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Multi objective performance analysis: A novel multi-criteria decision making approach for a supply chain

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ABSTRACT

This investigation introduces multi objective performance analysis (MOPA), a novel multi-criteria decision making (MCDM) approach to solve decision problems in a supply chain. In this paper, an innovative modified weight concept is employed to modify the weights of the criteria in order to reduce the affect of the inherent inaccuracy involved with direct use of weights. Modified weight and normalized performance rating are integrated to compute modified weighted performance (MWP). Aggregate modified weighted performances (AMWP) of the alternatives are determined to evaluate benefit cost ratio (BCR) which is considered as the final selection index of the alternative. The proposed algorithm MOPA is illustrated with six real life decision problems in various stages of a supply chain to adjudge its enviable significance from the point of simplicity, feasibility and applicability. In order to ensure the compatibility, the result obtained by the proposed algorithm MOPA is compared with the proven and established MCDM methodologies TOPSIS, SAW, MOORA, ELECTRE II, and VIKOR. The comparative analysis shows that the achieved result perfectly matches with most of the cited decision problems of previous research works published in various journals. Analysis of variance (ANOVA) reveal that the modified weight concept reduces the relative dispersion of weights significantly, leads to precise decision. Sensitivity analysis (SA) and other investigations also find MOPA as a simple, robust, effective and precise decision making tool.

1. Introduction

Decision making is the process of evaluation, ranking and selection of the best from available feasible alternatives. Precise decision making is the key to get success in any organization in order to survive in a highly volatile and competitive market. Appropriate decision making in modern, complex and uncertain industrial environment has posed a significant challenge to the contemporary managers. The managers are always in search of the right kind of decision support aid to meet that requirement. A decision making aid mainly depends upon the nature of the problem, type of organization, quality of human expertise relevant to that specific field. Usually, during data collection process on various aspects of decision problems in an organization, the experts come across many quantitative as well as qualitative assessment of the real situation. The decision makers used to assess the weights of the criteria depending upon the thoughts and expertise of the experts on their respective field. Further, for multi experts, multi decision makers it becomes more complex, conflicting and widely varies as per their difference of opinions. The decision makers also try to consider the weights on a specific scale which can never be the exact/true weights of the criteria. Often, the assessed weights are expressed as a range or scaled values which are inherently involved with relative inaccuracy. Some weight determination technique with in-built limitations also unable to determine the exact assessment of the criteria. Estimation and evaluation of the subjective data is very difficult due to its uncertainty. Qualitative data are necessarily vague, ambiguous, and inexact which are expressed in linguistic term. Even interpretation and conversion of the linguistic variables of the subjective assessment by the human experts often includes inherent inaccuracy leading to inexact decision. Correct assessment of the criteria is really a complex and hard task which is a major hindrance towards precise decision making. The situation demands a methodology which can overcome those difficulties by reducing the error to a major extent. To alleviate that gap, a new decision making approach multi objective performance analysis (MOPA) is proposed. MOPA deals with many experts and

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several criteria in a decision support system for the selection of the best alternative. Hence, MOPA may be regarded as a multi criteria decision making (MCDM) technique.

In this paper, the proposed decision making methodology MOPA find its rigorous illustration on various stages of a supply chain. A conventional supply chain (Fig. 1) is an arrangement of organizations involved through various stake-holders *i.e.* supplier, manufacturer, distributor, retailer, etc. and linked together through diverse processes and activities (Lee & Billington, 1992) producing value added products and services to satisfy customers. The objective of a supply chain is to maximize the generated value which is directly associated with profitability in that organization. Accurate and precise decision making in each stage of a supply chain have a strong impact on the overall profitability and success of an organization. Appropriate decisions in each linkage of the supply chain optimize its network in any organization. Appropriate decision making throughout the chain assists the management to respond quickly to the ever changing demand of the customers. It reduces the supply chain threat and vagueness, significantly reduces cost of a product and exceeding customer's delight. All these merits and challenges indicate the importance of a precise decision making model. The significance of the decision making is improved by the involvement of a committee comprising of high level managers of the organization along with exterior specialists. The committee considers many contradictory criteria in order to make decisions for the best alternative. The selection criteria can be broadly classified into three categories (Liang & Wang, 1991). The selection criteria are critical, objective and subjective in nature. A critical criterion is one which must be satisfied before further assessment of alternatives. Political stability, social or communal acceptance may be considered as examples of critical criteria. Objective criterion is quantitative and expressed by crisp number e.g. cost. Objective criteria are the basis of making decisions under certainty (Zeleny, 1982). Subjective criterion is qualitative and expressed in linguistic variables. Availability of suppliers, immediacy of warehouse to markets and customers, availability of labors and social stability are chosen as probable subjective factors (Heizer & Render, 2004; Stevenson, 2005). All these conflicting criteria of various combinations are considered as the selection attributes for decision making in any stage of a supply chain. Hence, supplier/vendor selection, factory location selection, machine tool selection, warehouse location selection, etc. of a supply chain is a multiple criteria decision making (MCDM) problem.

