Multi Criteria Supplier Selection Using PROMETHEE Outranking Procedures

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Abstract

Some authors implicitly claim that in some of times, you got to decide between two alternatives (suppliers). In other words, the two best-ranked alternatives are incomparable, and there is no clear evidence in favor of either of alternatives. However, some of the conventional MCDM (Multiple Criteria Decision Making) models introduced only one of them as the best alternative. Thus, it will cause biased in results and DMs (Decision Makers) to make the wrong decision. Since, in order to effectively solve this limitation, this paper proposed an outranking procedure, called PROMETHEE (Preference Ranking Organization METHods for Enrichment Evaluations) to deal with the supplier selection problem. Because, one of the advantages of this approach is bring out such incomparabilities. In other words, in the proposed method (PROMETHEE I), some alternatives are comparable, while some others are not. However, in this circumstance it is recommended that additional information is required, but other models ignored it. Therefore, the PROMETHEE I is an effective approach in dealing with this kind of decision problem. Moreover, the weights of the criteria are determined by using Entropy method. Finally, a comparative analysis is performed, and the proposed method seems to be more satisfactory than the other MCDM models (i.e. PROMETHEE II, AHP, and TOPSIS) for solving decision problems.

Keywords: MCDM, PROMETHEE, Incomparability, Supplier Selection Problem

Introduction

Now-a-days supply chain management is one of the most important affairs that applying its new approaches is essential among competitive industries and markets. For any company, the most significant decision is to purchase goods, materials and services from suppliers. Now the better suppliers perform the better company do. So the role of suppliers is critical in the competitive markets (Tabar and Charkhgard, 2012). Supplier selection is the process by which suppliers are reviewed, evaluated, and chosen to become part of the company's supply chain. The objective of supplier selection is to identify suppliers with the highest potential for meeting a company's needs consistently. In other words, the overall objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and build the closeness and long-term relationships between buyers and suppliers. Nevertheless, selecting suitable suppliers is the cornerstone of successful purchasing. However, identifying suitable supplier is not an easy task. One can argue that it is extremely difficult for any single supplier to excel in all criteria. An actual choice of supplier unavoidable involves trade-off among the attribute levels of different suppliers (Azadfallah, 2016_a). Hence, supplier selection is a MCDM problem, which is affected by several conflicting factors (Tahriri et al., 2008; Tabar and Charkhgard, 2012; Azadfallah, 2014; Kuo et al., 2015; and Azadfallah, 2016_b). Multi Attribute Decision Making (MADM) is the most well known branch of decision-making. It is a branch of a general class of Operations Research (or OR) models which deal with decision problems under the presence of a number of decision criteria. This supper class of models is very often called Multi Criteria Decision Making (or MCDM). MCDM is divided into Multi Objective Decision Making (or MODM) and Multi Attribute Decision Making (or MADM). MODM studies decision problems in which the decision space is continuous. A typical example is mathematical programming problems with multiple objective functions. On the other hand, MADM concentrates on problems with discrete decision spaces. In these problems, the set of decision alternatives has been pre-determined (Triantaphyllou et al., 1998). In other words, MADM models are selector models that are used for evaluating, ranking and selecting the most appropriate alternative from among several alternatives (Alinezhad and Amini, 2011). Generally, according to the viewpoint proposed by Boer et al. (2001), OR-models may enhance the effectiveness of purchasing decisions by: 1) aiding the purchaser in solving the 'right problem', e.g. refraining from dropping a supplier when the delivery problems are actually caused by feeding the supplier with outdated information, 2) aiding the purchaser in taking more and relevant alternatives criteria into account when making purchasing (management) decisions, e.g. more long-term considerations when deciding on make-or-buy, 3) aiding the purchaser to more precisely model the decisions situation, e.g. dealing specifically with intangible factors and group decision making. In addition, OR-models may improve the efficiency of purchasing (management) decision making by: 1) enabling automated and faster computation and analysis of decision making information, e.g. data on suppliers found on the internet, 2) enabling more efficient storage of purchasing decision making processes and access to this information in future cases, e.g. saving files that contain criteria-structures for supplier evaluation, 3) eliminating redundant criteria and alternatives from the decision or evaluation process, e.g. in extensive and expensive supplier audit programs, and 4) facilitating more efficient communication about and justification of the outcome of decision making processes, e.g. when reporting to management or suppliers.

