Analysing Future Trends of Adolescent Fertility for New Zealand Using Holt's Linear Method

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Abstract - **This research article uses annual time series data of adolescent fertility rate for New Zealand 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 0.9and 0.9 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline to levels below 15 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage authorities in New Zealand to identify and address major drivers of teenage pregnancies in the country with the aim of averting adverse pregnancy outcomes.**

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

New Zealand has one of the highest rates of adolescent pregnancy among OECD countries (Johnson & Denny, 2007). Teenage pregnancy is an important health issue because adolescent mothers and their children have an increased risk of medical, psychological, developmental and social problems (Amjad*et al.* 2019; Grønvik & Fossgard, 2018;Kirbas*et al.* 2016). Adverse maternal and child health complications for teenage mothers during pregnancy include pregnancy induced hypertension, premature delivery, antepartum hemorrhage, anemia and having low birth weight babies (Santelli *et al.*2017;Blum & Gates,2015;UNFPA*et al.*2015;Chandra-Mouli*et al.*2014;Patton*et al.*2009). Previously reported risk factors for teenage pregnancy include drug and alcohol abuse, exposure to family violence and domestic abuse, sexual abuse, mental health problems, peer influence, poor parental guidance and repeat teenage pregnancy (Cau, 2015). Children of teen mothers have been shown to be at increased risk of developmental disabilities, behavioral problems and infant mortality (Brooks-Gunn & Furstenberg, 1986). Studies done in the past identified long term complications such as higher risk of poor educational outcomes, depression, incarceration and continuation of an intergenerational cycle of teen parenting (American Academy of Pediatrics 1989, Horwitz *et al.* 1991). New Zealand has made significant progress towards ending teenage pregnancy over the past decades. According to World Bank adolescent fertility steadily declined from 1960 to 2020 reaching fertility levels below 30 births per 1000 women aged 15-19 years.

This paper applies the double exponential smoothing technique to model and forecast future trends of adolescent fertility for New Zealand. Findings of this study will depict the future burden of adolescent fertility in the country. This will inform national policies, planning and allocation of resources to teenage pregnancy prevention programs.

II. METHODOLOGY

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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

N_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 New Zealand 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	N
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.900
Forecast performance measures	

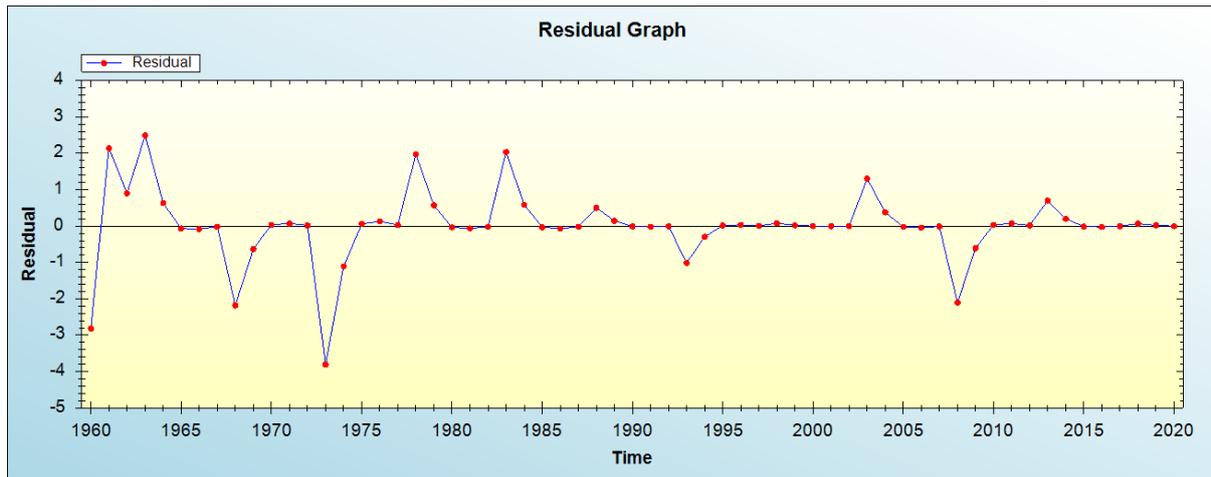| Mean Absolute Error (MAE)	0.498436
Sum Square Error (SSE)	58.196985
Mean Square Error (MSE)	0.954049
Mean Percentage Error (MPE)	0.109441
Mean Absolute Percentage Error (MAPE)	1.168828

