JCBD
JOURNAL OF COMPUTERS AND DIGITAL BUSINESS
E-ISSN : 2830 - 3121
Vol. 3, No. 3, September, 2024, pp. 112-120

Double Moving Average and Double Exponential Smoothing Method in Sales Forecasting

Mutia, Ibrahim Iskandar, Sunilfa Maharani Tanjung
Universitas Islam Negeri Ar-Raniry, Aceh, Indonesia
Universitas Syiah Kuala Banda Aceh, Indonesia
Universitas Islam Negeri Sumatera Utara, Medan, Indonesia

sunilfamaharani@gmail.com

DOI : 10.56427/jcbd.v3i3.599

ARTICLE INFO

Article History
Accepted : September 1, 2024
Reviewed : September 24, 2024
Approved : September 30, 2024

Keywords
Double Moving Average
Double Exponential Smoothing
Sales
Forecasting

ABSTRACT

At present, predictions concerning sales are predominantly based on historical sales data, a practice that frequently yields inaccurate results. Such inaccuracies can lead to substantial financial losses, compelling organizations to lower the capital expenditures associated with certain products to offset these losses. This issue primarily arises from the failure to employ an appropriate forecasting methodology, resulting in estimations that lack reliable analytical foundations. This research aims to evaluate the efficacy of the Double Moving Average method compared to the Double Exponential Smoothing technique for sales forecasting, specifically through a case study involving herbal products. This study also seeks to analyze and compute the Mean Absolute Percentage Error (MAPE) for each forecasting method based on prior observations and research. The analysis draws on a dataset comprising 200 sales transactions from the five top-selling products collected between April 2022 and April 2024. The outcomes of this investigation provide MAPE values derived from the sales data, followed by a comprehensive summation of the calculated MAPE for each method. For June 2024, the results recorded are slightly higher in some cases. For example, the DES result for HNI Eucalyptus Oil was 42.65 with a MAPE of 0.46, while the DMA was 44.44 with a MAPE of 0.44.

1. Introduction

Sales forecasting is a critical component of business strategy, enabling organizations to make informed decisions regarding inventory management, resource allocation, and financial planning [1]. Among various forecasting techniques, the Double Moving Average and Double Exponential Smoothing methods are widely used to predict future sales patterns [2]. These techniques account for trends and seasonal variations, allowing businesses to adapt to changing market conditions [3]. Understanding the differences between these methods is essential for selecting the most appropriate approach for accurate sales forecasting [4]. This comparison aims to highlight the strengths and weaknesses of each technique, outlining their applicability in varying business scenarios. Organizations can better anticipate future sales and optimize their strategies by analyzing past data. The Double Moving Average method smooths out fluctuations by averaging sales over a specified period, making it easier to identify trends [5].

The foundational mathematical formulation of the Double Exponential Smoothing method renders it a practical forecasting approach applicable to long-term, medium-term, and short-term projections, particularly

within the operational framework of a business entity [6]. This technique, introduced by Brown, initiates the forecasting process through iterative testing of the α value. Central to this method is the continuous recalibration of forecasts, which relies on the most current data [7]. Smoothing forecasting techniques entail distilling historical data by averaging values across several time periods to predict future outcomes. The double-moving average and double exponential smoothing methodologies serve as forecasting strategies, particularly in the presence of a discernible trend in the data [8]. Smoothing is executed using either moving averages or exponential smoothing techniques. The double moving average represents an advancement over the single moving average, placing greater emphasis on accurately modeling underlying trend patterns within the data. In practice, the double moving average is achieved by consecutively applying the single moving average procedure, hence the designation "double." This strategy encompasses analyzing moving averages by leveraging the data generated from the single moving averages to quantify the variances between the single and double moving averages, facilitating a simultaneous and more effective adjustment to trends [9].

This research aims to compare these two methodologies in terms of accuracy, ease of implementation, and applicability to different types of sales data, ultimately providing insights into which technique may be more advantageous for businesses looking to enhance their forecasting capabilities. By examining the performance of both methods across various datasets and scenarios, we hope to contribute valuable knowledge to sales forecasting and assist organizations in selecting the most suitable approach for their needs [2].

