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UTILIZING HOLT'S DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE TO FORECAST HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN THE DOMINICAN REPUBLIC

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Abstract:

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for the Dominican Republic from 1990 to 2020 to predict future trends of HIV prevalence over the period 2021 to 2030. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.1 respectively based on minimum MSE. The results of the study indicate that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, we encourage authorities to strengthen HIV prevention measures especially among high risk groups.

Keywords: *Exponential smoothing, Forecasting, HIV prevalence*

BACKGROUND

The Caribbean is the second most affected region in the world after sub-Saharan Africa with an HIV prevalence of 1.2% in 2017 (UNAIDS, 2017). Among Caribbean nations, Haiti has the largest number of people living with HIV, followed by the Dominican Republic (DR) (AIDS info, 2017). Although HIV rates in the DR have declined, with at least 50% lower HIV incidence in 2012 compared to 2001, HIV remains a critical public health concern in the region (UNAIDS, 2013). HIV prevalence among the general population in the DR is estimated to be 1% (UNAIDS, 2013). In the capital city of Santo Domingo, HIV prevalence among those tested dropped from 2% in 1995 to 1.1% in 1999, where it has stabilized through 2006 (Halperin *et al.* 2009). HIV infection rates vary among different groups (UNAIDS, 2013; Halperin *et al.* 2009). Women aged 20–24 living in the DR are almost twice as likely as men in that age group to be infected with HIV (UNAIDS, 2006), and female sex workers have an HIV prevalence of 1–4% (Halperin *et al.* 2009). Gay, bisexual, and other men who have sex with men (MSM) are also a high-risk group, accounting for 33% of new HIV infections annually in the DR (UNAIDS, 2013). Scaling up HIV testing and subsequent linkage to care are critical components in addressing the HIV epidemic in the DR.

The objective of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for the Dominican Republic using Holt's linear method. The results of this paper are expected to inform policy, planning and allocation of resources to targeted HIV programs in the country.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
Dunbar et al. (2021)	To present the epidemiology, social and cultural factors driving the HIV epidemic among men who have sex with men (MSM) in the Caribbean region and to highlight the regional and national responses, and what remains to be	A literature review was performed in the following databases: PubMed and Scopus. Articles published in the past 10 years were selected. The outcomes of interest were sociocultural risk factors, description of regional and national	The prevalence of HIV among MSM is high and the rates also do vary among Caribbean countries. Several factors influence the epidemic among MSM in the Caribbean but stigma and discrimination underlie the social vulnerability

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	addressed to close the gaps in order to ending AIDS by 2030.	efforts and potential challenges and barriers to effective control of the epidemic among MSM.	and play a central role in driving the HIV epidemic
Montgomery et al. (2020)	To evaluate sexual health and HIV testing behaviors among women in the rural DR.	Poisson regression analysis was used to identify demographics and behaviors associated with having had a previous HIV test	In the rural DR, numerous barriers contribute to low prevalence of HIV testing among women. Most women report willingness to have an HIV test and many engage in routine health care, indicating that this population may benefit from incorporating HIV testing and other sexual health promotion activities into routine medical care.
Chaumont et al. (2019)	To estimate out-of-pocket expenditures incurred by individuals with HIV in the Dominican Republic.	Data was obtained from an in-person survey of people living with HIV	The mean HIV-related expenditure reported by individuals in the sample in the last six months prior to the survey was in US$ 181; 15.4% of this total was spent for transportation and housing and costs to access the HIV facility. The mean expenditure reported by individuals for their current visit to an HIV center was US$ 10.
Odlum et al. (2019)	To identify country-specific HIV risk profiles for Latino communities in the US, understanding the socioeconomic, behavioral and personal risk reasons of HIV risk for older Dominican women	Conducted focus group discussions informed by the Theory of Gender and Power (TGP). The three constructs of the TGP: 1) Affective influences/social norms; 2) Gender-specific norms and. 3) Power and Authority guided the thematic analysis and identified themes that described the socio-cultural and contextual reasons that that contribute to	-participants were concerned about partner fidelity when visiting the Dominican Republic, as the country accounts for the second highest HIV rates in the Caribbean

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		perceptions of HIV risk.	
Sutherland (2019)	-To review literature and global data in order to explore the unique factors contributing to the HIV epidemic in the Dominican Republic -To compile multiple sources of literature to prove the importance of targeted prevention programs and provide suggestions on how to alleviate local issues, eventually lessening the global impact of HIV	Systematic Review	Sex workers, men who have sex with men and bateye residents were the identifiable key populations that contribute most to the HIV epidemic in this island nation according to a variety of compiled data sources. There is also a link between sex work and tourism, allowing local issues on the island to have a potential global impact

METHODOLOGY

This study utilizes Holt's double exponential smoothing technique to model and forecast future trends of annual HIV prevalence among individuals aged 15-49 years in the Dominican Republic. 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

$A_t = \mu_t + \rho_t \mathbf{t} + \varepsilon_t$ .....[1]

Smoothing equation

$S_t = \alpha A_t + (1-\alpha)(S_{t-1} + b_{t-1})$ .....[2]

$0 < \propto < 1$

Trend estimation equation

$b_t = \beta (S_t - S_{t-1}) + (1-\beta) b_{t-1}$ .....[3]

$0 < \beta < 1$

Forecasting equation

$f_{t+h} = S_t + hb_t$ .....[4]

A_t is the actual value of HIV prevalence 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 HIV prevalence 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 HIV prevalence among individuals aged 15-49 years in the Dominican Republic for the period 1990 – 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.

