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Analysis of decision support system for determining industrial sub-district using DEMATEL-MABAC methods

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Abstract

This paper aims to create a decision support system (DSS) application for determining industrial locations in Serang Regency, with mathematical calculations using the DSS (Decision Support System) hybrid method namely Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Multi-Attributive Border Approximation Area Comparison (MABAC). The DEMATEL method is used to obtain the criteria weights of each criterion and the MABAC method is used to rank the determination the best industrial sub-districts. The data used are primary data, namely interviewing interviewees to calculate the weight of the criteria and secondary data, namely the official website data of Central Bureau of Statistics. Then, the process and results of the DEMATEL-MABAC calculation method are implemented with a python-based desktop application. The results of this method indicate that the location of Cikeusal District in Serang Regency is the right location to be used as an industrial location with the criteria and alternative function values of 0.193.

Keywords: *Industrial locations; DSS; DEMATEL; MABAC;*

1. Introduction

The industrial sector contributes to the Indonesian economy, not only contributing to the economy, but also contributing to creating jobs. However, there are still some areas that have a fairly high unemployment rate, one of which is Serang Regency [1], many fields that do research on the determination of industrial locations, one of which is from the field of mathematics. Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Multi-

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Attributive Border Approximation Area Comparison (MABAC) are hybrid models of the DSS (Decision Support System) method, this system is used to determine the best solution for the position of the industry. Because the location of this industry will have an effect with the improvement of the economy of people around the industry. The variables used in decision making are land area, population density, central distance of sub-district to district center, number of productive lifespans, land price and distance to supplier.

This paper was carried out by the author by referring to several journals that had been done before and related to the method that the author used. The first journal [2], discusses the application of the MABAC method in the selection of transportation and handling resources at the logistics center. The second journal [3], this journal explaining the application of DEMATEL method to determine the weight of criteria that reflect the relative importance of the decision criteria given. In the journal, the DEMATEL method is compared to the method commonly used for the weight determination of criteria namely AHP. The conclusion obtained in this paper is that the weight stipulated using the DEMATEL method approach shows high compatibility compared to weight determination using the commonly used AHP method. The third journal [4], this journal discusses the technique of using the DEMATEL method. The fourth journal [5], this journal discusses the application of the MABAC method in receiving rastra assistance. The fifth journal [6], the journal discusses the application of decision support system (DSS) method to determine the location of the industry, where 8 village data was used in Kudus Sub-District using criteria such as city distance, land area, slope, population density using Technique For Order Preference by Similarity to Ideal Solution (TOPSIS) method. The sixth journal [7], this journal explained the implementation of decision support system (DSS) method to determine the location of industrial development using AHP method and Quantum GIS applications. The assessment criteria used in this paper are 8 criteria.

Based on the background of existing problems and previous research, therefore in this paper will be completed using DSS method namely MABAC and calculation of weight criteria using DEMATEL, then the results will be compared with the AHP method [8] which is a commonly used model as a decision-making system. And then will be made an application to simulate the recommendations of the location of the best industrial sub-districts with a python-based desktop application.

2. Methodology

2.1. DEMATEL Method

The following are the steps of the DEMATEL method [3]:

A. Collecting Respondent's opinions and calculating the average matrix B

By combining the opinions of experts, the direct-relation matrix can be obtained as in (1) as follows:

$$b_{ij} = \frac{1}{l}\sum_{k=1}^{l} b_{ij}^{k}, \quad i,j = 1,2,\dots,n \tag{1}$$

where matrix B is :

$$\mathbf{B} = \begin{bmatrix} 0 & b_{1,2} & \dots & b_{1,n} \\ b_{2,1} & 0 & \dots & b_{2,n} \\ \dots & \dots & \dots & \dots \\ b_{n,1} & b_{n,2} & \dots & 0 \end{bmatrix}.$$

B. Calculate the normalized direct effect matrix

When the direct-relation matrix is obtained, then the normalization matrix is carried out, it can be achieved using (2) and (3) as follows

$$Y = k.B \qquad (2) \qquad (2)$$

$$k = \frac{1}{\max\limits_{1\le i\le n}(\sum_{j=1}^{n} b_{ij})} \qquad (i,j = 1,2,\dots,n)$$

where $0 \le b_{ij} < 1, 0 \le \sum_{j=1}^{n} b_{ij} \le 1$.

