Fuzzy Anp Method And Internal Business Perspective For Performance Measurement In Determining Strategy SMEs

1Yeni Kustiyahningsih, 2Eza Rahmanita, 3Jaka Purnama
1Information System, Faculty of Engineering, Trunojoyo University, Madura, Indonesia
2Informatic Engineering, Faculty of Engineering, Trunojoyo University, Madura, Indonesia
3Industrial Engineering, Department of Engineering, ITATS, Surabaya, Indonesia
e-mail: 1ykustiyahningsih@trunojoyo.ac.id

Abstract—Suramadu bridge is one of the transport Infrastructures that can provide social and economic growth opportunities, especially in Madura Island. Bangkalan Indonesia district is closest to longest bridge access. The number of SMEs (Small, and Medium Enterprises) in Bangkalan Indonesia reach more than 125 thousand units, it is possible and potential as an engine of regional economic growth as well as a reduction aspects of unemployment and poverty in the future. Therefore, one important factor Influencing the ongoing advancement of SMEs is a performance measurement. Performance measurement in this study is based on a perspective of the Balanced Scorecard is an internal business. Internal business consists of several indicators, namely Variation Batik, Raw Material Price Increase, Weather Conditions, Production, total manpower, the number of new products, Sales Transactions, Ownership (Shop). This indicator is measured using methods FANP (fuzzy analythic network process), while FANP is a comparison matrix phase, conversion to triangular fuzzy number, geometric mean calculation, synthetic extend calculation, determining the degree of likelihood, determining the weight vector and normalization. This research approach integrated internal business perspective and fuzzy Analytic Network Process (FANP). The results of this research is a priority weighting of assessment indicators of internal business perspective. Based on sensitivity testing, then obtained batik variety of criteria and new product be a major factor in determining the future strategy for batik persisted with emphasis on local knowledge area.

Keywords—fuzzy Analytic Network Process (FANP), indicators, performance measurement, internal business

INTRODUCTION

SME stands for Small and Medium Enterprises. SMEs are governed by Act No. 20 of 2008 on Micro, Small, and Medium Enterprises. The number of SMEs in Bangkalan Indonesia currently reaches more than 125 thousand units, it is possible and potential as an engine of regional economic growth as well as a reduction of unemployment and poverty aspects Bangkalan Indonesia area. The number of SMEs in Bangkalan Indonesia cause difficulties in determining the cooperative business strategies and factors that affect the progress of SMEs. Therefore it is necessary to measure the performance so that all SMEs to know what factors should be done for the development and progress of the business. In this performance measurement using the method of Fuzzy ANP and Balanced Scorecard Internal business perspective. FANP used for weighting indicators in performance measurement, while the internal business balanced scorecard is determine the classification indicator. Methods used Fuzzy ANP because it is based on the need for a fuzzy logic approach due to the complexity and obscurity, which is inherent in the nature of the concept of competition [1]. Fuzzy logic theory [2] stated that some thought the right principles to understand the complexity of the problem. The principle of fuzzy logic in two respects, the first the need to take one's decisions and judgments when the complex problems and not enough information to explain it, the second is a problem that requires people to think, feel and decide. The concept of competition including possible decisions and behavior as well as the future rival of the results of these decisions and behaviors. Innovation measurement is influenced by many factors, including the use of multiple criteria decision making [3] [4], their conflicting criteria [5]. Some studies assume the independence criteria, however, in the real world, most of the criteria are not mutually independent [5]. Mathematical methods for engineering evaluation with data envelopment analysis (DEA) [6], analytic hierarchy process (AHP) [7], fuzzy AHP [8], fuzzy goal programming [9], fuzzy analytic network process (ANP) [10]. All of these methods use the concept of multi-criteria decision making (MCDM) for the evaluation and selection of performance measurement. The performance measurement SME consists of many criteria (Multi Criteria Decision Making / MCDM). In this paper, using a balanced scorecard approach, with the associated advantages in its efforts to translate the organization's mission and strategy into four perspectives: the customer, the community and industry partners; Internal business;

