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Adolescent Fertility Forecasting for Rwanda Using Holt's Linear Method

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***Abstract* - This research uses annual time series data of adolescent fertility rate for Rwanda 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 is expected to decrease throughout the out of sample period. Therefore, we encourage the Rwandan government to scale up educational campaigns among communities, continually promote girl child education and strictly enforce laws to protect women's rights.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The Agenda 2030 for sustainable development is an important document that was drafted to address various challenges affecting people around the world. The main goal was to provide a roadmap for the achievement of sustainable development by 2030. All 193 UN member states consider human health as a key component in the achievement of sustainable development (UN, 2020; WHO, 2019; UNICEF, 2018; UN, 2016, UN, 2015). The 3rd sustainable development goal (SDG-3) focuses on ensuring good health for all at all ages. Target 3.7.2 focuses on providing quality and affordable sexual and reproductive health services which includes adolescent SRH services. The aim of this target is to substantially reduce adverse maternal and child health outcomes as a result of unintended pregnancies including teenage pregnancies. Previous studies conducted in developing regions established that adolescent pregnancies are associated with complications such as STIs, unsafe abortions and adverse neonatal outcomes (Raman *et al.*2015 Kennedy *et al.*2013b). The 1994 International conference on Population and development (ICPD) was held in the Egyptian Capital, Cairo. The signatories agreed to address sexual and reproductive health issues for both sexes particularly upholding the rights of women and adolescent girls (UN, 1995). Since 1994 SRH and rights became a global health priority (WHO, 1998). WHO developed guidelines to reduce adverse reproductive health outcomes and these included legal reform, strategies to reduce child marriages, increased contraceptive use, reduce coerced sex, unsafe abortions and increase the use of maternity services (WHO, 2011).

The objective of this paper is to model and forecast future trends of adolescent fertility in Rwanda using the double exponential smoothing technique. Findings of this paper are expected to highlight future trends of adolescent fertility in Rwanda in the out of sample period. 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 Rwanda. 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 equations

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

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Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

R_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 Rwanda 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	R
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300
Forecast performance measures	

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Mean Absolute Error (MAE)	0.651026
Sum Square Error (SSE)	137.758736
Mean Square Error (MSE)	2.258340
Mean Percentage Error (MPE)	0.119490
Mean Absolute Percentage Error (MAPE)	0.994013

Residual Analysis for the Applied Model

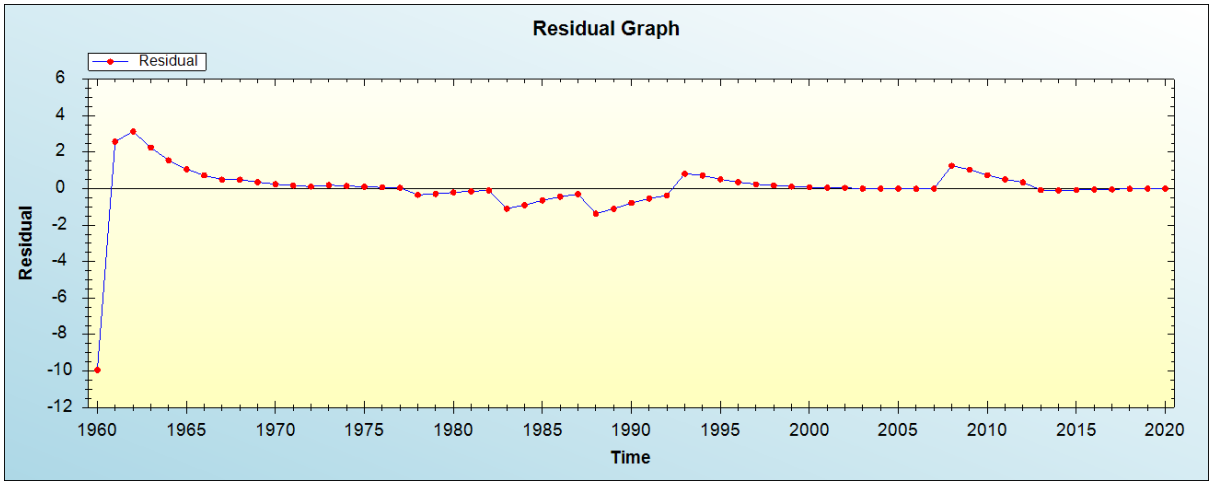

Figure 1: Residual analysis

In-sample Forecast for R

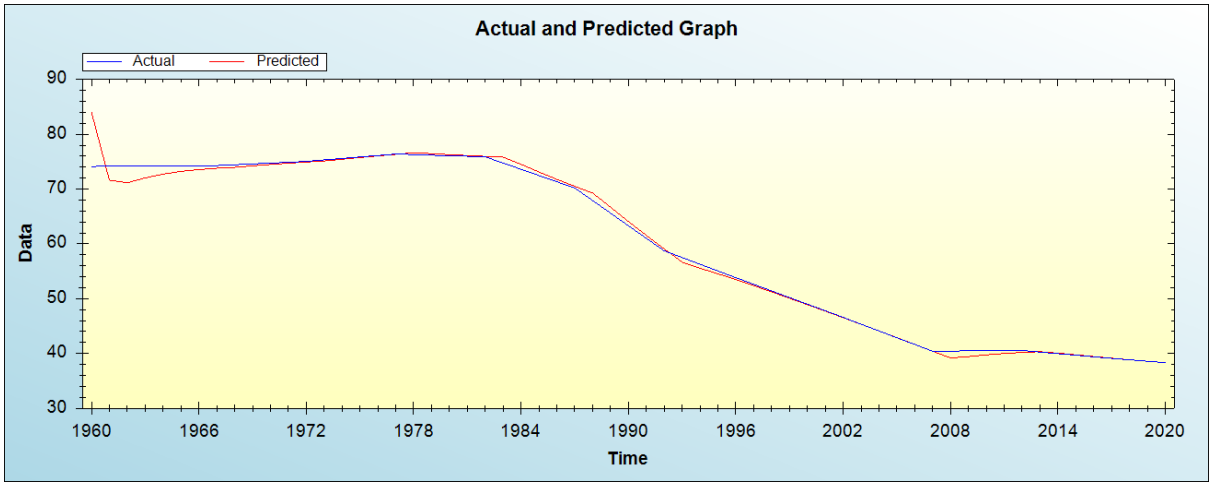

Figure 2: In-sample forecast for the R series

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Actual and Smoothed graph for R series

