Daengku: Journal of Humanities and Social Sciences Innovation *ISSN: 2775-6165 (online)*
Vol. 4 No. 2 (2024)
https://doi.org/10.35877/454RI.daengku2639

The Comparison of Single and Double Exponential Smoothing Models in Predicting Passenger Car Registrations in Canada

Ansari Saleh Ahmar[a], Sitti Masyitah Meliyana[a,*], Miguel Botto-Tobar[b,c], & Rahmat Hidayat[d]

[a]*Department of Statistics, Universitas Negeri Makassar, Makassar, 90223, Indonesia*
[b]*Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands*
[c]*Research Group in Artificial Intelligence and Information Technology, University of Guayaquil, 090510, Guayaquil, Ecuador*
[d]*Department of Information Technology, Politeknik Negeri Padang, Limau Manis, Padang, 25164, Indonesia*

Abstract

This study aims to compare the two main variants of exponential smoothing methods in the context of business forecasting: Single Exponential Smoothing (SES) and Double Exponential Smoothing (DES). In this study, we applied these three methods to the data on Monthly Passenger Car Registrations in Canada from 2019 to 2022. The performance of each method was evaluated using Root Mean Square Error (RMSE) as the primary metric. The analysis results showed that Single Exponential Smoothing (SES) produced the best performance with the lowest RMSE of 13.07859 for an alpha of 0.6, compared to DES, which yielded higher RMSE values. These findings indicate that although DES have the capability to handle trends and seasonality, in some cases, especially when the data has single fluctuations without significant seasonal patterns or trends, SES can provide more accurate forecasting results. This study provides valuable insights for practitioners in selecting the most appropriate forecasting method based on the characteristics of the data at hand.

Keywords: single exponential smoothing, double exponential smoothing, passenger car.

1. Introduction

Forecasting is a crucial aspect of business management and strategic decision-making. In various fields such as finance, marketing, and operations, the ability to predict future behavior based on historical data is highly valuable (Sarker, 2021; Thakkar & Chaudhari, 2021; Surendro, 2019). One of the widely used methods for this purpose is exponential smoothing. This method offers a simple yet effective approach to generating accurate predictions.

Exponential smoothing is a forecasting technique that uses weighted moving averages to smooth data and predict future values (Hyndman & Athanasopoulos, 2018). This method places greater weight on the most recent data, making it more responsive to changes in trends and patterns compared to other, more conservative forecasting methods. There are several variants of exponential smoothing, including Single Exponential Smoothing (SES), Double Exponential Smoothing (DES), and Triple Exponential Smoothing (TES), each with distinct characteristics and applications (Tratar, L. F., Mojškerc, B., & Toman, 2016; Hyndman, Koehler, Ord, & Snyder, 2008).

The primary advantage of exponential smoothing lies in its ease of implementation and computational efficiency (Ahmar, Fitmayanti, & Ruliana, 2021; Ahmar, Rahman, Rusli, Arss, & Panday, 2023). Additionally, this method can accommodate various data components such as level, trend, and seasonality, making it a flexible tool for a wide range of forecasting situations. With technological advancements and the increasing volume of available data, the use of exponential smoothing has become even more relevant and important in modern data analysis.

This study aims to explore the use of exponential smoothing in the context of business forecasting, analyze the strengths and weaknesses of this method, and compare it with other forecasting techniques. Through a thorough literature review and detailed case studies, this study hopes to provide a comprehensive insight into how exponential smoothing can be effectively implemented in various forecasting scenarios.

* Corresponding author.
E-mail address: sittimasyitahmr@unm.ac.id

With a better understanding of exponential smoothing, practitioners and academics can enhance their forecasting abilities, which in turn can aid in better decision-making and more effective business strategies. This study also aims to pave the way for the development of more advanced and adaptive forecasting methods in the future.