learning and growth; business and finance [11] [12]. This research based on one perspective in BSC for performance measurement, namely Internal business. It is Consist of number of new products (NP), Satisfaction of employees (SE), Variation Batik (VB), Raw Material Price Increase, Weather Conditions (WC), Transaction Sales (TS), Production (P), and Total manpower (TM). The assessment criteria weighted by importance level of each questioner different criteria. One method that can be used to measure the weight of the criteria is the fuzzy Analytic Network Process (FANP). This method is used because of its use there is dependence and feedback among each criterion. Results of this research are the weight of each indicator SME for mapping the creative industries Bangkalan Indonesia district and determine a strategy of innovation for the development of SMEs in Bangkalan Indonesia.This paper is divided into five sections. In Section 1, the studied problem is introduced. Section 2 briefly describes the ANP method. In Section 3, fuzzy analytic network process (ANP) calculation for SME is presented and the stages of the proposed model and steps are determined in detail. How the proposed model is used in a real world example is explained in Section 4. In Section 5, conclusions and future research areas are discussed.

LITERATURE REVIEW

a. Analytic network process

The ANP is a generalization of the analytic hierarchy process (AHP) [13]. The level of relations in the ANP allows a mutual relationship complex between the decision levels and attributes. At the ANP approach, replacing the feedback relationship hierarchy (as in AHP) into a network of relationships in which the relationship between the levels is not easily represented as either higher or lower, dominant or subordinate, directly or indirectly [14]. For example, not only the importance of the criteria to determine the importance of alternatives, such as in the hierarchy, but also the importance of alternatives may have an impact on the importance of the criteria [13]. Therefore, the hierarchical structure is not suitable for complex systems.

There are many studies in the literature using ANP to solve decision making problems. ANP is used for multi-criteria decision making (MCDM) problems [12]. This research integrates the model of fuzzy MCDM (multicriteria Decision Making) by combining fuzzy Decision Making Trial and Evaluation Lab Model (DEMATEL), ANP (Analytic Network Process) and Technique for Order Preference by Similarity to Ideal

Solution (TOPSIS). This study aimed to evaluate the supplier in accordance with the specifications of the company, which GSCM (green supply chain management) as a framework to determine KPI (key performance areas) [16], KPI based on BSC for education [21], the following study her with the same old methods of using the third combination of methods FDAMATEL, FANP FTOPSIS for innovation and decision-making of higher education in Taiwan [15]. [14] Used ANP in two of their studies. In the first study, alternative projects for agile manufacturing are evaluated via ANP and logistics and supply chain management analysis is performed in the second. Also in two separate studies performed [17], ANP is used in the interdependent information system project selection process. Besides, [18] used ANP in quality function deployment process. ANP in R&D project selection problem, modeling the metrics of lean, agile and agile supply chain, analyzing alternatives in reverse logistics for end-of-life computers, respectively [19]. ANP is used by [20] for SWOT analysis and by [1] to determine faulty behavior risks in work systems.

b. Fuzzy Membership Function

Membership Function (MF) or the degree of membership is a curve showing the mapping point of data input into the value of membership. One way that can be used to obtain the membership value is through the approach function. The functions used in this study curve which is essentially a combination of two lines (linear) as shown in Figure 2.1.
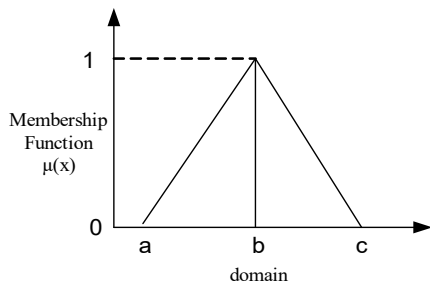

Fig 1. Triangular Fuzzy Number

Fuzzy Membership Function [1]

$$\mu(x) = \begin{cases} 0; & Otherwise \\ (x-a)/(b-a); & a \leq x \leq b \\ (c-x)/(c-b); & b \leq x \leq c \end{cases} \quad (1)$$

c. Fuzzy Analytical Network Process (FANP)

Fuzzy ANP method is applied for an extension of the AHP and ANP by combining the fuzzy set theory. In the ANP Fuzzy, Fuzzy ratio scale used to indicate the relative strength of the factors on which the relevant criteria. The fuzzy decision so that a matrix can be formed. Kahit of alternatives are also presented in the Figures Fuzzy [13]. Based Chang each object of each-each criterion and sub-criteria to be considered and extend the analysis to obtain a goal executed. This means it is possible to obtain the analysis which can extend the value indicated by the notation as follows [22, 23, 24].

