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Enhancing the efficacy of supplier selection decision-making on the initial stage of new product development: A hybrid fuzzy approach considering the strategic and operational factors simultaneously

Chun-Ying Shen [a,*], Kun-Tzu Yu [b]

[a] Department of Business Administration, Ching Yun University, 229, Chien-Hsin Road, Jung-Li, Taoyuan 320, Taiwan
[b] Department of Information Engineering and Informatics, Tzu Chi College of Technology, 880, Section 2, Chien-Kuo Road, Hualien 970, Taiwan

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ABSTRACT

The majority of the existing supplier selection approaches obtained their optimal solutions based on the operational metrics. This study considers the strategic and operational factors simultaneously to secure the efficacy of supplier selection (VS) on initial stage of new product development (NPD). We suggest strategic factors come from the supplier's management system itself (i.e., customer-, long-term-, and process-oriented criteria) while the related performances indices of supplier constitute operational factors (i.e., producer-, short-term- and outcome-oriented criteria). The work adopts supplier's process capability indices (PCIs) and process yields as operational factors to estimate their quality capabilities. The business process-oriented criteria related with the performance of business process improvement (BPI) are employed as the strategic criteria for supplier assessment visit. A fuzzy approach with supply risk consideration is employed then to aggregate the total scores of individual suppliers objectively. An empirical case study is performed to demonstrate the efficacy of the proposed system and to identify the best potential supplier(s) for further development. The results and processes of the case study also provide interesting managerial implications. The derived application of Herzberg's two-factor theory to the realm of supplier selection is discussed as well.

1. Introduction

Worldwide competition in global economies has posed significant challenges to companies wanting to fulfill the continuously changing requirements of the cost reduction, speedy time-to-market, and customization; they place increasing emphasis on supply chain management (SCM) and establish a sounder strategic alliance against competitors. Individual firms no longer compete as autonomous entities but rather by joining a supply chain alliance. Members in the supply chain always forge stronger alliances to compete against other supply chains (Lin & Chen, 2004). One of the competencies essential to supply chain success is an effective purchasing function (Cakravastia & Takahashi, 2004; Sarkis & Talluri, 2002). In most industries the cost of raw materials, component parts, and services constitutes the main cost of a product, in some cases it can account for up to 70–80% of the product costs (Ghobadian, Stainer, & Kiss, 1993; Weber, Current, & Benton, 1991).

Handfield, Ragatz, Petersen, and Monczka (1999) concluded that product design "lock in" as much as 80% of the total cost of a project, and that supplier involvement in buying firm's new product development (NPD) stage could reduce the development time and cost of a project. Suppliers often possess much of this critical expertise. In recent years, firms have downsized, focused on core competencies, and attempted to achieve competitive advantage by leveraging their strategic suppliers' capabilities and technologies (Kannan & Tan, 2002; Perona & Saccani, 2004; Tracey & Vonderembse, 2000). Improvements in product quality, quicker integration of technological breakthroughs, and shorter DPD lead times are the expected outcomes of supplier involvement. Although it is clearly important to keep production costs as low as possible by some improvements, in many ways, attempting cost saving at the manufacturing phrase is analogous to closing the stable door after the horse has bolted.

Supplier/vendor selection (VS) in industry is a group decision-making (GDM), cross-functional problem, frequently solved by a nonprogrammed decision-making process, with long-term commitment for firms. Researches found that the growing importance of cross-functional team involvement in the selection and evaluation of suppliers plays a significant role in the overall performance of a buying firm (Muralidharan, Anantharaman, & Deshmukh, 2002; Pearson & Ellram, 1995). Therefore, a good method for aggregating the various influences of individual opinions, evalua-

* Corresponding author. Tel.: +886 3 4581196x7118; fax: +886 3 4684014.
E-mail address: shency@cyu.edu.tw (C.-Y. Shen).

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tions, and ratings from multiple decision-makers (DMs) must be considered in VS problems.

VS is a decision-making problem at the strategic management level with a semi-structured process (Chou, Shen, & Chang, 2007). The inherent imprecision nature of the relevant information and decision process from such types of problems is broad, has foresight, is nonrecurring and is external. The majority of these factors are evaluated by human perception and judgment, which cannot be quantified precisely. In addition, exclusive the straight re-buy situation, potential suppliers frequently lack a directly proven track record for buying firms. As such, VS at the initial NPD stage typically involve the vagueness inherent in linguistic assessment and multiple criteria/attributes decision-making (herein namely MCDM) processes. Approaches employing only exact numerical (crisp) values cannot support decision-making procedures for such evaluation problems. Fuzzy set theory (FST), as pioneered by Zadeh (1965), which allows for vague boundaries, provides a mechanism to utilize fuzziness in subjective or imprecise determination of preferences, constraints, and goals (Kahraman, Ruan, & Dogan, 2003; Yager, 1982). The rationale behind this approach is that decision-making process often involves gray areas where the term "maybe" is more appropriate. FST is incorporated into many concepts and procedures when enhancing their capabilities to treat MCDM problems in vague environment (Kuo & Chen, 2004; Chang & Wang, 2006; Wang & Elhag, 2006).