C. Calculating the total relation of the matrix T

The total effect matrix T is calculated by adding up the direct and all indirect effects. It can be obtained as in (4) follows:

$$T = B + B^2 + B^3 + \cdots + B^h = B(I - B)^{-1},\ when\ h \to \infty \quad (3)$$

Where I is as identity matrix.

D. Calculating the number of rows and columns of the matrix

In this step, the vectors vector t_i^+ dan t_i^-, which represent the number of rows and the number of columns of the total effect matrix T, are determined by (5) as follows:

$$t_i^+ = \sum_{j=1}^{n} t_{i,j} + \sum_{j=1}^{n} t_{j,i}\ ,$$
$$t_i^- = \sum_{j=1}^{n} t_{i,j} - \sum_{j=1}^{n} t_{j,i}\ . \quad (4)$$

where $i = j$ and $i,j \in \{2,3,\ldots,n\}$; the horizontal axis vector t_i^+called "prominence" describes the strength of the influence exerted and received from the factor. While the vertical axis vector $t_i^-$is called "Relation" which shows the net effect given by the factor to the system. If $(t_j^+ - t_i^-)$ is positive, then factor F_i has a net effect on other factors and can be grouped into causal groups; if $(t_i^+ - t_j^-)$ is negative, then factor F_j is affected by other factors as a whole and should be grouped into the effect group.

E. Determine the criterion weight coefficient

The weight of the criteria is determined by using (6) :

$$t_i^{average} = \frac{1}{2}\left(t_i^+ + t_i^-\right) = \sum_{j=1}^{n} t_{i,j}\ . \quad (5)$$

F. Normalization of the criterion weight coefficient

Normalization of the criterion weight coefficient can be be seen (7) as follows:

$$w_i = \frac{t_i^{average}}{\sum_{i=1}^{n} t_i^{average}}\ . \quad (6)$$

2.2. MABAC Method

The following are the stages of the MABAC method which consists of 6 steps [2]:

A. Establishment of the initial decision matrix (X)

The formation of the initial decision matrix (X) can be seen in (8) as follows:

$$X = \begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \cdots \\ A_3 \end{array} & \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{11} & x_{22} & & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{1m} & x_{2m} & & x_{mn} \end{pmatrix} \end{array} \quad (7)$$

where m is the alternative number, n is the total number of criteria.

B. Normalization of the initial matrix elements

Normalization of the initial matrix elements which can be seen in (9) as follows:

$$X= \begin{array}{c c} & \begin{array}{c c c c} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \dots \\ A_3 \end{array} & \begin{pmatrix} t_{11} & t_{12} & \dots & t_{1m} \\ t_{11} & t_{22} & & t_{2n} \\ \dots & \dots & \dots & \dots \\ t_{1m} & t_{2m} & & t_{mn} \end{pmatrix} \end{array} \tag{8}$$

The normalized matrix elements (N) are obtained by applying (10) and (11) as follows:

- Benefit Criteria

$$t_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{9}$$

- Cost Criteria

$$t_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \tag{10}$$

Where :

x_i^+ = Max value
x_i^- = Min Value

C. Calculating the weighted matrix elements (V)

The formation of a weighted matrix which can be seen in (12) as follows:

$$V = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & \dots & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{bmatrix} \tag{11}$$

Where :