Findings of the study

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Exponential smoothing Model Summary

Table 1: ES model summary

Variable	A
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.126554
Sum Square Error (SSE)	1.411087
Mean Square Error (MSE)	0.045519
Mean Percentage Error (MPE)	-3.158940
Mean Absolute Percentage Error (MAPE)	14.212139

Residual Analysis for the Applied Model

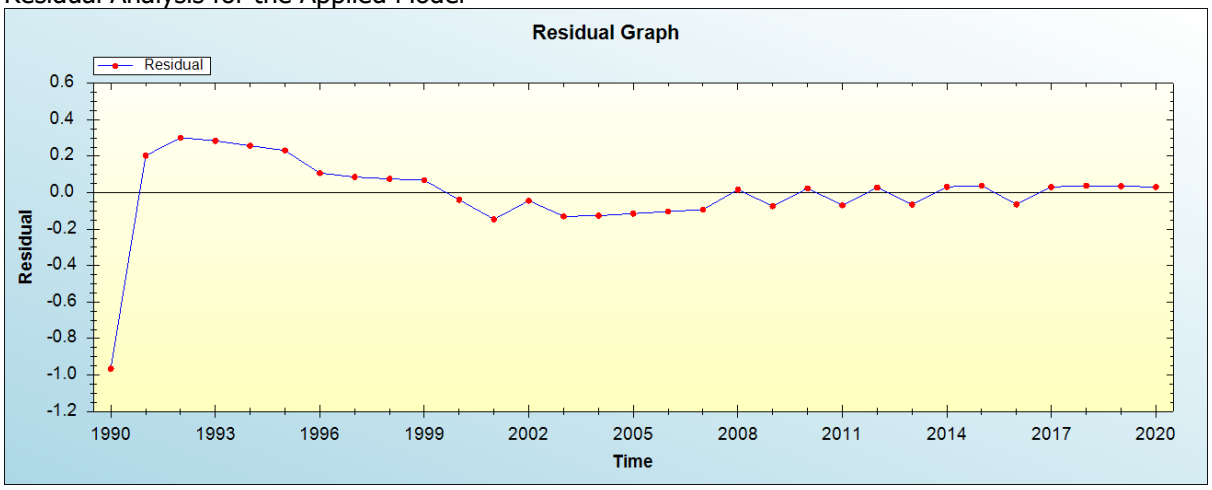

Figure 1: Residual analysis

In-sample Forecast for A

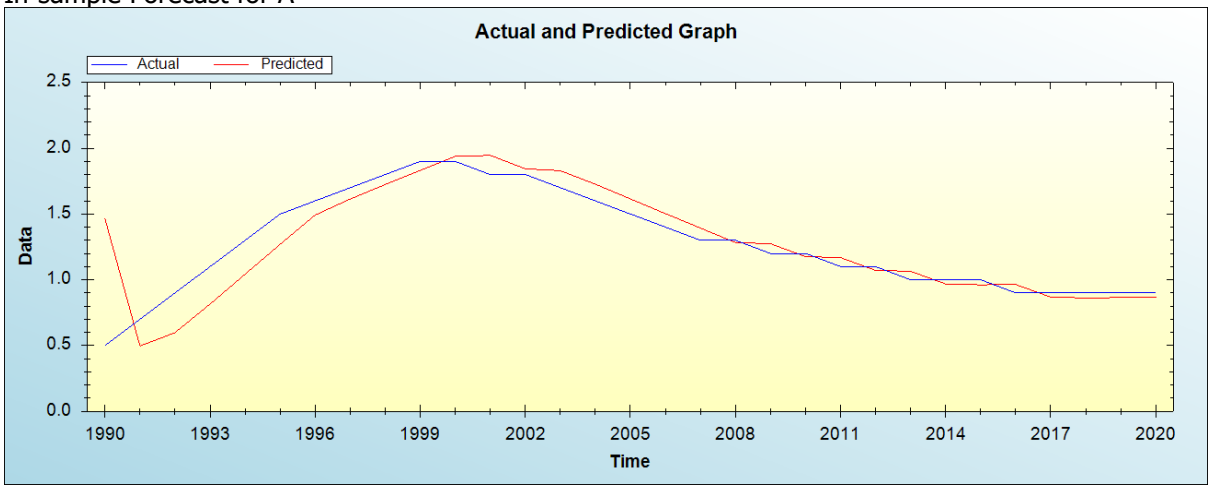

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Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

