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Tracking the Future Path of Adolescent Fertility for South Asia Using Holt's Linear Method

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***Abstract* - This research article employs annual time series data of adolescent fertility rate for South Asia 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 sharply decline to levels below 10 births per 1000 women aged 15-19 years in the out of sample period. Therefore, we encourage authorities in South Asia to continuously promote girl child education, enforce laws that protect sexual and reproductive health rights of girls and women and scale up campaigns against early child marriage and gender based violence.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Globally, approximately 16 million women below the age of 20 give birth every year. The biggest proportion of births to adolescents occur in developing countries. In South-East Asia region alone 6 million adolescents are giving birth annually (UN, 2011). Bangladesh has the highest adolescent fertility rate followed by India, Nepal, Bhutan, Indonesia, Timor Leste, Thailand, Sri Lanka, Myanmar, and lastly DPR Korea (WHO, 2014). Adolescent fertility has been on a downward trajectory over the past 25 years in the Asian region and this is attributed to the rising age for marriage, improvement in women's educational level, more job opportunities for women, urbanization and increased use of modern methods of contraception (WHO, 2014). Among other factors early child marriage has been found to be a major contributing factor to adolescent pregnancy in Asia (Girls not brides, 2020). Marriages in India and Bangladesh usually occur very early; in 2017, seven percent of women in India and 22 percent of women in Bangladesh were married by age 15 (Girls not brides, 2020).In South Asia, the challenge of child marriage is aggravated by the social norm to have children immediately after marriage. Less than one percent of births in India occur out of wedlock, in contrast with more than forty percent in the US, UK and Sweden (Chamie, 2017). The Asian region has laws, policies, and programs to prevent and reduce early child marriage, however their impact has been suboptimal despite strong government commitment to address the challenges. There is evident government commitment to tackle this challenge; Bangladesh, India, Nepal, and Pakistan are members of the South Asian Initiative to End Violence against Children. They participated in the Action to End Child Marriage in Asia in 2014, either acceded to or ratified the Convention on the Elimination of All Forms of Discrimination against Women, and have at least two decades of programs targeting child marriage (Girls not brides, 2020; UNICEF, 2020). In addition, there are several non-governmental organizations who support governments in the fight against gender based violence and elimination of harmful practices and forced or voluntary child marriage (Amin *et al.* 2018).

Holt's double exponential smoothing technique is applied in this study to model and forecast future trends of adolescent fertility in South Asia. The findings of this study are expected to depict the future burden of adolescent births in the out of sample period. This will inform regional policies, planning and allocation of resources to teenage pregnancy prevention programs with the aim of averting adverse maternal and child health outcomes.

II. LITERATURE REVIEW

Author(s)	Topic	Objectives	Methodology	Main Findings
Harvey et al. (2022)	Premarital conception as a driver of child marriage and early union in selected countries in south east	-to broaden understanding of how premarital conception in adolescence	-analyzed data was obtained from the recent demographic and health surveys and multiple cluster	Adolescent pregnancy is a significant driver of child marriage and early union in this

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	Asia and the Pacific	contributes to child marriage and early union in selected South Asian countries	surveys from 7 selected South Asian countries and Papua New Guinea	region
Scott et al. (2021)	Early marriage and early childbearing in South Asia: trends,inequalities,and drivers from 2005 to 2018	To describe prevalence, trends, inequalities, and drivers of early marriage and early child bearing in South Asia	Regression decomposition analyses.	Regression decomposition analysis showed that improvements in wealth and education explained 44% (India), 96% (Nepal) of the actual reduction in early marriage
Sarder et 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 determinants of unintended pregnancy
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 and meta-analysis	-reaching higher levels of education deters from teenage pregnancy in low- and lower-middle-income countries
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.

