International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048
Volume 6, Issue 12, pp 264-269, December-2022
https://doi.org/10.47001/IRJIET/2022.612050

Utilizing Holt's Double Exponential Smoothing Technique to Detect Abnormal Future Trends of Adolescent Fertility in Fiji

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Fiji 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 hover around 50 births per 1000 women aged 15-19 years throughout the out of sample period. throughout the out of sample period. In order to reverse the projected increase in adolescent births, authorities in Fiji are encouraged to increase awareness among communities and set up adolescent friendly clinics that are capacitated to handle various SRH problems encountered by adolescents and young adults.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adverse pregnancy outcomes in the developing world is a public health concern. High morbidity and mortality among pregnant teenage mothers and under five children in Sub-Saharan Africa and South Central Asia needs urgent attention as this will hinder the prospects of achieving set targets under the 3rd sustainable development goal. One of the leading causes of morbidity and mortality is adolescent pregnancy. An adolescent is an individual in the age group 10-19 years (WHO, 1999). Pregnancy and child birth during this stage increases the risk of adverse SRH outcomes to the mother and the baby (CSA, 2012; Mangiaterra *et al.* 2008). Adverse pregnancy outcomes include pre-eclampsia/eclampsia, obstetric fistula, increased risk of acquiring STIs, anemia in pregnancy, preterm delivery, low birth weight and malnutrition (Nguyen *et al.* 2019; Santelli *et al.* 2017; de Onis & Branca, 2016; Patton *et al.* 2016; Azevedo *et al.*2015; Rosenburg *et al.* 2015; UNFPA *et al.* 2015; Chandra-Mouli*et al.* 2014). It has been revealed in previous studies that social rejection, stigma and school dropouts contribute to the development of mental disorders among teenage mothers (Ochen *et al.* 2019; Ayele *et al.* 2018; Odimegwu & Mkwananzi, 2016;WHO, 2016; UNICEF, 2014; Neal *et al.* 2012). Several previous studies have indicated that poverty, peer influence, substance abuse, lack of SRH knowledge, social media and poor parental support are the main drivers of teenage pregnancies (Croft *et al.* 2018;Okigbo& Speizer, 2015). According to the World Bank, Fiji's adolescent fertility declined gradually from around 113 births per 1000 women aged 15-19 in 1960 to around 49 births per 1000 women aged 15-19 in 2020. These figures indicate that teenage pregnancy is still a problem in Fiji.

The objective of this study is to model and forecast future trends of adolescent fertility in Fiji using Holt's double exponential smoothing technique. The results are expected to depict the future burden of adolescent fertility in the out of sample period. This will assist in policymaking, decisions, planning and allocation of resources to teenage pregnancy prevention.

II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Fiji. 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 double exponential smoothing method is expressed as follows:

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Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

J_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 Fiji 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	J
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900

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Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	2.267631
Sum Square Error (SSE)	1293.049677
Mean Square Error (MSE)	21.197536
Mean Percentage Error (MPE)	0.388539
Mean Absolute Percentage Error (MAPE)	3.234830

