Decision-making on multi-criteria supplier selection using Analytic Network Process

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Abstract:
In today’s competitive and interrelated manufacturing environment, there many things that a company should do to make it’s Supply Chain Management success. Besides maintaining the customer relationship, the company should must to have a supplier relationship. To select a supplier or vendor, there are many factors or criteria to consider. Quite often, organizations use price as the determining factor when considering which supplier to select. Even though price is an important determining factor, other dimensions such as quality, cost and service management also must be considered at the same time. Every industry has their own categories or criteria to select the supplier. Each category of solutions can enable manufacturers to optimize their relationships and spend with the suppliers. Traditionally, vendors are selected from among many suppliers on their ability to meet the quality requirements, delivery schedule, and the price offered.

In this paper supplier selection in a multi-criteria decision-making process was dealt with the optimization of conflicting objectives such as quality, cost and service management. We propose a supplier selection system based on the Analytic Network Process (ANP), a commonly used model for multi-criteria decision-making problems. Using ANP on this multi-criteria problem, the solution provides satisfactory results allowing inter-dependency and feedback loop among decision criteria.

Keywords: Multi Criteria Decision Making, Supplier Selection, Analytic Network Process. SCM

Introduction
Nowadays in Supply Chain Management (SCM) entity, there are many potential, competitive and innovative resources. Beside from customer relationship views, supplier or vendor relationship is one of the important roles in SCM. Each company has their own categories or criteria based on their needs and the biggest problem is how the company decide the best supplier for its company.

Supplier selection criteria and supplier performances has been a focus point of many researchers in SCM problem. Usually the common vendor selection methods are based on cost, quality and services management. How the vendor can meet the company’s requirements?
A supplier’s product cost may have a high quality, but the cost of the product may not be the lowest. On the other hand, another supplier may propose the lowest cost, but the service may be the worst. Multiple criteria are required by the company to make a good decision making for supplier selection. There are many methods in supplier selection. They are case based reasoning systems, statistical models, decision supports systems, data envelopment analysis, analytic hierarchy process (Lee, et al. 2001), artificial intelligence, or mathematical programming.

For the hierarchical decision problems, Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty, has been widely used (Saaty, 2001). AHP is a multi-criteria problem technique to solving complicated problems. AHP is a comprehensive framework which is designed to cope with the intuitive, rational and irrational problems when multi-objective, multi-criteria and multi-factor decisions are made, with or without certainty, for any number of alternatives. In the decision problems in the SCM, inter-dependence exists among decision variables. As interactions are not allowed in the AHP, ANP model is proposed by Saaty (2004, 2005).

The purpose of this paper is to propose an ANP framework for a supplier selection. An example case with SCM is chosen. The eigen vector from the pairwise comparison is calculated using MATLAB version 6.5. A supermatrix is constructed and a supplier with highest value in the steady state condition is chosen as a best choice.

![Fig. 1](image)

**Analytic Network Process**

The basic assumption of AHP is the condition of functional independence of the upper part, or cluster, of the hierarchy, from all its lower parts, and from the criteria or items in each level. Saaty suggested the use of AHP to solve the problem of independence among alternatives or criteria, and the use of ANP to solve the problem of dependence among alternatives or criteria. Strategic decisions in SC intelligence using ANP is dealt in Raisinghani, and Meade (2005). A comparison of AHP and ANP in the SCM is proposed in Nakagawa and Sekitani (2004). Yuksel and Dagdeviren (2007) adopted ANP in SWOT analysis for a textile firm case. Applying an ANP for the supplier selection in an electronic firm is given in Gencer and Gurpinar (2007). The structural difference between AHP and ANP is shown in Fig. 1.

Nodes of the network represent components of the system; arcs denote interaction between them, where the directions of arcs signify directional dependence. Interdependency between two clusters, termed outer dependence, is represented by a two-way arrow. Inner dependencies among the elements of a cluster are...
represented by looped arcs.

