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An Implementation of the Entropy Method for Determining Weighing Coefficients in a Multicriteria Optimization of Public Procurements

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ABSTRACT

Determining the weights of criteria is a key problem in multicriteria analysis models. The problem of choosing an appropriate method of determining criteria weights in problems of multicriteria decision-making (MCDM) is a very important stage. Most authors suggest classifying the models of determining the weights of criteria into subjective and objective models. This paper presents the application of the Entropy method for determining criteria weights. The Entropy method is tested in the MCDM problem in public procurements. The results show that the Entropy method shouldn't be used as a correction method because in most cases, the decision maker Also shows that applying the Entropy method in MCDM problems for determining weighing coefficients can be counterproductive.

1. Introduction

Public procurements are an important part of business operations and performance in almost all public companies. Management in these companies is in the constant public eye because the public who uses their services wants better and high-quality services; they are also attractive to the companies that can participate in a tender because it is a risk-free business regarding payment issues. To evade possible illegality and pressure on the authorities in public companies, the procurements are conducted and regulated by law in the Republic of Serbia, so each procurement is treated as a multicriteria optimization task. Consequently, everything done has to be defined in advance, with precise procedures and formulas used in each concrete case. However, there are problems and dilemmas in this area. For example, Borović and Tanašćuk [1] presented automatic decision support in a tender process; Plećić *et al.,* [2] presented a new multicriteria methodology for bids evaluation. Zizovic *et al.,* [3] presented a new multicriteria analysis method for evaluation and decision-making by dominant criterion and applied the proposed tool to real-world examples.

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Furthermore, Csáki and Adam [4] presented public procurement as a regulated decision-making problem and a normative framework that goes beyond simple constraints on selecting suppliers. Çelen [5] presented a comparative analysis of different normalization procedures in the TOPSIS method and showed the application to the Turkish deposit banking market. Jahan *et al.,* [6] proposed a decision-making framework for weighting criteria in a ranking stage of the material selection process. Jin et *al.,* [7] presented the application of the analytic hierarchy process for procurement strategy selection in building maintenance work.

When regulating criteria or their weighing coefficients for the multicriteria problem of a specific procurement, these coefficients have to be defined in advance, or a method for determining them has to be given. There is a thought that giving weighing coefficients in advance is not proper because the procurement officer does not know what he will be offered in a concrete situation. One thinks that that question can be solved after "opening the bids in envelopes" with some "objective method for determining weighing coefficients", specifically with the Entropy method [8] that has to be defined in advance in a bidding material. This possibility will be solved in this paper, so in the further text, the procurement officer is the decision maker, and the tender bids are the alternatives to solving the multicriteria model.

In this paper, two situations will be analyzed. The first situation is where the decision maker does not have defined weighing coefficients, and the second one is where the decision maker has already published weighing coefficients, which he will correct (it also has to be published) using the Entropy method after opening the envelope bids, that is the alternatives.

When solving the problem using multicriteria optimization, the criteria almost always have different importance for the decision maker [9-11]. So, the decision maker has to define the level of importance of all criteria, which can be done by using weighing coefficients of the criteria. In most cases, we define the weighing coefficients in a normalized form (the sum of all weighing coefficients equals one). Hence, if we have a problem with *m* alternative $a_1, a_2, \ldots, a_m$ and *n* criteria $c_1, c_2, \ldots, c_n$, then we can solve this problem using the matrix type $m \times n$, which elements f_{ij} are the values in criteria *j* for the alternative *i*, that is:

$$
\begin{array}{c} \\ a_1 \\ a_2 \\ \vdots \\ a_m \end{array}
\begin{array}{c} \begin{array}{cccc} c_1 & c_2 & \cdots & c_n \end{array} \\
\begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{bmatrix} \end{array}
$$

Let's observe that the elements in the columns are values that do not necessarily have to be numerical. Still, they can also have descriptive characters, describing the condition of the alternatives by certain criteria. Moreover, let's observe that some criteria are minimizing (the smaller, the better), and some are maximizing (the larger, the better). It is common for non-numerical values to be transformed into numerical values (different transformation scales do this), meaning we can consider the decision-making matrix to be numerical. Furthermore, this matrix can be considered as a matrix with non-negative entries.

