Analysing Under Five Mortality for Belgium Using Double Exponential Smoothing Model

[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe

[2]Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract - **This study uses annual time series data on under five mortality rate (U5MR) for Belgium 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 model is stable in forecasting under five mortality rate in Belgium. The optimal values for the smoothing constants α and β are 0.9 and 0.1respectively based on minimum MSE. The Holt's linear exponential smoothing model projections revealed that annual U5MR will continue to drop over the out of sample period. Therefore we implore health authorities in Belgium to design child health policies that are meant to keep under five mortality under control.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

The 3rd sustainable development goal (SDG3) is an important objective highlighted in the agenda 2030 for sustainable development (UN, 2016; UN, 2015). It focuses on ensuring good health and promotion of well-being for all at all ages. It endeavors to reconfigure current strategies to suit the ever changing health needs of different populations around the world (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). Maternal and child health issues remain among the serious health challenges that have led to morbidity and mortality especially in developing countries. Many developing countries have made significant strides in improving the quality and access to maternal and child health services, however maternal, neonatal and under five mortality remain high in Sub-Saharan Africa (WHO *et al.* 2015). Lack of quality care, unsafe abortions and poor health infrastructure are the major contributing factors to maternal and neonatal deaths (WHO, 2017; Haddad, 2009). Several UN member states are committed to the 1994 International conference on Population and development (ICPD), agenda 2030 for sustainable development and adopted WHO recommendations to quickly respond to women's sexual and reproductive health rights and needs (Sullivan *et al.* 2020). The aim of this study is to model and forecast future trends of under-five mortality rate in Belgium using the Holt's linear exponential smoothing technique. We expect the study findings to help in policy making, planning and allocation of resources to child health programs with the aim of ending all preventable under five deaths by 2030.

II. LITERATURE REVIEW

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. 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. Development of models in the prenatal period, first 24 hours, and during hospital admission, cover key stages of mortality prediction in preterm infants. 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. A descriptive study was carried out by McNamara *et al.* (2018) to reveal intrapartum fetal deaths and unexpected neonatal deaths in Ireland from 2011 to 2014. Anonymised data pertaining to all intrapartum fetal deaths and unexpected neonatal deaths for the study time period was obtained from the national perinatal epidemiology centre. The findings of the study indicated that the corrected intrapartum fetal death rate was 0.16 per 1000 births and the overall unexpected neonatal death rate was 0.17 per 1000 live births.

III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

G_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 Belgium 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	G
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)	0.413263
Sum Square Error (SSE)	55.498632
Mean Square Error (MSE)	0.909814
Mean Percentage Error (MPE)	1.747566
Mean Absolute Percentage Error (MAPE)	3.138334

