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Group heterogeneity in multi member decision making model with an application to warehouse location selection in a supply chain

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ABSTRACT

Group decision making (GDM) is more effective in extracting the real case scenarios of the decision problems to add competitive advantages in a supply chain. Group members from wider spectrum of the environment naturally command variation in knowledge level to their respective domain. The degree of heterogeneity of the decision makers in a group plays a crucial role in realistic assessment of both alternatives and selection criteria. This paper proposes a new Multi criteria GDM approach in adroit exploitation of the group heterogeneity during evaluation process and restrict the biasness of information while decision making. The importance of the heterogeneous degree of expertise is established through pair wise preference comparison matrix. To overcome the biasness, the consistency check mechanism of analytical hierarchy process (AHP) is employed. A real case example on warehouse location selection in a supply chain is illustrated to demonstrate the validity and effectiveness of the proposed approach. In order to ensure the applicability, compatibility and validity of the proposed approach, comparative study is carried out with the proven and established MCDM methodologies SAW, MOORA, TOPSIS, VIKOR, ELECTRE II, COPRAS and PROMETHEE. ANOVA, Sensitivity analysis (SA) and other investigations find the proposed approach as a rational, robust, effective and precise decision making aid to the supply chain managers.

1. Introduction

Appropriate decision making in modern industrial environment is the key to survive in the ever increasing competitive business scenario. To acquire the competitive advantages, supply chain managers always look for the right kind of decision support aid to meet that requirement. A suitable decision making aid primarily depends upon the nature of the problem, type of organization, quality of human expertise relevant to that specific field. In any high performance global industrial organization, collective/group decision making are suitable to extract possible best solution which may not be possible by an individual decision maker. The experts/decision makers are the real pivotal points in choosing various decision variables in terms of alternatives and their selection criteria in a case problem. The decision maker(s) are truly responsible for realistic assessment of the decisions. In this respect the number of decision makers in a group/committee, their background and freedom of assessment in the given scenario are paramount to decision making environment. Group decision making (GDM) is a process of arriving at a collective decision based on rational, political or consensus mechanism. Bui (1989), Lahti (1996) and Bose, Davey, and Olson (1997) expressed the effectiveness of GDM for finding the final solution and advocated it for today's complex competitive and global industrial scenario. GDM can make decisions which may be beyond thought process capability of any single individual decision maker. This approach can provide more complete, realistic collective decision based on synergistic principle.

1.1. Heterogeneity in group decision making (GDM) environment

In GDM, the members of the committee may be homogeneous or heterogeneous depending upon the degree of expertise of each decision maker in the group. A decision making committee is classified as homogeneous if the evaluation and assessment authority and capability of the entire individual expert in the group assumed to be same, otherwise it is heterogeneous. In a real, complex industrial organization, the members in a decision making committee are picked from diverse zone of the situation considering their

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difference in age, education, expertise, gender, quality, cultural background etc. The members naturally possess difference in attitude, temperament and responsive level. Even these distinctly visible and variable external human characteristics also seem to be the tips in the iceberg in comparison to their divergent implied knowledge level. Hence, the preferred assessments by the individual decision maker vary substantially while evaluating decision information. Even expert(s) may/may not have the same level of expertise corresponding to same group of decision variables. Consequently, the degree of expertise of each decision maker in a committee can never be the same. Hence, the decision making committee can never become truly homogeneous. So, considering/assuming the decision making committee in a real industrial environment homogeneous may be detrimental to the very ethos of accurate decision making. On the contrary, most of the time the heterogeneous nature of the committee truly reflects the real case scenario and capable of delivering the right decision. So, the degree of expertise or the weights of the decision makers are always an important parameter which is to be considered first in heterogeneous decision making environment (Li, Huang, & Chen, 2010; Li & Wan, 2014; Perez, Alonso, Cabrerizo, Lu, & Herrera-viedma, 2011; Wan & Li, 2013).

Under the group heterogeneity concept in GDM, the team leader may/may not influence the other members while assessing the information. Hence, there is every possibility of biasness of information while assessing various decision variables. To overcome the biasness, the approach goes through the consistency check mechanism of analytical hierarchy process (AHP). The unavoidable inherent biasness is restricted utilizing the consistency check mechanism. As the number of conflicting criteria increases in the approach, pair wise comparisons matrices for different decision variables also increases. In spite of the inherent computational complexity, multiple comparisons based on heterogeneous decision maker's assessment can truly provide the rightful final decision which is primarily the basic objective of any case company. (Bhargava, Krishnan, & Miller, 1997) advocated the application of the right kind of information technology (IT) among the group members while assessing the information. IT enabled communication and facilities can overcome the computational complexity very easily.

