

## On the use of the MOORA method in the selection of investment projects

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### Abstract

As is well known, when faced with the problem of decision-making, involving several (eventually conflicting) objectives evaluated according to several criteria, multi-criteria analysis is one of the most appropriate methodologies to support the decision. The flexibility of multi-criteria decision analysis/making is one of its most recognized characteristics, which comes from the various methods that can be considered. Among them is the so-called MOORA (as the initials of Multi-Objective Optimization by Ratio Analysis) method.

**Keywords:** Decision Analysis, Multiple-Criteria Decision Making, MOORA.

### 1. Introduction

The goal of the MOORA method is to rank the several alternatives to optimize two or more conflicting objectives, possibly subject to a certain number of constraints. Given its characteristics – to be described below - It is a technique that can be applied to solve various types of decision-making problems characterized by a variable degree of complexity.

That said, it is not surprising the diversity of areas where the MOORA method has been used. Among others, it has been used in the following areas: contractor's ranking, project management/selection, privatization in a transition economy, and even an application for the, so-called Europe 2020.

### 2. Literature

Let us consider some of the most recent bibliographical references on the subject; see also the next section for a brief history of the MOORA method.

By its characteristics, the MOORA method has been applied more frequently in micro/industrial-decision problems (Karuppanna Prasad & Sekar, 2016). For instance, Chakraborty (2011) considered the problem of decision making in manufacturing environment, whereas Achebo & Odinikuku (2015) analyzed the optimization of gas metal arc welding process parameters using standard deviation and multi-objective optimization. On their turn, Madić et al. (2015) considered non-conventional machining processes selection.

Closely related to the previous area is the selection problem, which has also been recently targeted by applications of the MOORA method. Among others, El-Santawy & El-Dean (2012) studied the selection of a consulting firm by using also a standard deviation approach, whereas Karande & Chakraborty (2012) also applied multi-objective optimization for materials selection. See also Stanujkic et al. (2014) for a grinding circuit selection based on MOORA method and/or Shihab & Chanda (2015) for a multi response optimization of milling process parameters.

The problem of spatial location selection can be included in multi-criteria spatial analysis, which has been considered in the literature. For instance, Görener et al. (2016) applied the multi-objective optimization on the basis of Ratio Analysis for bank branch location selection, whereas Hamzaçebi et al. (2016) considered the selection of logistics center location for the Black Sea region of Turkey.

Other areas, such as ranking Serbian banks, were considered by Stanujkic et al. (2013), and inner climate evaluation, were also recently considered by Kalibatas & Turskis (2015). See also Singaravel et al. (2016) for a relation of MOORA to entropy.

### **3. The MOORA Method**

The MOORA method is relatively recent. The bases of the method were established in Brauers (2004a), which presented, although separately, three multi-objective optimization methods based on dimensionless measurements, namely: a) Ratio System; b) Reference Point Method, and c) Full Multiplicative Optimization. Brauers (2004b) combined these two first methods by using the ratios obtained in the Ratio System as scores in the Reference Point Method. Based on this combination, the name of the method (MOORA as the initials of Multi-Objective Optimization by Ratio Analysis) appeared in Brauers & Zavadskas (2006).<sup>1</sup> Since then, as the previous literature review indicates, it has been applied in a significant number of distinct areas.

In addition, the MOORA method was the subject of a theoretical development by Brauers & Zavadskas (2010), giving rise to the MULTIMOORA method, i.e. the MOORA method in a context of optimization of a purely multiplicative objective function. See, for instance, Datta et al. (2013) for a robot selection problem based on grey-MULTIMOORA approach, and/or Kundakci (2016) for a combined multi-criteria decision making approach based on Macbeth and Multi-MOORA methods.

