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INFLUENCE OF SUBJECTIVE PREFERENCES ON THE DECISION-MAKING PROCESS IN A MULTI-CRITERIA MODEL OF PUBLIC PROCUREMENT

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Abstract

Improvement of business is one of the primary goals of any business entity. One of the basic prerequisites for a successful business is the proper allocation of public resources. In this sense, the public procurement system is an important component in improving the efficiency of public finances, which are of special interest to modern society. This paper discusses the role and importance of the method of multi-criteria analysis for the evaluation of public procurement. The idea for this kind of analysis is the result of research into the possibility of applying different methods of decision making in the modern approach to decision making in the sector of public procurement. The emphasis is placed on those methods that use the alternative ranking. In addition to the theoretical dimension, the paper also presents one method of multi-criteria analysis, the AHP method, applied to empirical data obtained from the Gerontology center "Jelenac" in Aleksinac.

Key words: multi-criteria analysis, multi-criteria decision making, AHP method, t-test, public procurement.

УТИЦАЈ СУБЈЕКТИВНИХ ПРЕФЕРЕНЦИЈА НА ПРОЦЕС ОДЛУЧИВАЊА У ВИШЕКРИТЕРИЈУМСКОМ МОДЕЛУ ЈАВНИХ НАБАВКИ

Апстракт

Унапређење пословања је један од основних циљева сваког привредног субјекта. Једна од основних претпоставки за успешно пословање је правилна алокација јавних ресурса. У том смислу, систем јавних набавки представља важну компоненту за унапређење ефикасности јавних финансија које су од посебног интереса за савремено друштво. У овом раду разматра се улога и значај метода вишекритеријумске анализе за оцену јавних набавки. Идеја за оваквом врстом анализе настала је као резултат истраживања могућности

примене различитих метода вишеатрибутног одлучивања у савременом приступу доношења одлука у сектору јавних набавки. Акценат је на оним методама које користе рангирање алтернатива. Рад, поред теоријске димензије, презентује и један од метода вишекритеријумске анализе, АХП метод, на емпиријским подацима добијеним од стране Герантолошког центра „Јеленац“ из Алексинца.

Кључне речи: вишекритеријумска анализа, вишекритеријумско одлучивање, АХП метод, t-тест, јавне набавке

INTRODUCTION

In modern times, organizations are faced against many challenges. Business efficiency is conditioned by a successful response related to business-organizational structure. One of the biggest challenges for modern organizations is the adequate organization of the public procurement process. The effectiveness of the public procurement process is the factor which largely determines the performance of an organization. Additionally, the quality of the public procurement process could improve welfare due to the fact that public funds are used in the quantity sufficient to provide the required quantity and quality of the public procurement subject. Therefore, the management of an organization must assume a serious and responsible attitude towards the process of selection of the best bidder.

During the selection of the best offer, most modern organizations rely on subjective assessment of the decision makers. In order to meet the needs of the organization, the dominant criterion is usually the acceptance of offered price, which therefore strongly influences the final decision. However, there are many other criteria that should be taken into account in the decision-making process of choosing the best bidder, whose omission opens the possibility of different mechanisms of corruption. Considering that individuals have a limited ability of reasoning in given circumstances, when there are several different alternatives that can be valorized with the help of a number of different criteria, a method of multi-criteria analysis could provide assistance in the selection process. This is actually a scientific approach to solving the problem of choosing the best from a set of different alternatives that are evaluated using several different criteria. Usage of methods of multi-criteria analysis in assessing public procurement can significantly facilitate the process of decision making and reduce the abuse of the public procurement system, which is especially important considering the fact that the abuse of this system leads to inefficient allocation of public funds.

The main subject of this paper is multi-criteria modeling of the procurement process and the objective is quantification of subjective preferences of decision-makers. The paper is based on the results of empirical research and, in addition to the introductory part, it contains the following

sections: literature review, research methodology and hypotheses, results of analysis and discussion, and conclusion.

LITERATURE REVIEW

In the context of the review of the relevant literature that analyzes the problem defined above, this paper deals with the following two aspects of the application of multi-criteria analysis in the management of public procurement:

1. Presentation of the problem of the bidders in public procurement by a multi-criteria model and methods for its solution and
2. Quantification of subjective preferences of decision makers with the aim of determining the weight coefficients in the model of multi-criteria analysis.