The PROMETHEE methods belong to the class of outranking method (Brans and Mareschal, 2005). The outranking concept is moreover build upon the principle of dominating and dominated alternatives. Therefore, outranking models proceed to a pairwise comparison of the alternatives regarding their performance on each single criterion. Dominance occurs when one alternative performs better than another one on at least one criterion and no worse than the other on all other criteria (Schwartz and Gothner, 2009). It is well adapted to problems where a finite number of alternative actions are to be ranked considering several, sometimes conflicting, criteria. Methodology is one of the most efficient as well as the most easy in the use of methodology among other methods employing in the application field (Yilmaz and Dagdeviren, 2011). The implementation of the PROMETHEE method requires two types of information, which are the criteria weight and preference function. The PROMETHEE method assumes the DMs can decide the weights of the criteria. For each criterion, the preference function translates the difference between the evaluations that are obtained by the two alternatives into a preference degree ranging from 0 to 1 (Tsui and Wen, 2012). Six preference functions represented by specific shapes are available in the PROMETHEE method. Each shape is dependent on two thresholds, q and p. q is an indifference threshold representing the largest deviation that is considered negligible, and the preference threshold p represents the smallest deviation that is considered as decisive. P cannot be smaller than q. generally; the PROMETHEE method is based on the calculation of positive flow (Φ^{+}) and negative flow (Φ^{-}) for each alternative according to the given weight for each criterion. The positive outranking flow expresses how much each alternative is outranking all the others. The higher the positive flow ($\Phi^{+ \to 1}$), the better the alternative. The negative outranking flow expresses how much each alternative is outranked by all the others. The smaller the negative flow ($\Phi^{- \to 0}$), the better the alternative (Bogdanovic et al., 2012).

On the other side, according to the viewpoint proposed by Brans and Vincke (1985), some actions are comparable, while some others are not. In other words, sometimes, alternatives are not comparable because their differences are too high. For example, it is easy to compare the prestige of a BMW and a Mercedes because they are close. It is much more difficult to quantify precisely how many times a Mercedes is more prestigious than a Fiat. Because of the large difference. Typically, they do not belong to the same class of prestige (Ishizaka, 2012). Moreover, in (Azadfallah, 2016_{a}) we showed that in 49% of times (out of 100 cases) you got to decide between two alternatives (suppliers). In other words, the two best-ranked alternatives are incomparable, and there is no clear evidence in favor of either of alternatives; however, conventional method (particularly, TOPSIS method) introduced only one of them as the best alternative. Thus, it will cause biased in results and DMs to make the wrong decision. PROMETHEE method provides a partial ranking after identifying alternatives, which cannot be compared with each other (Ozturk et al., 2013). It is one of the advantages of the method to bring out such incomparabilities (Brans and Vincke, 1985). While, according to Macharis et al. (2004), PROMETHEE does not provide specific guidelines for determining criteria weights. In continuation, we follow Safari et al. (2012), in utilizing the entropy method weights as the criteria weights in PROMETHEE methods. Entropy is a well-known method in obtaining the weights for an MADM problem especially when obtaining a suitable weight based on the preferences and DM experiments are not possible (Lotfi and Fallahnejad, 2010).

In this paper, first, the weights of each criterion are calculated using entropy method. Then, PROMETHEE I is utilized to rank the suppliers.

The paper is organized as follow. In the second section, the literature and in the third section, the proposed approach is discussed. Numerical example is provided in the next section. The paper is concluded in the fifth and the last section.

