IOP Conf. Series: Materials Science and Engineering **336** (2018) 012023 doi:10.1088/1757-899X/336/1/012023

Model Multi Criteria Decision Making with Fuzzy ANP Method for Performance Measurement Small Medium Enterprise (SME)

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Abstract. SMEs have a very important role in the development of the economy in Indonesia. SMEs assist the government in terms of creating new jobs and can support household income. The number of SMEs in Madura and the number of measurement indicators in the SME mapping so that it requires a method.This research uses Fuzzy Analytic Network Process (FANP) method for performance measurement SME. The FANP method can handle data that contains uncertainty. There is consistency index in determining decisions. Performance measurement in this study is based on a perspective of the Balanced Scorecard. This research approach integrated internal business perspective, learning, and growth perspective and fuzzy Analytic Network Process (FANP). The results of this research areframework a priority weighting of assessment indicators SME.

1. Introduction

Currently, the number of SMEs in the city of Bangkalan Madura reached more than 125 thousand units. SMEs provide opportunities for economic growth, reduced unemployment, and poverty. It absorbs approximately 79.04 million workers or 99.4% of the total workforce (Bank Indonesia, 2006). SME productivity is also an important factor affecting the progress of SMEs, increasing the income of the community, and play a role in realizing national stability.There are many indicators or criteria in determining performance measurement and business strategic plan, so it takes a decision-making method many criteria. The method used in this research is Fuzzy Multi Criteria Decision Making (FMCDM). Fuzzy Method Multi-criteria is a method used to determine the criteria weighting of several alternatives based on one's assessment.

Fuzzy Multi Criteria Decision Making (FMCDM)method used in this research is Fuzzy Analytical Network Process (FANP). Analytic Network Process Method (ANP) is a method that can represent the importance of various parties by considering the interconnection between existing criteria and sub-criteria [1][2]. ANP is a development of AHP, has a more complex system of analysis and the consistency of index in the assessment of questioner [3]. Previous research has been done performance measurement according to indicator contained in balance Scorecard [3]. In this study more detail about the measurement of risk to SMEs. There are several performance assessment criteria: employee training, owner education, owner training, net income, sales transactions, ownership (shop), variations of batik motive, employee maturity, buyer satisfaction, preferred motives, raw material price

increases, weather conditions, production. There are difficulties during qualitative performance measurements such as preferred motives, weather conditions, and others. In measuring qualitative factors using fuzzy numbers make decisions easier and get more realistic results [4].

This research, FANP method is used to determine the best criteria and decision-making based on the existing criteria, both qualitative and quantitative. The use of Fuzzy in this study to accommodate the vague nature of decision-making by giving consideration that can overcome the uncertainty in qualitative criteria [4] [5].

2. Research Method

2.1. Fuzzy Theory

Fuzzy theory is used to overcome uncertainty due to imprecision and vagueness. Fuzzy contributed his ability to represent vague data[6]. The set is marked by a membership function (characteristic), which assigns each object a membership value ranging between zero and one [7]. A triangular fuzzy number(TFN), x is shown in Fig. 2.1. A TFN is denoted simply as (l/m, m/u) or (l, m, u). The parameters l, m and u, respectively, denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event. Membership Function (MF) or the degree of membership is a curve showing the mapping point of data input into the value of membership.

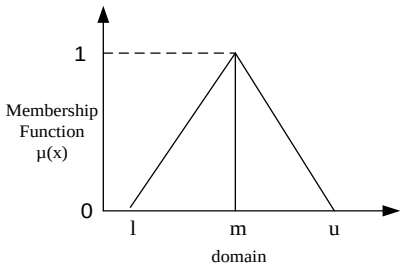

Figure 1. Triangular Fuzzy Number

Fuzzy Membership Function [4]

$$\mu(x) = \begin{cases} 0; & Otherwise \\ (x-l)/(\mathrm{m}-l); & l \le x \le m \\ (\mathrm{u}-x)/(\mathrm{u}-m); & m \le x \le u \end{cases} \quad (1)$$

2.2. 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 [8]. Based Chang each object of 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 [9].