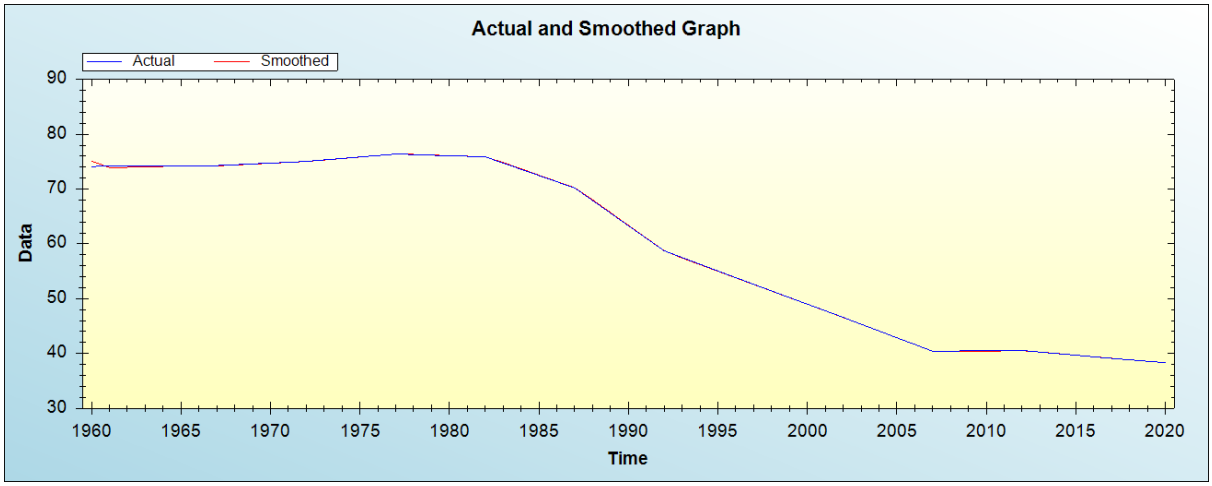

Figure 3: Actual and smoothed graph for R series

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

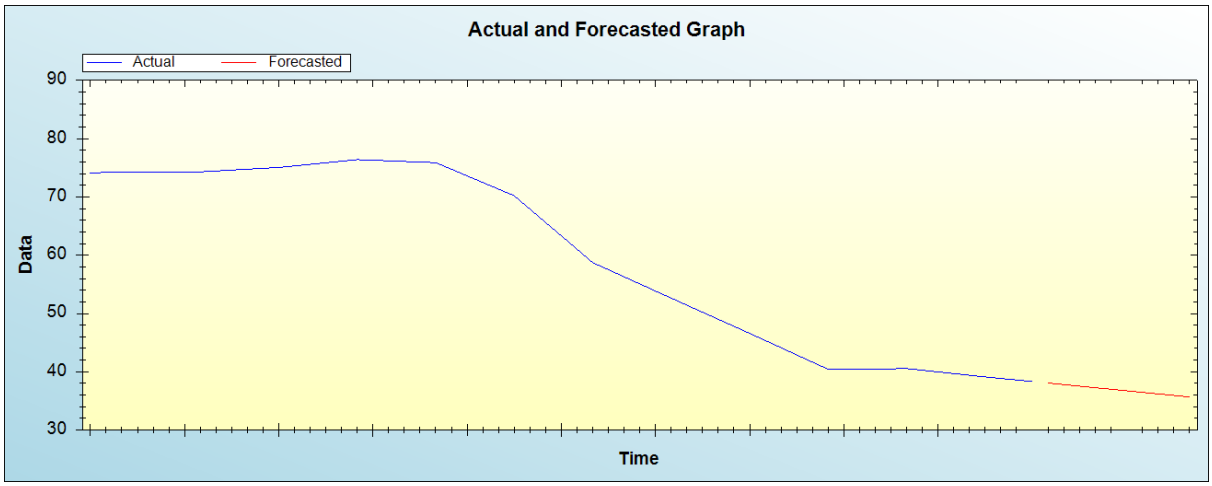

Figure 4: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	38.0637
2022	37.7997
2023	37.5357
2024	37.2717
2025	37.0077
2026	36.7437
2027	36.4797
2028	36.2157
2029	35.9517
2030	35.6877

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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 is expected to decrease throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

The Rwandan government has made significant progress towards the reduction of teenage pregnancy and child marriages. The country's adolescent fertility declined gradually from 74 births per 1000 women aged 15-19 years in 1960 to 38 births per 1000 women aged 15-19 years in 2020. This decline is attributable to the increase in the age at marriage, increased use of contraceptive methods, and improvements in educational levels among women among other factors. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Rwanda. Our research findings indicated that adolescent fertility will continue to decline throughout the out of sample period. Hence, we implore the Rwandan government to scale up educational campaigns among communities, continually promote girl child education and strictly enforce laws to protect women's rights.

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