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Early Detection of Abnormal Future Trends of Adolescent Fertility for the Central African Republic Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This research uses annual time series data of adolescent fertility rate for Central African Republic 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 are0.9 and0.1 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility rate will continue to decline but still remain very high throughout the out of sample period. Therefore, we encourage authorities in the Central African Republic to channel more resources towards educating communities, promote girl child education, strictly enforce laws to protect sexual and reproductive rights for women and ensuring the availability of birth control methods in every region of the country especially in the rural areas where access to SRH services is a challenge.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Many authors regard teenage pregnancy as a worldwide medical, economic and social problem that affects both developed and developing countries (Klein, 2005). Nearly twenty five percent of adolescent women are pregnant worldwide (Kassa *et al.* 2018;Kaphagawani & Kalipeni, 2017). The prevalence of adolescent pregnancy in Africa is 18.8 percent, of this, 19.3 percent occurred in Sub-Saharan Africa and 21.5 percent in eastern Africa (Kassa *et al.* 2018).The prevalence of adolescent pregnancy in eastern Africa ranges from 18 to 29 percent and around 50 percent of these pregnancies are unintended (Wado *et al.* 2019). Worldwide, approximately 3.9 million adolescents experience unsafe abortions, which contribute to the highest maternal mortality and morbidity (Darroch *et al.* 2016; Franklin &Corcoran, 2000). Pregnant teenagers have an increased risk of experiencing adverse sexual and reproductive health outcomes such as hypertension, anemia, obstructed labour, preterm delivery and antepartum hemorrhage (Sedgh *et al.* 2016; Larsson *et al.* 2002).Previous researchers found out that being poor, from rural areas, having little knowledge on family planning and with low educational level predispose teenage girls to teenage pregnancy (Monari*et al.* 2022; Blum & Gates, 2015;Pradhan *et al.* 2015;WHO, 2014). World Bank data revealed that in the Central African Republic, adolescent fertility declined gradually from 173 births per 1000 women in 1960 to 122 births per 1000 women aged 15-19 in 2020. This shows that this country has a huge burden of adolescent pregnancy and child births, hence there is need to channel more resources towards prevention of teenage pregnancy.

The aim of this paper is to model and forecast future trends of adolescent fertility in the Central African Republic using Holt's double exponential smoothing technique. Findings of this piece of work are envisioned to highlight the future burden of adolescent births in the out of sample period. This will facilitate 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 the Central African Republic. 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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

Q_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 slope of the trend at time t

b_{t-1} is the slope of the trend at time period t-1

Data Issues

This study is based on annual adolescent fertility rate in the Central African Republic 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	Q
Included Observations	61

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Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.710142
Sum Square Error (SSE)	135.829290
Mean Square Error (MSE)	2.226710
Mean Percentage Error (MPE)	-0.091789
Mean Absolute Percentage Error (MAPE)	0.438253

