

Holt's Linear Method Use in Forecasting Adolescent Fertility for Jordan

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Abstract - This study uses annual time series data of adolescent fertility rate for Jordan 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 rate will hover around 25 births per 1000 women aged 15-19 years throughout the out of sample period. Therefore, we encourage policy makers in Jordan to establish more adolescent friendly clinics that are well resourced to attend to the various adolescent health problems and address all the existing problems which contribute to teenage pregnancies.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

This era of sustainable development goals is a golden opportunity for UN member states to accelerate progress towards achieving their targets by the end of 2030. Top among the list of global challenges is to address maternal and child mortality affecting developing countries to a greater extent. Poverty reduction through sustainable agriculture and application of environmentally friendly industrial technologies should be encouraged as this is one of the pillars that support the health of any population (UN, 2020; UNICEF, 2018; WHO, 2019; UN, 2016; UN, 2015). Promoting peace and security will create a conducive atmosphere for businesses to thrive thereby stimulating economic growth and development which is a key determinant for health. Wars and armed conflicts are a recipe for collapse of health systems and therefore it is important for all UN countries to preserve peace at all costs. It is important to implement new strategies that will help reduce maternal and child mortality across the globe with specific attention being given to teenage pregnancy prevention. Teenage pregnancies continue to be a global health problem that has negative impact on the mother, her baby and family. Other Authors consider teenage pregnancy as a medical, economic and social problem (Muna *et al.* 2019; Ghouth *et al.* 2017). Adverse pregnancy outcomes associated with conception during the adolescence period include obstructed labour, hypertensive disorders, preterm delivery, antepartum hemorrhage, maternal and perinatal mortality and maternal mental disorders (Althabeet *et al.* 2015; Ganchimeg *et al.* 2014; Malabareyet *et al.* 2012). Teenage girls living in poverty, with family history of teenage pregnancy, having previous teenage pregnancy, alcohol abuse, parental absence, exposure to pornographic material, incorrect and inconsistent use of condoms, lack of sexual and reproductive health knowledge and low educational status are among the risk factors for teenage pregnancy (Sedgh *et al.* 2016; Gibbs *et al.* 2012; Larsson *et al.* 2002). Previous authors have highlighted the importance of improving educational levels among adolescents, addressing gender imbalances, increasing SRH knowledge and contraceptive prevalence in order to substantially reduce pregnancy among teenage girls (Shatilwe *et al.* 2022; Vasconcelos *et al.* 2022; Zegeye *et al.* 2021; Birhanuet *et al.* 2019; Samandari *et al.* 2019; Yakubu & Salisu, 2018; UN, 2016; UN, 2015; UN, 1995). Teenage pregnancy remains a problem in Jordan as revealed by the World Bank statistics. The country has recorded a gradual decline in adolescent fertility from around 123 births per 1000 women aged 15-19 years in 1960 to 25 births per 1000 women aged 15-19 in 2020. This reflects a significant decline in adolescent birth rate over the past decades, however new strategies are required to end teenage pregnancy in the country so as to prevent adverse maternal and child health outcomes.

The objective of this paper is to model and forecast future trends of adolescent fertility for Jordan using Holt's double exponential smoothing technique. The results of this piece of work are envisioned to highlight likely future trends of adolescent fertility in the out of sample period. This will inform policy, decisions, 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 Jordan. 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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

X_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 Jordan 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	X
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	0.538670
Sum Square Error (SSE)	83.809493
Mean Square Error (MSE)	1.373926
Mean Percentage Error (MPE)	0.271500
Mean Absolute Percentage Error (MAPE)	0.730050

