Indonesian Journal of Electrical Engineering and Computer Science
Vol. 31, No. 1, July 2023, pp. 423~432
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v31.i1.pp423-432

Sales forecasting of marketing using adaptive response rate single exponential smoothing algorithm

Tegar Arifin Prasetyo[1], Evan Richardo Sianipar[1], Poibe Leny Naomi[1], Ester Saulina Hutabarat[1], Rudy Chandra[1], Wesly Mailander Siagian[2], Goklas Henry Agus Panjaitan[1]
[1]Department of Information Technology, Faculty of Vocational Studies, Institut Teknologi Del, Sitoluama, Indonesia
[2]Department of Engineering Management, Faculty of Industrial Technology Faculty, Institut Teknologi Del, Sitoluama, Indonesia

Article Info

Article history:

Received Jan 27, 2023
Revised Mar 16, 2023
Accepted Mar 19, 2023

Keywords:

ARRSES
Exponential smoothing
Forecasting method
Mean absolute percentage error
Sales forecasting

ABSTRACT

Micro, small and medium enterprises (UMKM) is one of the important aspects to support the improvement of the economy in Indonesia. Zee Mart's business is one of the UMKM shop in Pematang Siantar City with sales and purchase transaction activities for supplies. The purpose of this study is to predict the sales of Zee Mart store goods in the coming month using the adaptive response rate single exponential smoothing (ARRSES) method. ARRSES is a method with the advantage of having two parameters, alpha and beta, where alpha will change every period when the data pattern changes. The dataset obtained will be pre-processed through data selection, cleaning, and transformation. The best beta is determined based on the level of accuracy calculated using the mean absolute percentage error (MAPE). Model development using the ARRSES method will produce forecasting percentages and errors for each product using MAPE. The number of sales data is 23,092 before pre-processing and 23,021 after pre-processing, with the total quantity of goods sold being 149,764 of 1,492 products. The results obtained using sales data 23,021 show the lowest MAPE value of 9.85 at the best beta of 0.6 with the highest accuracy of 90.15% and the model is implemented into a web interface.

Corresponding Author:

Tegar Arifin Prasetyo
Department of Information Technology, Faculty of Vocational Studies, Institut Teknologi Del
Sisingamangaraja Street, Sitoluama, Laguboti 22381, Indoneisa
Email: tegar.prasetyo@del.ac.id

1. INTRODUCTION

Forecasting is a method used to make estimates or estimates of events that are most likely to occur in the future. Forecasting can be done by analysing data obtained from the past. One of the functions of the forecasting system in the sales business is as a sales strategy for managing product inventory based on consumer demand. Especially for products whose sales are concentrated on short-term growth and quickly do not sell after the trend is no longer there [1]. Some products, such as milk, have stable consumption throughout the year, so sales can be predicted easily. However, some other items such as products that contain seasonal trends in their sales patterns cause complexity in the forecasting process [2]. Or affected by the failure of market promotion resulting in a decrease in product sales resulting in excess production capacity and a large waste of resources [3]. That way forecasting can help avoid excess production and reduce excess sales stock.

Forecasting is not only needed in the sales business of large companies but is also needed by small business actors such as micro, small and medium enterprises (UMKM) businesses. UMKM is one of the important aspects to support the improvement of the economy in Indonesia. Grocery retailers rely on accurate sales forecasts to coordinate their supply chains [4]. Therefore, marketing strategies must be formulated based on real data to be able to predict accurately based on future market development trends [5]. Quantitative forecasting eliminates most subjective factors and no longer relies heavily on the forecaster's individual ability [6]. Good sales of UMKM products are one of the benchmarks for realizing the success of these contributions. Zee Mart shop is one of the UMKM businesses owned by Mr. Rasit Rumahorbo, which is located in Pematang Siantar. This study raises a case study that occurred at the Zee Mart Store with the main problem being the supply or stock of goods that are not in accordance with the number of requests from buyers or consumers. The shop owner re-stocks the product without thinking about planning beforehand, in the sense that if the stock of the item is empty and the item is the best-selling item, the shop owner will immediately take action to buy or re-stock the item more than the previous time. This is not an effective way to be implemented in the future.

