The Analysis of Supplier Selection Method With Interdependent Criteria

Imam Djati Widodo
Department of Industrial Engineering
Islamic University of Indonesia, Yogyakarta, Indonesia
Tel: (+62) 8122755363, Email:imamdjati@uii.ac.id

Budi Baharudin
Department of Mechanical Engineering
Politeknik Negeri Batam, Batam, Indonesia
Tel: (+62)8122211184, Email: 13baharudin@gmail.com

Abstract. Supplier selection process plays an important role in reducing the cost and time to market besides maintaining product quality. This paper presents the way of selecting the best suppliers with some interdependent criteria. Analytic Network Process (ANP) is applied for weighting criteria and selecting supplier. The research has 5 steps including identify criteria, structuring network model, data gathering, data processing, and result analysis. A case study in one of Indonesia oil and gas industry is used in this study. Six important criteria with 14 sub criteria and their relations are identified. Based on developed network model and pair comparison, the best supplier (supplier 1) is selected.

Keywords: Supplier selection, interdependent criteria, Analytic Network Process

1. INTRODUCTION

Supply chain management, including the purchasing function and other important activities related between suppliers and distributors, is a substantial aspect of industrial business process. Hines (1997) stated that many successful organizations gained competitive advantage through their network of suppliers.

Purchasing, which have to get the raw materials, supplies and parts for the company, will have big role to the success of company because it influences to the production process and quality product. Mismanagement in purchasing will have serious impact to lead time, quality and service.

Supplier selection process, as part of purchasing, is essential to keep procurement process running well. Amid, et al (2011) emphasized that supplier selection was an important activity in procurement for achieving competitive advantage. It will effectively help the company to achieve the desired output. The lack of supplier selection of raw materials will have impact on company productivity. This is due to quality of the raw material will influence in the production process that can affect to the final product.

Companies generally have different requirements in supplier selection therefore the company will conduct periodic evaluations to ensure that the procurement of raw materials and suitable standards specified company. Some criteria and sub criteria are usually used to select suppliers.

Selection of suppliers is the problem of multi-criteria wherein each of the criteria used to have different interests and information on this case is not precisely known. Some multi criteria decision making method are usually applied, such as Preference Ranking Organization Method For Enrichment Evaluations (PROMETHEE), Technique for Order Preference by Similarity to Ideal Solution (*TOPSIS), and* Analytical Hierarchy Process (AHP).

However, in many cases there are interdependencies and feedback criteria among criteria. These cannot be solved by using AHP, *Promethee, and TOPSIS*. ANP is a practical tool for handling the interdependencies.

This paper will analyze a supplier selection case in an Indonesia petroleum industry.

2. LITERATURE STUDY

Many discrete multi criteria decision making (MCDM) methodologies have been developed and proposed, utilizing numerous numerical and empirical methods. AHP, developed by Thomas L. Saaty in 1980, is one of important and popular techniques used by the researchers and practitioners. Some of the researchers have proposed AHP to deal with the supplier

selection problem (Chan and Chan, 2004; Liu and Haim, 2005; and Ramanathan, 2007). Some researchers also applied AHP for sustainable energy policy decisions (Pohekar & Ramachandran, 2004).

ANP was developed by Saaty in 1996 as response of some AHP weaknesses. This method is becoming the first multi criteria mathematical theory that can deal systematically with dependence and feedback and reveals the composite weights through the calculations using the supermatrix phenomena (Bayazit, 2006). ANP has been widely applied to support decision making in many fields such as manufacturing strategy (Görener, 2012; Theiben & Spinier, 2014), balance scorecard (Boj, e al, 2014; Cheng et al, 2011, Yüksel & Dağdeviren, 2010), supplies selection (Sadeghi, et al, 2011; Dargi et al, 2014) and project and building (Cheng & Li, 2005,2007).

There are four steps to apply ANP, namely (Saaty, 1996): **Step 1:** defining problem and structuring network model. ANP applies feedback structure that does not have the linear top-to-bottom form of a hierarchy but it looks like a network, with cycles connecting its components of elements.

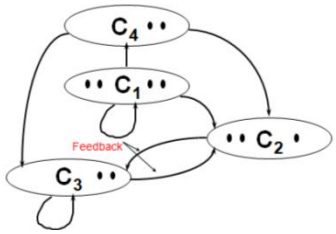


Figure 1: Feedback structure

Step 2: running pairwise comparisons. Interdependencies among criteria of a cluster must also be examined pairwise; the influence of each element on other elements can be represented by an eigenvector. The relative importance values are determined with Saaty's scale.