Also, all the criteria of the minimizing type can be transformed, using simple transformations, into maximizing type criteria. Transforming the values by criteria (also known as attribute transformation) can all be reformulated so that the best value by the given criteria is equal to 1 or that the sum of all values by the given criteria is equal to one.

All of this aids in solving the given problem, but again, the decision maker has to set weighing coefficients. Either he will express his opinion about them and their values. Then someone will calculate them using certain rules (this is the so-called subjective way of defining weighing coefficients), or the weighing coefficients will be defined using the decision-making matrix, again according to certain rules which are determined in advance (this is the so-called objective way of determining weighing coefficients). Alternatively, these two approaches can be combined. In any case, this is not an easy and simple task. We have many methods for determining weighting coefficients, depending on which rules we apply when defining weighing coefficients. Some reviews of the methods for determining weighing coefficients are given in the following papers [10,11]. More on weighing coefficients can be found in [12-14].

After determining weighing coefficients, the multicriteria optimization problem is solved using certain rules. Let us mention some papers that show certain multicriteria optimization methods [2,9,15,16]). Here, we emphasize that these methods are the rules for solving the problem when we have certain weighing coefficients and that multicriteria optimization methods already have integrated methods for determining weighing coefficients, such as Saaty [9]. It is also very important to say that there are numerous ways to normalize the decision-making matrix and that they also greatly impact solving the problem, as seen in *[1*7,18*]*.

Considering that we are going to deal with the Entropy method for determining weighing coefficients here, which in itself is an analogue of the original Shannon's method for measuring information [8], we will give a short review of the concept of information. There are different definitions for describing the concept of information. One would say that it is the comprehension of what we exchange with the world. It is one of the main natural entities [19]. In 1948, Shannon [8] developed a theory based on probabilities, often called the statistic information theory or simply – information theory. In this theory, many characteristics of information are neglected, such as its context, meaning, etc., and only its unexpectedness, that is, its indefiniteness, is observed. Hence, it starts as a finite probability system or a system with n conditions that appear with certain probabilities with a total sum equal to one. The amount of information for each condition is the negative value of the probability logarithm of that condition. The indefiniteness of the whole system or the Entropy system is an average indefiniteness (mathematical expectation) of these n pieces of information in the system, now with corresponding probability given for the conditions [20]. So, the Entropy is defined through the logarithm function (it will appear further in the text), which is uniquely determined (up to a multiplicative constant) by certain four natural conditions [21]. The amount of information defined like this served Shannon as a base for describing communication channels to make them as permeable as possible (what is more probable is going through the channel faster, which means that it is coded with fewer letters). After a successful interpretation of the communication channels, this theory has been applied more or less successfully in different areas, also finding application in a multicriteria analysis for determining weighing coefficients as one of the so-called "objective" methods, that is the method which gives the results directly from the decision-making matrix, independently of a decision maker. Today, under the name Entropy, this method for determining criteria weights can be found in various literature [22,23].

2. Algorithm for the Entropy Method

We present this method through several steps with a starting assumption that the task of the multicriteria optimization, for which the weighing coefficients should be determined, is given through the decision-making matrix with negative real numbers. Below, we have presented the steps for determining weighing coefficients:

Step 1: Let us transform the given multicriteria model into a new one where all criteria maximize type.

Step 2: We normalize the multicriteria model so that the sum of the numbers in each column is equal to one so that each column is transformed into the analog of the finite probability system:

$p_{ij} = \dfrac{f_{ij}}{\sum_{i=1}^{m} f_{ij}}$, for each $i = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n.$

Step 3: Determining the Entropy for each criterion, or its analog of the finite probability system:

$e_j = -\dfrac{1}{\log_b m} \cdot \sum_{i=1}^{m} p_{ij} \cdot \log_b p_{ij}$, for each $j = 1, 2, \ldots, n,$ (b > 1, it is often used for b = 2).

Step 4: Determining deviation concerning the maximum possible value for each e_j:

$d_j = 1 - e_j$, for each $j = 1, 2, \ldots, n.$

Step 5: Calculating weighing coefficients:

$w_j = \dfrac{d_j}{\sum_{j=1}^{n} d_j}$, for each $j = 1, 2, \ldots, n.$

Step 5': Correcting the weighting coefficients. If a decision maker has weighing coefficients defined in advance for the given problem of the multicriteria optimization $w_1, w_2, \ldots, w_n$, then

$w'_j = \dfrac{d_j w_j}{\sum_{j=1}^{n} d_j w_j}$, for each $j = 1, 2, \ldots, n.$

Remark 1. Step 5 is contained in step 5'. If the decision maker does not have defined weighing coefficients hypothetically, we can assume that all weighing coefficients are equal for him and that we have $w_j = \dfrac{1}{n}$ for each j.

