The SME performance recommendation system facing the 4.0 industrial revolution uses the Fuzzy ANP method

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Abstract. Madura is one of the regions in East Java Province whose economy is supported by the SME sector. Industrial Revolution 4.0, this refers to the concept of using the internet for various things, as well as cloud-based and smart manufacturing. The agency has difficulty in identifying needs of Batik UKM, so a performance recommendation model for Batik SMEs is needed to assist Dinas and UKM players in making decisions to determine the performance improvement of Batik SMEs. The purpose of this study is to determine recommendations by measuring the performance of MSMEs in facing the industrial revolution 4.0. This performance measurement is based on 9 indicators, namely Employee Training or SME owners, Number of Batik Motif Variations, Number of Consumers, Product Brands or Branding, Owner Education, Number of Information Technology Certified Employees, Owning a Markerplace, Online Marketing, and Online Payment. The method used in this research is the FANP method. Fuzzy has excellent performance, the decision-making process is more flexible, and is able to handle data that contains uncertainty and inaccuracy by making decisions based on many criteria. The advantage of ANP is that there is dependence and feedback between each criterion, so that all criteria are calculated proportionally. The results of this study are the weighting of priority indicators on all indicators that affect the industrial revolution 4.0. Based on the research and consistency ratio tests, the main indicators needed for SMEs in Bangkalan Madura to face the industrial revolution 4.0 are marketplace, online marketing and information technology certified employees.

1. Introduction
Small and Medium Enterprises (SME) is a business sector that is described as a sector that has an important role and able to survive multi-dimensional crisis in 1998 and global crisis in 2008. UKM is also an instrument to increase the people's welfare that is effective and sustainable (sustainability), and will always be the main political issue in attracting popular support. The MSME sector contributes 99.99% of all existing businesses, employs 97.16% of the private sector workforce, and contributes 57.5% to Indonesia's Gross Domestic Product\cite{1,2}. The existence of Batik SMEs in Bangkalan Madura district makes a positive contribution to the economy as well as a solution to alleviating economic and social problems. Entering the era of the Industrial Revolution 4.0 refers to the concept of using the internet of things, as well as smart and cloud based manufacturing, which has an impact on SMEs as builders of the economic sector. Empowering SMEs is one of Indonesia's top priorities in facing the industrial revolution 4.0. The main obstacles for batik SMEs in Bangkalan Madura in facing the 4.0 revolution are capital, managerial skills, and the use of technology.
Various government program efforts (Department of Cooperatives and SME Bangkalan) in assisting Batik SMEs in Bangkalan are through technology training programs, certification, business credit assistance, and product innovation exhibitions. These work programs are often not on target and less than optimal, because of the large number of Batik SMEs in Bangkalan. Many indicators are qualitative in nature (some indicators are unclear and imprecise), making it difficult for the agency to measure overall performance. The SME Office also has difficulty in identifying the needs of each SME so that a recommendation model for the performance of Batik SME is needed in determining the performance improvement and the SME system. This performance measurement is based on 9 indicators, namely Employee Training / SME owner per year, Number of Batik Motif Variations, Number of Online / Offline Consumers, Brand or Product Branding, Owner Education, Number of Information Technology Certified Employees, Owning a marketplace, online marketing, online payment, and has a Batik e-commerce Information System. The method used in this research is the FANP method. The FANP method is one of the Fuzzy Multi Criteria Decision Making (FMCDM) methods. Fuzzy has excellent performance, the decision-making process is more flexible, and is able to handle data that contains uncertainty and inaccuracy by making decisions based on many criteria. The advantages of ANP are that there is dependence and feedback between each criterion, so that all criteria are calculated proportionally.