**ANP Steps on supplier selection model.**

Steps for implementing ANP model is propped as the following seven steps adopting the model suggested in Gencer and Gurpinar (2007).

**Step 1:** The first step of the algorithm is the analysis of the supplier selection problem. The main goal of the supplier selection problem is selecting the best supplier that meets the requirements or criteria of the company.

**Step 2:** For the proposed supplier selection model, nine criteria are chosen from three major clusters which are given below.

- A. Quality Management
- B. Cost Management
- C. Service Management

All of the criteria and sub-criteria and detail criteria are given a code letter. These codes are given in next section.

**Step 3:** Alternatives are determined in this step. In this model sample, three supplier alternatives are assumed with their positive and negative aspect.

**Step 4:** The interactions between and within clusters and elements are determined. The supplier selection network model’s control hierarchy according to the determined criteria is given in Fig 2.

**Step 5:** Supermatrix is constructed according to the network built in step 4. The supermatrix structure is shown as the following matrix. The detailed version of the supermatrix is given in Table 3.

\[ W = \begin{bmatrix} W11 & 0 & 0 & W14 \\ W21 & W22 & 0 & W24 \\ W31 & 0 & W33 & W34 \\ W41 & W42 & W43 & 0 \end{bmatrix} \]

**Step 6:** The supermatrix which is constructed in step 5 is an unweighted one. Each column consists of eigenvectors. The element in the supermatrix is a column stochastic which means the sum of a column sums to one. The unweighted supermatrix is multiplied by the priority weights from the clusters, which yields the weighted supermatrix.

**Step 7:** By multiplying the weighted supermatrix by itself until the supermatrix’s row values converge to the same value for
each column of the matrix, the steady state is obtained. In this state, the supplier with the highest priority is chosen.

Application of Supplier Selection

In this paper, the model is consisted of three clusters which are quality, cost and service management. Each cluster has 3 sub-criteria. The hierarchical structure for supplier selection is given in Figure 3.

The explanation of the nine criteria for supplier selection is as follows.

![Hierarchical structure for supplier selection](image)

Quality Management (A)
- (A1) Match company’s requirement: Ability to meet specification and standard.
- (A2) ISO or TQM: Have qualified standardization for the production management process.
- (A3) Technology Capability: Production capability of each supplier to meet a specified production plan.

Cost Management (B)
- (B1) Pricing Term: Suppliers typically offer quantity discounts for larger batch sizes, or offer additional discounts for early payment
- (B2) Cost Reduction: Percentage of the actual cost reduction achieved by the suppliers as a result of pricing policies and technological improvement.
- (B3) Good Finance: financial profile of the suppliers’ total revenue, profitability, etc., of the previous year

Service Management (C)
- (C1) Complaint Availability: Capability for product guarantee or After Service.
- (C2) Catalog Online Information: Provide newest information from suppliers’ product
- (C3) Research and Development Capability: Potential capability of supplier in new product development.

Following seven steps, criteria weights with respect to the A1 and B1 are shown in Table 1 and 2. From these tables, a supermatrix is constructed as Table 3. From the operation of supermatrix, a steady state is attained and a supplier with the highest value is chosen as a solution.

Conclusion

In the SCM, supplier selection is crucial for the success of the value chain. A supplier selection problem is considered as a multiple criteria decision making process. In this paper, an ANP
model is selected for the supplier selection problem. An example data is chosen and applied for the model. In the past, AHP model has been adopted for the hierarchical and multiple criteria decision problem. But in the AHP, independence among criteria is assumed. AHP model allows the dependency and interrelationship among decision variables. For calculation of the super matrix, mathematical software like Matlab or other software should be used. In this paper, Matlab and Microsoft Excel are used to aid the super matrix calculation.

References
Table 1. Criteria weights with respect to the A1

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<tr>
<th>A1</th>
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<th>S2</th>
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Table 2. Criteria weights with respect to the B1

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Table 3. Supermatrix using eigenvector from the criteria weights.

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<th>A3</th>
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