$v_{ij} = w_i \square (n_{ij} + 1)$

w_i = represent normalized matrix elements (N)
t_{ij} = reperesent the criterion weight coefficient

w_i is the criterion weight coefficient that has been obtained by using the DEMATEL method calculation. By applying formula (12) we get a weighted matrix (V), which can also be written as in (13) as follows:

$$V = \begin{pmatrix} w_1 * t_{11} + w_1 & w_2 * t_{11} + w_2 & \dots & w_n * t_{1n} + w_n \\ w_1 * t_{21} + w_1 & w_2 * t_{22} + w_2 & & w_n * t_{2n} + w_n \\ \dots & \dots & \dots & \dots \\ w_1 * t_{m1} + w_1 & w_2 * t_{m2} + w_2 & \dots & w_n * t_{mn} + w_n \end{pmatrix} \tag{12}$$

Where "n" represents the total number of criteria, "m" represents the total number of alternatives

D. Determination of the approximate area boundary matrix (G)

The estimated boundary area for each criterion is determined according to (14) as follows:

$$g_i = \left(\prod_{j=1}^{m} v_{ij} \right)^{1/m} \tag{13}$$

Then a matrix of the approximate border area G is formed in the form of n x 1 , where n presents the total number of criteria for selecting the offered alternatives.

$$\begin{array}{c} \quad\; C_1 \quad C_2 \quad \dots \quad C_n \\ G = \begin{bmatrix} g_1 & g_2 & \dots & g_n \end{bmatrix} \end{array} \tag{14}$$

E. Calculation of alternative distance matrix elements from the approximate area of the border (Q)

Matrix formation can be seen in (16) as follows:

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix} \tag{15}$$

The alternative distance from the approximate boundary area (q_{ij}) is determined as the difference between the elements of the weighted matrix (V) and the value of the approximate boundary area (G). Can be obtained in equation (17) as follows:

$$Q = V - G \tag{16}$$

$$Q = \begin{bmatrix} v_{11} - g_1 & v_{12} - g_2 & \cdots & v_{1n} - g_n \\ v_{21} - g_1 & v_{22} - g_2 & \cdots & v_{2n} - g_n \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} - g_1 & v_{m2} - g_2 & \cdots & v_{mn} - g_n \end{bmatrix} \tag{17}$$

Which can be written in another way (18) as follows:

where :

g_i : approximate border area for criteria

C_i, v_{ij} : weighted matrix elements (V)

n : the number of criteria

m : alternative number (A_i)

The conditions for A_i for the approximate boundary as in (19) are as follow

$$A_i \in \begin{cases} G^+ \ if \ q_{ij} > 0 \\ G \ if \ q_{ij} = 0 \\ G^- \ if \ q_{ij} < 0 \end{cases} \tag{18}$$

where :
G^+ : the upper approximation area that represents the area where the ideal alternative lies
G^- : areas of lower estimates and represent areas where anti-ideal alternatives exist

F. Optimal ranking and selection of alternatives
Optimal ranking and alternative selection can be obtained in (20) as follow

$$S_i = \sum_{j=1}^{n} q_{ij} \,, j = 1, 2, \ldots, n, i = 1, 2, \ldots, m \tag{19}$$

Where n represents the number of criteria, and m represents a number of alternatives

3. Result And Analysis

3.1. The criteria and alternatives data

A. Criteria for Determining Industrial and Alternative Industrial Districts

The following are 6 criteria and 8 alternatives in the determination of industrial sub-districts in Serang Regency. These criteria and alternatives will be processed using the DEMATEL-MABAC method in accordance with the above settlement steps. The list of criteria can be seen in table 1 and the Alternate List can be seen in table 2

Table 1. List Of Criteria

Code	Criteria
K1	Population Density/km^2
K2	Land Area/km^2
K3	Distance to District Center (km)
K4	Total Productive Age of Labor
K5	Land Price/m^2
K6	Distance to Supplier (km)

Table 2. List of Alternatives

Code	Alternatives (Sub - district)
A1	Pamayaran
A2	Tunjung Teja
A3	Bandung
A4	Binuang
A5	Tanara
A6	Anyar
A7	Tirtayasa
A8	Cikeusal

And the data used was obtained from the official website of the Central Statistics Agency Serang Regency in 2018-2019 [1] as in table 3.

