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Forecasting Adolescent Fertility for Senegal Using Holt's Linear Method

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***Abstract* - This study uses annual time series data of adolescent fertility rate for Senegal 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 0.2 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 Senegal to relentlessly support girl child education, women empowerment and scale up awareness campaigns among communities.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Senegal is located in the Sahel region and is the most politically stable state in this region. It has the highest economic growth as a result of peace and tranquility enjoyed in the country (World Bank, 2020a). Youth unemployment has been on an upward trend since 2018, even though overall unemployment rate has remained relatively stable since 2015 (World Bank, 2020b). In 2019, thirty one percent of Senegalese women aged 20-24 were married before 18 years and 9 percent before 15 years (Save the Children, 2021). Over the past decades, the prevalence of child marriage has declined tremendously by 16 percent (Save the Children, 2017). Child marriage rates are lower in Senegal when compared with regional counterparts. Rural child marriage rates have been observed to be higher than urban ones ((Morgan, 2016). Several factors have been found to be associated with early child marriages and teenage pregnancy such as poverty, cultural norms, lower educational status and being unemployed ((Iris Group, 2021; Petroni *et al.* 2017). Senegal has made significant progress towards addressing gender inequality. The constitution guarantees equality between men and women and the current legal framework protects women's rights (Petroni et al., 2017).There has been remarkable improvement of women's participation in socioeconomic growth and development particularly in rural areas and the agricultural sector (UN Women, n.d.).

This paper applies Holt's double exponential smoothing technique to model and forecast future trends of adolescent fertility in Senegal. The findings of this paper are expected to depict the future burden of adolescent fertility in the out of sample period. This is anticipated to inform national policies, planning and allocation of resources to teenage pregnancy prevention programs.

II. LITERATURE REVIEW

Author (s)	Topic	objectives	methodology	Main findings
Bop etal. (2022)	Determinants of low birth weight in the health district of Bounkiling in Senegal	To identify the determinants of low birth weight.	Case control study	multivariate analysis showed that the determinants of LBW ($p < 0.05$) were the female sex of the newborn, the Apgar score at birth, the maternal age <=19 years, the household income < 83.96 USD,

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				maternal history of low birth weight and physical labor during pregnancy.
Zegeye et al. ((2021)	Modern contraceptive utilization and its associated factors among married women in Senegal: a multilevel analysis	To examine modern contraceptive use and its associated factors among married women in Senegal.	multilevel logistic regression models	both individual and community level factors are significantly associated with modern contraceptive use among married women in Senegal
Massaquoi et al. (2021)	Exploring health-seeking behavior among adolescent mothers during the Ebola epidemic in Western rural district of Freetown, Sierra Leone	to understand health-seeking behavior among adolescent mothers who were pregnant during the Ebola epidemic in Waterloo, Sierra Leone	Thisqualitative study used the "Three Delay" model	Many of the pre-existing maternal health, societal and social-economic challenges were exacerbated during the Ebola.
Seidu (2021)	Factors associated with early antenatal care attendance among women in Papua New Guinea: a population- based cross- sectional study	To assess the prevalence and factors associated with early initiation of ANC among women in Papua New Guinea (PNG).	population-based cross-sectional study	The study found that there was a relatively low prevalence of early ANC uptake among women in PNG. The factors associated with early ANC attendance were region of residence, parity, and working status of mothers
Peach et al. (2021)	Risk factors and knowledge associated with high unintended pregnancy rates and low family planning use among pregnant women in Papua New Guinea	To assess prevalence and predictors of unintended pregnancy and modern FP use among pregnant women in East New Britain Province, PNG.	Cross-sectional study	More than half (55%) the women reported their pregnancy as unintended. Few (18%) reported ever having used a modern FP method, and knowledge of different methods was low. Being single, separated or divorced, educated to a tertiary or vocational level and gravidity > 1

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				for each additional pregnancy were associated with unintended pregnancy; being accompanied by a male partner to ANC was associated with a reduced unintended pregnancy

III. METHODOLOGY

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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

X_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

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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 period t-1

Data Issues

This study is based on annual adolescent fertility rate in Senegal 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	X
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.021769
Sum Square Error (SSE)	301.754193
Mean Square Error (MSE)	4.946790
Mean Percentage Error (MPE)	0.055234
Mean Absolute Percentage Error (MAPE)	0.671984