3. Calculating Weighing Coefficients Using the Entropy Method

A hypothetical example of public procurement will be analyzed here. There is also an assumption that the Entropy method is determined in advance for solving weighing coefficients. Our goal is to analyze some of the possible consequences of using this method and determine possible remarks that are not technical but fundamental to the decision-maker and his ability to make the right choice. Finally, we hope that the decision-makers responsible for public procurements can conclude whether calculating weighing coefficients in such a way is good based on the results presented below.

4.1. Example

A multicriteria model with five alternatives must be marked with four criteria using the following decision-making matrix. To solve the model, weighing coefficients must be calculated using the Entropy method. We assume that we have five valid bids on the tender and that there were four criteria in the invitation to the tender.

We should emphasize that there will be no "finite" solution, so the alternatives will not be ranked here. However, in each invitation to the tender for the public procurement, all the rules must be defined from the beginning till the end of the realization. This "deviation" is introduced because our task in this case is to analyze the possibility of using the Entropy method to determine weighting coefficients.

Also, we assume here that the values in the decision-making matrix are real numbers between 1 and 10, so we assume there is a rule by which the data from the bids can be transformed into these numbers. We assume that all criteria are of maximizing type, which means there is a preset rule for transforming minimizing type criteria into maximizing type criteria (it is obvious that minimizing type criteria exist, at least one, such as the price of the public procurement). Our goal is to show that the Entropy method is the simplest one. After "opening the envelope bids," we get the following decision-making matrix, Table 1.

Table 1
Decision-making matrix for example 4.1

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7

It is assumed that all the criteria in the model are maximizing, so step 1 is unnecessary. Using step 2 of our algorithm, we get a new (transformed) decision-making matrix, as shown in Table 2.

Table 2
Transformed decision-making matrix

Alt.	c_1	c_2	c_3	c_4
a_1	0.21	0.18	0.25	0.07
a_2	0.21	0.25	0.14	0.19
a_3	0.18	0.18	0.19	0.22
a_4	0.21	0.18	0.22	0.26
a_5	0.18	0.21	0.19	0.26

Using Step 3, we can calculate the values $-p\log_2 p$, Table 3.

Table 3
Matrix with the values $-p\log_2 p$

Alt.	c_1	c_2	c_3	c_4
a_1	0.4728	0.4453	0.5000	0.2686
a_2	0.4728	0.5000	0.3971	0.4552
a_3	0.4453	0.4453	0.4552	0.4806
a_4	0.4728	0.4453	0.4806	0.5053
a_5	0.4453	0.4728	0.4552	0.5053

Then, using the algorithm, we calculate the entropies simply by adding all the values in each column from the previous matrix, and then the results are divided with the largest possible value for the Entropy. Then, we subtract these values from number one and get deviations, which can be seen in Table 4a.

Table 4a
Entropy and deviations

Entropy deviations			
e_1	0.995	d_1	0.005
e_2	0.995	d_2	0.005
e_3	0.986	d_3	0.014
e_4	0.955	d_4	0.045

We get the weighing coefficients at the end, as shown in Table 4b.

Table 4b
Weighing coefficients of example 4.1

Crit.	Weight
w_1	0.072
w_2	0.072
w_3	0.203
w_4	0.653

If the weighing coefficients were given during the invitation to the tender w_1 =0.4, w_2 =0.3, w_3 =0.2, w_4 =0.1, then we easily obtain new values, Table 4c.

Table 4c
Weighing coefficients after corrections

Crit.	Weight
w_1	0.184
w_2	0.138
w_3	0.260
w_4	0.418

There is an open question of whether the obtained values are meaningful: whether they satisfy a decision maker's interests, needs, and preferences. We simply do not know this, and that question has no answer! What was the reason for a high value for w_4? Simply, the small value for f_{14}. From here, we naturally have a question: Is f_{14} such an important value for the choice and for making a decision that it justifies an increase w_4 to this level? This question has no answer, especially because the value in dispute is the lowest value by the criteria c_4. From this example, we can already see that when using this method for calculating weighing coefficients, we should be very careful because there is well-founded suspicion that we will not always get good results.