2. Methodology

This study employs a quantitative research design to compare the effectiveness of the Double Moving Average (DMA) and Double Exponential Smoothing (DES) methods in forecasting sales. The methodology is structured as follows:

a. Data Collection: the data utilized in this analysis comprises historical sales figures from various industries over the last five years. This data is sourced from reputable databases and company records to ensure accuracy and reliability. Sales data is organized every month to evaluate seasonal patterns and trends effectively.
b. Model Implementation: Statistical software tools implement the DMA and DES forecasting models. The DMA model is computed by averaging the sales data over specified periods, allowing for smooth trends and reducing random fluctuations. The DES method, on the other hand, incorporates both level and trend components to accommodate data that display increasing or decreasing trends over time.
c. Performance Metrics: the performance of each forecasting method is evaluated using quantitative metrics, including Mean Absolute Error (MAE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE). These metrics are calculated by comparing the forecasted values against actual sales data to determine the accuracy of each method.

2.1 Double Moving Average (DMA) formula

In the Double Moving Average (DMA) method, the first step is to calculate the first moving average using formula (6).

$$S'_{t+1} = \frac{X_t + X_{t-1} + \cdots + X_{t-n+1}}{n} \quad (6)$$

Here, S'_{t+1} is the moving average in period $t+1$, and $X_t + X_{t-1} + \cdots + X_{t-n+1}$ is the actual data from period t up to $t-n+1$. The parameter n indicates the number of periods used in the moving average calculation. Furthermore, to calculate the second Double Moving Average, formula (7) is used.

$$S''_t = \frac{MA_t + MA_{t-1} + MA_{t-2} + \cdots + MA_{t-n+1}}{n} \quad (7)$$

In formula (7), S''_t is the double moving average in periods t and $MA_t + MA_{t-1} + MA_{t-2} + \cdots + MA_{t-n+1}$ is the moving average from $period\ t$ up to $t-n+1$. The parameter n also indicates the number of periods used in the double moving average calculation. For predictions using Double Moving Average, formula (8) is used.

$$F_{t+1} = 2 \times MA_t - MA_{t-1} \quad (8)$$

In formula (8), F_{t+1} is the predicted value in the $period\ t+1$, MA_t is the moving average in the period t and MA_{t-1} is the moving average in the period $t-1$.

2.2 Double Exponential Smoothing (DES) Formula

In the Double Exponential Smoothing (DES) method, the process begins with initialization data, where the initial level value is obtained based on the actual data in that period, as described in equation (1). To calculate the initial trend estimate, equation (2) is used.

$$S_t = Xt \quad (1)$$
$$T_t = Xt - X_{t-1} \quad (2)$$

In this equation.T_t represents the estimated trend in the period t while X_{t-1} is the actual data in the previous period. Furthermore, to smooth the trend estimation, equation (3) is applied.

$$T_t = \alpha Y_t + (1-\alpha)(A_{t-1} + T_{t-1}) \quad (3)$$

In equation (3), α a is the smoothing factor for the level, Y_t is the actual data in the period t, while A_{t-1} and T_{t-1} represent the level value and the estimated trend in the previous period, respectively. To calculate a smoother trend, equation (4) is used.

$$Tt = \beta(A_t - A_{t-1}) + (1-\beta)T_{t-1} \quad (4)$$

In the equation, β is the trend smoothing factor, A_t is the level value in the $period\ t$period, and A_{t-1} is the level value in the previous period. Finally, to make a prediction of future sales, formula (5) is used.

$$F_{t+k} = A_t + T_t \quad (5)$$

In equation (5), $F_{t+k}$is the predicted value in the period $t+k$where A_t is the level value in the period $t$period, and T_t is the estimated trend in that period.

2.3 RMSE, MAD, MSE, MAPE

To assess the performance of a prediction model, there are several error metrics that can be used, namely RMSE (Root Mean Squared Error), MAD (Mean Absolute Deviation), MSE (Mean Squared Error), and MAPE (Mean Absolute Percentage Error).

a. RMSE (Root Mean Squared Error): RMSE measures the error rate of model predictions in the same units as the original data. Its value is obtained by calculating the square root of the mean squared error. The RMSE equation is:

$$RMSE = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \check{y}_i)^2}}{2a} \quad (9)$$

In the equation, n denotes the number of periods analyzed, $y_i$is the actual value in period$i$and $\check{y}_i$is the predicted value for that period. RMSE provides an overview of the size of the prediction error in the same units as the original data, making it easier to interpret.

b. MAD (Mean Absolute Deviation): MAD calculates the average of the absolute errors without magnifying the larger errors. The equation to calculate MAD is:

$$MAD = \frac{1}{n}\sum_{i=1}^{n}|y_i - \check{y}_i| \quad (10)$$

In this formula, n is the number of periods under review, $y_i$is the actual value in period$i$period, and $\check{y}_i$ is the predicted value in the same period. MAD provides a measure of the average prediction error in the same units as the original data, without penalizing larger errors.

