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Research Article

Lean Manufacturing Facilitator Selection with VIKOR under Fuzzy Environment

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Abstract

Now a day, Lean manufacturing becomes a key strategy for global competition. In the lean manufacturing environment select the best lean facilitator is a complex multi criteria problem. To solve such types of problems the VIKOR method is applied. By using the VIKOR method the decision makers can take the decision which is closer to the ideal solutions. In this paper linguistic fuzzy data is used to find the ratings and weights. A numerical example is proposed to demonstrate with an application of the proposed technique.

Key words: *Lean manufacturing, facilitator selection, fuzzy ,VIKOR.*

1. Introduction

In manufacturing plants across the world, lean manufacturing techniques are used to meet increasing demands and withstand in the global market .Lean manufacturing techniques have facilitated them to dramatically increase their competitive edge, The journey starts from Henry Ford's continuous assembly lines for the Ford Model. The combination of this concept as well as a successful industrial practice of many others has come as one to create what we know now as lean manufacturing.
The main idea behind lean manufacturing is maximizing customer value while minimizing the seven deadly wastes. Waste is defined as an activity that does not add value to the product. Through the elimination of waste along the entire manufacturing process the company can produce quality products at low-cost.

Many companies have implemented lean manufacturing techniques to create more efficient workflows. In a lean manufacturing environment the role of lean facilitator is vital because they play the role of implementing lean in on the process line.

2.MCDA

Multi-criteria decision-making (MCDM) consigns to screening, prioritizing, ranking, or selecting a set of options under usually independent, incommensurate or conflicting attributes (Hwang & Yoon, 1981). Over some years, the Multi-criteria decision-making methods have been featured. The methods differ in many areas—theoretical environment, type of questions asked and the type of results known (Hobbs & Meier, 1994). Some methods have been crafted particularly for one specific problem, and are not useful for other problems. Other methods are more universal, and many of them have attained popularity in various areas. The most important idea for all the methods is to make a more formalized and better-informed decision-making process. There are many possible ways to classify the existing MCDM methods. Belton and Stewart (2002) classified them in 3 broad categories: Value measurement model such as multi-attribute utility theory (MAUT) and analytical hierarchy process (AHP); outranking models such as Elimination and (Et) Choice Translating Reality (ELECTRE) and Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE) and at last, goal aspiration and reference level models such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).The fundamental assumption in utility theory is that the decision maker chooses the alternative for which the expected utility value is a maximum (Keeney & Raiffa,1976). However, it is difficult in many problems to obtain a mathematical representation of the decision maker's utility function (Opricovic & Tzeng, 2007). The analytic hierarchy process (AHP) is widely used for tackling multi attribute decision-making problems in real situations (Chan & Kumar, 2007). In spite of its popularity and simplicity in concept, this method can deal with imprecision caused by the decision maker's inability to translate his/her preferences for some alternative to another into a totally consistent preference structure. In AHP, the so called consistency ratios are used in order to measure the consistency of the decision-making process. This consistency at calculated at every step of the

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procedure. In case pairwise comparisons in some steps appear to be inconsistent ,the pairwise comparisons can be repeated. Afterwards the consistency ratio for the whole process can be calculated and, if necessary, some of the pairwise comparisons may be reconsidered (De Boer, Wegan, & Telgen, 1998).The outranking methods are normally not used for the actual selection of alternatives, but they are suitable for the initial screening process (to categorize alternatives into acceptable or unacceptable). After the screening process another method must be used to get a full ranking or actual recommendations among the alternatives (Loken, 2007).

3.The Vikor Method

Opricovic (1998), Opricovic and Tzeng (2002) developed VIKOR,the Serbian name: VlseKriterijumska Optimizacija I KompromisnoResenje, means multi-criteria optimization and compromise solution(Chu, Shyu, Tzeng, & Khosla, 2007). The VIKOR method was developed for multi-criteria optimization of complex systems (Opricovic & Tzeng, 2004). This method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision. Here, the compromise solution is a feasible solution which is the closest to the ideal, and a compromise means an agreement established by mutual concessions (Opricovic & Tzeng, 2007). It introduces the multi-criteria ranking index based on the particular measure of ‘‘closeness” to the ‘‘ideal” solution (Opricovic, 1998).According to (Opricovic & Tzeng, 2004) the multi-criteria measure for compromise ranking is developed from the PLp-metric used as an aggregating function in a compromise programming method (Yu, 1973). The various J alternatives are denoted as $a_1; a_2; \ldots ; a_J$. For alternative a_j, the rating of the ith aspect is denoted by f_{ij} , i.e. f_{ij} is the value of ith criterion function for the alternative a_j ; n is the number of criteria. Development of the VIKOR method started with the following form of Lp-metric:

$$Lp;j = \left\{ \sum_{i=1}^{n} \left[w_i (f_1{}^* - f_{ij}) / (f^* - f_1{}^-)^p \right]^{1/p} \right\}$$

$1 \leq p \leq \infty$; j=1,2,3,.....j.