$$M_{gi}^1, M_{gi}^2, M_{gi}^3, M_{gi}^4, M_{gi}^5 \ldots\ldots M_{gi}^m \quad (2)$$

Set as goal (1,2,3, ... m), and M_{gi}^j (j = 1,2,3, ... m) are triangular fuzzy (Triangular Fuzzy Number), after identifying initial assumptions, extend the analysis of Chang can be described with the following stages:
1. Development a pairwise comparison matrix between all the elements / criteria, sub-criteria of the fund each dimension criteria in a hierarchical system based on an assessment of linguistic variables.

$$A = \begin{bmatrix} & C_1 & C_2 & C_3 & . & C_n \\ C_1 & 1 & a_{12} & a_{13} & . & a_{1n} \\ C_2 & a_{21} & 1 & a_{23} & . & a_{2n} \\ C_3 & a_{31} & a_{32} & 1 & . & a_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C_n & a_{n1} & a_{n2} & a_{n3} & . & 1 \end{bmatrix}$$

Fig 2. Pairwise Comparison Matrix

Where
n = number of criteria to be evaluated
C_i = i. Criteria
A_{ij} = interests of i. criteria based j

2. Change the linguistic variables in the form of fuzzy numbers. Questionnaire data in the form of linguistic variables fuzzy numbers are converted to forms. TFN Chang fuzzy numbers to be seen (the scale of the fundamental interests of Relative ANP) with a different level of importance.

Table 1. Triangular fuzzy number (TFN) scale and linguistic variables scale conversion

Linguistic Scale	Values interest in AHP	TFN Scale	TFN inverse scale
Equally important	1	(1,1,1)	(1,1,1)
A little more important	3	(1,3,5)	(1/5,1/3,1/1)
More important	5	(3,5,7)	(1/7,1/5,1/3)
Very important	7	(5,7,9)	(1/9,1/7,1/5)
The most important	9	(7,9,11)	(1/11,1/9,1/7)

3. Enter the search criteria and the weighting formula contained in steps - steps as follows [25] :
a) Determining the value of synthetic extend (the) associated with the object to i then represented as follows

$$si = \sum_{j=1}^m M_{gi}^j \otimes \left[\sum_{j=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \quad (3)$$

To get this $M_{gi}^j \sum_{j-1}^m$ done adding fuzzy operation of m with particular matrix

$$\sum_{j=1}^m M_{gi}^j = \left[\sum_{j=1}^m L_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j \right] \quad (4)$$

To get $\left[\sum_{j=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1}$ surgery fuzzy value from (j = 1,2,3....m)

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = \left(\sum_{j=1}^n l_j, \sum_{i=1}^n m_j, \sum_{i=1}^n u_j \right) \quad (5)$$

At the end of the first step of the determinant of the inverse vector

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \right) \quad (6)$$

b) Determining the degree of likelihood (degree of possibility) and fuzzy set m2 = (l2, m2, u2) ≥ M1 = (L1, M1, U1) is defined as
V (m2 ≥ M1) = supy≥x [min (μm1 (x), μm2 (y))]
x and y is the value on the axis of each membership function. Applied to the theory and applications of fuzzy TFN with 3-type of low, medium and upper (l, m, u) and membership functions have been formed with the following equation :
V ($m_2 \geq m_1$) = hgt ($m_1 \cap m_2$) = $\lambda m_2(d)$

$$V(m_2 \geq m_1) = \begin{cases} 1, & \\ 0, & if\ m_2 \geq m_1 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & if\ l_1 \geq u_2 \\ & otherwise \end{cases} \quad ..(7)$$

c) Determining the degree of likelihood for Confex fuzzy number is greater than k at Confex fuzzy number for Mi = (i = 1,2..k) can be defined as:
V = (M ≥ M1, M2 .... Mk)
    = V [(M ≥ M1)] and [M ≥ M2] and (M ≥ Mk)]
V = min (M ≥ Mi)
It is assumed that d` = min V (Si ≥ Sk)
For k = 1,2, ..., n k ≠ i then the weight vector used

W` = (d` (Ai), d` (A2), d` (A3), ..., d` (An)) T
Where Ai (i = 1,2,3, ..., n) is an element n

4. Through normalization, weighting vector normalization

W` = (d (A1), d (A2), ..., d (An)) T
Where we are nonfuzzy numbers.