c. MSE (Mean Squared Error): MSE measures the average of squared errors, where each error is squared before the average is calculated. The MSE equation is:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \check{y}_i)^2 \quad (11)$$

Here, n is the number of periods analyzed, y_i is the actual value in period $i$period, and $\check{y}_i$is the predicted value for that period. MSE is often used to evaluate models because it penalizes larger errors, making it more sensitive to outliers.

d. MAPE (Mean Absolute Percentage Error): MAPE measures the accuracy of the model by calculating the average percentage error between the actual and predicted values. The MAPE equation is:

$$MAPE = \frac{100\,\%}{n}\sum_{i=1}^{n}\left|\frac{yi-\bar{y}i}{yi}\right| \quad (12)$$

In this formula, n is the number of observations, y_i is the actual value at observation$i$and $\check{y}_i$is the predicted value at that observation. MAPE provides a measure of error in the form of a percentage, making it easy to compare between different models or data sets.

2.4 Formulas for Calculating MAPE DES and DMA

To assess the prediction accuracy of the DES and DMA methods, the MAPE value can be calculated for each method. The formula used to calculate the average MAPE in the DES method is as follows:

$$DES\ mean \sum \frac{MAPE\ DES}{amount\ of\ data} \quad (13)$$

As for the DMA method, the formula used is:

$$DMA\ mean \sum \frac{MAPE\ DMA}{amount\ of\ data} \quad (14)$$

In both formulas, MAPE DES and MAPE DMA refer to the MAPE calculation results for the DES and DMA methods separately, respectively, while the number of data refers to the total data used in the calculation process.

3. Results and Discussion

The HNI herbal product inventory data used in this research is taken from the information available at the company, covering the period from April 2022 to May 2024. This research will apply a combination of *Double Moving Average* and Double *Exponential Smoothing* methods to predict sales of herbal products in a certain period.

After conducting observations at the company, information was obtained regarding the sales of five HNI herbal products: Hni Eucalyptus Oil, Extra Virgin Olive Oil 2020, Honey Transparent Soap, Beauty Night Cream, Multiflora Honey (With Lock). However, in Table 1, the sales data is from HNI HEALTH products to determine sales estimates in the coming period. Here is Table 1:

Table 1. HNI HEALTH Product Sales Data

Item Name	Month	Year	Qty
MINYAK KAYU PUTIH HNI	April	2022	37
	May	2022	21
	June	2022	28
	January	2023	38
	February	2023	14
	...	...	...
	December	2023	54
	January	2024	56
	February	2024	38
	March	2024	39
	April	2024	42
	May	2024	44

Table 1 shows the sales data of HNI Eucalyptus Oil products in quantity (Qty) from April 2022 to May 2024. The data illustrates the monthly sales fluctuation: In April 2022, the number sold was 37 units, then dropped to 21 in May 2022 and rose again to 28 in June 2022. In January 2023, sales rose to 38 units but dropped dramatically in February 2023 to 14 units. In December 2023, sales reached 54 units, one of the peak sales. In early 2024, sales remained relatively stable, with 56 units sold in January 2024, dropping slightly to 38 in February and rising to 44 units in May 2024.

Overall, this data shows there are fluctuations in sales, with some months experiencing a significant decline and a gradual increase in the following period.

3.1 Calculating Double Exponential Smoothing

The following Table 2 shows the *Double Exponential Smoothing* (DES) forecast calculation for one of HNI HEALTH's herbal products from April 2022 to May 2024. Table 3 presents the calculation results of

MSE, RMSE, MAE, and MAPE for five HNI herbal products using the DES method with an alpha value of 0.5.

