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Detecting Future Trends of Adolescent Fertility for India Using the Double Exponential Smoothing Technique

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***Abstract* - This study employs annual time series data of adolescent fertility rate for India 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 is expected to be very low throughout the out of sample period. Therefore, we encourage authorities in India to prioritize improvement of accessibility and quality of adolescent health services especially in the rural areas.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

There are at least 243 million adolescents in India and this has a huge bearing on labor force and resources required to address challenges that come with adolescent pregnancies such as preterm deliveries, low birth weight and malnutrition which usually occurs among children born to adolescent mothers (India, 2018; CSO, 2017; Petroni *et al.* 2015;Achyut*et al.* 2011;Venkaiah *et al.* 2002; Jejeebhoy, 1998).According to NFHS-III, 12 percent of women aged 15–19 years become mothers and four percent of women aged 15–19 years are currently pregnant with their first child. The percentage of women who have begun childbearing increases sharply with age, from three percent at age 15 to thirty six percent at age 19. The proportion of women aged 15–19, who have begun childbearing, is more than twice as high in rural areas (19%) as in urban areas (9%). The level of teenage pregnancy and motherhood is nine times higher among women with no education than among women with 12 or more years of education. Above 25 percent of women aged 15–19 with no education have become mothers and almost one-third of them have begun childbearing (India MOH, 2007). NFHS-4 revealed that the prevalence of child marriage amongst 15-19 years old and 20-24 years old is 11.9% and 26.8% respectively for girls in India. Child marriage prevalence in rural and urban India is 14.1% and 6.9% respectively for age group 15-19 years and 31.5% and 17.5% respectively for rural and urban areas for age group 20-24 years. Furthermore, analysis of NHFS-4 indicates that the highest prevalence of child marriage is amongst Scheduled Tribe girls (15%) followed by Scheduled Castes (13%). District level analysis using NFHS-4 shows that amongst all the districts in India, Murshibad (39.9%) in West Bengal has the highest prevalence of child marriage amongst 15-19 years old, followed by Gandhinagar (39.3%) in Gujarat, Bhilwara (36.4%) in Rajasthan, Shrawasti (36.3%) in Uttar Pradesh, Birbhum (35.2%) in West Bengal, Khagaria (34.4%) in Bihar, Goalpara (33.9%) in Assam, Deoghar (32.7%) and Giridih (32.2%) in Jharkhand (Young Lives, 2018). Literature has shown that child marriage is associated with negative consequences such as early pregnancy, maternal and neonatal mortality, school dropouts, reduced employment prospects, exposure to gender based violence and sexual abuse (John *et al.* 2019; Raj &Boehmer, 2013).The government of India has made significant progress in the reduction of child marriages, however more needs to be done especially in the rural areas. In line with Vision 2030, this paper applies Holt's double exponential smoothing method to predict future trends of adolescent fertility. The findings will guide policy makingand resource allocation towards activities designed to end child marriage and the 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 India. 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.

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Holt's linear method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

Y_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

Data Issues

This study is based on annual adolescent fertility rate in India 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	Y
Included Observations	61

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Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.787780
Sum Square Error (SSE)	980.268819
Mean Square Error (MSE)	16.069981
Mean Percentage Error (MPE)	0.424926
Mean Absolute Percentage Error (MAPE)	2.661862