Residual Analysis for the Applied Model

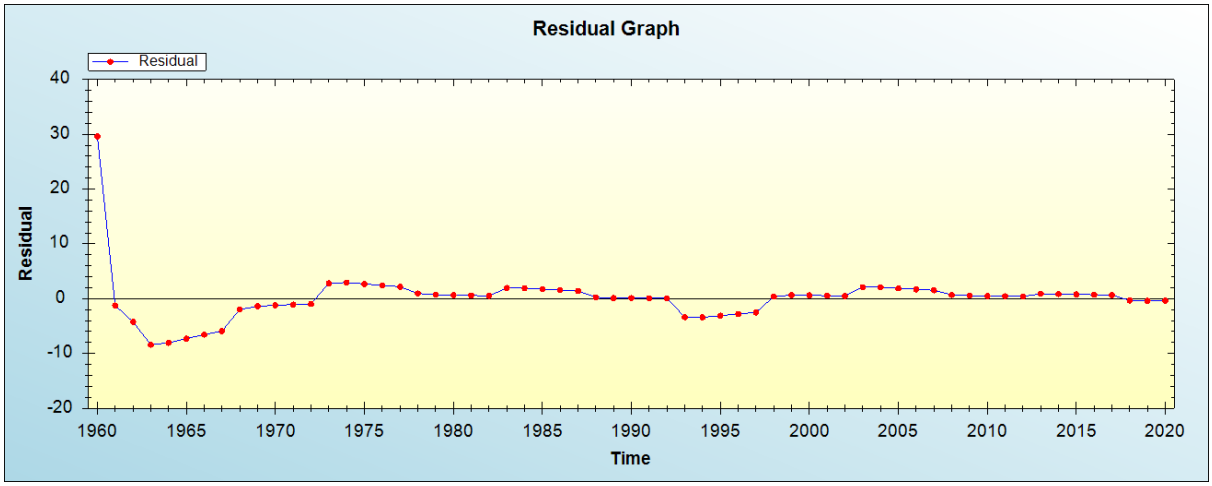

Figure 1: Residual analysis

In-sample Forecast for J

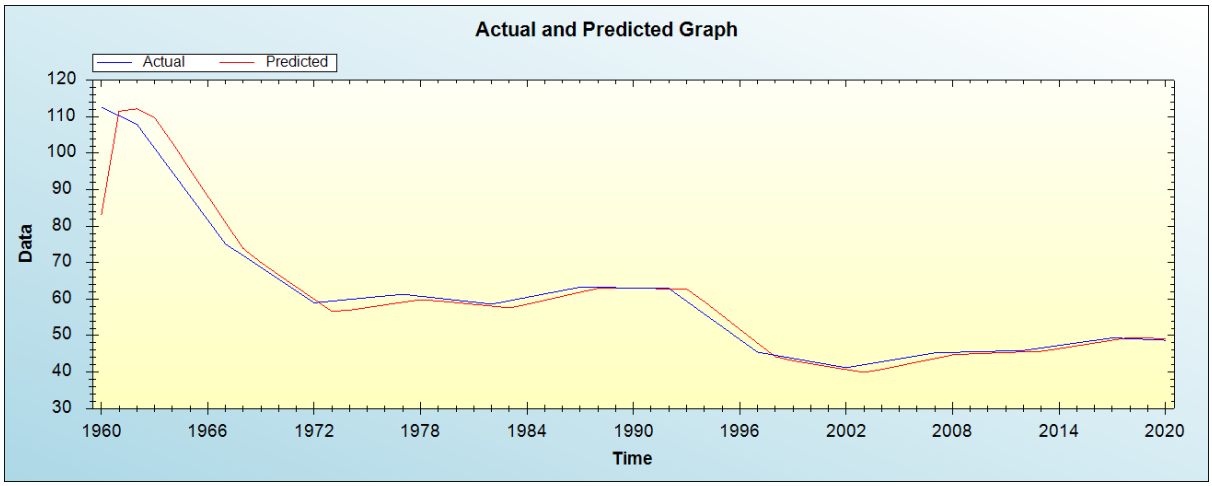

Figure 2: In-sample forecast for the J series

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Actual and Smoothed graph for J series

