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Supplier selection model using Taguchi loss function, analytical hierarchy process and multi-choice goal programming

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ABSTRACT

In recent years, determining the best supplier has become a key strategic consideration in the competitive market. Since the decision commonly involves evaluating different criteria or attributes, supplier selection process is a multiple criteria decision-making (MCDM) problem. This study integrates the Taguchi loss function, analytical hierarchy process (AHP) and multi-choice goal programming (MCGP) model for solving the supplier selection problem. The advantage of this proposed method is that it allows decision makers to set multiple aspiration levels for the decision criteria. A numerical example of application is also presented.

1. Introduction

Supplier selection is a multi-criteria decision-making (MCDM) problem that the selection process mainly involves evaluating a number of suppliers according to a set of common criteria for selecting suppliers to meet business needs. For any manufacturing or service business, selecting the right upstream suppliers is a key success factor that will significantly reduce purchasing cost, increase downstream customer satisfaction, and improve competitive ability.

Evaluation criteria may be tangible (measurable) items or intangible (immeasurable) items. Different sets of criteria have been proposed to evaluate suppliers. The criteria for supplier evaluation and selection were first proposed by Dickson (1966), who identified 23 different criteria, including quality, on-time delivery, price, performance history, warranties policy, technical capability and financial stability, and so on. Evans (1980) proposed that price, quality and delivery are the most important criteria for evaluating suppliers in industrial market. Shipley (1985) suggested three criteria, i.e., quality, price and delivery lead time, should be used for supplier selection. Ellram (1990) suggested that the firm need to consider the product quality, offering price, delivery time and service quality in supplier selection. Weber, Current, and Benton (1991) surveyed the frequency of Dickson's 23 criteria and found that price, delivery, quality, and productive capability were mostly used to measure suppliers' performance. Tam and Tummala (2001) proposed quality, cost, problem solving capability, expertise, delivery lead time, experience, and reputation for selecting a vendor for the telecommunications system. Pi and Low (2005) proposed quality, on-time delivery, price and service for supplier evaluation.

Generally, quality is considered the most decisive criterion for supplier selection (Weber et al., 1991). However, quality in itself is not sufficient to ensure that the suppliers can avoid extra costs while offering the right quality. When manufacturers try to decrease their inventory of purchased materials, they will increase their reliance on receiving the "right parts at the right time in the right condition" from their suppliers (Lyn, Unni, & Frank, 1994). Therefore, a just-in-time purchasing system involves a strong relationship with suppliers in terms of offering price, delivery leads time, and service capability.

In practice, the purchase price is a significant factor for the purchasing organization. In 1998, 92% of buyers responding to a *Purchasing* magazine survey cited negotiating price as one of their top responsibilities. Nearly as many respondents said price remains a key criterion they use to select a supplier (Kotler & Keller, 2006).

Losing profitable customers can dramatically affect a firm's profits. Thus, service satisfaction is a very important element of survival in a competitive market. While the most successful companies are aiming for total customer satisfaction, it is important to quantify service quality (Kotler & Keller, 2006). Li (2003)

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proposed two modified service quality loss functions to measure service performance. Similarly, the delivery performance such as delivery reliability, availability, and serviceability must also be assessed to match the service levels as set in service specifications and to increase customer satisfaction (Tam & Tummala, 2001).

Millen (1991) suggested manufacturers need to look at two supplier organizational systems: (1) a process-based evaluation systems, including cost delivery, quality, management and technology, and (2) a performance-based evaluation systems, including supplier's quality and delivery performance. In addition, warranty is an important factor in marketing products because a better warranty policy usually signals a higher product quality and provides greater assurance to customers (Wu, Lin, & Chou, 2006).

In this study, an integrated method of Taguchi loss function, analytical hierarchy process (AHP) and multi-choice goal programming (MCGP) model is proposed to solve the supplier selection problems. First, the Taguchi loss function is applied to assess the loss of each selection criteria. Second, AHP is used to calculate the relative weight of each criterion. Finally, based on the tangible and intangible constrains regarding the suppliers, a MCGP model is formulated and solved to identify the best supplier. The integrated method is shown in Fig. 1.

The rest of this study is organized as follows. Section 2 reviews the supplier evaluation and selection methods. Section 3 introduces the Taguchi loss functions, AHP, and MCGP. Section 4 applies the integrated method to the supplier selection problem with a numerical example. Finally, Section 5 provides the conclusion of the study.

