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Projecting Adolescent Fertility for Russia Using Holt's Double Exponential Smoothing Technique

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Russia 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 0.4 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility rate will continue to decline to reach levels below 10 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage the Russian government to persistently protect sexual and reproductive health rights of women and children, promote girl child education and continue supporting the national family planning program.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Teenage pregnancy is a global public health problem especially in low and middle income countries because of the associated pregnancy complications such as unsafe abortions, eclampsia and pre-eclampsia, anemia and mental disorders (WHO, 2014; Ganchimeg *et al.* 2014). Many teenage pregnancies occur in South East Asia and the Sub-Saharan Africa. Around 12 million young girls aged 15-19 years get pregnant every year, especially in socially and economically disadvantaged regions with 75 percent of teenage pregnancies occurring in Sub-Saharan Africa (Kassa *et al.* 2018). The 1994 International Conference on population and development discussed various strategies to reduce teenage pregnancies that included enacting and enforcing laws to increase the legal age of consent and marriage to 18 years and crafting policies that promote girl child education (UN, 1995). The 3rd sustainable development goalfocuses on adolescent sexual and reproductive health including the reduction of adolescent pregnancies (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). Under this particular goal, UN member states should come up with new initiatives to solve the problem of teenage pregnancies by drafting legislation to prevent child marriages and sexual abuse of adolescent girls and women. In addition, there is an urgent need to allocate resources that are required for the management of teenage pregnancies and its complications.

The objective of this paper is to model and forecast future trends of adolescent fertility in Russia 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 trigger an early response to the problem of teenage pregnancy through allocation of adequate resources to teenage pregnancy prevention programs.

II. LITERATURE REVIEW

Author (s)	topic	objectives	Methodology	Findings
Sarderet al. (2021)	Prevalence of unintended pregnancy and its associated factors: Evidence from six south Asian countries	To explore the prevalence of unintended pregnancy and explore its determinants among women of reproductive age in six South Asian countries.	Multivariate analysis was performed to explore the association between unintended pregnancy and its associated factors.	Women's age, wealth index, place of residence, number of children, family size, the intention of contraceptive use, living with a partner, and first cohabitation age are essential

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				determinants of unintended pregnancy.
Harringtonet al. (2021)	Family planning in Pacific Island Countries and Territories (PICTs): A scoping review	To identify and analyze evidence about family planning service provision in Pacific Island Countries and Territories (PICTs), with the aim of better informing family planning services for improved maternal health outcomes in the Pacific.	Scoping review	While culture and religion were considered as the main barriers to accessing family planning services, evidence showed health services were also responsible for limiting access
Mohr et al. (2019)	The Influence of Educational Attainment on Teenage Pregnancy in Low-Income Countries: A Systematic Literature Review	to review the association between education and teenage pregnancy in low- and lower-middle-income countries	Systematic review	reaching higher levels of education deters from teenage pregnancy in low- and lower-middle-income countries
Usynina et al. (2018)	Adverse Pregnancy Outcomes among Adolescents in Northwest Russia: A Population Registry-Based Study	To assess whether have increased of adverse pregnancy outcomes(APO) compared to adult women	Multivariable logistic regression was applied to assess the associations between age and APO	Adolescents were more likely to be underweight, to smoke, and to have infections of the kidney and the genital tract compared to adult women
Sychareun et al. (2021)	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.

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III. METHODOLOGY

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

Model equations

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

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 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 Russia 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.

