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Tracking Botswana's Future Progress towards Achieving Substantial Reduction of Under Five Mortality By 2030

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Abstract **- This study uses annual time series data on under five mortality rate (U5MR) for Botswana 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 Holt's linear method is stable in forecasting U5MR in Botswana. Optimal values of smoothing constants α and β are 0.9 and 0.3 respectively based on minimum MSE. The exponential smoothing model projections suggest that annual U5MR will decline over the out of sample period. Therefore, we encourage the government of Botswana to channel more resources to Maternal and child health (MNCH) program activities in order to substantially reduce under five mortality to levels as low as 25 deaths per 1000 live births by 2030.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

The launching of the global sustainable development goals (SDGs) in 2015 was meant to cover the gap left behind by millennium development goals (MDGs) (UN, 2016; UN, 2015). All countries are dedicated to the substantial reduction of maternal mortality ratio (MMR) to below 70 maternal deaths per 100 000 live births, neonatal mortality rate to at least 12 per 1000 live births and under five mortality to as low as 25 deaths per 1000 live births by 2030 (UN, 2020; WHO, 2019; UNICEF, 2019; UNICEF, 2018). Low and middle income countries are greatly affected by a huge burden of under-five and newborn mortality (UNICEF, 2018; Basu & Mckeey, 2010). It is of great concern that SSA has the highest neonatal mortality rate (NMR) (Kayode *et al.* 2017). This study is conducted in line with the Agenda 2030 for sustainable development to forecast future trends of under-five mortality rate for Botswana using Holt's linear exponential smoothing model. We expect the results to inform child health policies, planning and allocation of resources to the maternal and child health program activities to end all preventable under five deaths.

II. LITERATURE REVIEW

A cross-sectional survey was conducted by Irawaty*et al.* (2020) to analyze the causes of infant mortality in rural Indonesia and suggested strategies for its reduction. The study used data from the 2017 Indonesian Demographic and Health Survey (IDHS) dataset for children. The information on infant deaths collected from those mothers who experienced infant deaths. Series of logistic regression models were used to select the significant factors affecting infant mortality in rural Indonesia. Infant mortality is associated with intermediate social determinants such as birth order, birth weight, and breastfeeding status. Socio-demographic factors such as the educational status of mothers, wealth quintile, the smoking habit of the mother, age of mother at first delivery, and sex of the baby are also related to infant mortality. The study concluded the most crucial factors in rural Indonesia were the age of first-time mothers. Nyoni & Nyoni (2020) modelled and forecasted infant deaths in Zimbabwe using ARIMA model. The study utilized annual time series data on total infant deaths in Zimbabwe from 1960 to 2018. The best model based on AIC was the ARIMA (1, 2, 5) model. The study findings indicated that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend. Another forecasting study by Nyoni & Nyoni (2020) used monthly time series data on neonatal deaths cases at Chitungwiza Central Hospital (CCH) from January 2013 to December 2018; to forecast neonatal deaths over the period January 2019 to December 2020 using the Box-Jenkins SARIMA approach. The parsimonious model was found to be the SARIMA (0, 0, 3) (2, 0, 0)12 model and its predictions indicate slow but steady decrease in neonatal deaths at CCH. Elida *et al.* (2019) examined factors that influence infant mortality in West Aceh Regency. The research was quantitative with case control design, a case group was 45 mothers whose babies died when they were under one years old and a control group was 45 mothers whose babies were alive when they were under one year old. The matching was done on the babies based on their age and sex. The Data analyzed by using univariate and bivariate analysis with Mc Nemar test, meanwhile, multivariate analysis with conditional logistic regression test at the significant level of 0.25. The Result of analysis in this research showed that maternal age and parity significantly influence of infant mortality. In the other hand, maternal education did not significantly influence infant mortality. The most significant variable which influences infant mortality was maternal age (OR=4.745).

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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 Botswana. 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.