Moreover, if the starting weighing coefficients (given during the tender invitation) showed the decision maker's preferences in a real way, how real can they be after the correction?

4.2. Example of Adding one Alternative

In the following section, we will examine examples in which all alternatives appear a_1, a_2, a_3, a_4, a_5 that we have in example 4.1. and we will add one new alternative a_6. This situation is possible in public procurements. In other words, if there is a justifiable reason, it can happen that some bid is left out for some reason. Also, an applicant can file an appeal, and it often happens that the applicants are right. Then we have a new calculation, but now, instead of five alternatives, we have an enlarged number of alternatives (the bids accepted later on are added), that is – six. We are monitoring four possible new variants for the alternative a_6, the newly gained weighing coefficients are being discussed from a starting result standpoint.

This kind of adding new alternatives in a real example will be very interesting because the decision maker aims to choose the optimal offering from his tender. And our question is whether that is true with this way of determining weighting coefficients. Our question is: can the newly introduced alternative in the Entropy method give completely different weighing coefficients compared to the one from the previous example? If the differences are not small, our decision-maker should at least be aware of that possibility.

4.2.1 Variant

If the new alternative with the highest value for the first criteria is added to the starting decision-making matrix, the values are below average in the other places, Table 5.

Table 5
Decision-making matrix

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	10	3	4	2

Then, using the recommended procedure, we get the weighing coefficients in Table 5a.

Table 5a
Weighing coefficients of variant 4.2.1

Crit.	Weight
w_1	0.07
w_2	0.50
w_3	0.12
w_4	0.31

If the weighing coefficients were given again, as in the starting example, we would now have new values, as shown in Table 5b.

Table 5b
Weighing coefficients after the correction

Crit.	Weight
w_1	0.120
w_2	0.644
w_3	0.103
w_4	0.133

Here, we can see a very small decrease in the weighing coefficient for the first criterion, a significant decrease in the weighing coefficient for the fourth criterion, an enormous increase of the weighing coefficient for the second criterion, and a decrease in the weighing coefficient for the third criterion. The reason for such a result is the fact that the first column has stayed with the values that are the most aligned (same as the third), so our algorithm sees as if there is "nothing to choose" in these columns, which means that there are the least possibilities to choose from (the deviation from the highest value is minimal) and in the other columns "there are more or slightly more room for choosing" so the result is logical. Again, the corrections are under a question mark.

4.2.2 Variant

This section considers an example where a new alternative with the highest value is added in second place to the initial decision-making matrix. This alternative (a_6) has lower values than the average for the other criteria, Table 6.

Table 6
Decision-making matrix of variant 4.2.2

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	3	10	5	4

Then, after using a procedure for the Entropy method, we get new values for the weighing coefficients, as shown in Table 6a.

Table 6a
Weighing coefficients for variant 4.2.2

Crit.	Weight
w_1	0.221
w_2	0.240
w_3	0.144
w_4	0.395

The new weighing coefficients are presented in Table 6b.

Table 6b
Weighing coefficients after the correction

Crit.	Weight
w_1	0.385
w_2	0.315
w_3	0.126
w_4	0.173

Here, we have "the most aligned" column, which satisfies the third criterion. Hence, the algorithm sees that there is "no choice", compared to the other columns, so we again have a similar situation as in the previous variant where we had a small value of the weighing coefficients by the criterion where there was little choice, and higher (aligned) values of the weighing coefficients on the other three places, where there were "more" choices. The fourth criterion again becomes the most dominant criterion (here again, the crucial part of this situation determines the small value for the first alternative by the fourth criterion). Corrected weighing coefficients are "the most similar" to the given one. Is this a coincidence? Certainly!

4.2.3 Variant

Now, we add the highest value of the new alternative into the third column. The other values below the average are slightly changed, but even if they were the same, that wouldn't give any new significant results, Table 7.

Table 7
Decision-making matrix of variant 4.2.3

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	6
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	4	3	9	4

Then, after using a procedure for the Entropy method, we get the new values for the weighing coefficients, as shown in Table 7a.

Table 7a
Weighing coefficients of the variant 4.2.3

Crit.	Weight
w_1	0.13
w_2	0.23
w_3	0.08
w_4	0.56

Weighing coefficients after the correction are presented in Table 7b.