Table 3. District Details

Sub - district	Code of Criteria					
	K1	K2	K3	K4	K5	K6
Pamarayan	1293	41.92	34	32335	165000	33.9
Tunjung Teja	1092	39.52	22	25858	280000	24.3

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Bandung	1372	25.18	39	21583	180000	32.3
Binuang	1099	26.17	27	23452	500000	36.3
Tanara	774	49.30	33	25928	1000000	37.2
Anyar	939	56.81	35	37361	375000	39.7
Tirtayasa	687	64.46	30	18982	400000	29.2
Cikeusal	812	88.25	20	44492	150000	15.9

B. Result of DEMATEL method

1) Initial Matrix Assessment between Criteria

For a comparison assessment between criteria obtained from 3 interviewees who are experts in the field of industry, all three assessments are averaged and obtained the final result in table 4.

Table 4.Result of Assessment between Criteria

	K1	**K2**	**K3**	**K4**	**K5**	**K6**
K1	0	3	3	3	3	3
K2	3	0	3	3	3	3
K3	3	2	0	2	3	2
K4	3	3	3	0	3	3
K5	4	3	3	3	0	3
K6	3	3	3	3	3	0

2). Calculating matrix normalization

The following in table 5 is the result of the matrix normalization calculation.

3). Calculating the total effect matrix T

The following is the result obtained in table 6.

Table 5. Matrix Normalization Calculation Results

	K1	**K2**	**K3**	**K4**	**K5**	**K6**
K1	0.	0.188	0.188	0.188	0.188	0.188
K2	0.188	0.	0.188	0.188	0.188	0.188
K3	0.188	0.125	0.	0.125	0.188	0.125
K4	0.188	0.188	0.188	0.	0.188	0.188
K5	0.250	0.188	0.188	0.188	0.	0.188
K6	0.188	0.188	0.188	0.188	0.188	0.

Table 6. The Result of total effect matrix T

	K1	**K2**	**K3**	**K4**	**K5**	**K6**
K1	1.921	1.871	1.976	1.871	1.976	1.871
K2	2.079	1.713	1.976	1.871	1.976	1.871
K3	1.748	1.529	1.503	1.529	1.662	1.529
K4	2.079	1.871	1.976	1.731	1.976	1.871
K5	2.231	1.969	2.079	1.969	1.921	1.969
K6	2.079	1.871	1.976	1.871	1.976	1.713

4). Evaluating the number of rows and columns in the T matrix

The result is as in table 7

5). Determine the coefficient of the weight of the criteria

The result is as in table 8 follows:

Table 7. Result Of $\boldsymbol{t_i^+}$ And $\boldsymbol{t_i^-}$

	$\boldsymbol{t_i^+}$	$\boldsymbol{t_i^-}$
K1	23.623	-0.651
K2	22.31	0.662
K3	20.986	-1.986
K4	22.31	0.662
K5	23.625	0.651
K6	22.31	0.661

Table 8. Result of $\boldsymbol{t_1^{average}}$

	$\boldsymbol{t_i^{average}}$
K1	11.486
K2	11.486
K3	9.5
K4	11.486
K5	12.138
K6	11.486

6) Normalization of weight coefficient criteria

Calculate the normalization so that the result of the criteria weight coefficient will be obtained in table 9 below. Table 9 shows that the six criteria have almost the same weight so that it can be concluded that all 6 criteria mutually reinforce each other.

Table 9. Result Of Criteria Weighted Coefficient

Code of Criteria	w_i
K1	0.17
K2	0.17
K3	0.141
K4	0.17
K5	0.18
K6	0.17

Table 10 shows a paired matrix between criteria and alternatives in the range of values from 1 to 5.

