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Forecasting Under Five Mortality Rate for El Salvador Using Double Exponential Smoothing

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for El Salvador from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied model is stable in forecasting U5MR. Holt's linear exponential smoothing model was applied to forecast U5MR in this study. The optimal values of smoothing constants α and β are 0.6 and 0.2respectively based on minimum MSE. The findings of this study revealed that annual U5MR will continue to decline over the out of sample period. Hence, we encourage the government of El Salvador to address various challenges encountered by pediatric patients at all levels of healthcare.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

Exponential smoothing techniques are widely used for smoothing discrete time series in order to perform short term forecasts (Ostertagová1 & Ostertag, 2011). This popularity can be attributed to its simplicity, its computational efficiency, the ease of adjusting its responsiveness to changes in the process being forecast, and its reasonable accuracy (Montgomery *et al.* 1990). The procedure of exponential smoothing involves smoothing the original series the way the moving average does and to use the smoothed series in forecasting future values of the variable of interest. In exponential smoothing, the more recent values of the series have greater influence on the forecast of future values than the more distant observations. The biggest weight is assigned to the current observation, less weight to the immediately preceding observation, even less weight to the observation before that, and so on (exponential decay of influence of past data) (Aczel, 1989). Exponential smoothing models can be utilized successfully in modeling and forecasting public health data with reasonable accuracy. Therefore, in this study we apply the Holt's linear exponential smoothing method to forecast future trends of under-five mortality rate for El-Salvador with the aim of ending all preventable under five deaths by 2030.

II. LITERATURE REVIEW

A study conducted in Zimbabwe by Nyoni & Nyoni (2020) analyzed monthly time series data on neonatal death cases at Chitungwiza Central Hospital (CCH) from January 2013 to December 2018 using Box-Jenkins SARIMA models and found out that there will be a slow but steady decrease in neonatal deaths at CCH over the out-of-sample period. Another study by Nyoni & Nyoni, 2020 applied the Box-Jenkins ARIMA methodology to forecast neonatal deaths in Zimbabwe using annual time series data on neonatal deaths in Zimbabwe from 1966 to 2018.The ARIMA (8, 2, 0) was found to be the optimal model. The study findings revealed that the numbers of neonatal deaths per year would decline sharply over the next 25 years. A similar forecasting study by Nyoni & Nyoni, 2020 utilized the ARIMA model to model and forecast infant mortality in Zimbabwe. The ARIMA (1, 2, 5) was the best model and the forecast results indicated that the number of infant deaths per year, over the out-of-sample period, will follow a downward trend. Biracyaza & Habimana (2019) developed a model of infant mortality and its associated risk factors in Rwanda from 2011 to 2015.A cross-sectional survey was conducted using data from 2014/2015 Rwanda Demographic and Health Survey. The study concluded that factors associated with IM were grouped into community, ecological, socio-economic and proximate factors and identified that each group consists of multifactor that influence the infant mortality rate. Ezeh *et al.* (2014) examined the determinants of neonatal mortality in Nigeria using the Cox Regression model and found out that a higher birth order of newborns with a short birth interval of less or equal to 2 years and newborns with a higher birth order with a longer birth interval of greater than 2 years were significantly associated with neonatal mortality.

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III. METHODOLOGY

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

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

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 El-Salvador 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	J
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.600
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	2.074147
Sum Square Error (SSE)	883.856561
Mean Square Error (MSE)	14.489452
Mean Percentage Error (MPE)	1.749533
Mean Absolute Percentage Error (MAPE)	3.239659

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Residual Analysis for the Applied Model