Many researchers have tried to use conventional forecasting models to predict product sales by utilizing historical sales information data [7]. By utilizing data-based quantitative prediction technology, one can uncover intricate correlations among historical data, relevant characteristic data, and sales forecast data, leading to a substantial enhancement in the accuracy and adequacy of modeling [8]. Sesario *et al.* [9] used single exponential smoothing to predict drug supply and produced a value of $\alpha = 0.1$ with a mean absolute percentage error (MAPE) value of 7% [9]. Wulandari *et al.* [10] also conducted a similar study regarding forecasting mushroom sales using double exponential smoothing with data tested in June 2021-May 2022. That study produces a value of $\alpha = 0.6$ with a MAPE value of 6.23%. Pongdatu and Putra [11] in 2018 also used the exponential smoothing method to predict clothing sales for the next season. Sidqi and Sumitra [12] used single exponential smoothing and double exponential smoothing to predict product sales and produced MAPE for single exponential smoothing of 20% and MAPE for double exponential smoothing of 24%. Other study analyzed power bumi product sales during the COVID-19 pandemic, compared forecasting methods, and determined that exponential smoothing alpha 0.9 resulted in the most accurate forecast of 627.628 boxes with a median absolute deviation (MAD) value of 130.329, MSE of 28,251.23, and MAPE of 22.00% [13]. Another study employs the trend moment method to predict Unilever Indonesia's sales and earnings by year-end, with a MAPE error rate below 10% indicating the method's success [14]. In addition, machine learning methods have also been developed for the purpose of predicting product sales using several algorithms such as artificial neural networks [15], support vector machine [16], linear regression [17] and random forest [18]. Previous research has proposed utilizing machine learning classifiers and a voting system to make estimates with the average probability of the output class [19]. Other studies have used machine learning to predict product sales and the results have significant implications for entrepreneurs in developing business strategies, rationalizing purchases and controlling operational costs [20]. Another study has also developed a K-nearest neighbor regression model using factors such as the number of competing stores in a neighborhood and promotional activities to predict product sales at each drugstore in Germany [21].

In accordance with the problems, situations, and several research sources that have been described previously, in this research, we will use the adaptive response rate single exponential smoothing (ARRSES) method to forecast sales to determine the inventory of Zee Mart Store sales products in the future period with the dataset sales are obtained from Zee Mart Stores. The main feature of time series data is the dependence between adjacent observations [22]. The ARRSES method was chosen because it has an alpha smoothing constant that can change in a controlled manner in the sense that alpha changes when there is a change in the data pattern. This is in accordance with the data used, namely sales data that will change within a certain period. In general, accurate sales forecasting is a prerequisite for competing effectively in the entrepreneurial business [23]. To determine and obtain accuracy values based on forecasting results from product sales data, the forecasting results will calculate the accuracy value using the MAPE method. In addition, this method is a method of updating or upgrading single exponential smoothing (SES), and the forecasting results will calculate the value of forecasting accuracy using the MAPE method. Furthermore, the web interface will be implemented as a platform for users to find out product sales forecasts using the ARRSES method in the next month.

2. METHOD

This research is quantitative research where the forecasting calculation using the ARRSES method is based on historical sales data in the form of numbers from each existing sales product. To produce the accuracy of the forecasting calculation results can be calculated using MAPE method with the aim of calculating accuracy of forecasting error value assessment. The estimated inventory value will be used as a reference to state the number of purchases of goods in the coming month. The variables used in this study are alpha and beta. The alpha variable is the dependent variable, and the beta variable is the independent variable. The causal relationship between two variables is the dependent variable depending on the independent variable, in the sense that alpha depends on beta. This can be seen when the beta value is initialized in the experimental process to determine the best beta, the alpha value will change. The experiments carried out in this study were to determine the best beta value using overall product sales data based on quantity and applying the ARRSES method, as well as evaluating forecasting errors using the MAPE method. Figure 1 is the research design that will be carried out in this study.

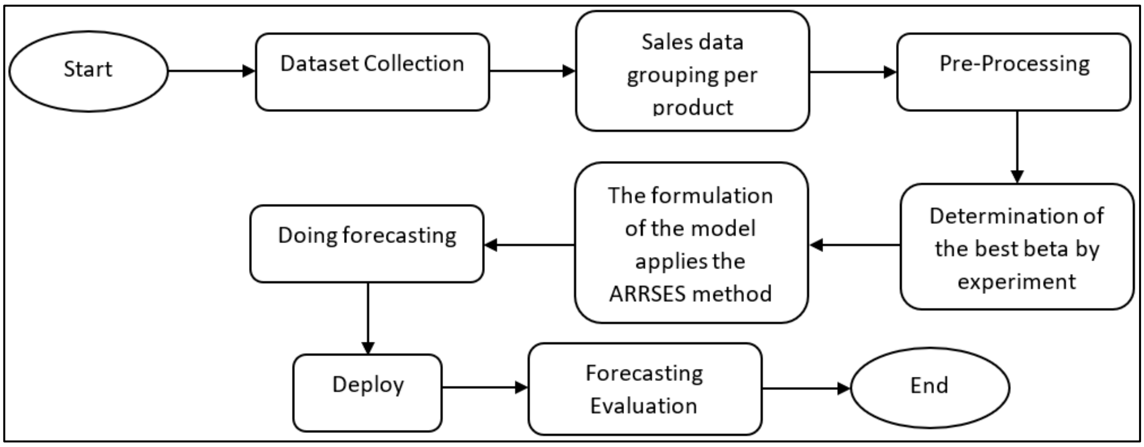

Figure 1. Research design

The ARRSES method is used as a forecasting method and MAPE as a method to calculate the accuracy of forecasting results. The ARRSES method has two parameters that will be used for forecasting, namely alpha and beta. The alpha variable in the ARRSES method is used for the calculation process F_{t+1} can be seen in the following as:

