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Multi-perspective strategic supplier selection in uncertain environments

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ABSTRACT

In this study, we examine the issue of strategic supplier selection in uncertain decision environments. In contrast to conventional supplier selection, strategic supplier selection comprehensively considers various influencing factors, such as supplier quality and offered price, as well as company strategies, uncertain environments, and human factors. Using a detailed literature review, we investigate the employment of human preference in supplier selection, including preference representation, modeling, and computation. To achieve successful strategic supplier selection, we propose a soft decision model involving multiple stakeholders and multiple perspectives. Founded on interval and hesitant fuzzy methodology, this novel model shows significant capabilities in handling ambiguous judgments of stakeholders and unbiased value preservation of conflicting opinions. The settings of this model guarantee that the selection process strictly conforms to the diverse strategies of the company and is applicable for a flexible number of stakeholders. We also provide numerical illustrations via a case study. To the best of our knowledge, this study is the first to perform theoretical decision modeling using interval and hesitant fuzzy methodology for strategic supplier selection. In addition, the proposed research framework and systematic investigations on preference elicitation theoretically facilitate knowledge accumulation and necessarily supplement previous studies on strategic supplier selection by providing research trends.

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1. Introduction

Suppliers are considerably important to a firm because of their role and overall influence in supply chains. Therefore, supplier selection is a crucial issue in both managerial and operational viewpoints because a smart decision considerably benefits a company. Otherwise, the current intensely competitive market will incur damages. Conventionally, supplier quality and offered price dominate other influencing factors, such as company strategies, human factors, operation techniques, decision environments, and the characteristics of different industries, which are consequently disregarded. Thus, scientific decision making with established systematic criteria is considerably important for supplier selection. To date, supplier selection under the paradigm of multi-criteria decision making (MCDM) has been widely accepted by academic and industrial communities, which has led to a new era of strategic supplier selection.

In the literature, there are at least three recent and popular academic surveys on supplier selection. Jain et al (2009) examined

the relationship between suppliers and buyers and discussed various techniques used in model establishment, such as agent technologies, petri nets, uncertain theories, and artificial intelligence, in studies prior to 2007. Ho et al. (2010) primarily summarized the literature between 2000 and 2008 in the paradigm of MCDM and critically answered two key questions regarding technique employment and criteria establishment in evaluation processing. The most popular techniques identified in the literature are data envelopment analysis (DEA), mathematical programming (MP), analytic hierarchy process (AHP), case-based reasoning, analytic network process (ANP), fuzzy set theory, genetic algorithm, and so on. The latest systematic literature review was conducted by Chai et al. (2013). Based on relevant literature between 2008 and 2012, 123 journal articles had been reviewed, particularly those concerning the three aspects of decision-making (DM) techniques: MCDM, mathematical programming, and artificial intelligence techniques. The study further identified AHP as the most popular DM technique, followed by MP, techniques for order performance by similarity to ideal solution, ANP, DEA, and multi-criteria optimization.

With time as a variable, we observe three main trends of supplier selection studies. The first trend is the transaction from singleton DM technique to hybrid multiple-technique approach. As a result of the increasing complexity of current global supply chain processes, multiple-technique hybridization is necessary for

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the advantages to be acquired. The second trend is the transaction from a certain decision model (26%) to various uncertain approaches (74%), as mentioned in the reviewed literature of [Chai et al. \(2013\)](#). This trend is rational, given that real-world uncertainties in the supply chain process have been considered by scholars. The third trend is the human effect comprehensively drawing attention in modeling the process of supplier selection, resulting in two research directions. Scholars become aware of the importance of human preference information (e.g., decision makers, domain experts, managers, and stakeholders); thus, they attempt to employ multi-farious techniques to depict supplier selection ([Rieger et al., 2014](#)). Preference relation is expected to become a most popular tool after 2000. Meanwhile, studies have started to explore theoretical modeling beyond onefold, while exhibiting more concern with diverse organizational or individual perspectives such as company strategies, stakeholder influence, enterprise resource planning, and policy environments, which consequently lead to an advanced DM paradigm called strategic supplier selection.

In this paper, we study strategic supplier selection in three aspects. First, we develop a simple research framework of this issue based on a detailed literature review. Second, we consider the human factor in the selection process and investigate how to elicit human preference in specific existing uncertainties. By incorporating representative literature, we analyze the means and tools of preference representation and preference modeling. Four commonly used preference relations are revisited, including foundational multiplicative and fuzzy preference relation, as well as recent linguistic and incomplete preference relation. A novel hesitant fuzzy preference relation is also introduced as the proper means for modeling the process of supplier selection. Third, based on the investigations, a novel soft decision model is proposed as the solution for practical strategic supplier selection under complex circumstances.