Intensity of importance	Explanation
1	Two criterion contribute equally to the objective
3	Experience and judgement slightly favor one over another
5	Experience and judgment strongly favor one over another
7	Criterion is strongly favored and its dominance is demonstrated in practice
9	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Used to represent compromise between the priorities listed above

Figure 2. The Saaty's scale of relative importance values

Step 3: formulating Supermatrix. As a result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two clusters in a system. There are three Supermatrix being calculated namely unweighted, weighted and limit supermatrix. Unweighted Supermatrix is to determine local priorities weight which do not consider their inter-cluster comparison (group matrix). Weighted supermatrix considers comparison among clusters (matrix group). Supermatrik weighted supermatrix is obtained. Limit supermatrik is obtained by adding up all the value in a cell in one row of supermatrik weighted divided by the number of existing cells.

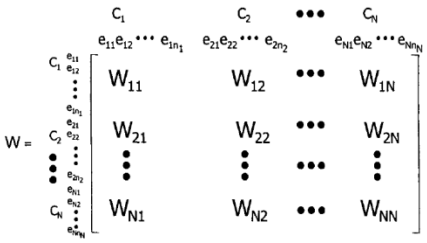


Figure 3. supermatrix

Step 4: Synthesizing the criteria and alternatives' priorities and selection of the best alternatives

3. METHODOLOGY

This paper implements 5 steps to reach the final result in supplier selection process. Literature study is performed to understand the problem based on theoretical and some experienced implementation. The first step is to identify the criteria used in the selection supplier in accordance with the company's goals. This phase is done through brainstorming and focus group activity with the stakeholders. Secondly, based on criteria identified, a network model is structured. Deep discussion with the stakeholder is performed to determine the relationship of dependence among the criteria. Then, network model is performed. Relationships affect among criteria illustrated with arrows. Interdependency between the two criteria referred to outer dependence is illustrated with two arrows while the inner dependence is illustrated by loop.

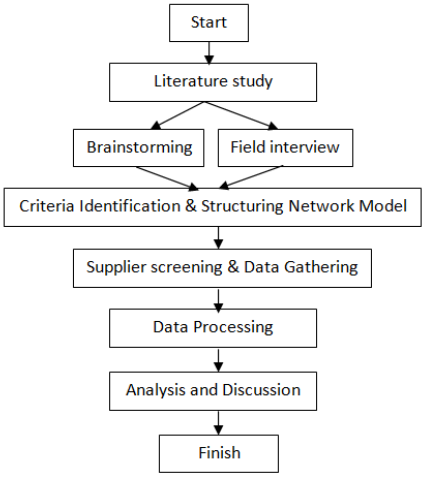


Figure 4: Research Flowchart

Third step is to get data. It is started by screening "feasible supplier" and respondent. Pairwise comparisons among criteria, sub criteria and alternatives are performed. The respondent must be an expert in the field and understand the integrated business process besides he/she has the responsibility for supplier selection decision.

The forth step is processing data questionnaire pairwise comparisons. The result of the fourth stage produces weight local and global weights to see how much the influence of the criteria used for the selection of suppliers. Super decisions software is used to help the computation. And the last step is to analyze the result and decision making.

A Plate supplier selection in Oil and Gas firm will be used as a case study to describe the process. Two senior purchasing manager are involved as expert in this research.

4. RESULT AND DISCUSSION

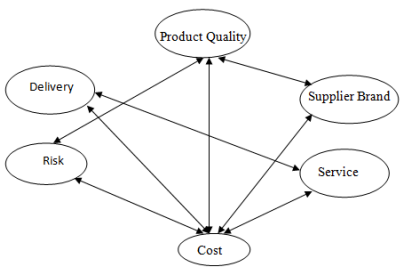
Based on brainstorming and deep discussion with stakeholders, six important criteria with 14 sub criteria are identified.

Table 1: Identified Criteria and sub criteria

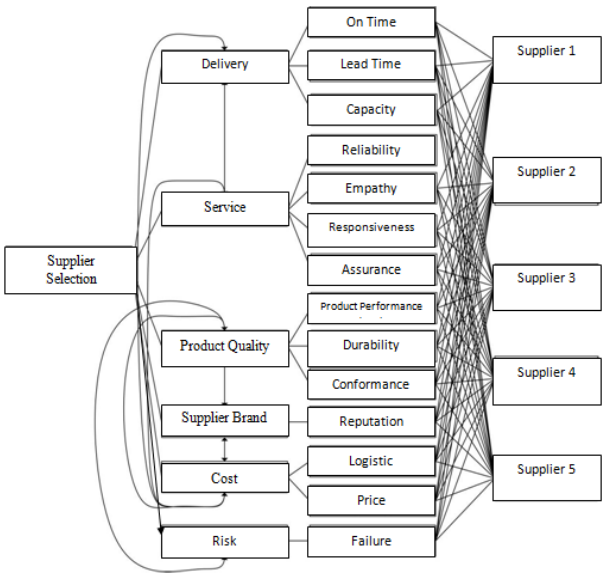
No	Criteria	Sub Criteria
1	Delivery	On Time Delivery
		Delivery Lead Time
		Delivery Capacity
2	Services	Reliability
		Empathy
		Responsiveness
		Service Assurance
3	Product Quality	Product Performance
		Durability
		Conformance
4	Supplier Brand	Reputation
5	Cost	Price
		Logistic cost
6	Risk	Failure

Based on some criteria and sub criteria identified and their relations, a structured network is showed in Figure 4. Cost and quality correlate with other criteria. This condition cannot be accommodated by AHP method.

