

Forecasting Future Trends of Under Five Mortality Rate for Guyana Using Double Exponential Smoothing

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Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Guyana from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation statistics indicate that the applied model is stable in forecasting U5MR. The Holt's linear exponential smoothing model was applied to forecast U5MR in Guyana. 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 revealed that annual U5MR will decline to levels below 25 deaths per 1000 live births over the out of sample period. Therefore, we encourage the authorities in Guyana to design child health policies that will help keep under five mortality under control.

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

This current period of sustainable development goals (SDGs) was designed to end all forms of poverty, health challenges and other deprivations (UN, 2016; UN, 2015). It is sad to mention that past successes can be reversed as a result of various challenges that are emerging each day. The emergence of the COVID-19 pandemic has created a very complex situation as the whole world has shifted its focus to managing the global health crisis leaving other global issues partially attended. The changes that are taking place in the global political landscape have triggered global food insecurity, economic downturn and aggravated the existing global health challenges. Therefore, it is ideal at this point in time for all UN member countries and global partners to strengthen the capacity of individual countries and to encourage collaborative approaches when addressing global health problems and other health related issues. The United Nations' 3rd sustainable development goal focuses on ensuring good health and promotion of well-being for all at all ages. This has target 3.2 which is meant to push all UN member states to work tirelessly to bring down newborn and under five mortality to levels as low as 12 neonatal deaths per 1000 live births and 25 under five deaths per 1000 live births by 2030 (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). In line with agenda 2030 for sustainable development, this paper applies the Holt's linear exponential smoothing method to forecast future trends of under-five mortality rate for Guyana. The findings of this study are envisioned to stimulate an early response to the problem of mortality among under five children.

II. LITERATURE REVIEW

A description of household factors associated with under-five mortality in Bankass, a remote region in central Mali was done by Boettiger *et al.* (2021). The authors analyzed baseline household survey data from a trial being conducted in Bankass. The survey was administered to households between December 2016 and January 2017. Under-five deaths in the five years prior to baseline were documented along with detailed information on household factors and women's birth histories. Factors associated with under-five mortality were analyzed using Cox regression. The study concluded that U5 mortality is very high in Bankass and is associated with living a greater distance from healthcare and several other household factors that may be amenable to intervention or facilitate program targeting. A forecasting study was carried out by Khan *et al.* (2019) to model and forecast infant mortality rates of Asian countries in the perspective of GDP. Secondary data of IMR and GDP (PPP) from 1980 to 2015 was analyzed and forecast was done from 2016 to 2025. AR (1) was found to be suitable for all the countries except Japan and Nepal for which ARIMA (1, 1, 1) model was appropriate based on FMSE and FRMSE. Cao *et al.* (2017) analyzed trends in mortality and causes of death among children aged under 5 years in Beijing, China between 1992 and 2015 and forecasted under-5 mortality rates (U5MRs) for the period 2016–2020. An entire population-based epidemiological study was conducted. Data collection was based on the Child Death Reporting Card of the Beijing Under-5 Mortality Rate Surveillance Network. Trends in mortality and leading causes of death were analyzed using the χ^2 test and SPSS 19.0 software. An autoregressive integrated moving average (ARIMA) model was fitted to forecast U5MRs between 2016 and 2020 using the EViews 8.0 software. The study concluded that Beijing has made considerable progress in reducing U5MRs from 1992 to 2015. However, U5MRs could show a slight upward trend from 2016 to 2020. Saravanou *et al.* (2016) studied the infant mortality prediction using features extracted from birth certificates. Training of classification models to decide whether an infant will survive or not was carried out. The authors focused on exploring and understanding the importance of features in subsets of the population and compared models trained for

individual races to general models. The study concluded that the applied methodology outperformed standard classification methods used by epidemiology researchers.

III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of under-five mortality rate in Guyana. 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.

$$W = \mu_t + b_t t + \varepsilon_t$$

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

W_t is the actual value of time series at time t

L_t is the exponentially smoothed value of time series 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

T_t is the trend estimate

Data Issues

This study is based on annual under five mortality rate in Guyana 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	W
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.547571
Sum Square Error (SSE)	59.804723
Mean Square Error (MSE)	0.980405
Mean Percentage Error (MPE)	0.032980
Mean Absolute Percentage Error (MAPE)	0.824153