Table 10. Result of Assessment of Criteria and Alternatives

	K1	K2	K3	K4	K5	K6
A1	5	3	4	4	5	4
A2	4	2	5	3	5	5
A3	5	1	3	3	5	4
A4	4	1	5	3	3	3
A5	3	3	4	3	2	3
A6	4	3	4	4	4	3
A7	3	4	4	2	3	5
A8	4	5	5	5	2	5

Table 11 show that the calculation of DEMATEL-MABAC method obtained the determination of the best industrial sub-district namely Cikeusal sub-district with a function value of 0.193. Where Cikeusal sub-district has a population density of 812/km^2, the area of land area is 88.25/km^2, the central distance of the sub-district to the central district is 20 km, the productive life of 44,492 people, the land price is Rp 150000/m^2 and the distance to the supplier is 15.9 km.

Table 11. Final Results of Ranking Recommendations for Determination of Industrial Districts

Code	Sub - district	Weight	Rank
A1	Pamarayan	0.111	4
A2	Tunjung Teja	-0.227	7
A3	Bandung	0.041	5
A4	Binuang	0.02	6
A5	Tanara	0.15	3
A6	Anyar	0.171	2
A7	Tirtayasa	-0.094	8
A8	Cikeusal	0.193	1

7) Comparison Method

The author also made comparisons with other DSS methods, namely the AHP (Analytical Hierarchy Process) method. A comparison of methods is performed to find out which method the result is more in accordance with the needs of the source. After calculating with the AHP method, the final result of the role can be seen in table 12 and 13.

Table 12 shows that the six criteria in the AHP method have a relatively large range of weights, so it can be concluded that from these 6 criteria there is only one very influential criterion, and other criteria have less influence on the selection of industrial locations in Serang.

Table 12. Result of Criteria Weighted Coefficient (AHP)

Code of Criteria	w_i
K1	0.038
K2	0.110
K3	0.029
K4	0.140
K5	0.142
K6	0.540

Table 13. The Final Result of AHP Method Ranking

Code	Sub - district	Weight	Rank
A1	Pamarayan	0.186	2
A2	Tunjung Teja	0.284	1
A3	Bandung	0.174	3
A4	Binuang	0.083	6
A5	Tanara	0.088	5
A6	Anyar	0.127	4
A7	Tirtayasa	0.041	8
A8	Cikeusal	0.046	7

Table 13 show that the calculation of AHP method obtained the determination of the best industrial sub-district namely Tunjung Teja sub-district with a function value of 0.284. Where Tunjung Teja sub-district has a population density of 1092/km2, the area of land is 39.52/km2, the central distance of the district to the central district is 22 km, the productive life of 25,858 people, the land price is Rp 280,000/m2 and the distance to the supplier is 24.3 km.

From the results of interviews with interviewee suggest the determination of industrial sub-districts more optimally using DEMATEL-MABAC method. Because from the above data can be summed up as follows:

- For the population density in Cikeusal sub-district has a number that is not very dense but adequate compared to Tunjung Teja sub-district which has a fairly dense population density.
- For the area of land in Cikeusal sub-district has a wider area of land than Tunjung Teja sub-district
- For the central distance of the sub-district to the central district in Cikeusal sub-district has a closer distance than tunjung teja sub-district
- For the number of productive ages in Cikeusal sub-district has a higher productive age compared to Tunjung Teja sub-district
- For the distance to suppliers in Cikeusal sub-district has a closer distance than Tunjung Teja sub-district

This is what makes the interviewee suggest the DEMATEL-MABAC method rather than the AHP method, because the suitability of the final ranking results is more in accordance with the existing data (interviewee result).

8) Output of Application

After the user enters the assessment between the criteria and also the criteria with alternatives then obtained output weight criteria that can be seen in fig 1.

In Fig 1 shows the display of the DEMATEL method calculation process, on this page the user can see 4 results of the calculation process, namely matrix normalization, matrix T, matrix t_i, and weight criteria. Then on the criteria weight tab, the user can press the Get Weight button to get the criteria weight results from the calculation of the first method, the DEMATEL method. Furthermore, the user can press the Next button to continue the calculation to the second method, namely the MABAC method.