The problem of management of public procurement procedure and its multi-criteria nature

One of the basic characteristics of methods of multi-criteria analysis is that they are focused on problem solving related to choosing one of the *m* alternatives series A_i, $i = 1, 2,..., m$ based on *n* criterion X_j, $j = 1, 2,..., n$ (Janković-Milić & Stanković, 2010).

In order to form an adequate multi-criteria model that could be applied in real conditions, it is necessary to consider its key elements. The basic elements of a multi-criteria model are alternatives, criterions, attributes, and solution.

Alternatives in the multi-criteria model that is used during the evaluation of public procurement are all the offers that are received by certain contracting authority related to the requested subject of public procurement by different bidders. Thereby, each bid has certain characteristics that should be valorized. These characteristics actually present the attributes of a bid, referring to the value of a certain criterion for a specific bid. More accurately, the attributes show the level of fulfillment for each of the criteria. The criteria in the multi-criteria model are used for evaluation of alternatives, where it is necessary to handle the fact that not all the criteria have the same impact for the decision makers. The significance of the multi-criteria model is showed by the weighting coefficients. Many methods for solving problems in a multi-criteria analysis require precisely expressed weighting coefficients. Adequate determination and assignment of weighting coefficients is even more significant if we take into consideration that the weighting coefficients have a large impact on the final ranking of alternatives, i.e. the selection of the best solution. There are many possible ways to determine the weighting coefficients. They can all be classified into three basic approaches: the subjective approach, the objective approach, and the combined approach,

which represents the combination of the first two approaches. One of the most subjective approaches for determining the weighting coefficients is the AHP method, which will be discussed later.

Great current relevance of multi-attribute decision issues resulted in the development of dynamic methods in this area. Multi-criteria analysis methods are suitable for solving a large number of real problems of a different nature. Several financial decision-making problems can be easily solved using the method of multi-criteria analysis (Zopounidis & Doumpos, 2002). Diverse nature of the factors that influence financial decisions (decision criteria, goals, and objectives), the complexity of the financial business and economic environment, and the subjective nature of many financial decisions are some of the characteristics of financial decisions that justify the application of the multi-criteria analysis method. Some of the major problems that are solved using multi-criteria analysis are supply chain management and logistics, business and marketing management, security and safety, production management, human resource management, management of energy resources, and others. Some of the most popular methods used for troubleshooting of multi-attribute decision include the analytic hierarchy process method, TOPSIS method (*Technique for Order of Preference by Similarity to Ideal Solution*), simple additive weighting method, and many others.

The simple additive weighting method has a wide range of application. Most composite indicators are calculated by this method (e.g. *GCI, The Global Competitiveness Index*). Some well-known examples of using the simple additive weighting method include selection of staff (Afshari, Mojahed & Yusuff, 2010), selection of the best location of health facilities (Lin, Liao, & Chang, 2010), and selection of the best locations for a factory (Chou, Changa & Shenc, 2008). Given that the impact of the weights can be most easily seen in the simple additive weighting method, it shall be discussed later in this paper.

Quantification of subjective preference of decision makers

The impact that specific criterion C_j (j=1,..., n) has on the final decision of the decision maker may be of varying intensity, depending on the relative significance of criteria for decision makers. There are several approaches that can be used to determine the relative significance criteria. To determine the subjective preferences of decision-makers, most authors suggest using several methods of multi-criteria analysis. Curtis (2004) proposes the use of the Delphi method for calculating the relative significance of elements in evaluation of the ecosystem of Australia. The use of the Delphi method for defining and evaluating the criteria on which the selection will be carried out for an automated information system for patient care can be found in the literature (Chocholik, Bouchard, Tan & Ostrow, 1991). Other authors suggest the possibility of using the method

of least squares when it is difficult to determine the weight coefficients (Chu, Kalaba & Spingarn 1979). Some authors propose the application of the method to calculate the eigenvalues of the relative significance of criteria (Takeda, Cogger & Yu, 1987). However, despite the great diversity of methods that can be used for assessing the subjective preferences of the decision maker found in the literature, the most common method for evaluating the relative significance of criteria is the analytic hierarchy process method (AHP) (Kwong & Bai, 2002; Park & Han, 2002; Torfia, Farahanib & Rezapourd 2010; Jaskowski, Biryukova & Bucheon, 2010; Tzengc, Yanga, Chiub & Yeh, 2008).

