

TELKOMNIKA, Vol.17, No.3, June 2019, pp.1310~1316

ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018

DOI: 10.12928/TELKOMNIKA.v17i3.12239

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## Fuzzy sequential model for strategic planning of small and medium scale industries

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### Abstract

*The use of strategic planning can be an alternative solution to improve industrial performance. In small and medium scale industries especially in apple chips industries, strategic planning helps to know the current industry situation and the steps that must be taken to overcome the existing problems. This study aimed to develop an improvement strategies using Fuzzy Sequential Modeling (FSM) model. FSM model was consisted a SWOT analysis, Root Cause Analysis (RCA), Bolden's Taxonomy and fuzzy AHP. Based on SWOT analysis, the external factors of threats was the similar business competition and low purchasing power. RCA described the issues that needed to be fixed using Bolden's Taxonomy as the reference for determining the action plans and produce four OIA (Open Improvement Area) there are old technology machines and equipment, difficulty of enterprise development, ineffective marketing media and low market share. The strategic planning was determined using Fuzzy AHP based on OIA and ABC enterprise needs to improve the low market share and ineffective marketing strategy.*

**Keywords:** fuzzy sequential model, small and medium scale industries, strategic planning

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### 1. Introduction

As time goes by, strategic planning concepts and practices have been used for all sectors around the world as they have an impact on organizational effectiveness. Strategic planning is an important aspect in the implementation of strategic management since it is an effective way to improve company performance [1]. Strategic planning helps identify long-term goals, current status and future organizational plans by identifying the root causes at all levels of an organization [2]. The scope of strategy planning is a theoretical interest that explains the planning process and its relation to obtain object management [3-5], and also a competitive business world in which decision-makers should be able to take good long-term action [6].

The growth of small and medium industries has always been hampered by various problems such as raw materials, capital, labor, and marketing. Marketing is the biggest threat to the development of small and medium industries. The main problems was a low market share due to the small rate of production and market access. Therefore, strategic planning was needed to improve the development rate of small and medium industries.

Strategic planning is implemented in different fields with different focus. One example is for agroindustry field that can be reviewed from various focuses such as production, process, storage and distribution [7]. Based on the theory of planning and decision making, the effect of the applied planning can be said as the effect of the planning structure and the person who does the plan [8]. Generally in previous studies, tactical and strategic problems are solved using integration (monolithic) or sequential model which are known as a hierarchical or multiple-intermediate model [9-10]. There are several studies on Multi Criteria Decision Making (MCDM) for supplier evaluation and selection [11-17]. MCDM is a part of the operations research discipline which is used in decision-making actions [18].

Strategic planning can also utilize fuzzy method as well as the research conducted by Chiou et.al., [19] which used fuzzy AHP to obtain weight criteria and rank the importance of sustainable development strategy criteria. This current study was aimed to identify the condition of the company as the basis for the organization in implementing strategic planning using Fuzzy

Sequential Modeling (FSM) method which consisted of SWOT analysis, Root Cause Analysis (RCA), Bolden’s Taxonomy and fuzzy AHP.

**2. Methodology**

FSM consisted of four consecutive methodologies as shown in Figure 1. The first step was to identify OIA (open improvement area) using SWOT analysis in the SME. All of the data were collected from apple chips industry especially in ABC enterprise, which is located in Malang, Indonesia. The data was collected through brainstorming technique to produce the element of the SWOT matrix. An affinity diagram were carried out to identify and classify the OIA in the ABC enterprise.

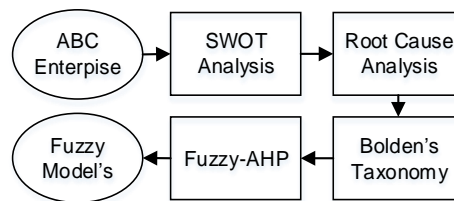


Figure 1. Four steps of the fuzzy sequential model

The second step was to identify the root of the problem in OIA using RCA method. RCA was an application process that focused on a permanent solution to the problem so the real reason behind the problem could be revealed. The techniques used could vary such as Failure Mode and Effect Analysis (FMEA), Ishikawa’s diagram, change analysis, Pareto’s diagram and fault tree analysis [20]. The technique used in this research was Ishikawa’s diagram.

