International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Ingénierie des Systèmes d'Information
Vol. 27, No. 6, December, 2022, pp. 887-893
Journal homepage: http://iieta.org/journals/isi

Decision Making Using the MABAC Method to Determine the Leading Small and Medium Industry Centers in Yogyakarta

Anton Yudhana[1*], Rusydi Umar[2], Aldi Bastiatul Fawait[2]

[1] Departement of Electrical Engineering, Universitas Ahmad Dahlan, Yogyakarta 55166, Indonesia
[2] Master Program of Informatics, Universitas Ahmad Dahlan, Yogyakarta 55166, Indonesia

Corresponding Author Email: eyudhana@ee.uad.ac.id

https://doi.org/10.18280/isi.270604

Received: 21 July 2022
Accepted: 20 November 2022

Keywords:
SMIs, MABAC, decision making, criteria, confusion matrix

ABSTRACT

Determining small-medium industries (SMIs) centers on producing SMIs capable of developing and excelling in Yogyakarta City. The determination of superior SMIs plays a crucial part in the development of new and creative industries. However, many unresolved SMIs decisions were made manually, thus making the long and ineffective process. Technology entry into various disciplines can make determining superior SMIs more efficient and systematic. To facilitate the determination of superior SMIs, it took advantage of the Decision Support System (DSS), where the author, when carrying out the analysis, applied the Multi-Attributive Border Approximation Area Comparison (MABAC) method for alternative rankings. This research resulted in the ranking of superior SMIs centers, namely alternatives (A6) ranked 1st, (A9) 2nd order, (A2) 3rd order, (A8) 4th order, (A10) 5th order, (A1) 6th order, (A3) 7th order, (A5) 8th order, (A4) 9th order, and (A7) 10th order. The MABAC method was successfully used in the decision-making of superior SMIs centers with a precision of 83.3% and an accuracy of 93.5%, calculated using a confusion matrix. The study's results discovered that the MABAC approach was successfully used for decision-making for determining superior small and medium industry centers.

1. INTRODUCTION

The Yogyakarta City Government, through the Yogyakarta City Cooperatives and Small and Medium Enterprises Industry Office, has set a target for establishing a flagship Small and Medium Industries (SMIs) center to be carried out by the end of 2021 [1]. The COVID-19 outbreak, a pandemic, has caused a decrease in economic activities globally, and one of the affected cities is Yogyakarta. From various problems related to the impact of the pandemic, the department has made various efforts to overcome and provide solutions so that the industrial sector in Yogyakarta will soon recover [2].

The determination of the superior SMIs center must be planned appropriately and carefully so that it can be ensured that with the existence of these businesses, it can develop the industrial sector in the region. Therefore, one of the steps now taken by the Yogyakarta City Government is to review and provide socialization and education about holding the flagship Small Medium Industries (SMIs) center program in various regions [3, 4]. Whereas socialization emphasizes that the area used as a place for superior SMIs must be responsible for properly developing its territory [5, 6].

Through the use of technology that is developing today, the author proposes a decision support system (DSS) as a solution to existing problems [7-9]. The author's motivation in research is to help the government determine the leading SMIs centers and contribute knowledge in the field of technology because of the nature of the decision support system method, which is accurate, fast, objective, and can be accessed using a computer. [10]. The DSS approach method applied in the study was the MABAC method. According to the results, the MABAC approach is more accurate and sensitive for the selected alternative ranking [11].

In determining the leading centers of SMIs centers, the Yogyakarta City Government, through the Yogyakarta City Office of Industry, Cooperatives, and Small and Medium Enterprises, pays attention to five criteria, namely related to the number of workers is 7%, the production capacity is 13%, the production value is 54%, the investment value is 5%, and the raw materials is 21% used. The growth of SMIs continues to be encouraged, but numerous complex parameters impact it, with the shortage of resources being the main one [12, 13]. The criterion factor that has a major influence in determining the superior SMIs is production value. This approach will make it easier for local governments to determine which SMIs is entitled to become the leading SMIs center [12, 14].

Small and medium industries (SMIs) are sectors that have great urgency and are important for the sustainability of the economy in Indonesia. SMIs is a business unit created by the community [15, 16]. As an independent business organization, SMIs has a fairly important role and influences economic and In the early stages of theory development, economic innovation theory saw competition as the main driver of innovation industrial growth in a country [17]. SMIs has contributed to reducing the number of unemployed both in developing and developed countries, including in Indonesia, where the unemployment problem can be significantly reduced due to the existence of SMIs. However, the potential in SMIs must be balanced with capabilities that can compete with large industries [17, 18].