Residual Analysis for the Applied Model

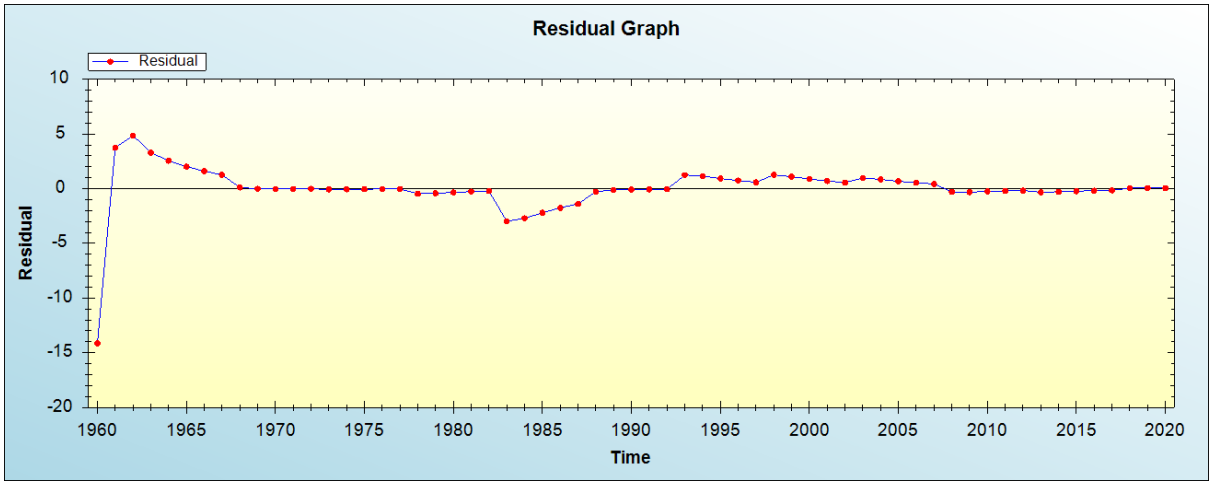

Figure 1: Residual analysis

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In-sample Forecast for X

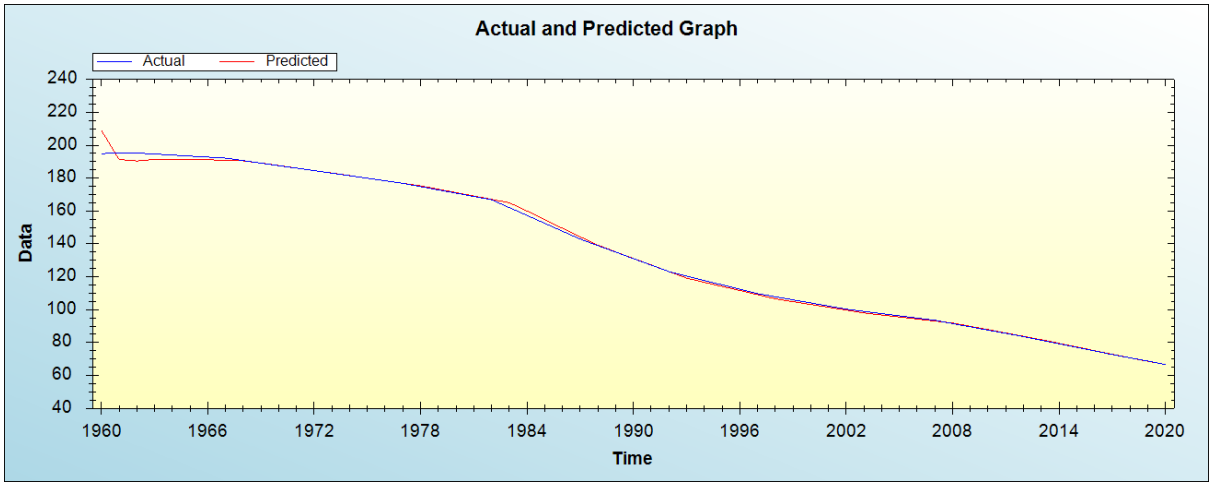

Figure 2: In-sample forecast for the X series

Actual and Smoothed graph for X series

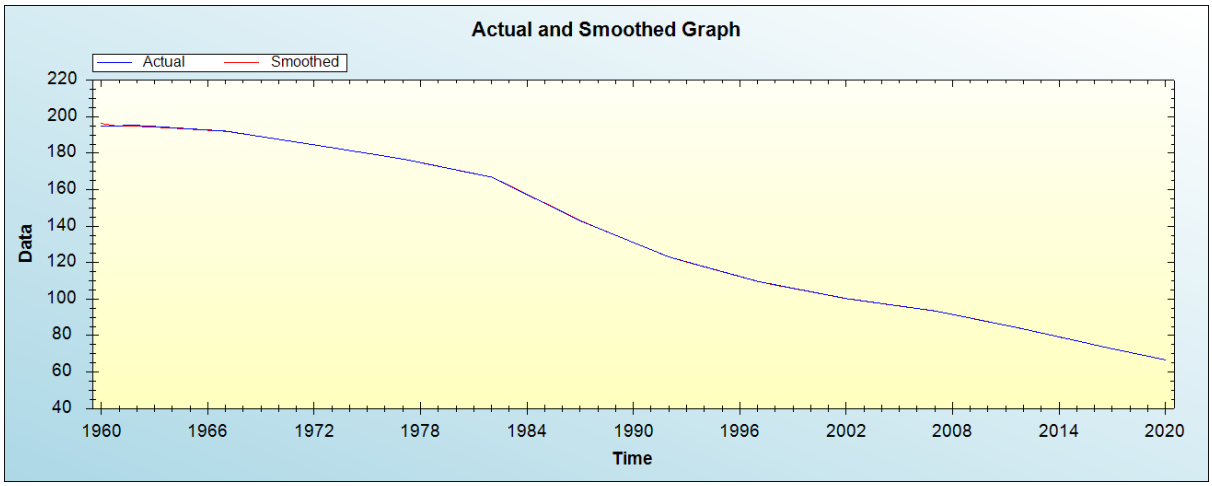

Figure 3: Actual and smoothed graph for X series

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

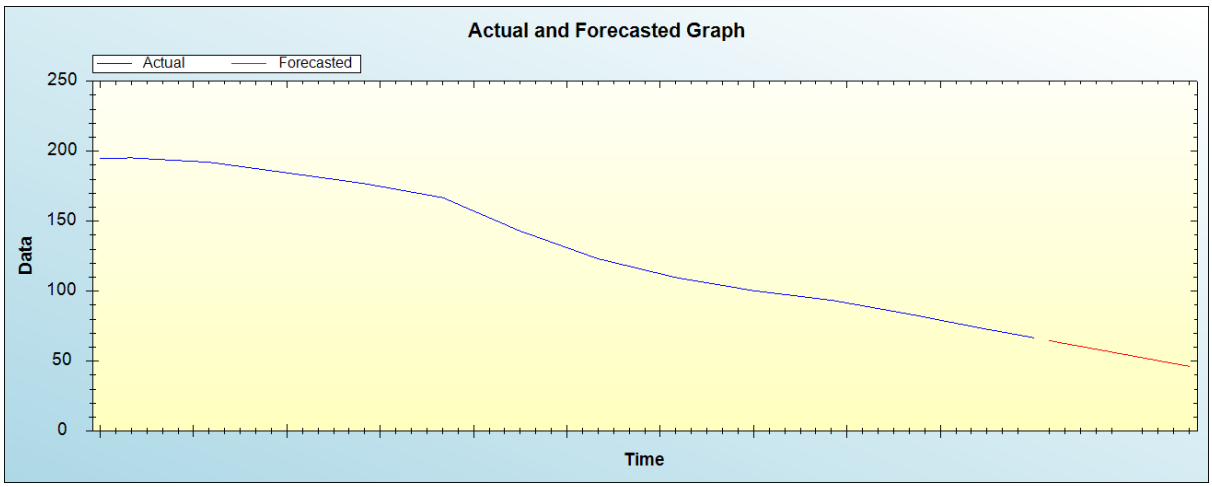

Figure 4: Out-of-sample forecast for X: actual and forecasted graph

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Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	64.6463
2022	62.6000
2023	60.5537
2024	58.5074
2025	56.4611
2026	54.4147
2027	52.3684
2028	50.3221
2029	48.2758
2030	46.2294

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 and child marriage are among the leading causes of maternal and child mortality in Senegal. Over the past decades, the prevalence of child marriage has declined tremendously by 16 percent. Several factors have been found to be associated with early child marriages and teenage pregnancy such as poverty, cultural norms, lower educational status and being unemployed. Adolescent fertility in Senegal declined steadily from 195 births per 1000 women aged 15-19 years in 1960 to 66.7 births per 1000 women aged 15-19 years in 2020. This study applied the double exponential smoothing to forecast future trends of adolescent fertility for Senegal. Our study findings suggested that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage the Senegalese government to relentlessly support girl child education, women empowerment and scale up awareness campaigns among communities.