Within the VIKOR method L1;j and L1;j is used to formulate ranking measure. L1;j is interpreted as’ concordance’ and can provide decision makers with information about the maximum group utility’ or ‘majority’. Similarly, L1;j is interpreted as ‘discordance’ and provides decision makers with information about the minimum individual regret of the ‘opponent’. Also TOPSIS, another MCDM method, is based on aggregating function representing ‘‘closeness to ideal”. In TOPSIS the chosen alternative should have the ‘‘shortest distance” from the ideal solution and the ‘‘farthest distance” from the ‘‘negative-ideal”. The TOPSIS method introduces two reference points, but it does not consider the relative importance of the distances from these points. These two MCDM methods use different kinds of normalization to eliminate the units of the criterion functions, whereas the VIKOR method uses linear normalization, the TOPSIS method uses vector normalization. The normalized value in the VIKOR method does not depend on the evaluation unit of criterion function, whereas the normalized values by vector normalization in the TOPSIS method may depend on the evaluation unit (Chuet al., 2007).

4.Fuzzy Approach

In the decision making process, the decision maker is frequently faced with doubts, problems and doubts. In other words usual language to express observation or judgment is always subjective, uncertain or unclear. To determine the vagueness, ambiguity and subjectivity of human judgment, fuzzy set theory (Zadeh, 1965) was introduced to express the linguistic terms in decision making (DM) process. Bellman and Zadeh (1970) developed fuzzy multicriteria decision making (FMCDM) methodology to resolve the lack of precision in assigning importance weights of criteria and the ratings of alternatives regarding evaluation criteria. This logical tools that people can depend on are generally measured the outcome of a bivalent logic (yes/no, true/false), but the problems posed by real-life situations and human thought processes and approaches to problem-solving are by no means bivalent (Tong & Bonissone, 1980). Just as conventional, bivalent logic is based on classic sets, fuzzy logic is based on fuzzy sets. A fuzzy set is a set of objects in which there is no clear-cut or predefined the boundary between the objects that are or are not members of the set. The key concept behind this definition is that of ‘‘membership”: any object may be a member of a set ‘‘to some degree”; and a logical proposition may hold true”to some degree”. Each element in a set is associated with a value indicating to what degree the element is a member of the set. This value comes within the range [0, 1], where 0 and 1, respectively, indicate the minimum and maximum degree of membership, while all the intermediate values indicate degrees of ‘‘partial” membership (Bevilacqua, Ciarapica, & Giacchetta, 2006). This approach helps decision makers solve complex decision making problems in a systematic, consistent and productive way (Carlsson & Fuller, 1996) and has been widely applied to tackle DM problems with multiple criteria and alternatives (Wang & Chang, 2007). In short, fuzzy set theory offers a mathematically precise way of modeling vague preferences for example when it comes to setting the weights of performance scores on criteria. Simply stated, fuzzy set theory makes it possible to mathematically describe a statement like: ‘‘criterion X should have a weight of around 0.8” (de Boer et al., 2001).

5.Chen and Hwang 5 Point Method

The method proposed by Chen and Hwang (1992) first converts linguistic terms into fuzzy numbers and then the fuzzy numbers into crisp scores. The method is described below.

This method systematically converts linguistic terms into their corresponding fuzzy numbers. It contains eight conversion scales. The conversion scales were proposed by synthesizing and modifying the works of Wenstop (1976), Bass and Kwakernaak (1977), Efstathiou and Rajkovic (1979), Bonissone (1982), Efstathiou and Tong (1982), Kerre (1982), and Chen (1988),To demonstrate the method, a 5-point scale having the linguistic terms low,fairly low, medium, fairly high, and high, as shown in Figure 4.1 (Chen and Hwang, 1992), is considered. These linguistic terms can be equated to other terms like

1. Low,
2. Below Average
3. Average,
4. Above Average
5. High.

The method uses a fuzzy scoring approach that is a modification of the fuzzy ranking approaches proposed by Jain (1976, 1977), and Chen (1985). The crisp score of fuzzy number 'M' is obtained as follows:

Linguistic term	Fuzzy number
Low	M1=0.115
Below average	M2=0.295
Average	M3=0.495
Above average	M4=0.695
High	M5=0.895

6.Proposed Method for Facilitator Selection

In this section a methodical approach of the VIKOR being applied to solve the facilitator selection problem under a fuzzy environment. The magnitude weights of various criteria and the ratings of qualitative criteria measured as linguistic variables. Because linguistic assessments merely about the slanted judgment of decision makers.

Facilitator selection in the lean manufacturing system is a group multiple criteria decision making (GMCDM) problem. This is illustrated by the following sets.

