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Predicting Future Trends of Under Five Mortality Rate for the Gambia Using the Double Exponential Smoothing Model

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for the Gambia from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation statistics indicate that the applied model is stable in forecasting under five mortality rate. In this study the Holt's linear exponential smoothing model was used to predict future trends of U5MR for the Gambia. The optimal values of smoothing constants α and β are 0.9 and 0.2 respectively based on minimum MSE. The results of the study indicated that annual U5MR will continue to drop over the out of sample period. Therefore, we encourage the Gambian government to address all the major challenges being faced by under five children across the country and ensure availability of medical supplies and staff particularly in the rural areas.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

Tracking of sustainable development goal (SDG) progress should always be part of the SDG implementation process (UN, 2016; UN, 2015). Each SDG has indicators that help in the follow up and review of progress. It is crucial for all UN member states to collect data for each indicator including disaggregated information. National statistical systems should relentlessly coordinate all statistical activities and programs to ensure the successful implementation of the global action plan. There is need to embrace new technologies that are useful in data collection, processing, analysis, storage and dissemination. Data on maternal and child health is important for tracking progress towards achieving SDG3 targets 3.1 and 3.2. By the end of 2030, every UN member state should have managed to reduce maternal mortality ratio to levels below 70 deaths per 100 000 live births, newborn deaths to levels as low as 12 neonatal deaths per 1000 live births and under five mortality to levels as low as 25 deaths per 1000 live births (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). In line with the Cape Town global action plan (2017) and the 2030 agenda for sustainable development, this study models and projects future trends of under-five mortality rate for the Gambia using the Holt's linear exponential smoothing method. The results are expected to trigger an appropriate response to the problem of under-five mortality in the country.

II. LITERATURE REVIEW

A cross-sectional study in Benin by Tanou *et al.* (2021) examined the effect of geographical accessibility to health facilities on antenatal care and delivery services utilization in Benin, with an emphasis on geographical zones by employing multivariate logistic regression. The findings of the study suggested that geographical accessibility to health facilities is critically important for the utilization of antenatal care and delivery services, particularly in the northern part of Benin. Mishra et al. (2019) gave a detailed presentation of how they used the ARIMA model to forecast infant mortality rates (2017 – 2025). The forecast of the sample period (1971 – 2016) showed accuracy by the selected ARIMA (2, 1, 1) model. The post-sample forecast with ARIMA (2, 1, 1) model showed a decreasing trend of infant mortality (2017 – 2025). The forecast infant mortality rate for 2025 in India is 15/1000 live births. Caluza (2018) utilized data mining technique using decision tree called J48 algorithm in classifying child mortality rate, life expectancy at birth, annual population growth, and the gross domestic product. Results revealed that annual population growth is highly correlated in predicting child mortality and generate three distinct rules. The generated model had high acceptability with 97.4% ROC curve result of the three classes in predicting child mortality under five years old. Another study by 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.

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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 Gambia. 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 Gambia 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	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.076026
Sum Square Error (SSE)	381.084893
Mean Square Error (MSE)	6.247293
Mean Percentage Error (MPE)	0.417173
Mean Absolute Percentage Error (MAPE)	0.668331

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Residual Analysis for the Applied Model

