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Forecasting Adolescent Fertility for Oman Using Holt's Double Exponential Smoothing Technique

[1]Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - This study uses annual time series data of adolescent fertility rate for Oman 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 to levels below 10 births per 1000 women aged 15-19 by the end of 2030. Therefore, we encourage authorities in Oman to address local factors which drive teenage pregnancy and child marriages.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adolescent pregnancy is defined as pregnancy occurring among females aged between 10-19 years (Yuce *et al.*2015; WHO, 1999). This health and social problem is distributed across the globe and has serious implications on maternal and child health particularly in developing countries (Lancet, 2016; Althabe *et al.* 2015; Neal *et al.* 2015Mukhopadhya*yet al.* 2010). More than 16 million babies are born to adolescent girls (WHO, 2011). According to the World Bank data, adolescent birth rates in the year 2016 were 0.045 in the World, 0.047 in Arab World 0.038 in the Middle East & North Africa, 0.022 in OECD members, 0.020 in North America, 0.019 in Asia, 0.010 in European Union. Studies conducted in the past established that teenage pregnancy is associated with adverse health and social outcomes for the mother, child and family (Ochen *et al.* 2019; Ayele *et al.* 2018; Black *et al.* 20Gibbs *et al.* 2012). Early marriage, low educational level, low level of sexual education and contraceptive use, poverty are the major drivers of adolescent pregnancy. Adolescent mothers are more likely to have poor prenatal health behaviors and poorer health status (Kingston *et al.* 2012). In addition, many adverse maternal and child health outcomes may occur such as anemia, preeclampsia, obstructed labor, preterm delivery, postpartum depression, and maternal death (Karataşlı*et al.* 2019; Ogawa *et al.* 2019; Santelli *et al.* 2017;Blum *et al.* 2015;UNFPA *et al.* 2015;WHO, 2014; UNFPA, 2013).Teenage motherhood significantly reduces the chances of continuing education, developing skills and finding paid work, thus creating a negative cycle of adverse health, economic and social outcomes(UNFPA, 2015). Peer pressure, poverty, inadequate parental support, inadequate SRH knowledge, pornography and increased curiosity to engage in intimate relationships have been found to be associated with teenage pregnancy (Magnusson *et al.* 2019;Peltzer, 2010).

This paper applies Holt's double exponential smoothing technique to forecast future trends of adolescent fertility in Oman. The findings are expected to depict the future burden of adolescent births in the out of sample period. This will stimulate an appropriate national response to the problem of teenage pregnancy in order to avert adverse maternal and child health outcomes.

II. METHODOLOGY

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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

O_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 Oman 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	O
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)	1.846781
Sum Square Error (SSE)	1067.276482
Mean Square Error (MSE)	17.496336
Mean Percentage Error (MPE)	1.601892
Mean Absolute Percentage Error (MAPE)	3.270964