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III. METHODOLOGY

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

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

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 South Asia 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	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.591222
Sum Square Error (SSE)	776.783837
Mean Square Error (MSE)	12.734161
Mean Percentage Error (MPE)	0.111775
Mean Absolute Percentage Error (MAPE)	1.775144

Residual Analysis for the Applied Model

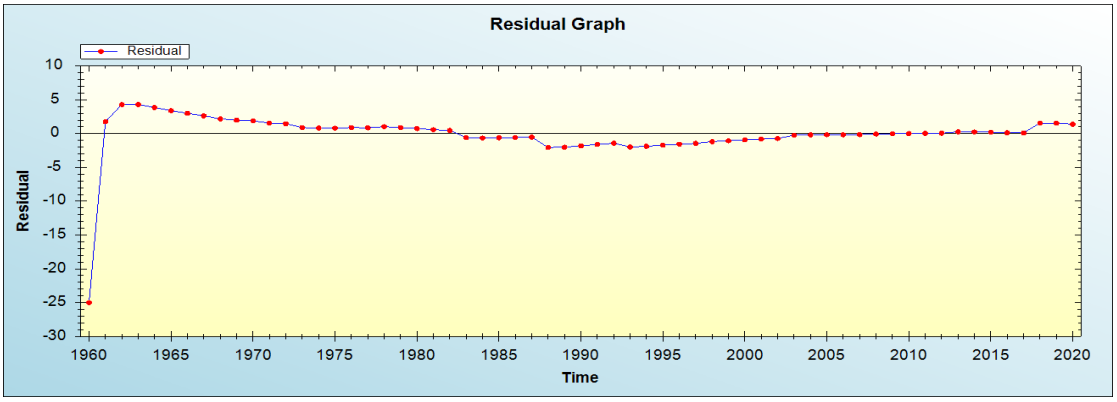

Figure 1: Residual analysis

In-sample Forecast for A

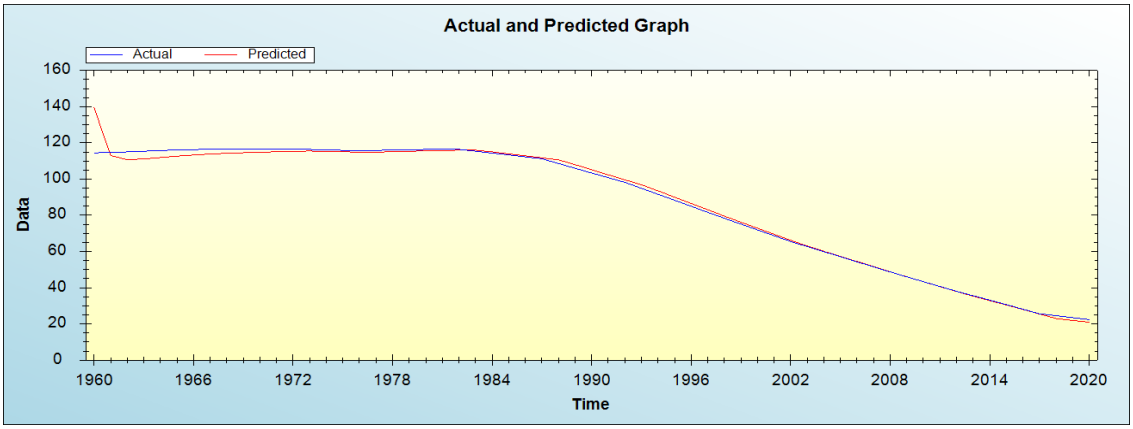

Figure 2: In-sample forecast for the A series

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Actual and Smoothed graph for A series