2. Literature Review

2.1. Single Exponential Smoothing (SES)

The Single Exponential Smoothing method is a technique that uses very little historical data and assumes fluctuating or non-stationary data. Exponential smoothing is a weighted moving average forecasting technique where data is weighted by an exponential function. Exponential smoothing is an advanced weighted moving average forecasting method, yet it remains easy to use. This method uses very little historical data. The exponential smoothing formula can be shown as follows (Rachman., 2018).

$$F_{t+1} = \propto X_t + (1-\propto)F_{t-1} \qquad (1)$$

Where; $F_{t+1} =$ Forecast for period $t+1$, X_t = Actual value for period t, $\propto$ = Smoothing constant $0 < \propto < 1$, $F_{t-1} =$ Forecast for period $t-1$

$$F_t = \propto A_{t-1} + (1-\propto)F_{t-1} \qquad (2)$$

Where; $F_t =$ New forecast, $A_{t-1} =$ Actual deand in the previous period, $\propto =$ Smoothing constant $0 < \propto < 1$

2.2. Double Exponential Smoothing (DES)

The Double Exponential Smoothing method is applied when the data exhibits a trend pattern. Exponential smoothing with a trend pattern is addressed through Single smoothing, where two components need to be updated in each period: the level (α) and the trend (β). The level is the smoothed estimation value at the end of each period, and the trend is the smoothed estimation of the average rate of change at the end of each period (Nazim & Afthanorhan, 2014)

The following formulas are used in the Double Exponential Smoothing method (Primandari & Kartikasari, 2020)

Level Smoothing: $L_t = \propto y_t + (1-\propto)(L_{t-1} + b_{t-1})$ (3)

Trend Smoothing: $b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1}$ (4)

The forecast value for m periods ahead is: $F_{t+m} = L_t + b_t m$ (5)

Where; $L_t =$ level estimate for period t, $\propto =$ Smoothing constant for the data, $y_t =$ Data for period t, $\beta =$ Smoothing constant for the trend, $\beta_t =$ Trend estimate for period t, $m =$ Number of periods to be forecasted

3. Research Method

This study utilizes passenger car registration data in Canada sourced from the European Automobile Manufacturers' Association obtained from the Organisation for Economic Co-operation and Development (OECD Data). This data has a monthly structure, covering the period from January 2019 to March 2022. The data is collected without conducting experiments, or it's secondary data because it's obtained by downloading pre-existing data available on the platform https://data.oecd.org/. The steps used in conducting the analysis:

a. Descriptive Analysis
b. Forecasting using the Single Exponential Smoothing and Double Exponential Smoothing method
c. Optimizing parameters for each method
d. Comparing RMSE values to determine the best method
e. Forecasting for the next 10 periods
f. Creating a comparison plot of actual data and forecasted data
g. Conclusion and recommendations

4. Results and Discussions

4.1. Descriptive Analysis

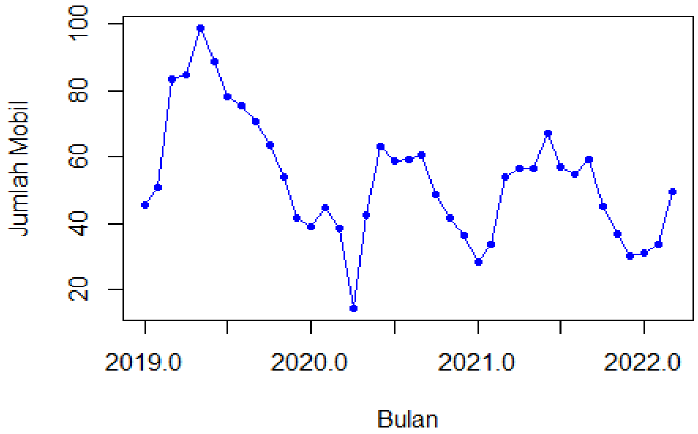

Figure 1. Time series plot for the number of passenger cars

In **Figure 1**, an upward data trend can be observed, indicating that an increase in egg prices means a decrease in egg availability, or vice versa. Additionally, the data shows fluctuating patterns, suggesting that it contains both trend and seasonal components. However, the seasonal pattern is not very pronounced due to the limited amount of data. This study will compare three methods are Single Exponential Smoothing and Double Exponential Smoothing to determine the best method based on the smallest Root Mean Square Error (RMSE).

4.2. Single Exponential Smoothing

The forecasting method for passenger car registration data in Canada using the Single Exponential Smoothing method.

Input the parameter value α. The parameter is determined by trial and error, with values ranging between 0 and 1. Here, α values of 0.1, 0.3, and 0.6 are used.