$$F_{t+1} = \alpha_t X_t + (1 - \alpha_t) F_t \quad (1)$$

to get value α in *t* period can be seen in the following as which is the absolute value of the division between E_t and M_t:

$$\alpha_{t+1} = \left| \frac{E_t}{AE_t} \right| \quad (2)$$

$$E_t = \beta e_t + (1 - \beta) E_{t-1} \quad (3)$$

$$AE_t = \beta | e_t | + (1 - \beta) AE_{t-1} \quad (4)$$

$$e_t = X_t - F_t \quad (5)$$

initialization of data is as follows:

$$E_t = AE_1 = F_1 = \alpha_1 = 0 \quad (6)$$

$$F_2 = X_1 \quad (7)$$

$$\alpha_2 = \beta \quad (8)$$

Description:
α =Alpha parameter or approximate value consideration from 0 to 1.
β =Beta constant between 0.1 to 0.9.
E_t =Exponential smoothing error.
AE_t =Smoothed error element value or mean absolute deviation.
e_t =Forecasting error for *t* period.
X_t =Actual data at the *t* time.
F_t =Forecasting data at that *t* time.
F_{t+1} =Forecasting data at a later time.

Where alpha will change every period (α_{t+1}) and alpha changes if α_2 has been obtained from the initialization of the beta value according to (8), namely $\alpha_2 = \beta$, beta value initialization starts from beta 0.1-0.9. This beta variable experiment will get the best beta value for use in forecasting in producing forecasts with a high level of accuracy and low error value.

Based on Figure 1, the first step is to collect datasets sourced from Zee Mart Store owners. The dataset provided is in the form of store sales in the form of a pdf format document. The pdf data will be converted into excel based on each data page and grouped into sales data per product. Furthermore, data pre-processing is carried out through three stages, namely data selection, data cleaning, and data transformation. In selecting the data, the process of selecting several attributes to be used is carried out, namely struk date and Qty. Then the data cleaning process is carried out to remove data that has missing values by using the dropna () function. After the data is cleaned, the next step is the transformation process. However, before data transformation is performed, firstly the Qty data type is changed to int 64 because the number type in Qty is integer, and the struk date data type is also changed from object to datetime because the contents of the struk date attribute are time periods.

The data that has been processed previously will be used for checking data patterns and determining the best beta value using python. Determination of the best beta is done by experimenting with initializing beta in the range 0.1-0.9. The best beta value is determined based on the MAPE value or the smallest error in the category of high forecasting accuracy. Figure 2 is a flowchart of the pre-processing process carried out in this study.

