

# Forecasting the Future Trends of Under Five Mortality Rate for Cuba Using Double Exponential Smoothing Model

<sup>1</sup>Dr. Smartson. P. NYONI, <sup>2</sup>Thabani NYONI

<sup>1</sup>ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

<sup>2</sup>Independent Researcher & Health Economist, Harare, Zimbabwe

**Abstract** - This study uses annual time series data on under five mortality rate (U5MR) for Cuba 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 model is stable in forecasting U5MR in Cuba. Holt's linear (double exponential smoothing) model was applied in this study. The optimal values of smoothing constants  $\alpha$  and  $\beta$  are 0.9 and 0.1 respectively based on minimum MSE. The results of the study showed that annual U5MR will continue to decline throughout the out of sample period. Therefore, we implore the Cuban government to continue supporting maternal and child health program activities in order to maintain under five mortality below 25 deaths per 1000 live births.

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

## I. INTRODUCTION

Statistical approaches used in data analysis are many and play a key role in public health and other fields to inform policies, decisions and allocation of resources (Nyoni & Nyoni, 2019 a & b; Nyoni, 2018; Box & Jenkins, 1970). Time series forecasting techniques are gaining more popularity in recent times as more researchers continue to acknowledge their relevance in detecting abnormal trends of diseases and outbreaks (Zhao *et al.* 2020; Panch *et al.* 2018; Zhou *et al.* 2018). It is critical at this point in time to highlight that time series prediction is important in tracking sustainable development goal (SDG) progress. This will guide policies, decisions and allocation of resources. Statistical and machine learning techniques can be utilized in forecasting problems. Statistical techniques such as exponential smoothing models are widely used in various fields and the forecast results have been seen to be reliable and accurate. In exponential smoothing the smoothed original series is used to generate future values with more recent values having more influence on the forecasts than the more distant past values (Ostertagová & Ostertag, 2011; Montgomery *et al.* 1990; Aczel, 1989). The aim of this paper is to forecast future trends of under-five mortality in Cuba using the Holt's linear exponential smoothing method. We expect the findings of this study to inform child health policies, decisions and allocation of resources in order to end all preventable deaths among under five children.

## II. LITERATURE REVIEW

Khan *et al.* (2019) modelled and forecasted infant mortality rates of Asian countries in the perspective of GDP. Secondary data of IMR and GDP (PPP) from 1980 to 2015 was analyzed and forecast was done from 2016 to 2025. AR (1) was found to be suitable for all the countries except Japan and Nepal for which ARIMA (1, 1, 1) model was appropriate based on FMSE and FRMSE. Kurniasih *et al.* (2018) applied the  $\alpha$ -Sutte Indicator in forecasting data. To see the accuracy of the methods, the forecasting results of the  $\alpha$ -Sutte Indicator was evaluated by comparing with the ARIMA and the Holt-winters method. Based on the results of forecasting, it was found that  $\alpha$ -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  $\alpha$ -Sutte Indicator smaller than ARIMA (2, 2, 2) and Holt-Winters i.e. 0.03; 3.06; and 3.15. A Cuban study by Kohut (2018) investigated the primary and reproductive care paradoxes presented to Cuban women today, specifically in rural Mayajigua, Cuba. A Mixed Methods approach that synthesizes information from a 2015 independent research quantitative survey alongside a 2016 independent research ethnographic project were used to assess the Cuban Medical Paradox in a holistic manner. Analysis showed that the Cuba Paradox exists due to a series of recent international developments, notably the 2016 Cuban Special Period. Gonzalez & Gilleskie (2017) developed a novel method to adjust country-specific reported infant mortality figures that may misrepresent development within a country. The study concluded that an "augmented" measure of mortality that includes both infant and late fetal deaths should be considered when

assessing levels of social welfare in a country. Also, mortality statistics that exhibit a substantially high ratio of late fetal to early neonatal deaths should be more closely scrutinized.

