Multi-Criteria Decision Making For Determining A Simple Model of Supplier Selection

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Abstract. Supplier selection is a decision with many criteria. Supplier selection model usually involves more than five main criteria and more than 10 sub-criteria. In fact many model includes more than 20 criteria. Too many criteria involved in supplier selection models sometimes make it difficult to apply in many companies. This research focuses on designing supplier selection that easy and simple to be applied in the company. Analytical Hierarchy Process (AHP) is used to weighting criteria. The analysis results there are four criteria that are easy and simple can be used to select suppliers: Price (weight 0.4) shipment (weight 0.3), quality (weight 0.2) and services (weight 0.1). A real case simulation shows that simple model provides the same decision with a more complex model.

Keywords: Supplier selection, simple model, criteria, AHP

1. Introduction
Supplier is a company and individuals who provide the resources needed by companies in both manufacturing and services to produce goods and services. Chen et al [3] stated that the problem of supplier selection is a very important issue in supporting the success of Supply Chain Management (SCM). Competitive opportunities in the philosophy of SCM can be achieved through a strategic collaboration with suppliers and other stakeholders [15]. It can be said that one key of SCM’s success depends on the ability of companies to select the best suppliers [20]. The effective supplier means suppliers who can deliver the goods with the right amount at the right time with high quality [14]. Supplier selection is the early stages of procurement of raw materials for the production process. It starts from purchase through to delivery to the warehouse or production floor [8]. The evaluation of business processes from purchase to delivery is an important factor in choosing a supplier for the company to win the competition.

Supplier selection is a decision with many criteria starts from main criteria such as price, quality and delivery up to supporting criteria such communication, attitude and relationships [5]. Activities of supplier selection may take time, resources and costs but the success of selection supplier is potential to establish long term relationship that could determine the success of SCM. Ng [15] explains that the supplier selection process starting from the determination of supplier qualification and evaluation criteria for the selection of suppliers based on existing criteria. There are many alternative criteria that can be used to select suppliers as partners. The general criteria that widely used is the price [26], [23], [9], product quality [22], [11], [21], supplier services including lead time, after-sales service and etc [1], [7], and flexibility [26]. The issue of the environment has also become next important factor for supplier selection criteria today, such as technical efficiency, environmental efficiency and eco-efficiency [13]. Even more, some companies use ethical criteria as a factor in choosing the best [4].
Previous research showed that the model of supplier selection generally involves more than five main criteria and more than 10 sub-criteria. In fact, some studies use up to twelve criteria [16]. The proposed methods is also varied from quantitative to qualitative models. Analytical Hierarchy Process (AHP) is a widely used method in the model of supplier selection [6], [19]. The other method that widely used are Fuzzy DEMATEL [2], Fuzzy Multi-Objective Linear Model [25], VIKOR [24], Technique For Order Preference By Similarity To Ideal Solution (TOPSIS) [12], data envelopment analysis (DEA) [10], [20]. Problems that happened from these variations in criteria and methods in supplier selection is the lack of opportunity to apply the model in real cases. Companies practically need ways or solutions that are easy and quick to solve a problem. Engagement so many criteria and the use of a complicated calculation or method makes the decision-makers in companies prefer to use intuition based on experience to choose suppliers. This way certainly have a deficiency because it is not based on scientific calculations. The validity of intuition usually could not be accounted. This research purpose to designing an easy and simple model for supplier selection. Formed criteria consists of only the main criteria without sub-criteria. Because the different of interest among criteria, it is necessary to calculate the criteria weight to present the importance of each criterion. Calculation of the weight uses AHP as one of Multi Criteria Decision Method (MCDM) model. AHP is used because this method is able to produce weight by decomposition procedure from a complex systems into hierarchies of goals and criteria up to alternative [18]. Resulted model of supplier selection is tested on a real case in manufacturing company to prove that it can be used and applied to industry and providing a simple decision making tools in supplier selection.

2. Analytical Hierarchy Process

AHP is a decision support models developed by Thomas L. Saaty [17]. This method is used because it accommodated the need to compare weight of each criteria without alternatives. The decision maker compares each criterion with the other and determines the level of preference for each pair of criteria. Generally, steps using AHP follows these procedure:

a. Establish the hierarchy of the problem.

The resolved problem is decomposed into its elements: criteria, sub criteria and alternatives, then it is compiled into a hierarchical structure such as this following figure:

![AHP Hierarchy Structure](image)

b. Determine pairwise comparisons between criteria and sub-criteria.

