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An integrated multi-objective decision-making process for supplier selection with bundling problem

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Abstract

When the cost of raw materials or component parts dominates the product cost, supplier selection becomes a crucial process for the company to maintain the cost while holding the quality of the products. At the same time, it is likely that the supplier offers bundling products, strategy to get more orders from the company. In this situation, purchasing manager requires decision-making tool which can deal with these problems simultaneously. This article presents an integrated multi-objective decision-making process by using analytic network process (ANP) and mixed integer programming (MIP) to optimize the selection of supplier. The criteria, which are gathered from experts by using Delphi method, are used to construct an ANP model, and are continued to be used by collecting the data from them. The results indicated that cost per unit and failure product cost are important determinants. Thereafter, the ANP results were used as coefficients of an objective function in MIP to allocate order quantities if the supplier uses bundling strategy. A hypothetical example is presented and the results indicated that the combination of ANP and MIP provided useful tool to select the optimal supplier.

Keywords: Supplier selection; Analytic network process (ANP); Bundling strategies; Mixed integer programming (MIP)

1. Introduction

Nowadays, competitive business environment has forced companies to satisfy customers who demand increasing product variety, lower cost, better quality, and faster response (Vondrembse, Uppal, Huang, & Dismukes, 2006). Therefore, offering higher product quality is the main requirement to gain global market share. In addition, companies operate at the lowest possible cost in a competitive market to generate substantial profit (Lau, Pang, & Wong, 2002). These objectives should deal carefully in the supplier selection process, since it enables companies to reduce purchasing cost and improve corporate competitiveness (Demirtas & Ustun, 2008; Ghodyspour & O'Brien, 2001).

However, selecting the right supplier is always a difficult task for many purchasing managers (Liu & Hai, 2005). Managers should realize that no supplier can satisfy all their requirements. Commonly, one supplier satisfies one part of the requirements and another supplier satisfies the other part of the requirements. Therefore, the company has to evaluate and select all possible supplier candidates to various requirements or attributes (Ghodyspour & O'Brien, 1998). These requirements are composed by qualitative as well as quantitative attributes, and the company has to choose the most suitable supplier as its supply chain members.

In Dickson (1966), proposed quality, cost and delivery performance as three of the most important attributes. Since then, many conceptual and empirical studies for supplier selection have been reported (Verma & Pullman, 1998). In general, there are two types of supplier selection problem,

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single sourcing and multiple sourcing (Demirtas & Ustun, 2008). Many studies proposed to deal with single sourcing problem, such as the well-known AHP (Barbarosoglu & Yazgac, 1997; Bhutta & Huq, 2003; Çebi & Bayraktar, 2003; Ghodyspour & O'Brien, 1998; Khurrum & Faizul, 2002; Korpelaa, Lehmusvaara, & Tuominen, 2001; Liu & Hai, 2005; Mohanty & Deshmukh, 1993; Narasimhan, 1983; Nydick & Hill, 1992; Sarkis & Talluri, 2000; Sarkis & Talluri, 2004; Weber & Current, 1991; Yahya & Kingsman, 1999) and ANP (Meade & Presley, 2002; Sarkis & Talluri, 2000), have been used. For multiple sourcing problem, scholars tend to use linear weighting methods (De Boer, Van der Wegen, & Telgen, 1998), mathematical programming (MP) techniques (Akinc, 1993; Barbarosoglu & Yazgac, 1997; Benton, 1991; Bender, Brown, Isaac, & Shapiro, 1985; Current & Weber, 1994; Degraeve & Roodhooft, 2000; Karpak, Kumcu, & Kasuganti, 1999; Narula & Vassilev, 1994; Rosenthal, Zydiak, & Chaudhry, 1995; Sadrian & Yoon, 1994), and the combination of ANP and MP techniques (Demirtas & Ustun, 2008). The bundling problem can be done by using MP techniques (Rosenthal et al., 1995; Sarkis & Semple, 1999), and this study integrates ANP and mixed integer programming to select the best supplier when they use product bundling strategy and defines the optimum quantities among the selected suppliers.

The context of this paper is the notebook industry in Taiwan, since it is the 4th largest manufacturer of computer-related products. Seventeen items of IT products made in Taiwan occupy over a half of the world's market. Among them, notebook computers occupy 61% of the world's market; main board, 75%; and LCD monitors, 61% (Lu, 2005). Although these facts mainly contributed to Taiwan's OEM industry, there is a growing sales trend that some of the Taiwanese notebook producers succeed in selling under their own brand. Due to a rapid technology change and high competition among the Taiwanese notebook manufacturers as well as abroad competitors, selecting suppliers is one of the most important steps to offer innovative products with high quality and reasonable price.

Relevant literature is reviewed in the section that follows. This article develops the ANP model based on the discussion results among practitioners and experts, which is followed by collecting the data by using Delphi method. Thereafter, the ANP results were used as coefficients of an objective function in MIP to allocate order quantities if the supplier uses bundling strategy. The ANP as well as MIP procedure is illustrated through numerical results based on experts' interview from Taiwan's notebook producers. The data were used to demonstrate the ANP and MIP application and examine its effectiveness. Finally, the conclusions and suggestions of the paper are described.

2. Analytical network process

Real business problems consist of interdependence among criteria and alternatives, and ANP can be used as an effective tool to represent these situations by forming a network structure (Saaty, 1996). While AHP employs a unidirectional hierarchical relationship among decision levels, ANP enables interrelationships among the decision levels and attributes to be taken into consideration in a more general form. Moreover, the proposed ANP can reduce judgmental forecast error through "reliability of information processing" (Niemira & Saaty, 2004). ANP uses ratio scale measurements based on pairwise comparisons, and models a decision problem using a systems-with-feedback approach. Fig. 1 shows the structural difference between hierarchical and network approaches. Nodes of the network represent components of the system, and arcs denote interactions between them. The directions of the arcs represent dependence, whereas loops signify inner-dependence of the elements in a cluster. As we can observe, a hierarchy is a simple and special case of a network; even the relative importance values in ANP are determined similar to AHP procedure.

From a general point of view, the ANP consists of two-stages: the construction of the network and the calculation of the priorities among elements. To construct the structure of the problem, all of the interactions among the elements should be considered that were evaluated by pairwise comparisons and by a supermatrix, which is a matrix of influence among the elements, obtained by priority vectors. The supermatrix is raised to limit powers to calculate the overall priorities, and thus the cumulative influence of each element on every other element with which it interacts is obtained (Saaty & Vargas, 1998). Table 1 shows the generalized supermatrix of a system of N clusters:

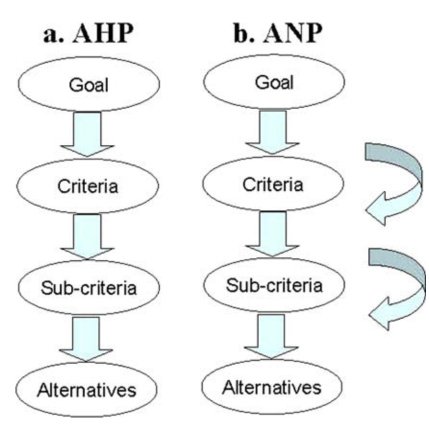

Fig. 1. Structural difference between AHP and ANP.

Table 1
Generalized supermatrix

	Goal	Criteria	Sub-criterion	Alternatives
Goal	I			
Criteria	W_{21}	W_{22}		
Sub-criterion		W_{32}	W_{33}	
Alternatives			W_{34}	I