The analytic hierarchy process method is one of the main tools used for solving the problem of multi-criteria decision making. The essence of this method consists of even comparisons on the basis of which a specific list of priorities is formed. The problem of decision making should be broken down into a series of hierarchies, where the simplest form of hierarchy can be presented at three levels: at the top there is a goal to be achieved by a particular decision and the second level contains the criteria used for evaluation of alternatives that are placed at the lowest, third, level. The purpose of a hierarchical set of problems lies in the need to consider the importance of the elements that are on the same level with respect to the elements that are placed on a higher level (Saaty & Vargas, 2013).

The modeling process requires four phases:

- Structuring the problem,
- Data collection,
- Evaluation of relative weightings, and
- Determination of the problem solutions.

The AHP allows the decision maker to structure the decision problem in a set hierarchy (Tahriri, Osman, Ali, Yusuff & Esfandiary, 2008). Therefore, the first phase involves the decomposition of a decision problem into a number of hierarchical levels, i.e. identification of the objective, the criteria for evaluating alternatives, and the set of available alternatives among which the best are selected.

The following stage involves the collection of required data and its evaluation. The essence of this stage is to use the even comparison of the attributes on the same hierarchy level in order to determine which of the observed attributes has a better value with respect to certain criteria at a higher hierarchy level, i.e. which of the given attributes contributes more to the realization of the established goal. The comparison is based on the scale of relative importance (Table 1).

Table 1. Scale of relative importance

Intensity	Definition	Explanation
1	Equal importance	Both alternatives contribute equally to the objective
3	Moderate importance	Experience and assessment slightly favor one alternative over another
5	Strong importance	Experience and assessment strongly favor an alternative to the second
7	Demonstrated importance	One alternative is strongly favored, and its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one alternative over another is of the highest possible order of affirmation
2, 4, 6, 8	Mean values between two adjacent assessments	When compromise is needed
The reciprocal of the elements different from zero	If the alternative *i* was assigned one of the above mentioned numbers different from zero while compared with alternative *j*, then the alternative *j* is assigned the reciprocal of the comparison with alternative *i*	

Source: Saaty, 1980.

The result of this stage is the comparison matrix.

The third stage is the actual determination of the relative weight of criteria. Pairwise comparison in the second stage results in a reciprocal *nxn* matrix A, where the elements are on the main diagonal 1, and elements a_{ji} are calculated as reciprocal values of elements a_{ij} and $i, j = 1, 2,..., n$ (Janković-Milić & Stanković, 2010).

On the basis of this comparison, in the fourth stage, at the level of the criteria, it is possible to determine the relative importance of each criterion, expressed through the weighting coefficient. On the other hand, at the level of an alternative, it is possible to determine the rank of alternatives for each of the monitored criteria, both partially as well as collectively.

RESEARCH METHODOLOGY AND HYPOTHESIS

Calculation of subjective preference shall is based on the data provided by the Gerontology Center "Jelenac" from Aleksinac. We used the information on public procurement from 2008 to 2012. The main objective of the analysis is to assign weight coefficients to the criteria relevant to the evaluation of the bids. Therefore, we used the AHP as one of the main subjective approaches to determine the preferences of decision makers.

The Gerontology Center "Jelenac", based on previous experience, evaluated bids for the 2008-2011 period based on five criteria: offered price, quality, payment period, method of payment, and place of delivery. In 2012, the criterion for the evaluation of bids was changed. The reason for this is the fact that a particular institution realized that place of delivery as a criterion had no significant impact on the final ranking of bids, as well as payment period and payment method, so these criteria were integrated into a single criterion – period and manner of payment. A new criterion, called validity period, was also introduced. The justification for the introduction of new criteria was found in the fact that in the previous years the market had become unstable and that many providers offered lower prices specified (they conducted price dumping) and later, when their bid was accepted, they would ask for a change of the terms, because the prices had gone up in the meantime. With this new criterion, the Gerontology Center "Jelenac" wanted to protect itself from such behavior of bidders, since during the period of validity of the bid the bidder has no right to seek the changes of the terms. This is also linked with the evaluation of this criterion, where the longest period of validity is actually the best offer.