The next step was to develop an action plan for each of the root causes using Bolden's Taxonomy on practice on ABC apple chips enterprise. Bolden's taxonomy was used as an action plan for OIA issues. The classification scheme shown by Bolden's taxonomy [3]. All action plans should be related to resources constraints such as time, cost and labor. In the priority determination of the problem Fuzzy Analytical Hierarchy Process (FAHP) method was used. FAHP was carried out using AHP and then combined with Fuzzy. According to [21], AHP method was started from making pairwise comparison matrix, priority vector calculation on each and sub criteria, calculating average, calculating  $\lambda$  maximum, calculating CI (Consistency Index), and CR (Consistency Ratio). Furthermore, the stages of data analysis using FAHP according to [22-24] were:

1. Making a pairwise fuzzy comparison matrix

Fuzzy comparison matrix used linguistic scale with Triangular Fuzzy Number (TFN) in which each of its membership functions (fuzzy number scale) namely, the lower point (1), the midpoint (m) and the upper point (u) at intervals where the function was defined. The representation of the fuzzy membership function for the triangle curve is as follows in Figure 2. The linguistic scale and TFN can be seen in Table 1 in which the determination of this TFN is supported by [25, 26].

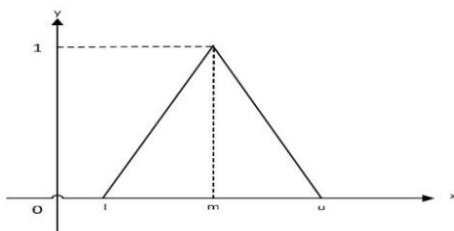


Figure 2. Fuzzy Membership Function [25]

Table 1. Linguistic Scale and Fuzzy Number [26, 23]

Linguistic Scale for Importance	TFN Scale
Just Equal	(1, 1, 3)
Equally Important	(1, 3, 5)
More Important	(3, 5, 7)
Very Important	(5, 7, 9)
Strongly Important	(7, 9, 9)
Most Important	(1, 1, 3)

2. Counting the value of  $\sum_{j=1}^m M_i^j = \sum_{j=1}^m lj, \sum_{j=1}^m mj, \sum_{j=1}^m uj$  by summing each Triangular Fuzzy Number in each row.
3. Counting the value of  $\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j$  by summing all Triangular Fuzzy Number in pairwise fuzzy comparison matrix.
4. Determining the value of priority fuzzy synthesis (Si) using the following formula:

$$S_i = \sum_{j=1}^m M_i^j \times \frac{1}{\sum_{i=1}^n \sum_{j=1}^m M_i^j}$$

in which:

$$\frac{1}{\sum_{i=1}^n \sum_{j=1}^m M_i^j} = \frac{1}{\sum_{i=1}^n ui, \sum_{j=1}^m mi, \sum_{i=1}^n li}$$

Notes:

M = object (criteria and sub criteria),

i = row -i,

j = column -j,

l = lower value,

m = medium value,

u = upper value.

5. Determining vector value (V) and ordinal defuzzification (d') value. If the result from each fuzzy matrix is  $M_2 \geq M_1$  ( $M_2=(l_2, m_2, u_2)$  and  $M_1=(l_1, m_1, u_1)$ ), the vector value can be formulated as follows:

$$V(M_2 \geq M_1) = \sup[\min(\mu_{M_1}(x), \min(\mu_{M_2}(y)))]$$

or equal with:

$$V(M_2 \geq M_1) = \begin{cases} 1 & \text{if } m_2 \geq m_1, \\ 0 & \text{if } 1 \geq \mu_2, \\ \frac{li - \mu_2}{(m_2 - \mu_2) - (m_1 - l_1)} & \text{lainnya} \end{cases}$$

If the fuzzy value is bigger than k,  $M_i$ , ( $i=1,2,\dots,k$ ), the vector value can be defined as follows:  $V(M \geq M_1, M_2, \dots, M_k) = V(M \geq M_1)$  and  $V(M \geq M_2)$  and  $V(M \geq M_k) = \min V(M \geq M_i)$

6. Performing weight calculation and normalization of weight vector so the value of main criterion weight could be revealed.

- $d'(A_i) = \min V(S_i \geq S_k)$  for  $k = 1, 2, \dots, n$ ;  $k \neq i$ , thus vector weight value is obtained
- $w' = (d'(A_1), d'(A_2), \dots, d'(A_n))^T$  in which  $A_i = 1, 2, \dots, n$  is fuzzy vector (W)
- $W = (d(A_1), d(A_2), \dots, d(A_n))^T$

7. Performing aggregate calculation of each value of vector weight normalization

8. Counting global value and ranking

After all the stages of FAHP were done, it could be known what was the most important factor to be considered in the strategic planning for apple chips enterprise. F-AHP was used to define priority problems that have previously been determined. It needed to be done to get the focus of the problem. F-AHP was also used as an approach to carry out sustainable improvement models.

