Predicting Future Trends of Adolescent Fertility for Lebanon Using Holt's Linear Method

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

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

Abstract - **This study uses annual time series data of adolescent fertility rate for Lebanon 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 0.6 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 Lebanon to address socio-economic and demographic factors that contribute to adolescent fertility as well as enforcing laws that protect the rights of women and girls.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The provision of sexual and reproductive health (SRH) services is a huge task in the Middle East due to the prevailing unfavorable circumstances (Balisnka *et al.* 2019; Dejong *et al.* 2017). In the case of Lebanon, there is continuous influx of displaced people and refugees and therefore the health system becomes overwhelmed (Amar *et al.* 2016). Shortage of resources has been identified as a major challenge in SRH services delivery. Since November 2011, Médecins Sans Frontières (MSF) has been providing free basic medical care to Syrian refugees in several places in Lebanon. These services are offered to Syrian refugees, Lebanese and Palestinian refugees from Syria, and the Lebanese host community (Balisnka *et al.* 2019).

Lebanon is characterized by a high level of diversity and inequality. The country is ranked sixth in the world for its wealth inequality (Oxfam, 2017). Fifty percent of the country's wealth is owned by 0.3% of the population. The country is currently facing negative impacts of its own civil war (1975-1990), which left it with the world's fourth highest debtto-GDP ratio (CIA Factbook, 2017). Lebanon is hosting approximately 1 million registered Syrian refugees, 175,000 registered Palestine refugees (PCBS, 2017) and tens – perhaps hundreds – of thousands of unregistered refugees (World Bank, 2016) . In addition, World Bank data shows that, in 2018 fertility rate stood at 1.7 births per woman. According to the government of Lebanon, as at September 2021, approximately three quarters of Lebanese people were living in poverty. Economic challenges are pushing Lebanese parents to employ desperate measures that affect their children, including reducing spendingon health and education, eating less and poorer-quality food, sending children to work in hazardous work environments, and marrying off young girls. Child labour and early marriage are on the rise as families attempt to cope with food shortages, price hikes, and inflation. This dire situation increases the risk of violence, exploitation and abuse, and physical and mental health issues among children including adolescents.

The objective of this paper is to model and forecast future trends of adolescent fertility in Lebanon using the double exponential smoothing technique. The findings are expected to highlight future trends of adolescent fertility in the out of sample period. This will guide policy, planning and allocation of resources to teenage pregnancy prevention programs.

II. LITERATURE REVIEW

Author(s)	Topic	Objectives	Methodology	Findings
Worku et al. (2021)	Prevalence and associated factors of adolescent pregnancy (15–19 years) in East Africa: a	To investigate the prevalence and associated factors of adolescent pregnancy in Eastern Africa.	multilevel binary logistic regression analysis	Age, contraceptive utilization, marital status, working status, household wealth status, community-level

	multilevel analysis			contraceptive utilization, age at initiation of sex, media exposure, educational level and relation to the household head were associated with adolescent pregnancy
Kassa et al. (2021)	Teenage pregnancy and its associated factors among teenage females in Farta woreda, Northwest, Ethiopia, 2020: A community-based cross-sectional study	To assess the prevalence and factors associated with teenage pregnancy among teenagers in Northwest Africa	Community based cross-sectional study	Residence, early age at 1st sexual intercourse, not knowing family planning methods, not utilizing contraception and not being aware of places where contraception is being offered were associated with teenage pregnancy
Ahinkorah et al. (2019)	Examining socio-cultural factors among adolescent girls in Komenda-Edina Eguafo-Abrem Municipality in the Central Region of Ghana: A case-control study	to examine the socio-cultural factors associated with pregnancy among adolescent girls in Komenda-Edina-Eguafo-Abrem (KEEA) Municipality in the Central Region of Ghana	matched case-control design	Adolescent pregnancy heightens the risk of negating birth outcomes that is independent of recognized confounding variables
Gunawardena et al. (2019)	Predictors of pregnancy among young people in sub-Saharan Africa: a systematic review and narrative synthesis	To systematically review predictors of pregnancy among young people in sub-Saharan Africa.	Systematic review and meta-analysis	The most obvious predictors included sexual coercion and pressure from male partners, low or incorrect use of contraceptives, and poor parenting or low parental communication and support
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 African countries	Systematic review	Several sociodemographic factors like residence, marital status, educational status of adolescents, their mother's and father's, and parent to adolescent SRH communication were

				associated with adolescent pregnancy.