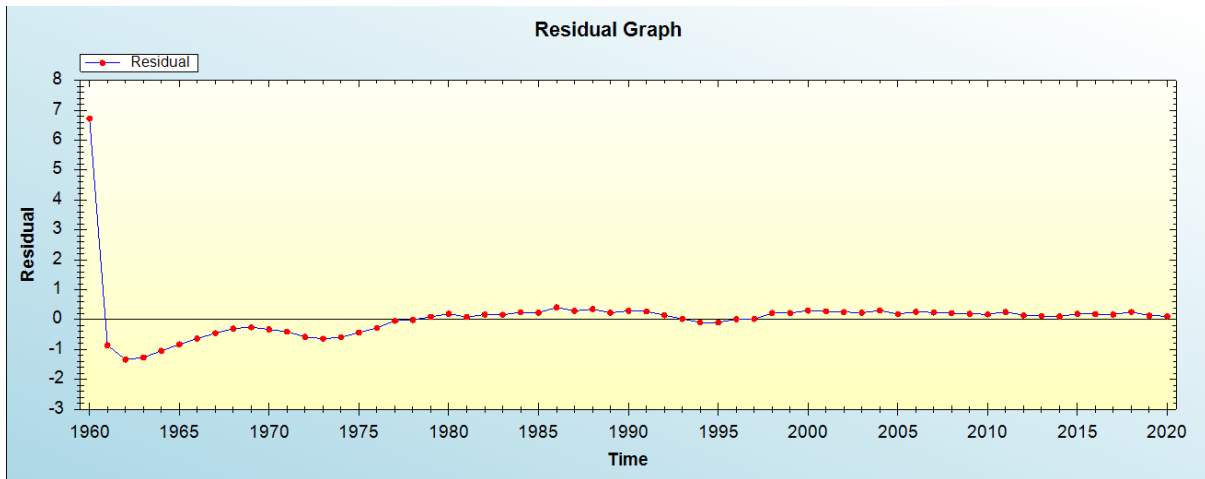Residual Analysis for the Applied Model

Figure 1: Residual analysis

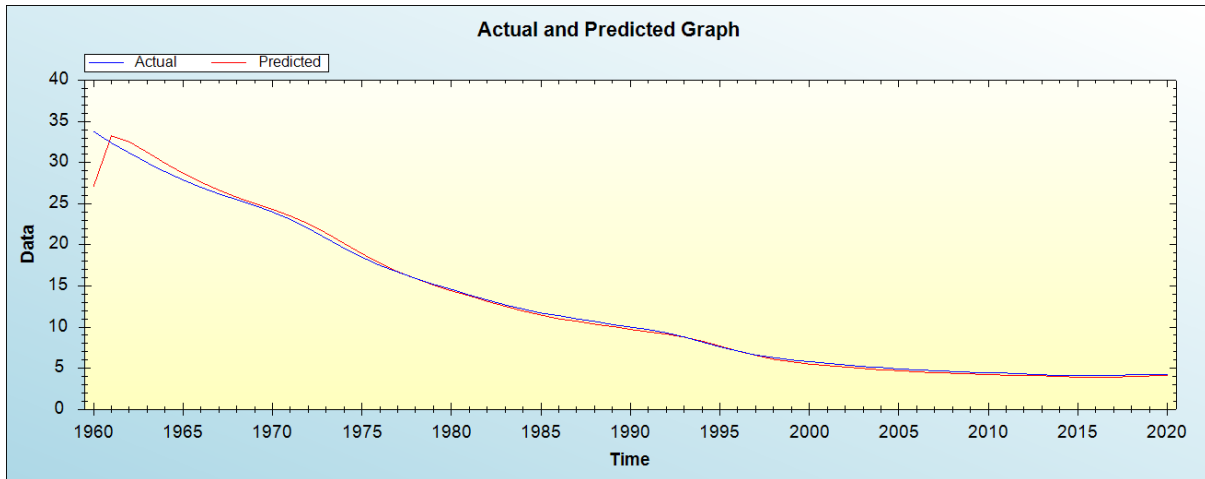In-sample Forecast for G

Figure 2: In-sample forecast for the G series
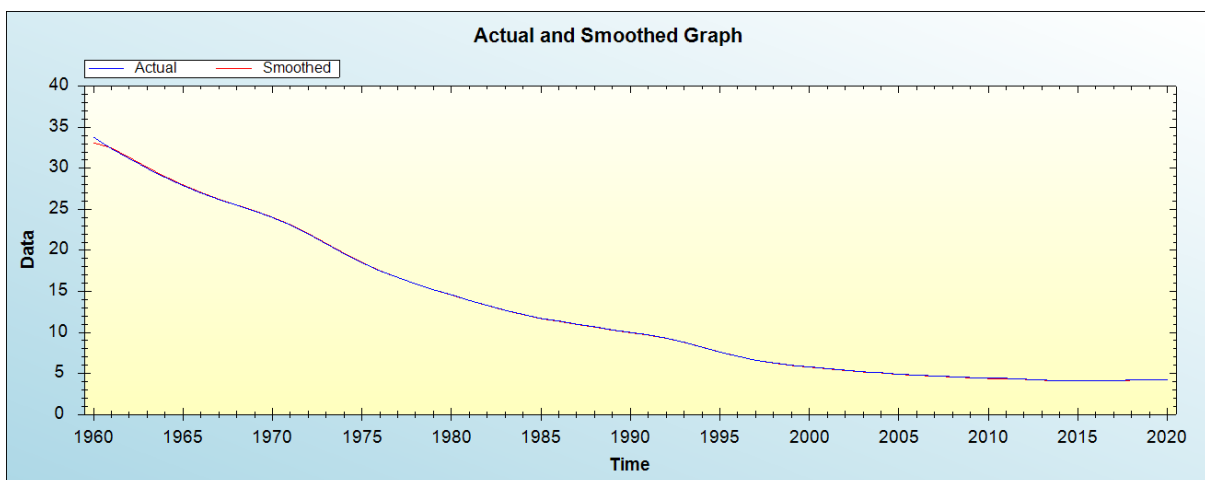
Actual and Smoothed G series

Figure 3: Actual and smoothed G series

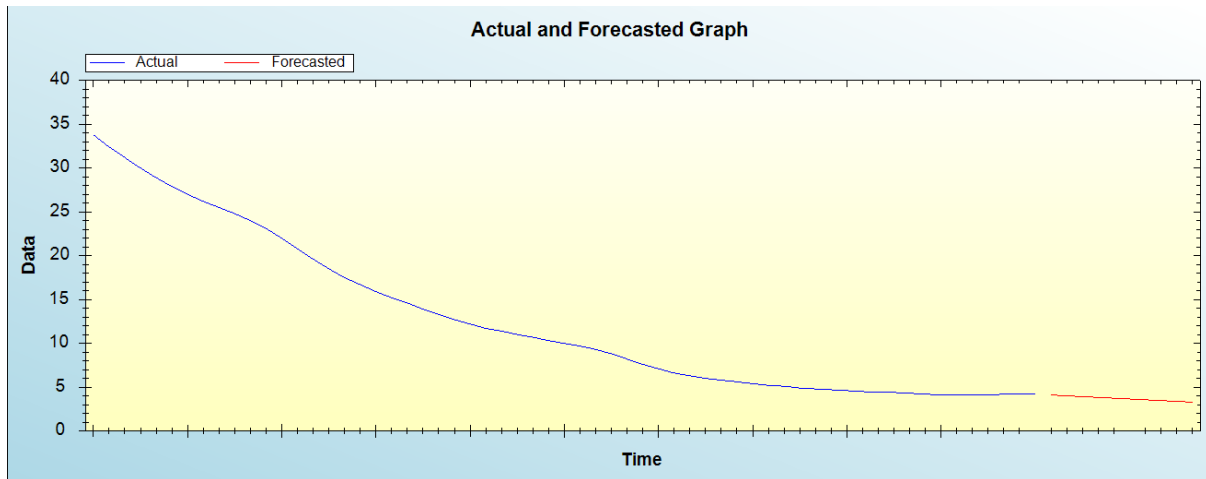Out-of-Sample Forecast for G: Actual and Forecasted Graph

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

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	4.0990
2022	4.0093
2023	3.9197
2024	3.8300
2025	3.7404
2026	3.6507
2027	3.5611
2028	3.4714
2029	3.3817
2030	3.2921

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

Developing and developed countries were signatories to the Agenda 2030 for sustainable development. They all agreed to ensure substantial reduction of under-five mortality to levels as low as 25 deaths per 1000 live births. Belgium demonstrated its commitment to this agenda by supporting programs and activities that are in line with this global agenda as under five mortality is consistently below the stated SDG 3 target. The findings of this study revealed that annual U5MR will continue to drop over the out of sample period. Therefore, Belgian health authorities should continue supporting this global agenda in order to keep under five mortality under control.

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