We particularly examine the practical circumstance of strategic supplier selection in the real world. Thus, the soft decision model is developed toward (1) the multi-strategies of a company, (2) multi-stakeholders as decision makers, and (3) multiple ambiguous and conflicting perspectives. With their considerable influence to profitability and operation of companies, first of all, the selected suppliers must strictly adhere to both managerial and operational strategies of companies. The mechanisms in the proposed model are established to ensure that suppliers are chosen in terms of established company strategies. Second, stakeholders as decision makers in the selection process come from comprehensive and diverse human resources, including company operational and managerial personnel as well as internal and external crew members. The proposed model can tolerate a flexible number of stakeholders and is thus feasible for a practical purpose. Third, by introducing the hesitant fuzzy preference relation and further developing the mean using interval fuzzy methodology, the established model demonstrates a significant capability in handling ambiguous judgments of stakeholders and unbiased preservation of conflicting opinions. This decision mechanism therefore allows a multi-perspective decision-making process, which has a significant positive influence on supply chain performance. To the best of our knowledge, this study is the first theoretical application of hesitant fuzzy methodology for preference elicitation toward strategic supplier selection. There appears to be limited academic research in the field of strategic supplier selection and, in particular, facing the complex practical circumstances of multi-strategies, multi-stakeholders, as well as multiple even conflicting perspectives. This current study pioneers the application and the development of interval and hesitant fuzzy techniques for the establishment of the decision model and the handling mechanism which has been verified through numerical case studies.

The rest of this paper is organized as follows. In the next section, we provide a detailed literature review on strategic supplier selection and a feasible research framework. [Section 3](#) elaborates our investigations on human preference elicitation for strategic supplier selection. We provide a preliminary theoretical decision in [Section 4](#). In [Section 5](#), we elaborate on the multi-perspective decision model for uncertainty strategic supplier selection based on the interval fuzzy methodology and hesitant fuzzy preference. [Section 6](#) details a case study and its numerical illustrations. We conclude this paper in [Section 7](#).

2. Strategic supplier selection: A literature review

Decision problems might have a variety of classification method. According to the essence of the problem, [Simon \(1955, 1962\)](#) initially considered the non-structural form that against general structural decision problems. With this dichotomy, he also suggested that the non-structural decision problem means that it has never been shown up before or its internal structure is very complex. It cannot be addressed via previous methods or models but needs people's creative thinking and intuitive observations in order for both qualitative and quantitative resolving. Therefore, human factors will be in a dominant position for a non-structural decision process. Based on this original thinking, strategic supplier selection as the typical MCDM problem can be generally studied at three levels: structural, semi-structural, and non-structural. First, the structural level addresses well-organized decision problems, including highly structured information tables and settled evaluation criteria. The main concerns of the MCDM problem are how to choose, modify, and utilize various DM techniques for ranking, sorting, and selecting suppliers from a collection of alternatives. In the literature, [Chai et al. \(2013\)](#) provided a systematic review of structural supplier selection based on the literature between 2008 and 2012. Interested readers can also refer to detailed investigations by [Chai \(2014\)](#) on structural supplier selection from the perspectives of decision theories, decision methods, and decision support systems.

Second, identification of the evaluation criteria will be the core concern of semi-structural supplier selection. [Levary \(2008\)](#) studied the criteria formulation of manufacturing industries in selecting global suppliers. A practical supply chain case was investigated, where global suppliers were from China, Brazil, and Ukraine, who were evaluated using multiple criteria that measured the reliability of the supplier, country, transportation, and supplier's suppliers. [Chan and Chan \(2010\)](#) explored the supplier selection in the fashion and textile industry. With the characteristics of flexibility and adaptability in the fast-changing fashion market, [Chan and Chan \(2010\)](#) provided a quick response criteria package, including delivery, shipment, flexibility, organizational strategic issues, perceived risk, and supplier quality. [Ho et al. \(2011\)](#) presented an integrated analytical approach and evaluated the requirements of company stakeholders and business strategies in identifying multiple and conflicting criteria. [Chai et al. \(2013\)](#) proposed a rule-based group decision model that considered the diverse nature of evaluation criteria, such as the condition criteria that preserve subjective assessments of decision makers and the decision criteria that preserve objective data of historical performance.

Aside from the effective criteria settings, extended concerns at the semi-structural level consist of the company's strategic orientation, the relationship among criteria such as dependence or confliction, the influence of decision makers on the criteria, the elicitation and aggregation of human preference, and so on. Some techniques have been employed for these concerns such as quality function deployment ([Bhattacharya et al., 2010](#)), rough set theory

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