We will analyze the procurement of high value, where the open procedure for public procurement is applied and the procurement should be carried out in lots. The subject of public procurement is consumer goods.

Use of the AHP method for determining the weighting coefficients in the sample

For the calculation of subjective preferences using the AHP method it is necessary to provide information on preferences of the persons in charge of evaluation of bids. Therefore, the management of the Gerontology Center "Jelenac" received a questionnaire with the criteria that should be evaluated ranging from 1 to 5, where the score of 1 means that the criterion has no significance for the evaluation of bids, whereas score 5 means that it is a very important criterion in the evaluation of bids. The questionnaire consisted of the following criteria: offered price, quality, delivery time, place of delivery, method of payment, validity period, and date and place of delivery. The following scores were obtained:

Table 2. Scores for criteria given by the management of the Gerontology Center "Jelenac"

Criterion	Score
Offered price	5
Quality	5
Delivery time	3
Method of payment	1
Place of delivery	2
Validity period	3
Date and place of delivery	2

The main objective of this paper is to show the importance of the procurement procedure for the organization, the possibilities and advantages of the multi-criteria analysis method for selecting the best bid, and the need for effective control of public procurement.

The basic premise of the paper is that the choice of the best offer deals with difficult conditions, where there are a number of criteria that can be used for their evaluation. The use of precise scientific methods for determining the relative significance of each of the criteria as well as their use for ranking bids can facilitate the decision making process.

The following hypotheses are tested in this paper:

X_0: there is a difference in the weighting coefficients determined by empirical methods and the subjective preferences of the members of the tender committee, and

X_1: application of weighting coefficients that are generated based on subjective preferences of decision makers resulted in an inversion of the range of alternatives.

In order to test the null hypothesis, a comparative analysis of the results was conducted. The t-test was applied in order to determine a potential existence of statistically significant differences in the weighting coefficients that are determined using the AHP method in relation to the empirical method. For the purpose of this analysis the statistical software EduStat was used. Correlation analysis was conducted to determine the relationship between the ranking of alternatives and the applied weighting coefficients.

Data analysis is performed on the basis of two models. One relates to the period from 2008 to 2011, analyzing the following criteria: offered price, quality, delivery time, method of payment, and place of delivery. The second model is related to the year 2012, where we look at the following criteria: offered price, quality, time and place of delivery, method of payment, and period of validity of the offer.

The first model:

Based on the obtained score, the comparison of criteria was performed. Comparison of importance of particular criteria regarding the established goal was performed based on the Saaty scale (Saaty, 1980). The obtained numerical values are entered into the comparison matrix.

Table 3. Comparison matrix

	Offered price	Quality	Delivery time	Method of payment	Place of delivery
Offered price	1.000	1.000	5.000	9.000	7.000
Quality	1.000	1.000	5.000	9.000	7.000
Delivery time	0.200	0.200	1.000	5.000	3.000
Method of payment	0.111	0.111	0.200	1.000	0.333
Place of delivery	0.143	0.143	0.333	3.000	1.000

For determining the vectors of weighting coefficients on matrix-based comparisons, it is possible to implement various methods, such as the following (Srđević, 2005):

- Eigenvector Method,
- Additive Normalization Method,
- Weighted Least Squares Method,
- Logarithmic Least Squares Method,
- Logarithmic Goal Programming Method,
- Fuzzy Preference Programming Method.

Calculation of weighting coefficients for a given problem is carried out by means of the Eigenvector Method. The essence of this method is the assumption that the corresponding vector of eigenvalues can be taken as a vector of priorities. Therefore, the algorithm of the AHP method is based on the eigenvector's ability to generate its own values, which are true or approximate weighting coefficients (Saaty, 1987). If the matrix of the comparison is positive, the square matrix, then one of its eigenvalues λ_{max} is positive and bigger or equal to all other eigenvalues, where there is positive vector of eigenvalues W, which is equal to this eigenvalue according to the following relation (Alonso & Lamata, 2006):

$$AW = \lambda_{max} W \quad \text{or} \quad (A - \lambda_{max} I)W = 0.$$

According to the method of eigenvalues, weighting coefficients should be calculated based on the vector of eigenvalues using the additive normalization. Methodology procedure of the additive normalization involves the summation of matrix values by columns, and then division of each element with the sum of the column in which the element is placed (Srđević, 2005):

$$w_i = \frac{1}{n} \sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, \; i, j = \overline{1, n}.$$