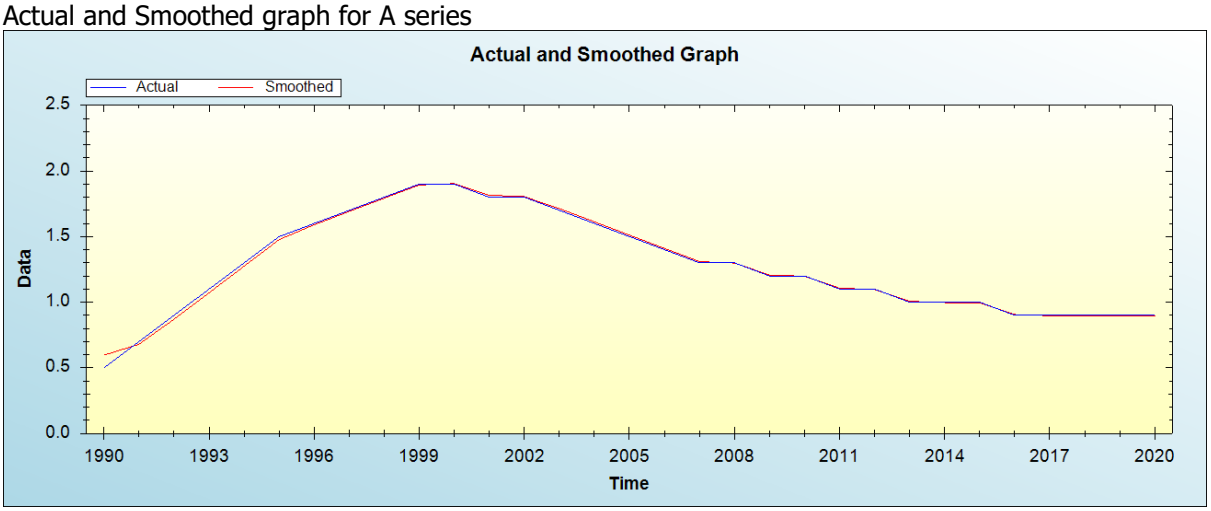

Figure 3: Actual and smoothed graph for A series

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

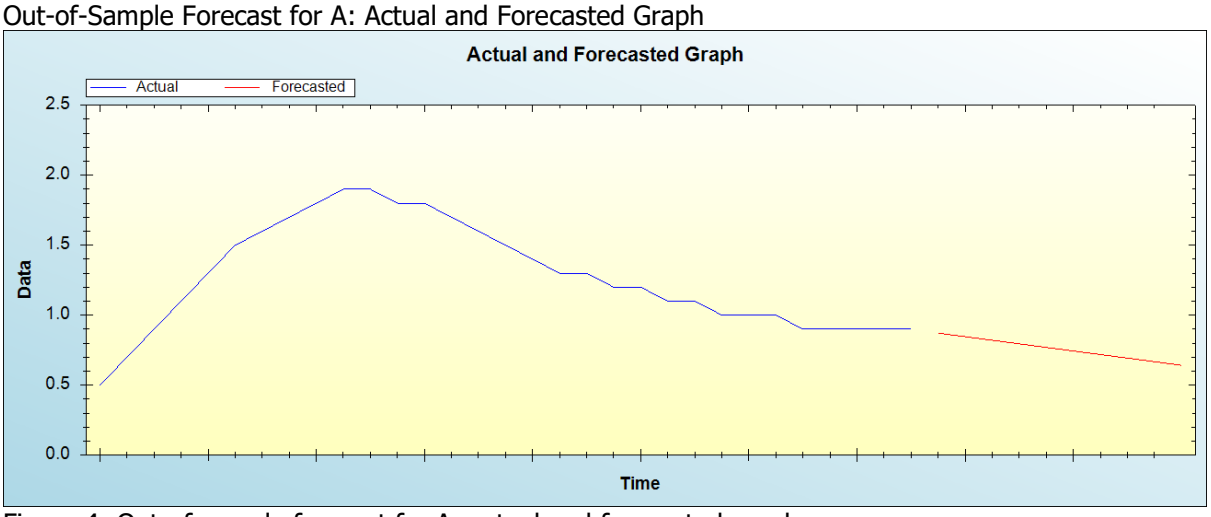

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.8713
2022	0.8458
2023	0.8203
2024	0.7948
2025	0.7693
2026	0.7439
2027	0.7184
2028	0.6929
2029	0.6674
2030	0.6419

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 HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period.

POLICY IMPLICATION AND CONCLUSION

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This study establishes that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, policy makers are encouraged to strengthen HIV prevention measures among high risk groups.

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