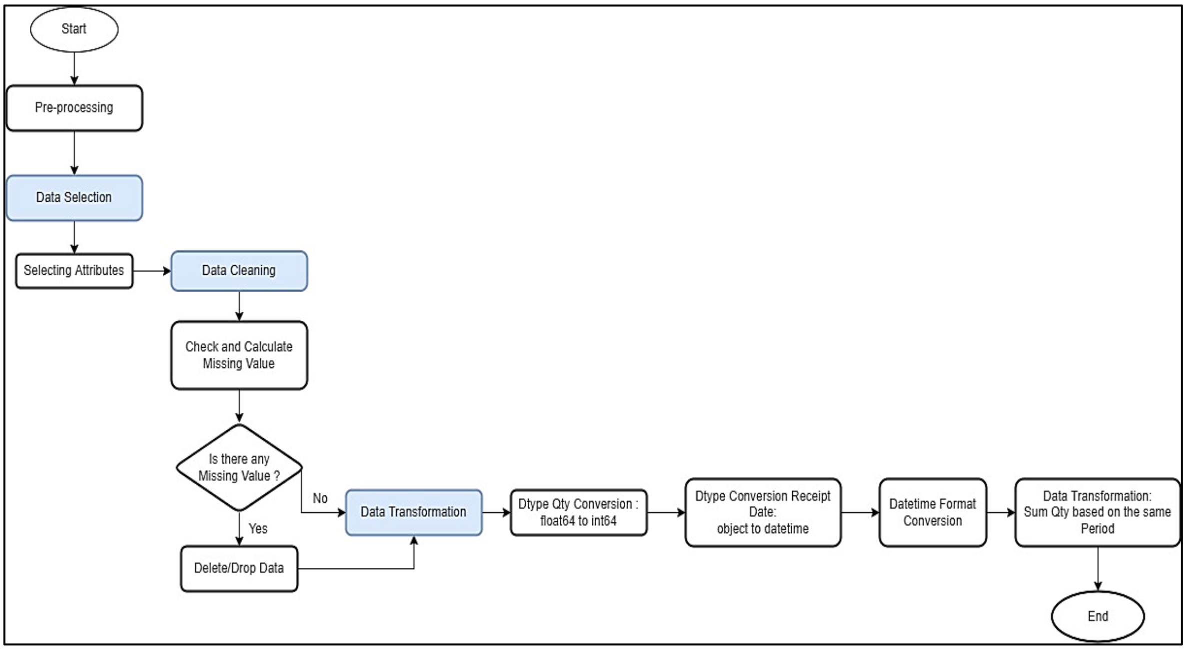

Figure 2. Flowchart of the pre-processing process

The ARRSES method is applied using (1) to (8), as shown in Figure 3. The first step is to initialize the best beta value, ranging from 0.1 to 0.9. Variables are then initialized, including the forecast value in the 2nd period (F2) which is the actual value obtained in the 1st period and then in the 1st period for the error value (e_t), smoothing errors (E_t), smoothing absolute error (AE_t), forecasting (F_1), and alpha value (α_1). Error is defined from the difference between the true value and the estimated value (5). When the error value has been obtained, then the error value will be smoothed again which is called smoothing error (E_t), and absolute smoothing is also done (AE_t) to smooth out the errors to be smaller. The alpha value is obtained from the results of the smoothing error comparison (E_t) with smoothing absolute error (AE_t) where the maximum alpha value is 1. Then to get the percentage error (PE) obtained from the absolute result of comparison of error in the t period (e_t) with the true value in t period. Forecasting results will be obtained when the iteration process has been carried out in the t period and to see the forecasting accuracy is seen based on the MAPE range obtained. The forecasting accuracy is determined by the MAPE range: <10% is very accurate, 10-20% is good, 20-50% is reasonable, and >50% is very low [24], [25].

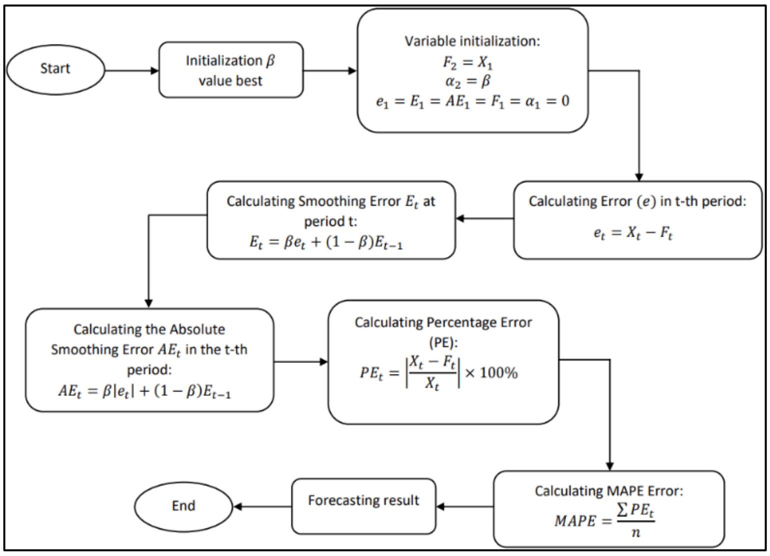

Figure 3. The stage of ARRSES calculation method

Based Figure 3, the level of forecasting accuracy can be determined by calculating the MAPE, which indicates the extent of the errors in the forecasting process. The MAPE is calculated by summing the percentage errors of all products, excluding the first period, which is used as the basis for forecasting the subsequent periods. To select the best beta for the model, we need to identify the value that results in the smallest MAPE with high accuracy. This value will be utilized in the modeling process, and the MAPE method will be used to compute the error value for each product. The accuracy of the forecasting model is determined by the magnitude of the forecasting error value. A smaller error value signifies greater forecasting accuracy, while a larger error value suggests lower forecasting accuracy.

3. RESULTS AND DISCUSSION

The model generated from the implementation process will be built into a web interface using the Django framework. The web interface is built to evaluate the model that has been built by forecasting the sales of each product. Figure 4 is a web interface that can be used by users to forecast sales by inputting sales data for six periods.

When the user has input sales data and presses the predict button, the results of the sales forecast for the next one-month period will be displayed, and a graph of the actual data for the 1st period (August 2021)-up to the 6th period (January 2022) as well as sales forecasting products in the 7th period (February 2022). Forecasting results can be seen in Figure 5.