Activities in developing small and medium industries are an effort to improve the existing economy because its potential is quite large to influence the movement of the national-level economy [19, 20]. Many small and medium industries also have a big role because of the many people whose lives depend on SMIs [21, 22]. Based on the description and explanation above, there is a need for a study on "Decision Making using the MABAC Method to Determine the Leading Small and Medium Industry Centers in Yogyakarta."

2. RESEARCH METHODS

2.1 Stages of research

Decision-making is the process of choosing among several action options intended to achieve certain goals and objectives [23, 24]. Making a decision is carried out by attempting to approach the problem by collecting data information and including several factors that can be considered in making a decision [25-27]. The following required actions in the decision-making process are listed the Figure 1.

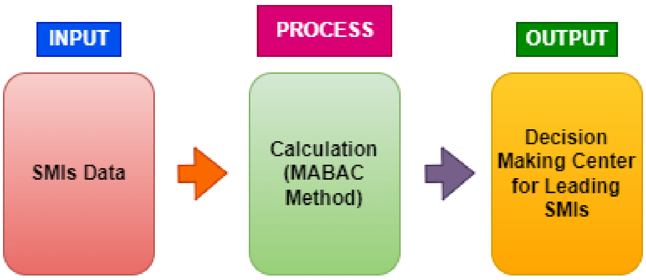

Figure 1. Stages of research

An explanation is provided below of the stages of decision-making based on Figure 1.

2.1.1 Input stage

At this stage, what was carried out was to enter SMIs data and criteria (labor, production capacity, investment value, production value, and raw materials) obtained from data collection in the Industrial Sector of the Yogyakarta City Cooperative and Small and Medium Enterprises Industry Office through interviews is all the latest data representing data from 2019 to 2021.

2.1.2 Process stage

In this stage, carry out the calculation process using the MABAC method.

2.1.3 Output stages

In this stage, the final results of the alternative ranking of decision-making on determining the leading SMIs center were obtained.

2.2 MABAC

The MABAC Decision Making Method was developed by Pamucar and Cirovic [28]. In his research was used namely DEMATEL and MABAC, where the DEMATEL method was used to get the weight coefficient of the criteria, and the MABAC method was used to compute the alternate ranks [28-30]. The MABAC approach was represented in the definition of the distance between each alternative's observed functioning criteria and the approximate area's border. Many researchers in recent years have favored this method because of its simple operation and accurate calculation results [31-33]. MABAC is one a decision making methods part of the Multiple Alternative Decision Making (MADM) theory has developed, that appraised all alternatives in accordance with efficiency values [32]. In addition, the MABAC is defined as the distance between the observed functional criteria of each alternative and the approximate area's border [34, 35]. Solving the decision-making problem by which the selection of the best alternative is carried out through several steps that make up this process, including identifying the criterion and weighing the criteria as well as the alternative rating and sensitivity of the analysis of the output results [36-38]. Determining the criteria by which the alternative is evaluated is among the most crucial parts of the decision-making [39, 40]. In the decision-making phases of the MABAC method work process, entering the process stage, the MABAC method work procedure is carried out with the following steps [41-43]: (1) Forming a matrix of initial decisions *(X)* in the first step was carried out an alternative evaluation of "m" with "n" criteria. Finally, alternatives are presented with vectors.

$$A_i = (x_{i1,}x_{i2,}\ x_{i3,} \ldots, x_{in}) \quad (1)$$

where, x_{ij} is the value of "*i*" alternatives by criteria "*j*" (*i*=1, 2, 3, …, *m*; *j*=1, 2, 3, …, *n*). There are *n* criteria in total, and *m* is an alternative number.

(2) The fundamental matrix has been a normalized element *(X)* of the normalized matrix element *(N)* is the result of applying the formula:

$$\text{Types of benefit criteria } t_{ij} = \frac{x_{ij}-x_i^-}{x_i^+-x_i^-} \quad (2)$$

$$\text{Types of cost criteria } t_{ij} = \frac{x_{ij}-x_i^+}{x_i^--x_i^+} \quad (3)$$

where, xij, x_i^+ and x_i^- demonstrates the components of the initial choice matrix (x), where x_i^+ and x_i^- is defined as follows: $x_i^- = max\ (x_1, x_2, x_3, \ldots, x_m)$ represents the maximum value of the criteria observed by the alternative. $x_i^+ = min\ (x_1, x_2, x_3, \ldots, x_m)$ represents the minimum value of the criteria observed by the alternative.

(3) Decision Weight Matrix *(V)* calculation. Decision Weight Matrix (*V*) is calculated according to the formula:

$$V_i = \sum_{j=1}^{m} (W_i * t_{ij}) + W_i \quad (4)$$

Description: w_i=presents normalized matrix elements (*n*), t_{ij}=presents the coefficient of the weight of the criterion.

