A New MADM Approach to Ranking Suppliers Based on Performance

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Abstract

One of the negative effects of cooperation with poor suppliers is damaging the brand image, whereas the poor suppliers do not accept the responsibility of those damages. In this paper, to resolve this limitation, a new MADM approach (Weighted Product Model) is proposed. The Weighted Product Model (WPM) is an effective approach in dealing with this kind of decision problem, because in the proposed approach, system with poor performance in some attributes is penalised more heavily. Therefore, the application of the WPM in supplier selection field is the aim of this paper. The main findings of this study confirm the effectiveness of the proposed models.

Keywords: MADM, Weighted Product Model (WPM), Supplier Selection Problem

Introduction

In order to maintain a competitive position in the global market, organisations have to follow strategies to achieve shorter lead times, reduced costs and higher quality. Therefore, suppliers play a key role in achieving corporate competitiveness, and as a result, selecting the right suppliers is a critical component of these new strategies (Azadfallah, 2014). One of the negative effects of cooperation with poor suppliers is damaging the brand image, whereas the poor suppliers do not accept the responsibility of those damages. Therefore, at least the possible action to do is to fine (penalise) these suppliers, because damaging the brand image, can have significant impact on your company's reputation and market shares, which could take years to repair. The Weighted Product Model (WPM) is an effective MADM approach in dealing with this kind of decision problem, because, according to Zhou, Ang and Poh (2006) in WPM models, system with poor performance in some attributes is penalised more heavily. The WPM has two main advantages when considering our problem: it has a low implementation complexity, expressed as processing overhead, and it is a dimensionless analysis method, meaning it eliminates any units of measure from the performance values of the alternatives (Botezatu, Manta & Stan, 2011).

Multi-attribute decision making 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 super 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 predetermined (Triantaphyllou, Shu, Sanchez & Ray, 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 & Amini, 2011). The Weighted Product Model (WPM) is a method that uses multiplication to rank alternatives instead of addition (which is used in the AHP and its previous additive variants). Each alternative is compared with others in terms of ratios, one for each criterion. Each ratio is raised to the power of the relative weight of the corresponding criterion (Triantaphyllou & Baig, 2005), and it is also called as multiplicative exponent weighting (MEW)(Savitha & Chandrasekar, 2011).

This paper aims to use a numerical example to illustrate the process of the proposed MADM method (WPM) in supplier selection context.

The paper is organised 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

To integrate the survey in various aspects, we divide it into two parts: MADM and WPM. Here, the main emphasis is on WPM. In the current literature, there are several examples where some MADM models are used, in the supplier performance measurement. For instance, Sarode and khoke (2009), (2011), and Yaghoubi et al., (2011). On the other side, in recent years, WPM has been successfully adopted in various fields. However, there is not any reference that deals with supplier performance measurement by WPM. For instance, Triantaphyllou and Lin (1996), developed the five fuzzy multi attribute decision making methods (i.e. AHP (original and ideal mode), WPM, TOPSIS, and the weighted sum model). Muley and Bajaj (2010), proposed a new approach to product configuration by applying the theory of fuzzy multi attribute decision-making (FMADM). So, the validity and the feasibility of the proposed method compared with WPM. Vijayalakshmi et al., (2010), developed a new architecture selection method based on multi criteria decision analysis (i.e. WPM, and multiplicative AHP). Athawale and Chakraborty (2011), considered ten most popular MCDM methods and their relative performance are compared with respect to the ranking of the alternative robots. So, the result indicated that, the performance of WPM, TOPSIS and GRA (Grey Relational Analysis) methods are slightly better than others. Bottzatu et al., (2011), used the WPM to evaluate the relations between different security solutions and to select the appropriate one based on variable runtime requirement, in energy fields. Savitha and Chandrasekar (2011), selected the best network from the available visitor networks (Vis) by the SAW and WPM (for the continuous connection by the mobile terminal). Ahmed et al., (2012), used multi criteria decision-making models (specially, WSM, WPM, and AHP) to business selection. Zavadskas et al., (2013), used the weighted sum model, WPM, and WASPAS (weighted aggregated sum product assessment) for assessment of facades alternatives. In addition, the result compared by well-known and reputed MADM model, MOORA (multiple objective optimization based on ratio analysis). Atomojo et al., (2014), modeled a simulation process for the tablet PCs selection using the WPM. Taghizadeh et al., (2014), presented the PAM (polygons area method) for solving the ECM (environmentally conscious manufacturing) program selection problem. In addition, the validity of the proposed method compare with the four well-known MADM methods (i.e. SAW, WPM, TOPSIS, and VIKOR).

