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Detecting Future Trends of Adolescent Fertility for the European Union Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This research article uses annual time series data of adolescent fertility rate for the European Union 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 to levels below 10 births per 1000 females aged 15-19 years by the end of 2030. Therefore, we encourage authorities in the European Union to focus on improving accessibility and affordability of adolescent health services particularly for immigrants who are socially and economically deprived.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adolescent pregnancy refers to pregnancy occurring among young women aged 10-19 years (WHO, 2020). It is regarded as a worldwide social, economic and medical problem that requires urgent action from all stakeholders (Papri *et al.* 2016; Lawlor & Shaw, 2004;Cunnington, 2001; Johnson *et al.* 2001). The resultant adverse maternal and child health outcomes can potentially lead to premature loss of life and undesirable lifelong consequences to the mother, baby and family (Kassa *et al.* 2018; Mehra *et al.* 2018; Pradhan *et al.* 2018; Sama *et al.* 2017). Sub-Saharan Africa is leading in the race of reporting high teenage pregnancy rates as a result of numerous serious challenges that will take long to resolve. Previous studies have revealed that existing problems such as poverty, hunger, high unemployment rates, low educational levels, drug and substance abuse among others have been identified as risk factors for adolescent pregnancy in the developing world (Odimegwu &Mkwananzi, 2016;Undie *et al.* 2015). Adolescent fertility has declined substantially in Europe, however current trends are still unacceptable (Sedgh *et al.* 2016). It varies from a low of 8 percent in Switzerland to 25 percent in Spain and Portugal, and 46 percent in the United Kingdom. In most Western European countries, 30-70 percent of adolescent pregnancies are terminated by abortion but only around half of these countries provide access to oral contraception (OC) without parental consent (WHO, 2018). Furthermore, 10%–15% of HIV infections are acquired before the age of 20 years (WHO, 2017). This has driven the governments of the European region to endorse an action plan in the area of sexual and reproductive health (WHO, 2016). Previous studies conducted in Europe have revealed that risk factors of adolescent pregnancy in the region include low socioeconomic status, ethnicity, and place of residence, early physical development and geographic region (Worku *et al.* 2021; Birhanu *et al.* 2019;Wado *et al.* 2019; Oke, 2010; Bonell *et al.* 2005; Paton, 2002;Hippisley-Cox*et al.* 2000).

The main objective of this paper is to model and forecast future trends of adolescent fertility for the European Union using the double exponential smoothing technique. The findings of this paper are anticipated to provide an insight of the future burden of adolescent fertility in Europe. This will inform regional policies, planning, decision making 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 for the European Union. 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

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

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 the European Union 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
Smoothing constants	

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Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.514771
Sum Square Error (SSE)	62.186876
Mean Square Error (MSE)	1.019457
Mean Percentage Error (MPE)	0.425590
Mean Absolute Percentage Error (MAPE)	2.189336