Residual Analysis for the Applied Model
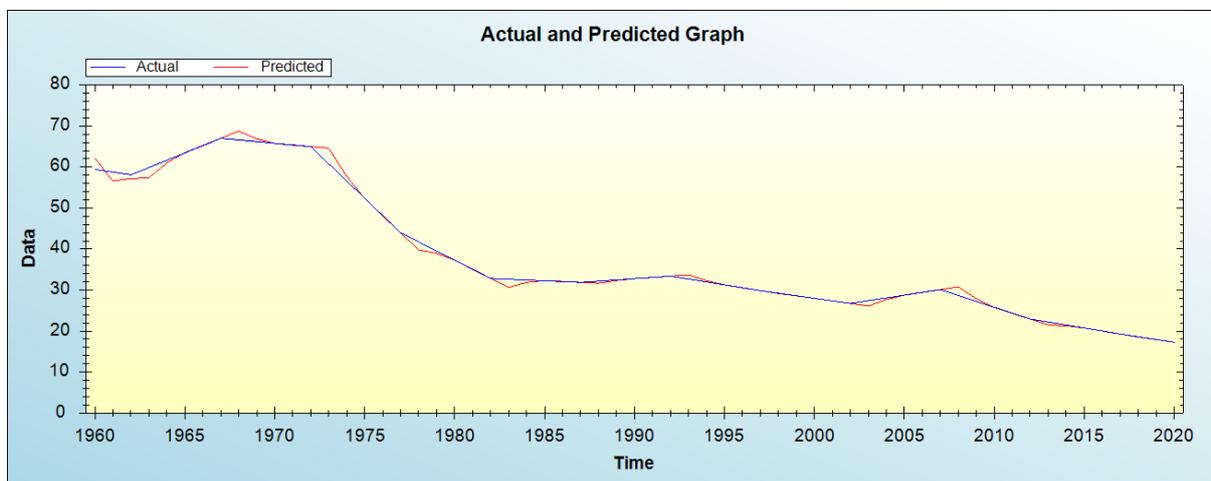

Figure 1: Residual analysis

In-sample Forecast for N

Figure 2: In-sample forecast for the N series

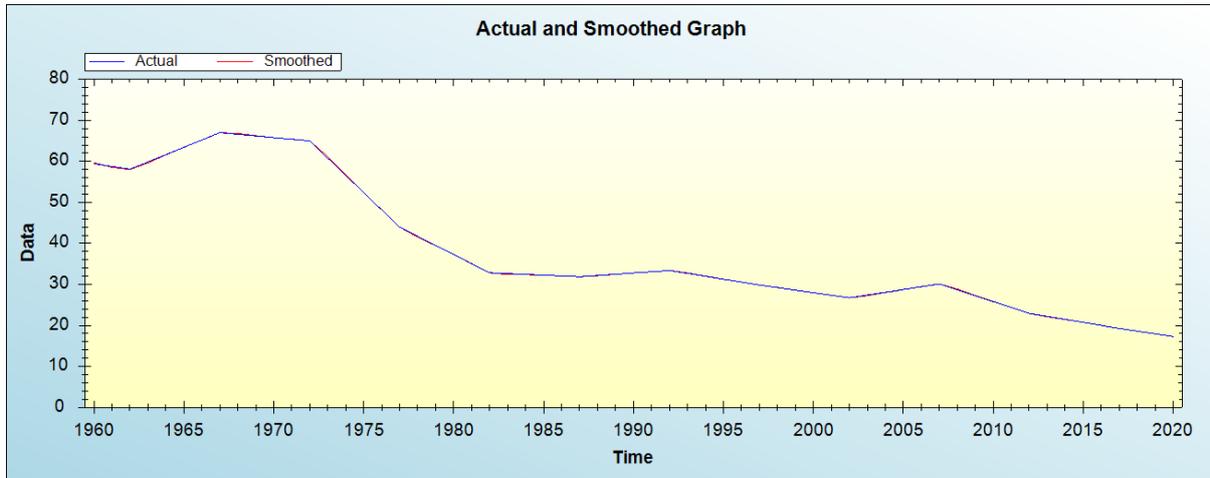Actual and Smoothed graph for N series

Figure 3: Actual and smoothed graph for N series

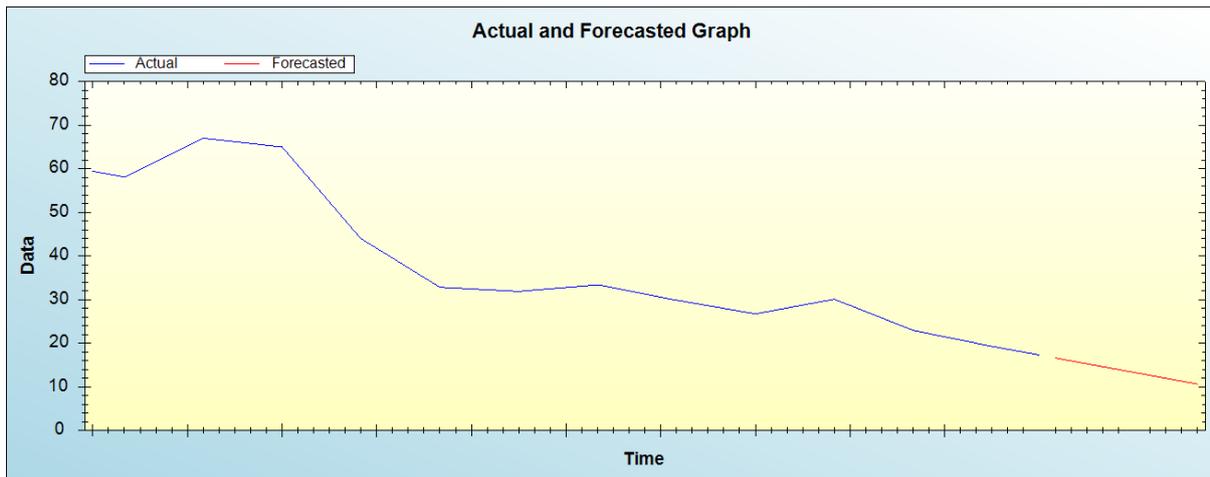Out-of-Sample Forecast for N: Actual and Forecasted Graph

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

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	16.6107
2022	15.9474
2023	15.2842
2024	14.6210
2025	13.9578
2026	13.2945
2027	12.6313
2028	11.9681
2029	11.3049
2030	10.6416

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

IV. POLICY IMPLICATION & CONCLUSION

New Zealand has one of the highest rates of adolescent pregnancy among OECD countries. It has made significant progress towards ending teenage pregnancy during the previous decades. As highlighted by the World Bank adolescent fertility steadily declined from 1960 to 2020 reaching fertility levels below 30 births per 1000 women aged 15-19 years. This decline can be attributed in part to the national family planning program. This study applied the double exponential smoothing technique to forecast future trends of adolescent fertility for New Zealand. Our study findings showed that adolescent fertility will continue to decline to levels below 15 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage the government to identify and address major drivers of teenage pregnancies in the country with the aim of eradicating the problem by 2030.

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