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Forecasting Adolescent Fertility for Syria Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Syria 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 throughout the out of sample period. Therefore, we encourage authorities in Syria to address local factors which drive teenage pregnancy in order to avert adverse pregnancy outcomes.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The Agenda 2030 for sustainable development is an important document signed by all 193 UN member states and the task at hand is to solve several issues that affect human lives. The signatories agreed to create a peaceful environment on this planet that will be the backbone of socio-economic development (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). Ensuring peace involves implementing strategies that prevent and those that end ongoing conflicts. Armed conflicts continue to create a strong barrier to the achievement of sustainable development goals including that on Health. The 3rd sustainable development goal focuses on ensuring good health and well-being for all at every stage of life. Target 3.7 specifically addresses sexual and reproductive health issues with special focus on adolescent health services which are essential in controlling adverse maternal and child health outcomes. Evidence shows that the situation in Syria has brought regrettable negative effects such as destruction of health infrastructure, displacement of people, increase in infant mortality, disease outbreaks and limited access to health care services for people with chronic ailments (Cheung, 2020; Mokdad *et al.* 2013; Akbarzada & Mackey, 2015; Taleb *et al.* 2015). This war has led to the death of at least 400 000 Syrians and 5.6 million refugees were displaced from Syria (UN High Commission for Refugees, 2019;Syrian Observatory for Human rights, 2018; Syrian Centre for Policy Research, 2015). Under the current circumstances in Syria, it will be difficult to eradicate teenage pregnancies in the country because of the unfavorable environment which makes sexual and reproductive health services hard to access.

In this paper we apply Holt's double exponential smoothing model to forecast future trends of adolescent fertility in the out of sample period. Forecast results are going to highlight the likely burden of adolescent births and thereby inform policy makers in planning, decision making and allocation of resources towards supporting national programs and activities that are aimed at ending child marriages and sexual abuse of women.

II. LITERATURE REVIEW

Author(s)	Topic	Objectives	Methodology	Main findings
Al-Jermmy et al. (2022)	Prevalence and Correlates of Anemia among Adolescents Living in Hodeida, Yemen	-To assesses the prevalence and correlates of anemia among adolescents living in the war-affected region of Hodeida in Yemen - to examine the effect of a nutrition education intervention on hemoglobin levels among anemic adolescents	-cross-sectional study	-The prevalence of anemia was 37.8%. Female gender, khat chewing, excessive menstruation, and experiencing headaches, fatigue, or dizziness were independent predictors of anemia -adolescents who attended

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				private schools, and reported snack consumption or hand washing had a significantly lower risk of anemia
Hunersen et al. (2020)	Child Marriage in Yemen:	To assess the prevalence of and risk factors for child marriage in Yemen, which was experiencing a nationwide conflict at the time of the study	Mixed methods study	Displaced girls experience child marriage more than boys or local girls
Kassa et al. (2018)	Prevalence and determinants of adolescent pregnancy in Africa: a systematic review and Meta-analysis	to estimate the prevalence and sociodemographic determinant factors of adolescent pregnancy using the available published and unpublished studies carried out in Africa	Systematic review and meta-analysis of published and unpublished studies in Africa.	Nearly one-fifth of teenagers fall pregnant in Africa. sociodemographic factors like residence, marital status, educational status , parent/child communication were associated with adolescent pregnancy
Yakubu & Salisu (2018)	Determinants of adolescent pregnancy in sub-Saharan Africa: a systematic review	to identify factors influencing adolescent pregnancies in sub-Saharan Africa	Systematic review	High levels of adolescent pregnancies in Sub-Saharan Africa is attributable to multiple factors and categorized these factors into three major themes; sociocultural and economic, individual, and health service related factors as influencing adolescent pregnancies.
Sychareun et al. (2018)	Determinants of adolescent pregnancy and access to reproductive and sexual health services for married and unmarried adolescents in rural Lao PDR: a qualitative study	To explore factors contributing to teenage pregnancy in rural Lao. Secondly, to understand the specific challenges adolescent mothers face in accessing maternal health services	Qualitative interviews	Determinants of teenage pregnancy included liberal attitudes to teen pre-marital sexual intercourse, early marriage and pregnancy, incomplete knowledge of sexual and reproductive health and limited access to appropriate services.

III. METHODOLOGY

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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

Y_t is the actual 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 t-1

Data Issues

This study is based on annual adolescent fertility rate in Syria 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.