2. Review of the supplier selection methods

In previous research, a number of alternative methods have been proposed for evaluating and selecting suppliers. Most of these models finalize decision-making on supplier selection based on a set of supplier performance criteria (Pi & Low, 2005; Youssef, Zairi, & Mohanty, 1996). Some important models or methods are summarized in the following subsections.

2.1. Cost-ratio method

The cost-ratio method evaluates the cost of each attribute as a percentage of the total purchase for the supplier. Summing these percentages and assigning them to the price percentage, DMs can obtain the total price of the purchasing parts (Tam & Tummala, 2001).

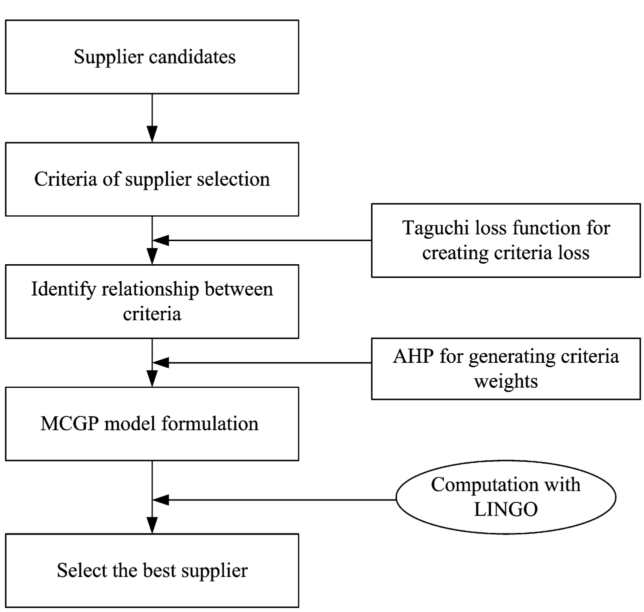

Fig. 1. The integration procedure.

2.2. Cost-based models

Monczka and Trecha (1988) recognized that material price is only a fraction of the cost of the purchased material in this model. There are two performance indexes; the service factor rating and the supplier performance index are considered in this model. Before calculating these two indexes, the evaluated items and performance parameters should be identified.

2.3. Categorical models

Willis and Houston (1990) proposed the categorical model; base on each criterion, the suppliers are classified on good, fair, and bad levels, and are assigned a (+), (0) or (−) to each level, respectively. A suppler is determined to be the best if it gets more (+) than all other. Based on the total score, suppliers then can be ranked and the highest score will be selected.

2.4. Weight-point model

Thompson (1990) provided a weight-point model, which can be expressed as:

$$S_j = \sum_{i}^{n} w_i p_{ij} \tag{1}$$

where S_i is a summation score that represents the total performance anticipated from vendor j; w_i is the importance weight attached to evaluative criteria i; p_{ij} denotes the performance rating on evaluative criteria i for supplier j; and n is the number of evaluative criteria. To use the above model, the criteria for supplier evaluation must be identified and assigned the weight point in the beginning (Willis & Houston, 1990). Then, purchaser will rate the supplier's performance with intuitive judgment.

2.5. Supplier profile method

Supplier profit method is a modified weight-point model (Thompson, 1990) that can be expressed as:

$$S_{jk} = \sum_{i}^{n} w_i p_{ijk} \tag{2}$$

where S_{ik} is the summation score for supplier j on iteration k of the simulation; w_i is importance weight attached to evaluative criteria i; p_{ijk} denotes the performance rating on evaluative criteria i for supplier j during iteration k from simulation; and n is the number of evaluative criteria.

The Monte Carlo simulation technique is used in this model for modeling the uncertainty associated with predicting supplier performance against the evaluative criteria. The simulation algorithm randomly samples values p_{ijk} from within each estimated performance range and then combines these values with importance weights in accordance with linear compensatory rules to produce a distribution of summated scores. Each computer generated S_{jk} amounts to a single iteration of the simulation process.

2.6. Dimensional analysis

This process of supplier evaluation involves a series of one-on-one comparisons, and only two vendors can be compared each time with dimensional analysis. The dimensional analysis ratio (DAR) can be obtained from Eq. (3):