Projecting Adolescent Fertility for St Lucia Using Holt's Linear Method

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Abstract - **This study uses annual time series data of adolescent fertility rate for St Lucia 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 St Lucia to focus on protecting sexual and reproductive health rights of adolescent girls and women and strictly enforce laws to stop sexual abuse of women and child marriage.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

In this era of sustainable development goals adolescent pregnancy is among the top global health priorities (Gurung *et al.* 2020; Sukra *et al.* 2020). The 3rd sustainable development goal emphasizes on ensuring good health and promotion of well-being for all at every stage of life. Target 3.1 and 3.2 focuses on the substantial reduction of maternal and child mortality, and target 3.7.2 aims at addressing sexual and reproductive health concerns especially that of adolescent girls and women (UN, 2020; WHO, 2019; UNICEF, 2018; UN, 2016, Patton *et al.* 2016; UN, 2015).Adolescent pregnancy continues to be among the leading causes of maternal and perinatal mortality around the globe (Odimegwu & Mkwananzi, 2016; WHO, 2016; Neal *et al.* 2012). Complications that occur during the antenatal, child birth and post natal periods can affect the mother and her baby. Maternal mortality can result from antepartum haemorrhage, postpartum haemorrhage and eclampsia (Althabe *et al.* 2015; Ganchimeg *et al.* 2014; Malabarey*et al.* 2012). Neonatal complications are as a result of hypoxia, sepsis, severe prematurity, low birth and birth trauma (Kaphagawani & Kalipeni, 2017; Sedgh *et al.* 2016). The prevalence of teenage pregnancy is reportedly highest in developing regions (Kassa *et al.* 2018). Previous studies established that among other factors poverty has been found to be a major determinant of teenage pregnancy in low and middle income countries (Wado *et al.* 2019). On the other hand, the substantial decline in adolescent fertility levels across the globe including developing regions is mainly attributed to correct and consistent condom use, improvements in educational level and use of modern methods of family planning (Birhanu *et al.* 2019). The government of St Lucia has made tremendous progress towards the achievement of the targets set under the 3rd sustainable development goal as the country has reported a steady decline in adolescent fertility from 1960 to 2020 (World Bank, 2020). However there is needed to come up with more innovations in order to end teenage pregnancy in this Caribbean country.

This paper applies the double exponential smoothing technique to model and forecast future trends of adolescent fertility in St Lucia. The research findings are expected to highlight the future burden of adolescent fertility in the out of sample period. This will enable the government to review its current policies and legal instruments so that adolescent girls and women are protected from sexual abuse and early child marriages.

II. METHODOLOGY

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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

Z_t is the actual value of adolescent fertility rate at time period 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 St Lucia 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.

III. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Z
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900

Beta (β) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	1.809798
Sum Square Error (SSE)	1036.396741
Mean Square Error (MSE)	16.990111
Mean Percentage Error (MPE)	0.386283
Mean Absolute Percentage Error (MAPE)	1.502420

