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Tracking the Future Path of Under Five Mortality Rate for Israel Using Double Exponential Smoothing

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Israel 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 in the State of Israel. The Holt's linear method was used to forecast under five mortality rate. Optimal values for smoothing constants α and β are 0.9 and 0.1respectively based on minimum MSE. The study findings indicate that annual under five mortality will be under control over the out of sample period. Therefore, we encourage Israel authorities to design child health policies that will keep under five mortality below 25 deaths per 1000 live births.**

Keywords: Exponential smoothing, Forecasting, U5MR

I. INTRODUCTION

The state of health systems in many developing countries is not pleasing as this is reflected by high maternal, newborn and under five mortality (UNICEF, 2019). There are many reasons why these countries are reporting high numbers of adverse maternal and child health outcomes. Social, cultural, economic and demographic factors are known to be contributing significantly to mortality among different groups of patients. The adoption of sustainable development goals was meant to guide UN member countries in their fight against poverty, hunger, global health problems and other deprivations (UN, 2016; UN, 2015). The global action plan outlines the importance of prioritizing maternal and child health issues especially in low resource settings (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). There is need to capacitate all levels of healthcare particularly primary healthcare to ensure universal health coverage and access to quality and affordable health care services. It is critical to promote vaccination against vaccine preventable diseases and carry out medical research which is essential for drug development and improvement of patient care. The objective of this study is to model and forecast future trends of under-five mortality rate for the State of Israel using double exponential smoothing (Holt). The findings are expected to guide child health policies and allocation of resources in order to end all preventable under five deaths.

II. LITERATURE REVIEW

Iriondo *et al.* (2020) developed and validated different mortality predictive models, using Spanish data, to be applicable to centers with similar morbidity and mortality. Infants born alive, admitted in NICU, and registered in the SEN1500 database, were included. Multivariable regression models were used for the different time periods. The study concluded that using dynamic models to predict individual mortality can improve outcome estimations. Nath *et al.* (2020) examined the effect of extreme prematurity and early neonatal deaths on infant mortality rates in England. Authors used aggregate data on all live births, stillbirths and linked infant deaths in England in 2006–2016 from the Office for National Statistic. Infant mortality decreased from 4.78 deaths/1000 live births in 2006 to 3.54/1000 in 2014 (annual decrease of 0.15/1000) and increased to 3.67/1000 in 2016 (annual increase of 0.07/1000). This rise was driven by increases in deaths at 0–6 days of life. 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 was 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 to reduce infant and child mortality rates in India are heading in the right direction although there is huge variation in performance between states. Another Indian study by 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.

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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 Israel. 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.

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

R_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 Israel 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	R
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)	0.528981
Sum Square Error (SSE)	99.428561
Mean Square Error (MSE)	1.629976
Mean Percentage Error (MPE)	1.840842
Mean Absolute Percentage Error (MAPE)	3.345277

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Residual Analysis for the Applied Model

