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Predicting Future Trends of Adolescent Fertility for Peru Using Holt's Linear Method

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Peru 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 0.4 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 the government of Peru to scale up educational campaigns among communities, protect sexual and reproductive rights of women and girls and establish more adolescent friendly clinics.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

According to the World Health Organization, the adolescence stage is the transition period between childhood and adulthood. It is the period between 10 and 19 years (WHO, 2020). The physical, psychological, and social changes encountered in this phase of life can expose young people to risky sexual behaviors (Paredes &Espinoza, 2021). Teenage pregnancy is increasingly becoming a major policy issue as several previous studies highlighted adverse maternal and child health outcomes linked to teenage pregnancy and child birth (Amjad *et al*. 2019; Grønvik & Fossgard, 2018; Kirbas*et al.* 2016; Neal *et al.*2016). Undesirable consequences include preterm delivery, low birth weight, pregnancy induced hypertension, maternal and perinatal mortality (Althabe*et al.* 2015; Ganchimeg *et al.* 2014; Malabarey *et al.* 2012).Previous studies have shown that predictors of teenage pregnancy include low socio-economic status, lack of access to education, previous history of teen pregnancy, domestic violence, and sexual harassment (Ochen*et al.* 2019; Islam *et al.* 2017; Wall Wieler *et al.* 2016; Garwood*et al.* 2015). The 2017 census revealed that 30.5 percent of women aged 14-19 years were pregnant or had children already (NIS, 2018). Despite significant investments in family planning services, the Peruvian government continues to report high teenage pregnancy rates (Favara *et al.* 2016).

This paper applies the double exponential smoothing technique to forecast future trends of adolescent fertility in Peru. The research findings are going to assist in policymaking, planning and allocation of resources to teenage pregnancy prevention programs.

II. METHODOLOGY

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

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

Smoothing equation

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

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$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

H_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 Peru 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	H
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	0.677006
Sum Square Error (SSE)	135.377461
Mean Square Error (MSE)	2.219303

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Mean Percentage Error (MPE)	0.023363
Mean Absolute Percentage Error (MAPE)	0.693244