This paper aims to shed some light on the choice of the appropriate MADM techniques; so that, supplier with poor performance in some attributes are penalized.

Proposed Approach

The WPM use multiplication to rank alternatives. Each alternative is compared with others by multiplying a number of ratios, one for each criterion. Each ratio is raised to the power of the relative weight of the corresponding criterion. Generally, in order to compare the two alternatives $A_k$and A_l, the following formula is used:

$$R = (A_k / A_l) = \prod^{N}_{j=1} (a_{kj} / a_{lj})^{Wj},$$

If the above ratio is greater than or equal to one, then (in the maximisation case) the conclusion is that alternative A_k is better than alternative A_l. obviously, the best alternative A^* is the one which is better than or at least as good as all other alternatives (Triantaphyllou & Lin, 1996).

As it was stated earlier, The WPM is sometimes called dimensionless analysis, because its structure eliminates any units of measure. Thus, the WPM can be used in single and multi-dimensional decision-making problems. An advantage of the method is that instead of the actual values it can use relative ones. This is true because:

$$a_{kj} / a_{lj} = (a_{kj} / \sum^{N}_{i=1} a_{ki}) / (a_{lj} / \sum^{N}_{i=1} a_{li}) = a'_{kj} / a'_{lj}$$

A relative value a'_{kj} is calculated by using the formula: $a'_{kj} = a_{kj} / \sum^{N}_{i=1} a_{kj}$ where the a'^{s}_{kj} are the actual values (Triantaphyllou *et al*., 1998).In addition,the following table summarizes the characteristics of the well-known MADM models (Table 1).

Table 1: Characteristics of MADM Models

No.	MADM models	Description	Advantages	Disadvantages
1	Weighted Product Model (WPM)	Alternatives are being compared with the other by the weights and ratio of one for each criterion.	1. Can remove any unit of measure. 2. Relative values are used rather than actual ones.	No solution with equal weight of DMs.

*. The table is partially taken from Aruldoss *et al*., 2013, P. 33.

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; S_1, $S_2 \ldots S_5$) and four criteria (C_1= quality, C_2= on-time delivery, C_3= service, and C_4= responsiveness). As you see, the performance values are shown in Table 2. In addition, several researchers have argued that the equal weight rule is often a highly accurate simplification of the decision-making process (Birnbaum, 1998).Thus, W_j = [0.25, 0.25, 0.25, and 0.25].

Table 2:Performance values

Cri Alt.	C1	C2	C3	C4
S1	5	3	7	3
S2	5	1	1	9
S3	9	9	9	1
S4	1	3	7	3
S5	1	7	9	3

When the WPM is applied, then the following values are derived:

$R (S_1/S_2) = (5/5)$ ^0.25 * (3/1) ^0.25 * (7/1) ^0.25 * (3/9) ^0.25 = 1.627 > 1.

Similarly, $R (S_1/S_3) = 0.811 < 1$,

$R (S_1/S_4) = 1.495 > 1$,

$R (S_1/S_5) = 1.136 > 1$,

$R (S_2/S_3) = 0.498 < 1$,

$R (S_2/S_4) = 0.919 < 1$,

$R (S_2/S_5) = 0.699 < 1$,

$R (S_3/S_4) = 1.844 > 1$,

$R (S_3/S_5) = 1.401 > 1$,

$R (S_4/S_5) = 0.760 < 1$.