Figure 4. User interface sales prediction

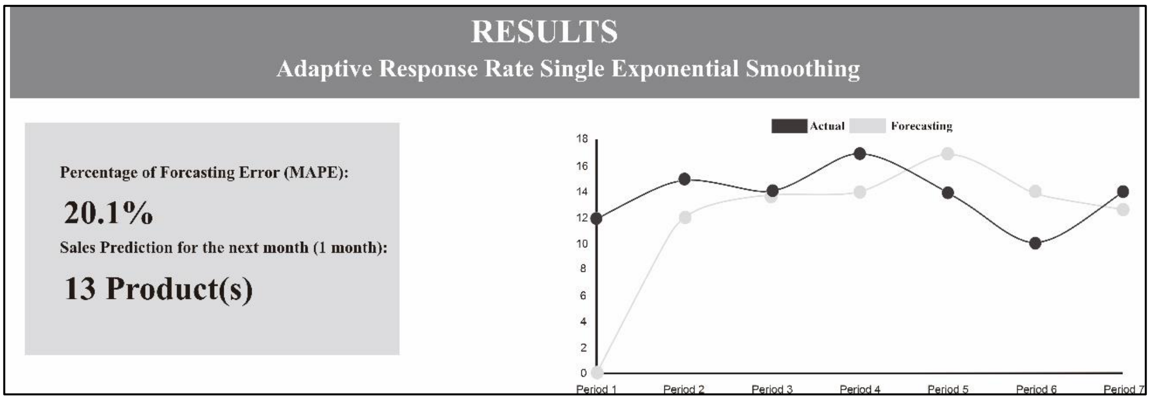

Figure 5. Result of sales prediction

The test is carried out based on the results of the implementation of the model that applies the ARRSES algorithm on the web interface. In this test, a forecasting experiment was conducted on 1,492 products with the best beta obtained. Table 1 are the results of tests that have been carried out using the model on the web interface.

Table 1. Result of test

No	Product	Xt						Ft	MAPE	Category
		Period 1	Period 2	Period 3	Period 4	Period 5	Period 6			
1	ABC CHOCOMALT-200 ML	0	15	0	0	31	50	46	57.52%	Low
2	ABC EXTRA PDS-70 G	0	2	0	0	5	12	11	58.25%	Low
3	ABC KECAP ASIN-133 ML	0	0	0	0	0	10	0	20.00%	Reasonable
4	ABC KECAP MANIS-135 ML	0	0	0	0	21	28	28	40.00%	Reasonable
5	ABC KECAP MANIS-520 ML	0	0	0	0	9	4	4	40.00%	Reasonable
6	ABC KECAP MANIS-80 ML	14	12	0	0	8	22	16	36.06%	Reasonable
7	ABC KICAP PEDAS-135 ML	8	0	0	0	0	0	0	0.00%	High
8	ABC KOPI MOKA-27 G	3	34	0	0	10	10	7	52.84%	Low
9	ABC KOPI SUSU-200 ML	0	20	0	0	28	20	18	54.40%	Low
10	ABC Mie Goreng Selera	0	0	0	0	155	134	134	40.00%	Reasonable
11	ABC SAMBAL ASLI-135 ML	33	15	0	0	0	0	0	24.00%	Reasonable
12	ABC SAMBAL EXTRA PDS-75 G (MERAH)	0	11	0	0	7	2	2	46.00%	Reasonable
13	ABC SAUS TOMAT-135 ML	0	5	0	0	12	5	5	50.40%	Low
14	ABC SUSU-31 GR	6	0	0	0	6	6	6	20.00%	Reasonable
15	ABC WHITE COFFE-27 GR	0	0	2	3	0	0	0	40.00%	Reasonable
16	ADABI PISANG GORENG-80 G	0	0	0	11	0	0	0	20.00%	Reasonable
17	ADABI TEPUNG GORENG PISANG-250 GR	0	0	0	0	10	27	27	40.00%	Reasonable
18	ADAM SARI CHING KU-	0	0	0	0	10	6	6	40.00%	Reasonable
19	ADAM SARI CHING KU BOTOL-	0	0	0	0	38	43	43	40.00%	Reasonable
20	ADAM SARI CHING KU KALENG	0	0	0	0	22	79	79	40.00%	Reasonable

The determination of the best beta value using the total quantity of the overall sales data is conducted by conducting experiments and evaluations using Python. The experiment was carried out nine times by initializing the beta value from 0.1 to 0.9. Based on these experiments, different MAPE values were obtained according to the input beta initialization. The results obtained in the beta value experiment can be seen in chapter 4 sub-chapter stages of determining the best beta value, with the largest MAPE value of 14.50% in the good category at a beta initialization of 0.9 while the smallest MAPE value was obtained at 9.85% at initialization beta 0.6 with the high category. In the research, the implementation of the ARRSES method has been successfully applied to determine the best beta but based on the stages of determining the best beta in the implementation chapter, which is carried out using Python. Table 2 is the acquisition of MAPE values based on beta initialization.