Based on the above formula it is possible to determine the weighting coefficient of each of the criteria, i.e. their relative significance:

Offered price:	$w_1 = 0.39696$
Quality:	$w_2 = 0.39696$
Time of delivery:	$w_3 = 0.11650$
Method of payment:	$w_4 = 0.03113$
Place of delivery:	$w_5 = 0.05845$

Considering that during the prioritization an inconsistency of decision makers can occur, the AHP provides the possibility of quantifying an error that occurs during prioritization by determining the consistency index and the degree of consistency. Consistency index is calculated according to the relation (Satty, 1980; Podvezko, 2009)

$$CI = \frac{\lambda_{max} - n}{n-1}.$$

The degree of consistency presents the relation of consistency index and random index (RI). Random index depends on the number of matrix lines, and its values are given in Table 4:

Table 4. Value of random index

n	1	2	3	4	5	6	7	8	9	10
Value of random index	0.0	0.0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: (Saaty, 1980)

If the degree of consistency is less than 0.10 the result is sufficiently accurate and there is no need for corrections. If the degree of consistency exceeds 0.10, the result should be analyzed again and it is necessary to identify the reasons for inconsistency. Table 5 shows the value of the consistency index and the degree of consistency.

Table 5. Degree of consistency 2008-2011

CI	0.05102
RI (n=5)	1.12
CR=CI/RI	0.04555

The second model:

As in the previous case, the comparison of importance for certain criteria was made based on the Saaty scale. The following comparison matrix was obtained:

Table 6. Comparison matrix of significance of criteria for public procurement in 2012

	Offered price	Quality	Time and place of delivery	Method of payment	Validity period
Offered price	1.000	1.000	7.000	9.000	5.000
Quality	1.000	1.000	7.000	9.000	5.000
Time and place of delivery	0.143	0.143	1.000	3.000	0.333
Method of payment	0.111	0.111	0.333	1.000	0.200
Validity period	0.200	0.200	3.000	5.000	1.000

The next step is to calculate the vector of eigenvalues of the matrix of comparison, determining the weighting coefficients and establishing the measurements of consistency.

By applying the methodology described above, the following weighting coefficients were determined:

Offered price: $w_{1\text{-}2012} = 0.39696$
Quality: $w_{2\text{-}2012} = 0.39696$
Time and place of delivery: $w_{3\text{-}2012} = 0.05848$
Method of payment: $w_{4\text{-}2012} = 0.03113$
Validity period: $w_{5\text{-}2012} = 0.11650$

Index value and degree of consistency are given in Table 7:

Table 7. Degree of consistency

CI	0.05102
RI (n=5)	1.12
CR=CI/RI	0.04555

A comparative analysis of the results of different approaches to determining the weighting coefficients

A comparative analysis of the results of different approaches is aimed towards assessing the differences in the weighting coefficients that are determined by different approaches. Furthermore, the initial hypothesis assumes that there is a difference in the preferences of decision makers about the importance of the criteria stated in the empirical method and those generated by applying the scientific method.

Table 8. Overview of the weighting coefficients determined by various methods (2008-2011)

Criterion	Empirical method	Subjective approach (AHP method)
Offered price	0.700000	0.392737
Quality	0.150000	0.392737
Time of delivery	0.050000	0.119726
Method of payment	0.050000	0.032623
Place of delivery	0.050000	0.062198

Table 9. Overview of the weighting coefficients determined by various methods (2012)

Criterion	Empirical method	Subjective approach (AHP method)
Offered price	0.650000	0.392737
Quality	0.150000	0.392737
Time and place of delivery	0.050000	0.062198
Method of payment	0.050000	0.032623
Validity period	0.100000	0.119706

Further, the t-test was used for comparative analysis of the results in order to determine the potential presence of a statistically significant difference in the weighting coefficients that are determined using different approaches. For the purpose of this analysis we used the statistical software EduStat. The results of the comparison are showed in tables 10 and 11.