5. Determination of global sub-criteria weights matrix by multiplying matrix interdependence with WT2 (weighted sub-criteria)

6. Measurement of sub-criteria using linguistic variables by multiplying the weight of global (global weight) with a value scale (scale value) each sub-criteria.

7. Consistency test is done by looking at the value of l, m and u. Value $l \leq m \leq u$ shows fuzzy consistent ratings. Fuzzy comparison matrix that consists of two dimensions, consistency index are always consistent

d. Balanced Scorecard

Balanced Scorecard is a management tool that consists of a series measurements that can provide a quick but thorough overview of the organization's performance in terms of both financial and non-financial [26]. The Balanced Scorecard is a set performance and approach to performance measurement that stresses meeting all the organization's objectives relating to its critical success factors. Framework of the balanced scorecard is divided into four perspectives: customer, internal business, learning and growth, financial. (Figure 2.3.) as follows [11,12].
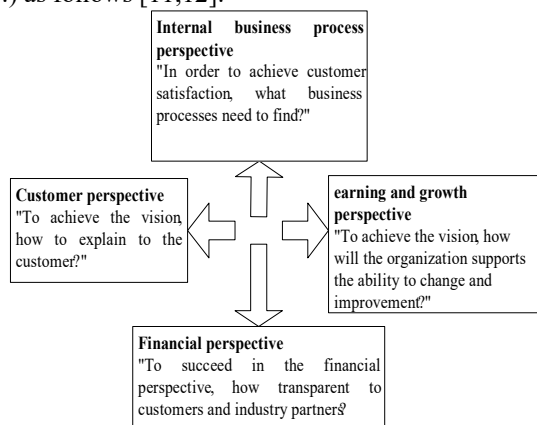

Fig 3. Balanced scorecard framework [11]

RESEARCH METHODS

This section discusses: the description of the system, needs analysis, analysis of input, output analysis, system design, and structure of the table that will be used to build a decision support system using the method FANP.

a. Description System

This system provides an assessment of the feasibility of priority based on weight, rank, and value using methods FANP. The system contained three questionnaires, namely the interest scale questionnaires and questionnaires linkages between the criteria required by the owners of SMEs and Cooperatives and SMEs Bangkalan Indonesia whereas risk assessment questionnaire standards set by the Department of Cooperatives and SMEs Bangkalan Indonesia. Then the results of the questionnaire will be processed to determine the criteria that affect the measurement of performance of SMEs.

b. Analysis of needs

In the process of designing the support system assessment decision SME performance is required among other things that the Hardware (Hardware), Software (Software), Data (data used is data questionnaire distributed to some SMEs in Bangkalan Indonesia), Score questionnaire , determine weights.
Criteria to be searched Weighs:
- The number of new products (NP)

- The satisfaction of employees (SE)
- Variation Batik (VB)
- Raw Material Price Increase (MP)
- Weather Conditions (WC)
- Transaction Sales (TS)
- Production (P)
- Total manpower (TM)
- Quality batik Cloth (QB)
- Process of making batik (MB)

The structure of ANP (Analytic Network Process) on SMEs 1, For the structure of the ANP (Analytic Network Process) on SMEs 1 can be seen in Figure 3.1.

c. Output analysis

In making this software in getting the following output:

1. Information database list of criteria in SMEs.
2. Weighting FANP dynamically through a method in which small business owners can switch the input comparison between consistent criteria.
3. Linkage criteria dynamically through FANP method in which SMEs can change the input linkages between criteria.
4. The final result in the form of priority criteria of the highest score to lowest.

