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

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Ethiopia from 1966 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 future trends of U5MR in Ethiopia. The Holt's linear method was applied in this study with optimal values of smoothing constants α and β are 0.9 and 0.1 respectively based on minimum MSE. Forecast results indicate that annual U5MR will drop over the out of sample period. Therefore, the Ethiopian government must allocate more resources to the maternal and child health program and address all the major drivers of mortality among under five children.**

***Keywords:*** Exponential smoothing, Forecasting, U5MR.

## I. INTRODUCTION

The existence of linkages between the 3rd sustainable development goal (SDG3) and other SDGs is very crucial to understand as this guide the implementation of the global action plan. SDG3 focuses on ensuring healthy lives and promotion of well-being for all at all ages (UN, 2016; UN, 2015). This part of the global action plan hopes to achieve universal health coverage and access to quality, affordable healthcare services. All countries are expected to promote research and development to ensure production of quality and affordable medicines and vaccines. Tackling the challenge of maternal, neonatal and under five mortality should be a priority especially in Sub-Saharan Africa and South Asia where the burden is high (UNICEF, 2018; Kayode *et al.* 2017; Basu & Mckeey, 2010). The ultimate goal is to ensure a substantial reduction of maternal mortality ratio to levels below 70 deaths per 100 000 live births, neonatal deaths to as low as 12 deaths per 1000 live births and under five deaths to levels as low as 25 deaths per 1000 live births (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). Successful reduction of poverty and hunger, and achievement of sustainable agriculture will ensure food security thereby improving the nutritional status of communities. Proper governance and political stability forms a good foundation for achieving all the set targets for SDG3. The existence of war and instability usually leads to destruction of health and other essential infrastructure which are necessary for sustainable development (Dejong *et al.* 2017). The aim of this paper is to project future trends of under-five mortality rate for Ethiopia using the Holt's linear exponential smoothing method. The findings will guide child health policies and allocation of resources to effectively tackle under five mortality in the country.

## II. LITERATURE REVIEW

Masaba & Phetoe (2020) described the trends of neonatal mortality within the two sub-Saharan countries. The study concluded that in 2018, the neonatal mortality rate for Kenya was 19.6 deaths per 1000 live births. The neonatal mortality rate had fallen gradually from 35.4 deaths per 1000 live births in 1975. On the other hand, South Africa had its neonatal mortality rate fall from 27.9 deaths per 1000 live births in 1975 to 10.7 deaths per 1000 live births in 2018.A study by Zeitlin *et al. (*2020) investigated the patterns of stillbirth and neonatal mortality rates in Europe between 2004 and 2010. Data about live births, stillbirths and neonatal deaths by gestational age (GA) were collected using a common protocol by the Euro-Peristat project in 2004 and 2010. The study indicated that stillbirths and neonatal deaths declined at all gestational ages in countries with both high and low levels of mortality in 2004. Islam *et al.* (2020) developed a predictive analytics framework to predict the death rates with high accuracy and to find the significant determinants that cause high child mortality. The framework used an automated method of information gain to rank the information-rich mortality variables for accurate predictions. Ethiopian Demographic Health Survey and Pakistan Demographic Health Survey data sets were used for the validation of the proposed framework. These real-world data sets were tested using machine learning classifiers, such as Naı¨ve Bayes, decision tree, rule induction, random forest, and multi-layer perceptron, for the prediction task. The study concluded that Naı¨ve Bayes classifier predicts the child mortality rate with the highest average accuracy of 96.4% and decision tree helps in identifying key classification rules covering the factors behind children deaths. Bhatia *et al.* (2019) analyzed the patterns and trends in the mortality rates of infants and children under the age of 5 in India (1992–2016) and quantified the variation in performance between different geographical states through three rounds of nationally representative household surveys. Three rounds of cross-sectional survey data. The study is conducted at the national level: India and its selected good-performing states, namely Haryana, Kerala, Maharashtra, Punjab and Tamil Nadu, and selected poor-performing states, namely Bihar, Chhattisgarh, Madhya Pradesh and Uttar Pradesh. The study revealed that attempts

 

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to reduce infant and child mortality rates in India are heading in the right direction although there is huge variation in performance between states.