1. A set of decision makers called D= {D1,D2,D3, }
2. A set of possible facilitator called F= {F1,F2,F3,F4,F5}
3. A set of criteria, C={C1,C2,C3,C4,C5}

The main steps of the wok are:

The proposed model has been applied to a lean facilitator selection process of a firm working in the field of automobile part manufacturing in the following steps:

Step 1:

The Company desires to select a good lean facilitator.After preliminary screening, five candidate facilitator (F1, F2, F3, F4, and F5) remains for further evaluation.

Step 2:

A committee of three decision makers(DM), D1; D2 and D3, has been formed to select the most suitable facilitator. The following criteria have been defined:

C1-Education Qualification
C2-Knowledge of the Process
C3-Coaching skill
C4-Leadership Quality
C5-Report Writing

Step 3:

Three decision makers use the linguistic weighting variables to assess the importance of the criteria. The importance weights of the criteria determined by these three decision makers are shown in Table 1. Also the decision makers use the linguistic rating variables to evaluate the ratings of candidates with respect to each criterion. The ratings of the five facilitators by the decision makers under the various criteria are shown in Table 2.

Table 1 Importance weight of criteria

	DM1	DM2	DM3	Weights
C1	A	A	AA	0.17
C2	H	AA	H	0.25
C3	H	AA	AA	0.23
C4	A	BA	A	0.14
C5	A	AA	H	0.21

Table 2 Rating of Facilitators

	C1			C2			C3			C4			C5		
	DM1	DM2	DM3	DM1	DM2	DM3	DM1	DM2	DM3	DM1	DM2	DM3	DM1	DM2	DM3
F1	BA	A	AA	AA	H	A	L	L	A	H	A	AA	H	A	AA
F2	H	H	AA	H	A	AA	H	A	AA	H	A	AA	L	L	A
F3	L	L	A	H	H	H	L	L	A	H	H	AA	BA	A	AA
F4	H	AA	H	A	A	L	AA	A	BA	H	H	AA	H	H	AA
F5	AA	A	BA	H	H	A	BA	A	AA	L	L	A	BA	A	AA

Step 4:

The linguistic evaluations shown in Tables 1 and 2 are converted into fuzzy numbers.Then the aggregated weight of criteria and aggregated fuzzy rating of alternatives is calculated to construct the fuzzy decision matrix and determine the fuzzy weight of each criterion, as in Tables 3

Table 3 Converted Data

	C1	C2	C3	C4	C5
Weight	**0.17**	**0.25**	**0.23**	**0.14**	**0.21**
F1	0.50	0.70	0.241	0.70	0.70
F2	0.90	0.70	0.70	0.69	0.30
F3	0.30	0.90	0.30	0.90	0.50
F4	0.70	0.30	0.50	0.90	0.90
F5	0.50	0.70	0.50	0.30	0.50

Step 5: The values of E,F and P are calculated by using the equations

$E_i=\sum_n^m[(m_{ij)max}-(m_{ij})]/[(m_{ij})_{max}-(m_{ij})_{min}]$

$Fi=\sum_n^m wj[(m_{ij)max}-(m_{ij})]/[(m_{ij})_{max}-(m_{ij})_{min}]$

Pi = v ((Ei - Ei-min) / (Ei-max - Ei-min)) + (1 - v) ((Fi - Fi-min) / (Fi-max - Fi-min))
for all the facilitators

E1=1.777	F1=0.760	P1=0.820
E2=1.117	F2=0.700	P2=0.321
E3=1.787	F3=0.760	P3=0.826
E4=1.384	F4=0.830	P4=0.668
E5=1.910.	F5=0.467	P5=0.500

Step 6: The ranking of the Lean facilitator by E, F and P in decreasing order is shown in Table 4.

The ranking of the facilitators by E, F and P in decreasing order.

Table 4 Ranking

Ranking of lean facilitator					
By E	F2	F4	F1	F3	F5
By F	F5	F2	F3	F1	F4
By P	P2	P5	P4	P1	P3

Step 6: As we see in Table 4 the facilitator F2 is the best ranked. Hence F2 is the best choice.

7. Conclusion

Many industries have stressed the advantages of lean manufacturing system to increase the competitive advantage. The facilitator selection problem becomes the most important issue to implement a successful system. The selection problem is often controlled by uncertainty in practice, and in such situation fuzzy set theory is an appropriate tool to deal with this kind of problems. In actual factory system, the decision maker is not able to express his rating precisely in numerical values and the evaluations are very often expressed in linguistic terms. In this work the VIKOR, a newly introduced MCDM method, in fuzzy environment is proposed to deal with the both qualitative and quantitative criteria and select the suitable facilitator effectively.

The proposed method is very flexible. Using this method not only enables us to determine the outranking order, but also assess and rate..Also the proposed method in fuzzy environment provides a systematic approach which can be easily extended to deal with other lean manufacturing decision making problems.

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