d. Design

The purpose of this system design is to model the user needs based on analysis of system requirements. System design approach used in this study Flowchart, use case and activity diagrams and so forth. To flowchart can be seen in the picture 3.2.below
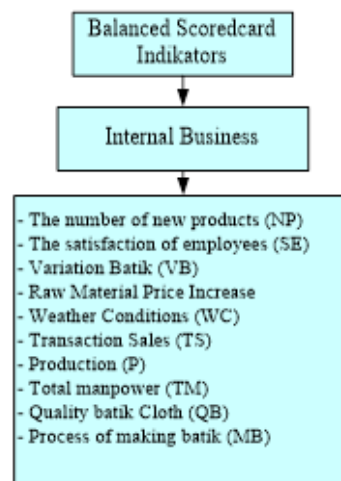

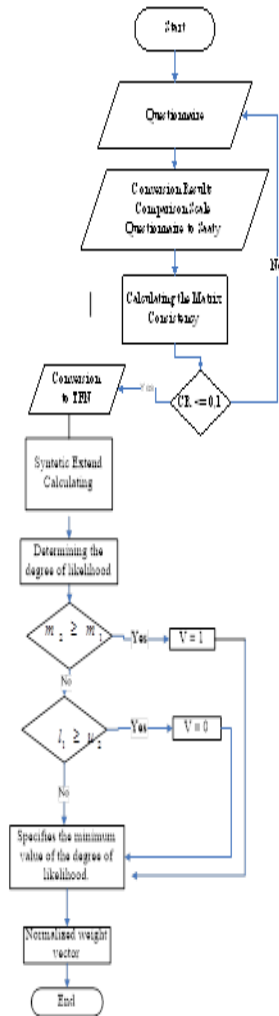Fig 4. Balanced Scorecard Criteria's with Internal Business

Fig 5. Flowchart fuzzy ANP

RESULTS AND DISCUSSION

a. Calculating Weight and Rangking

FANP calculation method. The initial step is to determine the weighting of each criterion alternatives through questionnaires owner. The rules and questionnaires pairwise comparisons interests of owners of SMEs who serves as an expert is as follows at Table 4.1. Level of importance ratings each alternative on criteria

Table 2. Level of importance ratings

Level of importance	Information
1	equally important
3	A little more important
5	More important
7	Very important
9	The most important

The following steps Weighting Calculation of SMEs :
1. Pairwise Comparison specify criteria as shown in Table 4.2.

Table 3. Pairwise comparison

Criteria	NP	SE	WC	MP	VB	TS	P	TM	QB	MB
NP	1	5	3	1		1	1	3	3	1
SE		1						3	3	
WC		3	1			3			3	
MP		5	7	1		7		5	5	5
VB	3	5	5	1	1	3		3	3	3
TS		3				1		3	5	
P		7	7	1	1	5	1	3	3	
TM			1					1		
QB							1		1	
MB		5	7			5	5	3	1	1

2. Determining Triangular Fuzzy Number to obtain the value of Lower (L), Middle (M), Upper (U).
3. Synthetic Extend determine the value of L, M, and U (Value of Si Based on Equation 3) as in table 4.3

Table 4. Value Synthectic Extend L, M and N

	L	M	U
NP	0,041	0,103	0,244
SE	0,014	0,046	0,126
WC	0,021	0,064	0,165
MP	0,096	0,202	0,435
VB	0,052	0,149	0,366
TS	0,029	0,076	0,190
P	0,071	0,155	0,343
TM	0,016	0,028	0,081
QB	0,016	0,027	0,075
MB	0,067	0,152	0,343

4. Possible values calculate the degree of Synthetic Extend Accordance Equation (6)
5. Specifies the minimum value of the degree of likelihood according Equation (7)
6. Determining Weight Vectors
7. Determining the normalization Weight Vector
8. Determining the relationship between the criteria to each other, if the value is 1 then there is a link, while a value of 0 then there is no linkage
9. If there is a link between the criteria with each other then multiplied by the questionnaire scale of interest
10. Normalization linkage, Between the weight vector matrix multiplication normalized
11. Results weights

Table 5. weighting criteria

Criteria	Weight
NP	0,119
SE	0,033
WC	0,066
MP	0,062
VB	0,133
TS	0,085
P	0,301
TM	0,023
QB	0,071
MB	0,107

Based on Figure 4.3. shown that the weighting criteria that most affect the determination of the SME strategy is a new product and the variations of batik. This is because it has the weight of the highest among other criteria, namely 0.133 and 0.119

b. Sensitivity Analysis

Sensitivity testing is a test for measuring the change in the value of ranking priorities if the weights do value the combination means the value of sensitivity to change the ranking order of performance of SMEs are flexible if priority is modified. Each criterion was changed value of its weight in order to see changes that occur. Combination of sensitivity test weights can be seen on the table 4.4. The table shows that the blue box as the weight of the highest criteria of each combination weights.