Smooth the data using the forecast package, where *h* is the number of periods to be forecasted, which is 10 periods ahead. Alpha is the smoothing parameter for each of the values 0.1, 0.3, and 0.6.

Table 1. Accuracy of Calculation Results Single Exponential Smoothing

Accuracy Test	**Smoothing Parameter (∝)**		
	0.1	0.3	0.6
SSE	**1244.2269**	9638.5784	6670.9304
MSE	329.3392	247.1430	**171.0495**
RMSE	18.1477	15.7208	**13.0786**

Based on the accuracy calculations on **Table 1**, it is evident that, among the three goodness-of-fit measures (SSE, MSE, and RMSE), the smoothing method with alpha = 0.6 has smaller accuracy values compared to the smoothing methods with alpha = 0.1 and alpha = 0.3. Therefore, in this case, it can be concluded that the smoothing method with alpha = 0.6 is better suited for forecasting the data.

4.3. Double Exponential Smoothing

The forecasting method for passenger car registration data in Canada using the Double Exponential Smoothing method.

Input the parameter values α and β: The parameters are determined by trial and error, with values ranging between 0 and 1. Here, α = 0.1 and β = 0.1, α = 0.3 and β = 0.3, and α = 0.6 and β = 0.6 are used.

Smooth the data: Smooth the data using the forecast package, where h is the number of periods to be forecasted, which is 10 periods ahead, for each of the parameter pairs: α = 0.1 and β = 0.1, α = 0.3 and β = 0.3, and α = 0.6 and β = 0.6.

Table 2. Accuracy of Calculation Results for Double Exponential Smoothing

Accuracy Test	Smoothing Parameter ($\propto$ dan β)		
	$\propto = 0{,}1\ dan\ \beta = 0{,}1$	$\propto = 0{,}3\ dan\ \beta = 0{,}3$	$\propto = 0{,}6\ dan\ \beta = 0{,}6$
SSE	37462.1985	14464.7699	**7728.2431**
MSE	960.5692	370.8915	**198.1601**
RMSE	30.9931	19.2585	**14.0769**

Based on the accuracy calculations on **Table 2**, it is evident that, among the three goodness-of-fit measures (SSE, MSE, and RMSE), the smoothing method with alpha = 0.6 and beta = 0.6 has smaller accuracy values compared to the smoothing methods with alpha = 0.1 and beta = 0.1 and alpha = 0.3 and beta = 0.3. Therefore, in this case, it can be concluded that the smoothing method with alpha = 0.6 and beta = 0.6 is better suited for forecasting the data.

4.4. Comparison Method

After performing forecasting using 2 methods, Single Exponential Smoothing and Double Exponential Smoothing, the root mean square error (RMSE) prediction values obtained shown in Table 3.

Table 3. Methods Comparison Output

Methods	$\propto$	β	RMSE
Single Exponential Smoothing	0,6		**13.0786**
Double Exponential Smoothing	0,6	0,6	14.0769

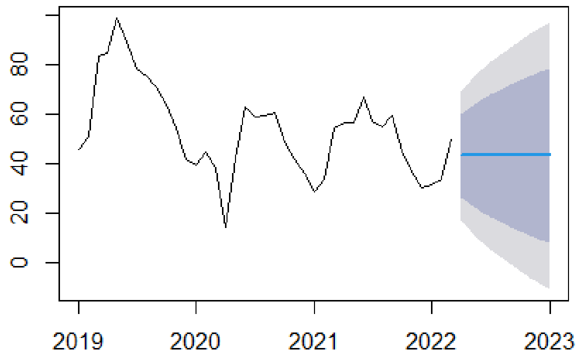

Figure 2. Forecasts from Single exponential smoothing

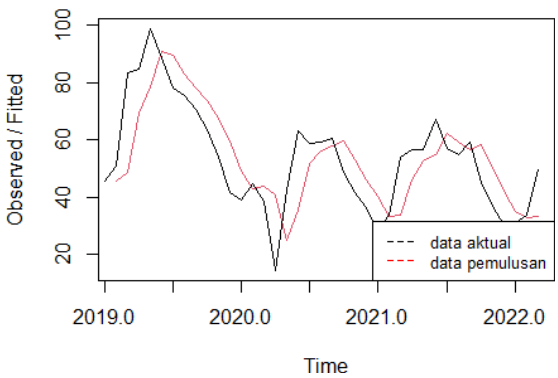

Figure 3. Plot comparing the actual data and the smoothed data

Based on the RMSE values, the best method for forecasting the passenger car registration data in Canada is determined to be the one with the lowest RMSE value is Single Exponential Smoothing. Therefore, the forecasting results from the Single exponential smoothing method will be used to predict the car registration data for the next 10 months is 43.1802. The forecast results can be seen in **Figure 2**.

