UDC 65.012.323

Zhyvko Z.
Doctor of Economics, Professor,
Lviv State University of Internal Affairs, Ukraine;
e-mail: professor2007@ukr.net; ORCID ID: 0000-0002-4045-669X
Voronka O.
Ph. D. in Economics,
Lviv State University of Internal Affairs, Ukraine;
ORCID ID: 0000-0001-8334-7613
Blikhar V.
Doctor of Philosophy, Professor,
Lviv State University of Internal Affairs, Ukraine;
ORCID ID: 0000-0001-7545-9009
Ruda I.
Ph. D. in Economics,
Lviv State University of Internal Affairs, Ukraine;
e-mail: dr.irynaruda@gmail.com
Kukharska L.
Ph. D. in Management,
Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine;
ORCID ID: 0000-0002-8957-6983

FORMATION OF THE HIERARCHY MODEL OF THREATS IMPACT ON PERSONNEL SECURITY OF BANKS

Abstract. The conducted theoretical and analytical study, which included acquaintance with the achievements of domestic and foreign scientists on ensuring the personnel security of banks and assessing the personnel security of the banking sector of the economy, allowed to develop oriented graphical models and corresponding reachability matrices, and served as a basis for hierarchical ordering of key threats to bank personnel security. The hierarchical ordering of threats to the personnel security of the banking sector of the economy is based on the application of the graph theory method. The models developed give an idea of the need to implement safeguards against key threats, which is important in view of resource constraints and maximizing the effectiveness of security actors. The result is averaged for most domestic banks, as each of them is influenced by the external environment and changes caused by internal processes. A mechanism for counteracting the influence of external and internal threats on the personnel security of banks has been constructed, which takes into account the current trends in the development of the banking sector. The application of system analysis and graph theory made it possible to hierarchically regulate the impact of key threats on personnel security, which became the basis for the development of a model that graphically determines the priority of developing and implementing security measures for each threat, and justifies the possibility of applying one of the options passive protection and active protection. As a result of the theoretical and analytical study, a number of key external and internal threats to personnel security of banks have been regulated and identified. By applying graph theory and mathematical modeling hierarchically ordered and determined the severity of the impact of threats on the personnel security of banks, which subsequently allowed to create a defense mechanism to counter them.

Keywords**:** bank personnel security, bank system, threat, security, crisis situation, mechanism.

JEL Classification D81, G21, F29, L20

Formulas: 16; fig.: 3; tabl.: 19; bibl.: 16.

Живко З. Б.
доктор економічних наук, професор,
Львівський державний університет внутрішніх справ, Україна;
e-mail: professor2007@ukr.net; ORCID ID: 0000-0002-4045-669X

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

Воронка О. З.
кандидат економічних наук,
Львівський державний університет внутрішніх справ, Україна;
ORCID ID: 0000-0001-8334-7613
Деліхар В. С.
доктор філософських наук, професор,
Львівський державний університет внутрішніх справ, Україна;
ORCID ID: 0000-0001-7545-9009
Руда І. І.
кандидат економічних наук,
Львівський державний університет внутрішніх справ, Україна;
e-mail: dr.irynaruda@gmail.com
Кухарська Л. В.
кандидат наук з управління,
Національна академія Сухопутних військ імені Гетьмана Петра Сагайдачного,
Львів, Україна;
ORCID ID: 0000-0002-8957-6983