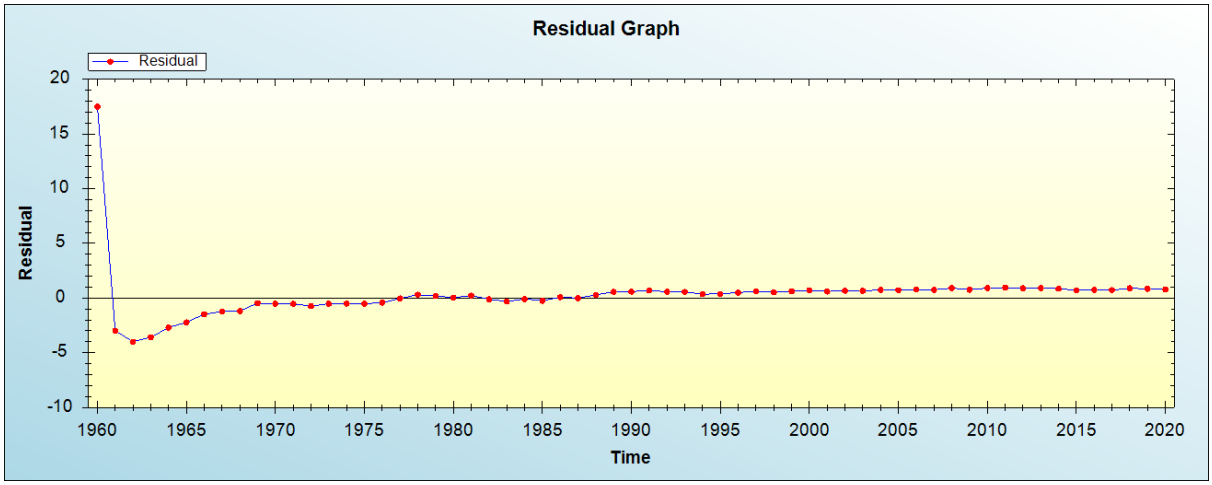

Figure 1: Residual analysis

In-sample Forecast for Y

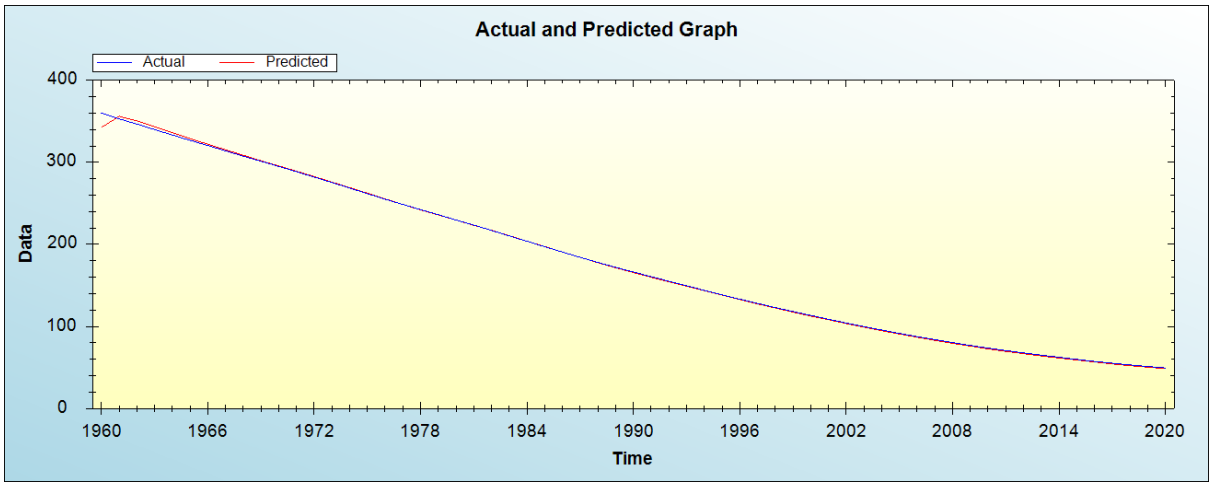

Figure 2: In-sample forecast for the Y series

Actual and smoothed graph for Y

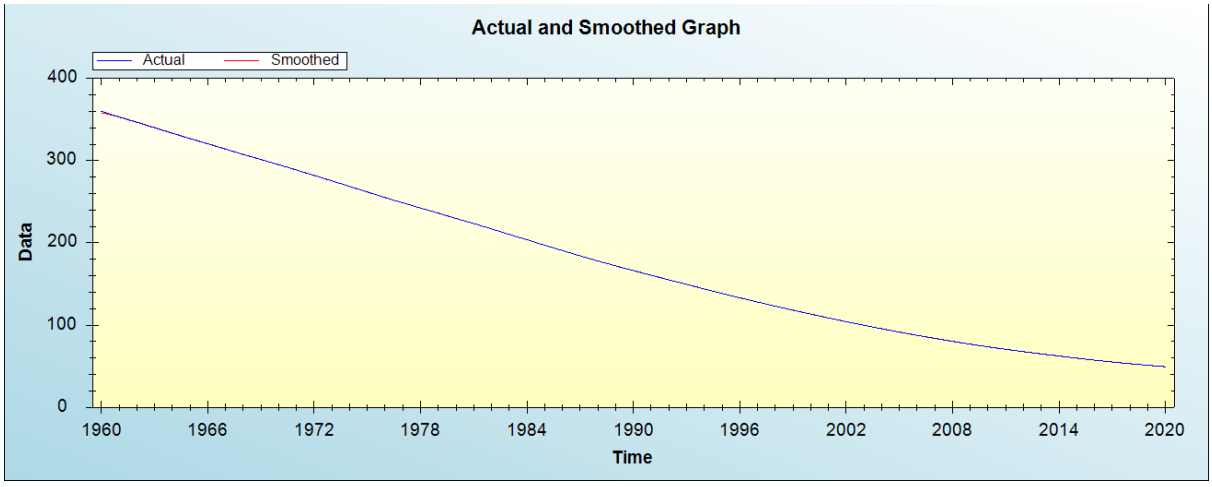

Figure 3: Actual and smoothed graph for Y

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

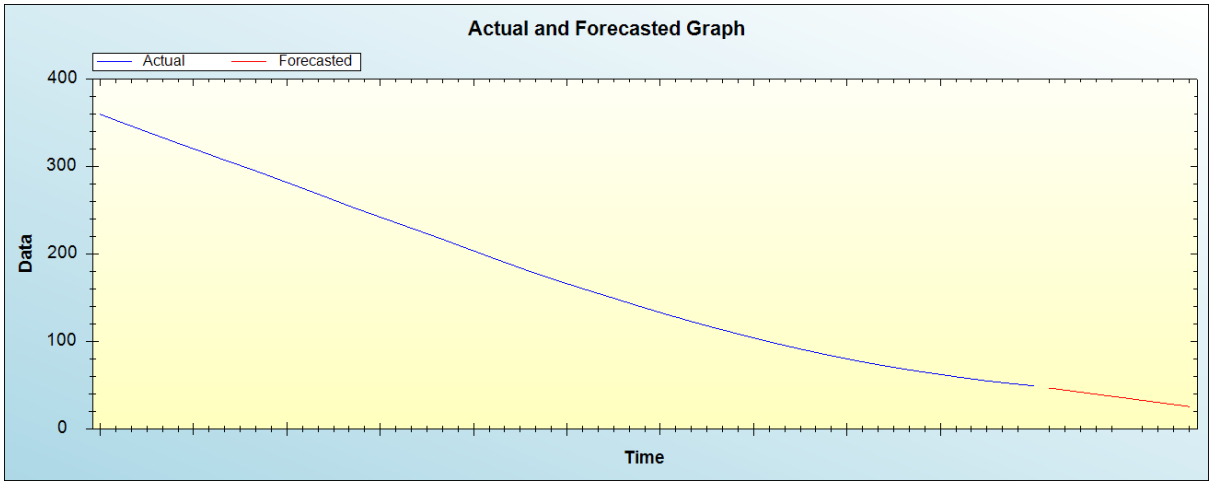

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	46.9561
2022	44.5914
2023	42.2267
2024	39.8620
2025	37.4973
2026	35.1326
2027	32.7679
2028	30.4032
2029	28.0385
2030	25.6738

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 drop over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Substantial reduction of under-five mortality to levels as low as 25 deaths per 1000 live births by 2030 should be the aim of the Gambian health authorities. The government should strive to improve coverage of childhood immunizations, Vitamin A supplementation, exclusive breastfeeding of babies for at least 6 months, and integrated management of childhood illnesses. This study applied the Holt's linear exponential smoothing model to forecast future trends of U5MR and the findings suggest that annual U5MR will continue to drop over the out of sample period. We encourage the Gambian government to address all major challenges being faced by under-five children across the country and to ensure availability of adequate medical supplies and staff particularly in the rural areas.

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