

Forecasting Under Five Mortality Rate for Colombia Using Double Exponential Smoothing Model

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Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Colombia from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation statistics of the applied model indicate that the model is stable in forecasting U5MR. The Holt's linear exponential smoothing model was applied in this study to predict U5MR in Colombia. The optimal values of smoothing constants α and β are 0.9 and 0.1 respectively based on minimum MSE. The findings of this study indicate that annual U5MR will continue to decline over the out of sample period. Therefore, we encourage the Colombian government to address various challenges that are faced by under five children who live in disadvantaged communities across the country.

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

The International conference on Population and development in 1994 and the Agenda 2030 for sustainable development in September 2015 recognized sexual and reproductive rights of women. Women must be accorded their rights to choose their sexual partners, number of children they wish to have and time of childbearing. They must have equal access to health information, education and SRH services. Many adolescent girls and women in Sub-Saharan Africa are at high risk of unwanted pregnancies, unsafe abortions, and STIs (Newman *et al.* 2015; Vos *et al.* 2013; Chinsebu, 2009). Lack of comprehensive knowledge on SRH services increases the risk of poor SRH outcomes (Newton-Levinson *et al.* 2016; Elkak, 2013; Aquaiz *et al.* 2012; Kahhalch, 2009; Dejong *et al.* 2007). The 3rd sustainable development goal does not only address sexual and reproductive health issues but also aims to end all preventable maternal, neonatal and under five deaths by 2030. It also focuses on preventing and treating substance abuse, communicable, non-communicable and neglected tropical diseases (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UNICEF, 2016; UNICEF, 2015). The aim of this study is to forecast future trends of under-five mortality rate for Colombia using Holt's exponential smoothing method to inform child health policies, planning and allocation of resources in order to end all avoidable under five deaths.

II. LITERATURE REVIEW

Taha *et al.* (2020) investigated the prevalence of and factors associated with preterm birth and LBW among mothers of children under two years in Abu Dhabi, United Arab Emirates. Data were collected in clinical and non-clinical settings across various geographical areas in Abu Dhabi. The data were analyzed using both descriptive and inferential statistics. A total of 1610 mother-child pairs were included in the study. The study found that factors that were positively associated with preterm birth were Arab mothers, maternal education level below secondary, caesarean section, and LBW. LBW was associated with female children, caesarean section (CS) first child order, and preterm birth. A Sub-Saharan African study by Bitew *et al.* (2020) determined the incidence density rate and predictors of neonatal mortality by utilizing electronic databases. The study findings indicated that the incidence density rate of neonatal mortality in Sub-Saharan Africa is significantly high. Multiple factors (neonatal and maternal) were found to be independent predictors. Romanello (2018) calculated the rate of infant mortality and child mortality in Yemen and put into evidence some characteristics of households that could influence the rate of child mortality. Data was obtained from the Yemen National Social Protection and Monitoring Survey (NSPMS). The Brass indirect method was used for calculating infant and child mortality rates, while Poisson regression was utilized for putting into evidence covariates that could affect mortality. According to the results of Brass indirect analysis, infant and child mortality rates were elevated in Yemen. Poisson regression revealed that mother education, quantity of water available, household economic situation and electricity in household were major factors in reducing child mortality. The study concluded that Yemen needs to increase the access to schools to the population, particularly girls, and improve the infrastructure of the country, mainly water and electricity supply, with the objective of further reduction of child mortality. An African study by Kayode *et al.* (2017) revealed that there is a wide variation in neonatal mortality in SSA. A substantial part of this variation can be explained by differences in the quality of healthcare governance, prevalence of HIV and socioeconomic deprivation.