There were five SMEs will be in the trial, based on analysis of test sensitivity in Table 4.4., It can be seen that if the weight criterion highest on variations of batik SMEs 2 has the best-performing high, if Weather Conditions (WC) has the most weight higher performing is SMEs 4, whereas if the weight of the fabric quality batik SMEs palin steeper 5, which has a top ranking

themselves. So based on this information it can be given the results of the SME strategy is based on the level of performance.

Table 6. Combination weight sensitifitas tes

Weight	NP	SE	WC	MP	VB	TS	P	TM	QB	MB
I	0,12	0,03	0,07	0,06	0,13	0,09	0,30	0,02	0,07	0,11
II	0,03	0,07	0,06	0,13	0,09	0,30	0,02	0,07	0,11	0,12
III	0,07	0,06	0,13	0,09	0,30	0,02	0,07	0,11	0,12	0,03
IV	0,06	0,13	0,09	0,30	0,02	0,07	0,11	0,12	0,03	0,07
V	0,13	0,09	0,30	0,02	0,07	0,11	0,12	0,03	0,07	0,06
VI	0,09	0,30	0,02	0,07	0,11	0,12	0,03	0,07	0,06	0,13
V	0,30	0,02	0,07	0,11	0,12	0,03	0,07	0,06	0,13	0,09
VI	0,02	0,07	0,11	0,12	0,03	0,07	0,06	0,13	0,09	0,30
V	0,07	0,11	0,12	0,03	0,07	0,06	0,13	0,09	0,30	0,02
VI	0,11	0,12	0,03	0,07	0,06	0,13	0,09	0,30	0,02	

c. Implementation

Implementation program is a process that must be done to determine the performance of the system that has been created. Form that will be found first when the program starts is the main form. This form is to see where the users take advantage of their privileged access to a wide range of options. Admin and SME owners can use the menu to login first to get into the control system in accordance the respective category (figure 4.1). Shown that following user data entry form to add user data, storing user data, while the display menu overall is the homepage, change passwords, criteria, sub-criteria, user data, the data of SMEs, weighting criteria, and others.
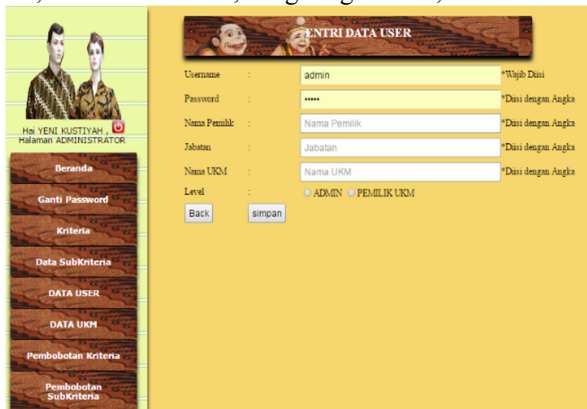

Fig 6. Menu form "Entry Data User"

CONCLUSIONS AND FUTURE RESEARCH

Based on this study it can be concluded that the measurement of the performance of SMEs using the method FANP produce better weight, because in this method there assessment criteria based on the level of interest and the current ratio it should be less than 10% and by using fuzzy hence the decision to have a consensus that high, because any individual can assign a value to each criterion. From the test results on the performance appraisal scale SMEs with different interests and also the relationship between the different criteria that performance appraisal obtained from a scale of high importance and there are many linkages between criteria. Factors affecting the highest risk in that on a variety of criteria UKM1 batik is 0.12. Interval Fuzzy ANP, using the interval method is more efficient in computation and results. Suggestions for improvement of this research is using fuzzy weighting method by Fuzzy Interval ANP, use to the interval method is more efficient in computation and result.

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