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# Tracking Future Trends of Adolescent Fertility for Zambia Using Holt's Double Exponential Smoothing Technique

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***Abstract* - Adolescent pregnancy and child birth is a huge problem in the developing world including Zambia. This public health problem has drown much research interest because pregnancy among adolescents is associated with a higher risk of adverse sexual and reproductive health outcomes. This research uses annual time series data on adolescent fertility rate for Zambia 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 drop but remain high throughout the out of sample period. Therefore, we encourage authorities in Zambia to persistently support girl child education, enforce laws that safeguard sexual and reproductive health rights of women and girls and finance youth empowerment projects.**

***Keywords:*** Exponential smoothing, Forecasting, adolescent fertility rate.

## I. INTRODUCTION

The problem of teenage pregnancy continues to delay progress towards achieving the set targets under the 3rd sustainable development goal (SDG-3).There has been a general global decline in teenage (15–19 years) pregnancy from around 90 births per 1,000 women aged 15-19 in 1960 to <45 per 1,000 women aged 15-19 years in 2015 (World Bank, 2016).Globally, the rates of teenage pregnancy range from as high as 143 per 1,000 women in some sub-Saharan countries to 2.9 per 1,000 women in South Korea (Mazaba, 2017). Low and middle income countries continue to report high rates of adolescent pregnancies with Sub-Saharan Africa being ranked at the top followed by South East Asia then lastly Latin America and the Caribbean (Mezmur *et al.* 2021; Gunawardena *et al*. 2019;Shibanuma *et al.* 2018; Ayanaw *et al.* 2017;Sedgh*et al.* 2015; Treffers, 2003;). Existing challenges like poverty, lack of education, social norms, and absence of parental guidance have been identified as causes of adolescent pregnancy and early sexual intercourse (Chung *et al.* 2018). Pregnancies among adolescent girls under 18 years of age can be associated with adverse sexual and reproductive health outcomes that will affect the mother and baby (UNFPA, 2013).According to Zambia 2018 demographic health survey summary report 29% of young women age 15-19 are already mothers or pregnant with their first child. Rural young women aged 15-19 are twice more likely to have begun childbearing than urban young women. By province, teenage pregnancy ranges from a low of 15 percent in Lusaka to a high of 43% in Southern. In Zambia, 20% of married women aged 15-49 have an unmet need for family planning—12% want to delay, while 8 percent want to stop childbearing. In addition, child marriage decreased from 41.6% in 2007 to 31.4% to 2015 among women aged 20–24 who reported being married before they were 18years old (Population Council *et al*. 2017). The number of girls marrying very early, before the age of 15, has also declined (Chata & Wodon 2016).Child marriage is one of the major drivers of adolescent pregnancies especially in developing countries like Zambia. The government has put in place strategies to prevent and end this problem. There is a legal framework and policies that address child marriage. The country is a signatory to international treaties that protect the rights of adolescent girls and women. It is also guided by international, regional and national laws and policies (Chitempa, 2017). In addition, the agenda 2030 for sustainable development, under the 5th goal, provides a guidance on the elimination of harmful practices and forced child marriage (UN, 2016; UN, 2015).

In line with Agenda 2030, this paper applies the double exponential smoothing technique to forecast future trends of adolescent fertility for Zambia. The findings are envisioned to depict the future burden of adolescent births and trigger an appropriate response by government to review the current legal instruments and policies so that they become in harmony with international laws and policies in order to prevent and end child marriages.

 

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## II. LITERATURE REVIEW

| Author (s) | Study area | Topic | Methodology | Findings |
|---|---|---|---|---|
| J. Svanemyr (2020) | Southern province of Zambia | Adolescent pregnancy and social norms in Zambia | Cross-sectional study | Risk factors for teenage pregnancy were found to be lack of resources, insufficient knowledge about sexuality and reproduction, gender norms governing sexual behavior and contraceptive use |
| Tebogo M.(2020) | Mpumalanga Province, South Africa | Experiences Leading to the Choice of Termination of Pregnancy Amongst Teenagers at a Regional Hospital in Mpumalanga Province, South Africa | Qualitative research method | -life experiences which influence termination of teenage pregnancy include 1) the concern of being rejected by parents and other family members and fear of being ridiculed by peers and the entire community amongst others |
| Chikalipo *et al.* (2018) | Blantyre,Malawi | Perceptions of pregnant adolescents on the antenatal care received at Ndirande Health Centre in Blantyre | Cross-sectionalstudy | The antenatal care adolescent girls received at Ndirande clinic is inadequate as it does not meet their needs |
| Branson and Byker (2017) | South Africa | Causes and consequences of teen child bearing : Evidence from reproductive health intervention in South Africa | Natural experiment | -living near a NAFCI clinic delayed child bearing among adolescents |
| M.L Mazaba (2017) | Zambia | Teenage Pregnancy – A thorny sexual and reproductive health issue of public health concern | Narrative review | Lack of sexualand reproductive health information is the majordriver of teenagepregnancy among the rural communities |