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

K_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 Botswana 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	K
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	2.643339
Sum Square Error (SSE)	2073.949609
Mean Square Error (MSE)	33.999174
Mean Percentage Error (MPE)	0.432922
Mean Absolute Percentage Error (MAPE)	2.894857

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Residual Analysis for the Applied Model

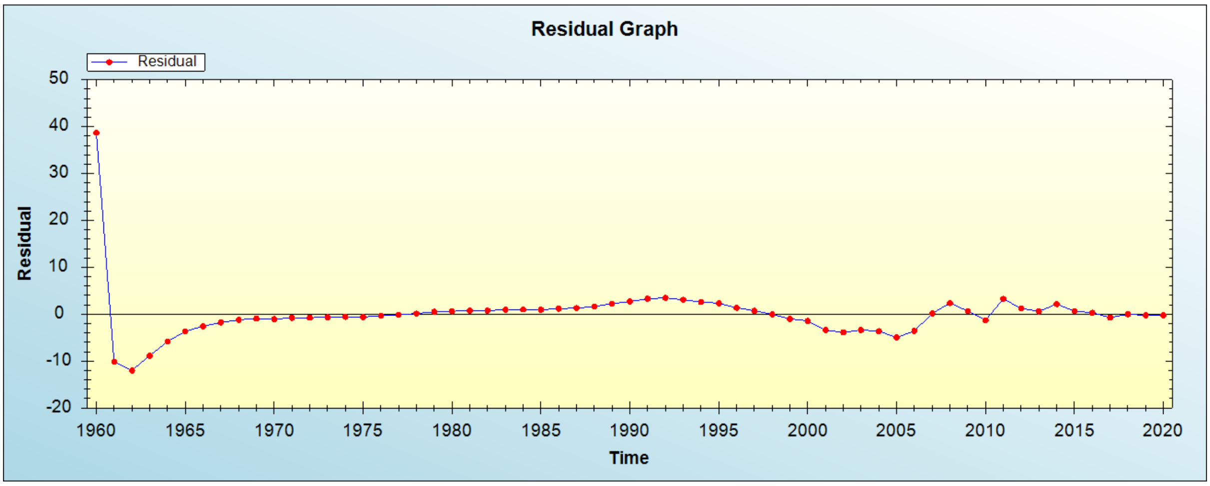

Figure 1: Residual analysis

In-sample Forecast for K

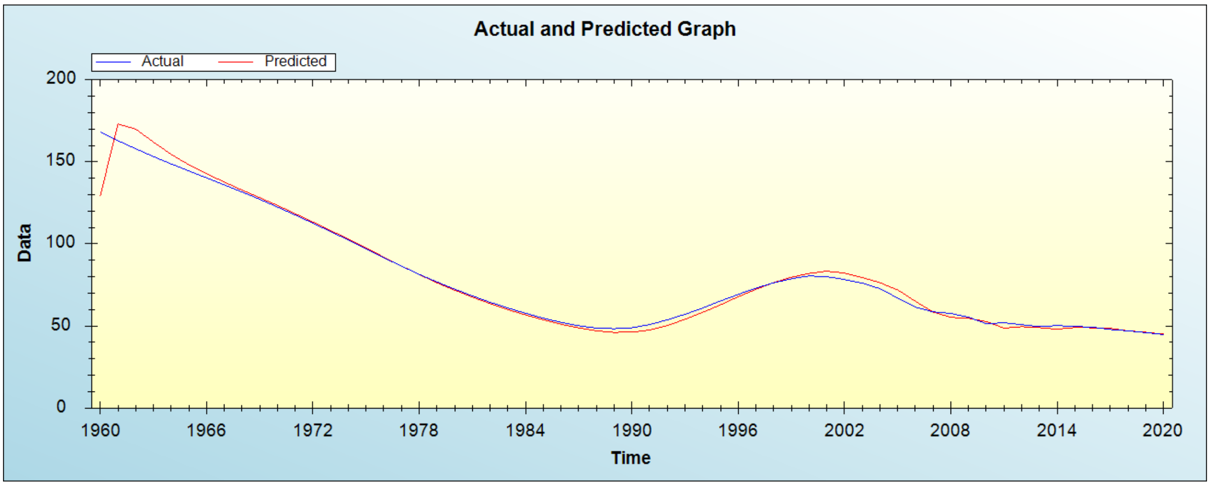

Figure 2: In-sample forecast for the K series

Actual and smoothed graph for K

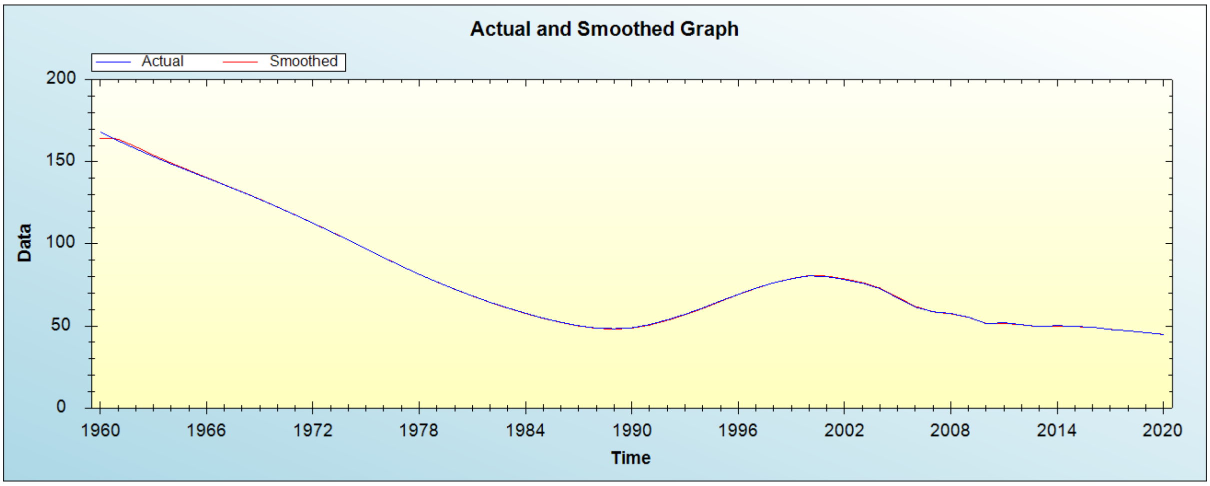

Figure 3: Actual and smoothed graph for K

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

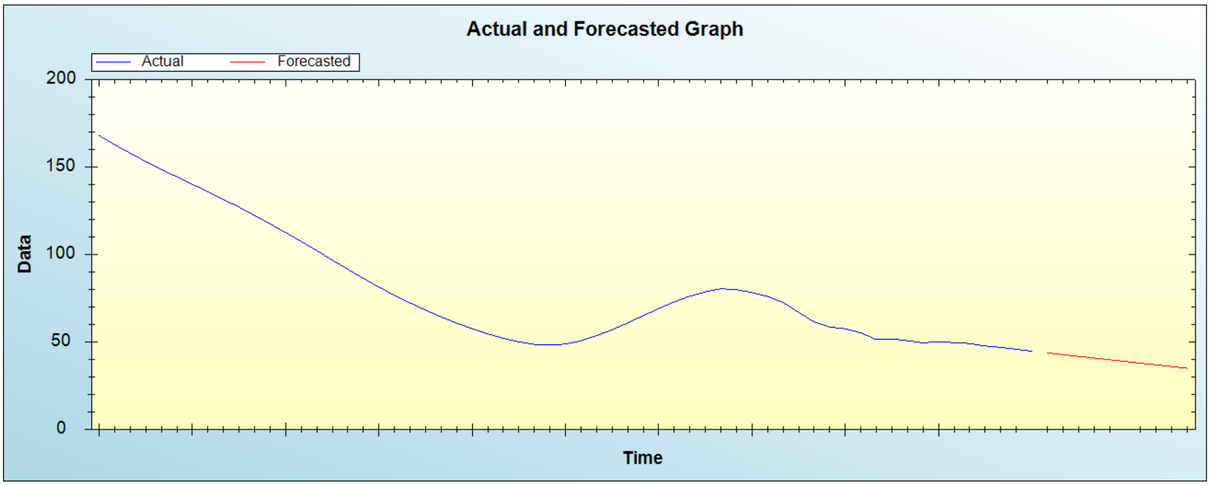

Figure 4: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	43.8408
2022	42.8618
2023	41.8828
2024	40.9037
2025	39.9247
2026	38.9457
2027	37.9667
2028	36.9876
2029	36.0086
2030	35.0296

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 over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Sub-Saharan African countries are characterized by high absolute numbers of under five deaths of which Botswana is included. Therefore there is need for authorities to design policies to urgently address this public health problem. Forecasting of under-five mortality will inform policies, decisions and allocation of resources. In this study we proposed Holt's linear exponential smoothing model to predict U5MR for Botswana and the findings indicate that annual U5MR will decline over the out of sample period. Therefore, we encourage authorities in Botswana to channel more resources to maternal and child health program activities to ensure availability of adequate medical supplies and staff at all levels of healthcare.

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