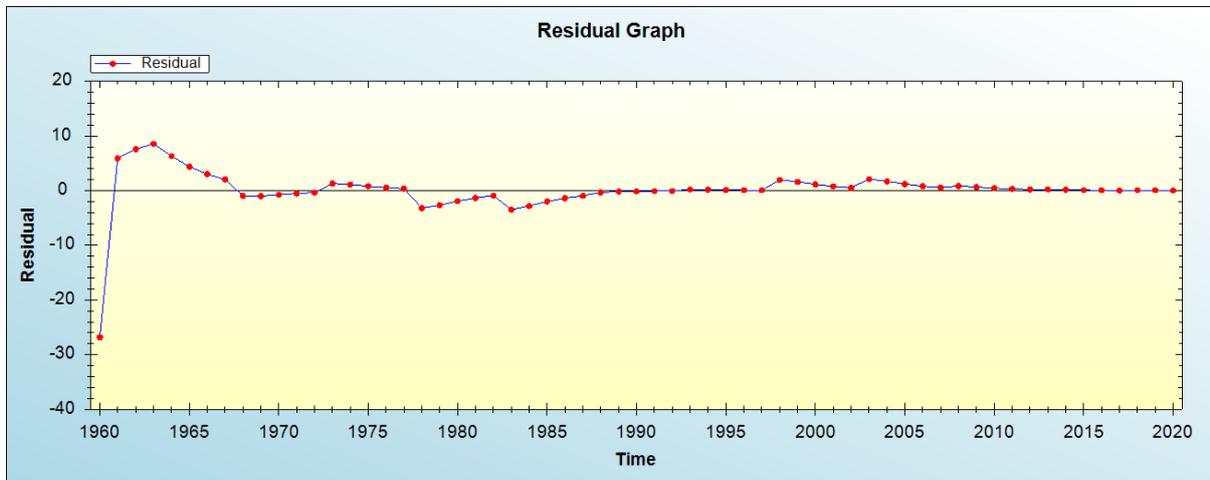Residual Analysis for the Applied Model

Figure 1: Residual analysis

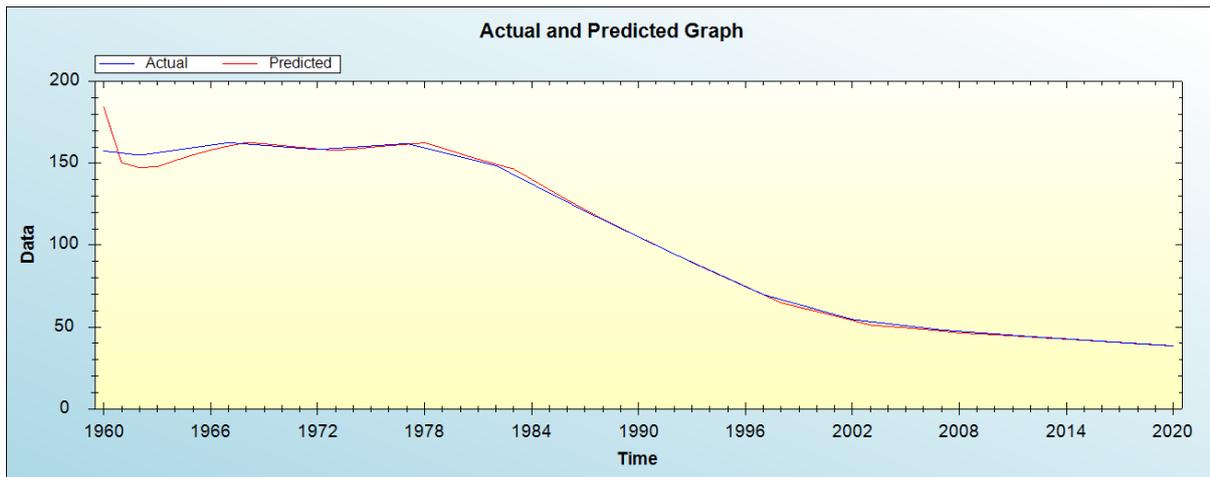In-sample Forecast for Z

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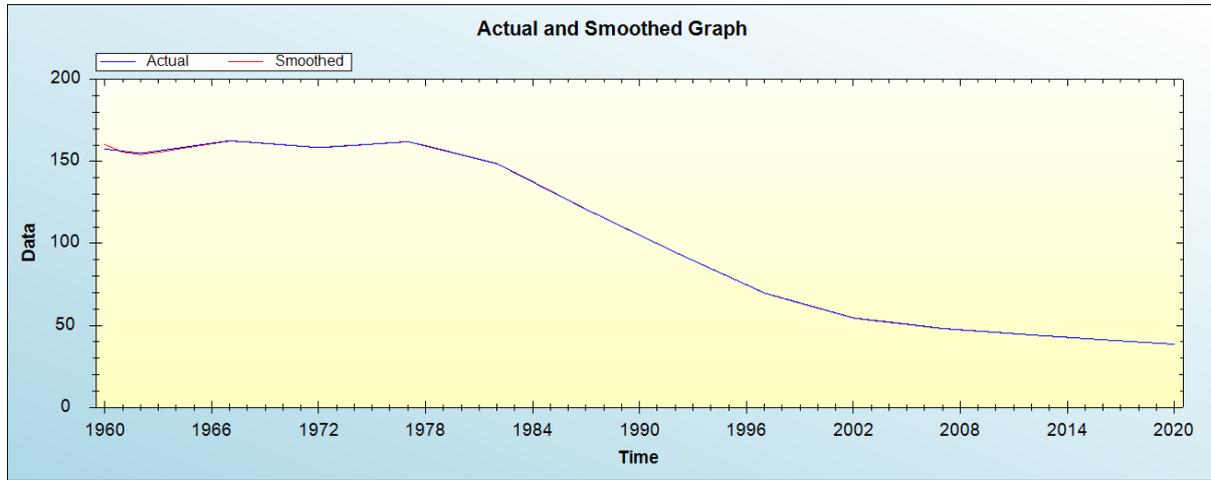
Actual and Smoothed graph for Z series