Criteria and alternatives are assessed through pairwise comparisons. According to Saaty [17], for any kind of problems, a scale of 1 to 9 is the best scale in expressing opinions. Values and definition of qualitative opinion on a scale of Saaty can be seen in following table:

| Scale | Meaning               |
|-------|-----------------------|
| 1     | Equal importance      |
| 3     | Moderate importance   |
| 5     | Strong importance     |
| 7     | Demonstrate importance|

2
c. Calculate the consistency ratio

Consistency index (CI) in AHP is measure with formula CI = (λ_max - n)/(n-1) where λ_max is the largest eigenvalue of A while A is n dimensional of AHP pairwise matrix. The degree of consistency is measured by the formula CR=CI/RI. Where RI is a random index consistency from Saaty table. If the consistency ratio ≤ 0.1 means the comparison from expert is consistent.

d. Calculate priority weight

This step is processed to calculate the weight of every alternatives.

3. Method

3.1. Data Collection

Data is collected from previous research about supplier selection. All research was conducted in Indonesia specific in manufacture industry. Collected data covers some information as follow:

1. Company
2. Research
3. Criteria
4. Pairwise comparison among criteria/sub criteria and alternatives
5. Result

There are nine companies that were carried as a data source. Data description for each research is shown in the table below:

| No | Research | Company               | Criteria                                   |
|----|----------|-----------------------|--------------------------------------------|
| 1  | Research 1 | PT. Jogia Indo Global | Price, Quality, Delivery, Service, Payment |
| 2  | Research 2 | Dii Leather           | Price, Quality, Quantity, Capability       |
| 3  | Research 3 | CV. Bumi Multimedia   | Price, Quality, Payment, Service           |
| 4  | Research 4 | Clothing Paradays     | Price, Quality, Delivery, Service, Relationship |
| 5  | Research 5 | CV. Jati Bhawono      | Price, Delivery, Quantity, Capability      |
| 6  | Research 6 | Harmoni Rock Clothes  | Price, Delivery, Quantity, Response, Flexibility |
| 7  | Research 7 | CV. Prima Grafika     | Price, Delivery, Quantity, Response, Flexibility |
| 8  | Research 8 | PT. GKI              | Price, Delivery, Quality, Response, Relationship, Environment |
| 9  | Research 9 | CV. Dita Kurnia       | Price, Delivery, Quality, Response, Flexibility |

The above data is the data of the main criteria used in each company. But in fact almost all companies use two-level hierarchy that includes sub-criteria for all of the criteria used. Recapitulation of eight common criteria used can be described in Pareto diagram as follow:
Fig 2. Pareto Diagram of Common Criteria

Using principle of Pareto 80:20, from the diagram above it can be concluded that there are four dominant criteria and they are used in all of company as consideration in supplier selection. Those criteria are: Price, Quality, Delivery, and Services.

4. Result
4.1. Data Processing Using AHP.
To obtain weight of each criteria is started by calculate the consistency index to convince the validity of the expert judgment. Calculation of consistency is applied for three expert from four company. Sample of calculation is shown in calculation of PT. Jogja Indo Global as follow:

Table 3. Pairwise Comparison Matrix

| Criteria     | Price | Delivery | Quality | Service/Response |
|--------------|-------|----------|---------|------------------|
| Price        | 1     | ⅛        | 9       | 7                |
| Delivery     | 2     | 1        | 9       | 7                |
| Quality      | ⅛     | 1        | 1       | ⅓                |
| Service/Response | ⅛    | 1        | 3       | 1                |

• Normalization Matrix

Table 4. Normalization Matrix

| Criteria     | Price | Delivery | Quality | Service/Response | Average |
|--------------|-------|----------|---------|------------------|---------|
| Price        | 0.307 | 0.285    | 0.409   | 0.456            | 0.365   |
| Delivery     | 0.614 | 0.570    | 0.049   | 0.456            | 0.513   |
| Quality      | 0.034 | 0.063    | 0.045   | 0.021            | 0.041   |
| Service/Response | 0.044 | 0.081    | 0.136   | 0.065            | 0.082   |

• Calculate Priority Weight

\[
\begin{bmatrix}
1.00 & 0.500 & 9.000 & 7.000 \\
2.00 & 1.000 & 9.000 & 7.000 \\
0.111 & 0.111 & 1.000 & 0.333 \\
0.143 & 0.143 & 3.000 & 1.000 \\
\end{bmatrix}
\times
\begin{bmatrix}
0.3645 \\
0.5126 \\
0.0412 \\
0.0817 \\
\end{bmatrix}
= \begin{bmatrix} 1.563 \\ 2.183 \\ 0.330 \\ 0.017 \end{bmatrix}
\]

\[
\text{Priority Weight (D)} = \frac{0.563}{0.364} = 1.563 \quad 2.183 \quad 0.330 \quad 0.017 = 4.289 \quad 4.3 \quad 8.02 \quad 0.214
\]