ФОРМУВАННЯ МОДЕЛІ ІЄРАРХІЇ ВПЛИВУ ЗАГРОЗ НА КАДРОВУ БЕЗПЕКУ БАНКІВ

Анотація. Проведене теоретико-аналітичне дослідження, яке передбачало ознайомлення з доробком вітчизняних і закордонних науковців стосовно забезпечення кадрової безпеки банків та здійснення оцінки кадрової безпеки банківського сектору економіки, дало змогу розробити орієнтовані графічні моделі та відповідні їм матриці досяжності, які відображають зв'язки між загрозами, і послугували основою для ієрархічного впорядкування ключових загроз для кадрової безпеки банків. Ієрархічне впорядкування загроз кадровій безпеці банківського сектору економіки здійснено на основі застосування методу теорії графів. Розроблені моделі дають уявлення про необхідність реалізації захисних заходів щодо ключових загроз, що важливо з погляду обмеженості ресурсів та досягнення максимальної ефективності дій суб'єктів безпеки. Отриманий результат є усередненим для більшості вітчизняних банків, адже кожен із них перебуває під впливом зовнішнього середовища та змін, які спричинені внутрішніми процесами. Побудовано механізм протидії впливу зовнішнім і внутрішнім загрозам кадровій безпеці банків, який ураховує сучасні тенденції розвитку банківської сфери. Застосування системного аналізу і теорії графів дало змогу ієрархічно впорядкувати вплив ключових загроз на кадрову безпеку, що стало підґрунтям для розроблення моделі, яка у графічному форматі визначає пріоритетність розроблення та реалізації захисних заходів стосовно кожної загрози та обґрунтовує можливість застосування одного з варіантів програми захисту: адаптаційного, пасивного захисту та активного захисту. За результатами проведеного теоретико-аналітичного дослідження визначено та ідентифіковано низку ключових зовнішніх і внутрішніх загроз для кадрової безпеки банків. Шляхом застосування теорії графів і математичного моделювання ієрархічно впорядковано та визначено вагомість впливу загроз на кадрову безпеку банків, що в подальшому дало змогу створити захисний механізм для протидії їм.

Ключові слова: кадрова безпека банку, банківська система, загроза, безпека, кризовий стан, механізм.

Формул: 16; рис.: 3; табл.: 19; бібл.: 16.

Introduction. There is a need to generate new knowledge to more effectively meet the new challenges to humanity, ensure national security, in particular economic, which is more related to the development of the banking system in the context of increased competition in the world markets. Banking institutions play the role of the vanguard of the domestic economy, which is able to stabilize and move the national economy to a new level of development by generating demand for new knowledge. Ukraine has the necessary potential for the development of the banking system, but insufficient attention to the secure aspect of their financial activities, particularlly in providing personnel security, not only complicates the functioning, but also creates the preconditions for the loss of the most valuable — labor resources. Effective activity of banks requires the use of an effective mechanism for ensuring personnel security, especially in the field of protecting the interests of employees and aligning them with the priorities of the development of the banking sector.

Analysis of the research and statement of the problem. The development of issues of personnel security as a component of economic security of the enterprise and banks has received a lot of attention from Ukrainian and foreign scientists, in particular: L. Abalkin, I. Bin'ko, N. Vavdiuk, Z. Varnaliy, O. Vlasyuk, V. Vorotin, T. Vasyltsev, V. Geyets, Z. Gerasymchuk, L. Gnylytska, N. Grebenyuk, M. Yermoshenko, Y. Zhalilo, Z. Zhivko, O. Zakharov, N. Zachosova, A. Kovalevskaya, G. Kozachenko, R. Kvasnitskaya, O. Liashenko, I. Migus, T. Momot, V. Muntiyan, E. Oleynikov, I. Ottenko, G. Pasternak-Taranushenko, V. Ponomarenko, N. Reverchuk, S. Rodchenko, I. Chumarin, V. Furman, M. Shvets, L. Shemaeva, S. Shkarlet, V. Shlemko and others. The research resulted in the development of criteria and indicators for assessing the level of personnel security, identifying individual elements and managing it as a key component of the bank's economic security. However, a number of issues, including those related to countering human security threats, remain poorly understood and need attention.

Research objective is to create a mechanism to counteract external and internal threats to the personnel security of banks (BPS).

