РОЗДІЛ III. КОМП'ЮТЕРНІ НАУКИ

UDC 339.186
DOI https://doi.org/10.26661/2413-6549-2022-1-11

DECISION-MAKING BY THE GROUP OF EXPERTS REGARDING THE EVALUATION OF PARTICIPANTS OF STATE TENDERS

Bondarenko V. E.
Doctor of Technical Sciences,
Professor at the Department of Computer Sciences
National University of Life and Environmental Sciences of Ukraine
Heroiv Oborony str., 15, Kyiv, Ukraine
orcid.org/0000-0001-5591-1504
victorbondarenko@ukr.net

Karanfilov M. S.
Senior Lecturer at the Department of Information Systems in Economics
Kyiv National Economic University
Peremogy ave., 54/1, Kyiv, Ukraine
orcid.org/0000-0002-2084-0571
123kms123@gmail.com

Key words: *decision-making, decision support systems, government procurement, Purchase Tender, supplier.*

The article is devoted to the development of a decision support system in a Purchase Tender. Such the system allows an institution that announced a Purchase Tender to estimate suppliers that have an interest in supply and can take part in such tender offering different conditions of purchase. The main method that is used to build a decision support system was chosen as the method of the analytic hierarchy process that was developed by T.L. Saaty based on construction pairwise comparisons matrices of suppliers and their features. These matrices are constructed by experts and they need for coherent often, because expert' assessment of one pair elements of a matrix can be controversial sometimes to assessment of second pair elements of such matrix. Such controversies are connected with difficulties for expert, which can be in process of complex relations estimation. This method is modified in the direction of building coherent matrices of pairwise comparisons. It presents an approach to assessing the consistency of pairwise comparisons matrices based on the analysis of the transitivity of the graph that is constructed with the help of the matrix of pairwise comparisons.

The pairwise comparisons matrix is seen as a adjacencies matrix of a graph.

Besides, the paper proposes an approach to the evaluation of pairwise comparisons of suppliers and their features with the help of a group of experts that helped make the evaluation more accurate. The estimate of elements of pairwise comparisons matrix is calculated as a weighted average of all experts' assessments with the coefficient of confidence. The coefficient of confidence is change for every expert. This change is connected with the correctness of experts' estimation in previous evaluations.

Based on the developed modification of the analytic hierarchy process it built a software system for decision support, which is implemented in the C++ language. One of the areas of the system application is the analysis of decision-making problems in the field of public procurement to assess the companies-bidders for the construction of industrial facilities.

УХВАЛЕННЯ РІШЕНЬ ГРУПОЮ ЕКСПЕРТІВ ЩОДО ОЦІНКИ УЧАСНИКІВ ДЕРЖАВНИХ ТЕНДЕРІВ

Бондаренко В. Є.
доктор технічних наук,
професор кафедри комп'ютерних наук
Національний університет біоресурсів і природокористування України
вул. Героїв Оборони, 15, Київ, Україна
orcid.org/0000-0001-5591-1504
victorbondarenko@ukr.net

Каранфілов М. С.
старший викладач кафедри інформаційних систем в економіці
Київський національний економічний університет
просп. Перемоги, 54/1, Київ, Україна
orcid.org/0000-0002-2084-0571
123kms123@gmail.com

Ключові слова: *ухвалення рішень, системи підтримки ухвалення рішень, державні закупівлі, тендер на закупівлю, постачальник.*