Residual Analysis for the Applied Model

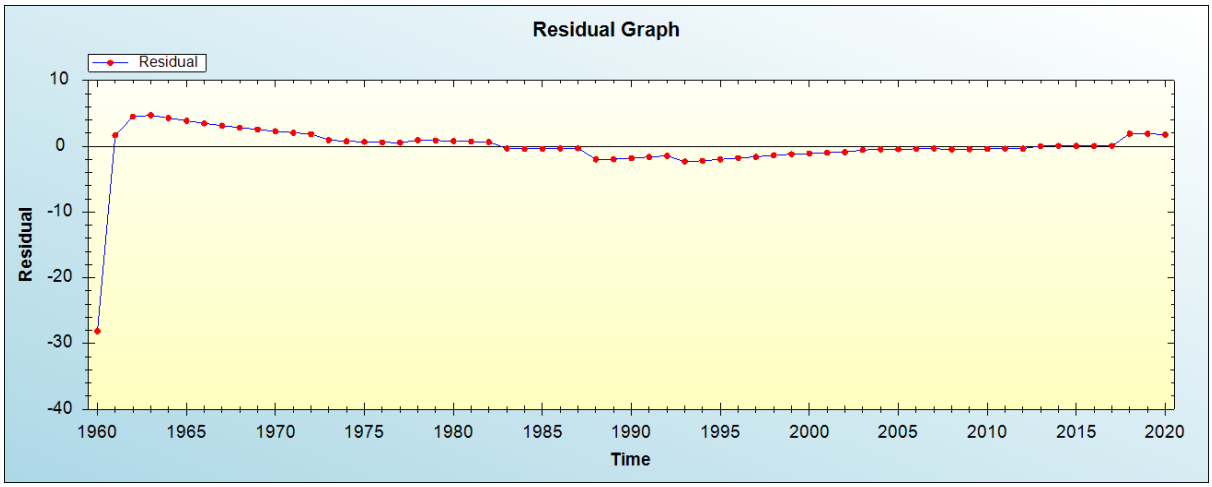

Figure 1: Residual analysis

In-sample Forecast for Y

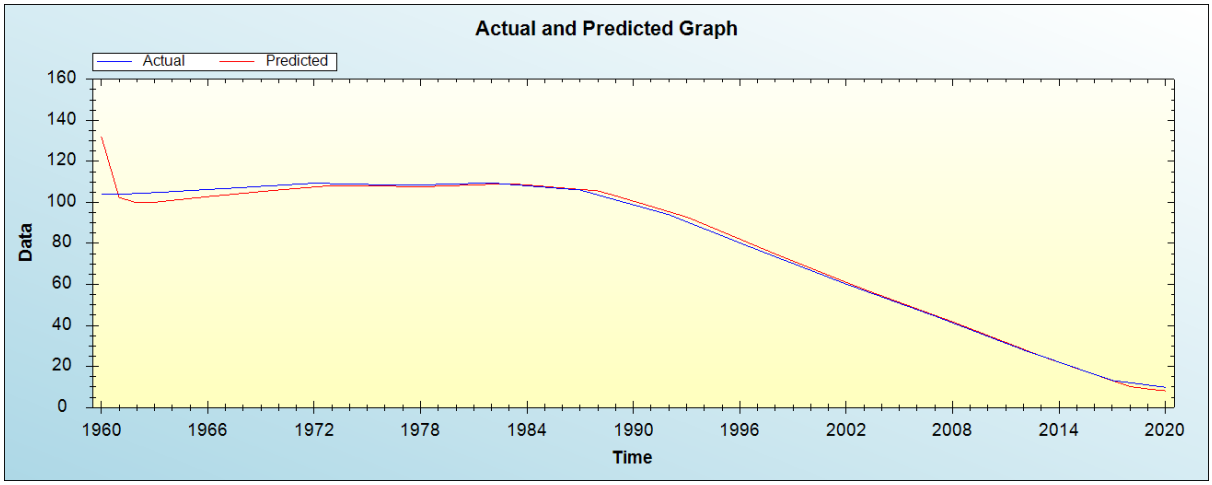

Figure 2: In-sample forecast for the Y series

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Actual and Smoothed graph for Y series

