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Forecasting Under Five Mortality Rate for Hungary Using Double Exponential Smoothing

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Hungary from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the Holt's linear method is stable for forecasting U5MR. Optimal values of smoothing constants α and β are 0.9and 0.1 respectively based on minimum MSE. The results of the study indicate that annual U5MR will be under control over the out of sample period. Therefore, the government should continue supporting maternal and child health programs in order to end all preventable under five deaths.**

Keywords: Exponential smoothing, Forecasting, U5MR

I. INTRODUCTION

All UN member states have a high expectation of reaching the set sustainable development goals by 2030 (UN, 2016; UN, 2015). One of the goals that have sparked a lot of discussions at international forums is the 3rd sustainable development goal (SDG3). This objective of the agenda 2030 for sustainable development encompasses sexual and reproductive health, maternal and child health, adolescent health, prevention and treatment of substance abuse, prevention of death from harmful substances and road traffic accidents (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). One of the targets for SDG3 is the implementation of appropriate strategies to substantially reduce under five mortality to as low as 25 deaths per 1000 live births by 2030 (UNICEF, 2019). Under five mortality can be reduced by immunizations against vaccine preventable diseases, prevention and treatment of diarrheal diseases, integrated management of childhood illnesses and exclusive breast feeding of newborns up to 6months (Yaya *et al.* 2018). The objective of this study is to project future trends of under-five mortality rate for Hungary using the Holt's linear exponential smoothing model. We expect the findings to inform child health policies, planning and allocation of resources in order to end all avoidable under five deaths.

II. LITERATURE REVIEW

Islam *et al.*(2020) developed a predictive analytics framework to forecast death rates with high accuracy and to find significant predictors of 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 results revealed that Naı¨ve Bayes classifier predicts 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. Weddhi et al (2019) investigated factors associated with neonatal mortality at the Referral Hospital in Nouakchott, Mauritania. A cross-sectional study was conducted between January 2013 and December 2013 and included neonatal patients hospitalized at the National Referral Hospital (NRH). Data were collected by reviewing the medical charts and through questionnaires administered to the parents. The authors concluded that neonatal mortality remains a significant burden in Mauritania. They identified different socioeconomic and clinical risk factors indicating the need for more intensified prenatal care and improved transport of high risk neonates, especially in the regions outside the capital. Kurniasih et al (2018) applied the α-Sutte Indicator in forecasting data. To see the accuracy of the methods, the forecasting results of the α-Sutte Indicator was evaluated by comparing with the ARIMA and the Holt-winters method. Based on the results of forecasting, it was found that α-Sutte Indicator has MSE and MAPE values that are lower than the other methods (ARIMA and Holt-Winters). This is supported by MSE data from α-Sutte Indicator smaller than ARIMA (2, 2, 2) and Holt-Winters i.e. 0.03; 3.06; and 3.15.Akinwande *et al.* (2016) Analyzed Infant and Child (Under-five) Mortality in Zaria using a regression Analysis technique. The study was carried out using secondary data from Ahmadu Bello University Teaching Hospital, Zaria, on infant and child (under-five) mortality and delivery rates. Findings from the study indicated that both infant and child mortality rates have a direct relationship with delivery rates. The correlation analysis result showed that there is a very strong and positive relationship between mortality and delivery rates. The study revealed that infant and child mortality rates will continue to decrease if there can be improvement in the factors under study.

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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 Hungary. 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.

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

N_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 Hungary 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	N
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)	0.733251
Sum Square Error (SSE)	116.833571
Mean Square Error (MSE)	1.915304
Mean Percentage Error (MPE)	1.658028
Mean Absolute Percentage Error (MAPE)	3.537322

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Residual Analysis for the Applied Model