Fuzzy has excellent performance, the decision-making process is more flexible, and is able to handle data that contains uncertainty and inaccuracy by making decisions based on many criteria\[3,4\]. Criteria are weighted based on an assessment of the level of importance and the network (network) or the relationship between criteria. The advantages of ANP are that there is dependence and feedback between each criterion, so that all criteria are calculated proportionally\[5,6\]. FANP is a development of the AHP method and has the ability to measure qualitative and quantitative indicators by comparing priority weights between indicators\[7\]. The use of a consistency index in the ANP method is used to control the error rate in decision making. The concept of index consistency in FANP is used to measure the performance of SME in Bangkalan\[8\]. Fuzzy logic techniques are very effective in dealing with the uncertainty of reasoning in making decisions based on the variables used\[9\]. Based on previous research, there is no smallest error control in decision making so that the level of objectivity in decision making is low. The contribution of this research is that the adaptive FANP method is used to dynamically weight all performance indicators of SME of Batik, which means that the indicator weight is determined based on the smallest consistency ratio (error rate) so that the recommendation for improvement is optimal performance and right on target. This research produces a recommendation model for SME performance with the main indicators needed by SME’s Bangkalan Madura in the face of the industrial revolution 4.0.

2. Research Methods

The research method of the SME performance recommendation system model has several stages that need to be prepared in order to produce a system capable of achieving goals as a decision making system in recommending SME performance according to the needs of each SME of Batik. The dataset used in this study is questionnaire data for 100 SME players of Batik, Bangkalan, Madura. The research method is the whole research stage to answer the problems contained in the introductory chapter. This research begins with a preliminary study of the performance recommendation model of SME of Batik, Bangkalan Regency. The stages of this research as a whole can be seen in Figure 1. While the ANP relative importance fundamental scale with different levels of importance, can be seen in Table 1. And the variables used are in the form of criteria, alternatives, assessors and respondents data.
Figure 1. Flowchart of the FANP process for the SME performance recommendation system in entering the industrial revolution 4.0.

Table 1. Triangular Fuzzy Number (TFN) scale and linguistic variables scale conversion.

| Linguistic Scale            | Values interest | TFNScale   | 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)    |

The FANP method is a combination of the Fuzzy and ANP methods. The ANP method is a development of the AHP method. The AHP concept is developed from the AHP theory which is based on the interdependence relationship between several components, so that AHP is a special form in ANP[10, 11]. Basically, FANP uses fuzzy ratios to replace the exact ratio of ANP in determining decision maker preferences. The steps of FANP method in decision making are as follows [12]: (a) Determining the paired matrix comparison value as in Table 1, (b) Determining the membership function of each criterion, (c) calculating the average matrix, (d) calculate the consistency value of the matrix. The membership function is a curve showing the mapping of input data points into their membership value (degree of membership) which has an interval of 0 to 1 [13,14]. To determine the priority arrangement of elements, the first step is to compile pairwise comparisons, namely comparing all the elements in related clusters in pairs. The purpose of determining the priority order of elements is to convert the criteria scale values as a basis for consistent pairwise comparison[15, 16]. This study proposes the FANP method, because this method is better than the AHP method, where the FANP method has the advantage of a simple concept and a deeper synthesis of the factors or decision criteria[17, 18]. Network in the ANP method describes a hierarchy of levels and feedback with the problems faced and the decisions to be taken [19, 20, 21]. Performance recommendation model system for Batik Bangkalan UMKM can increase productivity using the FANP method.

Therefore, several stages of modeling SMEs recommendations using FANP method are as follows: Determine the recommended indicators of SME, This stage is to determine recommendations for measuring the performance of MSMEs in the face of the industrial revolution 4.0. This performance measurement is based on 9 indicators, namely Annual Training for SME Employees / Owners, Number of Batik Motif Variations, Number of Online / Offline Consumers, Brand or Product Branding, Owner Education, Number of Information Technology Certified Employees, Owning a marketplace, online marketing, online payment, and has a Batik e-commerce Information System. Calculating the paired matrix comparison between criteria based on the assessment of the Department
of Cooperatives and SME Bangkalan. This stage is to compile a pairwise comparison matrix among all criteria, sub-criteria of each criterion based on the assessment with linguistic variables.