Residual Analysis for the Applied Model

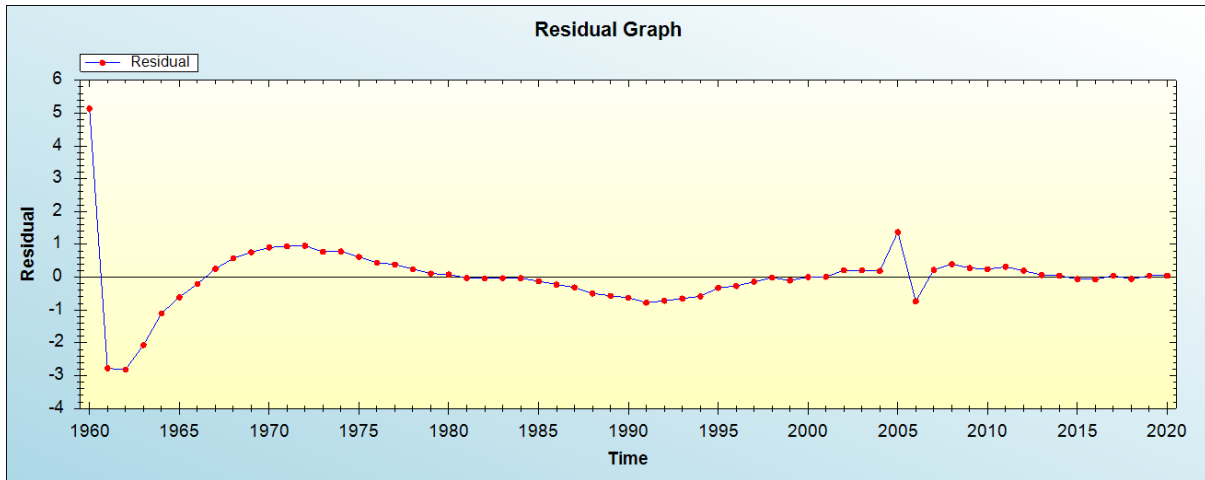


Figure 1: Residual analysis

In-sample Forecast for W

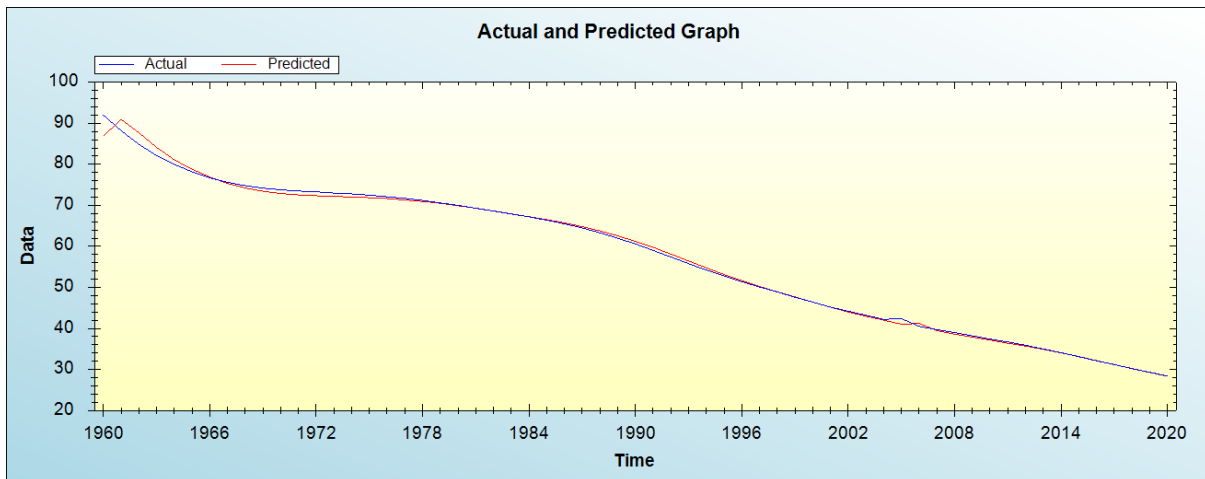


Figure 2: In-sample forecast for the W series

Actual and smoothed graph for W

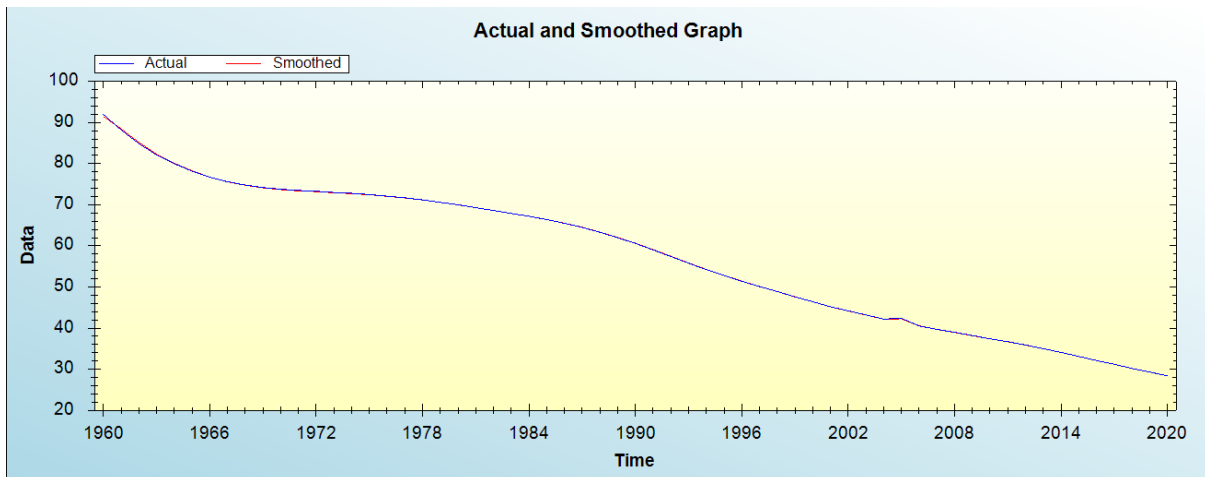


Figure 3: Actual and smoothed graph for W

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

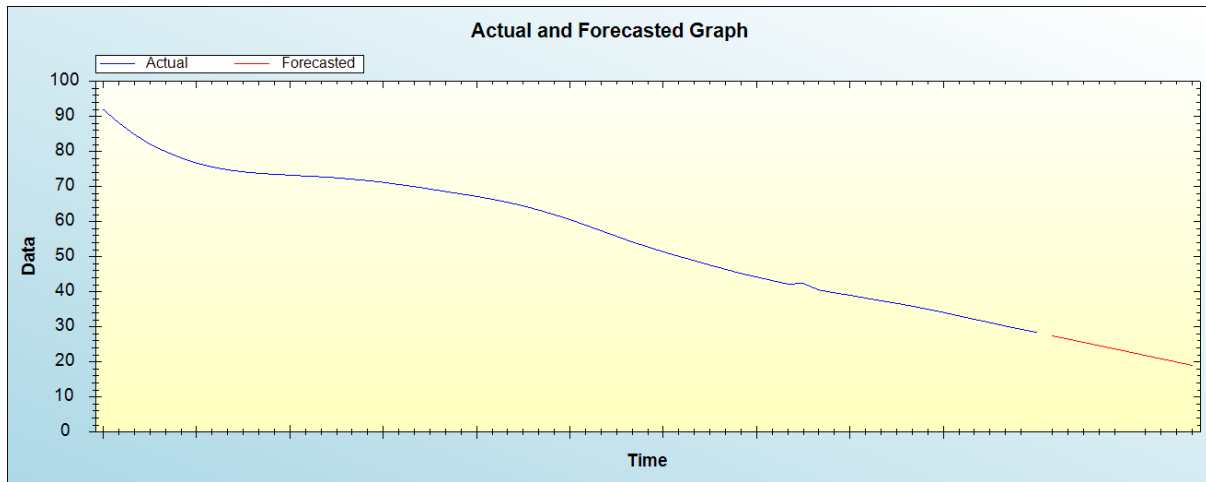


Figure 4: Out-of-sample forecast for W: actual and forecasted graph

Out-of-Sample Forecast for W: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	27.4547
2022	26.5144
2023	25.5740
2024	24.6336
2025	23.6933
2026	22.7529
2027	21.8126
2028	20.8722
2029	19.9318
2030	18.9915

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 U5MR will decline to levels below 25 deaths per 1000 live births over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Under five mortality remains a public health problem in Guyana, however the government has made significant strides in the reduction of under-five mortality rate. This study applies the Holt’s linear exponential smoothing model to predict future trends of under-five mortality rate in Guyana. The results of the study indicate that annual U5MR will decline to levels below 25 deaths per 1000 live births over the out of sample period. Therefore, we encourage the authorities in Guyana to design child health policies that will help keep under five mortality under control.

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