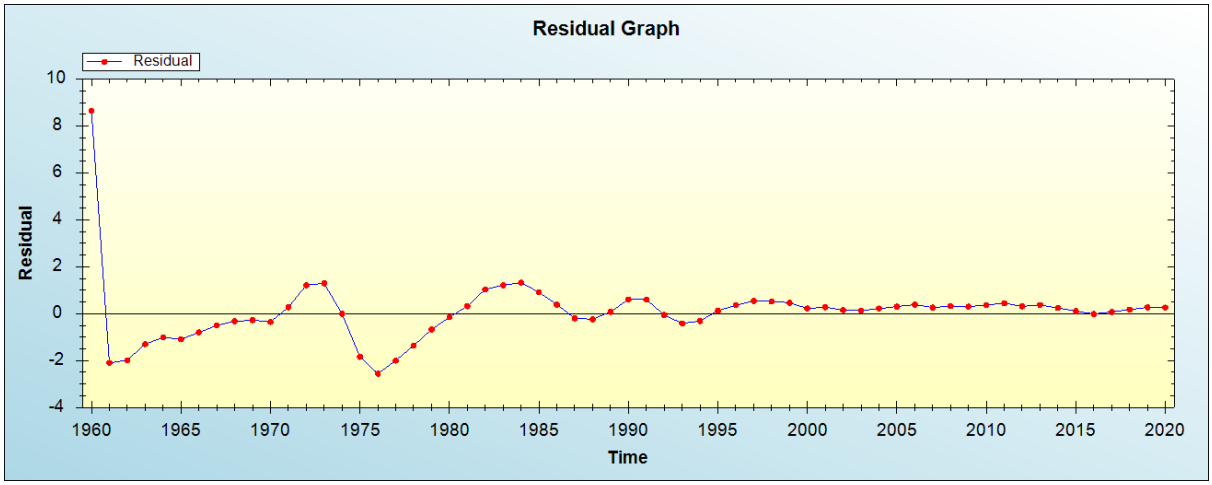

Figure 1: Residual analysis

In-sample Forecast for N

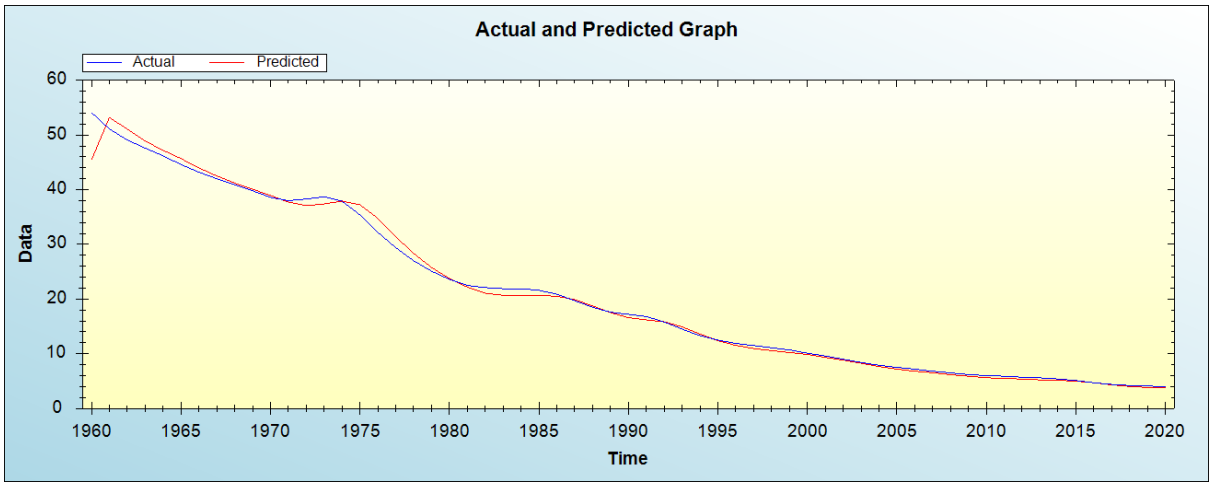

Figure 2: In-sample forecast for the N series

Actual and smoothed graph for N

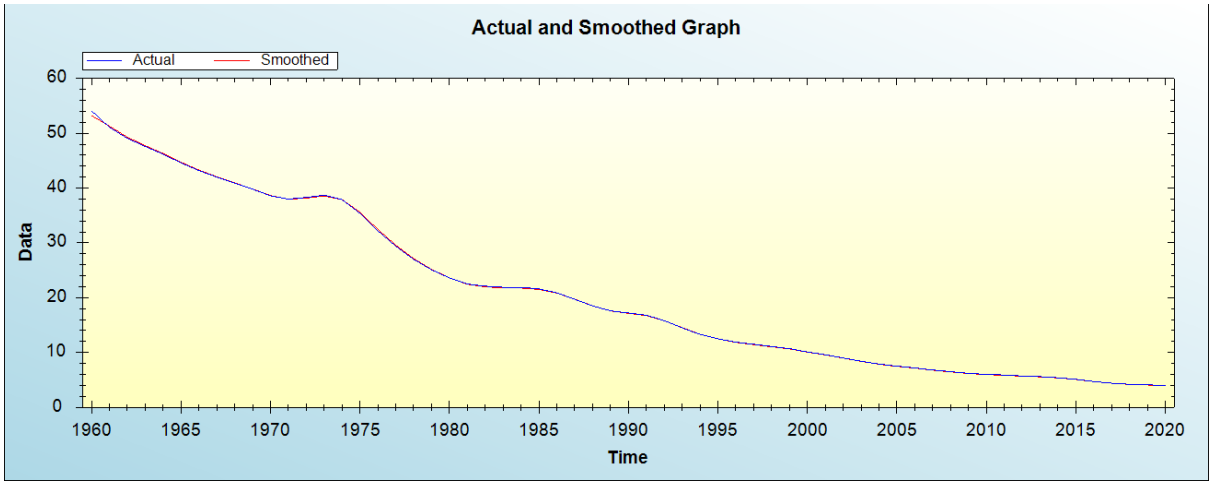

Figure 3: Actual and smoothed graph for N

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

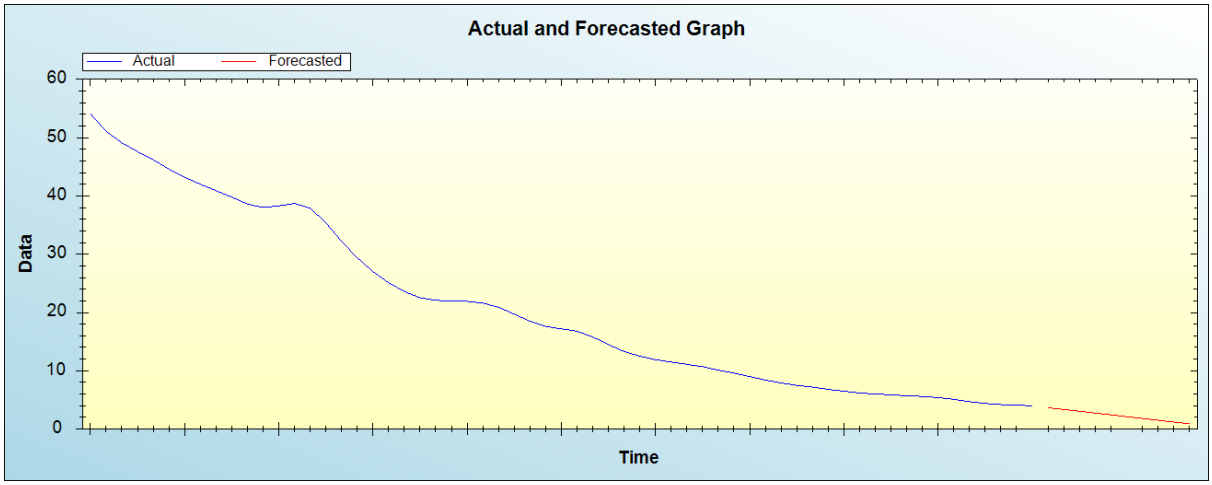

Figure 4: Out-of-sample forecast for N: actual and forecasted graph

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	3.6681
2022	3.3619
2023	3.0556
2024	2.7494
2025	2.4431
2026	2.1369
2027	1.8306
2028	1.5244
2029	1.2181
2030	0.9119

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 be under control over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

This study applied the Holt's linear exponential smoothing model to predict future trends of under-five mortality rate in Hungary and the findings revealed that annual U5MR will be under control over the out of sample period. Therefore, the government should continue supporting the maternal and child health program in order to end all preventable under five deaths.

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