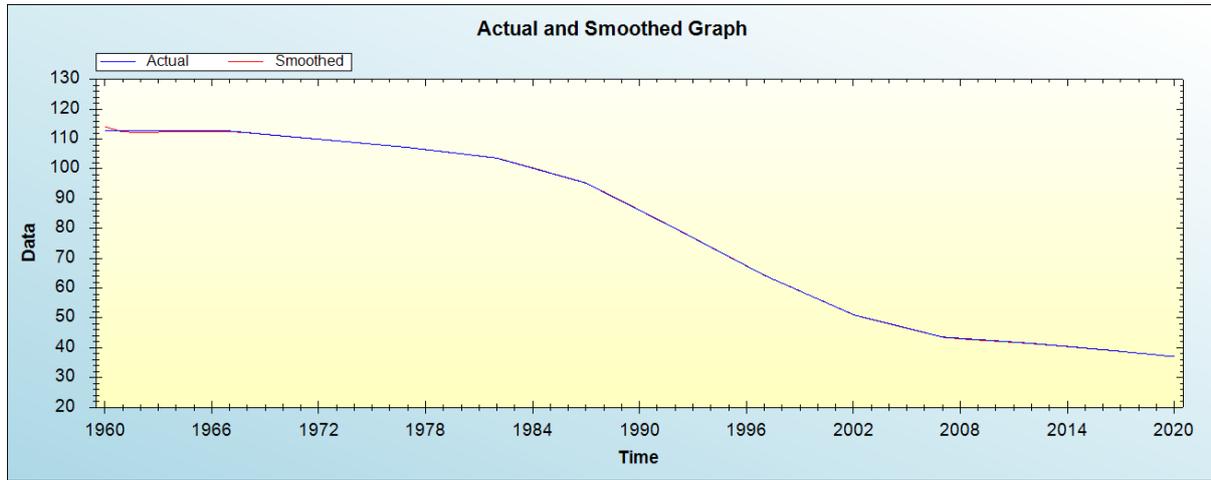


Figure 3: Actual and smoothed graph for P series

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

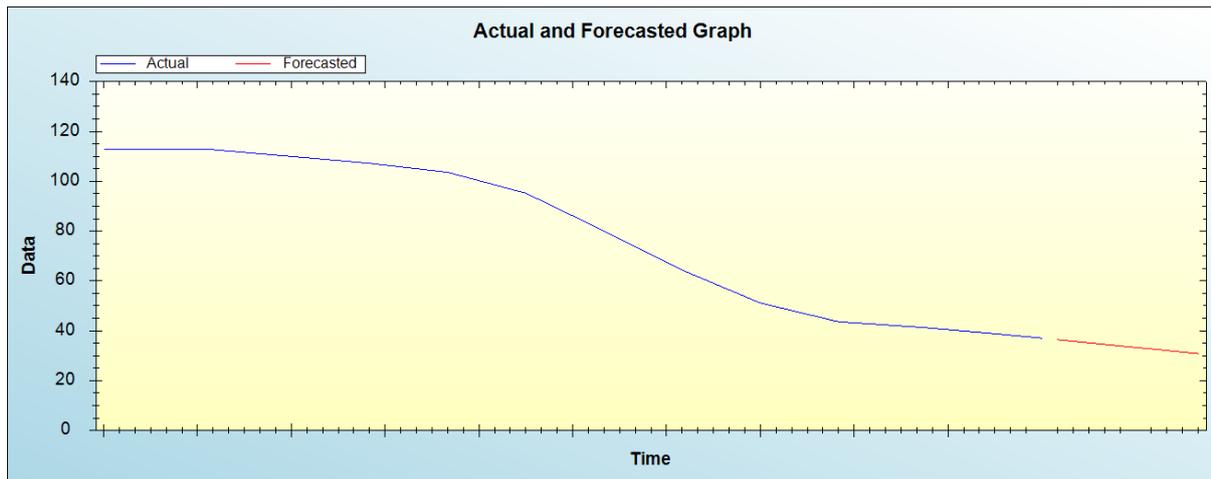


Figure 4: Out-of-sample forecast for P: actual and forecasted graph

Out-of-Sample Forecast for P: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	36.4024
2022	35.7813
2023	35.1602
2024	34.5391
2025	33.9180
2026	33.2969
2027	32.6758
2028	32.0547
2029	31.4336
2030	30.8125

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 drop throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

In South Asia, a huge proportion of women become pregnant in early life because of child marriage and the social expectation to have a child soon after marriage. Pregnancy among adolescents is usually a result lack of knowledge and misconceptions regarding contraception. In addition, limited education for women, low socioeconomic status, as well as being part of an ethnic or religious minority increase the prevalence of teenage marriages and pregnancies. As highlighted by the World Bank, adolescent fertility in Pakistan gradually declined from 112 births per 1000 women aged 15-19 years in 1960 to 37 births per 1000 women aged 15-19 in 2020. This decline can be attributed to the national family planning program, increase in age at marriage and awareness among adolescents. This study applied the double exponential smoothing technique to forecast future trends of adolescent fertility for Pakistan. Our study findings revealed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage authorities in Pakistan to continuously support girl child education and empowerment of women, and improve the quality, accessibility and affordability of adolescent health services especially in the rural areas.

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