Data gathering are started by selecting the experts that will evaluate and score pair comparison. Two experts from the firm are selecting and giving scores. Geometric average is applied to calculating the score.



(a)



(b)

Figure 4: Relation (a)among Criteria (b) criteria/sub-Criteria

Priority weight of all criteria is obtained from pairwise comparison (Table 2). It shows that delivery is the most important criteria. It is followed by risk and cost.

Table 2: Overall Priority Scores of Criteria/sub criteria

No	Criteria	Criteria weight	Sub Criteria	Sub Criteria Weight
1	Delivery	0.473	On Time Delivery	0.124
			Delivery Lead Time	0.645
			Delivery Capacity	0.231
2	Services	0.063	Reliability	0.542
			Empathy	0.130
			Responsiveness	0.069
			Service Assurance	0.258
3	Product Quality	0.063	Product Performance	0.380
			Durability	0.380
			Conformance	0.239
4	Supplier Brand	0.063	Reputation	1.000
5	Cost	0.168	Price	0.521
			Logistic cost	0.479
6	Risk	0.169	Failure	1.000

Local priorities are then calculated based on criteria weight. The weights of the local priorities are the result of the normalization of pairwise comparison matrices and will

be incorporated into unweighted supermatrik. Table 3 shows the local priority of suppliers for each criteria.

Table 2: Local Priority Weight Comparison among Alternatives Based on Criteria

No	Criteria	Sub Criteria	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
1	Delivery	On Time Delivery	0.2783	0.0505	0.0505	0.5702	0.0505
		Delivery Lead Time	0.6364	0.0909	0.0909	0.0909	0.0909
		Delivery Capacity	0.5556	0.1111	0.1111	0.1111	0.1111
2	Services	Reliability	0.2783	0.0505	0.0505	0.5702	0.0505
		Empathy	0.6364	0.0909	0.0909	0.0909	0.0909
		Responsiveness	0.5556	0.1111	0.1111	0.1111	0.1111
		Service Assurance	0.2783	0.0505	0.0505	0.5702	0.0505
3	Product Quality	Product Performance	0.6364	0.0909	0.0909	0.0909	0.0909
		Durability	0.5556	0.1111	0.1111	0.1111	0.1111
		Conformance	0.2783	0.0505	0.0505	0.5702	0.0505
4	Supplier Brand	Reputation	0.6364	0.0909	0.0909	0.0909	0.0909
5	Cost	Price	0.5556	0.1111	0.1111	0.1111	0.1111
		Logistic Cost	0.2783	0.0505	0.0505	0.5702	0.0505
6	Risk	Failure	0.6364	0.0909	0.0909	0.0909	0.0909

Limiting Supermatrix has stable priority of all criteria. Based on this, the priority of all criteria and alternative extracted and normalized. The priority of all criteria in limiting matrix is normalized for each cluster. The final priority is obtained (Table 3)

Table 3 Priority-normalized by cluster

No	Criteria	Sub Criteria	Priority-normalized by cluster
1	Delivery	On Time Delivery	0124
		Delivery Lead Time	0.616
		Delivery Capacity	0.260
2	Services	Reliability	0.563
		Empathy	0.125
		Responsiveness	0.061
		Service Assurance	0.251
3	Product Quality	Product Performance	0.605
		Durability	0.133
		Conformance	0.262
4	Supplier	Reputation	1
	Brand		
5	Cost	Price	0.167
		Logistic cost	0.833
6	Risk	Failure	1

Based on the weighting values obtained, priority analysis is performed. Table 4 shows the final rank of all alternatives

Table 4: Final Rank of Supplier

Alternative	Score	Normalized	Rank
Supplier 1	0.5515	0,5515	1
Supplier 2	0,1059	0,1059	5
Supplier 3	0,1097	0,1097	4
Supplier 4	0,1200	0,1200	2
Supplier 5	0,1127	0,1127	3

Supplier 1 is the best supplier because it has highest score accumulated from all criteria.

Conclusion

The problem of supplier selection with interdependent criteria can be successfully solved by implemented ANP method. It can accommodate all relation among criteria and sub criteria. For the case study, delivery is the most important criterion compared to others. Moreover, the most important sub criterion is delivery lead time. Finally, supplier 1 is recommended to be selected because it has highest total score for all the criteria.

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