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## III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate for Zambia. 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*

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

*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*

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

$Z_t$ is the adolescent fertility rate at time t

$\varepsilon_t$ is the time varying **error term**

$\mu_t$ is the time varying mean (**level**) term

$\rho_t$ is the time varying **slope term**

**t** is the trend component of the time series

$L_t$ is the exponentially smoothed adolescent fertility rate at time t

$\alpha$ is the exponential smoothing constant for the data

$\beta$ 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 Zambia 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 | 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) | 1.317452 |
| Sum Square Error (SSE) | 405.164256 |
| Mean Square Error (MSE) | 6.642037 |
| Mean Percentage Error (MPE) | -0.035536 |
| Mean Absolute Percentage Error (MAPE) | 0.768765 |

Residual Analysis for the Applied Model

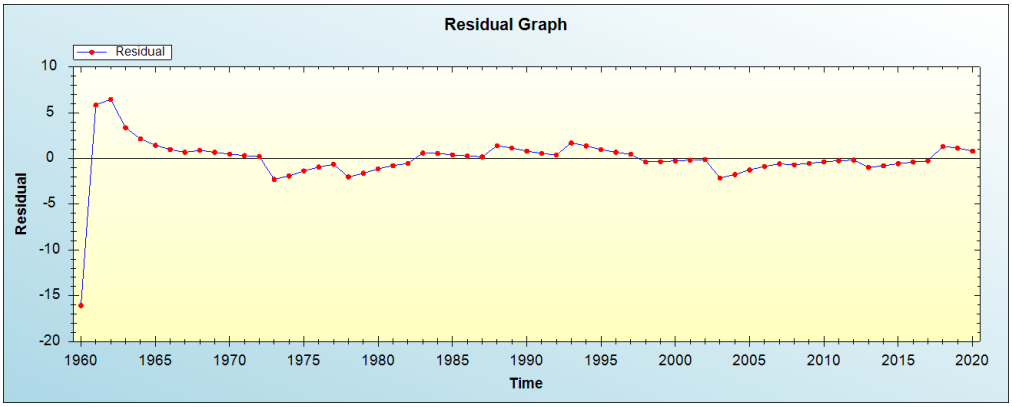


Figure 1: Residual analysis

In-sample Forecast for Z

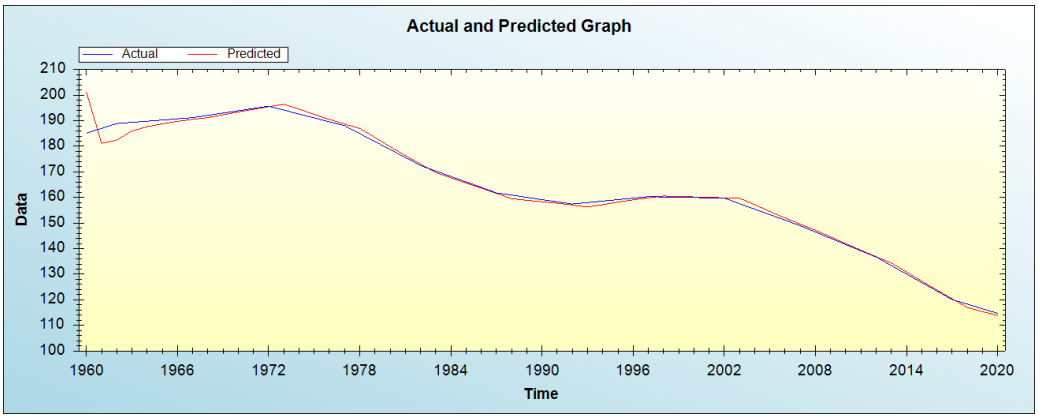


Figure 2: In-sample forecast for the Z series

 

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Actual and Smoothed graph for Z series