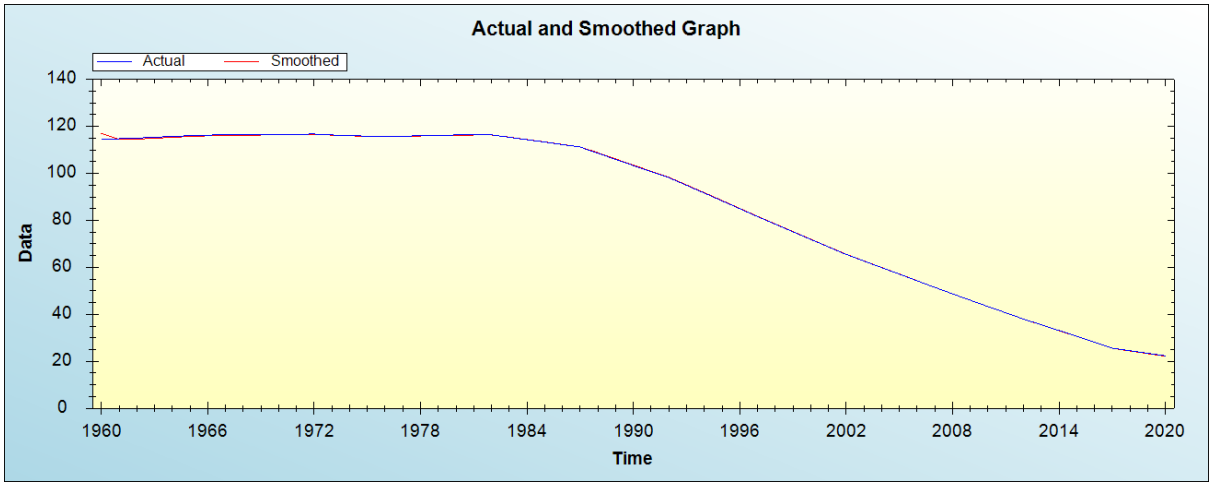

Figure 3: Actual and smoothed graph for A series

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

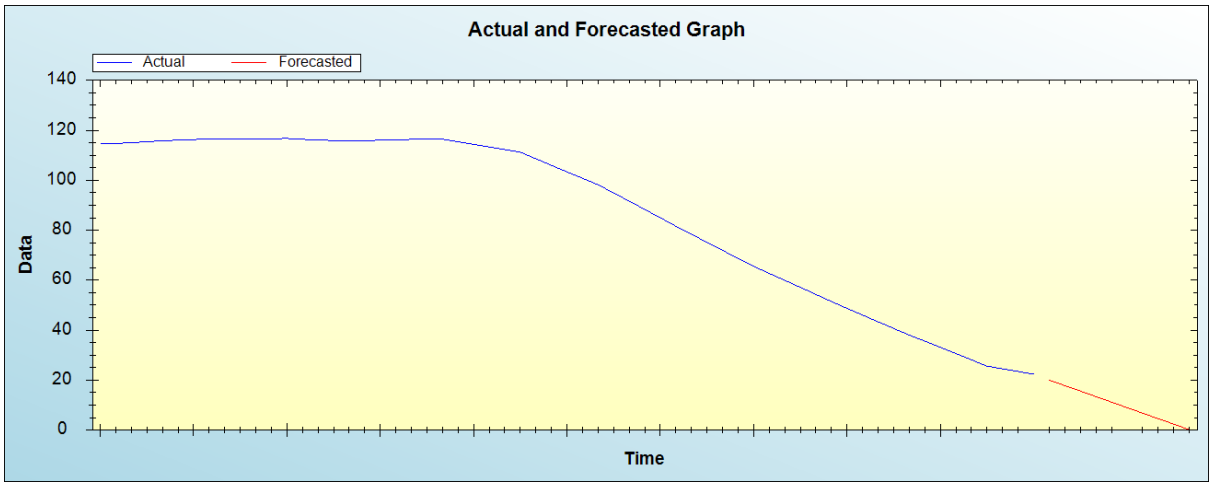

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	20.0098
2022	17.8022
2023	15.5947
2024	13.3871
2025	11.1795
2026	8.9719
2027	6.7644
2028	4.5568
2029	2.3492
2030	0.1416

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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

Adolescent fertility has been on a downward trajectory over the past 25 years in the Asian region and this canbe attributed to the rising age for marriage, improvement in women's educational level, more job opportunities for women, urbanization and increased use of modern methods of contraception. Among other factors early child marriage has been found to be a major contributing factor of adolescent pregnancy in Asia. Bangladesh has the highest adolescent fertility rate followed by India, Nepal, Bhutan, Indonesia, Timor Leste, Thailand, Sri Lanka, Myanmar, and lastly DPR Korea. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for South Asia region. The findings of this study revealed that adolescent fertility will sharply decline to levels below 10 births per 1000 women aged 15-19 years throughout the out of sample period. Therefore, we encourage authorities in South Asia to continuously promote girl child education, enforces laws that protect sexual and reproductive health rights of girls and women and scale up campaigns against early child marriage and gender based violence.

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