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Detecting Future Trends of Adolescent Fertility for Ecuador Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This study employs annual time series data of adolescent fertility rate for Ecuador 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 0.3 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline but remain high throughout the out of sample period. Therefore, we encourage authorities in Ecuador to scale up awareness campaigns among communities, strictly enforce laws that protect women's rights, promote girl child education and finance empowerment projects for youths.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adverse sexual and reproductive health outcomes remain a global health challenge especially in developing countries. Antepartum hemorrhage, hypertensive disorders, obstructed labour, birth trauma, preterm delivery and severe prematurity are among the leading causes of maternal and child mortality (WHO, 2014; UNFPA, 2013). Maternal deaths tend to be higher among teenage pregnant mothers when compared to females in their twenties (Grønvik & Fossgard, 2018; Banke-Thomas *et al.* 2017). It has been proven in previous studies conducted in developing and developed countries that infants born to teenage mothers have an increased risk of experiencing adverse pregnancy outcomes (de Vienne *et al.* 2009). Low-middle income countries have higher teenage pregnancy rates and poor outcomes as a result of many factors such as poverty, lack of adequate resources, low educational level and low contraceptive prevalence rates and inaccessible family planning services (UNFPA, 2015; UNFPA, 2013;McMichael & Gifford, 2010). The United Nations highlighted establishing health interventions targeting adolescent sexual and reproductive health is expected to reduce teenage pregnancy and its complications (UN, 2020; UNICEF, 20I8; UN, 2016; UN, 2015). Moreover, suitable legal and policy frameworks at national, regional and global levels are necessary to achieve gender equality and elimination of child marriage especially in developing countries (UN, 2015; UN, 1995). The agenda 2030 for sustainable development through its 3rd sustainable development goal (SDG-3) also emphasizes the importance of addressing adolescent sexual and reproductive health by providing accessible and affordable family planning services (UN, 2015).

This paper applies the double exponential smoothing technique to forecast adolescent fertility in Ecuador. Findings of this study will depict future trends of adolescent fertility in the out of sample period. This will trigger an appropriate national response to the challenge of teenage pregnancy and child marriage.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Ecuador. 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 exponential smoothing method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

A_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 Ecuador 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	A
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300

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Forecast performance measures	
Mean Absolute Error (MAE)	0.556617
Sum Square Error (SSE)	101.814043
Mean Square Error (MSE)	1.669083
Mean Percentage Error (MPE)	0.040784
Mean Absolute Percentage Error (MAPE)	0.501546