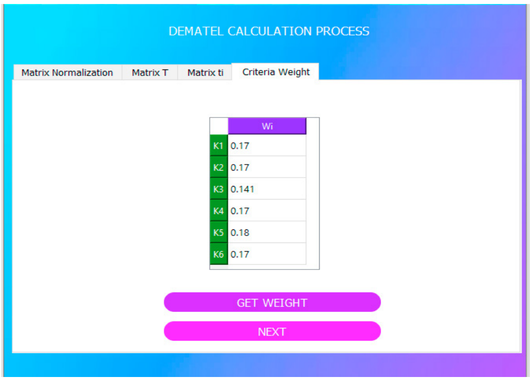

Fig. 1. Weight Criteria Output

After the weight gain, calculations will be performed for the next alternate role of the system will output ranking for the alternative and also the user can see the results based on the bar chart that can be seen in fig 3.

In Fig 2 and 3 shows a ranking page containing the name of the sub-district and the value of the criteria function with an alternative from the results of the calculation of the two methods, namely DEMATEL-MABAC, where the value of the function becomes a reference for the ranking of the sub-district, the higher the function value of a sub-district, the greater the chance of a sub-district to be an ideal solution. And the alternative rankings are sorted from the largest to the smallest function values.

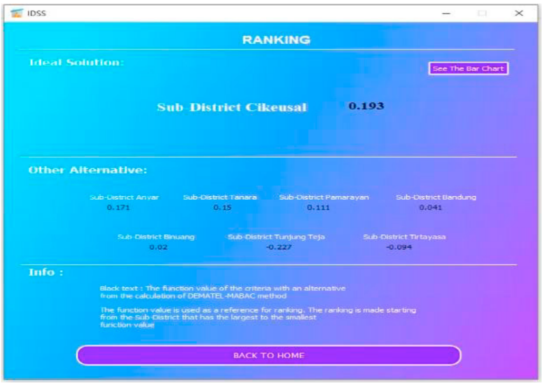

Fig 2. Alternative Ranking Output

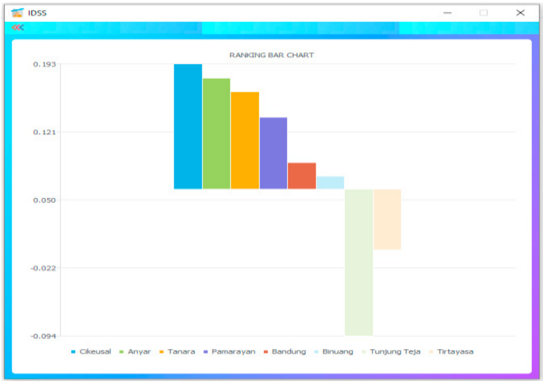

Fig 3. Alternative Rank Bar Chart Output

4. Conclusion

Based on the results of the analysis and discussion that has been done on this study, it can be drawn the following conclusions :

- The calculation of DEMATEL-MABAC method obtained recommendations for determining the best industrial location namely Cikeusal Sub-district with a function value of 0.193 and criteria that can influence the decision of determination of industrial location in Serang consists of 6 criteria namely population density, area of land area, central distance of district to the center of the district, number of productive lifespan, land price and distance to supplier with each weight value are 0.17, 0.17, 0.141, 0.17, 0.18, 0.17, where the six criteria have almost the same weight so that it can be concluded that all 6 criteria mutually reinforce each other.
- From the comparison of the methods carried out between DEMATEL-MABAC and AHP, the recommendations for determining different industrial districts are obtained, where AHP method, obtained the final result that the best sub-district that can be used as an industry is Tunjung Teja sub-district with a value of 0.284. However, the results from DEMATEL-MABAC are more in line with the needs required by the Interviewee and the weight of several criteria that have a large influence.
- The desktop application designed by the author meets the purpose of this paper. Where the application can solve problems in determining the location of the industry and can provide the best alternative recommendations from the 8 existing sub-districts. The applications is considered satisfactory enough for the user and can make it easier for the user to determine the best location of the industry.

For the development of further research is the addition of criteria and sub-criteria and expanded the scope of the sub-district from various districts so that it is not only in Serang Regency

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