



ANAYLSIS OF FUTURE TRENDS OF ANNUAL MATERNAL MORTALITY RATE FOR TURKMENISTAN USING HOLT'S LINEAR METHOD

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Abstract

This study uses annual time series data on MMR for Turkmenistan from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.4 respectively based on minimum MSE. The results of the study indicate that MMR will remain very low over the out of sample period. Therefore, we encourage authorities to address local drivers of maternal mortality.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio.

Introduction

Maternal health is the health status of women during pregnancy, childbirth, and the post -partum period, which incorporates the health care dimension of family planning, preconception, and prenatal and postnatal care to reduce maternal morbidity and mortality (WHO, 2015). Then maternal death refers to death of a woman whilst pregnant or within 6 weeks of termination of pregnancy, regardless of the duration and the site of the pregnancy, from any causes related to or aggravated by the pregnancy or its management but not from accidental or incidental causes according to the World Health Organization (WHO, 2015). Most maternal deaths are reported in low-middle countries. Approximately 830 women die every day globally as result of pregnancy-related causes, which can be avoided. Direct obstetric causes include hemorrhage and infection, while indirect causes encompass conditions like pregnancy-associated heart disease



(WHO, 2012). The global maternal mortality ratios (MMR) vary significantly due to factors such as individual behavioral traits, obstetric service accessibility/quality, socioeconomic/cultural contexts, and external environments (Mc Call et al. 2017). The World Health Organization estimated that 303,000 women worldwide will have died by the end of 2015 during and following pregnancy and childbirth. A recent World Health Organization report highlighted that maternal mortality has declined by 43% worldwide; however, maternal death is still high in sub-Saharan Africa and South Asia (WHO, 2023). This paper uses annual time series data of MMR to forecast future trends of MMR for Turkmenistan using Holt's linear method. The results of this paper will guide crafting of policies, planning and allocation of resources to the health sector in order to keep MMR under control.

Literature Review

Author(s)	Objective(s)	Methodology	Key finding(s)
Feng et al. (2025)	To analyze trends (1990–2021) and projected (to 2050) MMR in Southeast Asia using the Global Burden of Disease (GBD) 2021 database, addressing gaps in regional granularity	Data GBD 2021, covering MMR and age-standardized MMR (ASMR) for 1990–2021, stratified by country, age group, and cause. Analysis: Trend assessment was conducted using the estimated annual percentage change (EAPC), while 30-year projections were generated via an autoregressive integrated moving average (ARIMA) model	Regional Trends: The ASMR in Southeast Asia fell by 59%, dropping from 255.88 in 1990 to 104.56 per 100,000 live births by 2021
Soni et al. (2025)	to explore the prevalence of institutional delivery and its determinants in five South Asian countries	Data were extracted from five South Asian countries latest demographic and health survey data, including Afghanistan (2015), Bangladesh (2017–18), Nepal (2016), Myanmar (2015–16), and Pakistan (2017–18)	Women who didn't take any health care decision by-self had 16% lower chance of getting institutional delivery facility than others. Most importantly, rural area in south Asian countries presented lower odds of receiving healthy facility during delivery (OR 0.63, [0.59, 0.68])



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Rahman et al. (2024)	to assess socioeconomic disparities in the utilization of health care services by mothers and to determine the factors influencing this utilization among women aged 15 to 49 in five South Asian countries	Applied logistic regression	Several socioeconomic and sociodemographic variables of the individual population, as well as policy issues, all have an impact on maternal mortality
Baig et al. (2023)	to examine and critically evaluate existing literature on perceptions and investigations regarding maternal mortality in Southeast Asia, Europe and Africa, utilizing the three delays model approach as a categorization framework	Systematic review	primary cause of maternal mortality is the first delay, which refers to the lack of awareness in seeking medical care. On the other hand, in Africa and other European countries, the second and third delays are more prominently associated with maternal mortality
Aziz et al. (2021)	To explore the relationship between health expenditure and maternal mortality by using data set consisting of 18 years from 2000 to 2017	Fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) models were employed for the empirical analysis	The findings revealed that population growth has a significant long-term effect on maternal mortality—an increase of 40% in the case of FMOLS and 10% in the case of DOLS—and infers that an increase in population growth has also dampened efforts towards reducing maternal mortality in the South Asian panel
Sharma et al. (2018)	This was a systematic review on the effectiveness of community interventions in improving maternal health care outcomes in South Asia	Systematic review	Women's education interventions may improve the number of women seeking birth at a health care facility, but the evidence is of low quality
Girum and Wasie (2017)	to identify correlates of maternal mortality in developing countries	Scoping review	Maternal mortality is correlated with multiples of socio-economic factors, health care system associated factors, disease burden and their complex interactions



Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Turkmenistan. 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.