(4) Calculating the matrix of the border's approximate area (*G*):

$$g_i = (\prod_{j=1}^{m} v_{ij})^{1/m} \quad (5)$$

where, v_{ij} displaying matrix with weights elements (*V*), "*m*" presents the alternatives available in total.

(5) Calculation of the elements from the matrix alternative distances from the approximate area of the borders *(Q)* by the Eq. (6):

$$Q = V - G \quad (6)$$

Alternative distances from approximate border areas (q_{ij}) determined as a Difference Decision Weight Matrix (V) and the value of the border estimate area (G).

(6) Alternate ranking of the process of determining the criteria's values function with the alternative by Eq. (7) derived from the approximate area as the total of the several border lengths (q_i). Adding up matrix components Q with the line obtained the final value of the alternate criteria function.

$$S_i = \sum_{j=1}^{n} q_{ij}, j = 1,2,\ldots,n, i = 1,2,\ldots,m \tag{7}$$

where, n denotes the number of criteria and m, the number of alternatives [44].

3. RESULT AND DISCUSSIONS

3.1 Input stage

This study had two variables, namely "criteria and alternatives." The criteria for selecting each SMIs according to the data obtained are shown in Table 1.

In Table 1, it can be seen that there are 5 SMIs criteria used.

Table 2 is SMIs sample data obtained from the Yogyakarta City Cooperatives and Small and Medium Enterprises Industry Office with ten alternatives to be processed to determine superior SMIs centers.

Table 1. SMIs criteria

No.	Criteria	Symbol	Description
1	Labor	C1	The number of workers contained in the SMIs.
2	Production Capacity	C2	The number of production capacities contained in SMIs.
3	Investment Value	C3	The number of investment values contained in the SMIs.
4	Production Values	C4	The number of production values contained in the SMIs.
5	Raw Materials	C5	The number of raw materials contained in SMIs.

Table 2. SMIs sample data

No.	SMIs	Symbol	C1	C2	C3	C4	C5
1	Wisma Gorden	A1	6	6045	55000	54000	36000
2	Kota Gede Silver Craft	A2	7	22680	15000	596000	56000
3	Mrs. Santi Blangkon	A3	3	12000	40000	201600	138000
4	Batik Clothes	A4	5	2880	2000	64800	50400
5	Manding Skin Crafts	A5	11	4500	5000	289102	156702
6	Bakpia Pathok 25	A6	9	360	800000	350400	198000
7	Tailor Furing Bag	A7	5	1560	5000	93985	91560
8	Mr. Yadi's Meatballs	A8	4	22680	15000	596000	56000
9	Average Restaurant	A9	20	60000	500000	174000	600000
10	Bakpia Tugu Jogja	A10	10	1920	98150	216000	72000

3.2 Process stage

Data on alternative samples of small and medium-sized industries from the Yogyakarta, which have been presented in Table 3 for the calculation process of superior SMIs centers using the MABAC method.

Table 3. The weighting of SMIs criteria

No.	Criteria	Weighting Criteria	(%)
1	Labor (C1)	0.0682	7%
2	Production Capacity (C2)	0.1324	13%
3	Production Value (C3)	0.5374	54%
4	Investment Value (C4)	0.0501	5%
5	Raw Materials (C5)	0.2119	21%
	Sum	1	100%

Table 3 represents the SMIs weight criterion as a result of the data collection according to the criteria weight coefficient scale that has been determined by the Yogyakarta City Office of Cooperatives and Small and Medium Industries, then will be used in calculations using the MABAC technique to determine alternative rankings.

The process of formation of the initial decision matrix *(X)* determined the value of the normalization matrix according to the predetermined fuzzy table [45], as displayed in Table 4.

Table 4 is the initial decision matrix used in this study.

Determining the value of the normalization weight matrix by determining the benefit type and cost criteria in advance. Next, determine the maximum and minimum values in each criteria column. Finally, the results were obtained using Eq. (2) for the type of benefit criterion and Eq. (3) for the cost criterion, as displayed in Table 5.

Table 4. Initial decision matrix (x)

No.	SMIs	C1	C2	C3	C4	C5
1	A1	6	6045	55000	54000	36000
2	A2	7	22680	15000	596000	56000
3	A3	3	12000	40000	201600	138000
4	A4	5	2880	2000	64800	50400
5	A5	11	4500	5000	289102	156702
6	A6	9	360	800000	350400	198000
7	A7	5	1560	5000	93985	91560
8	A8	4	22680	15000	596000	56000
9	A9	20	60000	500000	174000	600000
10	A10	10	1920	98150	216000	72000
	Type	Benefit	Benefit	Benefit	Benefit	Cost

Table 5. Matrix normalization of decision weight (N)