Table 2. MAPE value

Beta initialization	MAPE value	Accuracy
0.1	13.77%	Good
0.2	13.02%	Good
0.3	12.19%	Good
0.4	11.18%	Good
0.5	10.4%	Good
0.6	9.87%	High
0.7	11.24%	Good
0.8	12.87%	Good
0.9	14.50%	Good

In this study, experiments were carried out using 1492 products to test the accuracy of forecasting for each product. The forecasting experiment process is carried out using a web interface that has implemented the calculation algorithm from ARRSES. It can be seen in Figure 6 which is a data visualization that shows the results of experiments carried out on the web interface where there are 89 products that have a "high" forecasting accuracy category with MAPE values in the MAPE<10%, 359 products have a category with a high level of forecasting accuracy. "good" with MAPE values in the 10%≤MAPE<20%, 552 product data have a "reasonable" forecasting accuracy category with MAPE ranges in the 20%≤MAPE<50%, and 492 products have accuracy level categories "low" forecasting and MAPE values in the MAPE≥50% range.

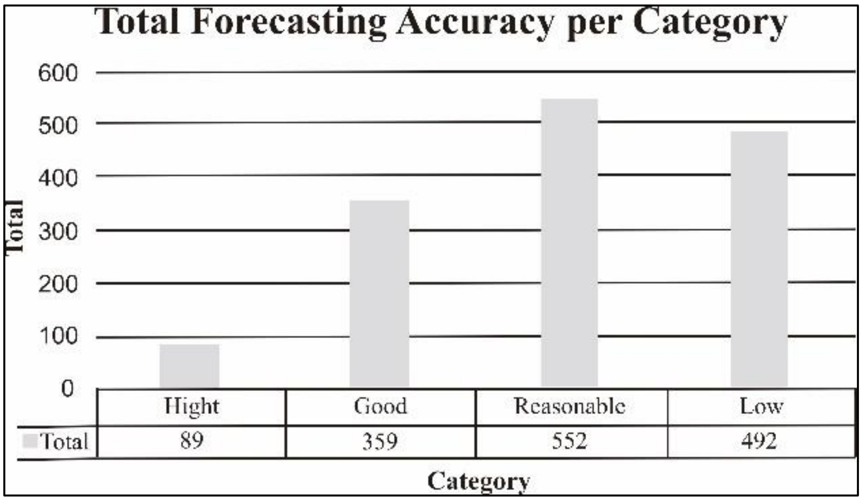

Figure 6. Data visualization about total forecasting accuracy per category

From the results of the tests carried out on each product, various levels of accuracy were obtained. Forecasting in the high category can be obtained if the product sales quantity is not too far away in each period, while the low category forecast is obtained when there is a fluctuation, or the product sales quantity has increased or decreased significantly in the sales period. The results of this study indicate that a low MAPE value occurs when significant fluctuations occur in the sales period and a high MAPE value occurs when fluctuations or decreases and sales increase are not too far away.

4. CONCLUSION

Based on experiments and tests carried out to obtain the best model with the best accuracy, the following conclusions from this research are that this research is able to obtain the best beta value and build a sales forecasting model by applying the ARRSES method and has obtained the accuracy and the error value of the forecasting results by using the MAPE method 2. The best beta value is influenced by beta initialization 0.1-0.9, with the determination of the best beta taking into account the lowest MAPE value and the best accuracy category. The best beta value obtained from the initialization of beta values 0.1-0.9 is 0.6. 3. The lowest MAPE value obtained in this study was 9.85% and had an accuracy of 90.15%. The best model accuracy value is influenced by the MAPE forecasting error value, where the smaller the forecast error value obtained, the greater the forecasting accuracy will be, and conversely, the greater the forecasting error value, the smaller the forecasting accuracy will be 4. The model has been built into a web interface using the Django framework, which is capable of forecasting each sales product.

REFERENCES

[1] D. An, S. Ji, and I. U. Jan, "Investigating the determinants and barriers of purchase intention of innovative new products," *Sustainability (Switzerland)*, vol. 13, no. 2, pp. 1–14, 2021, doi: 10.3390/su13020740.

[2] Y. Ensafi, S. H. Amin, G. Zhang, and B. Shah, "Time-series forecasting of seasonal items sales using machine learning – A comparative analysis," *International Journal of Information Management Data Insights*, vol. 2, no. 1, p. 100058, Apr. 2022, doi: 10.1016/j.jjimei.2022.100058.

