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Projection of Adolescent Fertility for Morocco Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Morocco 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 0.8 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 Morocco to continuously enforce laws that protect sexual and reproductive health rights of women and girls and scale up educational campaigns among the communities.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adolescence is a transitional period from childhood to adulthood characterized by significant physiological, psychological and social changes. However, adolescent girls suffer from a disproportionate share of teenage pregnancy which is a global public health and social problem that has adverse maternal and child health outcomes (CSA, 2012; Kyei, 2012;Mangiaterra*et al.* 2008;WHO, 1999).Globally, about 18 million adolescent girls between 15-19 years give birth every year. Babies born to adolescent mothers represent eleven percent of all global births of which ninety five percent of these occur in low and middle income countries (WHO, 2008). There is substantial evidence that indicates that teenage pregnancy is a recipe for serious health and social consequences (de Onis *et al.* 2016; Nguyen *et al.* 2016; Patton *et al.* 2016; Azevedo *et al.* 2015). There is an increased risk of eclampsia, anemia, preterm delivery, psychological disorders, low birth and malnutrition (Kaphagawani & Kalipeni, 2017; Sedgh *et al.* 2016; Larsson *et al.* 2002). Pregnancy during the adolescent stage increases the risk of experiencing complications during child birth such as placenta abruption, obstruction and far reaching psychological effects of obstetric fistulae (Global burden of Disease *et al.* 2017). Undesirable social consequences include stigma, rejection, violence and drops out of school (Croft *et al.* 2018; Okigbo & Speizer, 2015). Adolescent girls who become pregnant are more likely to be from poor families, with poorer nutrition and general health conditions. This in turn increases the risk of occurrence of fetal and maternal death adverse health outcomes (Gibbs *et al.* 2012). Previous research has revealed that refusal or inconsistent condom use, alcohol and drug abuse, peer pressure, inaccessible sexual and reproductive health services and poor parental guidance are among the significant factors that contribute to teenage pregnancy especially in developing countries (Magnusson *et al.* 2019; Peltzer & Pengpid, 2015; Hindin & Fatusi, 2009; Pettifor *et al.* 2009; Williamson *et al.* 2009; Castle, 2003). World Bank data shows that the government of Morocco has made significant strides in the reduction of adolescent pregnancies which have declined significantly over the past four decades. However, more needs to be done to prevent adverse maternal and child health outcomes.

This paper aims to model and forecast future trends of adolescent fertility in Morocco using Holt's double exponential smoothing technique. The results of this study are expected to depict the future burden of teenage births in the country. This will inform policy making, decisions, planning and allocation of resources to activities designed to reduce adolescent pregnancy and child marriages.

II. METHODOLOGY

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

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Holt's linear method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

K_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 Morocco 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	K
Included Observations	61

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Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.800
Forecast performance measures	
Mean Absolute Error (MAE)	0.644147
Sum Square Error (SSE)	137.950980
Mean Square Error (MSE)	2.261491
Mean Percentage Error (MPE)	0.238660
Mean Absolute Percentage Error (MAPE)	0.876237

