Integration of cluster analysis and fuzzy analytical hierarchy process in formulating cluster development strategy of tempeh chips SMEs

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Abstract. The aim of this study was to classify tempeh chips Small and Medium Enterprises (SMEs) in Malang City and to decide the development strategy priorities for each cluster. K-means clustering was used to classify tempeh chips SMEs, with criteria include monthly production capacity, length of business, average monthly sales value, investment value, and number of workers. The priorities of development strategy for each cluster were determined using Fuzzy Analytical Hierarchy Process (FAHP), with factors such as industrial cluster, government, and also supporting and related industries. The results indicated that two clusters of tempeh chips SMEs were formed. The first cluster classified as micro enterprises, consist of SME I and SME C, and the second cluster classified as small enterprises, consist of SME A, SEM B, SME D, SME E, SME F, SME G, and SME H. The priorities of development strategy for the first cluster are conducting product standardization and training to SMEs owners about business development, while for the second cluster are conducting product standardization and increasing sales and product promotion.

1. Introduction
Malang City is one of the cities in East Java that has a relatively good development of business. One of several industrial sectors developing rapidly is tempeh chips [1]. Based on that data, 308 Small and Medium Enterprises (SMEs) located in Sanan tempeh chips center produce both tempeh and tempeh chips, while the other 38 produces tempeh exclusively. The preliminary survey conducted in 2017 found that 18 SMEs in the area are still producing tempeh chips until recently.

One solution to increase competitive advantage of local industry increasing number of tempeh chips SMEs is to develop industrial cluster. National Development Agency stated that industrial cluster consists of related business units. Development of industrial cluster and business network is predicted to improve competitive advantage of SMEs [2]. Industrial cluster and business network allow SMEs to overcome their issue, which is to meet demand of the market that requires large amount of production, homogenous standard and regular production and channel of distribution. Industrial cluster development helps SMEs improving their competitive advantage due to agglomeration companies that have similar characteristics and business activities, limitation of resulted economic externality and significant reduce of production costs [3, 4].
The tempeh chips in Malang established an organization called Primer Koperasi Produsen Tempeh dan Tahu Indonesia (Primkopti) Bangkit Usaha Malang City. Primkopti Bangkit Usaha Malang City is a forum of which objective is to generate steady income for tempeh and tofu SMEs. However, total members of the organization is plummeting because many considered it ineffective and decided to run their business on their own. Another issue the tempeh chips SMEs encountered is the lack of capital. Due to the scale of their business, it is hard for the SMEs to get loan from cooperative and as the consequence, they struggle to develop their business. In addition, owners of the tempeh chips SMEs have limited knowledge on business or marketing strategy. Therefore, it is important to develop industrial cluster for tempeh chips SMEs in Malang in order to improve competitive advantage of tempeh chips industry in Malang [5]. Clustering analysis and Fuzzy Analytical Hierarchy Process (FAHP) are two methods used for developing the industrial cluster.

Clustering analysis used in this study because it is able to select objects from large population simplifying description of characteristics from each group [6]. FAHP is the method used for cluster development decision-making. Analytical Hierarchy Process (AHP) works by simplifying unstructured, strategic and dynamic complex issue into some sections and arrange these sections into a hierarchical order [7]. FAHP is an analysis method derived from AHP but FAHP is able to describe vague decision more effectively compared to AHP [8].

2. Materials and Methods
2.1. Clustering analysis
This study was carried out at Center of Sanan tempeh and tempeh chips SMEs, Malang City, East Java. Data analyses were conducted at System Analysis and Computation Laboratory, Department of Agro-industrial Technology, Universitas Brawijaya. K-means clustering was used to classify tempeh chips SMEs, with criteria include monthly production capacity, length of business, average monthly sales value, investment value, and number of workers. The steps K-means Clustering are as follows [6, 9]:
1. Data Normalization
2. Determination of Centroid
3. Calculation of Object Distance with Centroid
4. Allocate Objects
5. Centroid Position Determination
6. Interpretation and Profiling

2.2. Fuzzy Analytical Hierarchy Process (FAHP)
The priority of development strategy for each cluster was determined using FAHP, with factors such as industrial cluster, government, and also supporting and related industries. The steps in FAHP are as follows [10, 11]:
1. Developing Hierarchical Structural
2. Developing paired comparison matrix
3. Calculating priority vectors
4. Calculating maximum eigenvalue ($\lambda_{max}$)
5. Calculating Consistency Index (CI)
6. Calculating Consistency Ratio (CR)
7. Compiling fuzzy pairwise comparison matrix
8. Fuzzy Synthetic Extent score