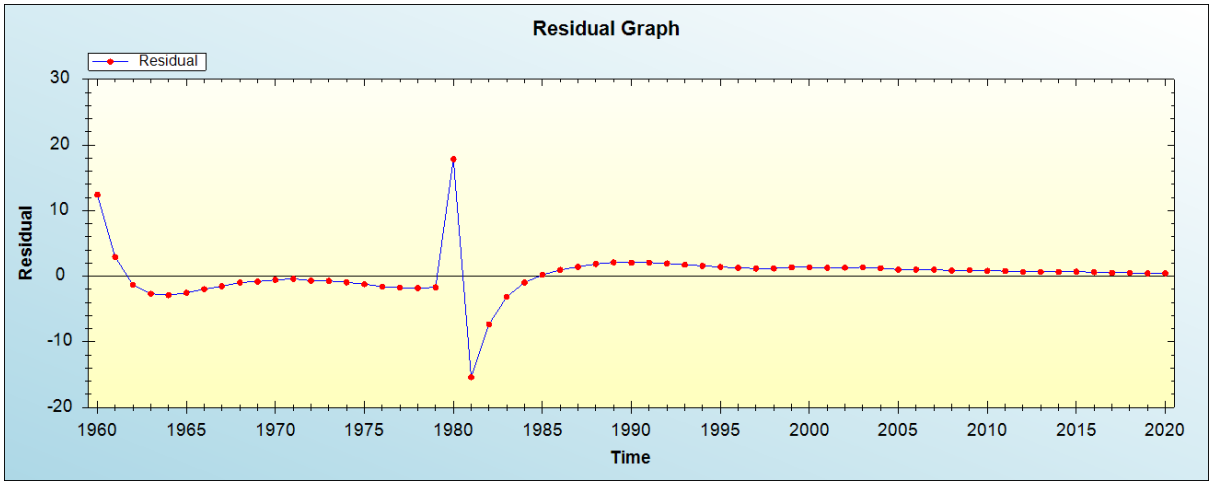

Figure 1: Residual analysis

In-sample Forecast for J

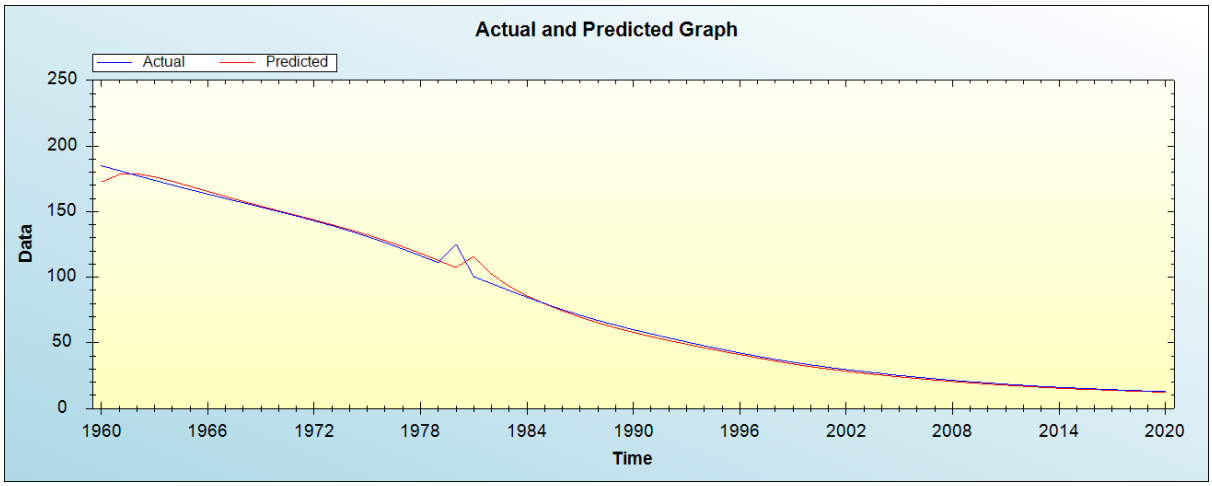

Figure 2: In-sample forecast for the J series

Actual and Smoothed J series

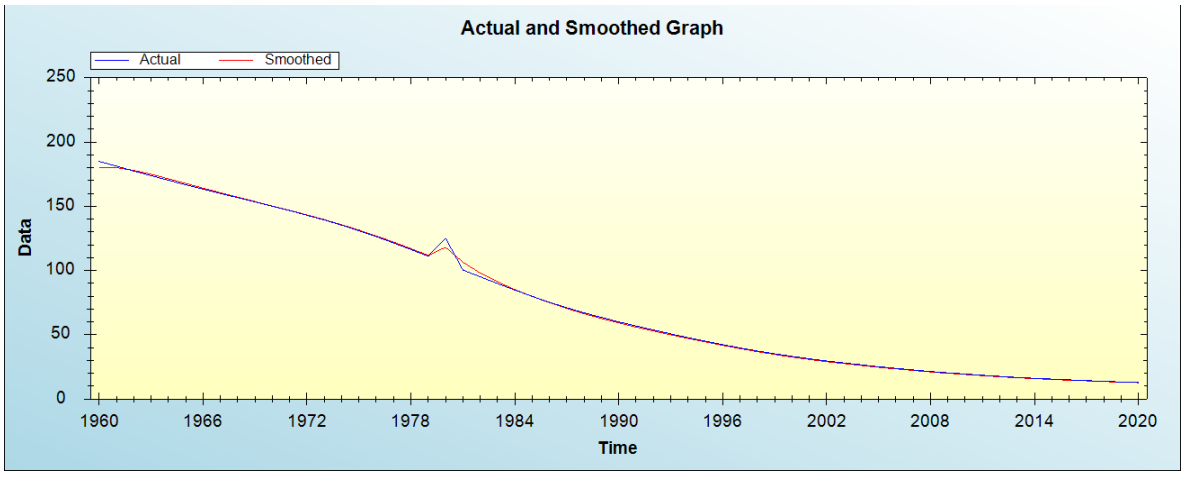

Figure 3: Actual and smoothed J series

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

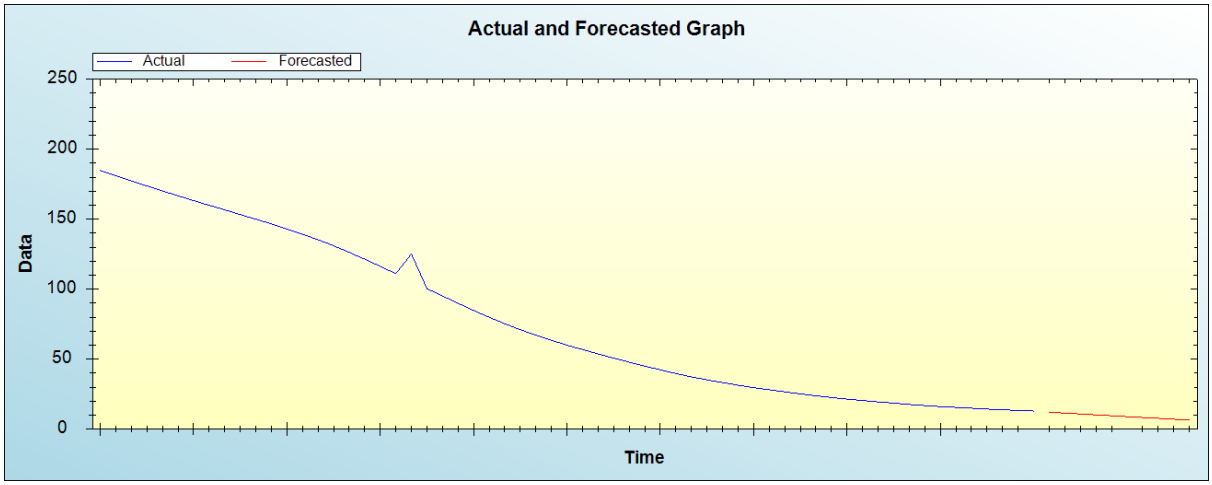

Figure 4: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	12.0785
2022	11.4447
2023	10.8109
2024	10.1771
2025	9.5433
2026	8.9095
2027	8.2758
2028	7.6420
2029	7.0082
2030	6.3744

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

Over the past decades, El Salvador reported a decline in under five and neonatal mortality rates as a result of measures implemented by government. The authorities must continue supporting maternal and child health program activities such as increasing coverage of child immunizations, Vitamin A supplementation and integrated management of childhood illnesses. This study applies Holt's linear method to forecast U5MR in El Salvador and the study findings suggested thatannual U5MR will continue to decline over the out of sample period. Hence, we implore the government to address all the challenges encountered by pediatric patients at all levels of healthcare.

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