Стаття присвячена розробленню системи підтримки ухвалення рішень у тендері на закупівлю. Така система дозволяє установі, яка оголосила тендер на закупівлю, оцінити постачальників, які зацікавлені в постачанні та можуть взяти участь у такому тендері, пропонуючи різні умови закупівлі. Основним методом, який використовується для побудови системи підтримки ухвалення рішень, обрано метод аналізу ієрархій, розроблений Т.Л. Сааті на основі побудови матриць попарного порівняння постачальників і їхніх характеристик. Ці матриці будуються експертами, і вони часто потребують узгодженості, оскільки експертна оцінка однієї пари елементів матриці іноді може суперечити оцінці другої пари елементів такої матриці. Такі суперечності пов'язані із труднощами для експерта, які можуть виникнути у процесі оцінки складних відношень. Цей метод модифікований у напрямі побудови узгоджених матриць попарних порівнянь. Представлено підхід до оцінки узгодженості матриць попарних порівнянь на основі аналізу транзитивності графа, побудованого за допомогою матриці попарних порівнянь. Матриця попарного порівняння розглядається як матриця суміжності графа, де його вершини мітяться постачальниками (характеристиками), а дуги між вершинами задають кількісне значення переваги одного постачальника (характеристики) над іншим. Окрім того, у роботі запропоновано підхід до оцінки попарних порівнянь постачальників та їх характеристик за допомогою групи експертів, що допомогло зробити оцінку більш точною. Оцінка елементів матриці попарних порівнянь розраховується як середньозважене значення всіх оцінок експертів із коефіцієнтом довіри. Коефіцієнт довіри змінюється для кожного експерта. Ця зміна пов'язана із правильністю оцінки експертів у попередніх оцінках. На основі розробленої модифікації методу аналізу ієрархій побудовано програмну систему підтримки ухвалення рішень, яка реалізована мовою C++. Одним із напрямів застосування системи є аналіз проблем ухвалення рішень у сфері державних закупівель для оцінки компаній – учасників торгів на будівництво промислових об'єктів.

1. INTRODUCTION

A Purchase Tender (PT) is used to drive competition between several suppliers to get the best offer for a list of products or services. An institution announces a Purchase Tender and suppliers that have an interest in supply can take part in such tender offering different conditions of purchase, where each supplier is competing with one another. An institution can select the supplier that offers the best conditions.

We have many papers that describe Consumer Decision-Making [1–3]. There exist sites that can help in a purchase tender organization (www.tendertiger.com, www.indiatenders.com). C. Csaba [4] describes general questions of decision making of public procurement. The group of authors [5] investigates the lowest cost for a project. It does not guarantee the terms of time and quality of a project. More particularly, the risk exposure during the tendering process is usually very high and the success of the project is strongly related to managing this risk.

In [6] authors research the algorithm of suppliers evaluation based on the weight coefficients. This algorithm does not evaluate the expert's logic that can do contradictory assessments. Besides, the confidence to experts is constant and do not connect with their previous estimations quality. This can influence on the results quality.

Authors [7] describe tender price evaluation of construction project. As we know price is very important feature, but we have other features that we should take into account, for example, term of work finish.

Take into account the experience of existing papers, we will describe an analytical approach and an algorithm of the estimate the best supplier from a tender group on the base of a features' set with the help of the concordance opinion an experts' group.

Therefore, aim of this paper is to find approach, which allows us to find the best supplier from *n* suppliers on the base of *m* features. These features determine characteristics of suppliers. For example, goods price, service quality, the warranty term, et al.

In this paper, the selected subject area is the decision-making in the field of public procurement, which is regulated by the Law of Ukraine "On Public Procurement" [8]. As the trends of the Ukrainian government aimed at combating corruption, and the bulk of corruption in the state related to public procurement, it is advisable to automate the public procurement process, which minimizes interference of corrupt officials in this process. Therefore, the topic of work devoted to such automation is extremely relevant to Ukraine.

Therefore, the main purpose of this paper is to consider an approach to the construction of an expert system that can estimate Purchase Tender suppliers on the base of their features set.

Let there is a set of n suppliers $D_1, D_2, \ldots, D_n$ participants of a Purchase Tender. Let there is a set of m features $k_1, k_2, \ldots k_m$ that characterized the suppliers. For example, price of goods, warranty service, location of the enterprise, fixed assets of the enterprise.

The main idea of an expert system construction is based on the analytic hierarchy process [9] that is modified in this paper.

According to the analytic hierarchy process, it is necessary for every feature to form a matrix of pairwise comparisons suppliers. Expert evaluation of n suppliers on the base feature k_l is formed into a matrix of the form (Table 1).

Table 1

Matrix of pairwise comparisons of suppliers

k_l	D_1	D_2	…	D_n
D_1	1	a_{12}		
D_2	a_{21}	1		
…			1	
D_n	a_{n1}			1

The cells a_{ij} of the matrix include the estimates of experts which mean how many times more preferable from the point of view of feature k_l we can select the supplier D_i, which marks the row of the matrix than the supplier D_j, which marks the column of the matrix. From this definition, it can be seen that the main diagonal of the matrix has values 1.

Thus, if $D_i = pD_j$, i.e. the supplier D_i occurs p times more preferable than the supplier D_j, then we have $D_j = 1/p\ D_i$.