Table 2. DES Forecast Calculation Results

Period (t)	**Xt**	**Ft**	**S't**	**S "t**	**et**	**Et^2**	**|et|**	**|et/Yt|**
Apr-2022	37		37	37				
May-2022	21	37	29	33	-16	256	16	76.19%
Jun-2022	28	21	28.5	30.75	7	49	7	25%
Jul-2022	30	24	29.25	30	6	36	6	20%
Aug-2022	47	27.75	38.125	34.063	19.25	370.563	19.25	40.957%
.....	...	.....	.....	.....	.....	.....	.....	.....
Sep-2023	49	53.041	49.174	48.338	-4.041	16.327	4.041	8.246%
Oct-2023	55	50.846	52.087	50.213	4.154	17.253	4.154	7.552%
Nov-2023	33	55.836	42.544	46.378	-22.836	521.487	22.836	69.2%
Dec-2023	54	34.875	48.272	47.325	19.125	365.784	19.125	35.418%
Jan-2024	56	50.166	52.136	49.73	5.834	34.041	5.834	10.419%
Apr-2024	42	36.669	42.017	43.367	5.331	28.422	5.331	12.693%
May-2024	44	39.317	43.008	43.188	4.683	21.927	4.683	10.642%
MSE (Mean Squared Error)						504.215		
RMSE (Root Mean Squared Error)						22.455		
MAE (Mean Absolute Error)							15.735	
MAPE (Mean Absolute Percentage Error)								46.069 %

In Table 2, the MSE (Mean Squared Error) is 504,215, the average of the squared errors across all periods. This value indicates a relatively high level of error in forecasting. The RMSE (Root Mean Squared Error) is 22,455, which indicates the average standard deviation of the error. MAE (Mean Absolute Error) of 15,735 shows the average of the absolute errors regardless of positive or negative sign. MAPE (Mean Absolute Percentage Error) shows an average error in percentage terms of 46.069%, which indicates that overall, the forecasts missed 46% of the actual values on average.

Table 3. DES Error Calculation Results

Product Name	**α (alpha)**	**MSE**	**RMSE**	**MAE**	**MAPE**
MINYAK KAYU PUTIH HNI	0,5	504.215	22.455	15.735	46.069 %
EXTRA VIRGIN OLIVE OIL 2020	0,5	13,025.060	114.127	88.299	29.640 %
SABUN TRANSPARAN MADU	0,5	3,063.484	55.349	41.694	49.979 %
BEAUTY NIGHT CREAM	0,5	1,127.515	33.578	23.042	56.403 %
MADU MULTIFLORA (WITH LOCK)	0,5	1,507.224	38.823	30.632	44.938 %

Table 3 shows that Extra Virgin Olive Oil 2020 has the highest squared error (MSE and RMSE). Still, its MAPE is relatively lower (29.640%), indicating that although the error variation is significant, the percentage error is still moderate. On the other hand, Beauty Night Cream has the highest MAPE (56.403%), indicating the least accurate forecasting. Meanwhile, HNI Eucalyptus Oil has a lower error than the other products, but the MAPE still shows forecasting that misses almost half the actual value (46.069%).

3.2 DES Prediction Results

Table 4 shows the DES prediction results. After performing calculations with the DES method for a prediction period of three months and using alpha 0.5, the sales results have decreased, with the value in July being only about 42,471, as shown in Table 4.

Table 4. DES Prediction Results

Period (n)	F_t
Jun-2024	42.650
Jul-2024	42.471
Aug-2024	42.292

Figure 1. DES Prediction Result Graph

From the prediction result graph shown in Figure 1, the author can conclude that in the calculation using the DES method, the actual and predicted values show a similar pattern of decline in June 2024.

3.3 Calculating Double Moving Average

The following Table 5 presents the calculation results of MSE, RMSE, MAE, and MAPE for the five best-selling products using the *Double Moving Average* (DMA) method.

Table 5. DMA Forecast Calculation Results

Period (t)	Y_t	MA	F_t	e_t	e_t^2	$\|e\|_t$	$\|e_t / y\|_t$
Apr-2022	37						
May-2022	21						
Jun-2022	28						
Jul-2022	30	28.667					
Aug-2022	47	26.333					
Sep-2022	26	35					
Oct-2022	43	34.333	30	-13	169	13	30.233%
Nov-2022	71	38.667	31.889	-39.111	1529.679	39.111	55.086%
Dec-2022	104	46.667	36	-68	4624	68	65.385%
.....	...	.....	...	...	...	...	.....
Sep-2023	49	50.333	44.222	-4.778	22.827	4.778	9.751%
Oct-2023	55	50.333	48	-7	49	7	12.727%
Nov-2023	33	51.333	50.333	17.333	300.444	17.333	52.525%
	...	.....	.....	.....	.....	.....	.....
Mar-2024	39	49.333	46.889	7.889	62.235	7.889	20.228%
Apr-2024	42	44.333	48.111	6.111	37.346	6.111	14.55%
May-2024	44	39.667	47.111	3.111	9.679	3.111	7.071%
MSE (Mean Squared Error)					557.373		
RMSE (Root Mean Squared Error)					23.609		
MAE (Mean Absolute Error)						16.817	
MAPE (Mean Absolute Percentage Error)							43.714 %