Literature Review

According to the viewpoint proposed by Brans and Mareschal (2005), a considerable number of successful applications has been treated by the PROMETHEE methodology in various fields such as banking, industrial location, manpower planning, water resources, investments, medicine, chemistry, health care, tourism, ethics in OR, dynamic management. The success of the methodology is basically due to its mathematical properties and to its particular friendliness of use. In continuation, among various papers, which are available for supplier selection problem, we assessed just those ones, which were based on PROMETHEE methods. Dulmin and Mininno (2003) used PROMETHEE (especially, PROMETHEE/GAIA techniques plus high-dimensional sensitivity analysis) for supplier selection problem. Wang, Chen and Chen (2008) presented the fuzzy PROMETHEE method to evaluate four potential suppliers based on seven criteria and four decision makers by using a realistic case study. Rao and Rajesh (2009) proposed an effective decision making framework for software selection in manufacturing industries using a Multiple Criteria Decision Making, PROMETHEE. Shirinfar and Haleh (2011) first, used the fuzzy ANP to weighting evaluation criteria and alternatives evaluating by fuzzy TOPSIS and fuzzy-PROMETHEE approaches. Then, the fuzzy Goal Programming model developed selects the most appropriate outsourcers suitable to be strategic partners with the company and simultaneously allocates the quantities to be ordered to them. Yilmaz and Dagdeviren (2011) proposed an integrated approach for equipment selection problem. Two different methods, F-PROMETHEE and ZOGP, and then proposed combined approach are introduced respectively. Alternative equipment's and the set of criteria are determined according to the views of the decision making team, and the weights for the criteria in F-PROMETHEE method and the goal in ZOGP method are assigned with regards to decision making teams experiences and conviction. Safari et al. (2012) applied a new integrated method for supplier selection process, so that, the weights of each criterion are calculated using of Shannon's entropy. After that, PROMETHEE is utilized to rank the alternatives. Then the best supplier based on these result selected. Tsui and Wen (2012) suggested an integrated method which combine AHP, PROMETHEE I and II methods to solve the green supplier selection problem for TFT-LCD case. Goncalo and Alencar (2014) proposed a multi criteria decision support model with two phases: 1. the analysis of the products/services from suppliers that need to be evaluated, using PROMSORT (a PROMETHEE SORTING method), and 2. The analysis of the suppliers of such products/services, which is considered critical using PROMETHEE II. Hesani et al. (2014) studied first, weight and importance of components of selecting supplier are calculated using DEMATEL method and, in the second part, appropriate supplier is selected with regard to weight of any criterion and using DEMATEL-PROMETHEE method. Rdfar and Salahi (2014) developed a hybrid supplier evaluation model, using fuzzy DEA and PROMETHEE. Mahmoudi et al. (2015) solved supplier selection problem under group decision making and fuzzy environment. To do so, a hybrid approach, which employs both fuzzy rule based system (FRBS) and PROMETHEE, is used. Adali et al. (2016) proposed an alternative version of the fuzzy PROMETHEE method. So, preference functions used in PROMETHEE method are handled in terms of fuzzy distances between alternatives with respect to each criterion. Akbib (2016) applied the PROMETHEE method to a real case of an inductive components company to help the decision maker choose the best supplier for each product according to his preferences. In addition, Sari and Timor (2016) used ANP method for calculations of the weights of the criteria and these weights have been transferred to quality loss via Taguchi loss functions. Then, a case study for supplier evaluation and selection in automotive industry is presented and finally a comparison with PROMETHEE method is discussed.

Proposed Approach

PROMETHEE Method

Steps of the PROMETHEE method can be listed as follow (Ozturk et al., 2013):

Step 1: in PROMETHEE method, firstly, the alternatives of the problem, the criteria, and the weights with regard to criteria are identified and then a data matrix is determined for these values. Table 2 presents the data matrix for A= (A, B, C …) alternatives.

Table 1: Data Matrix

-		criteria				
		f_1	f_2	f_3	…	f_k
Alternatives	A	$f_1(A)$	$f_1(A)$	$f_1(A)$	…	$f_1(A)$
	B	$f_1(B)$	$f_1(B)$	$f_1(B)$	…	$f_1(B)$
	C	$f_1(C)$	$f_1(C)$	$f_1(C)$	…	$f_1(C)$
	…	…	…	…	…	…
Weights		W_1	W_2	W_3	…	W_k

Step 2: preference functions are determined depending on the nature of the criteria and the required features of the alternatives associated with the criteria. Preference functions enable the decision makers to limit the criteria according to values determined by him. Preference functions to be used during the application of the method are given below.

Preference functions are:

1. Type I (Usual),
2. Type II (U) shape,
3. Type III (V) shape,
4. Type IV (Level),
5. Type V (Linear),
6. Type VI (Gaussian).

Step 3: based on the preference functions identified for criteria, common preference functions obtained through pair wise comparisons are determined for alternative pairs under the alternative set.

When A and B represent two decision points, the below given equation is used for the common preference function.

$$P(A, B) = 0, f(A) \leq f(B), \quad (1)$$

$$P[f(A) - f(B)], f(A) > f(B) \quad (2)$$

Step 4: in this section, the below given equation is used to determine preference index for each alternative pairs (Brans and Vincke, 1985):

$$Л(a, b) = 1/K \sum^{K}_{h=1} P_h(a, b) \quad (3)$$

Step 5: positive and negative outranking flows are determined for the alternatives. Positive outranking flow (Φ^+) expresses the outgoing flow:

$$\Phi^+(a) = \sum_{x\varepsilon k} Л(a, x), \quad (4)$$

And the negative outranking (Φ^-) expresses the incoming flow:

$$\Phi^-(a) = \sum_{x\varepsilon k} Л(x, a). \quad (5)$$

The larger Φ^+ (a), the more a dominates the other actions of K.

