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# A fuzzy linguistic computing approach to supplier evaluation

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ABSTRACT

Harnessing the supply base is an important but complex task for enterprises. Supplier performance evaluation is increasingly seen as a strategic issue for companies to maintain and enhance the competitive edge. However, evaluating suppliers is complicated by the fact that various criteria must be considered in the decision-making process, and is inherently a multicriteria decision-making (MCDM) problem. It also concerns the evaluation by different experts of multiple attributes, both qualitative and quantitative. To perceive and to estimate effectively the capability of suppliers are real arduous tasks for executives. This paper takes advantage of the 2-tuple linguistic computing to coping with the heterogeneity and information loss problems while the evaluation processes of subjective integration. The proposed approach based on the group decision-making scenario assists executives in adroit manipulation of the heterogeneity during integration processes and averts the information loss effectively. Finally, we demonstrate the validity and feasibility by means of a high-technology company in Taiwan.



## 1. Introduction

The globalization of competition in the manufacturing industry and the diversification of customers' demands as well as rapid technological developments continue to spur enterprises at a frenetic pace. The evaluation of supplier performance is undeniably regarded as the cornerstone of successful purchasing and supply management to maintain and enhance the competitive edge. Gencer and Gürpinar [1] pointed out that there are two main reasons for this. Firstly, the costs of the purchased goods and services account for more then 60% of the cost of goods sold in many firms. Secondly, over 50% of all quality defects can be traced back to purchase material. Therefore, supplier selection has been long recognized as a critical factor for the companies desiring to be successful in nowadays competition conditions.

As firms increasingly emphasize cooperative relationships with crucial suppliers, executives of buyers are using supplier evaluations to ensure that their business objectives are met consistently and at an acceptable overall performance. Moreover, more firms become interested in developing and implementing strategic partnership with their suppliers [2]. Evaluating and managing supplier performance is becoming increasingly important and challenging. An effective tool/approach is therefore required urgently to assist these firms in prequalifying their suppliers based on their overall performances, selecting the best suppliers and in developing and managing the strategic partnership.

However, evaluating suppliers is a complicated task and inherently a multiple criteria decision-making (MCDM) problem because of the fact that various criteria must be deliberated in the decision-making process. Muralidharan et al. [3]

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compared the advantages and limitations of nine previously developed methods of supplier rating, and combined multiple criteria ng and analytic hierarchy processes to construct a multicriteria group decision-making model. The attributes of quality, delivery, price, technique capability, finances, attitude, facility, flexibility and service were used for supplier evaluation, and the attributes of knowledge, skill, attitude and experience were used for individual assessments. Araz et al. [4] developed an outsourcer evaluation and management system for a textile company by use of fuzzy goal programming (FGP). The approach did not take account of group decision situation. Vonderembse and Tracey [5] investigated the extent to which supplier selection criteria and supplier involvement are used by manufacturers. It also provided support for the claim that firms employing these practices have enhanced supplier and manufacturing performance.

Guneri et al. [6] aimed to present an integrated fuzzy and linear programming approach to the supplier selection problem in supply chain management process. The proposed linear programming model was based on the coefficients of suppliers, buyer's budgeting, suppliers' quality and capacity constraints and order quantities assigned to each supplier according to the linear programming model. Chen et al. [7] applied linguistic values to assess the ratings and weights of supplier selection criteria and then proposed a hierarchy multiple criteria decision-making model based on fuzzy set theory to deal with the supplier selection problems in the supply chain system. By calculating the candidate suppliers' distances to the both fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS) simultaneously, a closeness coefficient is defined to determine the ranking order of all suppliers.

In fact, during the evaluation process of self-superiority and technology capability of supplier performance, most judgments of experts however are determined in qualitative representations by past experience, vague, imprecise knowledge or subjective cognition. The contents are mainly numerical, interval and linguistic, and result in heterogeneous assessment. Integrating suchlike information turns into an important managerial topic. This paper therefore attempts to present an impersonal and systematic evaluation mechanism and the platform of supplier performance.

Evaluation techniques can be mainly classified into two groups; these are qualitative methods and quantitative methods. Qualitative methods describe the characteristics of each measure in sufficient detail to allow them to be understood. Quantitative methods use mathematical models to simulate the effect of measures on problem outcomes. These two kinds of methods, qualitative and quantitative, can be used separately or together. In addition, multicriteria decision-making methods are an important set of tools for addressing challenging business decisions because they allow the manager to better proceed in the face of uncertainty, complexity, and conflicting objectives [5,8]. In order to evaluate the performance of suppliers more appropriately, it should consider not only quantitative index but also qualitative dimensions or factors which are evaluated by multiple decision-makers or experts. The evaluation process appropriately should be regarded as a group multiple criteria decision-making problem as well [9,10].

Experts devote to judge by their experiential cognition and subjective perception in the decision-making process of supplier performance measurement. However, there exist considerable extent of uncertainty, fuzziness and heterogeneity [11]. This is not a seldom situation. In addition, it is prone to information loss happen during the integration processes, and gives rise to the evaluation result of performance level may not be consistent with the expectation of evaluators. Herrera and Martinez [12] indicated a limitation of the fuzzy linguistic approach imposed by its information representation model and the computation methods used when fusion processes are performed on linguistic values. They expressed the linguistic information by means of 2-tuples which are composed by a linguistic term and a numeric value. Together with the 2-tuple representation model they developed a computational technique for computing with words without any loss of information. In addition, they [13] developed a procedure for combining numerical and linguistic information without loss of information in the transformation processes between numerical and linguistic information, taking as base for representing the information the 2-tuple fuzzy linguistic representation model. For supporting recommender systems to evaluate and filter the great amount of information available on the Web to assist people in their search processes.

In addition, Herrera-Viedma and Peis [14] presented a fuzzy evaluation method of Standard Generalized Markup Language documents based on computing with words. Herrera-Viedma et al. [15] proposed an information retrieval system (IRS) based on fuzzy multi-granular linguistic information and a method to process the multi-granular linguistic information in which aspects of different nature are assessed with different uncertainty degrees. Herrera-Viedma et al. [16] presented different fuzzy linguistic multi-agent models for helping users in their information gathering processes on the Web. In this paper we describe a new fuzzy linguistic multi-agent model that incorporates two information filtering techniques (a content-based filtering agent and a collaborative filtering agent) in its structure.

Accordingly, developing an effortless means to estimate the performance ratings while the processes of evaluation integration and appropriately to manipulate the operation of qualitative factors and expert judgment in the supplier evaluation process could brook no delay. In this paper we propose a suitable model based on 2-tuple fuzzy linguistic information to evaluate the supplier performance. The proposed approach not only inherits the existing characters of fuzzy linguistic assessment but also overcomes the problems of information loss of other fuzzy linguistic approaches.

The remainder of this paper is organized as follows. Section 2 describes the measurement dimensions of supplier evaluation. In Section 3 we introduce the basic definitions and notations of the fuzzy number, linguistic variable and 2-tuple fuzzy linguistic representation and operation, respectively. A supplier performance evaluation method based on 2-tuple fuzzy linguistic information is proposed in Section 4. The proposed model is then illustrated with an example for a high-technology company in Taiwan. Section 5 concludes the paper.