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

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Madagascar 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 will continue to decline but still remain high throughout the out of sample period. Therefore, we encourage authorities in Madagascar to focus on improving accessibility and affordability of adolescent sexual and reproductive health services, enforce laws that protect the girl child, promote girl child education and must establish a youth empowerment program that will enable youths to contribute meaningfully to the economic growth of the country.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Madagascar is a low-income country with a young and rapidly growing population (Madagascar, 2021). High maternal, perinatal and fertility rates define the country's health delivery system (Madagascar, 2014; Madagascar, 2010; Madagascar, 1998).According to documented evidence from previous studies, the etiology of maternal deaths in Madagascar is the delay or absence of medical care in cases of obstetric complications (Madagascar, 2018; Madagascar, 2014). In 2018, the Multiple Indicator Cluster Survey (MICS) revealed that only 30.3 percent of pregnant women received four antenatal follow-ups as recommended by the WHO and that only 49 percent of births were assisted by a skilled birth attendant. The majority of deliveries were home deliveries and were assisted by traditional birth attendants. The majority of primary healthcare facilities are not readily accessible. In fact, 25.8% of Malagasy people live more than 10 km from medical clinics of which the majority are understaffed, and 53.5% are not accessible year-round (Madagascar, 2018). In 2018, 51% of local clinics had only one caregiver, 50.3% did not have a doctor, and only 17.7% were available to receive basic emergency obstetric care (Madagascar, 2018). I addition, a lack of equipment and stock outs of medicine and supplies are constant challenges (Lang *et al.* 2018; Martin, 2017). There are several challenges that need urgent attention such as gender inequality, poverty, high unmet need for family planning and relatively low contraceptive prevalence (Madagascar, 2021). The estimated modern contraceptive prevalence rate for married women rose from 33.4 percent in 2012 to 43 percent in 2020, and for all women from 27.2 to 35.2 percent, while an estimated 17,000 maternal deaths were averted from 2012 to 2020 (FP2020).According to the Madagascar Multiple Cluster survey 2018, Madagascar is one of the countries in the world with highest rates of child marriages. Marriage before the age of 15 isa common finding as it affects nearly 13% of women aged between 20 and 24. The most affected regions with very high child marriage rates are Atsimo Atsinanana (60%), Atsimo Andrefana (66%), Melaky (54%), Betsiboka (51%) and Sofia (54%).

The aim of this paper is to forecast adolescent fertility for Madagascar using the double exponential smoothing technique. The findings are expected to depict the future burden of adolescent fertility in the out of sample period. This will inform policies, 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 Madagascar. 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 double exponential smoothing method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

A_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 t-1

Data Issues

This study is based on annual adolescent fertility rate in Madagascar 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	A
Included Observations	61

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Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	1.013217
Sum Square Error (SSE)	262.652506
Mean Square Error (MSE)	4.305779
Mean Percentage Error (MPE)	-0.041302
Mean Absolute Percentage Error (MAPE)	0.674574