Step 6: in this step, PROMETHEE I partial ranking is obtained. Partial ranking is made by comparing the positive and negative outranking flows. When A and B represents two alternatives in the alternative set, the below given cases come out (Ozturk et al., 2013):

When one of the following is ensured, A is preferred over B.

$$\Phi^+(A) > \Phi^+(B) \text{ Ve } \Phi^-(A) < \Phi^-(B) \quad (6)$$

$$\Phi^+(A) > \Phi^+(B) \text{ Ve } \Phi^-(A) = \Phi^-(B) \quad (7)$$

$$\Phi^+(A) = \Phi^+(B) \text{ Ve } \Phi^-(A) < \Phi^-(B) \quad (8)$$

When the following is ensured, A and B alternatives are identical.

$$\Phi^+(A) = \Phi^+(B) \text{ Ve } \Phi^-(A) = \Phi^-(B) \quad (9)$$

When one of the following is ensured, A and B cannot be compared.

$$\Phi^+(A) > \Phi^+(B) \text{ Ve } \Phi^-(A) > \Phi^-(B) \quad (10)$$

$$\Phi^+(A) < \Phi^+(B) \text{ Ve } \Phi^-(A) < \Phi^-(B) \quad (11)$$

Notice: in this paper, we will use the terms A, B; a, b; a_i, a_j; and a_{ij} to denote the same concept [pair wise comparisons] (because of use the diverse references).

Entropy Method

Shannon's concept is capable of being deployed as a weighting calculation method, through the following step (Shirouyehzad et al., 2013):

Step1. Normalize the evaluation index as:

$$P_{ij} = x_{ij} / \sum_j x_{ij} \quad (12)$$

Step 2. Calculate entropy measure of every index using the following equation:

$$e_j = -k \sum^{n}_{j=1} P_{ij} \operatorname{Ln}(P_{ij}) \quad (13)$$

Where $k = (\operatorname{Ln}(m))^{-1}$.

Step 3. Define the divergence through:

$$div_j = 1 - e_j \quad (14)$$

The more the divj is the more important the criterion jth

Step 4. Obtain the normalized weights of indexes as:

$$W_j = div_j / \sum_j div_j \quad (15)$$

Numerical Example

In this section, a numerical example is used to illustrate the application of the proposed method. Assume that there are five alternatives (suppliers; S1, S2, …, and S5) and six criteria (C1=reduced cost, C2=shorter lead-time, C3=performance of supplier, C4=higher quality, C5=responsiveness, and C6=price). As you see, the data matrix and complementary needed information are shown in table 2 and 3.

Table 2: Data matrix

-		Criteria					
		C1	C2	C3	C4	C5*	C6**
Alternatives (suppliers)	S1	122	13	105	31	Very low	500
	S2	70	19	134	70	High	400
	S3	131	11	94	55	Moderate	350
	S4	136	14	178	59	Moderate	400
	S5	76	22	138	39	Moderate	330
Weights***		0.146	0.131	0.101	0.159	0.292	0.170

*.the used scale in this study is Very low=1, low=2, Moderate=3, High=4, and very High=5.

**. Cost type criteria

***. As discussed later in this paper (table 6).

In this section, we have used PROMETHEE I method to find the preference ordering, as follow. As seen from table 3 (especially, preference function type row), DM has pointed out the type of each criterion and the values of the corresponding parameters. We then have (interested readers may refer to Brans and Vincke (1985) for more discussions on the existing preference function type).

Type IV: level criterion

$$P(x) = \begin{cases} 0, & x \leq q, \\ 1/2, & q < x \leq q+p, \\ 1, & x > q+p \end{cases} \quad (16)$$

Table 3: Complementary Needed Information (Type of Criteria and Parameters)

-	C1	C2	C3	C4	C5	C6
Min/Max	Maximize	Maximize	Maximize	Maximize	Maximize	Minimize
Weight	0.146	0.131	0.101	0.159	0.292	0.170
Preference function	Linear (s and r)	Level (p and q)	Linear (s and r)	Level (p and q)	Linear (s and r)	Linear (s and r)
Indifference threshold	2.7	0.25	4	0.5	05.	0.5
Preference threshold	13.5	1.25	8	1.5	1.5	1.5
Threshold unit	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute

Type V: criterion with linear preference and indifference area (or linear)

$$P(x) = \begin{cases} 0, & x \leq s, \\ (x-s)/r, & s < x \leq s+r, \\ 1, & x \geq s+r \end{cases} \quad (17)$$

For instance, for P (A, B) with linear preference function:

P (A, B; or a_{12}) = 122-70=52

Then,

$$P(x) = \begin{cases} 0, & x \leq 2.7, \\ (x-s)/r, & 2.7 < x \leq 2.7+13.5, \\ 1, & x \geq 2.7+13.5 \end{cases}$$

$P(x) = 52 \geq 2.7+13.5$, so, $P(x) = 1$.