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

Set asa goal (1,2,3,…,m), and M_{gi}^{j} (j= 1,2,3,...,m) areTriangular Fuzzy Number, after identifying initial assumptions, extend the analysis of Chang can be described with the following stages:

1. Decision Modeling with fuzzy ANP by specifying criteria and sub-criteria.

2. Development B 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.

$$B = \begin{bmatrix} & C_1 & C_2 & C_3 & \dots & C_n \\ C_1 & 1 & b_{12} & b_{13} & \dots & b_{1n} \\ C_2 & b_{21} & 1 & b_{23} & \dots & b_{2n} \\ C_3 & b_{31} & b_{32} & 1 & \dots & b_{3n} \\ \text{M} & \text{M} & \text{M} & \text{M} & \text{M} & \text{M} \\ C_n & b_{n1} & b_{n2} & b_{n3} & \dots & 1 \end{bmatrix}$$

Figure 2. Pairwise Comparison Matrix

Where
n = number of criteria to be evaluated
Ci = i. Criteria
bij = interests of i. criteria based j

3. Normalization Matrix, determine the consistency value of the index, if Consistency Ratio (CR) <= 0.1 then proceed to step number 4, otherwise it will be re-questioner.
4. 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	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)

5. Enter the search criteria and the weighting formula contained in steps as follows [9,10] :
   a. Determining the value of synthetic extend (the) associated with the object to i then represented as follows

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

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

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

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)

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

At the end of the first step of the determinant of the inverse vector $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right)$ (6)

b. Determining the degree of likelihood (degree of possibility) and fuzzy set m2 = (l2, m2, u2) ≥ M1 = (L1, M1, U1) is defined as

$$V\ (m2 \geq M1) = \sup y \geq x\ [\min\ (\mu m1\ (x), \mu m2\ (y))]$$

x and y are 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 :

$V\ (m_2 \geq m_1) = hgt\ (m_1 \cap m_2) = \lambda\, m_2(d)$

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

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

b. Through normalization, weighting vector normalization
W` = (d (A1), d (A2), ..., d (An)) T
Where we are nonfuzzy numbers.

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

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

e. 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.

f. Hitung Bobot akhir Kriteria

g. Jika bobot tidak sesuai maka dapat dilakukan looping lagi dengan menentukan skala dan kuisioner ulang.

Framework model for measurement of the SME is provided in Fig. 2.3.

3. Results and Analysis

This stage consists of modeling, simulation, and analysis of results. The modeling stage is theidentification of MCDM problems by determining the number of variables to be used in the study (criteria, alternatives, and respondents) as shown in Figure 3.1. Standard indicator this stage will be made the network structure of the criteria of measurement with the concept of multi-criteria and a decision maker. Some of the measurement indicators of SME in this study are determined based on

integrated internal business perspective, learning and growth perspective [11]. The next stage is Simulation and Analysis. Based on the framework model, the simulation and analysis of the model have been made based on existing indicators in SME. This is done to determine the optimal solution in decision-making and the smallest threshold value to determine the recommendation of Strategy map SME, SWOT, and clustering SME.

The stages of the simulation of this research program is

1. Doing questioners to some expert people to determine the comparative matrix assessment.
2. Calculating the consistency matrix of pairwise matrices, if the consistency ratio (threshold) is less than 0.1 then the matrix is considered consistent.
3. Determining the linguistic scale by using TFN.
4. Conversion scale TFN
5. Synthetic Extend Calculate
6. Normalize Criteria Weight
7. Perform an iteration to determine the criteria weights with different scales
8. Determine the final weight.

Based on results from table 1. Pairwise Comparison and table 2. Criteria Weight, the authors conclude that the most influential weights on the progress of SMEs are the number of production (0.902) and the weather (0.534).