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

(1)

Calculating the Consistency Ratio (CR), if CR <= 0, then the matrix is consistent and continues to the next step, otherwise the paired matrix comparison assessment will be carried out. Calculating the conversion of paired matrices into triangular fuzzy scale, Converting linguistic variables in the form of fuzzy numbers. Questionnaire data in the form of linguistic variables are converted into fuzzy numbers. The fuzzy number for the Chang TFN appears (ANP Relative importance fundamental scale) with different importance levels. Calculating the value of synthetic extend (si) associated with the object to i then represented, among others:

\[
si = \sum_{j=1}^{m} M_{gi}^j \otimes \left[ \sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1}
\]  

(2)

To obtain \( \sum_{i=1}^{n} M_{gi}^j \) do the fuzzy addition operation of m with a particular matrix

\[
\sum_{i=1}^{m} M_{gi}^j = \left[ \sum_{i=1}^{m} l_j, \sum_{i=1}^{m} m_j, \sum_{i=1}^{m} u_j \right]
\]  

(3)

Then to get \( \left[ \sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} \) the inverse of the vector determinant

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

(4)

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

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

(5)

Calculating the degree of possibility and fuzzy sets \( m_2 = (l_2, m_2, u_2) \geq M_i = (l_1, M_1, U_1) \)

Calculating the degree of possibility for the confex fuzzy number greater than \( k \) in the fuzzy number confex form for \( M_i = (i=1,2,..k) \) can be defined as:

\[
V = (M \geq M_1, M_2\ldots M_k)
\]  

(6)

\[
= V [(M \geq M_1) \] and \([M \geq M_2 \) and \( \ldots \) and \( M \geq M_k)\]

(7)

\[
= \min V (M \geq M_i)
\]  

(8)

It is assumed that \( d = \min V (Si \geq Sk) \)

To \( k = 1,2,\ldots, n \) \( k \neq i \) then the weight vector is used

\[
W = (d (A_1), d (A_2), d_1 (A_3), \ldots, d (A_n))^T
\]  

(9)

where \( A_i (i = 1,2,3,\ldots, n) \) is an element of \( n \)

Through normalization, vector weights are normalized

\[
W^* = (d (A_1), d (A_2), \ldots, d (A_n))^T
\]  

(10)

where \( w \) is A non-fuzzy number

Making ANP method hierarchical structure. The ANP network model structure is based on the inner dependence relationship between sub-criteria and one criterion, while the independent relationship between criteria and between sub-criteria, Normalization of criteria and Multiplying the matrix between the criteria weights and the normalized weights

3. Results And Discussion

This stage is the steps for solving problems in the SME performance recommendation system based on industry 4.0 in accordance with the design and analysis of system requirements. The SME performance recommendation model that will be made in accordance with the conditions of the Batik SMEs in Bangkalan Madura using the FANP method to increase the productivity and performance of SMEs. Recommended indicators consist of 9 indicators, namely Employee Training or SME owners
per year, Number of Batik Motif Variations, Number of Online or Offline Consumers, Product Brands or Branding, Owner Education, Number of Information Technology Certified Employees, Owning a Marketplace, Online Marketing, and Online Payment at Figure 2. At the testing stage and algorithm performance analysis is to use the consistency index of the assessment criteria with an error rate of ≤ 0.1.

![Figure 2. Indicators for measuring MSME industrial revolution 4.0.](image)

**Table 2.** Criteria pairwise comparison matrix.

| Criteria          | K1     | K2     | K3     | K4     | K5     | K6     | K7     | K8     | K9     |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| K1                | 1      | 1      | 3      | 5      | 7      | 9      | 7      | 5      | 3      |
| K2                | 1.00   | 1      | 1      | 3      | 5      | 7      | 5      | 7      | 3      |
| K3                | 0.33   | 1.00   | 1      | 1      | 3      | 7      | 3      | 1      | 5      |
| K4                | 0.20   | 0.33   | 1      | 1      | 1      | 5      | 5      | 3      | 7      |
| K5                | 0.14   | 0.2    | 0.33   | 1      | 1      | 3      | 1      | 5      | 5      |
| K6                | 0.11   | 0.14   | 0.14   | 0.2    | 0.33   | 1.00   | 3      | 5      | 3      |
| K7                | 0.14   | 0.2    | 0.33   | 0.2    | 1      | 0.33   | 1      | 3      | 3      |
| K8                | 0.2    | 0.14   | 1      | 0.33   | 0.2    | 0.20   | 0.33   | 1      | 1      |
| K9                | 0.33   | 0.33   | 0.2    | 0.14   | 0.2    | 0.33   | 0.33   | 1      | 1      |

Table 1 is a comparison matrix of UKM criteria, this matrix is filled using the comparison of the level of importance of the criteria. The assessor of the level of importance of this criterion is the UMKM Cooperative Office, Bangkalan Regency.