From the above results, it can be easily derived that, the implied ranking is as follow:

$S_1 > S_2 > S_3 > S_4 > S_5$

Therefore, the best alternative is S_1, since it is superior to all the other alternatives. Meanwhile, S_4 have very bad performance.

Beside, In order to compare the result with the AHP results (as one of major tools of MADM models), we use the same numerical example (Table 2). We assume that the reader is familiar with the AHP models and is not repeated here, and the result is as follow:

S_1= 0.185, S2= 0.196, S3=0.286, S4=0.137, and S_5=0.196

A comparison of the test results is given in Table 3.

Table 3: Comparison of results

Model	Rank
Weighted Product Model (WPM)	$S_1>S_2>S_3> S_4>S_5$
Analytic Hierarchy Process (AHP)	$S_3> S_2\approx S_5>S_1>S_4$

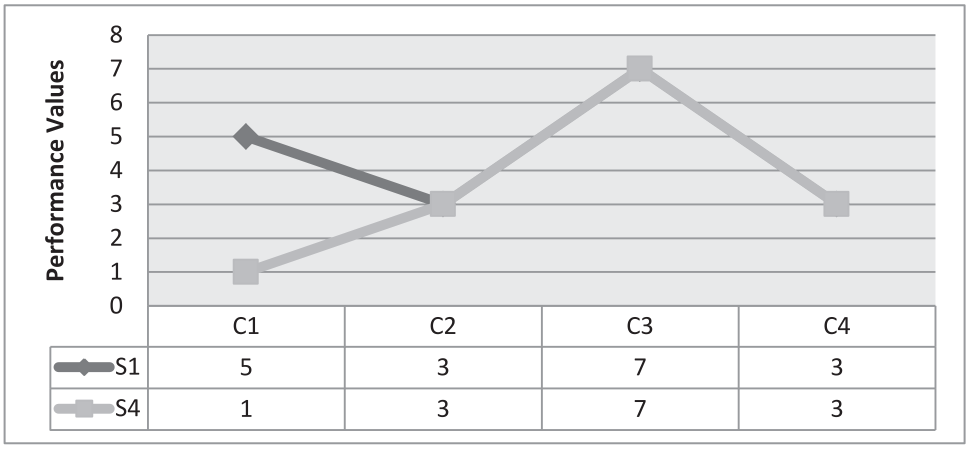
As seen in Table 3, in this illustrative example the differences between two models (WPM/ AHP) are quite clear.

Findings in this paper confirm the effectiveness of proposed method. Results, in consistency to Zhou *et al.* (2006) viewpoints, showed that the system with poor performance in some attributes is penalised more heavily. So that, the poor performancein one criterion (i.e. C_1 in Table 4 and Fig. 1, for S_4) has a great effect on the results (penalised properties). In other words, as can be seen from Table 4 and Fig. 1, despite the fact that there are many similarities between alternative one and four in inputs, we gain different output. Since, it has demonstrated that the WPM method work well.

Table 4:Performance Values (for Two Suppliers, S_1 and S_4)

Alt. / Cri.	C_1	C_2	C_3	C_4
S_1	5	3	7	3
S_4	1	3	7	3

Fig. 1: Performance values (S_1 and S_4)



Concluding Remarks

One of the negative effects of cooperation with poor suppliers is damaging the brand image. Therefore, in this paper, a different method to protect company's brand image is discussed, i.e. Weighted Product Method (WPM). Why WPM? Because in WPM, system with poor performance in some attributes is penalised more heavily. Thus, the likely of choice of the poor supplier is diminished. In general, findings in this paper indicate that result obtained by WPM were significantly different from those obtained using another MADM method (i.e. AHP). While, $S_1>S_2>S_3>S_4>S_5$ is the supplier ranking obtained from application of WPM, AHP rank S_3, S_2 and S_5 over S_1 and S_4. Despite the fact that there are many similarities between alternative one and four in inputs, we gain different output. The findings in this paper confirm the effectiveness of proposed method. In addition, further research can apply this proposed approach to other managerial issues or compared with another MADM methods.

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