No.	SMIs	C1	C2	C3	C4	C5
1	A1	0.1765	0.0953	0.0664	0.0000	1.0000
2	A2	0.2353	0.3742	0.0163	1.0000	0.9645
3	A3	0.0000	0.1952	0.0476	0.2723	0.8191
4	A4	0.1176	0.0423	0.0000	0.0199	0.9745
5	A5	0.4706	0.0694	0.0038	0.4338	0.7860
6	A6	0.3529	0.0000	1.0000	0.5469	0.7128
7	A7	0.1176	0.0201	0.0038	0.0738	0.9015
8	A8	0.0588	0.3742	0.0163	1.0000	0.9645
9	A9	1.0000	1.0000	0.6241	0.2214	0.0000
10	A10	0.4118	0.0262	0.1205	0.2989	0.9362
	Weight	0.0682	0.1324	0.5374	0.0501	0.2119

Table 5 is the result of the calculation of the Matrix normalization of Decision Weight *(N).*

In the process of calculating the weight of the decision. The matrix of the weight of the criterion *(W)* was multiplied by the decision normalization matrix (*N*) and then added up by the weight of the criterion (*W*). For example. the following was the calculation of the weight of the decision using Eq. (4). Then the results are obtained as provided in Table 6.

Table 6 obtained the results of the calculation of the decision weight matrix (*V*).

Table 6. Matrix of decision weights (*V*)

No.	SMIs	C1	C2	C3	C4	C5
1	A1	0.0802	0.1450	0.5731	0.0501	0.4238
2	A2	0.0842	0.1820	0.5462	0.1002	0.4163
3	A3	0.0682	0.1582	0.5630	0.0637	0.3855
4	A4	0.0762	0.1380	0.5374	0.0511	0.4184
5	A5	0.1003	0.1416	0.5394	0.0718	0.3785
6	A6	0.0923	0.1324	1.0748	0.0775	0.3629
7	A7	0.0762	0.1351	0.5394	0.0538	0.4029
8	A8	0.0722	0.1820	0.5462	0.1002	0.4163
9	A9	0.1364	0.2648	0.8728	0.0612	0.2119
10	A10	0.0963	0.1359	0.6022	0.0651	0.4103

Determine the value of the border estimate matrix (*G*) formula to calculate the boundary estimation matrix's value (*G*) of each criterion using Eq. (5). First, multiply the values on each of the same criteria. and then the total multiplication was further raised by one per number of alternatives.

Table 7 is the border estimate matrix value (*G*).

Alternate distance matrix element computation using the boundary estimate area (*Q*) to determine the value of the boundary alternative distance matrix element based on the Border estimate matrix Value (*G*) using Eq. (6). Then the results presented in Table 8. Table 8 obtained the results of the calculation of the matrix of alternative distances from the approximate border area (*Q*).

Table 7. Border estimate matrix value (*G*)

SMIs	C1	C2	C3	C4	C5
G	0.0865	0.1578	0.6208	0.0675	0.3763

Table 8. Alternate distance matrix of the approximate border area (*Q*)

No.	SMIs	C1	C2	C3	C4	C5
1	A1	-0.0063	-0.0127	-0.0477	-0.0174	0.0475
2	A2	-0.0023	0.0242	-0.0746	0.0327	0.0399
3	A3	-0.0183	0.0005	-0.0578	-0.0037	0.0091
4	A4	-0.0103	-0.0198	-0.0834	-0.0164	0.0421
5	A5	0.0138	-0.0162	-0.0814	0.0044	0.0021
6	A6	0.0058	-0.0254	0.4540	0.0100	-0.0134
7	A7	-0.0103	-0.0227	-0.0814	-0.0137	0.0266
8	A8	-0.0143	0.0242	-0.0746	0.0327	0.0399
9	A9	0.0499	0.107	0.252	-0.0063	-0.1644
10	A10	0.0098	-0.0219	-0.0186	-0.0024	0.0339

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{1/m}$$

$$C1 = (0.0802 * 0.0842 * 0.0682 * 0.0762 * 0.1003 * 0.0923 * 0.0762 * 0.0722 * 0.1364 * 0.0963)^{1/10} = 0.0865$$

$$C2 = (0.1450 * 0.1820 * 0.1582 * 0.1380 * 0.1416 * 0.1324 * 0.1351 * 0.1820 * 0.2648 * 0.1359)^{1/10} = 0.1578$$

$$C3 = (0.5731 * 0.5462 * 0.5630 * 0.5374 * 0.5394 * 1.0748 * 0.5394 * 0.5462 * 0.8728 * 0.6022)^{1/10} = 0.6208$$

$$C4 = (0.0501 * 0.1002 * 0.0637 * 0.0511 * 0.0718 * 0.0775 * 0.0538 * 0.1002 * 0.0612 * 0.0651)^{1/10} = 0.0675$$

$$C5 = (0.4238 * 0.4163 * 0.3855 * 0.4184 * 0.3785 * 0.3629 * 0.4029 * 0.4163 * 0.2119 * 0.4103)^{1/10} = 0.3763$$

Thus obtained calculation *G*. The results are presented in Table 7.