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

(1)

$$\sum_{j=1}^{m} M_{ij} = \sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j$$

(2)
\[ \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij}} = \frac{1}{\sum_{i=1}^{n} u_i \sum_{j=1}^{m} m_i, \sum_{i=1}^{n} l_i} \]  

(3)

Where:
- \( M \) = triangular fuzzy number
- \( j \) = column
- \( i \) = line
- \( l \) = lower value
- \( m \) = medium value
- \( u \) = upper value

9. Calculating vector \((V)\) and defuzzification ordinates \((d')\).

Vector can be formulated as follows:

\[ V(M_2 \geq M_1) \]  

(4)

Probability score for Fuzzy is obtained with the following equation:

\[ V(M_2 \geq M_1) = \begin{cases} 
1 & \text{if } m_2 \geq m_1, \\
0 & \text{if } l_1 \geq u_2 \\
\frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{others}
\end{cases} \]  

(5)

10. Normalizing weighted average of Fuzzy vector \((w')\).

Weighted vector is obtained based on normalizing the weighted vector. The formula is as follows:

\[ d(A_n) = \frac{dr(A_n)}{\sum_{i=1}^{n} dr(A_n)} \]  

(6)

3. Results and Discussion

3.1. Cluster analysis

The clustering analysis was able to develop 2 (two) clusters based on similarity and differences between the SMEs. The first Cluster consists of 2 members (SMEs I and C), while the second cluster consists of 7 members (SMEs A, B, D, E, F, G, and H). The SMEs characteristics of each cluster formed can be seen in Table 1.

| No | Variables                          | First Cluster (SMEs I, C) | Second Cluster (SMEs A, B, D, E, F, G, H) |
|----|-----------------------------------|--------------------------|------------------------------------------|
|    | Center Cluster                   | Min | Max       | Center Cluster | Min   | Max       |
| 1  | Monthly production capacity (kg) | 950 | 900       | 1,000         | 3,085.71 | 2,500    | 3,900    |
| 2  | Length of business (years)       | 14  | 11        | 17            | 19.28   | 6        | 32       |
| 3  | Average monthly sales value (IDR) | 2,850,000 | 2,700,000 | 3,000,000    | 66,628,571.43 | 40,000,000 | 90,000,000 |
| 4  | Investasi value (IDR)            | 5,000,000 | 5,000,000 | 5,000,000    | 3,064,285.71 | 100,000   | 10,000,000 |
| 5  | Number of workers                | 3.5 | 3         | 4             | 8       | 5        | 12       |
The SMEs in the first cluster was categorized as micro-scale business. According to the Bank of Indonesia, micro-scale business is a business entity that generates less than IDR 300 million from their annual sales [12]. Micro-scale industry can hire between 1 and 4 employees [13]. Due to limited amount of funding, average production capacity of SMEs in the first cluster is far less than SMEs in the second cluster. As a result, the SMEs in the first cluster are unable to increase their production capacity. High production capacity results in higher production cost. When production cost is high but utilization is low, SMEs may suffer from significant financial loss. Therefore, careful planning and preliminary studies are two requirements for estimating production capacity. The SMEs in the second cluster are in business longer than those SMEs in the first cluster making production capacity of the later group lower. The SMEs in the second cluster have more business experience and higher product demand; as a result, they have higher sales and production capacity. In other words, length of business influences growth of a business entity. Length of business refers to the amount of time a business entity is in operation and it represents the ability of a business entity to survive amidst fierce business competition [14].

The SMEs in the second cluster are classified as small-scale business. According to the Bank of Indonesia, small-scale business is a business entity that generates between IDR 300 million to IDR 2.5 billion from their annual sales [12]. Small-scale industry can hire between 5 and 19 employees [13]. The SMEs in the second cluster are in business longer than SMEs in the first cluster. It shows that the former group has more business experience than the later one. Length of business results in business experience. Besides that, it also affects sales, income and profit, productivity, efficiency and production cost. The more experienced a business professional is, the more insights he or she has on customer behavior and interest. Similar to the SMEs in the first cluster, the owners of the SMEs in the second cluster also used their own money to start their business. Compared to the SMEs in the first cluster, average investment of SMEs in the second cluster is lower because the SMEs in the second cluster are in business longer than those in the first cluster. It helps them selling more products. Preliminary investment is one of the most pivotal production factors for all scale of business [15].