III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

Y_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 Colombia 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	Y
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)	1.552752
Sum Square Error (SSE)	736.480406
Mean Square Error (MSE)	12.073449
Mean Percentage Error (MPE)	1.469864
Mean Absolute Percentage Error (MAPE)	2.796600

Residual Analysis for the Applied Model

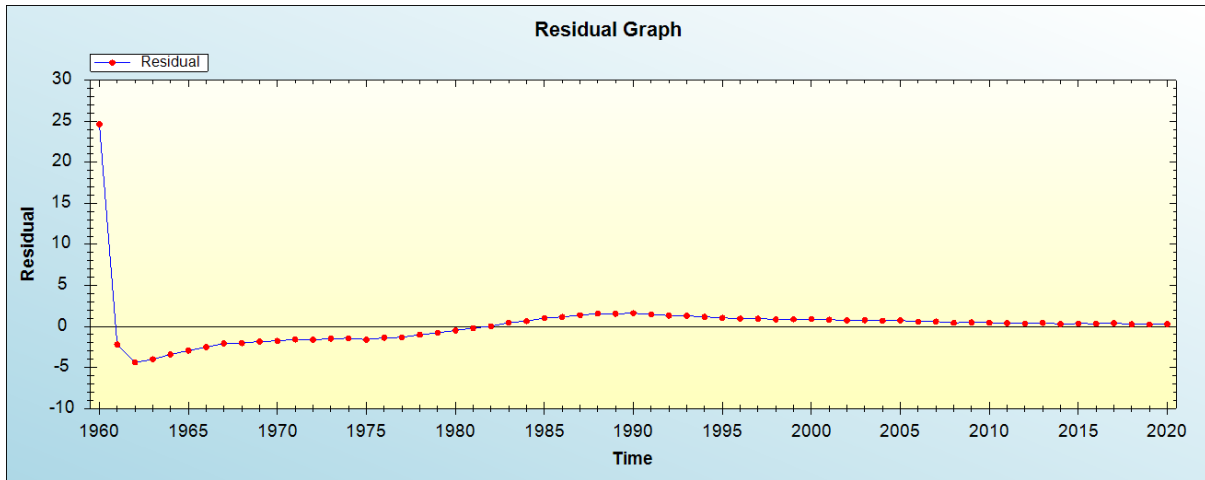


Figure 1: Residual analysis

In-sample Forecast for Y

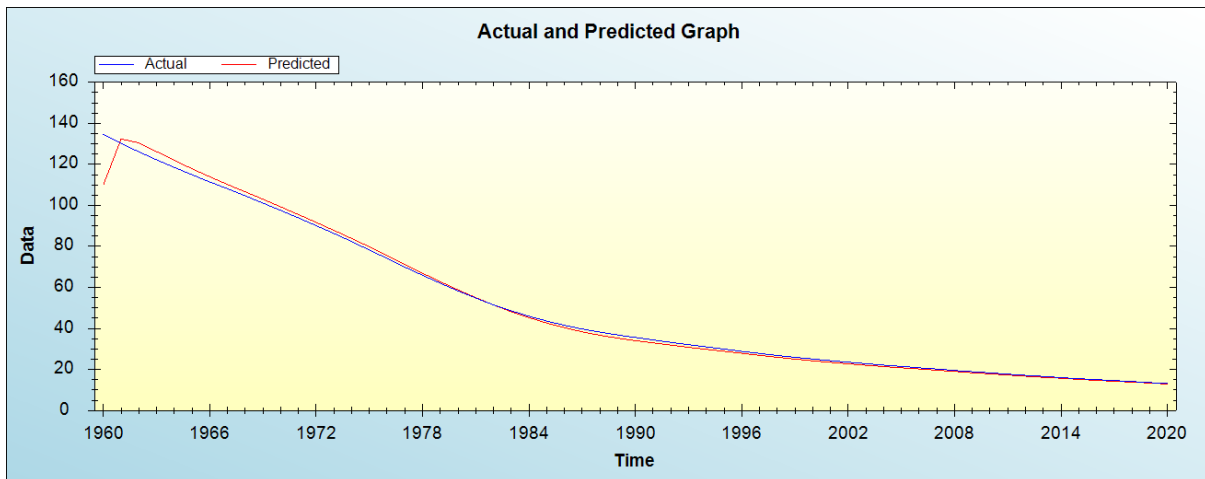


Figure 2: In-sample forecast for the Y series

Actual and Smoothed Graph for Y

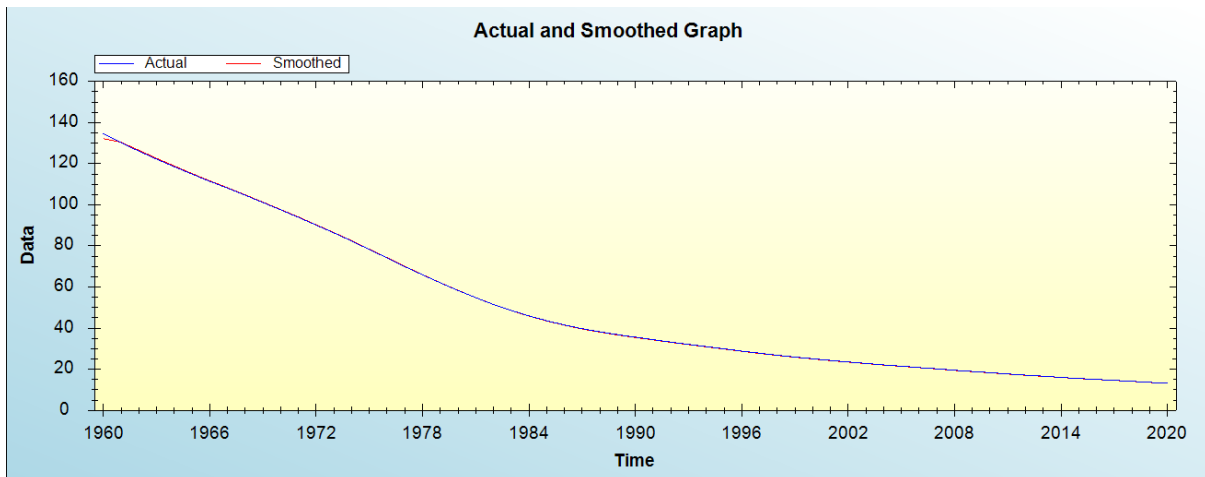


Figure 3: Actual and smoothed Y series

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

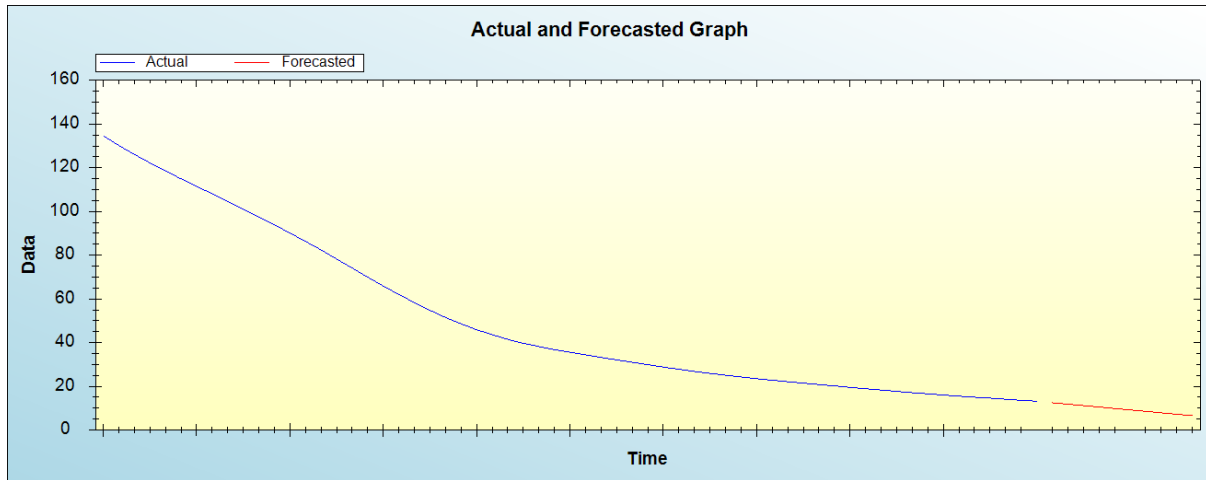


Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	12.5123
2022	11.8553
2023	11.1983
2024	10.5414
2025	9.8844
2026	9.2275
2027	8.5705
2028	7.9136
2029	7.2566
2030	6.5996

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 continue to decline over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The problem of under-five mortality is a major public health concern that requires urgent action. Informed policies, decisions and allocation of resources is critical in order to effectively control this challenge. In this study we propose Holt’s linear method to forecast future trends of under-five mortality in Colombia. The projections revealed that annual U5MR will continue to decline over the out of sample period. Therefore, we encourage Colombian authorities to focus on addressing different challenges encountered by under five children living in disadvantaged communities across the country.

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