3.3 Output stage

Alternative rankings (*S*) to determine the value of the alternative ranking were solved by the Eq. (7). Then the results presented in Table 9 are obtained.

Table 9. Alternative ranking (*S*)

No.	Alternative	S	Ranking
1	A1	-0.0366	6
2	A2	0.0200	3
3	A3	-0.0702	7
4	A4	-0.0878	9
5	A5	-0.0773	8
6	A6	0.4310	1
7	A7	-0.1014	10
8	A8	0.0079	4
9	A9	0.2382	2
10	A10	0.0008	5

Table 9 is the calculation value of the alternative ranking (*S*).

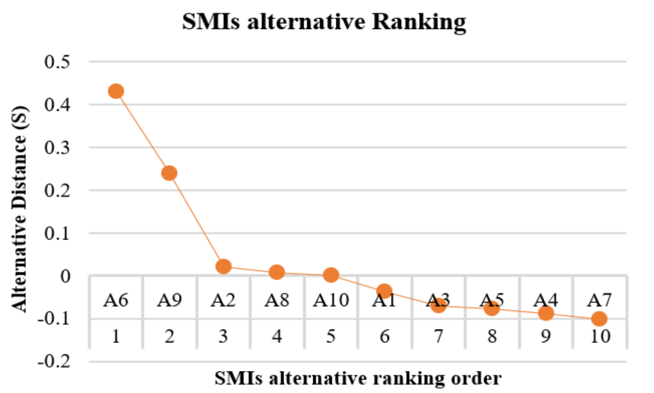

Figure 2. Results of alternative ranking of SMIs

In Figure 2, the results were obtained, namely Bakpia Pathok 25 (A6) ranked 1st; Average Restaurant (A9) in 2nd; Kotagede Silver Craft (A2) in 3rd place; Yadi's Meatballs (A8) in 4th place; Bakpia Tugu Jogja (A10) in 5th place; Wisma Gorden (A1) in 6th place; Mrs. Santi Blangkon (A3) in 7th place; Manding Skin Crafts (A5) in 8th place; Batik Clothes (A4) in 9th place; and Tailor Furing Bag (A7) in 10th.

3.4 Precision and accuracy test

The confusion matrix method was used in testing ranking results. A confusion matrix is a prediction matrix that will be compared with the original input data. This formula performed calculations with two outputs: Precision and Accuracy. Table 10 shows the values in the confusion matrix [46].

Table 10. Confusion matrix results

Real	Feasible Data	Not feasible data	Total
Feasible	10	2	12
Not feasible	2	48	50

The values from Table 10 are the data matched in the MABAC method with the real data. 12 data that are declared FEASIBLE in actual terms are also predicted by MABAC as FEASIBLE as many as 10 data (*TP*). And the remaining 2 data are predicted as NOT FEASIBLE (*FP*). The 50 data declared NOT FEASIBLE were predicted as NOT FEASIBLE as many as 48 (*FN*), and the remaining 2 were declared FEASIBLE (*TN*). From Table 10, the following calculations of the values of precision and accuracy are carried out.

$$\text{Precision: } \left(\frac{TP}{TP+FP}\right)$$
$$Precision = \frac{(10)}{(10+2)} = \frac{10}{12} = 0.83333 = 83.3\% \quad (8)$$

$$\text{Accuracy: } \left(\frac{TP+FN}{FN+FP+TN+TP}\right)$$
$$Accuracy = \frac{(10+48)}{(48+2+2+10)} = \frac{58}{62} = 0.93548 = 93.5\% \quad (9)$$

Here are the results of the Accuracy and Precision values in the MABAC method presented in Table 11.

Table 11. Precision and accuracy value

Value	Result
Precision	0.8333
Accuracy	0.9354

In Table 11, the Precision value is obtained, 83.3% and the accuracy value is 93.5%.

4. CONCLUSIONS

This study used the MABAC method with criteria, namely labor (C1), production capacity (C2), production value (C3). investment value (C4). and raw materials (C5). Therefore. it is expected to be able to assist in making decisions on determining the superior SMIs center.

This research resulted in the ranking of superior SMIs centers, namely Bakpia Pathok 25 (A6) ranked 1st; Average Restaurant (A9) in 2nd; Kotagede Silver Craft (A2) in 3rd place; Mr. Yadi's Meatballs (A8) in 4th place; Bakpia Tugu Jogja (A10) in 5th place; Wisma Gorden (A1) in 6th place; Mrs. Santi Blangkon (A3) in 7th place; Manding Skin Crafts (A5) in 8th place; Batik Clothes (A4) in 9th place; and Tailor Furing Bag (A7) in 10th.