Outline of the main research material. Based on the results of the analytical study, which included acquaintance with the work of domestic and foreign scientists on ensuring the financial security of the banking sector and assessing the personnel security of banks, in particular, many key threats to the personnel security of banks were collected. The most significant threats to the personnel security of banks include:

- political and social instability in the country;
- adverse situation in the national economy;
- unsatisfactory level of functioning of social infrastructure institutions (education, health care, housing, public transport, communication, culture, consumer services);
- ineffective use of recruitment and recruitment tools, vocational training;
- insufficient staff qualification;
- inefficient functioning of the system of motivation of workers to productive work;
- the possibility of abuse of office by the administrative staff of the bank;
- likelihood of theft of property and bank fraud.

Listed threats to the PS have to be describesby a set of variables. Then the process of threats can be considered as a function:

$$Z_{.} = f(a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8). \quad (1)$$

To simplify further analysis, we will transfer the identified threats to *Table 1* and mark them with the appropriate lettering.

Table 1

BPS threats

Marks	Threat
a_1	political and social instability in the country
a_2	unfavorable situation in the national economy (state fiscal policy, consumer demand in the domestic market, competitiveness of domestic products in foreign markets, competition from foreign producers)
a_3	poor functioning of social infrastructure institutions
a_4	ineffective use of recruitment and recruitment tools, vocational training
a_5	lack of staff qualifications
a_6	inefficient functioning of the system of motivation of workers to productive work
a_7	the possibility of abuse of office by the administrative staff of the bank
a_8	the risk of theft and fraud in a bank

Source: compiled by the author.

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

Specified threats refer to the linguistic variables that are used in solving economic problems, in particular, which relate to forecasting the state of the national economy and particular sectors of economy [1—6]. Valid values of linguistic variables form a term set, or a fuzzy set subject to a certain limitation [7; 8]. Linguistic uncertainties are set through linguistic models based on the theory of linguistic variables [9].

In the process of solving this problem, a method [10] was applied, which takes into account not only the number of dependencies between constraints, but also distinguishes their types by giving different expert weight to each of them, and has already been applied to solve economic problems [5; 11].

By examining experts, we find out the mutual effects of the PS threats. Mutual influences are determined by filling the *Table 2*, where «1» indicates the presence of influence of one threat on another, and «0» means its absence.

Table 2

Matrix of mutual influence of threatsof PS

	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8
a_1	0	1	0	0	0	0	0	0
a_2	0	0	1	1	0	1	0	0
a_3	0	0	0	0	1	0	0	0
a_4	0	0	0	0	1	0	1	0
a_5	0	0	0	0	0	0	0	0
a_6	0	0	0	0	1	0	1	1
a_7	0	0	0	0	0	0	0	0
a_8	0	0	0	0	0	0	0	0

Source: calculated by the authors.

The resulting matrix makes it possible to construct an orientation graph (*Fig. 1*), at the vertices of which there are elements of a subset of the BPS threats, directly connecting adjacent pairs of vertices for which a relation is defined. The direction of the arrow indicates that one threat is dependent on another.

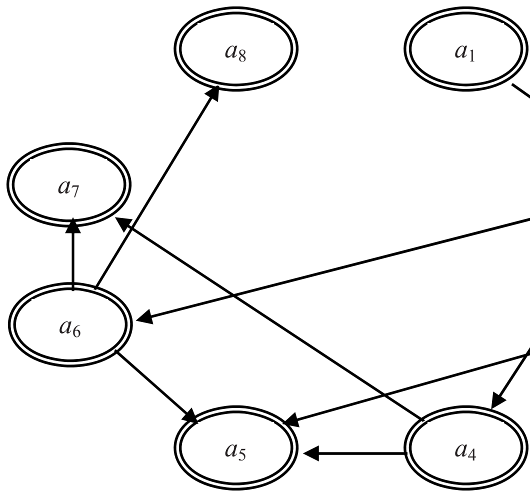


Fig. 1. **Graph of the relationship between the threats to the bank's personnel security**

Source: developed by the author.

Based on the graph (see *Fig. 1*), for each of the threats, we construct hierarchical trees of their relation to other threats of the BPS (*Fig. 2*), taking into account the effects of both types: direct and indirect (i.e., those that pass through another threat).