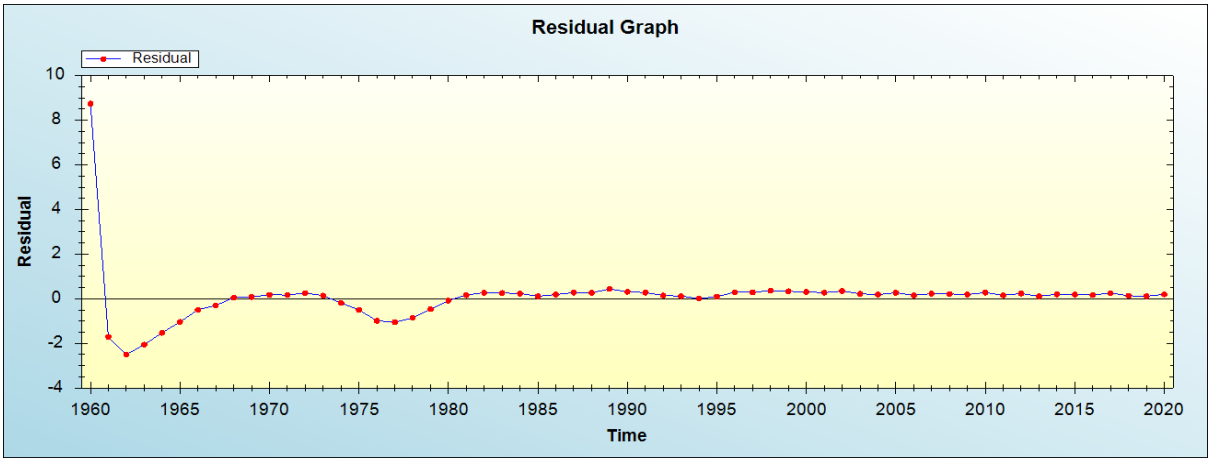

Figure 1: Residual analysis

In-sample Forecast for R

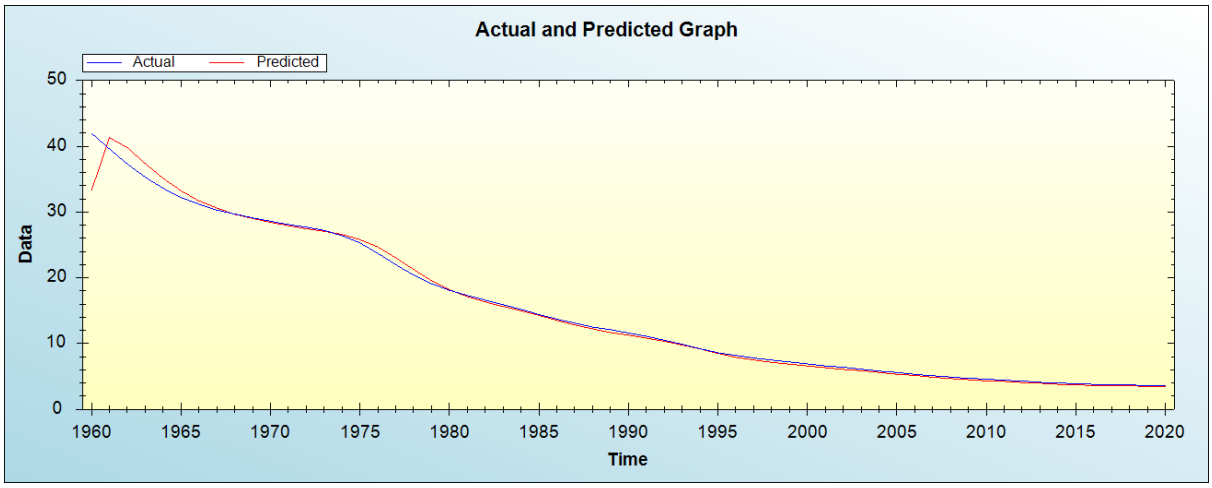

Figure 2: In-sample forecast for the R series

Actual and smoothed graph for R

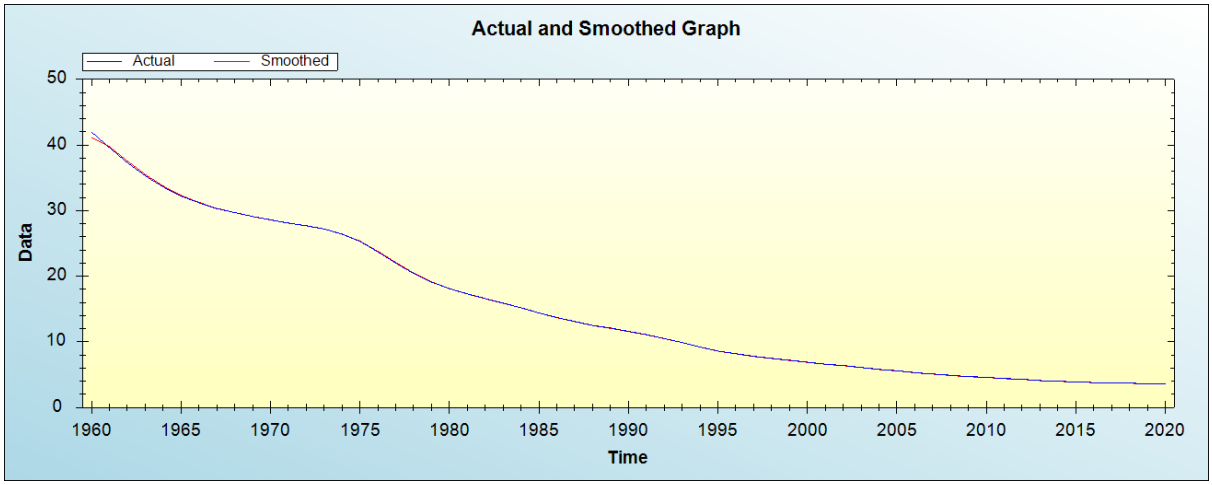

Figure 3 Actual and smoothed graph for R

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

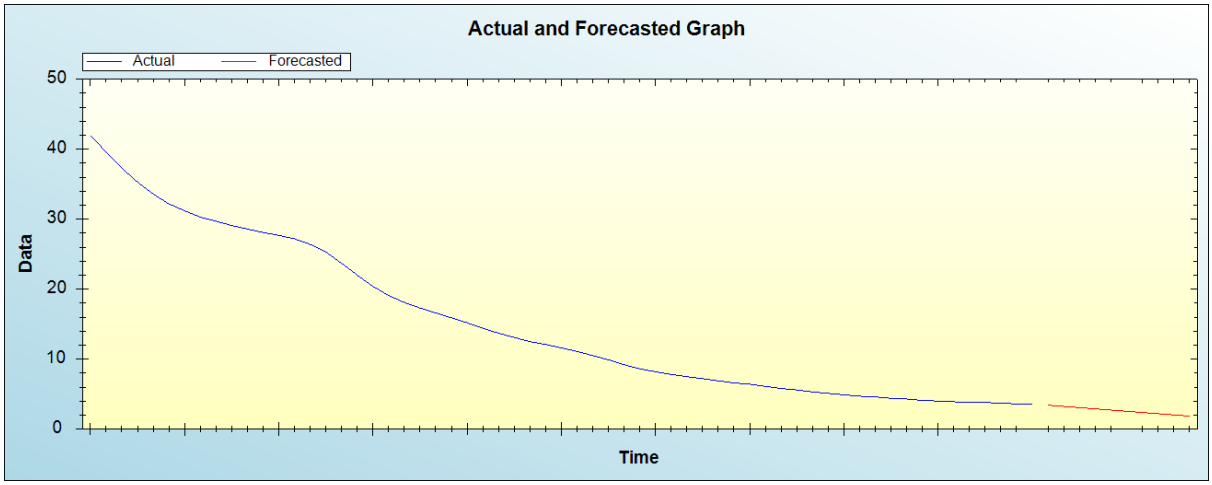

Figure 4: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	3.4083
2022	3.2367
2023	3.0651
2024	2.8935
2025	2.7219
2026	2.5503
2027	2.3788
2028	2.2072
2029	2.0356
2030	1.8640

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 under five mortality will be under control over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The 3rd sustainable development goal(SDG-3)focuses on ensuring good health and promotion of well-being for all at all ages. The State of Israel has made significant milestones towards achieving all the set targets under SDG3. The country has recorded a downward trend ofunder-five mortality rate over the past decades reflecting political will in addressing all major health challenges existing across the whole country. This study applied Holt's linear exponential smoothing model to predict under five mortality rate for the State of Israel.The results of the study revealed thatannual under five mortality will be under control over the out of sample period. Therefore, we encourage health authorities to design child health policies that will help to keep under five mortality below 25 deaths per 1000 live births.

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