The confusion matrix according to test results. Precision was 83.3% and accuracy was 93.5%. The study results indicate that the MABAC methods can be applied to decision-making for determining superior SMIs centers.

REFERENCES

[1] Faidati. N., Khozin. M., Mahendra. G.K. (2021). Community empowerment program model for msmes' actors affected by Covid-19 in special region of yogyakarta. Jurnal Studi Pemerintahan, 12(2): 169-192. https://doi.org/10.18196/jgp.122133

[2] Hadi. S., Supardi. S. (2020). Revitalization strategy for small and medium enterprises after Corona virus disease pandemic (COVID-19) in Yogyakarta. J. Xian Univ. Archit. Technol., 12: 4068-4076. https://doi.org/10.37896/jxat12.04/1149

[3] Utami. Y.S., Simanjuntak. O.S., Permadi. V.A., Sasmita. A. (2020). SWOT analysis as an instrument for strategic planning of batik kayu craft small medium-sized enterprises (SMEs) in krebet bantul yogyakarta. Tourism and Sustainable Development Review, 1(2): 94-102. https://doi.org/10.31098/tsdr.v1i2.14

[4] Haque. M.G. (2020). The effect of digital marketing and media promotion utilization to a bakpia patok yogyakarta SMES'sales performance. Jurnal Ilmiah Ilmu Administrasi Publik: Jurnal Pemikiran dan Penelitian Administrasi Publik., 10(1): 233-242. https://doi.org/10.26858/jiap.v10i1.14336

[5] Islam. A.M., Qamari. I.N. (2021). Effect of supply chain management on competitive advantage and organizational performance. studies on the batik industry in Yogyakarta City. In 4th International Conference on Sustainable Innovation 2020-Accounting and Management (ICoSIAMS 2020). pp. 334-339. https://doi.org/10.2991/aer.k.210121.047

[6] Yudhana. A., Rahmayanti. J., Akbar. S.A., Mukhopadhyay. S., Karas. I.R. (2019). Modification of manual raindrops type observatory ombrometer with ultrasonic sensor HC-SR04. International Journal of Advanced Computer Science and Applications. 10(12): 277-281. https://doi.org/10.14569/ijacsa.2019.0101238

[7] Wei. G., He. Y., Lei. F., Wu. J., Wei. C., Guo. Y. (2020). Green supplier selection with an uncertain probabilistic linguistic MABAC method. Journal of Intelligent & Fuzzy Systems, 39(3): 3125-3136. https://doi.org/10.3233/JIFS-191584

[8] Umar. R., Yudhana. A., Dernata. J. (2022). The admission decision support system for muhammadiyah student association cadres using the profile matching method. JUITA: Jurnal Informatika, 10(1): 53-58. https://doi.org/10.30595/juita.v10i1.12430

[9] Patalay, S., Bandlamudi, M.R. (2021). Decision support system for stock portfolio selection using artificial intelligence and machine learning. Ingénierie des Systèmes d'Information, 26(1): 87-93. https://doi.org/10.18280/isi.260109

[10] Yudhana. A., Sulistyo. D., Mufandi. I. (2021). GIS-based and Naïve Bayes for nitrogen soil mapping in Lendah. Indonesia. Sensing and Bio-Sensing Research, 33: 100435. https://doi.org/10.1016/j.sbsr.2021.100435

[11] Şahin. R., Altun. F. (2020). Decision making with MABAC method under probabilistic single-valued neutrosophic hesitant fuzzy environment. Journal of Ambient Intelligence and Humanized Computing, 11(10): 4195-4212. https://doi.org/10.1007/s12652-020-01699-4

[12] Raco. J.R., Krejci. J., Ohoitimur. J., Raton. Y., Adrian. A.M., Rottie. R., Sumakud. E. (2021). Priority sector of small and medium enterprises using AHP: A case study of Yamaru enterprise. International Journal of the Analytic Hierarchy Process, 13(2): 220-239.