That is, if the estimate $a_{ij} = p$, then $a_{ji} = 1 / p$ and $a_{ii} = 1$.

Similar to the supplier matrices, experts build a matrix of pairwise comparisons of features (Table 2), where each row and column of the matrix is marked by the features $k_1, k_2, \ldots k_m$ that characterize suppliers.

Table 2

Matrix of pairwise comparisons of features

	k_1	k_2	…	k_m
k_1	1	a_{12}		
…		1		
k_m	a_{m1}			1

For the matrix of features, as for the matrix of suppliers, there are relations: $a_{ij} = p$, then $a_{ji} = 1 / p$, and $a_{ii} = 1$.

Expert evaluations of a_{ij} are recorded in the cells of the matrix, which means how many times is more preferable for a tender announces institution the feature k_i, which marks the row of the matrix than the feature k_j, which marks the column of the matrix.

2. Expert group evaluation of pairwise comparison matrices of suppliers and features

To improve the construction of suppliers and features matrices, it is advisable to use an expert team for this comparison [10]. The method of such use is developed by the author and it is given below.

The evaluation of the *i*-th supplier (feature) relative to the *j*-th supplier (feature) a_{ij} of pairwise comparisons is performed by a group of *m* experts according to the algorithm below with the possible use of *T* evaluation steps to improve its quality.

The algorithm 1.

1. The estimate a_{ij} is calculated as a weighted average by the following formula (1)

$$a_{ij} = \frac{\sum_{k=1}^{m} \rho_k S_{ij}^{k}}{\sum_{k=1}^{m} \rho_k}, \quad (1)$$

where ρ_k is the coefficient of confidence to the *k*-th expert (in the first stage of evaluation, the coefficients of confidence of all experts are the same and equal to 1), S_{kij} is the estimate of the *i*-th supplier (feature) relative to the *j*-th supplier (feature) determined by the *k*-th expert, *m* is the number of experts. The indicators S_{kij} are estimated by each expert based on the scale of preference, which values are determined in the range from 1 to 9.

2. The coefficient of confidence to the *k*-th expert is adjusted according to the following formula (2):

$$\acute{A}_k = \frac{1}{T}\sum_{t=1}^{T} \acute{A}_k^t , \quad (2)$$

where *T* is the number of evaluation stages, ρ_k^t is the coefficient of confidence to the *k*-th expert at the *t*-th stage of evaluation (3):

$$\acute{A}_k^t = exp(-\frac{\left(G_{ij} - S_{ij}^k\right)^2}{2\tilde{A}_k}), \quad (3)$$

where G_{ij} is a posteriori evaluation of the *i*-th supplier (feature) relative to the *j*-th supplier (feature) (that is, the estimate, which is determined in the process of checking the matrices of suppliers and features for inconsistency), σ_k is forgetting factor of the *k*-th expert.

3. Checking the consistency of the matrix a_{ij} and its correction by experts. As a result, we get a new matrix a_{ij}^{new}.

4. Paragraphs 1–3 will be repeated until the change in estimates, matrices of suppliers (features) due to the inconsistency check is less than the specified value ε (4).

$$\sum_{i=1}^{B}\sum_{j=1}^{B}\left|a_{ij}^{new} - a_{ij}\right|^2 < \mu \quad (4)$$

3. harmonization of suppliers and features matrices

In the process of constructing the matrices of the features and suppliers, they must be coordinated, that is, the transitivity given by the matrix of relations must be performed.

Transitivity allows us to test the logic of the expert's thinking. If the expert considers that the factor *A* (supplier or feature) exceeds the factor *B*, and the factor *B*, in turn, exceeds the factor *C*, then by a pairwise comparison the factor *A* must exceed the factor *C*, that is, the inequality $A > B > C$ must be satisfied, where the symbol ">" means outperforms.

In addition, numerical estimates of the transitivity of relationships must be performed. For example, if factor *A* exceeds factor *B* 2 times, and factor *B*, in turn, exceeds factor *C* 3 times, then factor *A* must exceed factor *C* in $m = 2 \times 3 = 6$ times.

Lack of consistency can be a serious limiting factor for using the method.

To study the transitivity of relations in the matrices of features and suppliers, the paper proposes to use oriented graphs.

One of the first questions that arise when studying graphs is the question of the existence of paths between pairs of vertices. The answer to the question is the above ratio of reach at the vertices of the graph $G = (V, E)$, where *V* is the set of vertices, and *E* is the set of relations between the vertices of the graph.