### 3. Result and Discussion

#### 3.1. Open Improvement Area of ABC Enterprise

In ABC enterprise, there was division of work according to its division such as: production, product development, quality assurance, finance, and marketing. In this study, the researchers interviewed each member of the division directly to determine the strength and OIA of each division. The focus of SWOT analysis conducted on the marketing division of ABC

enterprise. It was because the competition was getting tough and the existence of more competitors. The goal was to reveal the description of external and internal factors of ABC enterprise, which was depicted in the Table 2.

**Table 2. SWOT Analysis on ABC Enterprise**

SWOT Indicator	Apple chips
Strengths	Availability of adequate raw materials High product quality Homeindustry product Business licensing (BPOM and PIRT)
Weakness	Unattractive packaging High product price Low product variety
Opportunities	Regional product's icon
Threats	Similar business competition Limited retail distribution

Based on the above SWOT analysis, the main problems for ABC enterprise could be from external factors of threats. Threats in the form similar business competition and limited retail distribution could cause problems in market share competition. It definitely made the market share of ABC enterprise became low. This problem was commonly identified in Root Cause Analysis (RCA). The identification result of external and internal factors that have been done in SWOT analysis provided information about the area that should be improved. Then, the area was identified the cause and the root of the problems by using Ishikawa's diagram. In identifying the root cause, the main members of the enterprise consisting of owners, managers and supervisors were involved. The root of the problem that could be identified was low market share. The three main causes which were determined by ABC enterprise were inadequate marketing strategy, low product diversity and marketing division inadequacy.

The root of the problem and its causes described in RCA became the basis for determining the focus of the improvement area and the desired action plan at the strategic level. This action plan referred to Bolden's Taxonomy. The description can be seen in Table 3. Root cause analysis of small market share has been presented in Figure 3, whereas open improvement area of ABC enterprise has been presented in Table 4.