Residual Analysis for the Applied Model

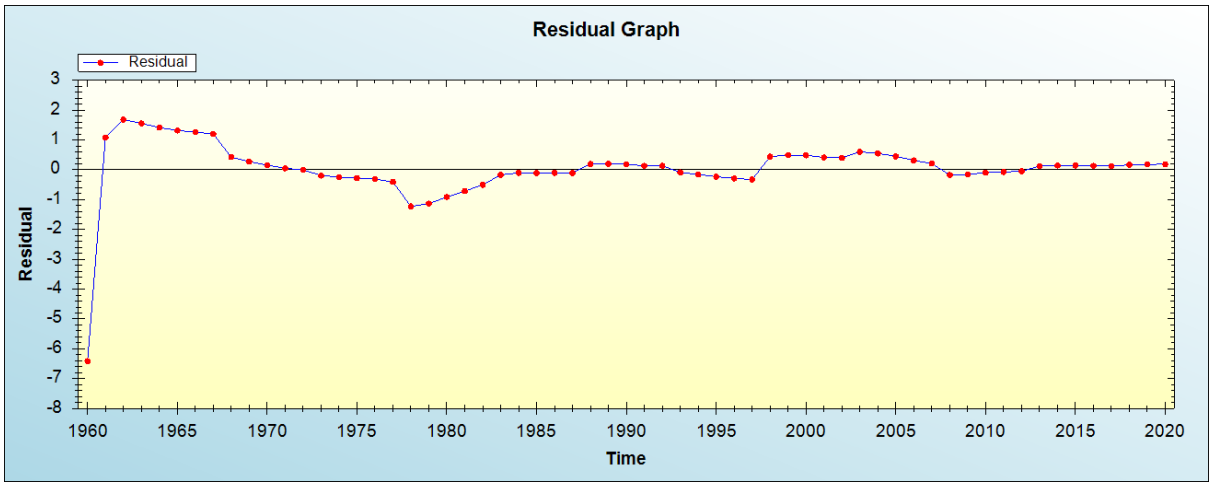

Figure 1: Residual analysis

In-sample Forecast for A

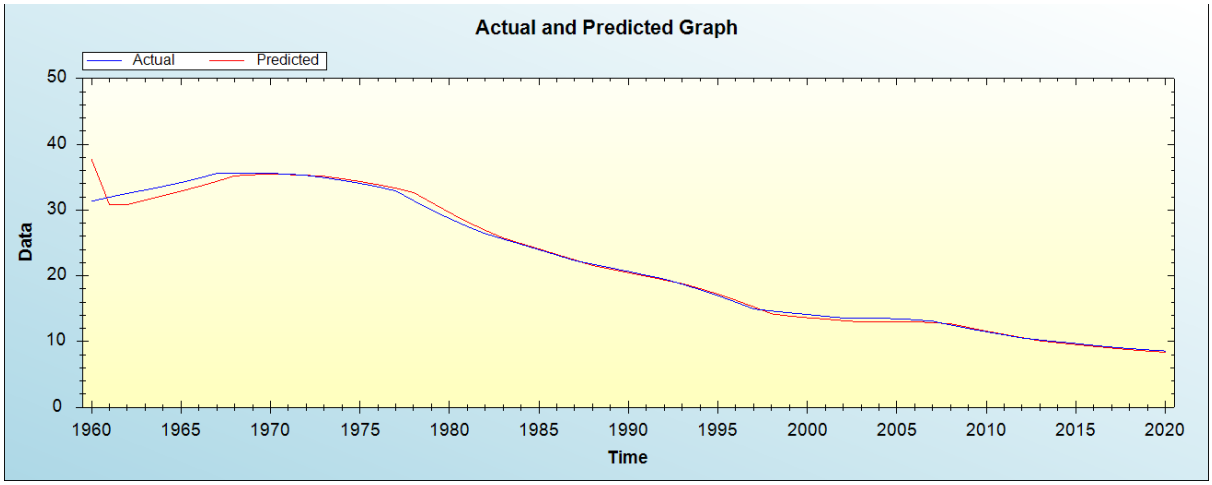

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

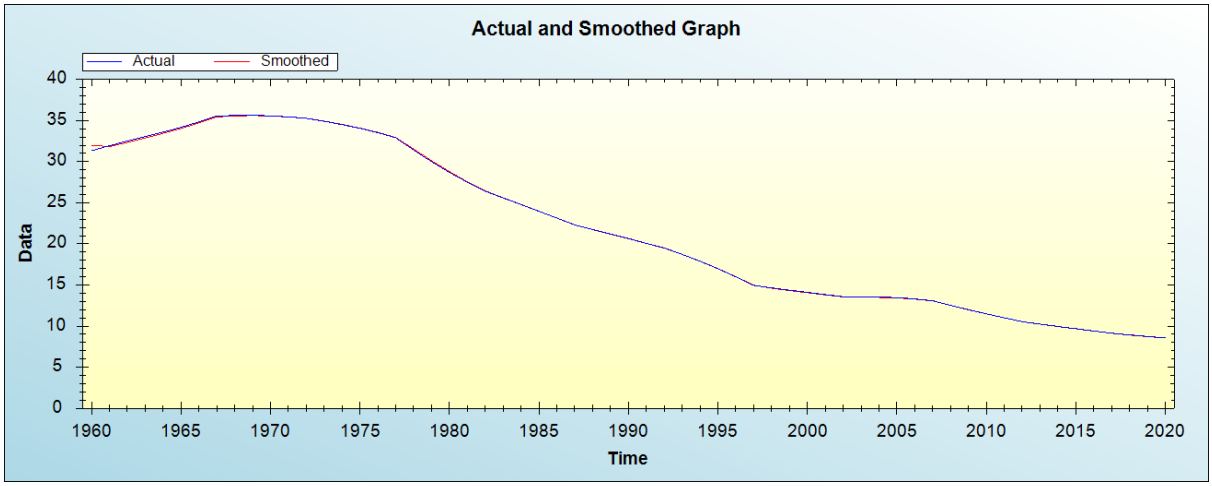

Figure 3: Actual and smoothed graph for A series

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

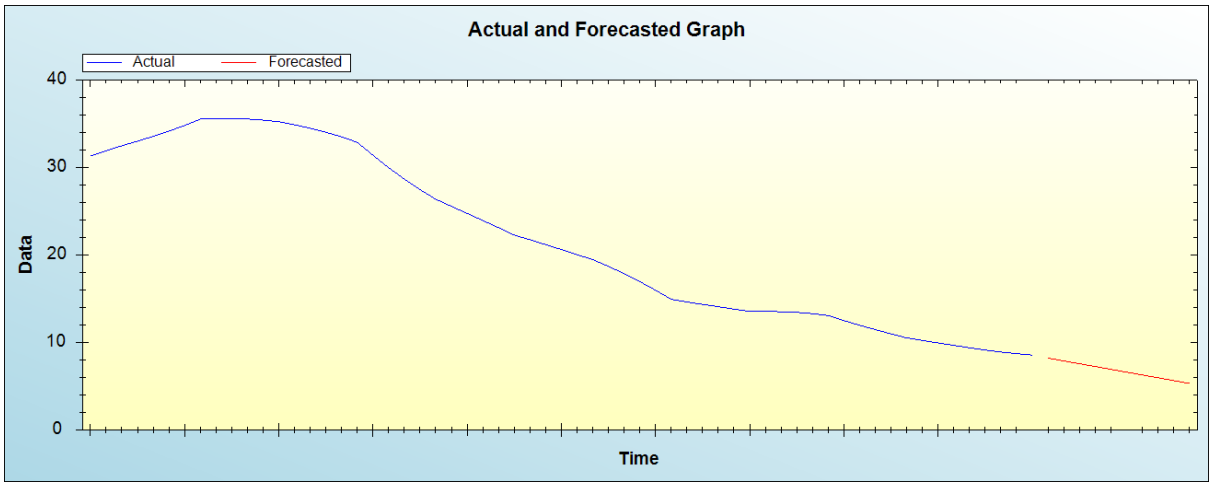

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	8.2301
2022	7.9092
2023	7.5883
2024	7.2674
2025	6.9464
2026	6.6255
2027	6.3046
2028	5.9837
2029	5.6628
2030	5.3419

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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 decline to levels below 10 births per 1000 females aged 15-19 years by the end of 2030.

IV. POLICY IMPLICATION & CONCLUSION

Adolescent fertility has declined substantially in Europe, however current trends are still unacceptable. It varies from a low of 8 percent in Switzerland to 25 percent in Spain and Portugal, and 46 percent in the United Kingdom. In most Western European countries, 30-70 percent of adolescent pregnancies are terminated by abortion but only around half of these countries provide access to oral contraception (OC) without parental consent. In this region, risk factors for adolescent pregnancy include low socioeconomic status, ethnicity, and place of residence, early physical development and geographic region. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for the European Union. Our study findings revealed that adolescent fertility will continue to decline to levels below 10 births per 1000 females aged 15-19 years by the end of 2030. Therefore, authorities in the European Union must focus on improving accessibility and affordability of adolescent health services particularly for immigrants who are socially and economically deprived.

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