The table above presents forecasting data using the Moving Average (MA) method from April 2022 to May 2024. Columns include actual values (Yt), forecast values (Ft), forecasting error (et), as well as error measures such as squared error (et^2), absolute error (et), and percentage absolute error (et/Yt). In October 2022, an actual value of 43 and a forecast of 30 resulted in an error (et)-13, with a percentage absolute error of 30.233%. In November 2022, the error increased to -39,111, with an absolute error percentage of 55.086%. The most significant error occurred in December 2022, with an et of -68 and an absolute error of 65.385%. In April 2024, the forecast is closer to the actual value, with an error of only 6,111 and an absolute error percentage of 14.55%. In May 2024, the error decreased to 3,111 (7.071%). Overall, the forecasting was entirely accurate in the last few months, despite the significant errors at the beginning of the period.

Table 6. DMA Error Calculation Results

Product Name	Displacement Period	MSE	RMSE	MAE	MAPE
MINYAK KAYU PUTIH HNI	3	557.373	23.609	16.817	43.714 %
EXTRA VIRGIN OLIVE OIL 2020	3	9,983.352	99.917	75.500	27.414 %
SABUN TRANSPARAN MADU	3	2,726.072	52.212	40.000	41.677 %
BEAUTY NIGHT CREAM	3	1,355.931	36.823	27.467	82.028 %
MADU MULTIFLORA (WITH LOCK)	3	1,133.647	33.670	25.022	36.744%

Table 6 presents the error calculation results for each product using the DMA method with a three-period displacement.

3.4 DMA Prediction Results

After performing calculations using the DMA formula, sales estimates for May, June, and July are obtained with a period displacement of two and a total forecasted period of three months. The relevant table will be presented below.

Table 7. DMA Prediction Results

Period (n)	F_t
2024-Jun	44.444
2024-Jul	42.815
2024-Aug	42.309

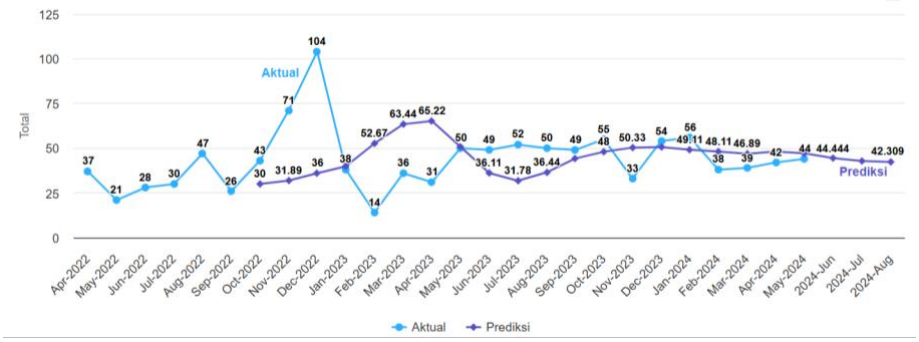

Figure 2. Graph of DMA Prediction Results

Figure 2 shows a DMA prediction result graph depicting one of the sales calculation results of HNI WHITE WOOD OIL herbal products from April 2022 to May 2024, where the blue colored line represents actual data and the purple line represents predicted data. From the graph, the author concludes that overall, there is a slight downward trend in sales forecasting value from June to August 2024.

3.7 Outcome Decision

After performing calculations for each best-selling product using the *Double Exponential Smoothing* (DES) and *Double Moving Average* (DMA) methods, the MAPE (Mean Absolute Percentage Error) value can be seen in Table 7. Furthermore, the total MAPE value is summed up and divided by the number of MAPEs available.