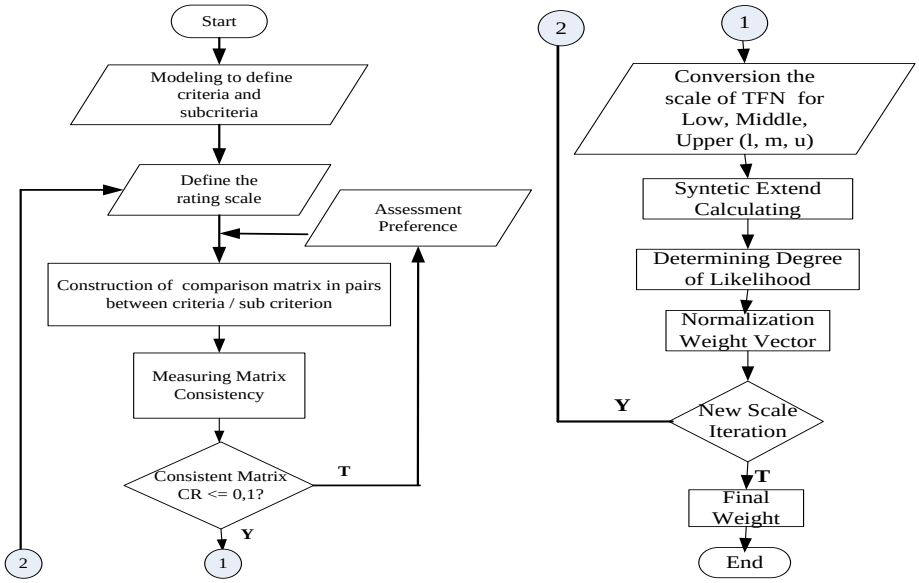

Figure 3. Framework model for measurement of the SME

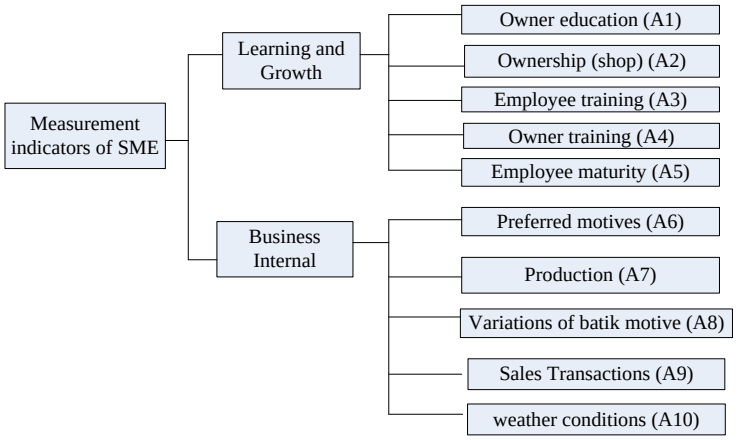

Figure 4. SME Criteria

Table 2. Pairwise Comparison

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1	1	5	3	1	0,33	1	1	3	3	1
A2	0,20	1	0,33	0,20	0,20	0,33	0,14	3	3	0,20
A3	0,33	3	1	0,14	0,20	3	0,14	1	3	0,14
A4	1	5	7	1	1	7	1	5	5	5
A5	3	5	5	1	1	3	1	3	3	3
A6	1	3	0,33	0,14	0,33	1	0,2	3	5	0,2
A7	1	7	7	1	1	5	1	3	3	0,2
A8	0,33	0,33	1	0,20	0,33	0,33	0,33	1	1	0,33
A9	0,33	0,33	0,33	0,20	0,33	0,20	0,33	1	1	1
A10	1	5	7	0,20	0,33	5	5	3	1	1

Table 3. Criteria Weight

Criteria	Weight
A1	0,35706
A2	0,03269
A3	0,1986
A4	0,12444
A5	0,40038
A6	0,08506
A7	0,90165
A8	0,04688
A9	0,28328
A10	0,53465

4. Conclusions

Based on this research can be concluded that the recommendation SME performance can be determined based on framework model measurement SME with integrated internal business perspective, learning and growth perspective and fuzzy Analytic Network Process (FANP). This

method determines the weighting of criteria based on the level of importance of the SME. This framework is adaptive and dynamic. The advantages of this Framework is to provide benefits for decision makers in determining the fuzzy scale and iterating dynamically to get the optimal decision. The resulting decisions can have high accuracy if there are preliminary data. Decisions are taken also consider the opinions of respondents by checking the consistency ratio. Future research on SME measurements can be used Adaptive Interval Fuzzy AHP and Adaptive Interval Fuzzy ANP.

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