REFERENCES

[1] World Bank (2020b). Unemployment, youth total (% of total labor force ages 15-24) (modeled ILO estimate)—Senegal. World Bank Data. https://data.worldbank.org/indicator/SL.UEM.1524.ZS?end=2020&locations=SN&start=1991&view=chart

[2] World Bank (2020a). The World Bank in Senegal [Text/HTML]. World Bank. https://www.worldbank.org/en/country/senegal/overview

[3] Save the Children. (2017). Child Marriage in Senegal [Fact Sheet and Brochure]. Save the Children. https://resourcecentre.savethechildren.net/node/13233/pdf/child-marriage-senegal.pdf

[4] Save the Children. (n.d.). Save the Children Group-based Inequality Database (GRID)—Country Dashboard—Senegal—Child marriage. Save the Children. Retrieved January 8, 2021, from https://www.savethechildren.net/grid

[5] Morgan, J. (2016). Family Honour and Shattered Dreams: Girl Brides in Mali, Niger and Senegal. Plan International.

[6] Petroni, S., Steinhaus, M., Fenn, N. S., Stoebenau, K., & Gregowski, A. (2017). New Findings on Child Marriage in Sub-Saharan Africa. Annals of Global Health, 83(5–6), 781–790. https://doi.org/10.1016/j.aogh.2017.09.001

[7] Iris Group (2021). Political Economy Analysis of Child, Early, and Forced Marriage in Senegal. Chapel Hill, USA.

[8] UN Women. (n.d.). Senegal. UN Women | Africa. Retrieved December 18, 2020, from https://africa.unwomen.org/en/where-we-are/west-and-central-africa/senegal

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