

Tracking Progress towards the Substantial Reduction of Adolescent Fertility for Mexico Using Holt's Linear Method

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Abstract - This research article uses annual time series data of adolescent fertility rate for Mexico 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 throughout the out of sample period. Therefore, we encourage authorities in Mexico to enforce laws that protect sexual and reproductive rights of women and girls, establish adolescent friendly clinics in marginalized regions and promote youth empowerment programs.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Teenage pregnancy is one of the most challenging public health problems of our time (Papri *et al.* 2016; Lawlor *et al.* 2004; Johnson *et al.* 2001). The problem is wide spread across the whole world with low and middle income countries reporting the highest teenage pregnancy rates (Sedgh *et al.* 2015). Health authorities across the globe are very much concerned of this problem because teenage pregnancy can be associated with adverse maternal and child health outcomes (Berthelon & Kruger, 2017; Fall *et al.* 2015). Literature shows that complications may occur during the antenatal, child birth and postnatal periods (Sserwanja *et al.* 2021; Sserwanja & Kawuki, 2020; Ayanawet *et al.* 2017). Anemia in pregnancy, obstetric hemorrhage, pregnancy induced hypertensive disorders, preterm delivery, low birth weight and sepsis are among the problems that are encountered by pregnant mothers (Envuladu, 2014; Uwaezuoke *et al.* 2004). In Latin America and the Caribbean, adolescents aged 15–19 represent 16 percent of total fertility among women of reproductive age, which represents the highest share of adolescent pregnancy of any region in the world (UN, 2019). An increasing proportion of these pregnancies is unplanned, especially among lower poverty quintiles (Rodriguez, 2017). Among the countries of the Organization for Economic Co-Operation and Development, Mexico has the highest birth rate (64.2 births per 1000 women aged 15–19 years) among adolescents between 15 and 19 above Chile, Costa Rica Uruguay and Peru (UNFPA, 2013; PAHO, 2017), nations of the same level of development (OECD, 2012). In 2012, 20 percent of all births in Mexico were to adolescents (Reyes *et al.* 2015). The adolescent birthrate was 76.4 births per 1000 females aged 15–19 years in 2011, dropping to 70.5 per 1000 by 2018 (CONAPO, 2018). The Mexican government has made its commitment to address adolescent pregnancy by implementing a National Strategy for the Prevention of Adolescent Pregnancy (ENAPEA) since 2015. The aim of the strategy is to ensure availability of quality, affordable and accessible sexual and reproductive health services to all women including adolescents. However, the major challenge is that it is still difficult for adolescent mothers to access contraception after experiencing a birth (Saavedra- Avendano *et al.* 2017).

The aim of this paper is to model and forecast future trends of adolescent fertility in Mexico using the double exponential smoothing technique. We expect the findings of this study to depict the future burden of adolescent births in the country. This will inform policy, 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 Mexico. 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

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

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 period t-1

Data Issues

This study is based on annual adolescent fertility rate in Mexico 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
Forecast performance measures	
Mean Absolute Error (MAE)	0.521463
Sum Square Error (SSE)	63.453362
Mean Square Error (MSE)	1.040219
Mean Percentage Error (MPE)	0.015871
Mean Absolute Percentage Error (MAPE)	0.524036