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IV. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	A
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	0.854561
Sum Square Error (SSE)	192.120008
Mean Square Error (MSE)	3.149508
Mean Percentage Error (MPE)	0.051679
Mean Absolute Percentage Error (MAPE)	2.738060

Residual Analysis for the Applied Model

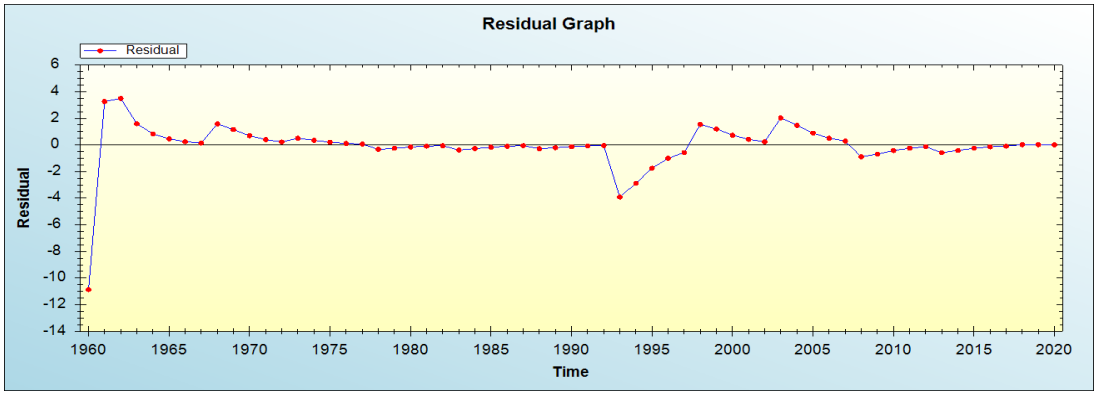

Figure 1: Residual analysis

In-sample Forecast for A

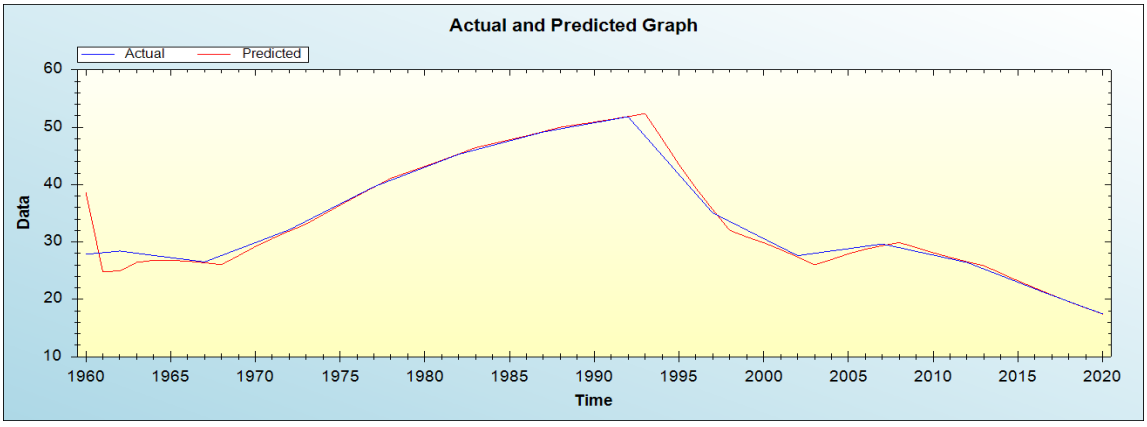

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

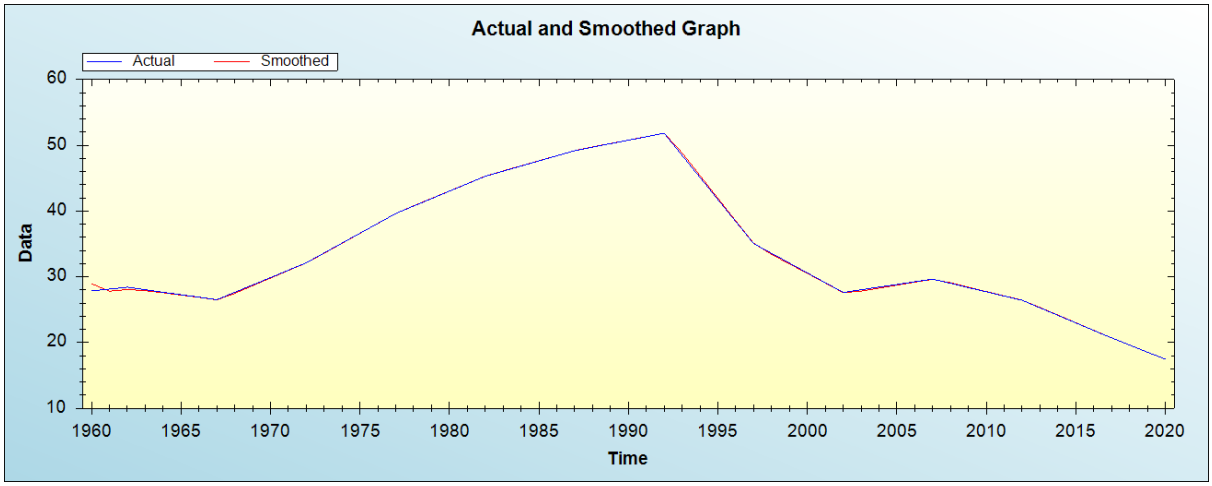

Figure 3: Actual and smoothed graph for A series

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

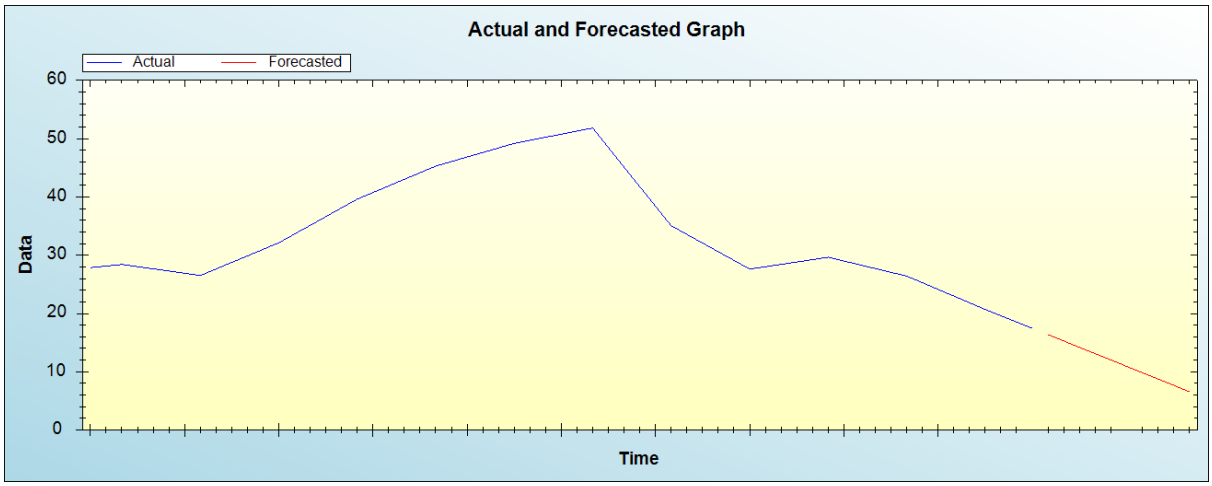

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	16.3728
2022	15.2862
2023	14.1997
2024	13.1131
2025	12.0266
2026	10.9400
2027	9.8535
2028	8.7669
2029	7.6804
2030	6.5938

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

IV. POLICY IMPLICATION & CONCLUSION

The Russian government has made significant progress towards addressing adolescent sexual and reproductive health issues as evidenced by a substantial decline of adolescent fertility from 51.82 births per 1000 women aged 15-19 in 1992 to 17.46 births per 1000 women aged 15-19 years in 2020. This decline is a reflection of successful family planning programs in the country. This study applies Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Russia. Our research findings indicate that adolescent fertility will continue to decline to reach levels below 10 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage the Russian government to persistently protect sexual and reproductive health rights of women and children, promote girl child education and continue supporting the national family planning program.

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