• Calculate \( \lambda \) maks

\[
\lambda \text{maks} = \frac{4.2894 + 4.3 + 8.028 + 0.214}{4} = 4.19
\]

• Calculate Consistency Index (CI)

\[
\text{CI} = \frac{(\lambda \text{maks} - n)}{(n - 1)} = \frac{(4.19 - 4)}{(4 - 1)} = 0.066
\]

• Calculate Consistency Ratio (CR)

Using score for \( n=4 \) in Saaty's table is 0.9 so consistency ratio (CR) can be calculated as:

\[
\text{CR} = \frac{0.66}{0.9} = 0.73
\]
Since those score of consistency ratio is under 0.01 so pairwise comparison in the company can be said consistence and valid to be used for next process.

4.2. Geometric Mean
To calculate the weight of each of the selected criteria, entries adjustments are made for pairwise comparison matrix to accommodate opinion from three expert. Geometric mean is used to calculate average value of three rate with following formula:

\[ \prod_{i=1}^{n} x_i = \sqrt[n]{x_1 \cdot x_2 \cdot x_3 \cdots x_n} \]

The geometric mean resulting from three expert calculation above are presented in the following table:

| Criteria   | Price | Quality | Delivery | Service/Response | GM |
|------------|-------|---------|----------|------------------|----|
| Price      | 1     | 1       | 1        | 1                | 1  |
| Quality    | 0.333 | 0.874   | 1        | 1                | 1  |
| Delivery   | 0.111 | 1       | 0.48     | 0.111            | 1  |
| Service/Resp | 0.143 | 0.333   | 0.333    | 0.251            | 1  |

4.3. Criteria Weight
The final pairwise comparison matrix for three expert is shown in the table below:

| Criteria   | Price | Delivery | Quality | Service/Response | Weight |
|------------|-------|----------|---------|------------------|--------|
| Price      | 0.3837| 0.3407   | 0.4074  | 0.4626           | 0.3986 |
| Delivery   | 0.3354| 0.2975   | 0.2824  | 0.2224           | 0.2844 |
| Quality    | 0.1846| 0.2062   | 0.1958  | 0.1988           | 0.1964 |
| Service/Resp| 0.0963| 0.1556   | 0.1144  | 0.1163           | 0.1206 |

From the calculation above it can be seen that the Price is still be the most important criteria for the supplier selection decision making with weight 0.4, and then followed by delivery (0.3), quality (0.2) and the last is service/response of the supplier (0.1).

4.4. Simulation
At this step, that simple model of supplier selection using four weighted criteria will be used to determine the rank of suppliers in a real case. Company in real case previously had calculated the rank of with using AHP-Promithee method. The company ranks three supplier using 5 criteria with 11 sub criteria. Score of each supplier based on AHP pairwise comparison is shown in the following table:

| Criteria   | Score |
|------------|-------|
| Bobot      | 0.077 | 0.057 | 0.154 | 0.356 | 0.356 |
| Supplier 1 | 0.362 | 0.328 | 0.353 | 0.327 | 0.327 |
| Supplier 2 | 0.322 | 0.343 | 0.333 | 0.346 | 0.346 |
| Supplier 3 | 0.316 | 0.328 | 0.314 | 0.327 | 0.327 |
By using more complicated formula of Promithee, the calculation obtains that the sequence supplier based on its criteria is supplier 1, supplier 2 and supplier 3. In the simple model, since every criterion already has weight from the previous calculation, so that the weight of every supplier can be simply calculated by the formula below:

\[ V_n = X_n . R_i \]

Where \( V_n \) is the value of each supplier, \( X_v \) is the score of each supplier in each criterion and then \( R_i \) is the weight of every criterion. The result using the formula above are presented in the following table:

Table 9. Simulation Result Using Simple Model

| Supplier | Value |
|----------|-------|
| Supplier 1 | 0.346 |
| Supplier 2 | 0.330 |
| Supplier 3 | 0.320 |

5. Conclusion
Calculations with a simple model provides the best suppliers of the same series. Supplier 1 became the best supplier followed by Supplier 2 and Supplier 3. It is resulted both using complex model and simple model. From these results it can be concluded that the application of simple model and complex model did not give different results. But using simple model is more suggested because of its ease and effectiveness.

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