Table 8. Calculation of MAPE Results of DES and DMA Methods

No.	Date	Products	Results DES	MAPE DES	Results DMA	MAPE DMA
1	Aug-2024	MINYAK KAYU PUTIH HNI	42.29	0.46	42.31	0.44
2	Aug-2024	EXTRA VIRGIN OLIVE OIL 2020	150.01	0.30	255.53	0.27
3	Aug-2024	SABUN TRANSPARAN MADU	194.43	0.50	108.68	0.42
4	Aug-2024	BEAUTY NIGHT CREAM	-4.21	0.56	30.57	0.82
5	Aug-2024	MADU MULTIFLORA (WITH LOCK)	140.93	0.45	88.37	0.37
6	Jul-2024	MINYAK KAYU PUTIH HNI	42.47	0.46	42.81	0.44
7	Jul-2024	EXTRA VIRGIN OLIVE OIL 2020	167.59	0.30	258.48	0.27
8	Jul-2024	SABUN TRANSPARAN MADU	180.91	0.50	107.93	0.42
9	Jul-2024	BEAUTY NIGHT CREAM	1.62	0.56	30.93	0.82
10	Jul-2024	MADU MULTIFLORA (WITH LOCK)	132.90	0.45	86.78	0.37
11	Jun-2024	MINYAK KAYU PUTIH HNI	42.65	0.46	44.44	0.44
12	Jun-2024	EXTRA VIRGIN OLIVE OIL 2020	185.17	0.30	281.11	0.27
13	Jun-2024	SABUN TRANSPARAN MADU	167.39	0.50	109.44	0.42
14	Jun-2024	BEAUTY NIGHT CREAM	7.45	0.56	34.78	0.82
15	Jun-2024	MADU MULTIFLORA (WITH LOCK)	124.86	0.45	92.00	0.37

The table above compares the forecasting results using two methods, Double Exponential Smoothing (DES) and Double Moving Average (DMA), for five products from June to August 2024. The values of the forecasting results are shown along with the MAPE (Mean Absolute Percentage Error) to measure their accuracy. DMA generally shows lower MAPE values, which means it is more accurate than DES for most products. The Beauty Night Cream product has a significant difference, where DMA shows a much higher MAPE (0.82) than DES (0.56), indicating that DES is superior in forecasting this product.

4. Conclusion

From this research, it can be concluded that the main objective of developing and implementing a sales management information system for herbal products at Halal Mart using the Double Exponential Smoothing (DES) and Double Moving Average (DMA) methods has been achieved. This study aims to provide solutions and compare methods that allow companies to predict sales more accurately so that inventory optimization and product order planning can be done more efficiently to meet growing customer demand. This study utilizes 125 sales data for the past two years, from April 2022 to May 2024, covering eight best-selling products.

For June 2024, the results recorded are slightly higher in some cases. For example, the DES result for HNI Eucalyptus Oil was 42.65 with a MAPE of 0.46, while the DMA was 44.44 with a MAPE of 0.44. The DES and DMA results for Honey Transparent Soap and Beauty Night Cream also showed variations, with DES being higher than DMA in some products. However, comparing DES and DMA results on various products shows that both methods provide varying forecasting results. DMA often provides higher results on some products, such as Extra Virgin Olive Oil and Beauty Night Cream. Overall, the DMA method is more accurate than DES for most of the products in this table, except for the Beauty Night Cream product, where DES has a lower MAPE and is more accurate.

References

[1] P. Becerra, J. Mula, R. Sanchis, "Sustainable Inventory Management in Supply Chains: Trends and Further Research."

[2] M.E. Rana, T.W. Yao, V.A. Hameed, "Optimizing Sales Forecasting: Implementing a Deep Learning Model for Accurate and Timely Predictions."
[3] W.I. Butarbutar, S.I. Latuconsina, N.F. Palisoa, R.A.R. Sasmita, N.A. Tuanaya, K.L. Talaud, Y.W.A. Nanlohy, "Peramalan Harga Taksiran Emas Dan Uang Pinjaman Pada Pt. Pegadaian Cabang Passo Dengan Menggunakan Metode Double Moving Average."
[4] Y. Chen, Y. Fang, X. Li, J. Wei, "A factor pricing model based on double moving average strategy."
[5] A. Schmidt, M.W.U. Kabir, T. Hoque, "Machine Learning Based Restaurant Sales Forecasting."
[6] S. Sanggup, F.S. Papilaya, "Prediksi Jumlah Siswa Menggunakan Metode Double Exponential Smoothing Pada SD 07 Dungkan."
[7] N.A. Yulianti, D. Cahyawati, E. Susanti, "Penggunaan Metode Double Exponential Smoothing pada Peramalan Kasus COVID-19 di Provinsi Sumatera Selatan."
[8] B. Biswas, M. Sanyal, T. Mukherjee, "AI-Based Sales Forecasting Model for Digital Marketing."
[9] M. Ye, L. Zino, Ž. Mlakar, J. Bolderdijk, H. Risselada, B. Fennis, M. Cao, "Collective patterns of social diffusion are shaped by individual inertia and trend-seeking."