Residual Analysis for the Applied Model

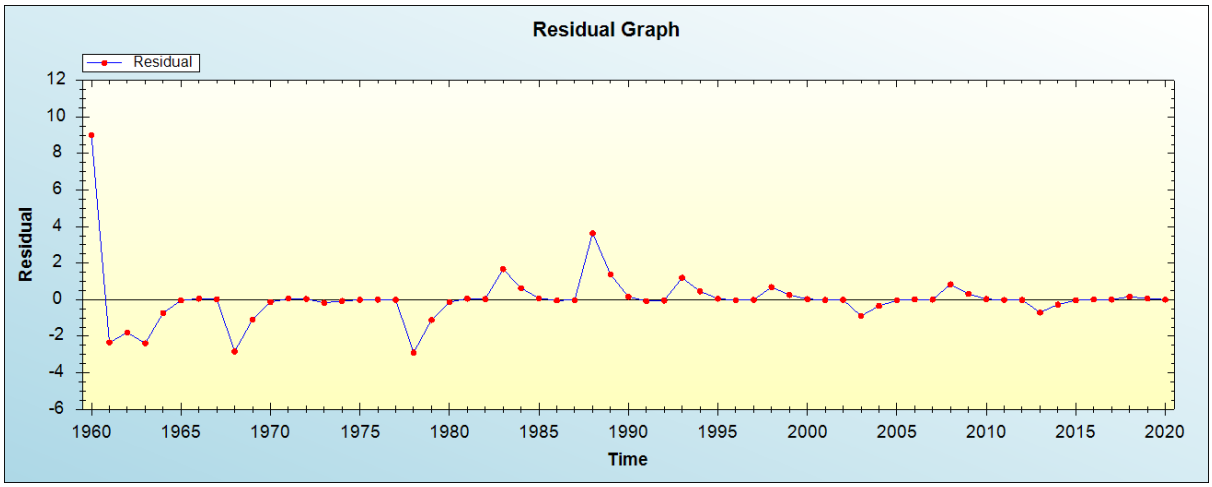

Figure 1: Residual analysis

In-sample Forecast for K

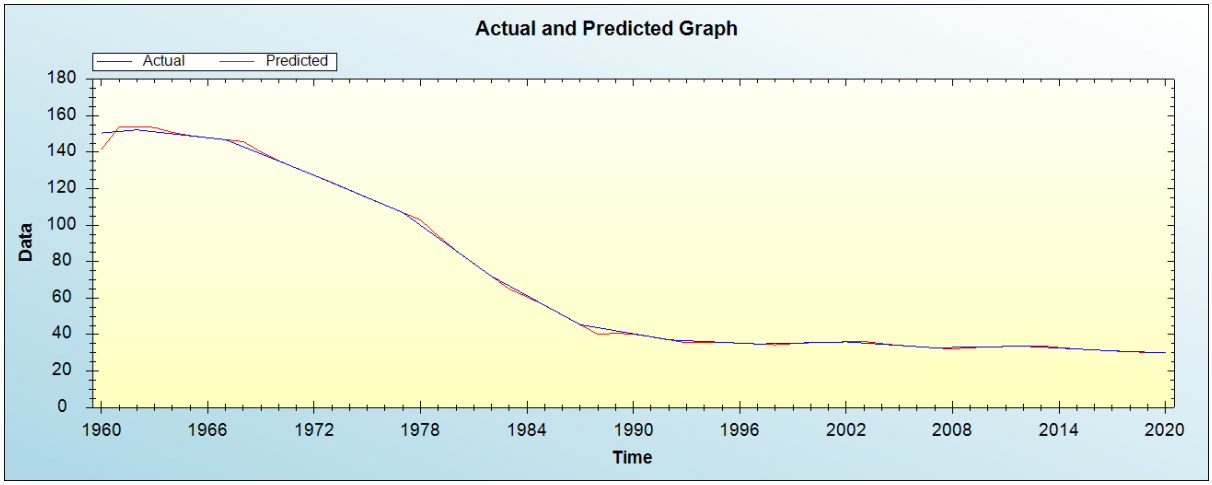

Figure 2: In-sample forecast for the K series

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Actual and Smoothed graph for K series