Residual Analysis for the Applied Model

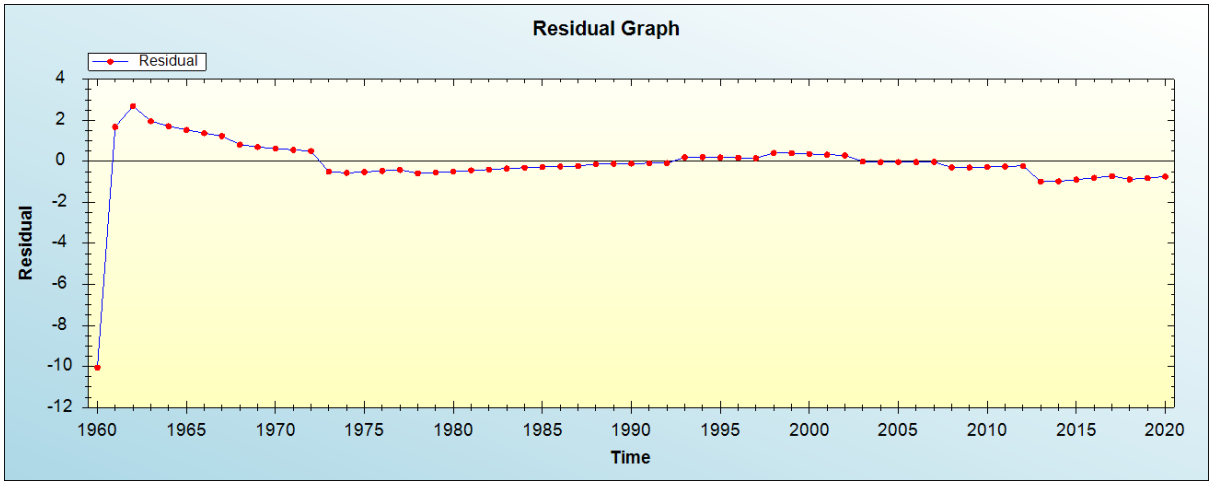

Figure 1: Residual analysis

In-sample Forecast for Q

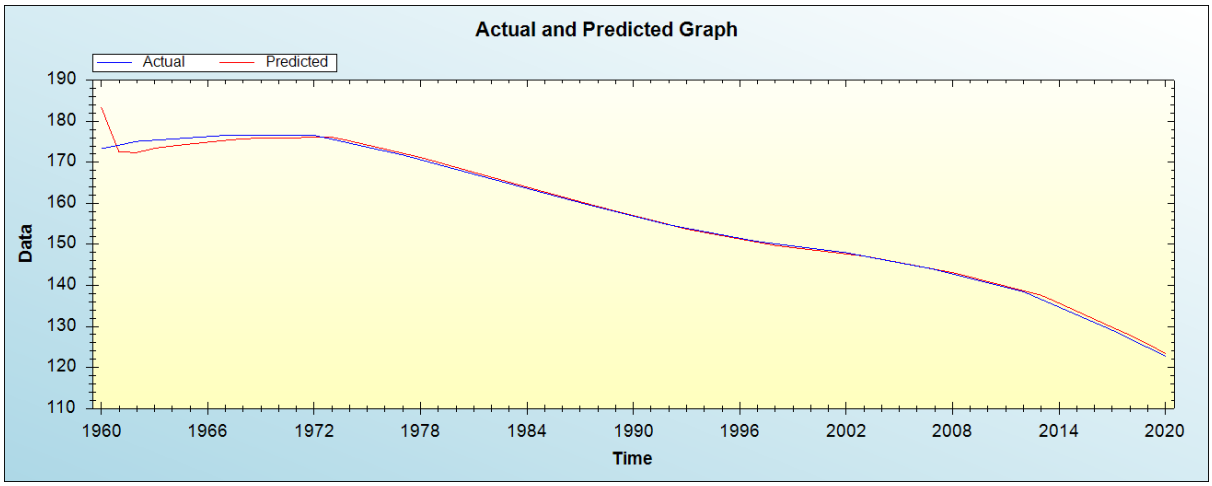

Figure 2: In-sample forecast for the Q series

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Actual and Smoothed graph for Q series