The optimization principles to the obtain the optimal solutions applying the MOORA method can be performed using minimax or Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods and comparative calculations of efficiency parameters. This is so as the priority is given to the alternative which is nearest to ideal variant under review. See, among others, Kecek & Demirag (2016) for a comparative analysis of TOPSIS and MOORA in laptop selection, and/or Önay (2016) for a multi-criteria assessment of better life via TOPSIS and MOORA methods,<sup>2</sup> and/or Önay & Yıldırım (2016) for an evaluation of NUTS

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<sup>1</sup> Despite the many contributions of several authors, it is fair to acknowledge Brauers and Zavadskas' primordial role in the creation and development of the MOORA method. See also Brauers (2008; 2012) and Brauers & Zavadskas (2009; 2012; 2013).

<sup>2</sup> Patel et al. (2015) also combined the MOORA and TOPSIS methods.

Level 2 Regions of Turkey by TOPSIS, MOORA and also another MCDM method, VIKOR (from Serbian: ViseKriterijumska Optimizacija I Kompromisno Resenje).<sup>3</sup>

Besides the crisp situation, the (Multi)MOORA method has also been applied to fuzzy situations. Among others examples of fuzzy MOORA applications, Dey et al. (2012) considered a MOORA based fuzzy multi-criteria decision making approach for supply chain strategy selection, Mandal & Sarkar (2012) analyzed the selection of best intelligent manufacturing system, and Li (2014) extended the MULTIMOORA method for multiple criteria group decision making based upon hesitant fuzzy sets. The fuzzy MOORA method was also used by Seema et al. (2014) for supplier selection and Stanujkić (2016) for an extension of the ratio system approach of MOORA method for group decision-making based on interval-valued triangular fuzzy numbers;<sup>4</sup> see also Pérez-Domínguez et al. (2015).

#### 4. Mathematical description of the MOORA method

Based on the methodology of the multi-criteria analysis, the MOORA method consists of considering the following steps:

1. Definition of a matrix  $\mathbf{X}$  as follows:

$$\mathbf{X} = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix},$$

where  $x_{ij}$  is the response of alternative  $j$  on objective or attribute  $i$ , being  $m$  the number of alternatives and  $n$  the number of objectives.

As is well-known, the two components of the MOORA method are the Ratio System and the Reference Point. These are to be determined in the subsequent steps.

2. The normalized response of alternative  $j$  on objective or attribute  $i$  is given by

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{j=1}^m x_{ij}^2}}$$

3. Assuming that, among the  $n$  objectives, the first  $g$  are to be maximized and the  $n-g$  are to be minimized, the normalized assessment of alternative  $j$  with respect to all objectives is given by

$$y_j^* = \sum_{i=1}^g w_i x_{ij}^* - \sum_{i=g+1}^n w_i x_{ij}^*,$$

where  $w_i$  is the weight associated to objective  $i$ .

4. The  $i^{\text{th}}$  coordinate of the reference point,  $r_i$ , results from a min max metric of Tchebychev as follows:

<sup>3</sup> Tasci & Gorener (2016) also combined the MOORA method with another MCDM method, the so-called Analytic Hierarchy Process (AHP) to evaluate the strategies of medical tourism sector.

<sup>4</sup> Of particular interest in this area, are Stanujkic et al. (2012), which considered interval grey numbers and Stanujkic et al. (2012), which considered decision-making problems with interval data.

$$\min\{\max(r_i - x_{ij}^*)\},$$

i.e. the use a minmax decision criterion applied to the (absolute) differences between the reference points and the normalized responses.