Residual Analysis for the Applied Model

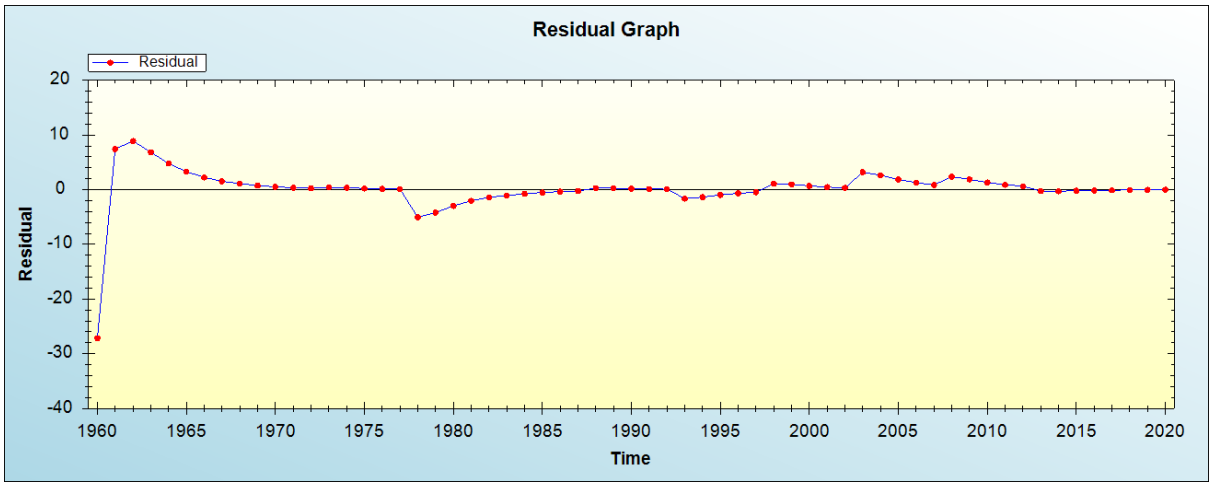

Figure 1: Residual analysis

In-sample Forecast for 0

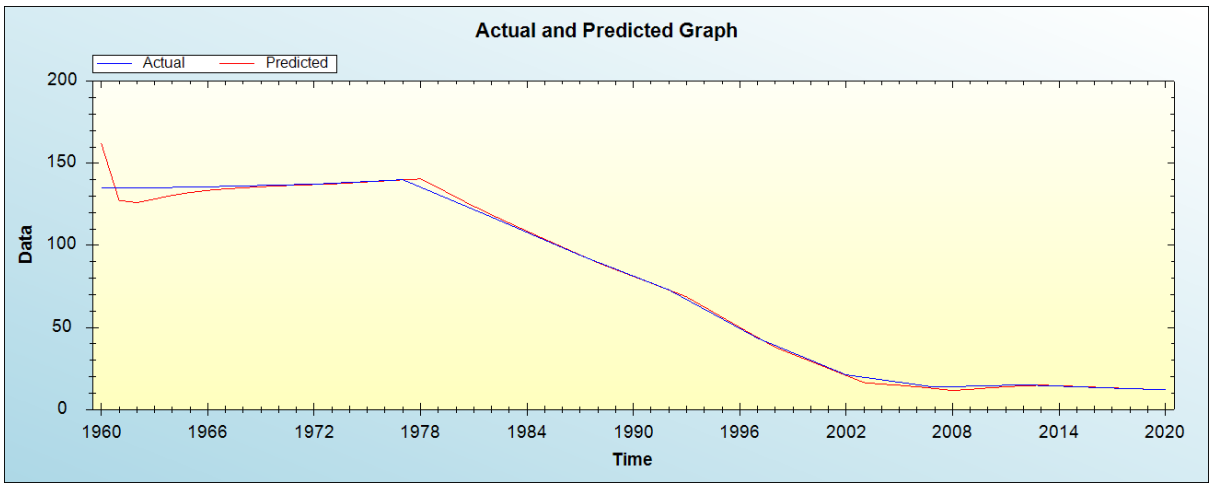

Figure 2: In-sample forecast for the O series

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Actual and Smoothed graph for O series