[3] W. Feng, "Sales forecast of marketing brand based on BP neural network model," *Computational Intelligence and Neuroscience*, vol. 2022, pp. 1–11, Jun. 2022, doi: 10.1155/2022/1769424.

[4] R. Fildes, P. Goodwin, and D. Önkal, "Use and misuse of information in supply chain forecasting of promotion effects," *International Journal of Forecasting*, vol. 35, no. 1, pp. 144–156, Jan. 2019, doi: 10.1016/j.ijforecast.2017.12.006.

[5] G. Zhang and H. Qiu, "Competitive product identification and sales forecast based on consumer reviews," *Mathematical Problems in Engineering*, vol. 2021, pp. 1–15, Sep. 2021, doi: 10.1155/2021/2370692.

[6] M. Zellner, A. E. Abbas, D. V. Budescu, and A. Galstyan, "A survey of human judgement and quantitative forecasting methods," *Royal Society Open Science*, vol. 8, no. 2, p. rsos.201187, Feb. 2021, doi: 10.1098/rsos.201187.

[7] C. Giri and Y. Chen, "Deep learning for demand forecasting in the fashion and apparel retail industry," *Forecasting*, vol. 4, no. 2, pp. 565–581, Jun. 2022, doi: 10.3390/forecast4020031.

[8] X. Zhang, "Prediction of purchase volume of cross-border e-commerce platform based on BP neural network," *Computational Intelligence and Neuroscience*, vol. 2022, pp. 1–9, Apr. 2022, doi: 10.1155/2022/3821642.

[9] R. Sesario, T. Duha, A. Alfiah, S. A. Pramono, P. A. Cakranegara, and P. N. Pontianak, "Single exponential smoothing in forecasting tools and medicine stocks," *Infokum*, vol. 10, no. 4, pp. 27–32, 2022, [Online]. Available: https://infor.seaninstitute.org/index.php/infokum/article/view/667.

[10] W. Wulandari, H. Syafwan, and M. Ihsan, "Forecasting oyster mushroom sales using the double exponential smoothing method at kub rumah mushroom bersama," *Jurnal Riset Informatika*, vol. 4, no. 4, pp. 313–318, Sep. 2022, doi: 10.34288/jri.v4i3.417.

[11] G. A. N. Pongdatu and Y. H. Putra, "Seasonal time series forecasting using SARIMA and holt winter's exponential smoothing," *IOP Conference Series: Materials Science and Engineering*, vol. 407, no. 1, p. 012153, Sep. 2018, doi: 10.1088/1757-899X/407/1/012153.

[12] F. Sidqi and I. D. Sumitra, "Forecasting product selling using single exponential smoothing and double exponential smoothing methods," *IOP Conference Series: Materials Science and Engineering*, vol. 662, no. 3, p. 032031, Nov. 2019, doi: 10.1088/1757-899X/662/3/032031.

[13] V. Wineka Nirmala, D. Harjadi, and R. Awaluddin, "Sales forecasting by using exponential smoothing method and trend Method to optimize product sales in PT. Zamrud Bumi Indonesia during the Covid-19 pandemic," *International Journal of Engineering, Science and Information Technology*, vol. 1, no. 4, pp. 59–64, 2021, doi: 10.52088/ijesty.v1i4.169.

[14] S. Ivanov and M. Ivanov, "Marketing forecasting based on Big Data information," *SHS Web of Conferences*, vol. 107, p. 05002, May 2021, doi: 10.1051/shsconf/202110705002.

[15] A. Chawla, A. Singh, A. Lamba, N. Gangwani, and U. Soni, "Demand forecasting using artificial neural networks—A case study of american retail corporation," *Advances in Intelligent Systems and Computing*, vol. 697, pp. 79–89, 2019, doi: 10.1007/978-981-13-1822-1_8.

[16] Q. Wen, W. Mu, L. Sun, S. Hua, and Z. Zhou, "Daily sales forecasting for grapes by support vector machine," *IFIP Advances in Information and Communication Technology*, vol. 420, pp. 351–360, 2014, doi: 10.1007/978-3-642-54341-8_37.

[17] T. Wahyudi and D. S. Arroufu, "Implementation of data mining prediction delivery time using linear regression algorithm," *Journal of Applied Engineering and Technological Science*, vol. 4, no. 1, pp. 84–92, Sep. 2022, doi: 10.37385/jaets.v4i1.918.

[18] S. Punia, K. Nikolopoulos, S. P. Singh, J. K. Madaan, and K. Litsiou, "Deep learning with long short-term memory networks and random forests for demand forecasting in multi-channel retail," *International Journal of Production Research*, vol. 58, no. 16, pp. 4964–4979, Aug. 2020, doi: 10.1080/00207543.2020.1735666.