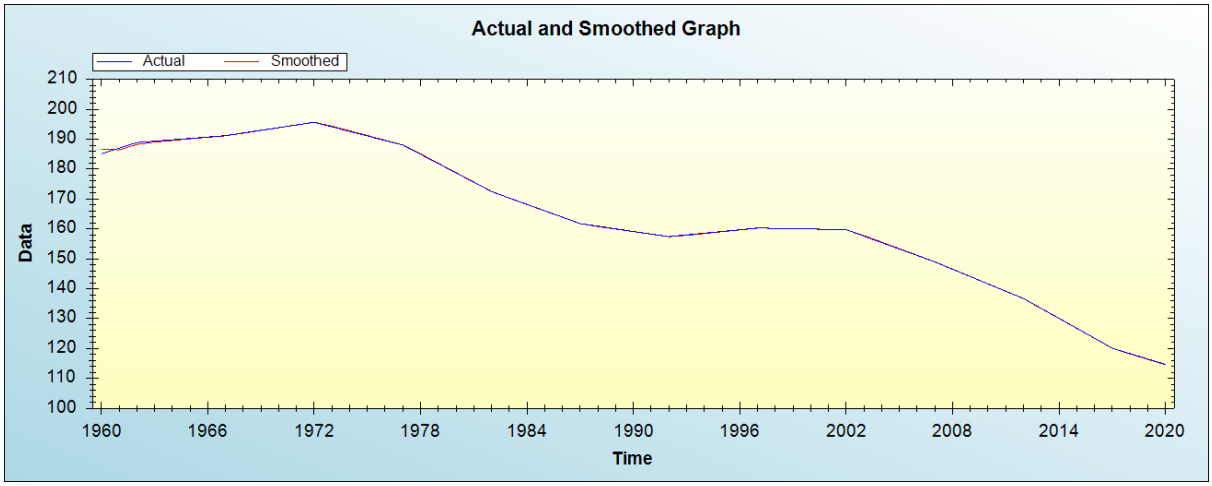


Figure 3: Actual and smoothed graph for Z series

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

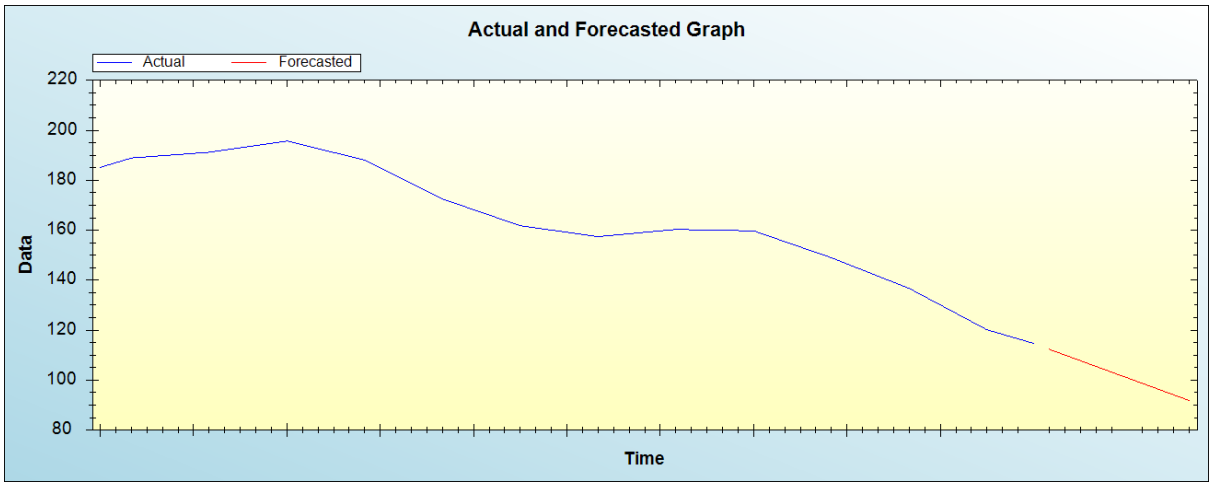


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| Year | Forecasted adolescent fertility rate |
|---|---|
| 2021 | 112.3287 |
| 2022 | 110.0474 |
| 2023 | 107.7661 |
| 2024 | 105.4848 |
| 2025 | 103.2035 |
| 2026 | 100.9222 |
| 2027 | 98.6409 |
| 2028 | 96.3595 |
| 2029 | 94.0782 |
| 2030 | 91.7969 |

 

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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 but remain throughout the out of sample period.

## V. POLICY IMPLICATION & CONCLUSION

Teenage pregnancy remains a public health challenge in developing countries like Zambia. Teen pregnancy and child bearing has geographic variation in this country with rural young women being twice more likely to experience this problem when compared with urban women. Risk factors for teenage pregnancy include lack of resources, insufficient knowledge about sexuality and reproduction, gender norms governing sexual behavior and contraceptive use. The government is implementing multiple strategies to reduce unintended pregnancies among teenagers such as including incorporation of comprehensive sexuality education in the education curriculum, awareness campaigns and family planning services at all levels of care. The impact of these strategies is evidenced by the steady decline of adolescent fertility over the past decades. However, adolescent fertility remains very high. This study applied the double exponential smoothing technique to forecast future trends of adolescent fertility for Zambia. The study established that adolescent fertility will decline but remain very high throughout the out of sample period.

Therefore, we implore the government to adopt our 3-fold policy recommendation:

i. Continuously support girl child education
ii. Strictly enforce laws that safeguard sexual and reproductive health rights of women and girls
iii. Finance youth empowerment projects.

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