

Relying on Holt's Double Exponential Smoothing Technique to Forecast Future Trends of Adolescent Fertility for Egypt

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Abstract - This study uses annual time series data of adolescent fertility rate for Egypt 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 0.6 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility rate will continue to decline throughout the out of sample period. Therefore, Egyptian authorities should set up adolescent friendly health facilities that are accessible and offering affordable comprehensive sexual and reproductive health care services, enforce laws to protect women's rights and continually promote girl child education.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adverse pregnancy outcomes can affect the mother, baby and family (Envuladu *et al.* 2014; Atuyambe *et al.* 2008; Uwaezuoke *et al.* 2004). Prevention and management of complications related to pregnancy and child birth is essential in order to reduce morbidity and mortality among teenagers and their infants. Annually about 21 million adolescent girls in low- and middle-income countries become pregnant (Mayor, 2004). Both the adolescent mother and her newborn baby have a higher risk of morbidity and mortality. The risk of health complications is increased and complications can occur such as hypertensive disorders, anemia, antepartum hemorrhage and low birth weight (Atuyambe *et al.* 2008). Many researchers in previous studies identified causes of teenage pregnancy in Africa and these include inadequate information on sexual and reproductive health (SRH), peer pressure, sexual assault and rape, social media influence, poverty, poor access to contraceptives and cultural factors such as early marriage, among others (Alabi *et al.* 2018; Ahmed *et al.* 2017; Ochiogu *et al.* 2011). In addition, pregnancy during the adolescent stage is linked to problems such as school dropouts, unsafe abortion, poverty, repeat teen pregnancies, exclusion from family and friends, and an increased tendency to be involved in criminal activities (Ayamolowo *et al.* 2019; Dare *et al.* 2016; Envuladu *et al.* 2014). According to World Bank, adolescent fertility declined from 150 births per 1000 women aged 15-19 in 1960 to around 52 births per 1000 women aged 15-19 years in 2020. This indicates that adolescent pregnancy is still a huge problem in this country.

This paper aims to model and forecast future trends of adolescent fertility in Egypt using Holt's double exponential smoothing technique. Findings of this paper are expected to depict the future burden of adolescent births in the out of sample period. This will inform national policy, planning and allocation of adequate 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 Egypt. 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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

E_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 slope of the trend at time t-1

Data Issues

This study is based on annual adolescent fertility rate in Egypt 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 | E |
| Included Observations | 61 |
| Smoothing constants | |
| Alpha (α) for data | 0.900 |
| Beta (β) for trend | 0.600 |
| | |

| Forecast performance measures | |
|---------------------------------------|-----------|
| Mean Absolute Error (MAE) | 0.595179 |
| Sum Square Error (SSE) | 75.950648 |
| Mean Square Error (MSE) | 1.245093 |
| Mean Percentage Error (MPE) | 0.130438 |
| Mean Absolute Percentage Error (MAPE) | 0.698319 |