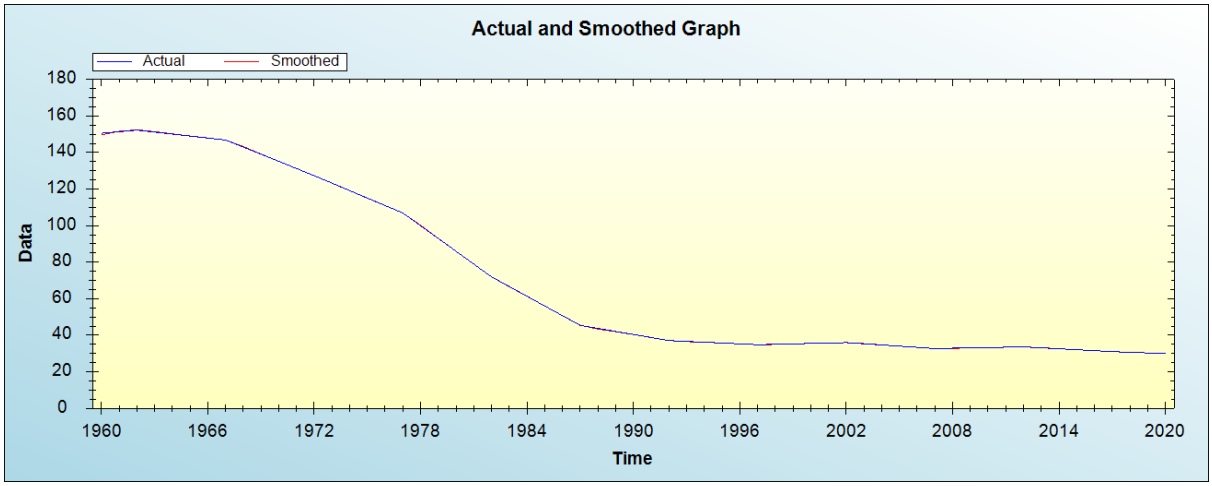

Figure 3: Actual and smoothed graph for K series

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

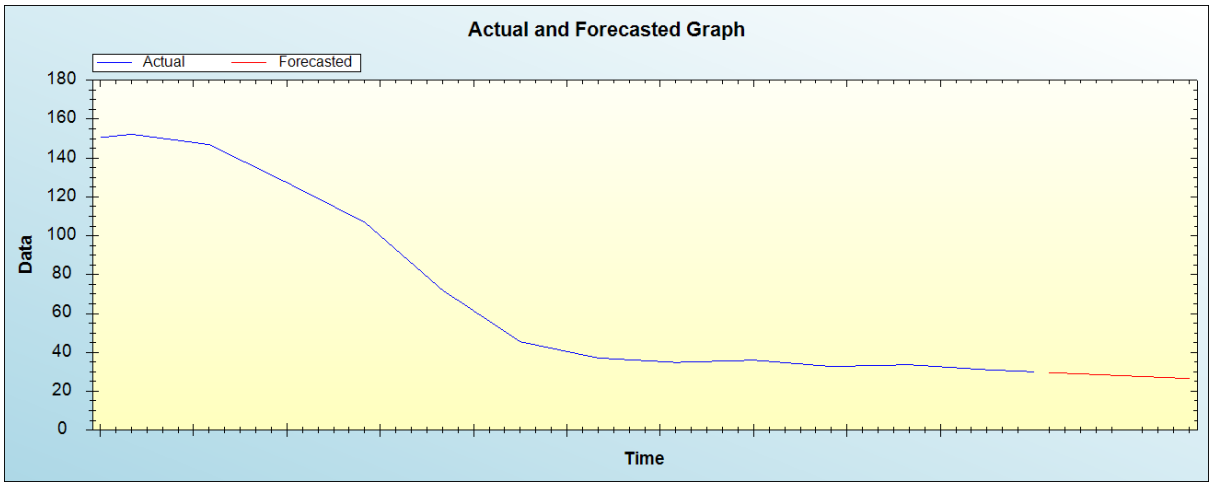

Figure 4: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Projected adolescent fertility rate
2021	29.6255
2022	29.2768
2023	28.9280
2024	28.5793
2025	28.2305
2026	27.8817
2027	27.5330
2028	27.1842
2029	26.8355
2030	26.4867

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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 throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

High adverse pregnancy outcomes in developing countries remain a public health challenge. Teenage pregnancy is among the leading causes of adverse SRH outcomes such as maternal and child mortality, hypertensive disorders, anemia, preterm delivery and obstructed labor. The substantial decline of adolescent fertility across Africa is attributed to improvements in educational levels among women, increase in contraceptive use and increase in SRH knowledge. This study applied Holt's double exponential smoothing method to forecast adolescent fertility for Morocco. Our findings showed that adolescent fertility will continue on downward trend throughout the out of sample period. Therefore, we encourage the government to continuously enforce laws that protect sexual and reproductive health rights of women and girls and scale up educational campaigns among the communities.

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