A number of decision making models have already been proposed by the past researchers. These models include the MCDM models, computer-assisted models, statistical models, production system performance optimization models and other approaches (Hwang & Yoon, 1981). MCDM models include multi-attribute decision making (MADM) models, multi-objective decision making (MODM) models and other similar approaches. In MODM, the decision maker's objective, such as optimized use of resources and enhanced quality, remain unequivocal and are allocated weights which consider their comparative significance (Chen, 1985). Using MCDM, the decision-maker can consider engineering, vendor-related, and cost attributes (Narasimhan & Vickery, 1988). Liang and Wang (1991), Kuo, Chi, and Kao (1999) applied fuzzy set theory (FST) and its extended version to solve decision problems. Liang (1999) created a fuzzy multiple attribute decision-making method to identify the optimal alternative based on ideal and anti-ideal point concepts. Chen (2000) advanced the technique for order preference by similarity to ideal solution (TOPSIS) for group decision making under fuzzy environment. Many other MCDM methods have also been successfully applied by past researches as decision making models for many years. These methods include Simple Additive Weighting (SAW), Multi Objective Optimization on the basis of Ratio Analysis (MOORA), Analytic Hierarchical Process (AHP), Complex Proportional Assessment method with the applications of the Grey systems theory (COPRAS-G), Multi-criteria Optimization and Compromise Solution (called VIKOR), ELimination and Et Choice Translating Reality (ELECTRE) and Grey Relational Analysis (GRA), etc. Each method has its own basic concept, aim, ranking and selecting capability, advantages and disadvantages (Dessler, 2000).

Recent literatures also indicate the trend of various MCDM models and their relevance in decision making in supply chain perspective. Wang, Shaw, and Chen (2000) proposed fuzzy multiple attribute decision making (FMADM) approach on machine selection in flexible manufacturing cell. Chen (2001) developed a new FMADM approach for distribution center location selection problem based on a stepwise ranking procedure. Chu (2002) presented a fuzzy technique for order preference by similarity to ideal solution (FTOPSIS) model to solve the facility location selection problem under group decision making. Kahraman, Ruan, and Ibrahim (2003) solved facility location problems using four different fuzzy multi-attribute group decision making (FMAGDM) approaches considering both quantitative as well as qualitative criteria. Authors judged the approaches in context of computational complexity and found fuzzy AHP as the most complex among all. Bhattacharya, Sarkar, and Mukherjee (2004) proposed a method for selecting plant location under MCDM environment with

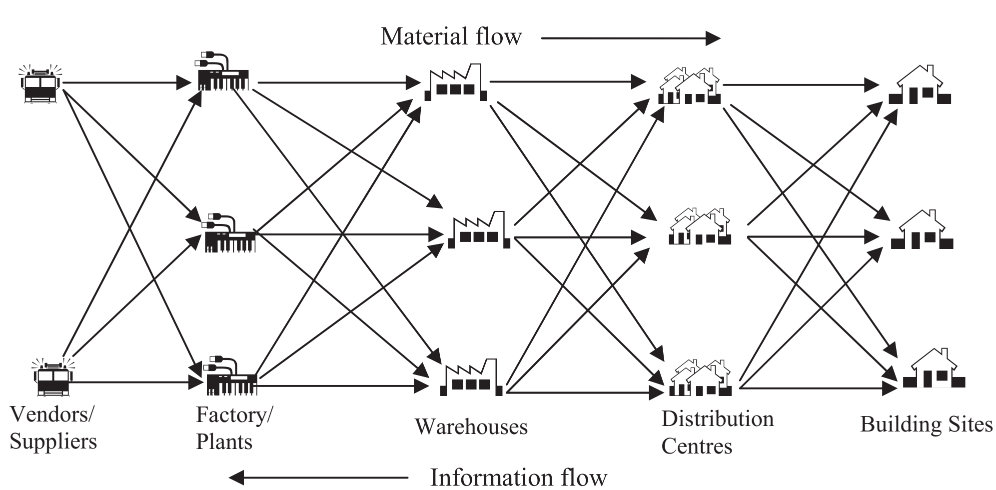

Fig. 1. Stages in a supply chain.