https://doi.org/10.13033/ijahp.v13i2.862
[13] El-Feky S.F., Abou-El-Enien T.H.M. (2019). Hybrid algorithm for rough multi-level multi-objective decision making problems. Ingenierie des Systemes d'Information, 24(1): 1-17. https://doi.org/10.18280/isi.240101
[14] Tiurmida. N., Sulistiana. U., Triono. T.A. (2022). Optimizing traditional market functions for culinary MSMES In Yogyakarta City. Int. J. Econ. Bus. Account. Res., 6(1): 608-628. https://doi.org/10.29040/ijebar.v6i1.4841
[15] Falentina. A.T., Resosudarmo. B.P., Darmawan. D., Sulistyaningrum. E. (2021). Digitalisation and the performance of micro and small enterprises in Yogyakarta. Indonesia. Bulletin of Indonesian Economic Studies. 57(3): 343-369. https://doi.org/10.1080/00074918.2020.1803210
[16] Budi. I.Y., Karuniasa. M., Nurcahyo. R. (2020). Effectiveness of ISO 14001: 2015 implementation in small and medium enterprises (Case study: A laundry machine industry SME in Bantul Yogyakarta). In IOP Conference Series: Earth and Environmental Science. 423(1): 012010. https://doi.org/10.1088/1755-1315/423/1/012010
[17] Yudhana. A., Muslim. A., Wati. D.E., Puspitasari. I., Azhari. A., Mardhia. M.M. (2020). Human emotion recognition based on EEG signal using fast fourier transform and K-Nearest neighbor. Adv. Sci. Technol. Eng. Syst., 5(6): 1082-1088. https://doi.org/10.25046/aj0506131
[18] Putri. I.P., Nasruddin. E., Wahab. J.A. (2019). Creative industry and imagined communities: A case study of Yogyakarta Creative City. Int. Conf. Bus. Sustain. Innov. https://doi.org/10.15405/epsbs.2019.08.59
[19] Pratondo, K., Kusmantini. T., Sabihaini. S. (2021). Gaining supply chain resilience and performance sustainability through supply chain agility in furniture SMEs in Yogyakarta. International Journal of Social Science and Business. 5(3): 392. https://doi.org/10.23887/ijssb.v5i3.37945
[20] Hardyastuti. S., Maulida. Y.F. (2021). Financial feasibility of cassava industries in daerah istimewa yogyakarta and central java. In IOP Conference Series: Earth and Environmental Science, 662(1): 012001. https://doi.org/10.1088/1755-1315/662/1/012001
[21] Yudhana. A., Fadlil. A., Rosidin. M. (2019). Indonesian words error detection system using nazief adriani stemmer algorithm. International Journal of Advanced Computer Science and Applications. 10(12): 219-225. https://doi.org/10.14569/ijacsa.2019.0101231
[22] Kavyashree. N., Supriya. M.C., Lokesh. M.R. (2021). Critical success factor estimation for software security in small and medium scale industry using AHP and TOPSIS approach. In 3rd International Conference on Integrated Intelligent Computing Communication & Security (ICIIC 2021), pp. 137-147. https://doi.org/10.2991/ahis.k.210913.018
[23] Nurhayati. B.D., Kusmantini. T., Wahyuningsih. T. (2021). Antecedents and implications of innovation capability: Empirical study of bakpia msmes in yogyakarta. J. Indones. Econ. Bus., 36(2): 179-203. https://doi.org/10.22146/jieb.v36i2.1399
[24] Agarwal. S., Chakraborty. S., Chakraborty. S. (2020). A DEMATEL-MABAC-based approach for grading and evaluation of jute fi bers. Res. J. Text. Appar., 24(4): 341-355. https://doi.org/10.1108/RJTA-02-2020-0016
[25] Yudhana, A., Fadlil, A., Prianto, E. (2018). Performance analysis of hashing mathods on the employment of app. International Journal of Electrical and Computer Engineering (IJECE), 8(5): 3512-3522. https://doi.org/10.11591/ijece.v8i5.pp3512-3522
[26] Yudhana. A. (2019). Development of door safety fingerprint verification using neural network. In Journal of Physics: Conference Series, 1373(1): 012053. https://doi.org/10.1088/1742-6596/1373/1/012053
[27] Aggarwal. L., Goswami. P., Sachdeva. S. (2021). Multi-criterion intelligent decision support system for COVID-19. Applied Soft Computing, 101: 107056. https://doi.org/10.1016/j.asoc.2020.107056
[28] Pamučar. D., Ćirović. G. (2015). The selection of transport and handling resources in logistics centers using Multi-Attributive Border Approximation Area Comparison (MABAC). Expert Systems with Applications, 42(6): 3016-3028. https://doi.org/10.1016/j.eswa.2014.11.057
[29] Mishra. A.R., Saha. A., Rani. P., Pamucar. D., Dutta. D., Hezam. I.M. (2022). Sustainable supplier selection using HF-DEA-FOCUM-MABAC technique: A case study in the Auto-making industry. Soft Computing, 1-20. https://doi.org/10.1007/s00500-022-07192-8
[30] Simarmata. A.M., Gowasa. S. (2021). Determination of eligibility for employee transfers using the mabac algorithm. Jurnal Mantik, 5(2): 1096-1103. https://doi.org/10.35335/jurnalmantik.vol5.2021.1470.pp1096-1103
[31] Zhang. H., Wei. G., Chen. X. (2021). CPT-MABAC method for spherical fuzzy multiple attribute group decision making and its application to green supplier selection. Journal of Intelligent & Fuzzy Systems, (Preprint), 1-11. https://doi.org/10.3233/JIFS-202954
[32] Zhao. M., Wei. G., Chen. X., Wei. Y. (2021). Intuitionistic fuzzy MABAC method based on cumulative prospect theory for multiple attribute group decision making. Int. J. Intell. Syst., 36(11): 6337-6359. https://doi.org/10.1002/int.22552
[33] Bobar. Z., Božanić. D., Djurić. K., Pamučar. D. (2020). Ranking and assessment of the efficiency of social media using the fuzzy AHP-Z number model-fuzzy MABAC. Acta Polytechnica Hungarica, 17(3): 43-70. https://doi.org/10.12700/APH.17.3.2020.3.3
[34] Muravev. D., Mijic. N. (2020). A novel integrated provider selection multicriteria model: The BWM-MABAC model. Decision Making: Applications in Management and Engineering, 3(1): 60-78. https://doi.org/10.31181/dmame2003078m
[35] Tang. S., Wei. G., Chen. X. (2022). Location selection of express distribution centre with probabilistic linguistic MABAC method based on the cumulative prospect theory. Informatica, 33(1): 131-150. https://doi.org/10.15388/21-INFOR467
[36] Bozanic. D., Tešić. D., Milić. A. (2020). Multicriteria decision making model with Z-numbers based on FUCOM and MABAC model. Decision Making: Applications in Management and Engineering, 3(2): 19-36. https://doi.org/10.31181/dmame2003019d
[37] Yudhana. A., Andriliana. Y.D., Akbar. S.A., Mukhopadhyay. Sunardi. S., Karas. I.R. (2019). Monitoring of rainfall level ombrometer observatory (Obs) type using android sharp GP2Y0A41SK0F sensor.