IV. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Y
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)	1.011617
Sum Square Error (SSE)	267.522248
Mean Square Error (MSE)	4.385611
Mean Percentage Error (MPE)	0.157793
Mean Absolute Percentage Error (MAPE)	1.133850

Residual Analysis for the Applied Model

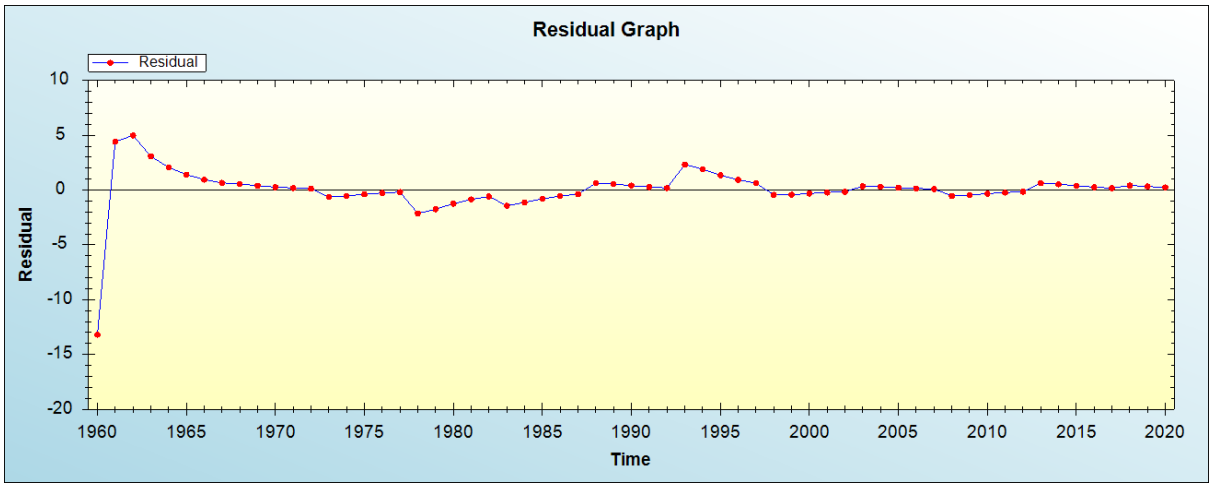

Figure 1: Residual analysis

In-sample Forecast for Y

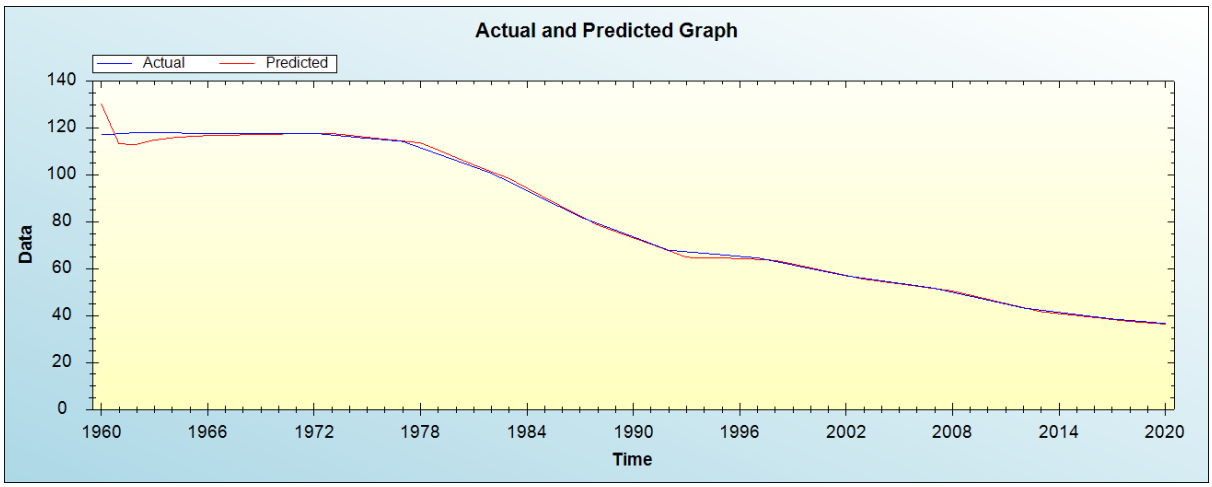

Figure 2: In-sample forecast for the Y series

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Actual and Smoothed graph for Y series