Table 7b
Weighing coefficients of the variant 4.2.3. after the correction

Crit.	Weight
w_1	0.269
w_2	0.358
w_3	0.083
w_4	0.290

Here, we have "the most aligned" column, which satisfies the third criterion, and a slightly less alignment for the first, so the algorithm sees that there is "nothing to choose" compared to the other columns. So again, like in the previous variant, we have small values of the weighing coefficients for the criteria where there is a small number of choices and higher values of the weighing coefficients on the other two places where there are "more" choices. The fourth criterion is, for the same previous reason, the most dominant. The corrected weighing coefficients are again "weird".

4.2.4 Variant

If, in the starting decision-making matrix, we add a new alternative with the highest value for the fourth criterion, and in the other places, the values are below the average for those criteria, Table 8.

Table 8
Decision-making matrix of variant 4.2.4

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	5	4	5	9

Then, after using the procedure for the Entropy method, we get new values for the weighing coefficients, as shown in Table 8a.

Table 8a
Weighing coefficients of the variant 4.2.4

Crit.	Weight
w_1	0.120
w_2	0.075
w_3	0.224
w_4	0.581

Weighing coefficients after the correction are presented in Table 8b.

Table 8b
Weighing coefficients of the variant 4.2.4. after the correction

Crit.	Weight
w_1	0.277
w_2	0.130
w_3	0.258
w_4	0.335

Here, we have "the most aligned" column, which satisfies the second criterion, so the algorithm recognizes that there are "fewer choices than in the other criteria", then we have the first criterion, then the third, while in the fourth criterion, we again have "many choices" and consequently a high weighing coefficient.

Again, the corrected weighing coefficients significantly deviate from the values given in the tender invitation. In general, if the weighing coefficients are not given, the applicants can be surprised by "the values of the weighing coefficients achieved using this method", but if the weighing coefficients are given together with the values that "will be corrected" using this method, then they at least must be surprised with the corrections.

6. Introducing Fictitious Bids from the First Bidder

6.1. One Fictitious Bid from the First Bidder

We shall assume that five bids have applied for the tender, and these are the values that we already have in Table 2, and that the first bidder gives the fictitious sixth bid (bid a_1), that is, by someone in a deal with the first bidder, as shown in Table 9.

Table 9
The matrix with the fictitious bid from the first bidder

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	1	7	1	7

When we use the procedure, we get the following weighing coefficients, Table 9a.

Table 9a
Weighing coefficients with the fictitious bid

Crit.	Weight
w_1	0.341
w_2	0.071
w_3	0.404
w_4	0.184

If the weighing coefficients are given in advance, we have newly corrected values, Table 9b.

Table 9b
Weighing coefficients with the fictitious bid after correction

Crit.	Weight
w_1	0.5309
w_2	0.0829
w_3	0.3155
w_4	0.0716

The question is whether the first bidder "got the job" and if he managed to gain an advantage over all the other bidders (he could not know our final table in advance). The fictitious bid causes the weighing coefficient of the third criterion to become significantly high, where the first bidder is the best. Furthermore, the fictitious bid has increased the level of the first criterion. Still, according to this criterion, the others are also in a good position, so this is not very important to the first bidder. However, the impact of the fourth criterion is reduced, according to which the first bidder is extremely bad. Whether this is enough for the first bidder to "get the job" is unimportant to our analysis. Still, the fact is that we can change or significantly change the weighting coefficients of the criteria using fictitious bids.

We can conclude that "the fictitious bid has done a good job when we have weighed coefficients in advance." Whether the first bidder can "secure the job" can be even more radicalized so that the first bidder can introduce two, three, four, or five similar fictitious bids. What will happen in these situations?

6.2. Two Fictitious Bids from the First Bidder

The situation where we have two "similar" fictitious bids from the first bidder is given in the following decision-making matrix, Table 10.

Table 10
Matrix with the two fictitious bids from the first bidder

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	1	7	1	7
a_7	3	6	2	8

After the procedure, we get the following weighing coefficients, Table 10a.

Table 10a
Weighing coefficients with two fictitious bids

Crit.	Weight
w_1	0.328
w_2	0.074
w_3	0.429
w_4	0.169

We also have corrections if we have the given weighing coefficients, as shown in Table 10b.