Table 10. T-test results (2008-2011)

Criterion	*p-value*
Offered price	0.0741
Quality	0.1434
Time of delivery	0.6536
Method of payment	0.9104
Place of delivery	0.9370

Table 11. T-test results (2012)

Criterion	*p-value*
Offered price	0.1018
Quality	0.1194
Time and place of delivery	0.9323
Method of payment	0.9036
Validity period	0.8910

Considering the fact that the p-value in any of the comparison is a value of less than 0.05 it can be concluded that the weighting coefficients determined by the empirical methods are acceptable from a scientific point of view, and that there is no evidence of their faults. In other words, there was no statistically significant difference between the weighting coefficients determined by the empirical method and the weighting coefficients determined by subjective methods.

The influence of subjective preferences of decision makers to ranking of alternatives in the multi-criteria model of public procurement

The simple additive weighting method can be considered as the simplest method for troubleshooting multi-attribute decision making. This method usually gives results that are convenient and easy to interpret and that can help decision makers select the best alternative from a set of possible alternatives. This method was first used by Churchman and Ackoff in 1954 for solving the problem of optimal portfolio selection (Tzengc & Huang, 2011). Today it is probably the best known and most widely used method of multi-attribute decision making. Choosing the best alternative comes down to a choice of the one that is the most useful to the decision maker, which can be represented by the following equation:

$$A^* = \{u_i(x) | \max_i u_i(x), i = 1,2 \dots m\},$$

where

$$u_i(x) = \sum_{j=1}^{n} w_j \, r_{ij}(x),$$

and where

$u_i(x)$ – utility of *i* alternative, *i=1,2...m*

w_j – weighting coefficient of *j* criterion, *j=1,2...n*

$r_{ij}(x)$ – normalized value of the attribute.

Regarding the normalization of attributes, what characterizes the simple additive weighting method is the application of the linearized decision matrix. Before applying the algorithm, it is necessary that the decision maker determine a vector of weighting coefficients. Therefore, this method can be directly applied to the decision matrix, and it consists of three steps:

1) The normalization of the decision matrix for comparability,
2) The application of the weighting value of the criteria for a normalized decision matrix, and
3) Summation of the difficult decision matrix for each alternative.

This method belongs to the group of methods where the decision maker has the possibility of active participation and can impact the final decision, namely the ranking of alternatives. The decision maker can achieve this by assigning weighting coefficients to each criterion. In this way, the decision maker expresses their preferences and determines the

importance of each criterion. The weighting coefficients are normalized, which means that their sum is equal to one. Below, this paper describes the use of the simple additive weighting method for evaluation and ranking of bids received in the public procurement system.

Based on the data provided by the management of the Gerontology Center "Jelenac" in Aleksinac and the previously determined weighting coefficients, a ranking of bids for public procurement in a representative year was performed. The year 2009 was elected as the representative year, in accordance with the fact that it was the year when most of the tenders were launched, and the year with the highest number of bidders that applied.

The results are given in tables 12-15.

Table 12. Ranking of bids for public procurement of processed meat products

Bidder	Utility	Rank
T.C. "Jabuka 55" Ltd. Belgrade	0.58552	2
T.C. "Miloduks" Aleksinac	0.43398	4
T.C. "Galija" Aleksinac	0.58494	3
"Naše vreme" Ltd. Niš	0.96260	1

Table 13. Ranking of bids for public procurement of flour and processed grains

Bidder	Utility	Rank
"Jumis" Niš	0.96624	4
T.C. "Jabuka 55" Ltd. Belgrade	0.83531	6
T.C. "Miloduks" Aleksinac	0.96377	5
PA "Zrno"	0.98098	2
"Naše vreme" Ltd. Niš	0.98344	1
T.C. "AS"	0.97795	3

Table 14. Ranking of bids for public procurement of colonial goods

Bidder	Utility	Rank
"Jumis" Niš	0.98558	3
T.C. "Jabuka 55" Ltd. Belgrade	0.84704	5
T.C. "Miloduks" Aleksinac	0.98286	4
"Naše vreme" Ltd. Niš	0.99447	2
T.C. "AS"	1.00001	1

Table 15. Ranking of bids for public procurement of fresh fruits

Bidder	Utility	Rank
"Ivan – Okiprom"	0.81376	5
Agricultural household "Ilić Bojan"	0.84438	4
Agricultural household "Zoran Terzić"	0.87263	2
PA "Zrno"	0.85670	3
T.C. "AS"	0.99974	1