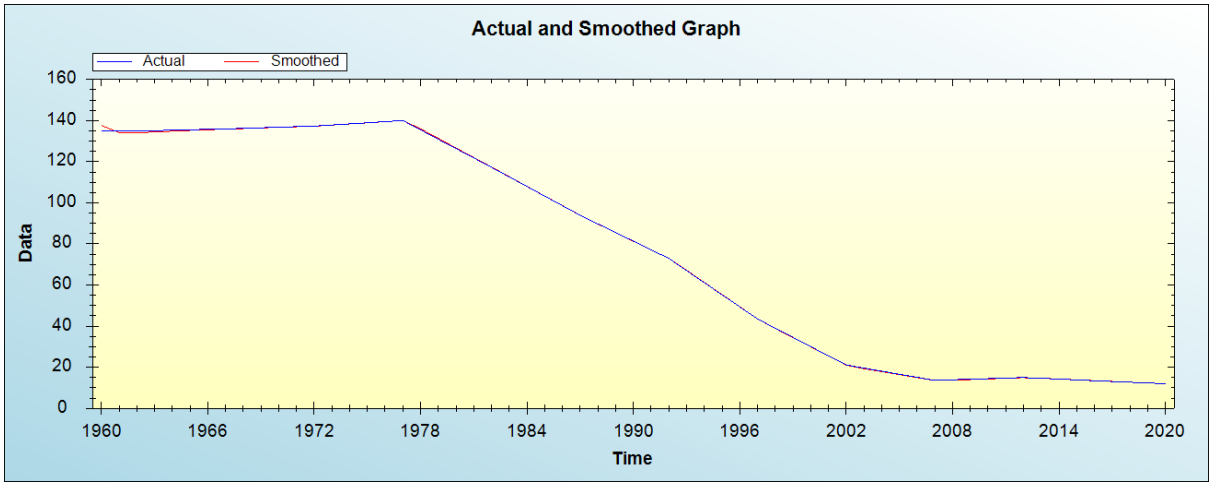

Figure 3: Actual and smoothed graph for O series

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

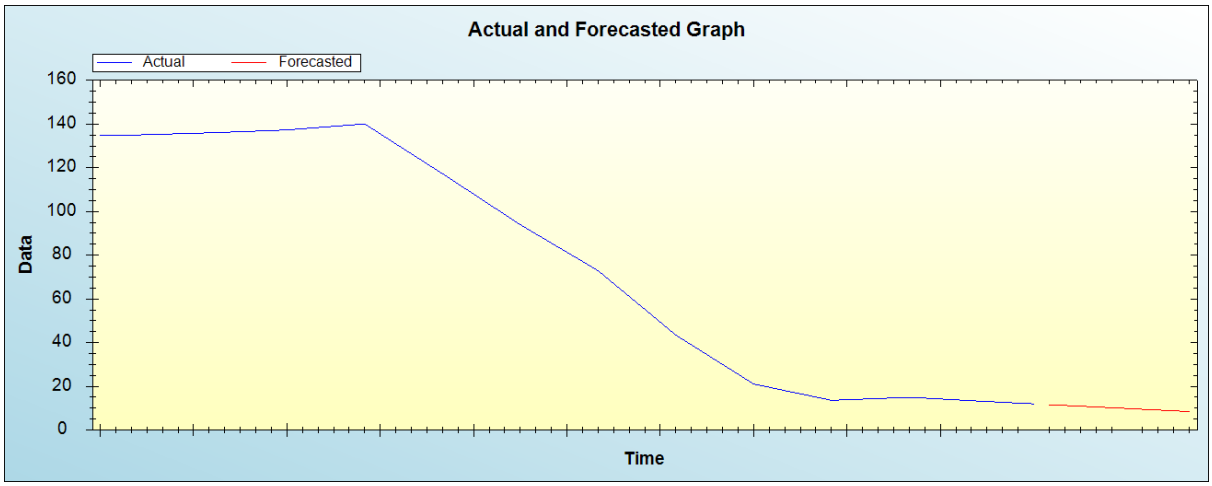

Figure 4: Out-of-sample forecast for O: actual and forecasted graph

Out-of-Sample Forecast for O: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	11.6265
2022	11.2744
2023	10.9223
2024	10.5703
2025	10.2182
2026	9.8662
2027	9.5141
2028	9.1621
2029	8.8100
2030	8.4580

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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 to levels below 10 births per 1000 women aged 15-19 by the end of 2030.

IV. POLICY IMPLICATION & CONCLUSION

The government of Oman has made significant progress towards the substantial reduction of adverse maternal and child health outcomes. Evidence shows that maternal and child mortality declined substantially over the past two decades. The country's adolescent fertility declined from 135 births per 1000 women aged 15-19 years in 1960 to 12 births per 1000 women aged 15-19 years in 2020. This decline in fertility levels is attributed to increase in age at marriage, use of modern methods of contraception, improvements in education and increase in SRH knowledge among adolescents. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Oman. Our study findings indicated that adolescent fertility will continue to decline to levels below 10 births per 1000 women aged 15-19 by the end of 2030. Therefore, we encourage authorities in Oman to address local factors which drive teenage pregnancy and child marriages.

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