Similarly, the following values are derived (table 4).

In this section, we want to get a weight for each criterion by using the proposed approach (Entropy method). So, in table 5, the normalized rates, and in table 6, entropy, degree of diversification and weight are presented.

Table 4: Values of P (a_{ij}) and P(x)

Criteria	Preference values																			
	P(a_{12})	**P(x)**	**P(a_{13})**	**P(x)**	**P(a_{14})**	**P(x)**	**P(a_{15})**	**P(x)**	**P(a_{21})**	**P(x)**	**P(a_{23})**	**P(x)**	**P(a_{24})**	**P(x)**	**P(a_{25})**	**P(x)**	**P(a_{31})**	**P(x)**	**P(a_{32})**	**P(x)**
C1	52	1	-9	0	-14	0	46	1	-52	0	-61	0	-66	0	-6	0	9	.467	61	1
C2	-6	0	2	1	-1	0	-9	0	6	1	8	1	5	1	-3	0	-2	0	-8	0
C3	-29	0	9	.625	-73	0	-33	0	29	1	40	1	-44	0	-4	0	-11	0	-40	0
C4	-39	0	-24	0	-28	0	-8	0	39	1	15	1	11	1	31	1	24	1	-15	0
C5	-3	0	-2	0	-2	0	-2	0	3	1	1	.333	1	.333	1	.333	2	1	-1	0
C6	-100	0	-150	0	-100	0	-170	0	100	1	-50	0	0	0	-70	0	150	1	50	1
Criteria	P(a_{34})	P(x)	P(a_{35})	P(x)	P(a_{41})	P(x)	P(a_{42})	P(x)	P(a_{43})	P(x)	P(a_{45})	P(x)	P(a_{51})	P(x)	P(a_{52})	P(x)	P(a_{53})	P(x)	P(a_{54})	P(x)
C1	-5	0	55	1	14	.837	66	1	5	.170	60	1	-46	0	6	.244	-55	0	-60	0
C2	-3	0	-11	0	1	.5	-5	0	3	1	-8	0	9	1	3	1	11	1	8	1
C3	-84	0	-44	0	73	1	44	1	84	1	40	1	33	1	4	0	44	1	-40	0
C4	-4	0	16	1	28	1	-11	0	4	1	20	1	8	1	-31	0	-16	0	-20	0
C5	0	0	0	0	2	1	-1	0	0	0	0	0	2	1	-1	0	0	0	0	0
C6	50	1	-20	0	100	1	0	0	-50	0	-70	0	170	1	70	1	20	1	70	1

Table 5: Normalized Rates (P_{ij})

Criteria / Alternative	C1	C2	C3	C4	C5	C6
S1	0.228	0.165	0.162	0.122	0.071	0.278
S2	0.131	0.241	0.206	0.276	0.286	0.222
S3	0.245	0.139	0.145	0.217	0.214	0.167
S4	0.254	0.177	0.274	0.232	0.214	0.222
S5	0.142	0.278	0.213	0.154	0.214	0.111

Table 6: Entropy, Degree of Diversification and Weight

-	C1	C2	C3	C4	C5	C6
Entropy	0.977	0.980	0.984	0.975	0.955	0.974
Degree of diversification	0.023	0.020	0.016	0.025	0.045	0.026
weight	0.146	0.131	0.101	0.159	0.292	0.170

From the above results, it can be concluded that, the criteria weights is as follow.

W_j= (0.146, 0.131, 0.101, 0.159, 0.292, and 0.170)

Next, according to whether the criterion has to be Min or Max we obtain Л (a_i, a_j), i,j=1,2,…,5. For instance, for a_{12}:

a_{12}= 1/5*(1(0.146)+0(0.131)+0(0.101)+0(0.159)+0(0.292)+0(0.170))=0.029

Similarly, the following values are derived (table 7).