Table 10b
Weighing coefficients with two fictitious bids after correction

Crit.	Weight
w_1	0.512
w_2	0.087
w_3	0.335
w_4	0.066

Again, we achieved values similar to those of the weighing coefficients with one fictitious bid. However, the statement is that the weighting coefficients of the third criterion increase, which is "the main goal" of the fictitious bid. By analogy, it is the same for the corrections.

6.3. Three Fictitious Bids from the First Bidder

The situation where we have three "similar" fictitious bids from the first bidder is given in the following decision-making matrix, Table 11.

Table 11
Matrix with the three fictitious bids from the first bidder

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	1	7	1	7
a_7	3	6	2	8
a_8	2	7	1	6

After the procedure, we get the following weighing coefficients, Table 11a.

Table 11a
Weighing coefficients with three similar fictitious bids

Crit.	Weight
w_1	0.213
w_2	0.064
w_3	0.589
w_4	0.134

We also have corrections if we have the given weighing coefficients, as shown in Table 11b.

Table 11b
Weighing coefficients with three similar fictitious bids after correction

Crit.	Weight
w_1	0.362
w_2	0.081
w_3	0.500
w_4	0.057

Here, we greatly favor the third criterion with the lowered weighing coefficients at the second and fourth criteria and a bigger decrease at the first criterion. Overall, the "goal" of the fictitious bid is archived – the first is "certain to get the job. In the case of the correction, the first is "certain to get the job".

6.4. Four Fictitious Bids from the First Bidder

The situation where we have four "similar" fictitious bids from the first bidder is given in the following decision-making matrix, Table 12.

Table 12
Matrix with the four fictitious bids from the first bidder

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	1	7	1	7
a_7	3	6	2	8
a_8	2	7	1	6
a_9	2	6	2	7

After the procedure, we get the following weighing coefficients, as shown in Table 12a.

Table 12a
Weighing coefficients with four identical fictitious bids

Crit.	Weight
w_1	0.345
w_2	0.107
w_3	0.533
w_4	0.020

If we have the given weighing coefficients, we also have corrections, as shown in Table 12b.

Table 12b
Weighing coefficients with four similar fictitious bids after correction

Crit.	Weight
w_1	0.515
w_2	0.081
w_3	0.371
w_4	0.007

The weighing coefficient of the third criterion is again very high, and the weighing coefficient of the fourth criterion is very low, so here we can say with certainty that the first bidder "got" the job (the complete bid was considered). It is the same in the case of correction.

6.5. Five Fictitious Bids from the First Bidder

The situation where we have five "similar" fictitious bids from the first bidder is given in the following decision-making matrix, Table 13.

Table 13
Matrix with the five fictitious bids from the first bidder

Alt.	c_1	c_2	c_3	c_4
a_1	7	5	9	2
a_2	7	7	5	5
a_3	6	5	7	6
a_4	7	5	8	7
a_5	6	6	7	7
a_6	1	7	1	7
a_7	3	6	2	8
a_8	2	7	1	6
a_9	2	6	2	7
a_{10}	3	6	1	7

After the procedure, we get the following weighing coefficients, Table 13a.

Table 13a
Weighing coefficients with five fictitious bids

Crit.	Weight
w_1	0.241
w_2	0.091
w_3	0.559
w_4	0.109

If we have the given weighing coefficients, we also have corrections, Table 13b.

Table 13b
Weighing coefficients with five similar fictitious bids after correction

Crit.	Weight
w_1	0.391
w_2	0.111
w_3	0.454
w_4	0.044

In this situation, the first bidder achieved their goal, namely favoring the third criterion and lowering the fourth criterion, where the first bidder had a weak bid. Lowering the second criterion was also favorable, where our fictitious bidder thinks he does not have a good offer. It is the same in the case of correction. The favoring of other bidders can also be done similarly.

7. Conclusion

In short, the Entropy method is not a method to be used in this area of multicriteria optimization and for determining weighing coefficients at public procurements. Moreover, it shouldn't be used as a correction method because, from the previous text, it can be concluded that the decision maker, the public procurement authority, will not choose the bid that suits him the most. Ultimately, we can conclude that this method for determining weighting coefficients can be counterproductive. And we can even add that it should be forbidden as a possibility.

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Conflicts of Interest
The author declares no conflicts of interest.

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