### III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

$Z_t$  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 Cuba 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	Z
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha ( $\alpha$ ) for data	0.900
Beta ( $\beta$ ) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.672040
Sum Square Error (SSE)	170.766691
Mean Square Error (MSE)	2.799454
Mean Percentage Error (MPE)	1.740108
Mean Absolute Percentage Error (MAPE)	3.109779

Residual Analysis for the Applied Model

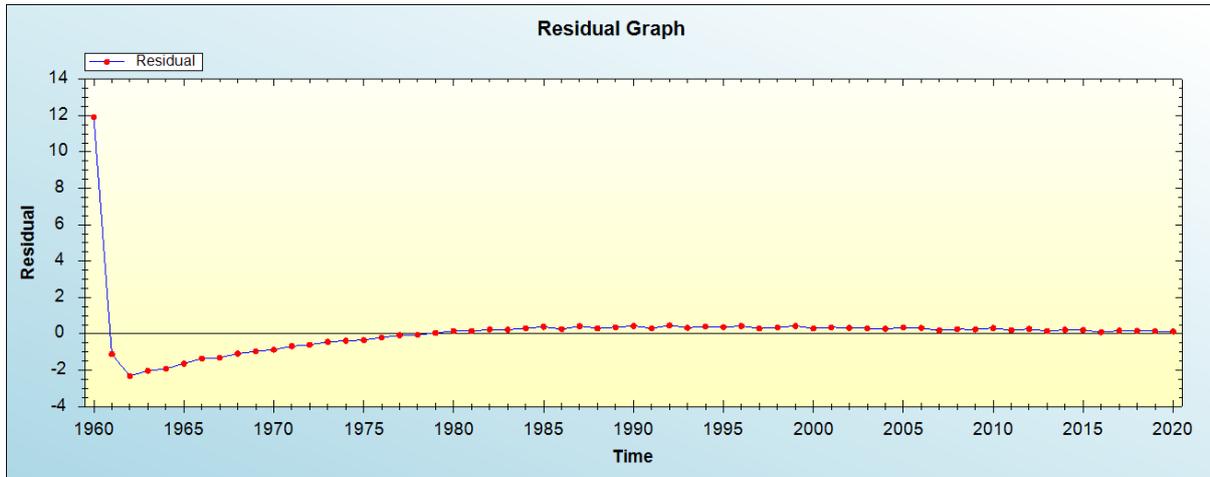


Figure 1: Residual analysis

In-sample Forecast for Z

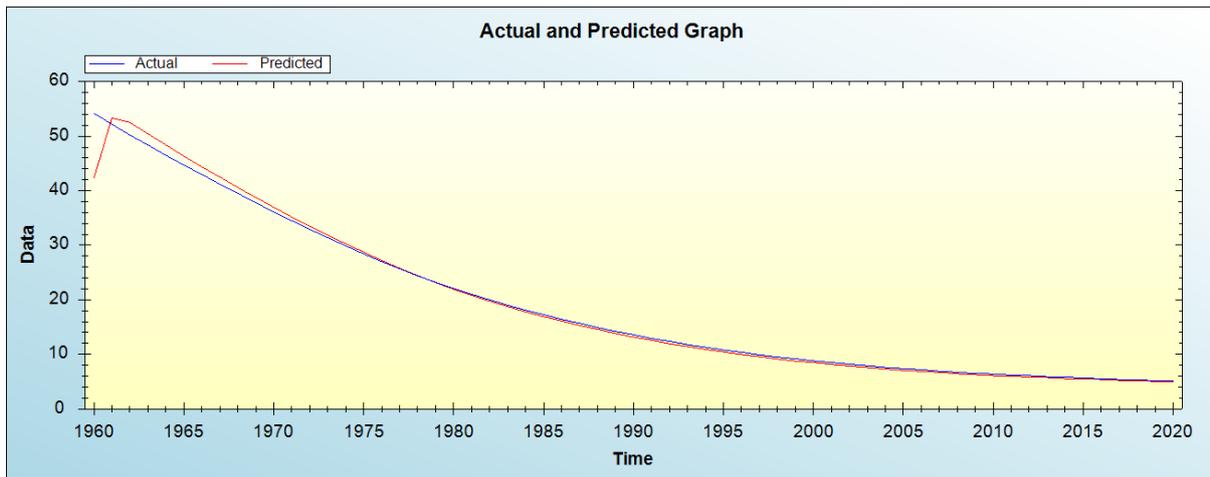


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

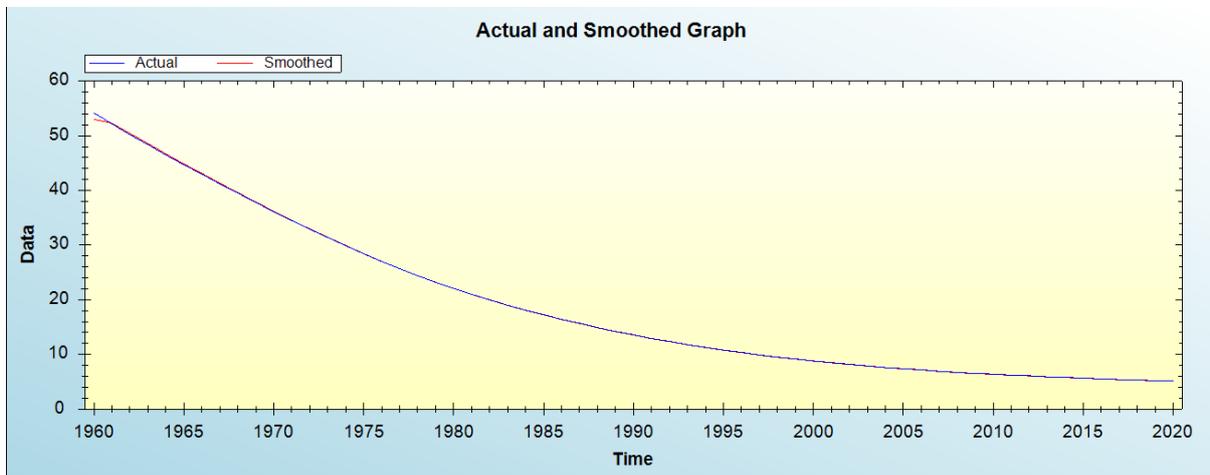


Figure 3: Actual and smoothed Z series

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

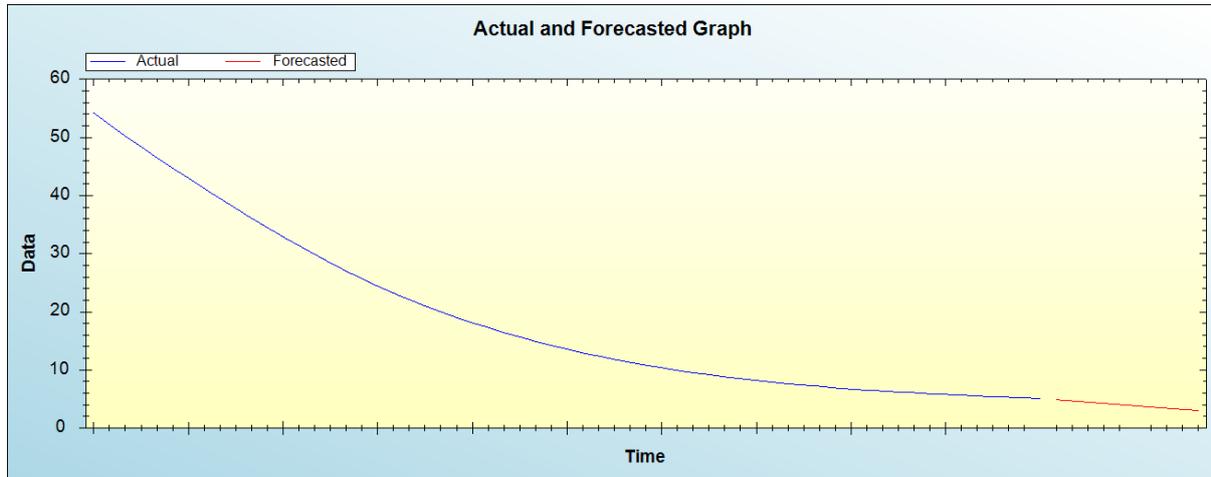


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	4.8798
2022	4.6729
2023	4.4661
2024	4.2592
2025	4.0524
2026	3.8455
2027	3.6387
2028	3.4319
2029	3.2250
2030	3.0182

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 decline throughout the out of sample period.

### V. POLICY IMPLICATION & CONCLUSION

The Cuban government has done very well in the reduction of under-five mortality by increasing investments in primary healthcare. The country has recorded a downward trend of under-five, infant and neonatal mortality over the past decades. This reflects the government’s commitment to improve child survival and the quality of life of under five children. This study proposes Holt’s linear model to predict future trends of under-five mortality in Cuba. The findings indicated that annual U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the Cuban government to continue supporting maternal and child health program activities in order to keep under five mortality below 25 deaths per 1000 live births.

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