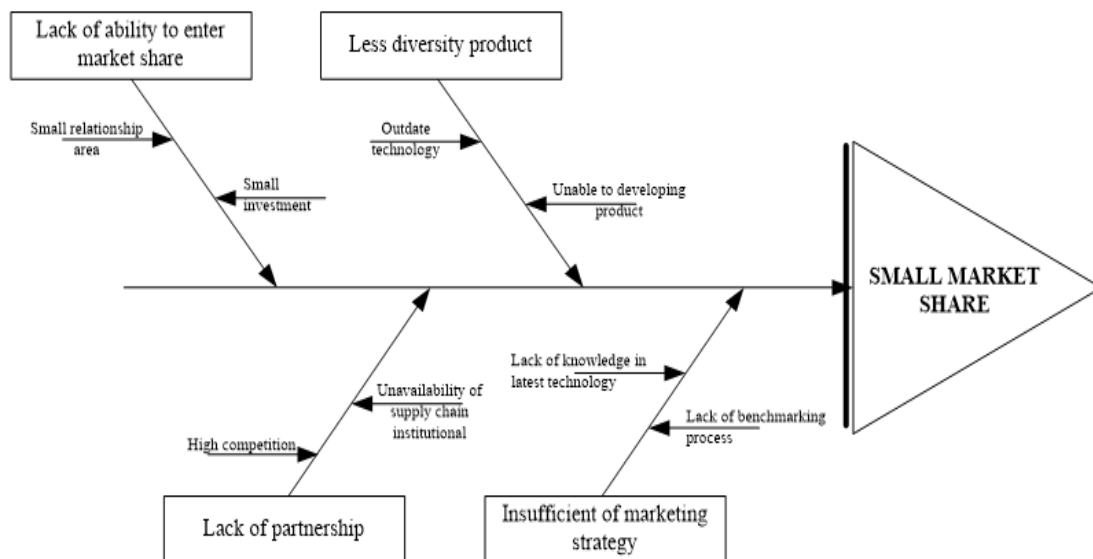


Figure 3. Root cause analysis of small market share

Table 3. Modified Bolden’s Taxonomy

Primary Domain of App.	Improved Quality (A)	Reduced Cost (B)	Improved Technology (C)	Employee Development (D)
Design And Production (I)	1. Quality Standards 2. Quality Fuction Development	1. Reduced Work In Progress 2. Process Mapping 3. Re-Usability	1. Automation	1. Job Rotation 2. Multi-Skilling 3. Training And Development 4. Attitude Surveys 5. Safety Management
Inventory And Stock (II)	1. Supply Chain Partnering 2. Customer Feedback 3. Conformance Checks	1. Reduced Inventory 2. Single Sourcing 3. Forecasting 4. Logistics Management	1. Electronic Data Interchange	1. Product Team Responsibility For Purchasing And Distribution
Work Organization (III)	1. Quality Improvement Teams 2. Operator Responsibility For Quality 3. Quality Training	1. Downsizing 2. Delayering 3. Casual Labor	1. Computer Supported Management Co-Operative Work 2. Manufacturing Resource Planning	1. Team-Based Work 2. Job Enrichment
Wider Organization Of Manufacturing (IV)	1. Total Quality Management 2. Benchmarking For Quality	1. Cost Management 2. Time-Based Management 3. Benchmarking For Costs	1. Computer-Based Management Tools 2. Benchmarking For Technology	1. HRM Strategy 2. Performance-Related Pay 3. Benchmarking For Employee Effectiveness
Social Impact (V)	1. Recyclable Package 2. Branding Marketing	1. Green Supply Chain Management	1. Waste Management 2. E-Commerce	1. Training For Green Management

Table 4. Open Improvement Area of ABC Enterprise

Level	No.	Open Improvement Area (OIA)	Root of Cause	Action Plan
Strategy	OIA 1.1	Old technology machine and equipment	Ineffective cost management	IVB1
	OIA 1.2	Enterprise development difficulty	Inadequate market information	IIB3
	OIA 1.3	Ineffective marketing media	Lack of technology infrastructure	VC2
	OIA 1.4	Small market share	Ineffective new media	VA2

Note:

OIA : Open improvement areas.

IVB1 : fourth row of Primary domain of app, business focus on column B, on the first section.

IIB3 : second row of Primary domain of app, business focus on column B, and third section.

VC2 : fifth row of Primary domain of app, Organizational focus on column C, on the second section.

VA2 : fifth row of Primary domain of app, Organizational focus on column A, and first section.

### 3.2 Improvement Strategy

Determination of OIA priority level employed F-AHP method. Data analysis employed Fuzzy Analytic Hierarchy Process (FAHP) on four main OIA criteria such as OIA 1.1 old technology machines and equipment, OIA 1.2 enterprise development difficulty, OIA 1.3 ineffective marketing media and OIA 1.4 small market share which resulted total CR (Consistency Ratio) from expert 1 to expert 3 with CR≤10% (0.10), which is indicated that the questionnaires have been responded were consistent. In the calculation of Fuzzy Analytic Hierarchy Process, the normalized value of vector weight was not more than 1. The result of this

analysis was compared to the research journal conducted by [27] on the FAHP resulting CR value should be less than 10% and the normalization of the weight vector should be based on the value of 0 to 1. It revealed that the result of this study was consistent based on the data from the questionnaires filled by the experts from ABC enterprise. Aggregate result of criteria has been presented in Table 5.

Table 5. Aggregate Result of Criteria

Criteria	Aggregate result of criteria	Criteria rank
OIA 1.1	0.44	3
OIA 1.2	0.14	4
OIA 1.3	0.46	2
OIA 1.4	0.48	1

The result was shown on Table 5, the aggregate were obtained among the main criteria. The calculation was derived from multiplication between criteria resulting in aggregate value in OIA 1.1 of 0.44, OIA 1.2 of 0.14, OIA 1.3 of 4.6, and OIA 1.4 of 0.48. The aggregate value was derived from the multiplication of each main criteria and then it was rooted according to the number of experts. The benefit of this calculation was to perceive the average of all main criterion values. The criteria which had the highest criteria rank needed the most improvement priority compared to other criteria. The criteria were based on the order from the highest to lowest rank i.e. OIA 1.4 with aggregate value 0.48, OIA 1.3 with aggregate value of 0.46, OIA 1.1 with aggregate value 0.44, and OIA 1.2 with aggregate value 0.14. Based on these results, if ABC enterprise wants to focus or prioritize improvement as a future planning, the appropriate strategy is to make improvement especially on OIA 1.4 by increasing market share and OIA 1.3 by developing effective marketing.

#### 4. Conclusion

A sequential model was developed consisting different methodologies to address the strategic planning issues in the apple chip industries. This sequential model included four steps: determining the OIA, determining the root cause, developing an action plan for each root cause and determining priority. In the case study of ABC enterprise, it is necessary to make certain improvements on the low market share aspect and to refine ineffective marketing.

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