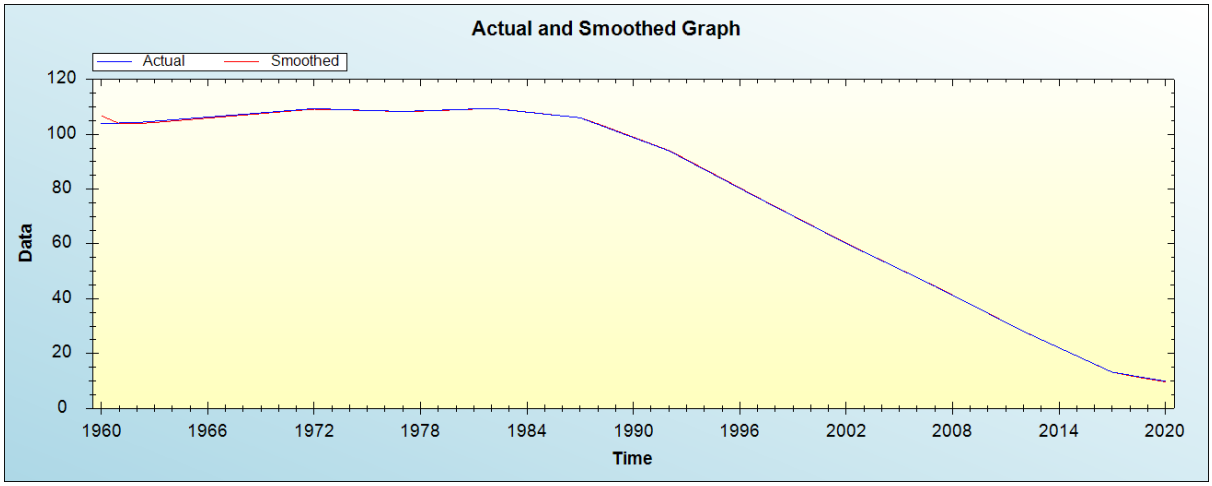

Figure 3: Actual and smoothed graph for Y series

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

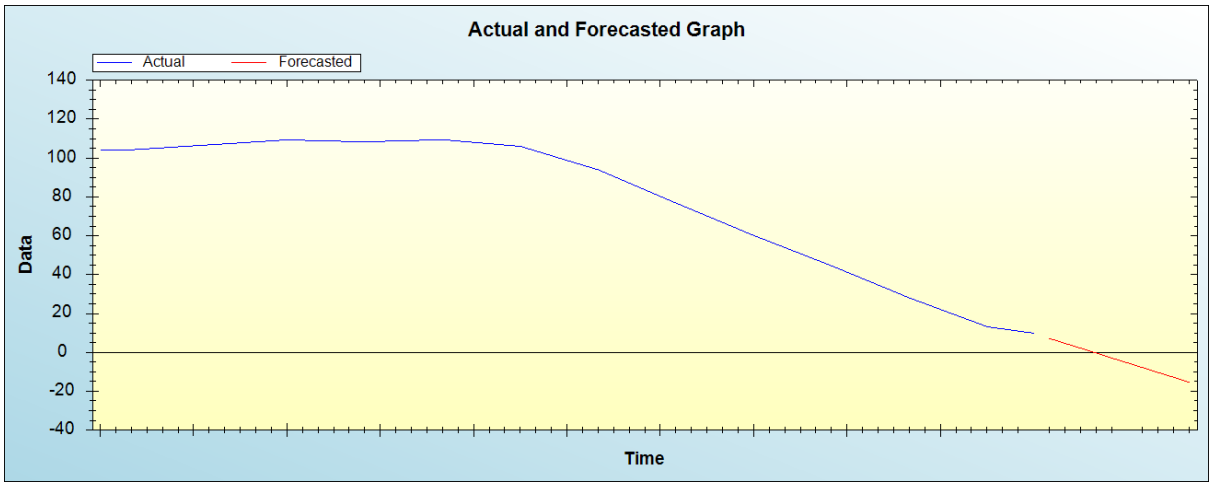

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	7.1768
2022	4.6702
2023	2.1636
2024	-0.3429
2025	-2.8495
2026	-5.3561
2027	-7.8627
2028	-10.3693
2029	-12.8759
2030	-15.3825

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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 is expected to be very low throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Teenage pregnancy and child marriage continues to be an important public health problem in India. It is important to highlight that India has made tremendous progress towards ending teenage pregnancy and child marriage as evidenced by the substantial decline of adolescent birth rate during the period 1960-2020 as a result of the increase in age at marriage, national family planning program, improvements in the educational levels among women and better employment opportunities for women. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for India. Our study results revealed that adolescent fertility will be very low throughout the out of sample period. Therefore, the Indian government is encouraged to prioritize improvement of accessibility and quality of adolescent health services especially in the rural areas.

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