Residual Analysis for the Applied Model

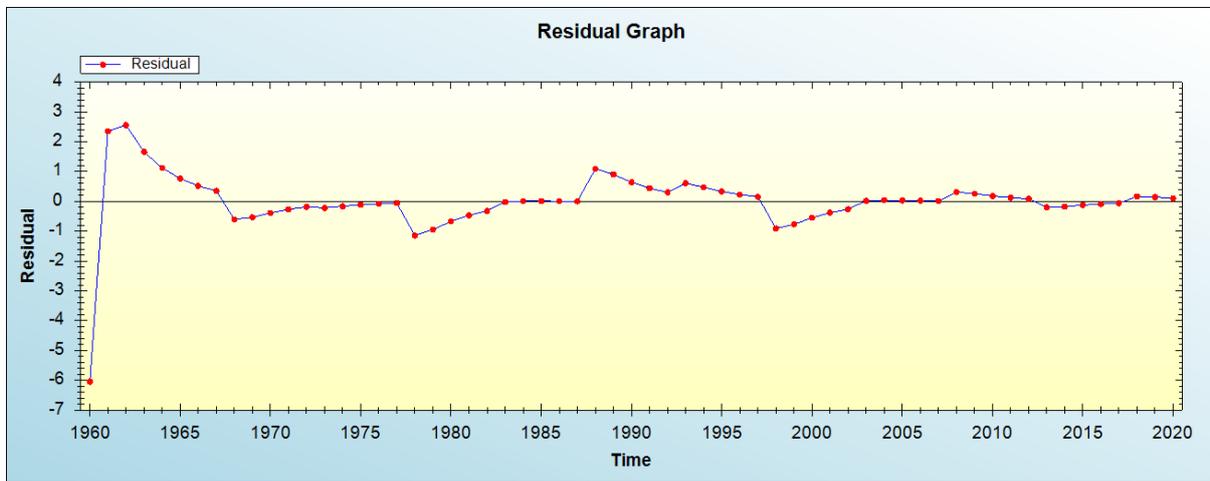


Figure 1: Residual analysis

In-sample Forecast for A

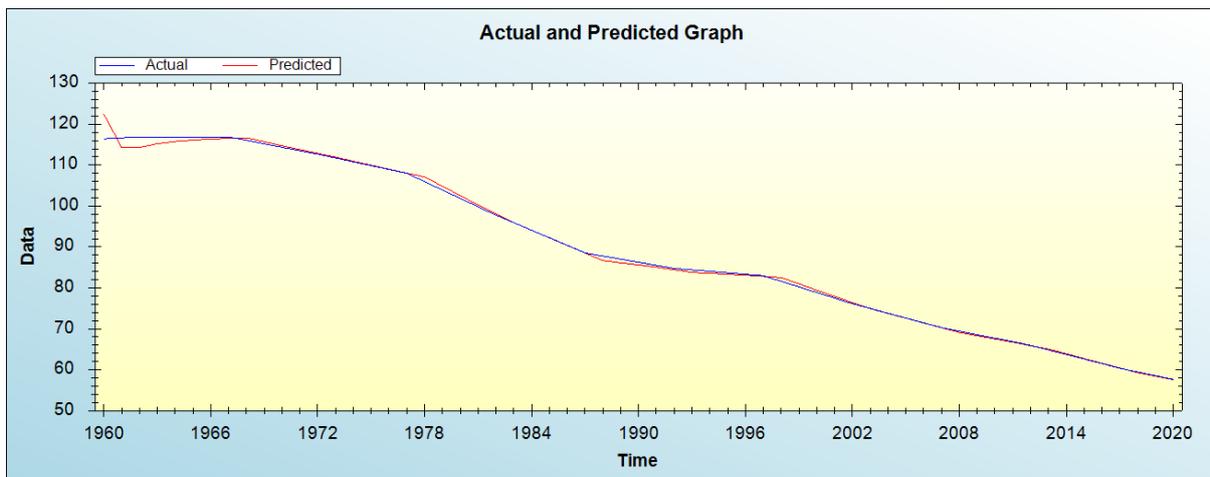


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

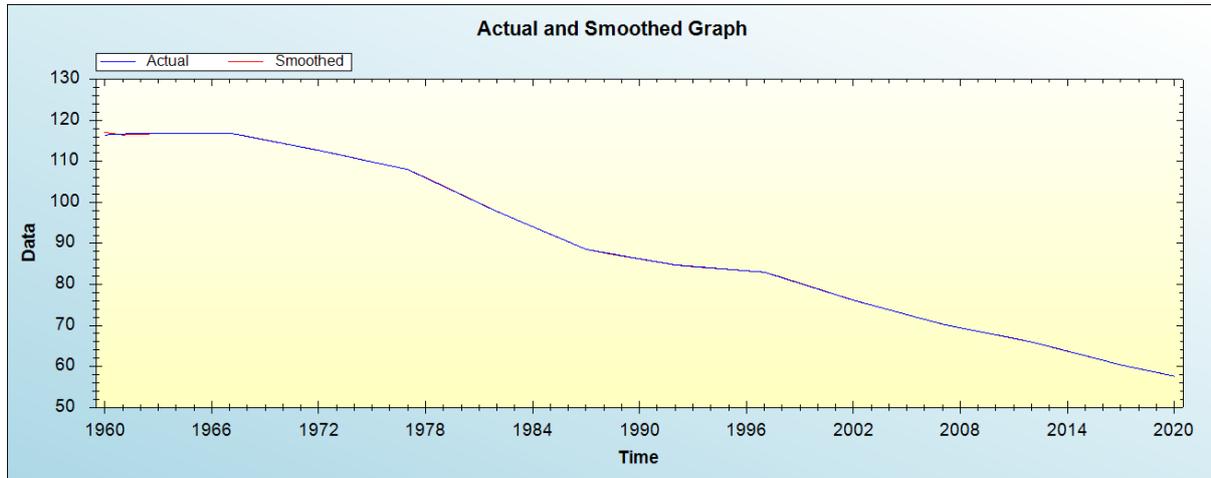


Figure 3: Actual and smoothed graph for A series

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

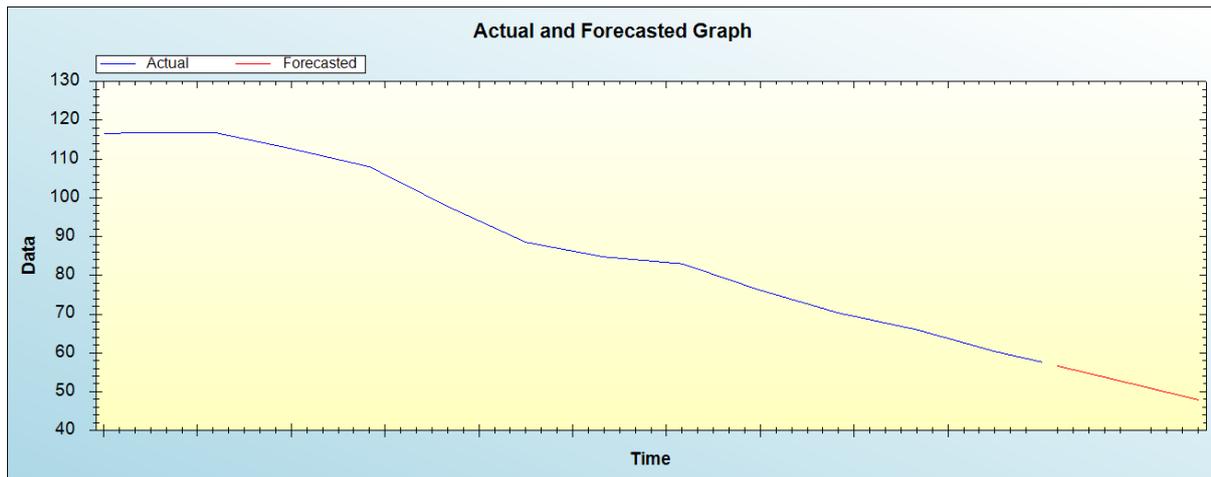


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	56.6492
2022	55.6764
2023	54.7035
2024	53.7306
2025	52.7578
2026	51.7849
2027	50.8120
2028	49.8392
2029	48.8663
2030	47.8935

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

Teenage pregnancy continues to be a challenge across the globe. The problem is more pronounced in developing regions due to poverty, low educational levels, social norms and lower contraceptive prevalence and high unmet need for family planning services. The general decline of adolescent fertility in developing countries can be attributed to availability of family planning services and increase in the age at marriage among other factors. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Mexico. We established that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage the Mexican government to enforce laws that protect sexual and reproductive rights of women and girls, establish adolescent friendly clinics in marginalized regions and promote youth empowerment programs.

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