The vertex $w \in V$ is reachable from the vertex $v \in V$ if $v = w$ or G is the path from *v* to *w*. In other words, the reach ratio is a reflexive and transitive closure of the *E*.

To analyze the matrices of features and suppliers, we construct a graph using the matching matrix as the adjacency matrix of the graph, where the values of the element of the matrix will be interpreted as the weight of the edges of the graph.

Since the matrix of features and suppliers is constructed in such a way that, $a_{ji} = \frac{1}{a_{ij}}$, where a_{ij} is an element of the matrix of features or suppliers, it is possible do not use the relations for which $a_{ij} < 1$ for $i \neq j$ and $a_{ii} = 1$.

The matrix is shown in Table 3 compares some features that characterize suppliers.

Using the matrix of Table 3 as the matrix of adjacencies of a graph, we construct a graph for the analysis of inconsistencies of a matrix of pairwise comparisons (Fig. 1). To simplify the image, branches with weights less or equal to 1 were not displayed on the graph.

From the analysis of the graph in Fig. 1, it can be seen that the pairwise comparisons matrix (Table 3) is inconsistent because the path 1–2–4 has a weight of 18, and the path 1–4 only 8. Path 1–3–2 has a weight of 15, and path 1–2 only 3. Path 1–3–4 has a weight of 45, and path 1–4 only 8.

Fig. 1b shows a graph based on a harmonized by experts matrix of pairwise comparisons of features. Such the harmonized pairwise comparisons matrix is given in Table 4.

Table 3

Matrix of pairwise comparisons of features that characterize suppliers

	Price of goods	*Warranty service*	*Location of the enterprise*	**Fixed assets of the enterprise**
Price of goods	1	3	5	8
Warranty service	1/3	1	1/3	6
Location of the enterprise	1/5	3	1	9
Fixed assets of the enterprise	1/8	1/6	1/9	1

Table 4

Matrix of pairwise comparisons of features of suppliers (after concordance)

	Price of goods	*Warranty service*	*Location of the enterprise*	*Fixed assets of the enterprise*
Price of goods	1	6	2	8
Warranty service	1/6	1	1/3	1,33
Location of the enterprise	1/2	3	1	4
Fixed assets of the enterprise	1/8	1/1,33	1/4	1

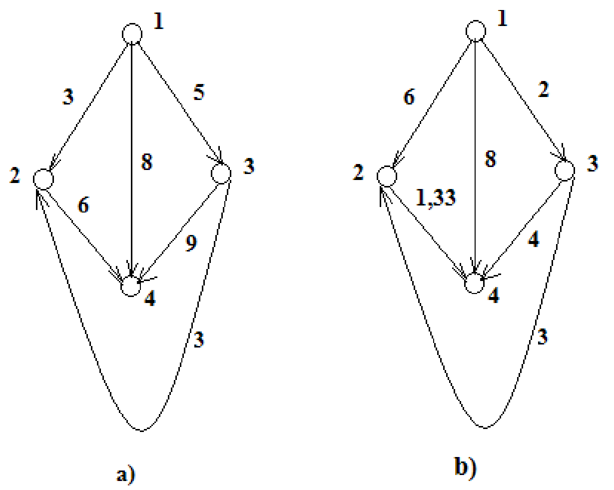

Fig. 1. Graph to analyze inconsistencies of the matrix of pairwise comparisons: a) the pairwise comparison matrix is inconsistent; b) the pairwise comparison matrix is consistent.

Matrix matching of pairwise comparisons is performed by an expert team in an iterative mode.

4. Estimation of suppliers' priority

To determine the priority suppliers and features of each supplier, it is necessary to determine the geometric average (5), which indicates the typical value of a set of numbers by using the product of their values. We will obtain a normalized vector of features if this typical value will be divided by the sum of typical values of all suppliers (6).

The vector $\{c_r\}^n_{r=1}$ can be calculated by the following relation:

$$c_r = (W_{r1} \times W_{r2} \times \ldots \times W_{rn})^{1/n}, \qquad (5)$$

where W_{ij} are the elements of the pairwise comparisons matrix of features, *m* is the number of features.