III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Lebanon. 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 model is specified as follows:

Model equation

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

N_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**

$\mathbf{t}$ 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 Lebanon 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	N
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.600
Forecast performance measures	
Mean Absolute Error (MAE)	0.350799
Sum Square Error (SSE)	21.616636
Mean Square Error (MSE)	0.354371
Mean Percentage Error (MPE)	0.296042
Mean Absolute Percentage Error (MAPE)	1.004505

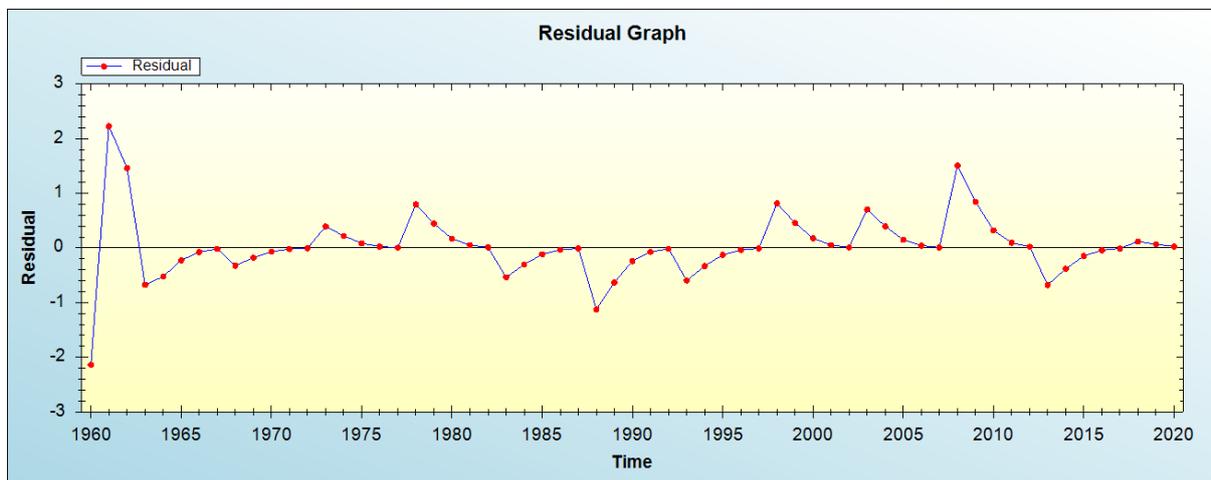Residual Analysis for the Applied Model

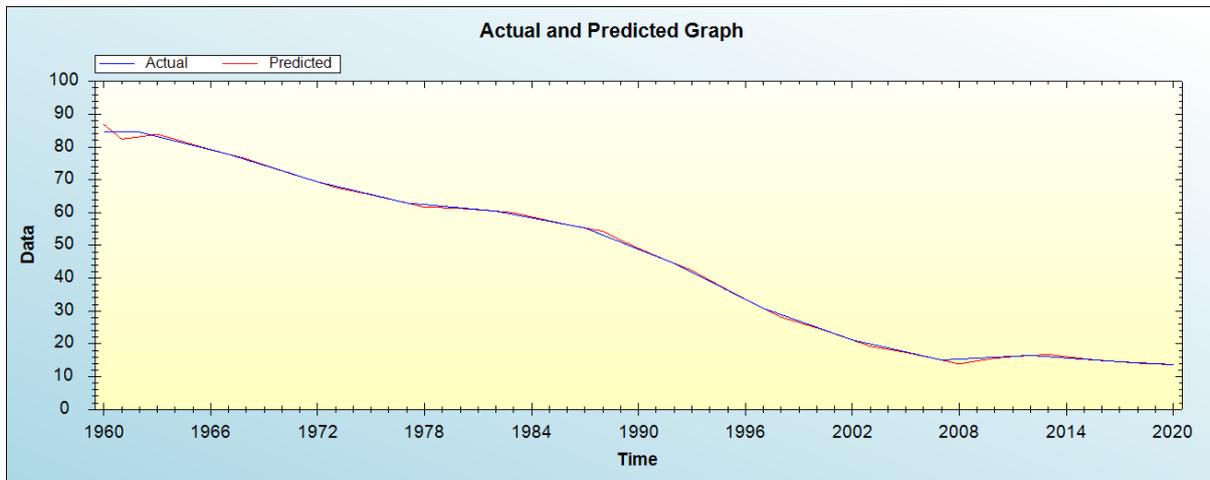Figure 1: Residual analysis

In-sample Forecast for N

Figure 2: In-sample forecast for the N series
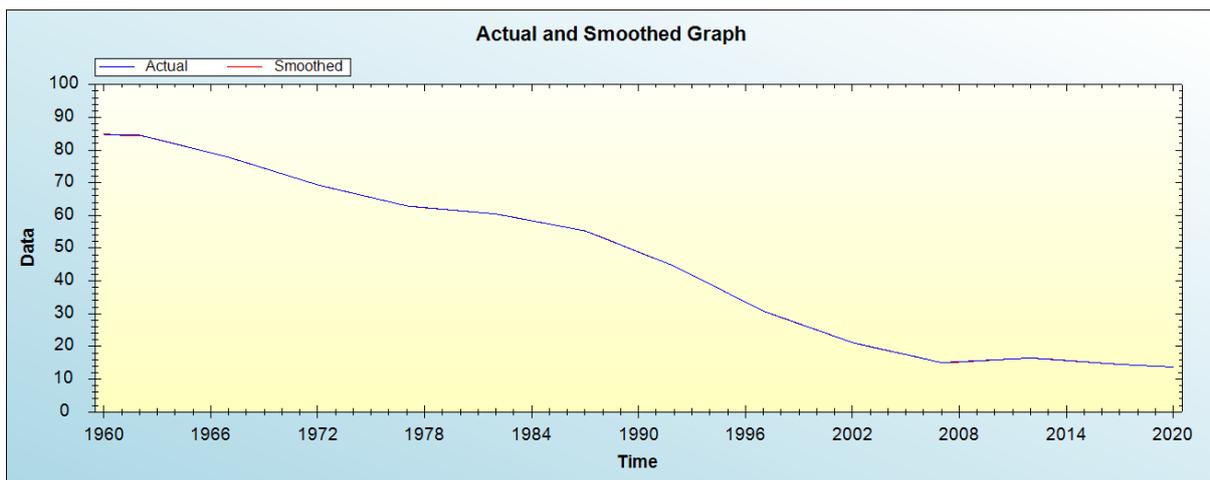
Actual and Smoothed graph for N series

Figure 3: Actual and smoothed graph for N series

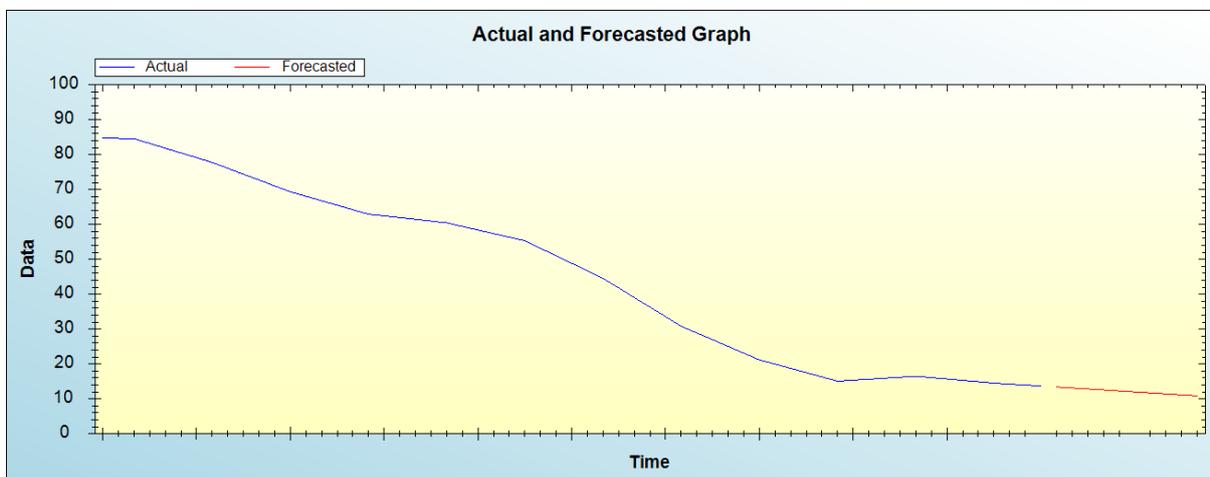Out-of-Sample Forecast for N: Actual and Forecasted Graph

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

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rates
2021	13.3875
2022	13.1062
2023	12.8249
2024	12.5436
2025	12.2622
2026	11.9809
2027	11.6996
2028	11.4183
2029	11.1370
2030	10.8557

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

Teenage pregnancy is an important public health issue in Lebanon because of adverse pregnancy outcomes associated with it. Complications can occur during pregnancy and child birth such as hypertensive disorders, anemia, obstructed labor, preterm delivery and perinatal mortality. Several challenges contribute to teenage pregnancy such as poverty, child marriage and sexual violence against women. Adolescent fertility in Lebanon substantially declined from 1960 to 2020 with fertility levels falling below 20 births per 1000 females aged 15-19 yrs. This reflects significant progress made by the government in addressing teenage pregnancy and child marriage. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Lebanon. Our study findings revealed that adolescent fertility will continue to drop throughout the out of sample period. Therefore, we encourage the government to address socio-economic and demographic factors that contribute to adolescent fertility as well as enforcing laws that protect the rights of women and girls.

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