**Table 3.** The degree of possibility of each criterion.

|       | Low  | Middle | Upper |       | Low  | Middle | Upper |
|-------|------|--------|-------|-------|------|--------|-------|
| K1    | 0.069| 0.150  | 0.322 | K5    | 0.039| 0.087  | 0.192 |
| K2    | 0.047| 0.109  | 0.239 | K6    | 0.036| 0.088  | 0.202 |
| K3    | 0.049| 0.112  | 0.248 | K7    | 0.018| 0.057  | 0.148 |
| K4    | 0.044| 0.105  | 0.237 | K8    | 0.027| 0.055  | 0.121 |
| K9    | 0.026| 0.064  | 0.156 |       |      |        |       |

Table 2 is the value of the degree of likelihood for each criterion, the value is determined based on the weight of the synthetic extend (si) vector, each sub-criterion is calculated as lower, middle and upper in each of its fuzzy intervals. After calculating the level of probability, proceed with calculating and determining the minimum value of the degree of possible sub-criteria, as below:
Minimum degrees possible criteria

\[ D'(k_1) = \min (1,1,1,1,1,1,1,1,1)=1 \]

\[ D'(k_2) = \min (0.8669,1,1,1,1,1,1,1,1)=0.8669 \]

\[ D'(k_3) = \min (0.6179,0.7636,0.9232,1,1,1,1,1,1)=0.6179 \]

\[ D'(k_4) = \min (0.7136,0.8515,1,1,1,1,1,1,1)=0.7136 \]

\[ D'(k_5) = \min (0.5785,0.7229,0.9571,0.8816,1,1,1,1,1)=0.5785 \]

\[ D'(k_6) = \min (0.4221,0.5632,0.7917,0.7204,0.8364,1,1,1,1)=0.4221 \]

\[ D'(k_7) = \min (0.1343,0.2786,0.5161,0.4470,0.5705,0.7712,1,1,1)=0.1343 \]

\[ D'(k_8) = \min (0.341,0.0666,0.2971,0.2363,0.3584,0.5866,0.8290,0.8995,1)=0.341 \]

\[ D'(k_9) = \min (0.0518,0.1946,0.4299,0.3637,0.4868,0.6975,0.9311,1,1)=0.0518 \]

**Table 4.** The final weight of each criterion.

| Criteria | Final Weight | Criteria | Final Weight |
|----------|--------------|----------|--------------|
| K1       | 0.2143       | K5       | 0.1320       |
| K2       | 0.1981       | K6       | 0.2146       |
| K3       | 0.1407       | K7       | 0.2306       |
| K4       | 0.1614       | K8       | 0.2210       |
|          |              | K9       | 0.0117       |

Based on Table 3, the final weight of each criterion is \( K1 = 0.21 \) \( K2 = 0.1981 \), and the 3 highest weights are \( K7, K8 \) and \( K6 \). The three indicators are that SMEs have a marketplace, have online marketing and the number of certified employees. Based on sensitivity testing, marketplace indicators, online marketing and information technology certified employees are obtained as main indicators needed by SMEs in Bangkalan Madura in the face of industrial revolution 4.

**4. Conclusion**

The recommended model for performance of SMEs in facing the industrial revolution 4.0 using the Fuzzy ANP method contributes to the main indicators needed by SMEs in Bangkalan Batik. The main indicators are marketplace, online marketing and information technology certified employees. The results of the FANP method use an index consistency or error rate of less than 0.1, the final weight of each indicator is \( K1 = 0.214, K2 = 0.1981, K3 = 0.1407, K4 = 0.1614, K5 = 0.1320, K6 = 0.2146, K7 = 0.2306, K8 = 0.2210, \) and \( K9 = 0.0117 \). This system can assist SME Services and Batik SMEs in increasing the productivity of batik production and identifying the main needs of SMEs. Further research can be developed using different indicators and a hybrid of FANP method with weighting using OWA, AHP, and interval based.

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