The most important task for buying firms on formulating VS criteria is assessing the key competitive factors in their industry and translating these dimensions into VS criteria. Strategic management decisions influence the relative importance of the various criteria in the VS process (Talluri & Narasimhan, 2004; Weber, Current, & Desai, 2000). The choice and the number of criteria to be included in the VS process must be cautiously determined in order to represent the buying firm's competitive strategies (Sarkis & Talluri, 2002; Talluri & Narasimhan, 2003). The majority of VS models in existing publications ignore the fact that evaluation criteria must be in alignment with a firm's strategy. The framework based on analytic network process (ANP) employed by Sarkis and Talluri (2002), the combined data envelopment analysis (DEA) method proposed by Talluri and Narasimhan (2004) for discriminating vendor strategic capabilities and performance metrics are to some extent relevant in this strategy-oriented context.

This study is devoted to find a useful hybrid fuzzy MCDM approach considering strategic and operational factors simultaneously to select the strategy-oriented qualified supply chain partners on the initial stage of NPD with multiple DMs in a dynamic and uncertain environment. The proposed methodology has an intention of having the following characteristics in practice.

The formulations of multiple criteria must be in alignment with a firm's operations management and/or supply chain strategy.

The model can treat VS problems on the initial NPD stage in which the potential supplier's directly proven track records are not sufficient and the weights of the multiple criteria and the ratings of the alternatives can be associated with fuzzy values.

The adjustment mechanism toward supply risks of individual potential suppliers must be considered in the VS model objectively.

Simplify the problem to save subsequent implementation planning and evaluation cost while making decisions effectively without significant loss of quality in the dynamic and uncertain decision-making environment.

The remainder of this paper is organized as follows. Section 2 discusses the related literatures. Section 3 presents a conceptual framework and illustrates the procedures of this model we proposed. Section 4 using an empirical example to perform the model's efficacy and highlight the managerial implications based on the case analysis. The derived applications of Herzberg's two-factor theory in VS realm are discussed as well. Conclusions and suggestions are finally drawn in Section 5.

2. Literature review

The following sub-sections review current literatures for each of the constructs in the proposed model.

De Boer, Labro, and Morlacchi (2001) developed a prescriptive framework for classifying the available models in the literature. The diversity of the buying situation in terms of complexity and importance of the purchasing practice, including new task purchase, modified re-buy, and straight re-buy, are on one axis of the framework. The other axis it covers the four different phrases in the supplier evaluation process: (1) defining the problem, (2) formulation of the criteria, (3) qualification of suppliers, and (4) final selection. The vast majority of the decision-making methods found apply to the qualification and final selection phrase of the buying process, that of choosing a supplier. These methods include linear weighting models, mathematical programming models, total cost of ownership models, statistical models, and artificial intelligence models (Chou et al., 2007). The majority of VS models in existing publications ignore the fact that evaluation criteria must be in alignment with a firm's strategy. In addition, candidate vendors frequently lack a directly proven track/transaction record on the initial NPD stage of a buying firm. Our MCDM approach has a distinctive feature, namely, simultaneous considerations with the strategic and operational factors of VS problem on initial NPD stage. It is well-known that problem formulation is critical to the success of optimization. Therefore, we should use a set of criteria that are well recognized and accepted.

VS decisions are complicated by the fact that various criteria must be considered in the decision-making process. The criteria used may vary across different product categories and purchase situations. There may not be a generalized consensus on how to identify the suitable criteria since these are highly firm- and situation-specific (Choy, Lee, & Lo, 2003; Liu & Hai, 2005; Schmitz & Platts, 2004). The seven most mentioned criteria in Dickson (1966) survey were quality, delivery, performance history, warrant and claim policy, production facilities and capacity, net price, and technical capability. Weber et al. (1991) concluded that the six most mentioned criteria were price, delivery, quality, facilities and capacity, geographic location, and technical capability. Ghodsypour and O'Brien (1998) agreed that cost, quality, and service are the three main categories when deciding supplier selection parameters. Hong, Park, Jang, and Rho (2005) identified important criteria of both supply risk and supply benefit. They defined the supply risk criteria which can be used to evaluate a supplier's capability of delivering the desired product in right quantity and right time. On the other hand, the criteria can be used to evaluate supply benefit as price, quality and quantity. Tracey and Tan (2001) pointed out that there is no evidence that selecting suppliers based on price has a positive impact on firm performance. Mohammady Garfamy (2004, 2005) also concluded that the price criterion has no relation with a firm's operating performance of Business process improvement (BPI). In general, only when two or more suppliers appear equally capable of satisfying purchase requirements, will price play a dominant role in the purchase decision.

BPI, a process- and customer-oriented approach of improvement, is an effective and comprehensive means to improve a firm's performance (Zairi, 1997), and plays a very important role in pursuit of a market competitiveness in the long run (Carpinetti, Buosi, & Gerólamo, 2003). The exploratory case study of Mohammady Garfamy (2004) concluded that BPI is a significant approach that may involve making long-term alliances with suppliers and customers. His study pointed out that how and why BPI through