Figure 3: Actual and smoothed graph for Z series

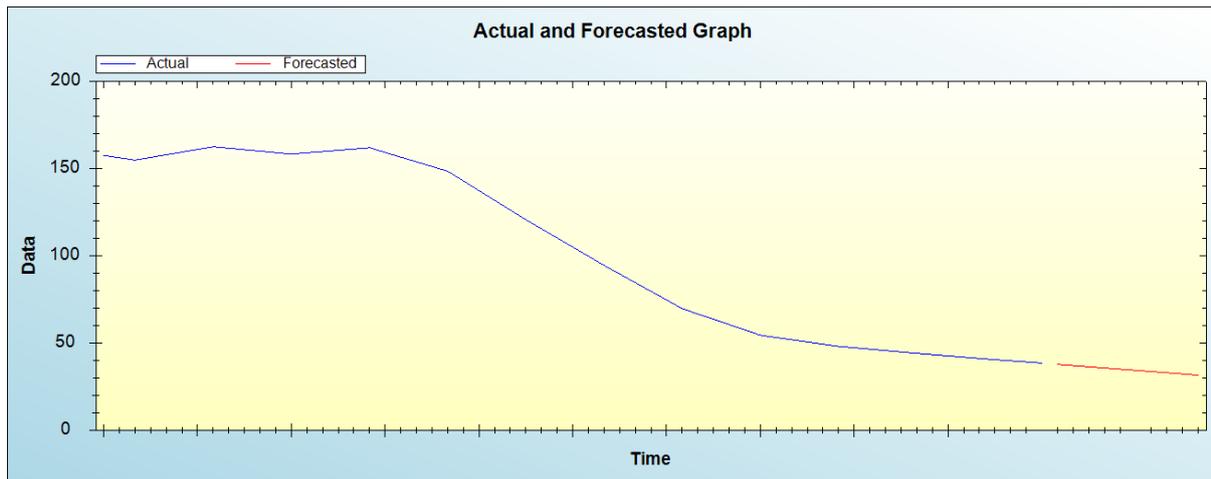Out-of-Sample Forecast for Z: Actual and Forecasted Graph

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

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasting adolescent fertility rate
2021	37.8692
2022	37.1786
2023	36.4880
2024	35.7974
2025	35.1068
2026	34.4161
2027	33.7255
2028	33.0349
2029	32.3443
2030	31.6537

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.

IV. POLICY IMPLICATION & CONCLUSION

The decline of adolescent fertility over the previous decades in St Lucia is a strong indication of the positive impact of the national family planning program and other strategies designed to end child marriages and teenage pregnancy in the country. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for St Lucia. We established that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage authorities in St Lucia to focus on protecting sexual and reproductive health rights of adolescent girls and women and strictly enforce laws to stop sexual abuse of women and child marriage.

REFERENCES

[1] World Bank (2020). Adolescent pregnancy women aged 15-19 years.

[2] United Nations. (2015). transforming our world: The 2030 agenda for sustainable development, A/RES/70/1. New York: UN General Assembly.

[3] UN (2020) sustainable development goals. https://www.un.org/sustainabl development/development-agenda

[4] UNICEF (2018). Every Child alive. New York: UNICEF

[5] World Health Organization (WHO) (2019). SDG 3: Ensure healthy lives and promote wellbeing for all at all ages.

[6] United Nation. Transforming our world: The 2030 agenda for sustainable development 2016.