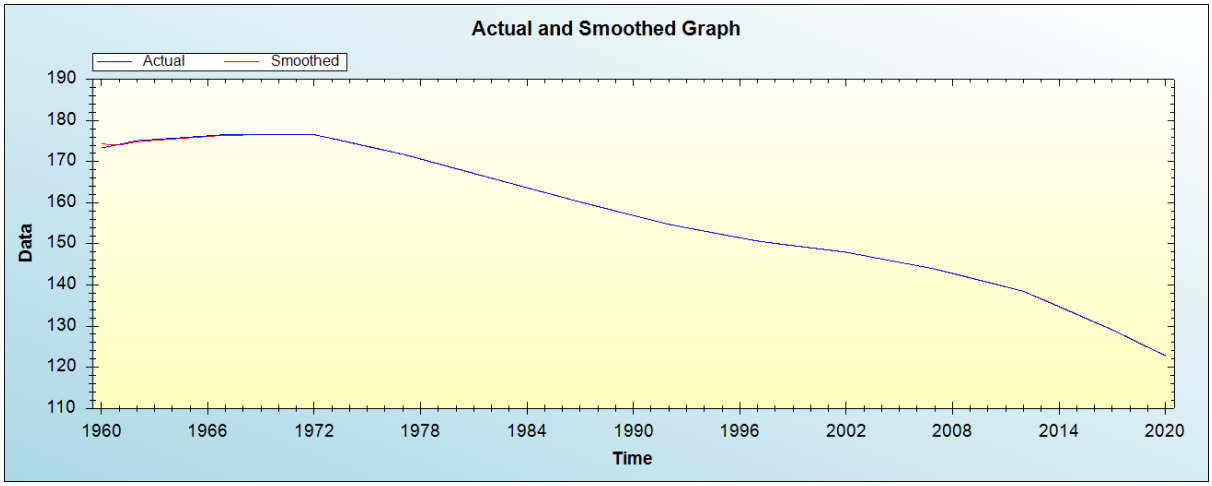

Figure 3: Actual and smoothed graph for Q series

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

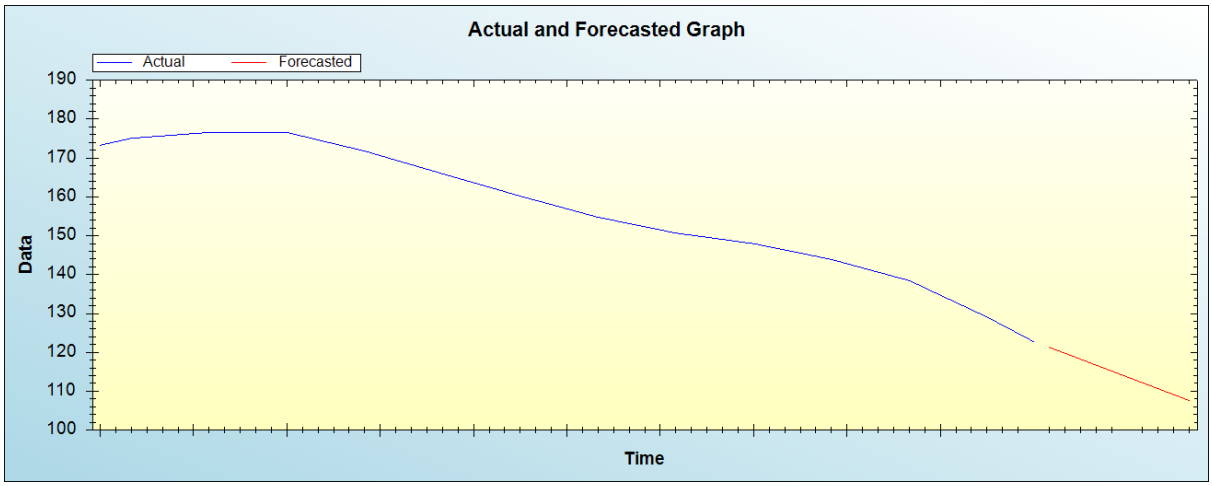

Figure 4: Out-of-sample forecast for Q: actual and forecasted graph

Out-of-Sample Forecast for Q: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	121.2937
2022	119.7711
2023	118.2485
2024	116.7259
2025	115.2033
2026	113.6807
2027	112.1581
2028	110.6355
2029	109.1128
2030	107.5902

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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 ratewill continue to decline but remain very high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

In the Central African Republic, adolescent fertility declined gradually from 173 births per 1000 women in 1960 to 122 births per 1000 women aged 15-19 in 2020. This shows that this country has a huge burden of adolescent pregnancy and child births, hence there is need to channel more resources towards prevention of teenage pregnancy. Being poor, from rural areas, having little knowledge on family planning and with low educational level predispose teenage girls to teenage pregnancy. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Central African Republic. Our study findings revealed that adolescent fertility will continue to decline but remain very high throughout the out of sample period. Therefore, the government must channel more resources towards educating communities, promote girl child education, strictly enforce laws to protect sexual and reproductive rights for women and ensuring the availability of birth control methods in every region of the country especially in the rural areas where access to SRH services is a challenge.

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