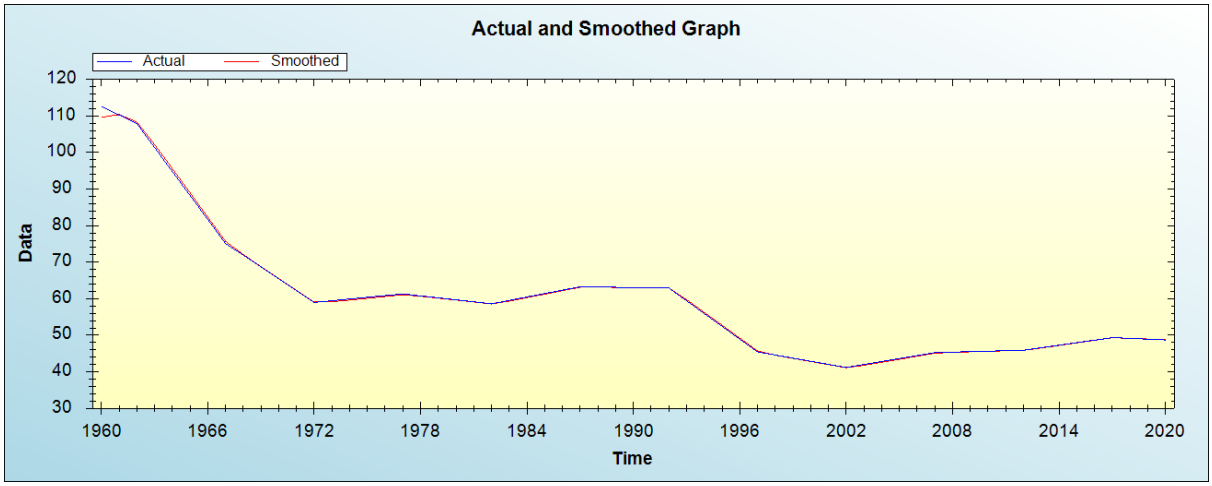

Figure 3: Actual and smoothed graph for J series

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

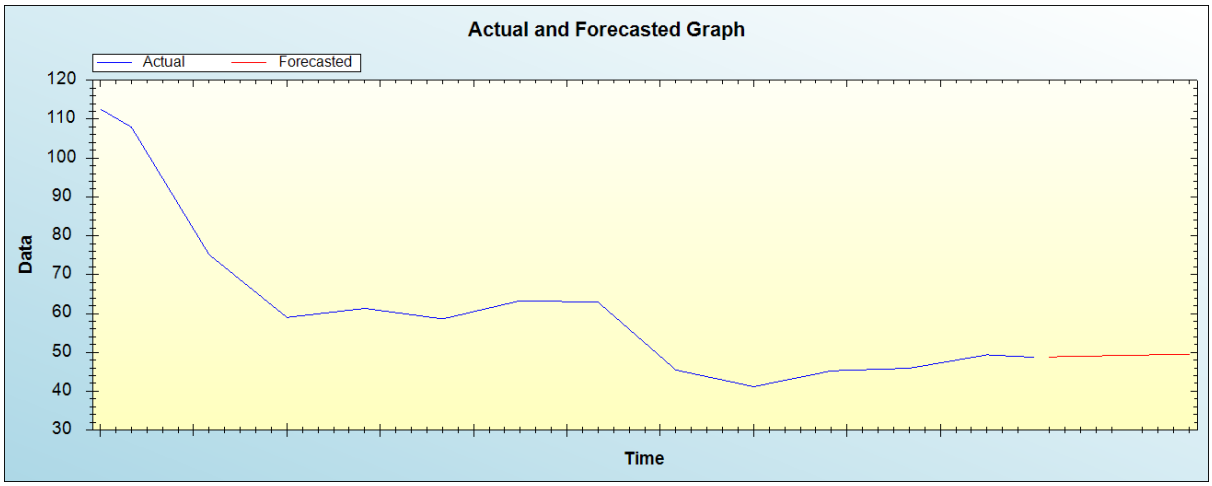

Figure 4: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	48.8299
2022	48.9079
2023	48.9858
2024	49.0638
2025	49.1417
2026	49.2197
2027	49.2976
2028	49.3756
2029	49.4535
2030	49.5315

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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 hover around50 births per 1000 women aged 15-19 years throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

One of the leading causes of morbidity and mortality among pregnant women is adolescent pregnancy. There is an increased risk of adverse pregnancy outcomes such as pre-eclampsia/eclampsia, obstetric fistula, increased risk of acquiring STIs, anemia in pregnancy, preterm delivery, low birth weight and malnutrition poverty, peer influence, substance abuse, lack of SRH knowledge, social media and poor parental support are the main drivers of teenage pregnancies. Fiji's adolescent fertility declined gradually from around 113 births per 1000 women aged 15-19 in 1960 to around 49 births per 1000 women aged 15-19 in 2020. These figures indicate that teenage pregnancy is still a problem in Fiji. This study applied Holt's double exponential smoothing technique to predict adolescent fertility for Fiji. Our study findings revealed that adolescent fertility will hover around 50 births per 1000 women aged 15-19 years throughout the out of sample period. throughout the out of sample period. Therefore, the government must increase awareness among communities and set up adolescent friendly clinics that are capacitated to handle various SRH problems encountered by adolescents and young adults.

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ISSN (online): 2581-3048
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Citation of this Article:

Smartson. P. NYONI, Thabani NYONI, "Utilizing Holt's Double Exponential Smoothing Technique to Detect Abnormal Future Trends of Adolescent Fertility in Fiji" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 12, pp 264-269, December 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.612050

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