COMPARATIVE ANALYSIS OF RESULTS AND DISCUSSION

The results obtained by using ranking of alternatives and applying the method of simple additive weighting can be further analyzed. The purpose of this analysis is to establish the impact of different specific weighting coefficients on the ranking of alternatives, which is obtained by using a specific method. In other words, the aim is to determine whether there is a difference in the ranking of alternatives obtained by using the weighting coefficients that are determined using the exact scientific methods in relation to the ranking of alternatives determined by applying weighting coefficients established by the empirical method.

Table 16. Overview of the ranking of bids for public procurement of processed meat products determined by the application of various methods

Bidder	Rank according to the scientific method	Rank according to the empirical method
T.C. “Jabuka 55” Ltd. Belgrade	2	2
T.C. “Miloduks” Aleksinac	4	4
T.C. “Galija” Aleksinac	3	3
"Naše vreme" Ltd. Niš	1	1

Table 17. Overview of the ranking of bids for public procurement of flour and processed grains determined by the application of various methods

Bidder	Rank according to the scientific method	Rank according to the empirical method
“Jumis” Niš	4	4
T.C. “Jabuka 55” Ltd. Belgrade	6	6
T.C. “Miloduks” Aleksinac	5	5
PA “Zrno”	2	1
“Naše vreme” Ltd. Niš	1	3
T.C. “AS”	3	2

Table 18. Overview of the ranking of bids for public procurement of colonial goods determined by the application of various methods

Bidder	Rank according to the scientific method	Rank according to the empirical method
“Jumis” Niš	3	4
T.C. “Jabuka 55” Ltd. Belgrade	5	5
T.C. “Miloduks” Aleksinac	4	1
“Naše vreme” Ltd. Niš	2	3
T.C. “AS”	1	2

Table 19. Overview of the ranking of bids for public procurement of fresh fruits determined by the application of various methods

Bidder	Rank according to the scientific method	Rank according to the empirical method
"Ivan – Okiprom"	5	5
Agricultural household "Ilić Bojan"	4	4
Agricultural household "Zoran Terzić"	2	2
PA "Zrno"	3	3
T.C. "AS"	1	1

For the purpose of this analysis the statistical software EduStat was used. The correlation analysis was performed in order to determine the relationship between the ranking of alternatives and the applied weighting coefficients.

Table 20. Spearman correlation coefficient

	Empirical method	AHP
Empirical method	1.000	0.776
AHP	0.776	1.000

Based on the values of the Spearman correlation coefficient, it can be concluded that there is no agreement in rankings between the empirical method and the exact methods, i.e. the inversion of ranking occurs when determining the alternatives based on the empirical method in relation to the ranking acquired by using the exact methods. At the same time, the lower the correlation coefficient is, the greater is the discrepancy, i.e. the rank inversion is higher.

Application of weighting coefficients defined by the AHP method leads to the inversion of ranking in relation to the use of the empirical method when ranking the alternatives. In particular, with the analysis of a representative year it can be seen that the value of the correlation coefficient between the ranks defined by the method of simple additive weighting compared to the empirical method is 0.776, which shows that the application of the exact scientific method resulted in a change in the sequence of the observed alternatives.

CONCLUSION

The system of public procurement is an area of public finances, which is of special interest to the modern society. Through the effective functioning of this system it is possible to conduct fair and efficient allocation of public resources and the optimal quantity of goods to be

financed by public funds. Consequently, the application of the multi-criteria analysis method becomes necessary and highly useful.

Usage of multi-criteria analysis methods in the assessment of public procurement can greatly facilitate the process of decision making and reduce abuse of the public procurement system, which is especially important considering the fact that the abuse of this system leads to inefficient allocation of public funds. The efficiency of the public procurement system leads to an increase in welfare due to the fact that public funds are used in a quantity that is sufficient to provide the required quantity and quality of the subject of procurement. Therefore, this paper endeavored to prove that for an adequate, efficient, and consistent decision making in the public procurement system it is important to implement the multi-criteria analysis method.