[19] U. Ahmed, H. Waqas, and M. T. Afzal, "Pre-production box-office success quotient forecasting," *Soft Computing*, vol. 24, no. 9, pp. 6635–6653, 2020, doi: 10.1007/s00500-019-04303-w.

[20] B. Singh, P. Kumar, N. Sharma, and K. P. Sharma, "Sales forecast for amazon sales with time series modeling," in *2020 1st International Conference on Power, Control and Computing Technologies, ICPC2T 2020*, Jan. 2020, pp. 38–43, doi: 10.1109/ICPC2T48082.2020.9071463.

[21] S. Kohli, G. T. Godwin, and S. Urolagin, "Sales prediction using linear and KNN regression," in *Advances in Machine Learning and Computational Intelligence: Proceedings of ICMLCI 2019*, 2021, pp. 321–329, doi: 10.1007/978-981-15-5243-4_29.

[22] W. R. Padilla, J. García, and J. M. Molina, "Improving time series forecasting using information fusion in local agricultural markets," *Neurocomputing*, vol. 452, pp. 355–373, Sep. 2021, doi: 10.1016/j.neucom.2019.11.125.

[23] R. Y. K. Lau, W. Zhang, and W. Xu, "Parallel aspect-oriented sentiment analysis for sales forecasting with big data," *Production and Operations Management*, vol. 27, no. 10, pp. 1775–1794, Oct. 2018, doi: 10.1111/poms.12737.

[24] D. M. Khairina, Y. Daniel, and P. P. Widagdo, "Comparison of double exponential smoothing and triple exponential smoothing methods in predicting income of local water company," *Journal of Physics: Conference Series*, vol. 1943, no. 1, p. 012102, Jul. 2021, doi: 10.1088/1742-6596/1943/1/012102.

[25] W. Anggraeni, F. Mahananto, A. Q. Sari, Z. Zaini, K. B. Andri, and Sumaryanto, "Forecasting the price of Indonesia's rice using hybrid artificial neural network and autoregressive integrated moving average (hybrid NNS-ARIMAX) with exogenous variables," *Procedia Computer Science*, vol. 161, pp. 677–686, 2019, doi: 10.1016/j.procs.2019.11.171.

BIOGRAPHIES OF AUTHORS

Tegar Arifin Prasetyo current lecturer and researcher member in information technology department at Institut Teknologi Del since 2020. Have experience specializing in building mathematical models, machine learning model, analytical android tools development, control system, and computer programming. He dedicates himself to university teaching and conducting research. His research interests include artificial intelligence, machine learning and algorithm computational, optimal control, mathematical model in epidemiology and bioinformatics. He can be contacted at email: tegar.prasetyo@del.ac.id.

Evan Richardo Sianipar is now a third-year student in information technology department at Institut Teknologi Del. Have experience in software engineering in web or mobile application. His research interests include forecasting methods and machine learning method in infrastructure website and mobile programming. He can be contacted at email: if319019@students.del.ac.id.

Poibe Leny Naomi is now a third-year student in information technology department at Institut Teknologi Del. Have experience in classification disease using neural network, web and desktop developing and UX design. Her research forecasting method algorithm. She can be contacted at email: if319037@students.del.ac.id.

Ester Saulina Hutabarat is now a third-year student in information technology department at Institut Teknologi Del. Have experience in sales forecasting using several methods, web developing and computer programming. Her research interest includes sales forecasting methods. She can be contacted at email: if319039@students.del.ac.id.

Rudy Chandra current lecturer and researcher member in information technology department at Institut Teknologi Del since 2022. Have experience specializing in building machine learning models, artificial neural network, decision support system, distributed system, software testing, and computer programming. He dedicates himself to university teaching and conducting research. His research interests include artificial intelligence, neural network, machine learning and algorithm computational, decision support system, distributed system, and software testing. He can be contacted at email: rudychandra@del.ac.id.

Wesly Mailander Siagian current lecturer and researcher member in engineering management department at Institut Teknologi Del since 2020. As a professional trading must be detail and looking exactly when the best time to trading. Always following risk and money management rules and NEVER lets one losing trade wipe out a significant amount of his capital. His research interests include machine learning and algorithm computational in forecasting model. He can be contacted at email: wesly.siagian@del.ac.id.

Goklas Henry Agus Panjaitan current lecturer and researcher member in information technology department at Institut Teknologi Del since 2021. Have experience specializing in machine learning model, mobile and web development, and computer programming. He dedicates himself to university teaching and conducting research. His research interests include machine learning and computer vision, database management system and mobile and web development for government and campus, and digital transformation. He can be contacted at email: goklas.panjaitan@del.ac.id.