Residual Analysis for the Applied Model

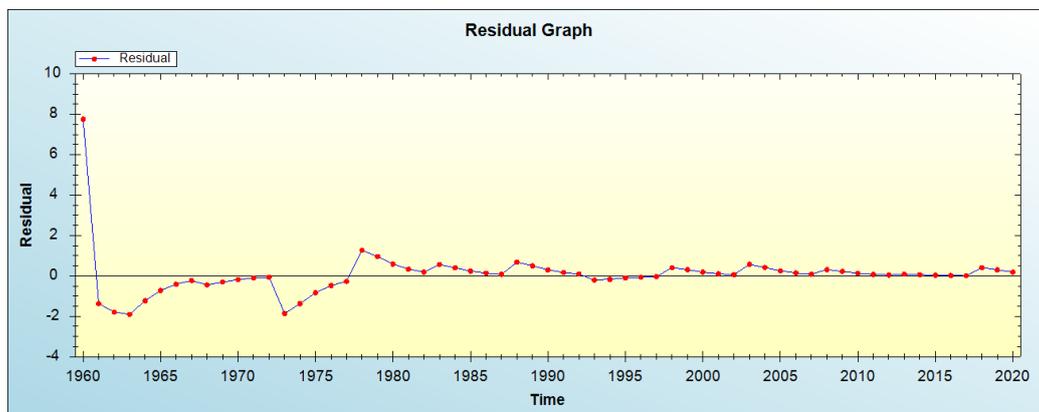


Figure 1: Residual analysis

In-sample Forecast for X

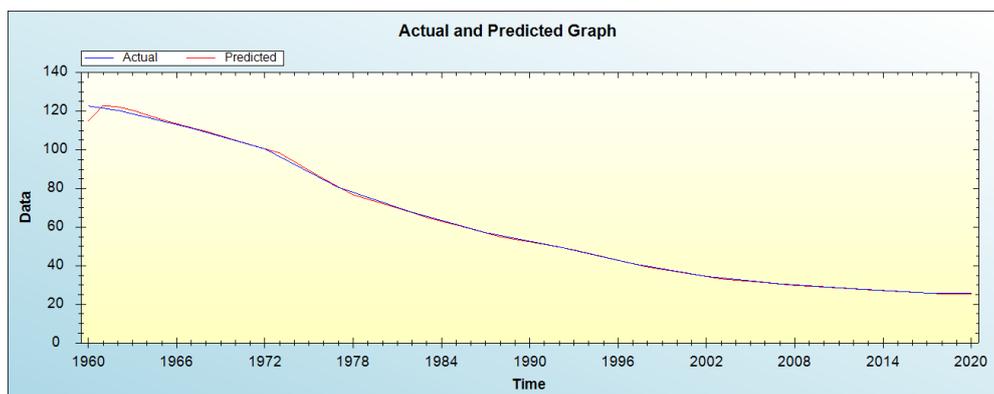


Figure 2: In-sample forecast for the X series

Actual and Smoothed graph for X series

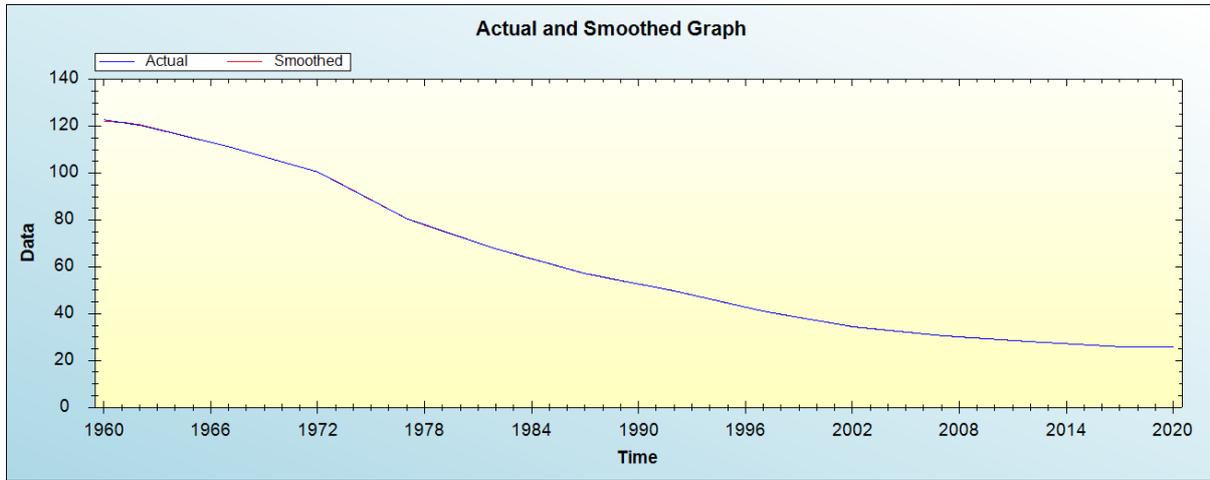


Figure 3: Actual and smoothed graph for X series

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

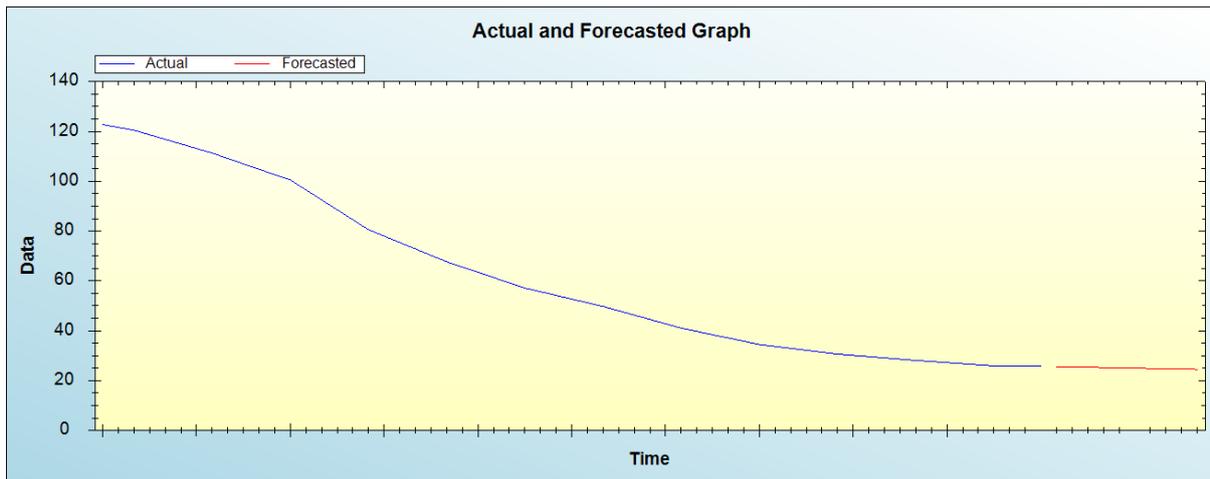


Figure 4: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	25.6290
2022	25.5062
2023	25.3835
2024	25.2607
2025	25.1379
2026	25.0151
2027	24.8923
2028	24.7695
2029	24.6467
2030	24.5239

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 hover around 25 births per 1000 women aged 15-19 throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Teenage pregnancy remains a public health problem in Jordan as revealed by the World Bank statistics. The country has reported a gradual decline in adolescent fertility from around 123 births per 1000 women aged 15-19 years in 1960 to 25 births per 1000 women aged 15-19 in 2020. This indicates a significant decline in adolescent birth rate over the past decades due to improvements in the education sector, use of modern methods of contraception and better employment opportunities for women. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Jordan. Our study findings revealed that adolescent fertility will hover around 25 births per 1000 women aged 15-19 years throughout the out of sample period. Therefore, we encourage the government to establish more adolescent friendly clinics that are well resourced to attend to the various adolescent health problems and address all the existing problems which contribute to teenage pregnancies.

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