Based on the results of the research it can be concluded that the initial hypothesis has not been proved. Specifically, based on the t-test it was shown that there was no difference in the weighting coefficients defined by the empirical method and by the subjective preferences of the members of the tender evaluation committee.

Regarding the second hypothesis, it was confirmed as the results of the comparative analysis showed that there is a difference in the ranking of alternatives determined by applying the weighting coefficients specified using the AHP method in relation to the ranking of alternatives determined by applying the weighting coefficients defined by the empirical method. Therefore, the application of weighting coefficients generated on the basis of subjective preference of decision making resulted in an inversion of the ranking of alternatives.

Finally, for their further investigation, the authors will be focused on the analysis of business institutions and organizations dealing in social protection of vulnerable groups of citizens. The investigation will primarily deal with the analysis of business organizations that care for the elderly, for persons with disabilities, and for children without parental care, in terms of expanding and increasing the representativeness of the sample of decision makers, in order to define the proper criteria for effective and efficient conduct of the state in the implementation of public procurement in this sector.

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УТИЦАЈ СУБЈЕКТИВНИХ ПРЕФЕРЕНЦИЈА НА ПРОЦЕС ОДЛУЧИВАЊА У ВИШЕКРИТЕРИЈУМСКОМ МОДЕЛУ ЈАВНИХ НАБАВКИ

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Резиме

Један од изазова сваког привредног субјекта је успешна организација система јавних набавки. Успешност пословања је условљена ефикасним и квалитетним спровођењем поступка јавних набавки. Избор најповољније понуде се у највећој мери заснива на субјективној процени доносиоца одлуке, али постоје и бројни други критеријуми које треба узети у обзир приликом доношења такве одлуке. Да би се олакшао процес доношења одлуке и смањиле злоупотребе у систему јавних набавки као јако заначајне показале су се методе и модели вишекритеријумског одлучивања.

Методи вишекритеријумске анализе су погодни за решавање великог броја реалних проблема различите природе. Значај сваког појединачног критеријума у вишекритеријумском моделу приказан је и одређен тежинским коефицијентима. Адекватно одређивање и додела тежинских коефицијената нарочито добија на значају уколико се узме у обзир да тежински коефицијенти имају велики утицај на коначан поредак алтернатива, односно за одабир најповољнијег решења посматраног проблема. Одређивање тежинских коефицијената се може вршити: субјективним приступом, објективним приступом и комбинованим приступом. За одређивање субјективних преференција доносиоца одлуке најчешће се користи метода Аналитичких Хијерархијских Процеса – АХП метода. Ова метода сатоји се из три нивоа: на врху се налази циљ који треба постићи доношењем одређене одлуке, на другом нивоу се налазе критеријуми који служе за евалуацију алтернатива, док се саме алтернативе налазе на трећем нивоу. Процес моделирања у вишекритери-

јумској анализи неког реалног проблема захтева четри фазе: структуирање проблема, прикупљање података, оцењивање релативних тежина, и одређивање решења постављеног проблема.

На основу података добијених од стране менаџмента Герантолошког центра „Јеленац“ из Алексинца у овом раду извршено је рангирање понуда на тендерима за јевне набавке који су расписани у репрезентативној години. Као репрезентативна година узета је 2009. година јер је тада расписан највећи број тендера на којима је учествовао највећи број понуђача. Оцена понуда вршена је на бази пет критеријума: понуђене цене, квалитета, рока и начина плаћања, места испоруке и рока важења понуде. Рангирање понуда извршено је на основу тежинских коефицијената који су одређени искуственом методом и тежинских коефицијената који су одређени научном (субјективном) методом. Компаративном анализом резултата различитих приступа оцењене су разлике у тежинским коефицијентима.

На бази резултата спроведеног истраживања закључено је да су са научног аспекта прихватљиви тежински коефицијенти одређени искуственом методом, односно да не постоји доказ о њиховој неисправности. Другим речима, не постоји статистички значајна разлика између тежинских коефицијената одређених искуственом методом и тежинских коефицијената одређених субјективном методом. Такође, на основу резултата компаративне анализе показано је да постоји разлика у поретку алтернатива које су утврђене на основу тежинских коефицијената одређених искуственом, односно субјективном методом. Примена тежинских коефицијената генерисаних на основу субјективних преференција доносилаца одлуке доводи до инверзије у рангу алтернатива.