The normalized vector $\{X_l\}$ for features of suppliers is calculated by the formula (6):

$$X_l = \frac{c_l}{\sum_{i=1}^{n} c_i}, \quad l=1,2,\ldots n. \qquad (6)$$

The local priority vector $\{Y_l\}$ is calculated by the formula (7):

$$\begin{Vmatrix} Y_1 \\ Y_2 \\ \ldots \\ Y_m \end{Vmatrix} = \begin{Vmatrix} W_{11}\ W_{12}\ W_{13} \ldots\ W_{1n} \\ W_{21}\ W_{22}\ W_{23} \ldots\ W_{2n} \\ \ldots \\ W_{m1}\ W_{m2}\ W_{m3} \ldots\ W_{mn} \end{Vmatrix} \times \begin{Vmatrix} X_1 \\ X_2 \\ \ldots \\ X_n \end{Vmatrix}, \qquad (7)$$

where the matrix $| W_{ij}|$ is pairwise comparisons matrix of features.

The global priority vector $\{P_l\}$ is calculated by the formula (8):

$$\begin{Vmatrix} P_1 \\ P_2 \\ \ldots \\ P_n \end{Vmatrix} = \begin{Vmatrix} Z_{11}\ Z_{21}\ Z_{31} \ldots Z_{m1} \\ Z_{12}\ Z_{22}\ Z_{32} \ldots Z_{m2} \\ \ldots \\ Z_{1m}\ Z_{2m}\ Z_{3m} \ldots Z_{mn} \end{Vmatrix} \times \begin{Vmatrix} Y_1 \\ Y_2 \\ \ldots \\ Y_m \end{Vmatrix}, \qquad (8)$$

where $\{Z_{ij}\}$ is the local priority matrix for the pairwise comparisons matrices of suppliers (j) for every feature (i).

Consider a simple example. Let the experts created the pairwise comparisons matrix of suppliers' features in this form (Table 5).

Table 5

Example of pairwise comparisons matrix of features

	k_1	k_2	k_3
k_1	1	1/6	1/9
k_2	6	1	1/9
k_3	9	9	1

Then the normalized vector $\{X_l\}$ for features of suppliers is calculated by the formula (6) as follows (9).

$$c_1 = (a_{11} \times a_{12} \times a_{13})^{1/3} = (1 \times 1/6 \times 1/9)^{1/3} = 0{,}265.$$

$$c_2 = (a_{21} \times a_{22} \times a_{23})^{1/3} = (6 \times 1 \times 1/9)^{1/3} = 0{,}874.$$

$$c_3 = (a_{31} \times a_{32} \times a_{33})^{1/3} = (9 \times 9 \times 1)^{1/3} = 4{,}327.$$

$$S = c_1 + c_2 + c_3 = 0{,}265 + 0{,}874 + 4{,}327 = 5{,}46. \quad (9)$$

$$X_1 = c_1/s = 0{,}265/5{,}46 = 0{,}05.$$

$$X_2 = c_2/s = 0{,}874/5{,}46 = 0{,}15.$$

$$X_3 = c_3/s = 4{,}327/5{,}46 = 0{,}8.$$

We obtain the local priority vector $\{Y_l\}$ by the formula (7).

$$\begin{Vmatrix} Y_1 \\ Y_2 \\ Y_3 \end{Vmatrix} = \begin{Vmatrix} 1\ 1/6\ 1/9 \\ 6\ 1\ 1/9 \\ 9\ 9\ 1 \end{Vmatrix} \times \begin{Vmatrix} 0.05 \\ 0.15 \\ 0.8 \end{Vmatrix} = \begin{Vmatrix} 0{,}16 \\ 0{,}54 \\ 2{,}6 \end{Vmatrix}. \quad (10)$$

Let the matrices of pairwise comparisons of suppliers for each feature created by the experts in this form (Table 6).

We obtain (11, 12, 13) performing calculations similar to the calculations of the features.

For feature k_1:

$$c_1 = (a_{11} \times a_{12})^{1/2} = (1 \times 1/2)^{1/2} = 0{,}71.$$

$$c_2 = (a_{21} \times a_{22})^{1/2} = (2 \times 1)^{1/2} = 1{,}41.$$

$$s = c_1 + c_2 = 0{,}71 + 1{,}41 = 2{,}12. \quad (11)$$

$$X_1 = c_1/s = 0{,}71/2{,}12 = 0{,}33.$$

$$X_2 = c_2/s = 1{,}41/2{,}12 = 0{,}67.$$

For feature k_2:

$$c_1 = (a_{11} \times a_{12})^{1/2} = (1 \times 1/1{,}5)^{1/2} = 0{,}82.$$

$$c_2 = (a_{21} \times a_{22})^{1/2} = (1{,}5 \times 1)^{1/2} = 1{,}22.$$

$$s = c_1 + c_2 = 0{,}82 + 1{,}22 = 2{,}04. \quad (12)$$

$$X_1 = c_1/s = 0{,}82/2{,}04 = 0{,}4.$$

$$X_2 = c_2/s = 1{,}22/2{,}04 = 0.6.$$

For feature k_3:

$$c_1 = (a_{11} \times a_{12})^{1/2} = (1 \times 8)^{1/2} = 3{,}0.$$

$$c_2 = (a_{21} \times a_{22})^{1/2} = (1/8 \times 1)^{1/2} = 0{,}35.$$

$$s = c_1 + c_2 = 3{,}0 + 0{,}35 = 3{,}35. \quad (13)$$

$$X_1 = c_1/s = 3{,}0/3{,}35 = 0{,}89.$$

$$X_2 = c_2/s = 0{,}35/3{,}35 = 0{,}11.$$

We calculate the local priority vectors $\{Z_{ij}\}$ (14–16) of suppliers' matrices of pairwise comparisons for every feature k_1, k_2, k_3.

$$\begin{Vmatrix} Z_{11} \\ Z_{12} \end{Vmatrix} = \begin{Vmatrix} 1\ 1/2 \\ 2\ 1 \end{Vmatrix} \times \begin{Vmatrix} 0.33 \\ 0.67 \end{Vmatrix} = \begin{Vmatrix} 0.665 \\ 1.33 \end{Vmatrix} \quad (14)$$

$$\begin{Vmatrix} Z_{21} \\ Z_{22} \end{Vmatrix} = \begin{Vmatrix} 1\ 1/1{,}5 \\ 1{,}5\ 1 \end{Vmatrix} \times \begin{Vmatrix} 0{,}4 \\ 0{,}6 \end{Vmatrix} = \begin{Vmatrix} 0{,}8 \\ 1{,}2 \end{Vmatrix} \quad (15)$$

$$\begin{Vmatrix} Z_{31} \\ Z_{32} \end{Vmatrix} = \begin{Vmatrix} 1\ 8 \\ 1/8\ 1 \end{Vmatrix} \times \begin{Vmatrix} 0{,}89 \\ 0{,}11 \end{Vmatrix} = \begin{Vmatrix} 1{,}77 \\ 0{,}22 \end{Vmatrix}. \quad (16)$$

The global priority vector $\{P_l\}$ is calculated by the formula (8).

$$\begin{Vmatrix} P_1 \\ P_2 \end{Vmatrix} = \begin{Vmatrix} 0.665\ 0.8\ 1.77 \\ 1.33\ 1.2\ 0.22 \end{Vmatrix} \times \begin{Vmatrix} 0.16 \\ 0.54 \\ 2.6 \end{Vmatrix} = \begin{Vmatrix} 5.14 \\ 1.43 \end{Vmatrix}. \quad (17)$$

The obtained results show that the first supplier is more preferable in the Purchase Tender because his rating is 5,14.

Based on the described approach, an expert system was developed. The software implementation of the expert system is made in C++ language in the C++ Builder environment.

Table 6

Example the matrices of pairwise comparisons of suppliers

k_1	D_1	D_2
D_1	1	1/2
D_2	2	1

k_2	D_1	D_2
D_1	1	1/1,5
D_2	1,5	1

k_3	D_1	D_2
D_1	1	8
D_2	1/8	1

 ISSN 2413-6549

5. Conclusion

1. It is proposed modification of the analytic hierarchy process (T. Saaty [9]) for decision-making in a Purchase Tender.

This modification consists in next:

a) it is proposed the algorithm of estimation of pairwise comparisons of features and suppliers with the help of a group of experts;

b) it is proposed the algorithm of harmonization of suppliers and features matrices.

2. The algorithm presented in this paper allows us to effectively use a team of experts to evaluate the suppliers. The presented algorithm improves the quality of work of the expert system requiring taking into account the level of trust in the competence of experts, as well as the speed of change of experts' trust by the decision-maker.

3. One of the areas of the system application is the analysis of decision-making problems in the field of public procurement to assess the companies-bidders for the construction of industrial facilities. However, the algorithm has universal character and we hope it can be used for decision making in other spheres of procurement tenders, different competition selections.