Residual Analysis for the Applied Model

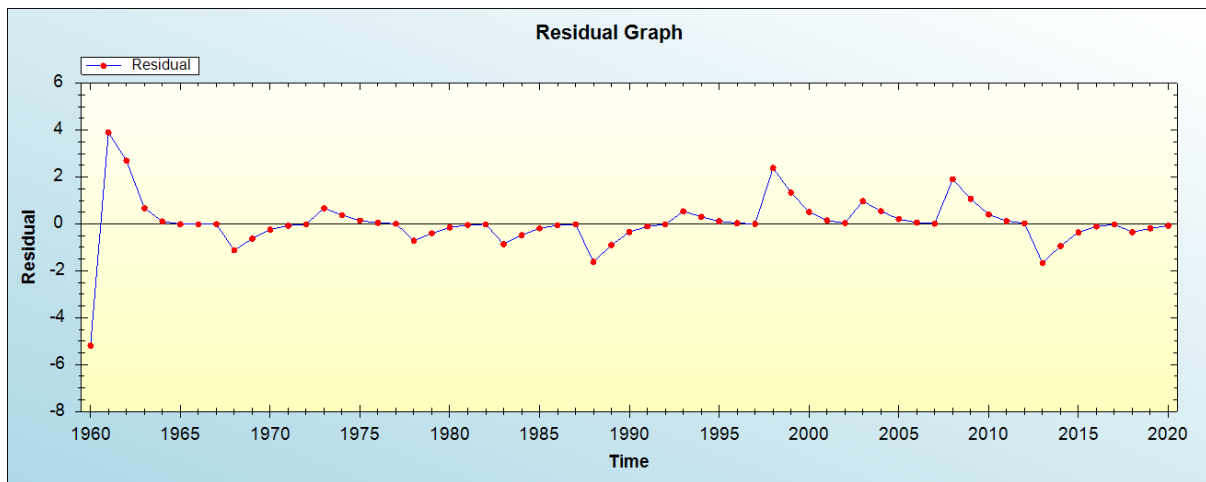


Figure 1: Residual analysis

In-sample Forecast for E

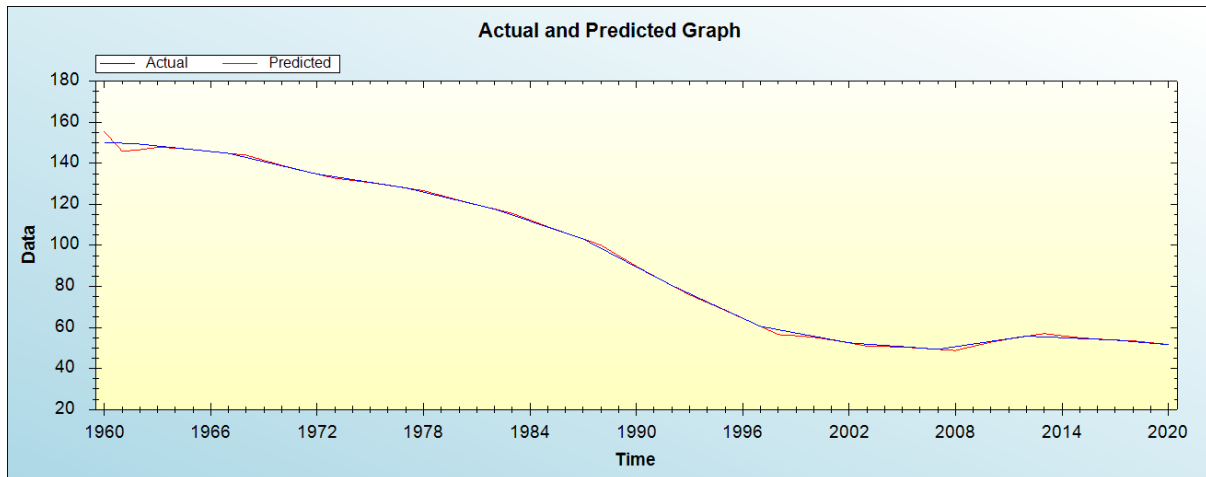


Figure 2: In-sample forecast for the E series

Actual and Smoothed graph for E series

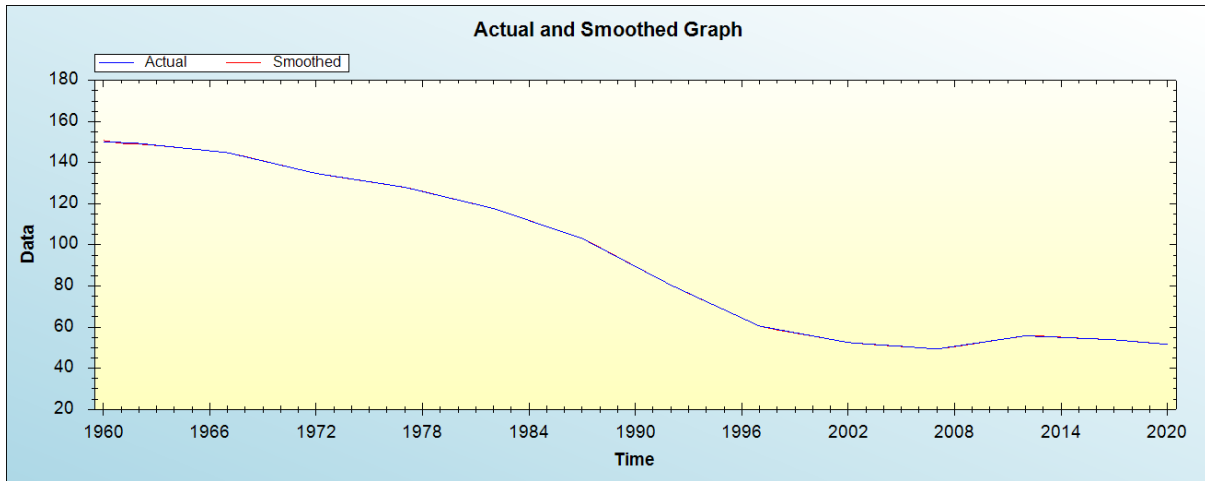


Figure 3: Actual and smoothed graph for E series

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

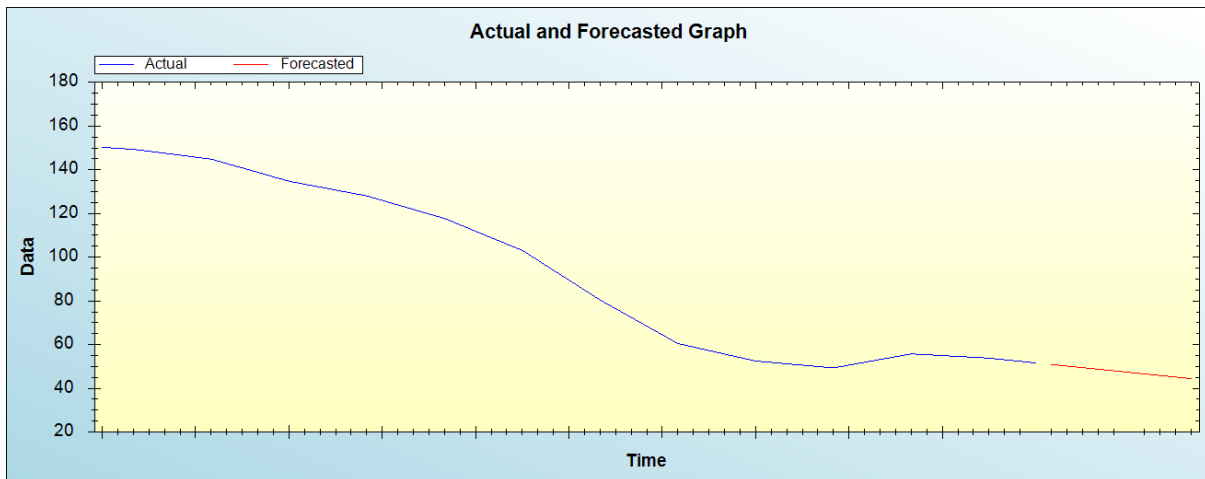


Figure 4: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| Year | Predicted adolescent fertility rate |
|------|-------------------------------------|
| 2021 | 50.9086 |
| 2022 | 50.1899 |
| 2023 | 49.4712 |
| 2024 | 48.7526 |
| 2025 | 48.0339 |
| 2026 | 47.3152 |
| 2027 | 46.5965 |
| 2028 | 45.8778 |
| 2029 | 45.1591 |
| 2030 | 44.4405 |

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

Prevention and management of complications related to pregnancy and child birth is essential in order to reduce morbidity and mortality among teenagers and their infants. Pregnancy among teenagers has been identified as an important factor which contributes to higher adverse pregnancy outcomes especially in developing countries. Pregnancy during the adolescent stage is linked to problems such as school dropouts, unsafe abortion, poverty, repeat teen pregnancies, exclusion from family and friends, and an increased tendency to be involved in criminal activities. Adolescent fertility declined in Egypt 150 births per 1000 women aged 15-19 in 1960 to around 52 births per 1000 women aged 15-19 years in 2020. This means that teenage pregnancy and child birth is still a huge problem in this country. This study proposed Holt's double exponential smoothing technique to predict adolescent fertility for Egypt. Our findings indicated that adolescent fertility will continue to drop throughout the out of sample period. Therefore, the Egyptian government must set up adolescent friendly health facilities that are accessible and offering affordable comprehensive sexual and reproductive health care services, enforce laws to protect women's rights and continually promote girl child education.

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