[7] Bunyarit Sukrat., Chusak Okascharoen., Sasivimol Rattanasiri., Wichai Aekplakorn., Jiraporn Arunakul., Kittipong Saejeng., Dankmar Böhning and Ammarin Thakkinstian (2020).Estimation of the adolescent pregnancy rate in Thailand 2008–2013: an application of capture-recapture method, BMC Pregnancy and Childbirth (2020) 20:120 https://doi.org/10.1186/s12884-020-2808-3

[8] Althabe F., Moore J.L., Gibbons L., Berrueta M., Goudar S.S., Chomba E., Derman R.J., Patel A., Saleem S., Pasha O (2015). Adverse maternal and perinatal outcomes in adolescent pregnancies: The Global Network's Maternal Newborn Health Registry study. Reprod Health. 12(Suppl 2):S8.

[9] Ganchimeg T., Ota E., Morisaki N., Laopaiboon M., Lumbiganon P., Zhang J., Yamdamsuren B., Temmerman M., Say L., Tuncalp O (2014). Pregnancy and childbirth outcomes among adolescent mothers: a World Health Organization multicountry study. BJOG. 121(Suppl 1):40–8.

[10] Malabarey O.T., Balayla J., Klam S.L., Shrim A., and Abenhaim H.A (2012). Pregnancies in young adolescent mothers: a population-based study on 37 million births. J Pediatr Adolesc Gynecol. 25(2):98–102.

[11] Rejina Gurung., Mats Målqvist., Zhou Hong., Pragya Gautam Poudel., Avinash K. Sunny., Srijana Sharma., Sangeeta Mishra., Nisso Nurova and Ashish KC (2020).The burden of adolescent motherhood and health consequences in Nepal. BMC Pregnancy and Childbirth (2020) 20:318 https://doi.org/10.1186/s12884-020-03013-8

[12] Patton G.C., Sawyer S.M., Santelli J.S., Ross D.A., Afifi R., Allen N.B (2016). Our future: a lancet commission on adolescent health and wellbeing. Lancet. 387(10036):2423–78.

[13] Neal S., Matthews Z., Frost M., Fogstad H., Camacho A.V., Laski L (2012). Childbearing in adolescents aged 12–15 years in low resource countries: a neglected issue. New estimates from demographic and household surveys in 42 countries. Acta Obstet Gynecol Scand. 91(9):1114–8. https://doi.org/1 0.1111/j.1600-0412.2012.01467.x.

[14] WHO (2016). Global health estimates 2015: deaths by cause, age, sex, by country and by region, 2000-2015. Geneva.

[15] Odimegwu C., and Mkwananzi S (2016). Factors associated with teen pregnancy in sub-Saharan Africa: a multi-country cross-sectional study. Afr J Reprod Health. 20(3):94–107. https://doi.org/10.29063/ajrh2016/v20i3.14.

[16] Kaphagawani N., and Kalipeni E (2017). Socio cultural factors contributing to teenage pregnancy in Zomba district, Malawi. Glob Public Health. 12(6):694– 710. https://doi.org/10.1080/17441692.2016.1229354.

[17] Sedgh G., Ashford L.S., and Hussain R (2016). Unmet need for contraception in developing countries: examining women's reasons for not using a method. New York: Guttmacher Institute. 2:2015-6.

[18] Kassa G.M., Arowojolu A., Odukogbe A., and Yalew A.W (2018). Prevalence and determinants of adolescent pregnancy in Africa: a systematic review and meta-analysis. Reprod Health. 15(1):195. https://doi.org/10.1186/s12978018-0640-2.

[19] Birhanu B.E., Kebede D.L., Kahsay A.B., and Belachew A.B (2019). Predictors of teenage pregnancy in Ethiopia: a multilevel analysis. BMC Public Health.19(1): 601. https://doi.org/10.1186/s12889-019-6845-7

[20] Wado Y.D., Sully E.A., Mumah J.N (2019). Pregnancy and early motherhood among adolescents in five east African countries: a multi-level analysis of risk and protective factors. BMC Pregnancy Childbirth. 19(1):59. https://doi.org/10.1186/s12884-019-2204-z.

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