Residual Analysis for the Applied Model

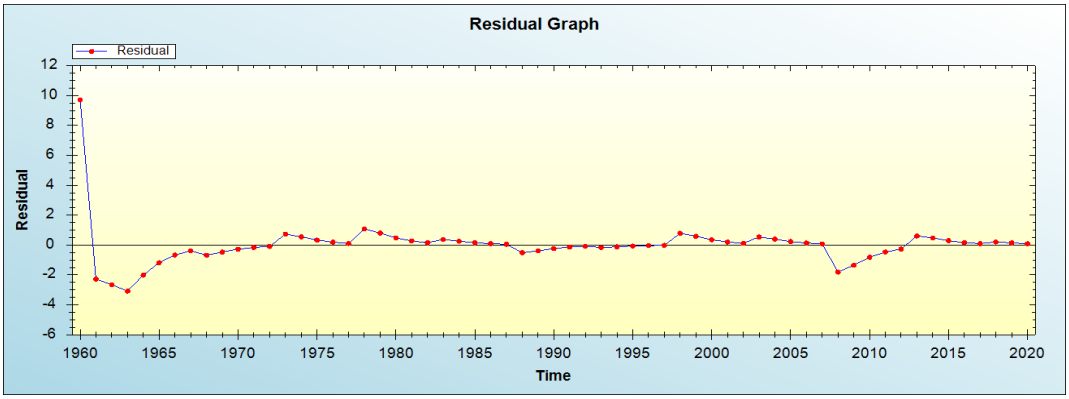

Figure 1: Residual analysis

In-sample Forecast for H

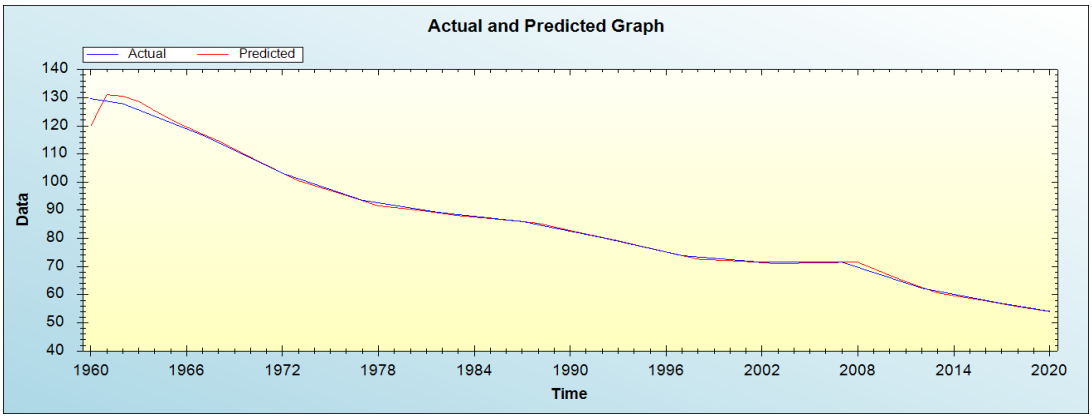

Figure 2: In-sample forecast for the H series

Actual and Smoothed graph for H series

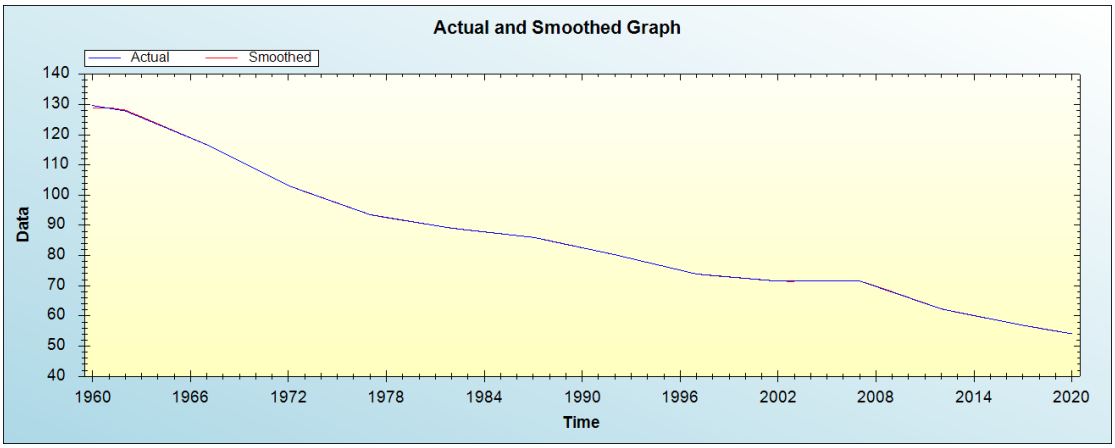

Figure 3: Actual and smoothed graph for H series

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

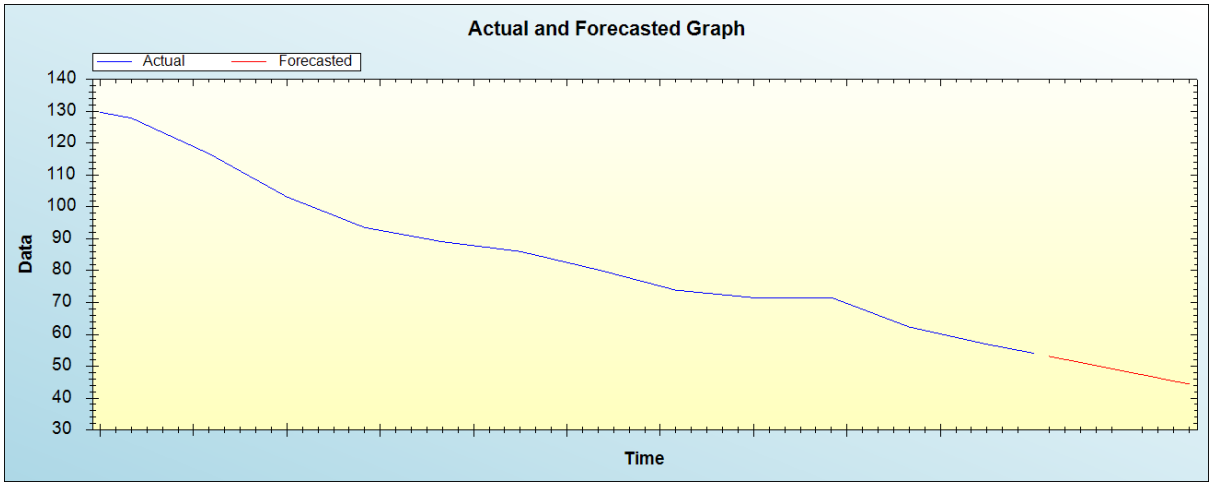

Figure 4: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	53.1112
2022	52.1398
2023	51.1684
2024	50.1969
2025	49.2255
2026	48.2541
2027	47.2827
2028	46.3112
2029	45.3398
2030	44.3684

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

Despite significant investments in family planning services, the Peruvian government continues to report high teenage pregnancy rates. Adolescent fertility declined steadily from 129.68 in 1960 to 54 in 2020. Low socio-economic status, lack of access to education, previous history of teen pregnancy, domestic violence, and sexual harassment are among the factors which significantly contribute to teenage pregnancy. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Peru. Our study findings showed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage the Peruvian government to scale up educational campaigns among communities, protect sexual and reproductive rights of women and girls and establish more adolescent friendly clinics.

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