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Utilizing Holt's Double Exponential Smoothing Technique to Detect Future Trends of Adolescent Fertility for Djibouti

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

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

***Abstract* - This research uses annual time series data of adolescent fertility rate for Djibouti 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 0.1 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 Djibouti to continue supporting SRH programs for adolescents and adults by availing enough resources for the various activities that are designed to reduce adolescent fertility across the whole country.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Approximately, there are1.2 billion adolescents around the world of which fifty percent are in the 10-14 years age group (Woog and Kagesten, 2017). In 2016, 545 million very young adolescents were from low-middle countries with 63% from Asia, 26 percent from Africa, 10 percent from Latin America, and the Caribbean (Woog and Kagesten, 2017). Pregnancy during the adolescence stage can be associated with health, economic and social consequences to the mother and the fetus (WHO, 2018; Woog *et al.* 2017; UNFPA, 2016; Chalasani *et al.* 2013; Muula *et al.* 2008). Previous research findings indicate that there is increased risk of mortality and morbidity among adolescents. Adverse pregnancy outcomes include preterm delivery, eclampsia, anemia, malnutrition, repeat pregnancy and mental stress (Michaels-Igbokwe *et al.* 2015; Ickovics*et al.* 2011; WHO, 2007). Pregnant adolescents encounter complex psychosocial problems compared to older pregnant women because of the low self-esteem and stigma associated with adolescent pregnancy (Daley*et al.* 2013; Gross *et al.* 2012). In addition, stress and rejection may lead to unhealthy behaviors such as substance abuse and poor nutritional intake resulting in adverse perinatal outcomes (Ganchimeg *et al.* 2014; Novick *et al.* 2012; WHO, 2007). Several risk factors associated with teenage pregnancy include early sexual debut, peer pressure, poor parental guidance, poverty, lack of education and nonuse of contraceptive methods (Magnusson *et al*. 2019; Bankole *et al.* 2008).In addition, the exposure of teenagers to pornographic material in the media can trigger their desire to engage in early sexual activity (Magnusson *et al*. 2019; Peltzer & Pengpid, 2015; Peltzer, 2010; Pettifor*et al*. 2009). Unprotected sex exposes them to unintended pregnancies, STIs and HIV (Peltzer & Pengpid, 2015). According to the World Bank, adolescent fertility in Djibouti has been declining steadily since 1960. In 2020 the country recorded an adolescent fertility rate of 17.65 births per 1000 women aged 15-19 years. This reflects significant progress made in reducing teenage pregnancy and early child marriages.

This paper aims to forecast future trends of adolescent fertility in Djibouti using Holt's double exponential smoothing technique. Research findings are expected to depict 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 in the country.

II. METHODOLOGY

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

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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 exponential smoothing method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

D_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 Djibouti 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

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Table 1: ES model summary

Variable	D
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.890284
Sum Square Error (SSE)	326.832521
Mean Square Error (MSE)	5.357910
Mean Percentage Error (MPE)	0.075442
Mean Absolute Percentage Error (MAPE)	2.158039