## 5. Application of the MOORA method in the selection of investment projects

Taking into account the mathematical description of the MOORA method, we now proceed with a demonstration of its applicability. To exemplify the applicability of the MOORA method, we will use a case from our lectures on MCDM, which consists of 10 investment projects (the alternatives) that are classified in accordance to 2 criteria (employment and environment) as the following table shows:

**Table 1. The alternatives and the objectives**

Investment Projects	Employment	Environment
1	6.259346	26.20014
2	95.19333	46.83981
3	30.83895	67.63207
4	24.02722	5.056917
5	9.704886	7.367168
6	65.04715	33.52458
7	73.04910	61.16214
8	2.114933	37.3329
9	85.50981	45.26811
10	5.838191	96.51784

Considering both criteria as equally important – but, of course, one can consider other weights – the application of the MOORA method leads to the following results:<sup>5</sup>

**Table 2. The MOORA (Ratio System) results**

Alternatives	Employment <sup>2</sup>	Environment <sup>2</sup>	Normalized Employment	Normalized Environment	Weighted Sum	Rank 1
1	39.179	686.45	0.0376	0.1652	0.1014	8
2	9061.8	2194.0	0.5726	0.2953	0.4339	1
3	951.04	4574.1	0.1855	0.4264	0.3059	5
4	577.31	25.572	0.1445	0.0319	0.0882	9

<sup>5</sup> An Excel file illustrating all the steps - as described in section 4 - easily adjustable to other cases, is available on request.

5	94.185	54.275	0.0584	0.0464	0.0524	10
6	4231.1	1123.9	0.3912	0.2114	0.3013	6
7	5336.2	3740.8	0.4394	0.3856	0.4125	2
8	4.4729	1393.8	0.0127	0.2354	0.1240	7
9	7311.9	2049.2	0.5143	0.2854	0.3999	3
10	34.084	9315.7	0.0351	0.6085	0.3218	4
<b>Sum</b>	<b>27641.27</b>	<b>25157.73</b>	<b>max 0.5726</b>	<b>0.6085</b>		
<b>Square root</b>	<b>166.26</b>	<b>158.61</b>				

**Table 3.** The MOORA (Reference Point) results

<b>Alternatives</b>	<b>Employment</b>	<b>Environment</b>	<b>max</b>	<b>Rank 2</b>
1	0.5349	0.4433	0.5349	6
2	0000.0	0.3132	0.3132	2
3	0.3871	0.1821	0.3871	4
4	0.4280	0.5766	0.5766	10
5	0.5142	0.5621	0.5621	9
6	0.1813	0.3972	0.3972	5
7	0.1332	0.2229	0.2229	1
8	0.5598	0.3731	0.5598	8
9	0.0582	0.3231	0.3231	3
10	0.5375	0.0000	0.5374	7

## 6. Conclusion

In this chapter, we considered a multi-criteria analysis approach, namely the so-called MOORA (initials of Multi-Objective Optimization by Ratio Analysis) method. Being a relatively recent method, its popularity in terms of the various application areas, as the literature review has shown, is a sign of its versatility and robustness. As an illustration of a possible application of this multi-criteria decision making (MCDM) method, the economic decision to select investment projects was considered in this chapter. Before this, the process of application of the method was explained, so that it can be easily applied in other economic decision problems, particularly business and management problems, usually associated with multi-criteria decision analysis.

Something recently, the MOORA method was extended, giving rise to the MULTI-MOORA method. This extension has not in fact been considered (for the time being) in this chapter, but can easily be put into operation whenever the problem so requires. For example, using the R routine MCDM (Ceballos Martin, 2016), applied to the example above, the results are shown in table 4.

**Table 4.** The Multi-MOORA results

Alternatives	Ratio System	Rank	Reference Point	Rank 1	Multiplicative Form	Rank 2	MultiMOORA Rank
1	0.1014	8	0.2675	6	0.0016	7	7
2	0.4339	1	0.1566	2	0.0423	2	2
3	0.3059	5	0.1935	4	0.0198	5	4
4	0.0882	9	0.2883	10	0.0012	8	9
5	0.052	10	0.2810	9	0.0007	10	10
6	0.3013	6	0.1986	5	0.0207	4	5
7	0.4125	2	0.1115	1	0.0424	1	1
8	0.1240	7	0.2799	8	0.0007	9	8
9	0.3999	3	0.1616	3	0.0367	3	3
10	0.3218	4	0.2687	7	0.0053	6	6

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