Table 7: Values of Л (a_i, a_j)

-	0.029	0.039	0	0.029
0.171	-	0.098	0.077	0.051
0.138	0.063	-	0.034	0.061
0.182	0.049	0.083	-	0.081
0.171	0.067	0.080	0.060	-

Then we can calculate the positive and negative outranking flow as shown in table 8. For instance, for S1:

$$\Phi^{+} = 0.029+0.039+0+0.029=0.097$$

Similarly, the following values are derived (table 8).

Table 8: Positive and Negative Outranking Flow

Alternative	Φ^{+}	Φ^{-}
S1	0.097	0.662
S2	0.397	0.208
S3	0.296	0.300
S4	0.396	0.171
S5	0.378	0.222

From the above results (table 8), it can be easily derived that, the implied ranking is as follow (for positive and negative outranking flows, respectively):

Φ^{+}: **S2>S4**>S5>S3>S1

Φ^{-}: **S4>S2**>S5>S3>S1

Finally, we can depict the partial ranking of PROMETHEE I as shown in figure 1.

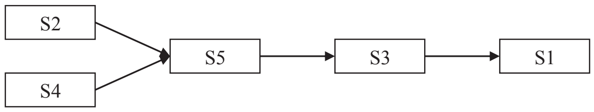
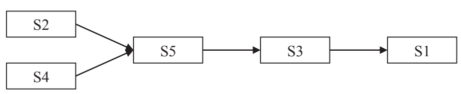


Fig. 1: Partial PROMETHEE I Relation

From the above results, it can be concluded that S2 and S4 are both regarded as the best-ranked alternatives because both of them are ranked first in the final complete partial order. Therefore, the best-ranked suppliers are S2 and S4 together. In other words, two alternatives are incomparable. The incomparability between S2 and S4 happens because S2 is good on a set of criteria on which S4 is weak (C2, C4, and C5) and vice-versa for S4 (C1 and C3). Moreover, it can be seen in table 8, S2 is preferred to alternative S4 in positive outranking flow but S4 is preferred to S2 in the other one (negative outranking flow), then the two alternatives are incomparable in the final partial order. Hence, it seems that, it is logical for S2 and S4 to have the highest rank.

It is also worth noting here that, according to Brans and Mareschal (2005), incomparability holds for most pair wise comparisons, so that it is impossible to decide without additional information. This information can for example include: trade-offs between the criteria, a rule function aggregating all the criteria in a single function in order to obtain a mono-criterion problem for which an optimal solution exists, weights giving the relative importance of the criteria, preferences associated to each pair wise comparison within each criterion, thresholds fixing preference limits, etc. in addition, here, more studies have been done. In order to compare this result with the PROMETHEE II, AHP, and TOPSIS results, we will use the same numerical example (table2). We assume that the reader is familiar with the PROMETHEE II, AHP, and TOPSIS models, and is not repeated here. The result is as follow (table 9).

Table 9: The Comparative Results

Method	Priority
PROMETHEE I	
PROMETHEE II	
AHP	S2 > S4 > S5 > S3 > S1
TOPSIS	S2 > S4 > S3 > S5 > S1

As seen from table 9, the results obtained with different methods were not identical. Nevertheless, compared results show that the proposed algorithm is effective and seems to be more satisfactory than the other methods, in treatments to incomparability's.

Concluding Remarks

According to Azadfallah (2016_a), in some of times, you got to decide between two alternatives (suppliers). In other words, the two best-ranked alternatives are incomparable, and there is no clear evidence in favor of either of alternatives. However, some of the conventional models introduced only one of them as the best alternative (particularly, TOPSIS method). Thus, it will cause biased in results and DMs to make the wrong decision. Since, in this paper, to resolve this limitation, a PROMETHEE I method is proposed. Because of PROMETHEE I method is capable of taking the incomparability's into account. Also, relative weights of each criterion are determined by using entropy method. Next, PROMETHEE I method are used for selecting the best supplier. According to the results (Fig. 1), the set of best alternatives includes suppliers S2 and S4. They are incomparable but preferable to other alternatives (S2 & S4 > S5 > S3 >S1). In final, a comparative analysis is performed, and the proposed method seems to be more satisfactory than the other MCDM methods (table 9). As noted earlier; while, two best ranked alternatives are incomparable (S2 and S4), and there is no clear evidence in favor of either of alternatives, the other MCDM methods (PROMETHEE II, AHP, and TOPSIS) introduced only one of them as the best (optimal) alternative. In addition, further research can apply this proposed approach to other managerial issues (i.e. selecting plant location, personnel selection, etc.).

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