Residual Analysis for the Applied Model

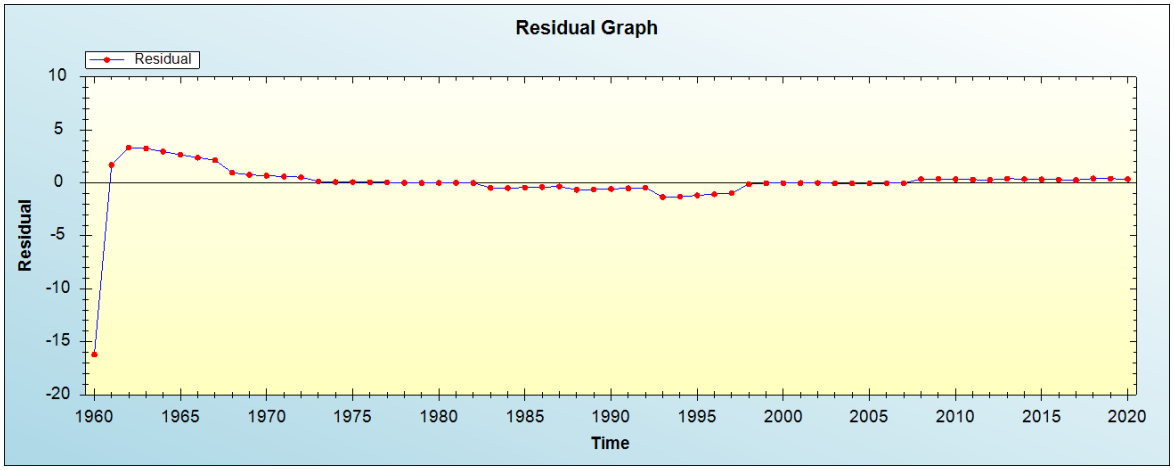

Figure 1: Residual analysis

In-sample Forecast for D

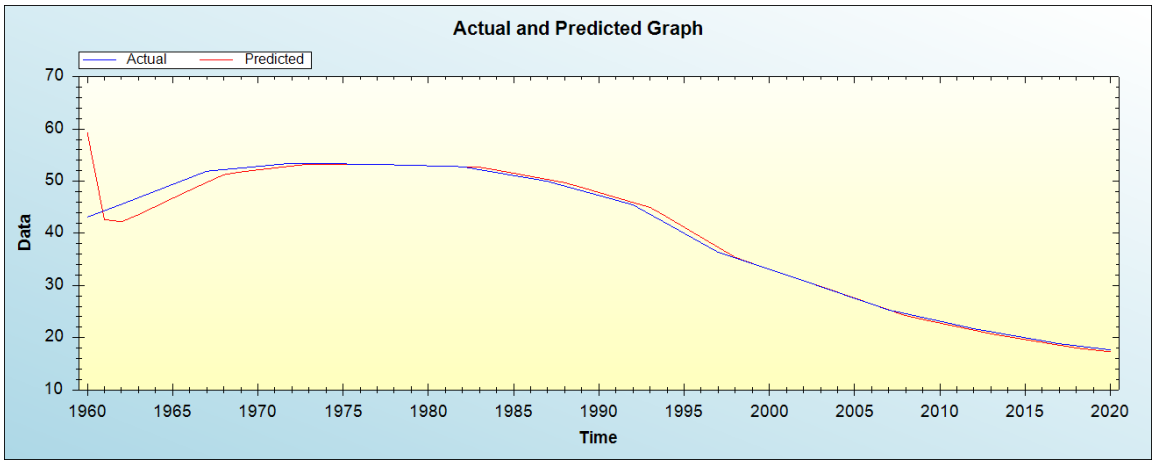

Figure 2: In-sample forecast for the D series

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Actual and Smoothed graph for D series