Holt's linear method is specified as follows:

Model equation

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

Smoothing equation

$$S_t = \alpha Z_t + (1-\alpha) (S_{t-1} + b_{t-1})$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (S_t - S_{t-1}) + (1-\beta)b_{t-1}$$

$$0 < \beta < 1$$

Forecasting equation

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

Z_t is the actual value of MMR at time t

ε_t is the time varying **error term**

μ_t is the time varying mean (**level**) term

ρ_t is the time varying **slope term**

t is the trend component of the time series

S_t is the exponentially smoothed value of MMR 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

b_t is the trend estimate (slope of the trend) at time t

b_{t-1} is the trend estimate at time $t-1$



Data Issues

This study is based on annual MMR in Turkmenistan for the period 1985– 2023. The out-of-sample forecast covers the period 2024 – 2035. All the data employed in this research paper was gathered from the World Bank online database.

Findings of the study

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Z
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	1.323067
Sum Square Error (SSE)	177.276405
Mean Square Error (MSE)	4.545549
Mean Percentage Error (MPE)	2.166864
Mean Absolute Percentage Error (MAPE)	6.435583

Residual Analysis for the Applied Model

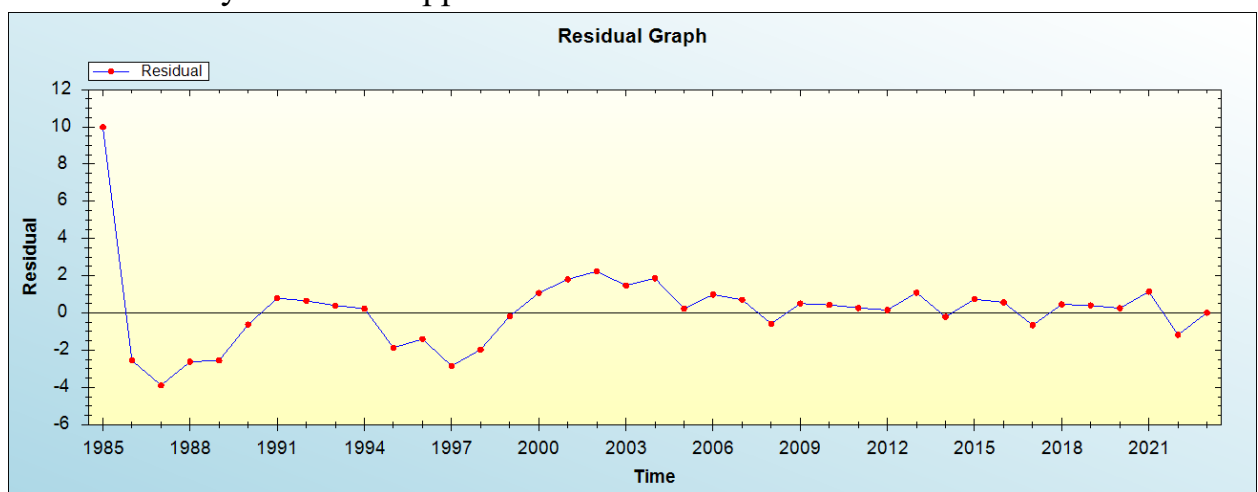


Figure 1: Residual analysis



In-sample Forecast for Z

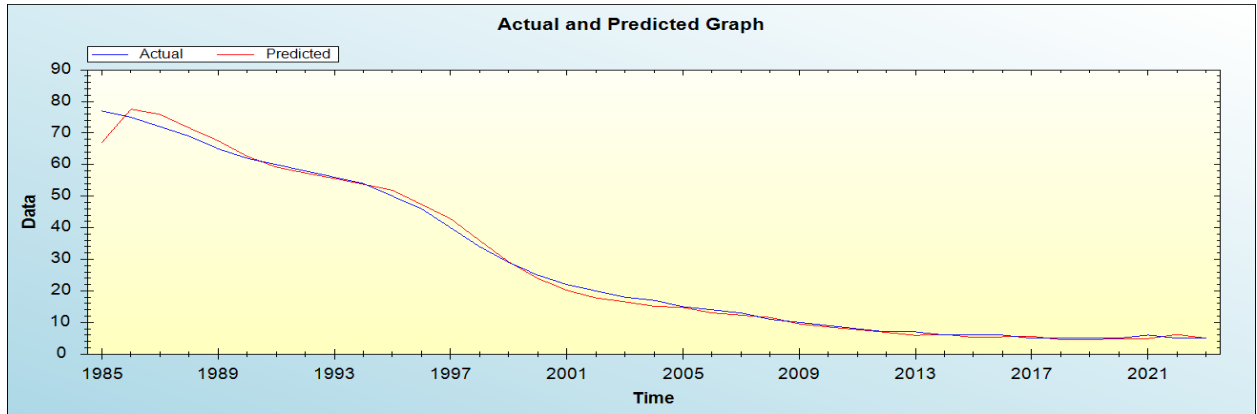


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

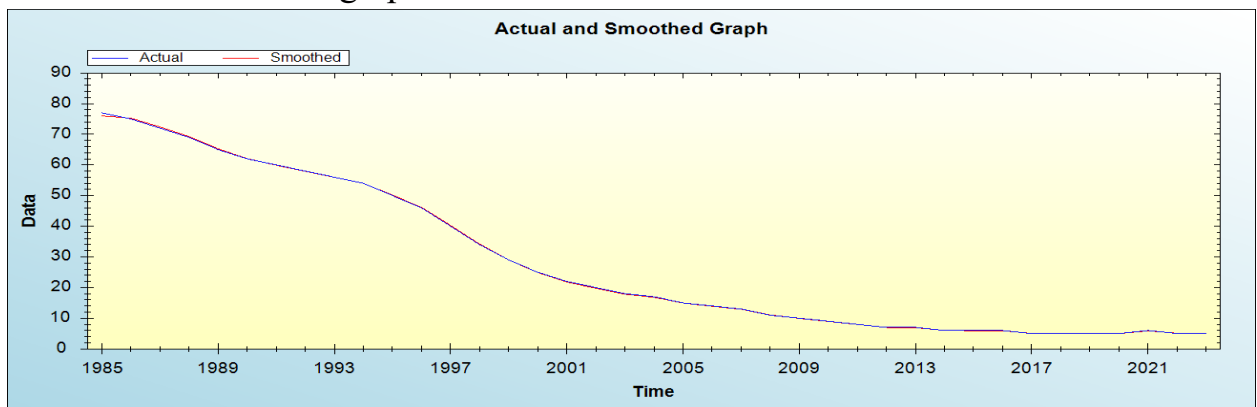


Figure 3: Actual and smoothed graph for Z series

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

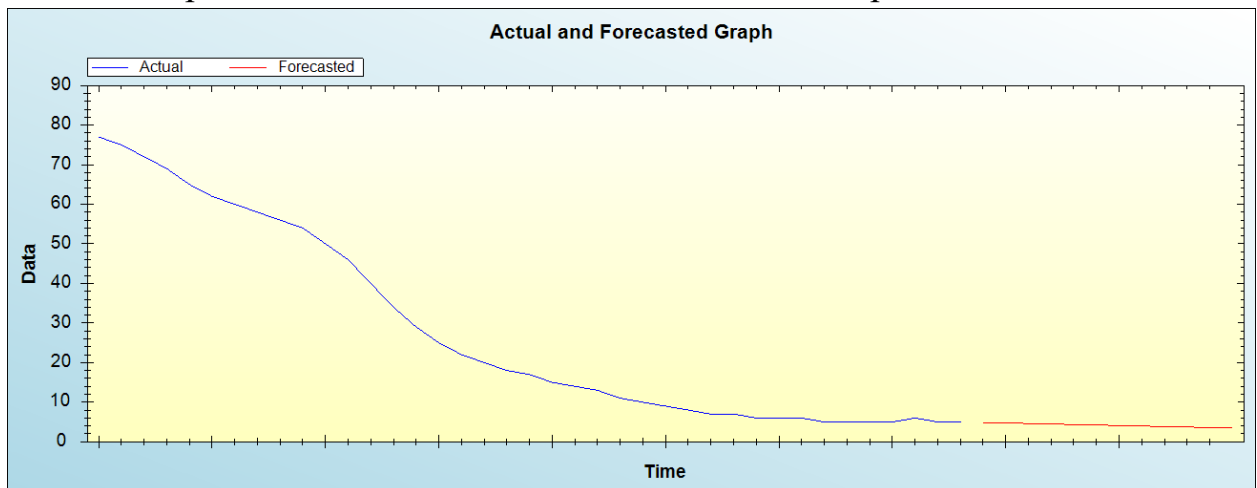


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph



Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	4.8714
2025	4.7444
2026	4.6173
2027	4.4902
2028	4.3631
2029	4.2361
2030	4.1090
2031	3.9819
2032	3.8548
2033	3.7277
2034	3.6007
2035	3.4736

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 MMR will remain very low over the out of sample period.

Conclusion

This paper utilized the double exponential smoothing technique to model and forecast MMR for Turkmenistan and results indicate that MMR will remain very low in the forecast period. Hence, we implore health authorities to relentlessly address local causes of maternal deaths.

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