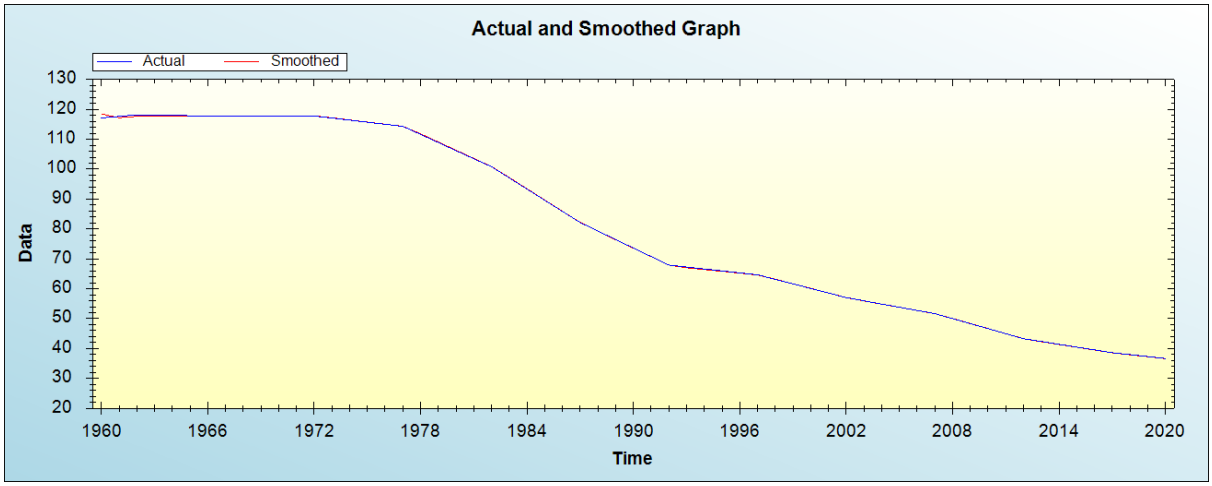

Figure 3: Actual and smoothed graph for Y series

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

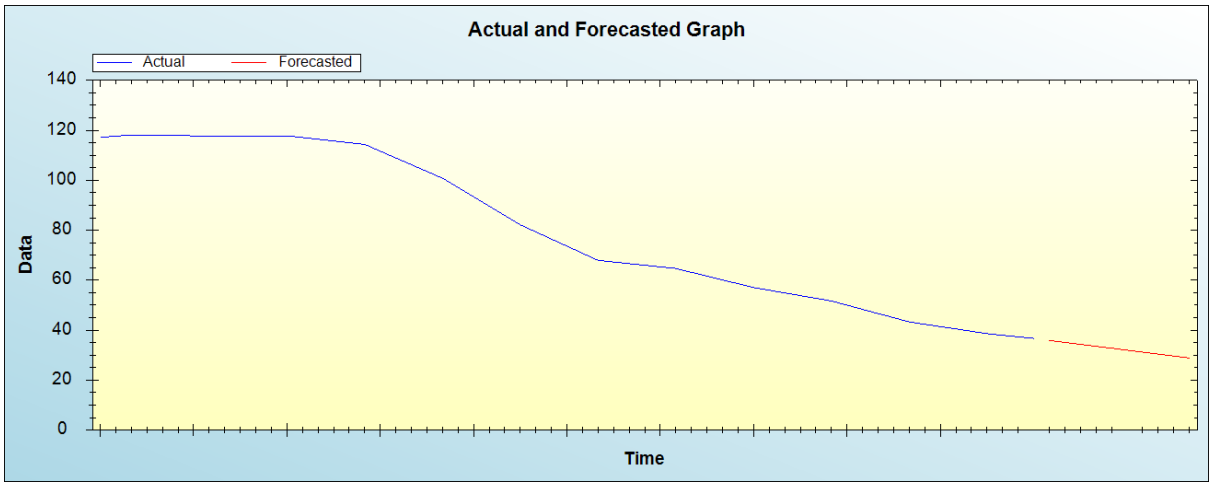

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	35.8679
2022	35.0896
2023	34.3113
2024	33.5330
2025	32.7547
2026	31.9765
2027	31.1982
2028	30.4199
2029	29.6416
2030	28.8633

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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.

V. POLICY IMPLICATION & CONCLUSION

The war in Syria has led to too much human suffering and loss of lives. The destruction of important health infrastructure and mass exodus of healthcare workers has negatively impacted on the delivery of quality, accessible and affordable sexual and reproductive health services including adolescent health services. As indicated by the World Bank, adolescent fertility has steadily declined over the previous decades. In this study we proposed Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Syria. We established that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage the Syrian government to address local factors which significantly contribute to teenage pregnancy.

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