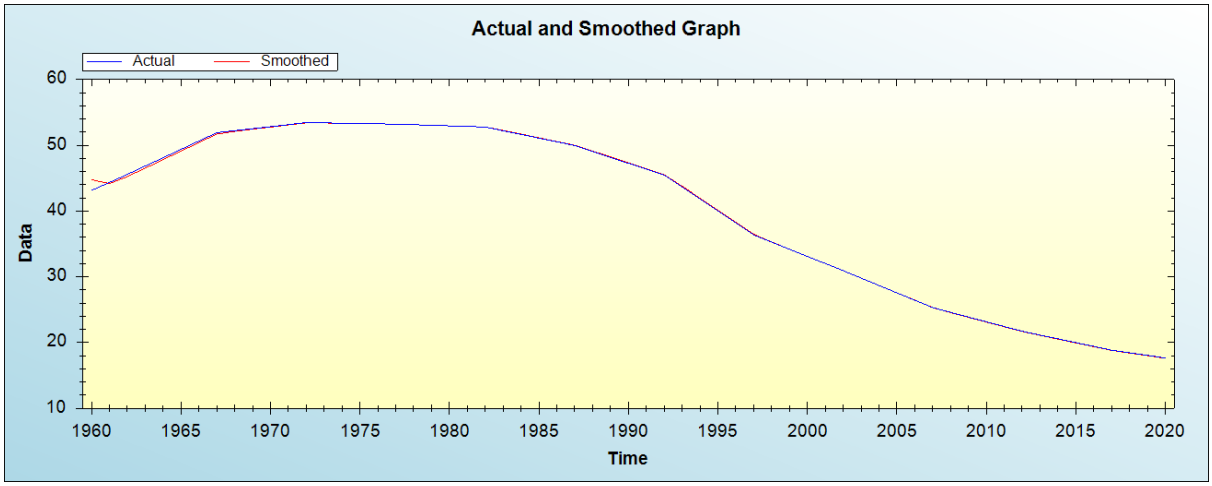

Figure 3: Actual and smoothed graph for D series

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

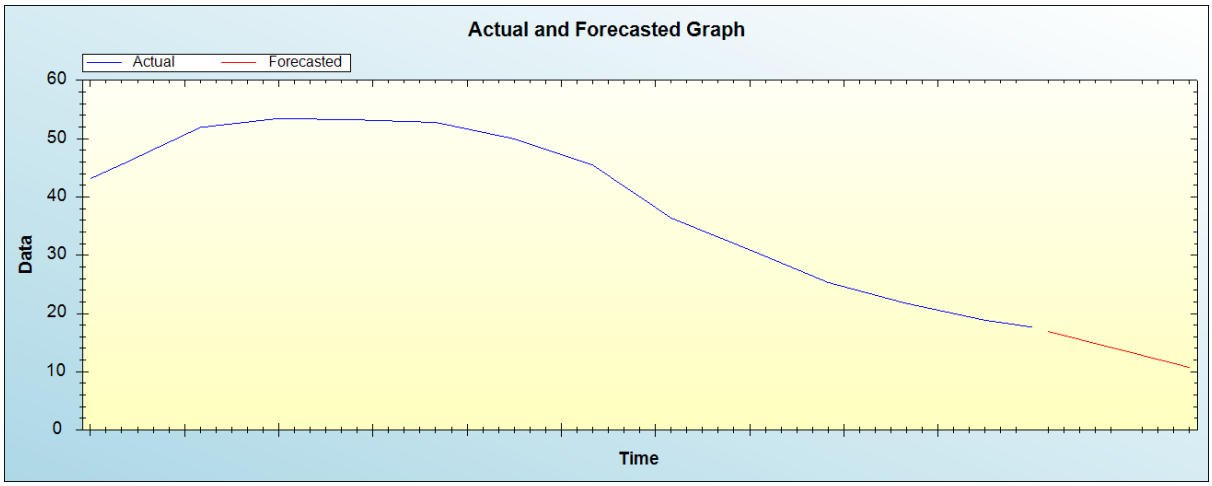

Figure 4: Out-of-sample forecast for D: actual and forecasted graph

Out-of-Sample Forecast for D: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	16.9265
2022	16.2409
2023	15.5552
2024	14.8696
2025	14.1839
2026	13.4983
2027	12.8126
2028	12.1270
2029	11.4413
2030	10.7557

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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

Adolescent pregnancy and child birth is still an important problem in Djibouti. Pregnant adolescents continue to experience adverse obstetric outcomes such as maternal deaths, newborn mortality, hypertensive disorders, anemia, preterm delivery, low birth weight, STIs and unsafe abortions. Among other factors poverty and low educational level have been identified as significant predictors for adolescent pregnancy. Adolescent fertility in Djibouti has been declining steadily since 1960. In 2020 the country recorded an adolescent fertility rate of 17.65 births per 1000 women aged 15-19 years. This reflects significant progress made in reducing teenage pregnancy and early child marriages through the implementation of national strategies such as the national family planning program and universal education. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Djibouti. Our findings revealed that adolescent fertility will continue to decline throughout the out of sample period. Therefore, the government must continue supporting SRH programs for adolescents and adults by availing enough resources for the various activities that are designed to reduce adolescent fertility across the whole country.

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