From the **plot** in **Figure 3**, it can be seen that the black line represents the actual data, while the red plot represents the forecast results from the Single Exponential Smoothing method. It is evident that the forecast results from the Single Exponential Smoothing method can predict the movement of the actual data.

5. Conclusion

Based on the analysis discussed earlier, the conclusions that: (1) based on the forecasting results using the Single Exponential Smoothing method, the optimal parameter value obtained is α equal to 0.6. The forecasting error measurement, Root Mean Square Error (RMSE), for this method is 13.0786, (2) based on the forecasting results using the Double Exponential Smoothing method, the optimal parameter values obtained are α equal to 0.6 and β equal to 0.6. The forecasting error measurement, Root Mean Square Error (RMSE), for this method is 14.0769, (3) After conducting forecasting using Single Exponential Smoothing and Double Exponential Smoothing, it can be concluded that the best method for forecasting the passenger car registration data in Canada is the Single Exponential Smoothing method more effective, as it has a lower Root Mean Square Error (RMSE) compared to the Double Exponential Smoothing method.

References

Ahmar, A. S., Fitmayanti, F., & Ruliana, R. (2021). Modeling of inflation cases in South Sulawesi Province using single exponential smoothing and double exponential smoothing methods. *Quality & Quantity*, 1-11.

Ahmar, A. S., Rahman, A., Rusli, R., Arss, N., & Panday, A. K. (2023). Implementation of Exponential Smoothing in Forecasting the Export Value Price of Oil and Gas in Indonesia. *Quantitative Economics and Management Studies, 4*(4), 819-1022.

Baharaeen, & A. S. Masud. (1986). A computer program for time series forecasting using Single and double exponential smoothing techniques. *Comput. Ind. Eng.*, 11(1–4), 151–155.

Hyndman, R.J., & Athanasopoulos, G. (2018). *Forecasting: principles and practice*. OTexts.

Hyndman, R., Koehler, A. B., Ord, J. K., & Snyder, R. D. (2008). *Forecasting with exponential smoothing: the state space approach*. Springer Science & Business Media.

Makridakis. (1999). *Metode dan Aplikasi Peramalan*. Jakarta: Erlangga.

Montgomery, D. C., Jennings, C. L., & Kulahci, M. (2008). *Introduction to Time Series Analysis and Forecasting*. New Jersey : John Wiley & Sons.Inc.

Nazim, A. & Afthanorhan, A. (2014). A comparison between single exponential smoothing (SES), double exponential smoothing (DES), holt's (brown) and adaptive response rate exponential smoothing (ARRES) techniques in forecasting Malaysia population. *Global Journal of Mathematical Analysis*, 2 (4), 276-280.

Primandari A. H. & Kartikasari M. K. (2020). *Analisis Runtun Waktu dengan R*. Sleman, D. I. Yogyakarta: Prodi Statistika Universitas Islam Indonesia.

Rachman, R.(2018). Penerapan Metode Moving Average Dan Exponential Smoothing Pada Peramalan Produksi Industri Garment. *J. Inform.*, 5, (2), 211–220. doi: 10.31311/ji.v5i2.3309.

Sarker, I. H. (2021). Data science and analytics: an overview from data-driven smart computing, decision-making and applications perspective. *SN Computer Science*, *2*(5), 377.

Surendro, K. (2019, March). Predictive analytics for predicting customer behavior. In *2019 International Conference of Artificial Intelligence and Information Technology (ICAIIT)* (pp. 230-233). IEEE.

Thakkar, A., & Chaudhari, K. (2021). Fusion in stock market prediction: a decade survey on the necessity, recent developments, and potential future directions. *Information Fusion*, *65*, 95-107.

Tratar, L. F., Mojškerc, B., & Toman, A. (2016). Demand forecasting with four-parameter exponential smoothing. *International Journal of Production Economics*, *181*, 162-173.