Int. J. Adv. Comput. Sci. Appl., 10(11): 360-364. https://doi.org/10.14569/IJACSA.2019.0101150

[38] Lukić. R.M. (2021). Analysis of the efficiency of financial institutions in Serbia based on the OCRA method. Tehnika, 76(1): 103-111. https://doi.org/10.5937/tehnika2101103l

[39] Ahmad. S., Bingöl. S., Wakeel. S. (2020). A hybrid multi-criteria decision making method for robot selection in flexible manufacturing system. Middle East Journal of Science. 6(2): 68-77. https://doi.org/10.23884/mejs.2020.6.2.03

[40] Estiri. M., Dahooie. J.H., Vanaki. A.S., Banaitis. A., Binkytė-Vėlienė. A. (2021). A multi-attribute framework for the selection of high-performance work systems: The hybrid DEMATEL-MABAC model. Economic Research-Ekonomska Istraživanja, 34(1): 970-997. https://doi.org/10.1080/1331677X.2020.1810093

[41] Mohammadi. S., Babaeian. M., Ataei. M., Ghanbari. K. (2021). Quantifying roof falling potential based on CMRR method by incorporating DEMATEL-MABAC method: A case study. Journal of Mining and Environment, 12(1): 151-162. https://doi.org/10.22044/jme.2020.9878.1911

[42] Liu. P., Zhang. P. (2021). A normal wiggly hesitant fuzzy MABAC method based on CCSD and prospect theory for multiple attribute decision making. International Journal of Intelligent Systems, 36(1): 447-477. https://doi.org/10.1002/int.22306

[43] Büyüközkan. G., Mukul. E., Kongar. E. (2021). Health tourism strategy selection via SWOT analysis and integrated hesitant fuzzy linguistic AHP-MABAC approach. Socio-Economic Planning Sciences, 74: 100929. https://doi.org/10.1016/j.seps.2020.100929

[44] Jokić. Ž., Božanić. D., Pamučar. D. (2021). Selection of fire position of mortar units using LBWA and fuzzy MABAC model. Oper. Res. Eng. Sci. Theory Appl., 4(1): 115-135. https://doi.org/10.31181/oresta20401156j

[45] Puška, A., Stojanović, I. (2022). "Fuzzy multi-criteria analyses on green supplier selection in an agri-food company. J. Intell. Manag. Decis., 1(1): 2-16, 2022. https://doi.org/10.56578/jimd010102

[46] Luque. A., Carrasco. A., Martín. A., de Las Heras. A. (2019). The impact of class imbalance in classification performance metrics based on the binary confusion matrix. Pattern Recognition, 91: 216-231. https://doi.org/10.1016/j.patcog.2019.02.023