Residual Analysis for the Applied Model

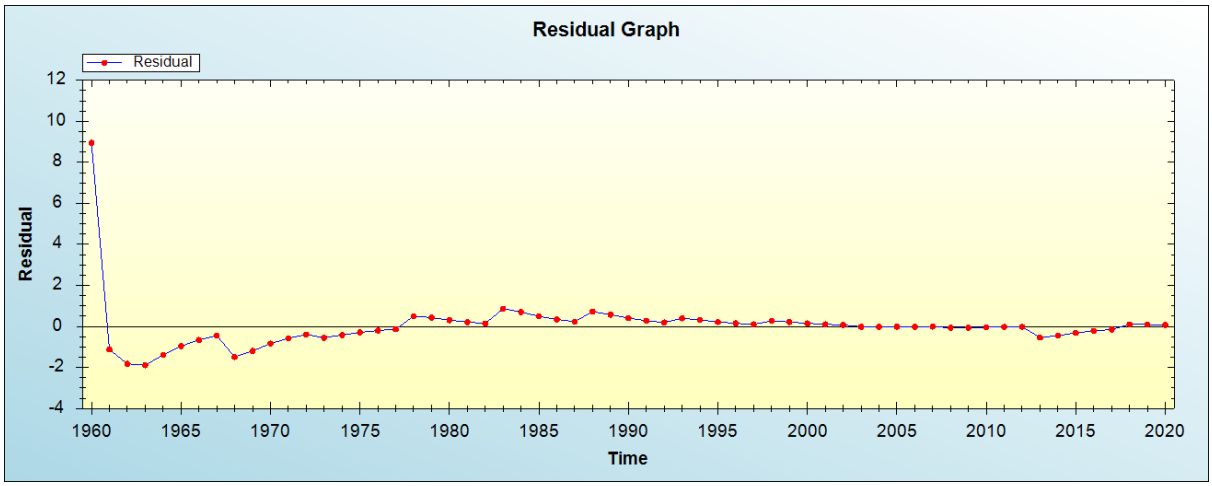

Figure 1: Residual analysis

In-sample Forecast for A

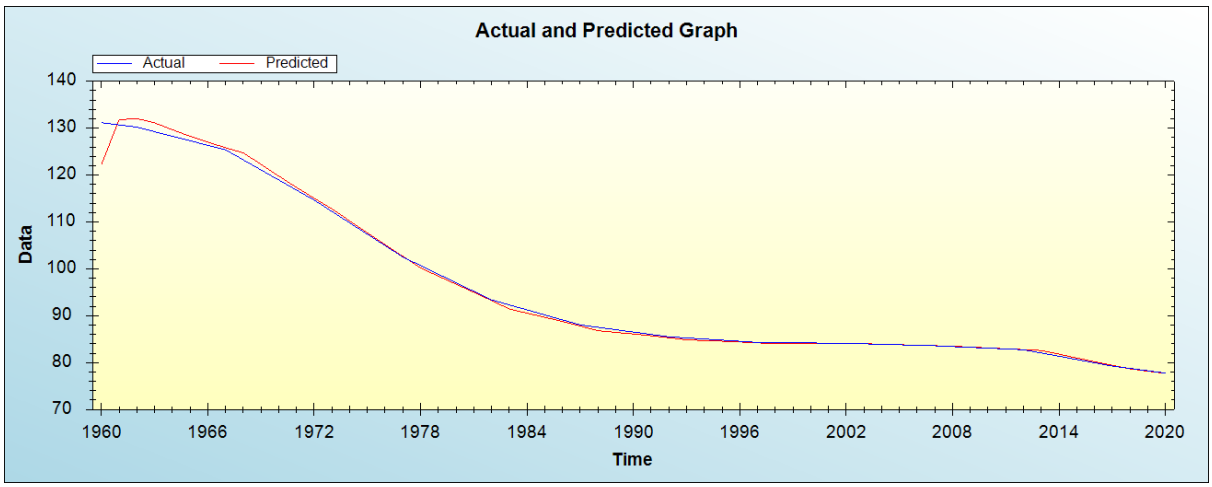

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

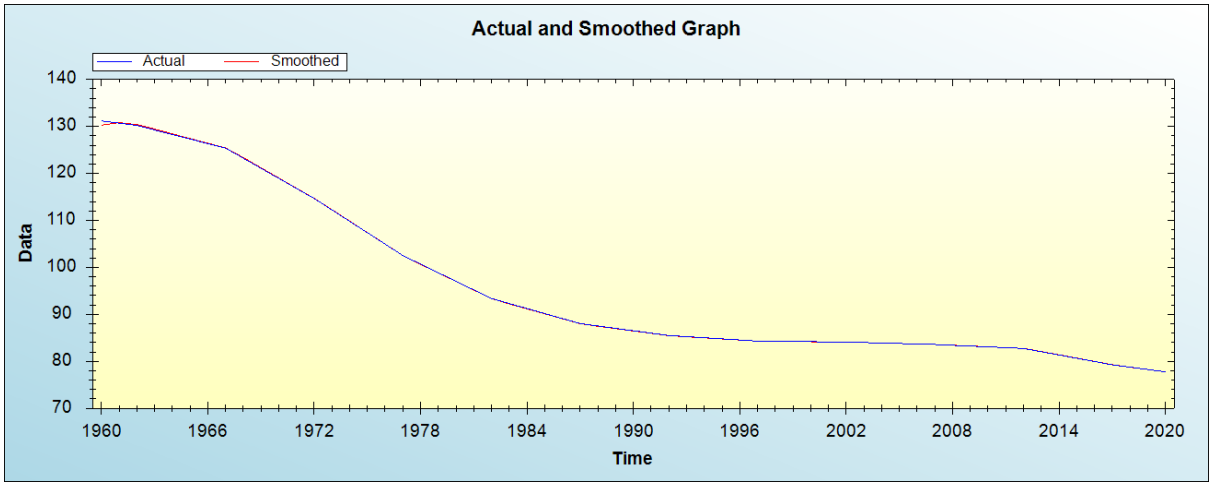

Figure 3: Actual and smoothed graph for A series

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

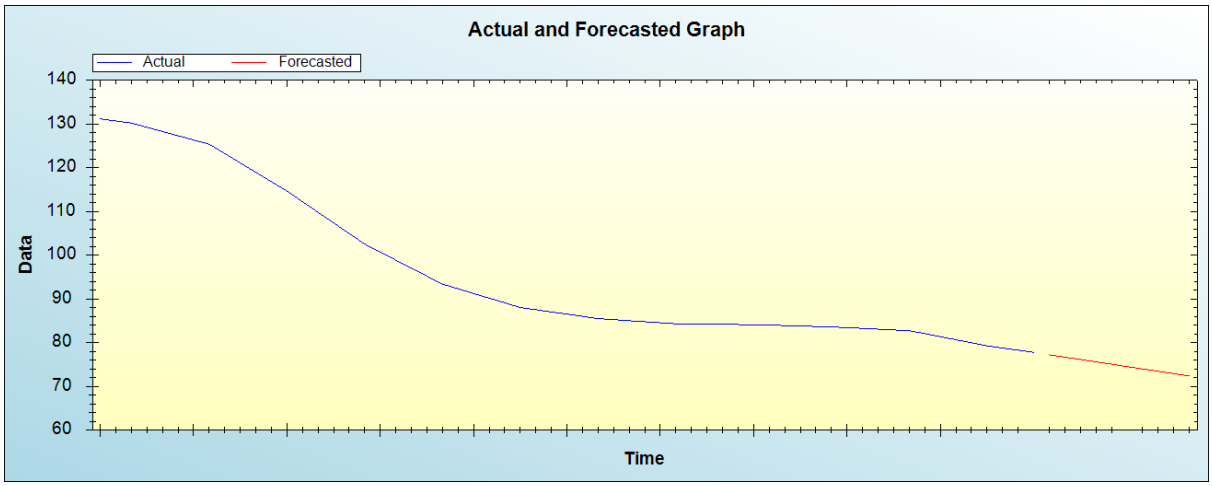

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	77.2197
2022	76.6804
2023	76.1412
2024	75.6019
2025	75.0627
2026	74.5234
2027	73.9842
2028	73.4449
2029	72.9057
2030	72.3665

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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 will continue to decline but remain high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Low-middle income countries have higher teenage pregnancy rates and poor outcomes as a result of many factors such as poverty, lack of adequate resources, low educational level and low contraceptive prevalence rates and inaccessible family planning services. Adverse pregnancy outcomes include anemia, hypertensive disorders, obstructed labor, preterm delivery and low birth weight. Prevention of teenage pregnancy will definitely translate to the reduction of adverse pregnancy outcomes such as maternal and child mortality. Under the 3rd sustainable development goal, all UN member states must endeavor to substantially reduce maternal mortality to less than 70 maternal deaths per 100 000 live births, under five mortality to levels as low as 25 deaths per 1000 live births and neonatal mortality to at 12 deaths per 1000 live births by 2030. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Ecuador. We established that adolescent fertility will continue to decline but will remain high throughout the out of sample period. Therefore, the government must scale up awareness campaigns among communities, strictly enforce laws that protect women's rights, promote girl child education and finance empowerment projects for youths.

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