ЛІТЕРАТУРА

1. Belch G., Belch M. Advertising and Promotion. *An Integrated Marketing Communications Perspective.* 8'th ed. Homewood, IL, Irwin, 2009. P. 325–370.
2. The Shopping Momentum Effect / R. Dhar et al. *Journal of Marketing Research*. 2007. Vol. 44. № 3. P. 370–378.
3. Stankevich A. Explaining the Consumer Decision Making Process: Critical Literature Review. *Journal of International Business Research and Marketing.* 2017. Vol. 2. № 6. P. 7–14.
4. Csaba C. Investigating the Decision-Making Practice of Public Procurement Procedures. *The Second International Public Procurement Conference*, *Italy, Rome, 21–23 September 2006.* Rome. P. 869–899.
5. A system for tender price evaluation of construction project based on big data / Y. Zhanga et al. *The Creative Construction Conference*, *Italy, Rome, Dec. 15–17, 2015.* Procedia Engineering 123. Rome. P. 606–614.
6. Research of the Supplier Evaluation System in Electronic Government Procurement Based on Multiple Amended Weight Coefficient / W. Haizi et al. *The International Forum on Computer Science-Technology and Applications, Italy, Rome, Dec. 25–27, 2009.* Vol. 2. Rome. P. 90–92.
7. Decision making framework for tender evaluation and contractor selection in public organizations with risk considerations / A. Cheaitou et al. *Socio-Economic Planning Sciences*. December 2019. Vol. 68. P. 34–39.
8. On Public Procurement : The Law of Ukraine. *Information of the Verkhovna Rada*. 2016. № 9. P. 89.
9. Saaty T.L. Axiomatic foundation of the analytic hierarchy process. *Management Science*. 1986. Vol. 32. № 7. P. 841–855.
10. Bondarenko V.E. Subjective-probability approach to design an expert system for assessment of states of complex systems in conditions of non-regular destructive influences. *Proceedings of the IEEE International Conference on Advanced Trends in Information Theory, Ukraine, Kiev, 18.12.2019–20.12.2019.* Kiev. P. 183–186.

REFERENCES

1. Belch G., Belch M. (2009). Advertising and Promotion. An Integrated Marketing Communications Perspective, 8'th ed. Homewood, IL, Irwin, pp. 325–370.
2. Dhar R., Huber J., Khan U. (2007). The Shopping Momentum Effect. *Journal of Marketing Research*. Vol. 44, № 3, pp. 370–378.
3. Stankevich A. (2017). Explaining the Consumer Decision Making Process: Critical Literature Review. *Journal of International Business Research and Marketing,* vol. 2, № 6, pp. 7–14.
4. Csaba C. (2006). Investigating the Decision Making Practice of Public Procurement Procedures. Proceedings of the *Second International Public Procurement Conference* (Italy, Rome, 21–23 September 2006), Rome. Pp. 869–899.
5. Zhanga Y., Luoa H., Hea Y. (2015). A system for tender price evaluation of construction project based on big data. Proceedings of the *Creative Construction Conference* (Italy, Rome, Dec. 15–17, 2015), Procedia Engineering 123, Rome. Pp. 606–614.
6. Haizi W., Li Z., Juan L., Tongtao Z. (2009). Research of the Supplier Evaluation System in Electronic Government Procurement Based on Multiple Amended Weight Coefficient. Proceedings of the *International Forum on Computer Science-Technology and Applications* (Italy, Rome, Dec. 25–27, 2009), vol. 2, Rome. Pp. 90–92.
7. Cheaitou A, Larbi R., Al Housani B. (2019). Decision making framework for tender evaluation and contractor selection in public organizations with risk considerations. *Socio-Economic Planning Sciences*, vol. 68, December 2019. Pp. 34–39.

8. The Law of Ukraine “On Public Procurement”. Information of the Verkhovna Rada, № 9, 2016, 89 p.
9. Saaty T.L. (1986). Axiomatic foundation of the analytic hierarchy process. *Management Science*, vol. 32, № 7, pp. 841–855.
10. Bondarenko V.E. (2019). Subjective-probability approach to design an expert system for assessment of states of complex systems in conditions of non-regular destructive influences. Proceedings of the IEEE International Conference on Advanced Trends in Information Theory (Ukraine, Kiev, 18.12.2019–20.12.2019). Kiev. Pp. 183–186.