Residual Analysis for the Applied Model

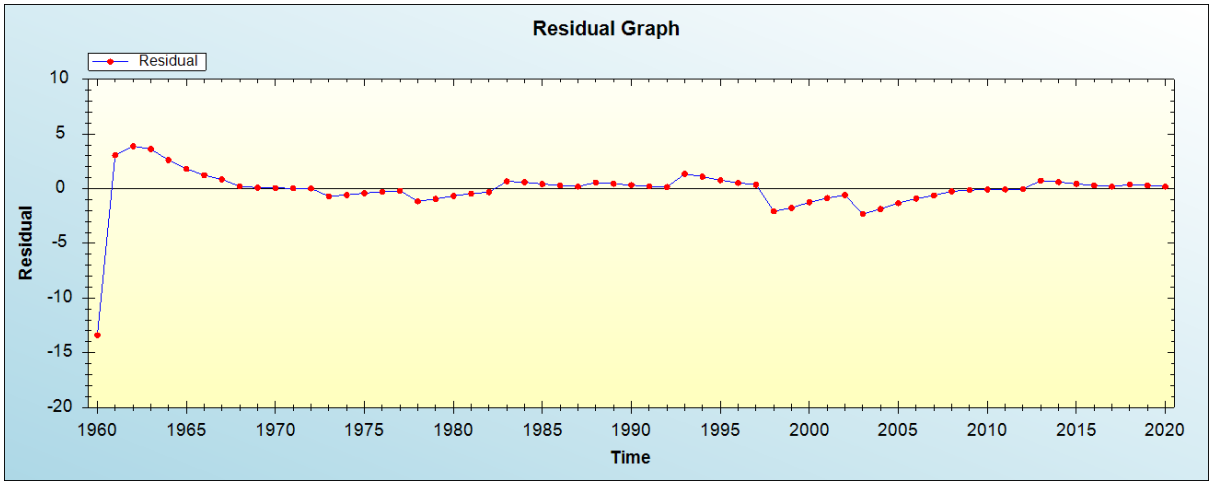

Figure 1: Residual analysis

In-sample Forecast for A

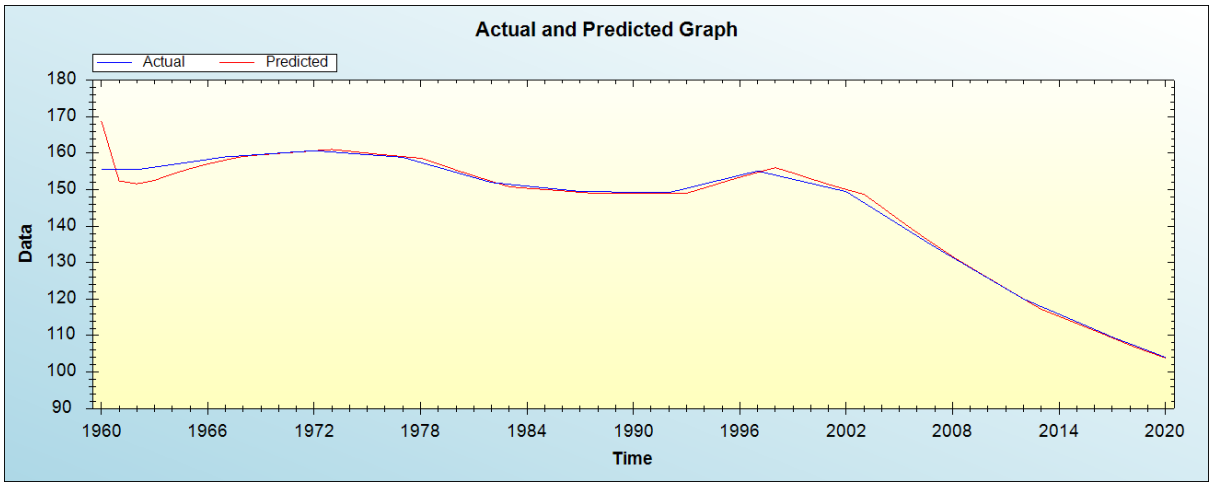

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

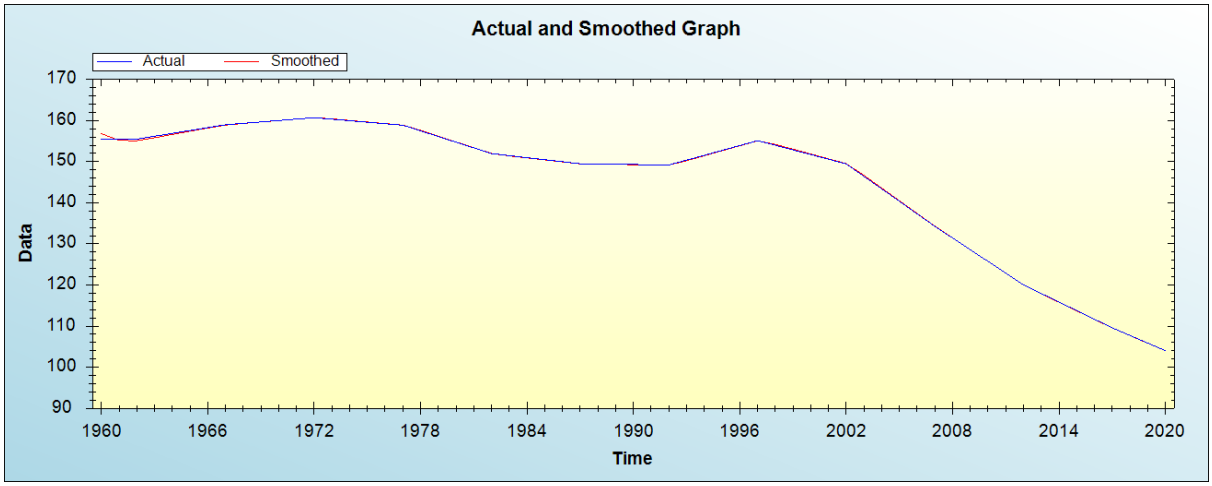

Figure 3: Actual and smoothed graph for A series

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

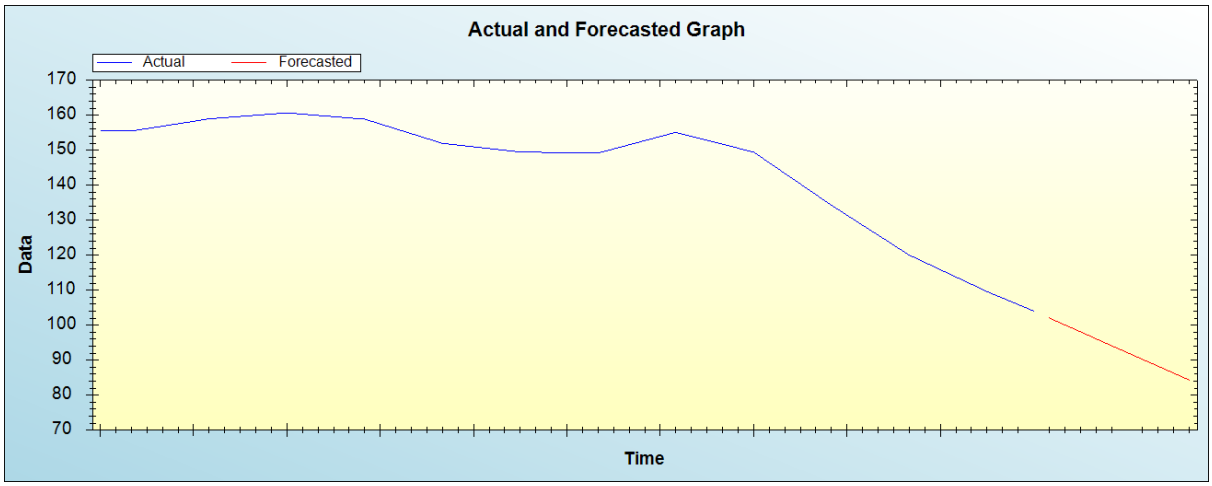

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	102.0390
2022	100.0663
2023	98.0935
2024	96.1208
2025	94.1481
2026	92.1754
2027	90.2026
2028	88.2299
2029	86.2572
2030	84.2844

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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 but still remain high throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

Madagascar is a low-income country with a young and rapidly growing population. The country continues to report high maternal, perinatal and fertility rates. Teenage pregnancy has been identified as one of the leading causes of adverse pregnancy outcomes. Adolescent fertility has been declining gradually during the period 1960 to 2020. Despite government efforts adolescent births are still very high in this country. There are several challenges that need urgent attention such as gender inequality, poverty, high unmet need for family planning and relatively low contraceptive prevalence. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Madagascar. Forecast results revealed that adolescent fertility will continue to drop but remain high throughout the out of sample period. Therefore, we encourage the government to focus on improving accessibility and affordability of adolescent sexual and reproductive health services, enforce laws that protect the girl child, promote girl child education and must establish a youth empowerment program that will enable youths to contribute meaningfully to the economic growth of the country.

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