## III. METHODOLOGY

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

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

*Smoothing equation*

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

*Trend estimation equation*

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

*Forecasting equation*

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

$E_t$ is the actual value of time series at time t

$L_t$ is the exponentially smoothed value of time series at time t

$\alpha$ is the exponential smoothing constant for the data

$\beta$ 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 Ethiopia for the period 1966– 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 | E |
|---|---|
| Included Observations | 55 (After Adjusting Endpoints) |
| | |
| Smoothing constants | |
| Alpha (α) for data | 0.900 |
| Beta (β) for trend | 0.100 |
| | |
| Forecast performance measures | |
| | |
| Mean Absolute Error (MAE) | 2.776094 |
| Sum Square Error (SSE) | 1787.225837 |
| Mean Square Error (MSE) | 32.495015 |
| Mean Percentage Error (MPE) | 0.354646 |
| Mean Absolute Percentage Error (MAPE) | 1.686753 |

 

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Residual Analysis for the Applied Model

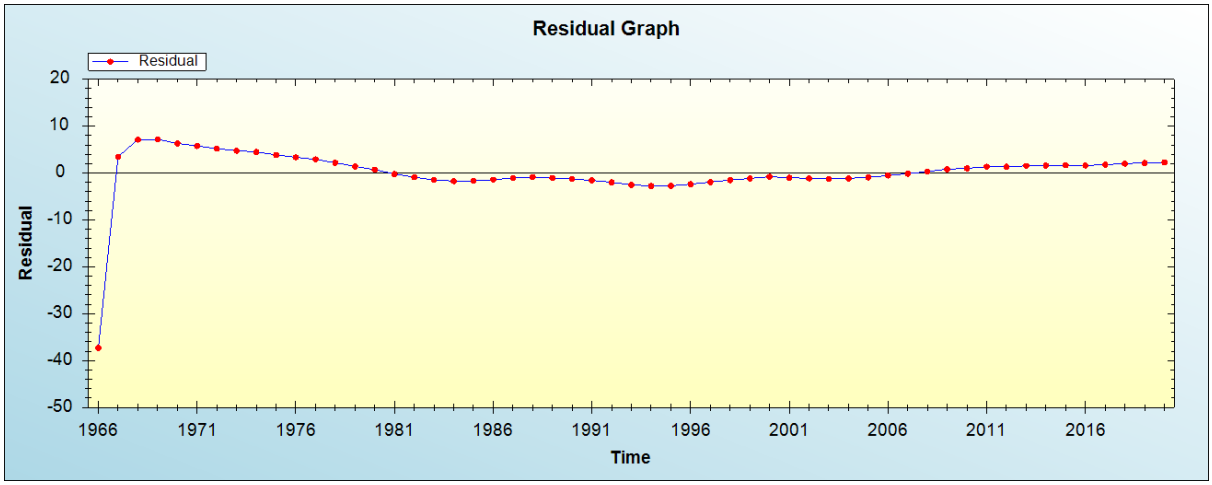


Figure 1: Residual analysis