3.2. Cluster development strategy

FAHP is the method used for Sanan tempeh chips SMEs cluster development strategy. This hierarchical structure consists of 4 stages, namely objective, factor, criteria and alternative strategy. Questionnaire was distributed to several experts based on their knowledge and business experience. The data analysis methods were AHP which was then converted into Fuzzy Synthetic Extent to get prioritized strategy for each cluster [16]. Figure 1 described hierarchical structure development strategy of the first cluster, while Figure 2 described hierarchical structure development strategy of the second cluster.
Based on Figure 1, priority of business development of tempeh chips Malang SMEs in cluster 1 is industrial cluster that weighed 0.637. Industrial cluster gets the highest priority because the industrial cluster is the one developing their business. Business owner’s managerial skill is the most dominant factor that influence achievement of business development capacity [17]. Criterion with the highest priority is increasing sales (weighing 0.550). It becomes the main priority because the members of cluster 1 has lower sales compared to those in cluster 2. Thus, the major target for cluster 1 is sales increase. Sales can influence profitability and therefore, higher sales will result in higher gross profit and eventually higher profitability [18]. When a business entity can increase sales and generate more income, its business scale will increase. The prioritized alternative is product standardization (weighing 0.447). Based on the government regulation (PP Nomor 102 Tahun 2000) about National Standardization, standardization is formulation, establishment, implementation and revision of particular standardization that has been applied by various individuals or organization in orderly manner. Standardization is reference for product quality and safety which is described to meet customer’s demand and provides warranty for customers of food product safety [19].

Based on Figure 2, the priority in the second cluster is industrial cluster (weighing 0.663). Cluster development is a more effective strategy for business development of the SMEs in second cluster. It happens because industrial cluster development is right on target and able to meet characteristics of particular group of SMEs.
Industrial clusters are an industrial system in which this industrial cluster can consist of several industries [20]. Objective of the industrial cluster is to categorize industry based on several criteria. The priority is to improve quality of products (weighing 0.630). The SMEs in the second cluster should improve quality of their products in order to increase selling price and attract more customers. Improving product quality also allows Sanan tempeh chips SMEs owners to develop their products. Higher quality will result in higher customer satisfaction and higher sales. In addition, it improves competitive advantage of their products as well as increases market share and sales because they can sell their products at a higher price. A high quality product is one that has very few weakness or no defect at all. High quality results in customer satisfaction in which satisfaction leads to loyalty and loyalty generates profitability. An alternative that becomes is standardization of products (weighing 0.580). One solution to win business competition, the major challenge for the SMEs in cluster 2, is the ability to provide warranty for consumers; warranty that their products are of high quality, safe, and affordable. Food standardization is an instrument for policy enforcement that can improve the economic structure and provide protection to the community [19].

The tempeh chips SMEs in the first cluster are classified as micro-scale business while those in second cluster are classified as small-scale business. Due to the scale of their business, development strategy implemented in these clusters is different. The following table discusses focus and priority of development strategy applied in the first cluster and the second cluster (Table 2).
Table 2. The focus and priority development strategy of each cluster.

| No | Cluster 1                                                                 | Cluster 2                                                                 |
|----|---------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 1  | Focus of development strategy implemented in the first cluster is increasing sales which leads to increase in both production capacity and these SMEs’ income | Focus of development strategy in the second cluster is to improve product quality which results in increase in customer trust and competitive advantage. |
| 2  | Methods to improve product standardization in the first cluster are selecting qualified raw materials, smooth production, using safe food products as additional ingredients, designing new label and packaging, and using scale to weight each package of tempeh chips so that each package has similar weight. | Methods to improve product standardization in the second cluster are product standardization and changing packaging technique to sealing with gas filling. This new packaging technique prevents tempeh chips from breaking down during distribution. |

4. Conclusion
The findings in this study confirmed that K-means clustering divides 2 clusters based on their production capacity, length of business, average sales, preliminary investment and number of employees. The first cluster consists of 2 members (SMEs I and C), while the second cluster consists of 7 members (SMEs A, B, D, E, F, G, and H). Based on FAHP, the development strategy for the first cluster emphasizes on product standardization and training on business development. On the other hand, the development strategy for the second cluster emphasizes on product standardization, promotion and sales using a more current marketing strategy.

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