1.2. Decision making process under GDM environment

A decision making approach takes the advantages of cognitive navigation of human mind. Environmental requirements are the source of a decision problem. Realizing the importance, human brain compares themselves to evaluate the degree of expertise in relation to other experts. Using the sense organs of the human body, the brain preliminarily identifies the feasible location alternatives as well as the tangible and intangible selection attribute/criteria. These human experts with higher level of domain knowledge assess the ratings of the alternatives. The cognitive brain also appropriately assesses the weights of the criteria for the better perception of evaluation procedure. Thereafter the brain, with the mental abilities of judgment, evaluation, reasoning, comprehension and computation, develops a new method or modifies an existing suitable methodology. Consequently, the cognitive process of the individual decision maker of the committee is navigated to the domain of real/environmental phenomenon in order to provide an appropriate solution to the decision problem. Cognitive navigation related to the decision problem, currently related to warehouse location selection in a supply chain, is pictorially depicted in Fig. 1. Many decisions making methods have been developed and illustrated by earlier researchers related to various case studies in supply chain perspective as described in the next sub section.

1.3. Literature review

A number of decision making models have already been proposed by the past researchers. These models include the multi criteria decision making (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. These decision support systems may be based on objective/subjective criteria or by both. Objective criterion is quantitative and expressed by crisp/real number. Subjective criteria are qualitative and expressed in linguistic variables. Furthermore, decision making approaches may be comprises of single/group decision maker(s). Even, the group members in a committee may be homo/heterogeneous in nature. Chen, Zhang, and Dong (2015) carried out an in-depth review on the fusion process with heterogeneous preference relations in GDM and categorized them into three classes. These models include the indirect approach (Chiclana, Herrera, & Herrera-Videna, 1993; Herrera-Videna, Herrera, & Chiclana, 2002), optimization-based approach (Fan, Xiao, & Hu, 2004; Ma, Fan, Jiang, & Mao, 2006) and direct approach models (Dong & Zhang, 2014; Herrera & Herrera-Videna, 1996). In indirect approach, heterogeneous preference structures are normalized/unified by some transformation functions. Multi objective optimization models are used in the optimization models. In the direct approach model, global priority vectors are obtained by simply aggregating all the individual priority vectors. Authors also suggested that the direct approach models have the capacity to provide highest degree of consensus during decision making. These direct approach models also follow up consistency check mechanism while framing preference relations. Zhang, Xu, and Wang (2015) proposed a deviation modeling approach in heterogeneous MCGDM with incomplete weight information. Liang, Shih, and Chiang (2015) argued that team cohesion and cooperation will mediate the effects of team members' demographic characteristics and trait diversity on team helping.

Many GDM models under certainty/uncertainty in a supply chain are proposed by the past researchers. Zeleny (1982) established the application of classical MCDM under certainty. Zadeh (1965) pioneered the use of fuzzy set theory in decision making under uncertainty. Chen (2000a) extended the technique for order preference by similarity to ideal solution (TOPSIS) for group decision making under fuzzy environment. Chen (2000b) developed the aggregation of fuzzy opinions approach in the group decision making environment. 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) tried to solve facility location problems using four different fuzzy multi-attribute group decision making (FMAGDM) approaches considering both quantitative as well as qualitative criteria. They compared the approaches in terms 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 certainty. Byun and Lee (2005) developed a decision support system for the selection of a rapid prototyping process using the modified TOPSIS method. Chou, Yao, and Chun (2008) presented fuzzy simple additive weighting (SAW) method for solving facility location selection though the work is unable to handle problems related to multi facility location. Bairagi, Dey, Sarkar, and Sanyal (2015) proposed a de novo multi criteria decision making technique for the performance evaluation of decision alternatives. Dey, Bairagi, Sarkar, and Sanyal (2016) proposed multi objective performance analysis (MOPA) for making decisions in various stages of a supply chain. Abyazi-Sani and Ghanbari (2016)