In-sample Forecast for E

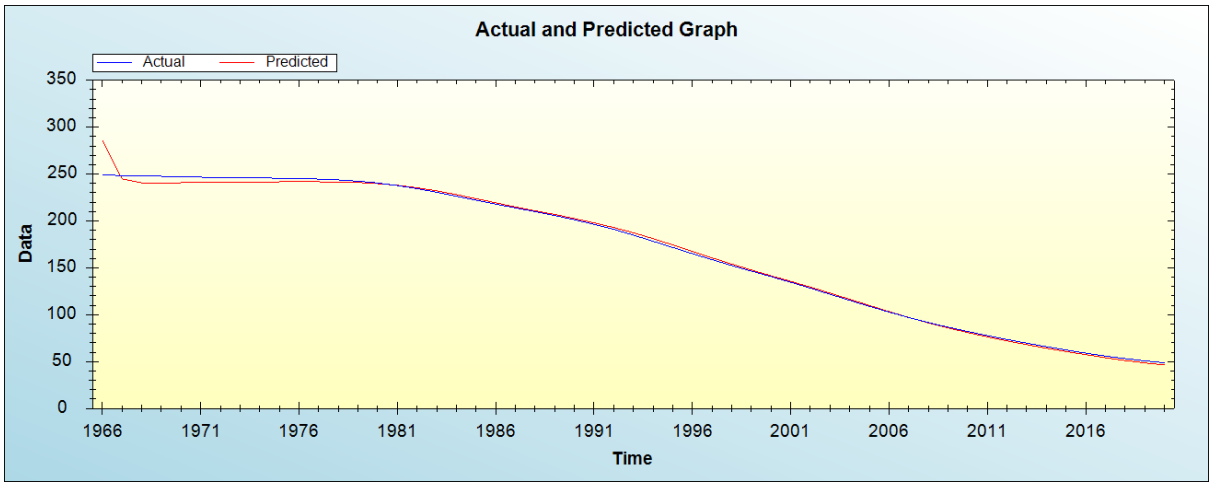


Figure 2: In-sample forecast for the E series

Actual and Smoothed graph for E series

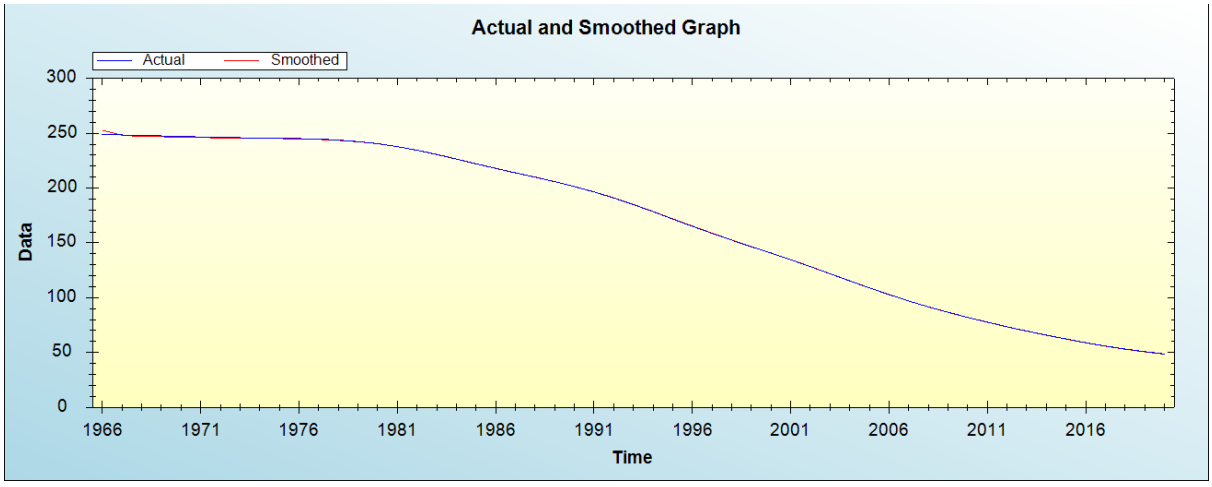


Figure 3: actual and smoothed E series

 

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

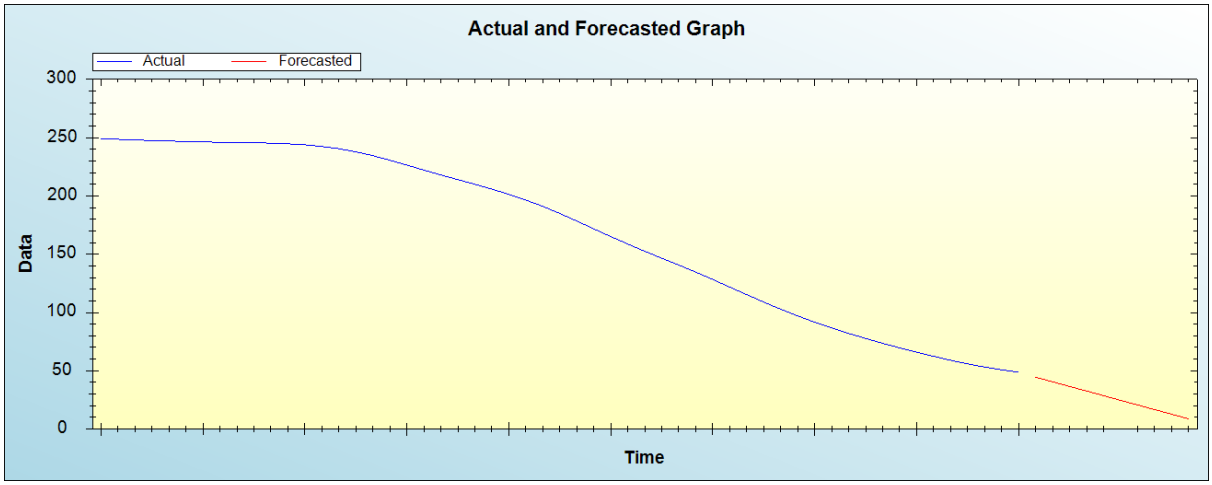


Figure 4: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| | |
|---|---|
| 2021 | 44.5000 |
| 2022 | 40.5295 |
| 2023 | 36.5590 |
| 2024 | 32.5885 |
| 2025 | 28.6180 |
| 2026 | 24.6475 |
| 2027 | 20.6770 |
| 2028 | 16.7065 |
| 2029 | 12.7360 |
| 2030 | 8.7655 |

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 drop over the out of sample period.

## V. POLICY IMPLICATION & CONCLUSION

Ethiopia has made significant progress in the reduction of under-five mortality as evidenced by the downward trend of under-five and neonatal mortality rates reported over the past decades. This study applied the Holt's linear method to project U5MR and the results revealed that annual U5MR will drop over the out of sample period. Therefore, we encourage health authorities to allocate more resources to the maternal and child health program, and address all the major drivers of under-five mortality in the country.

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