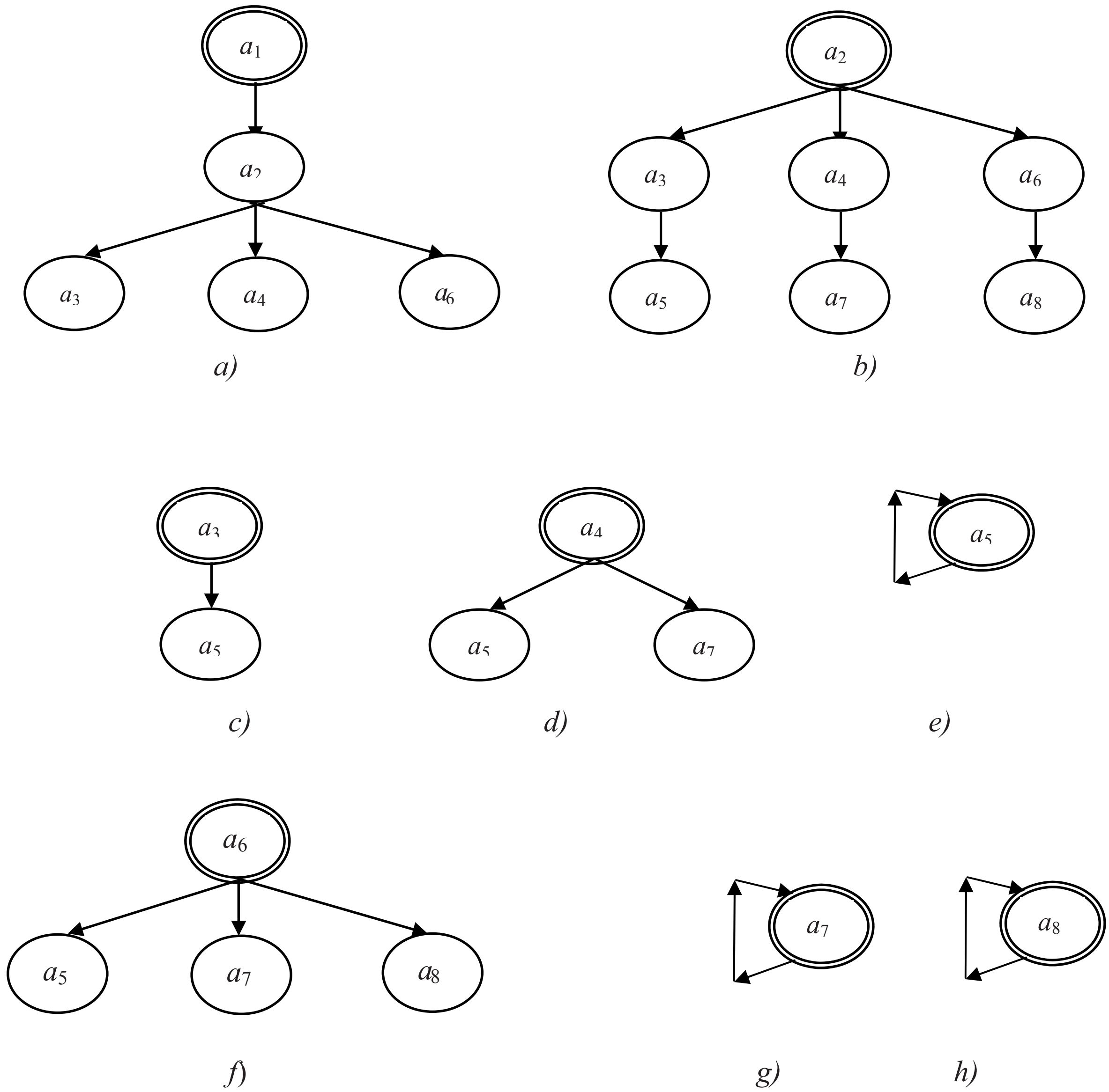


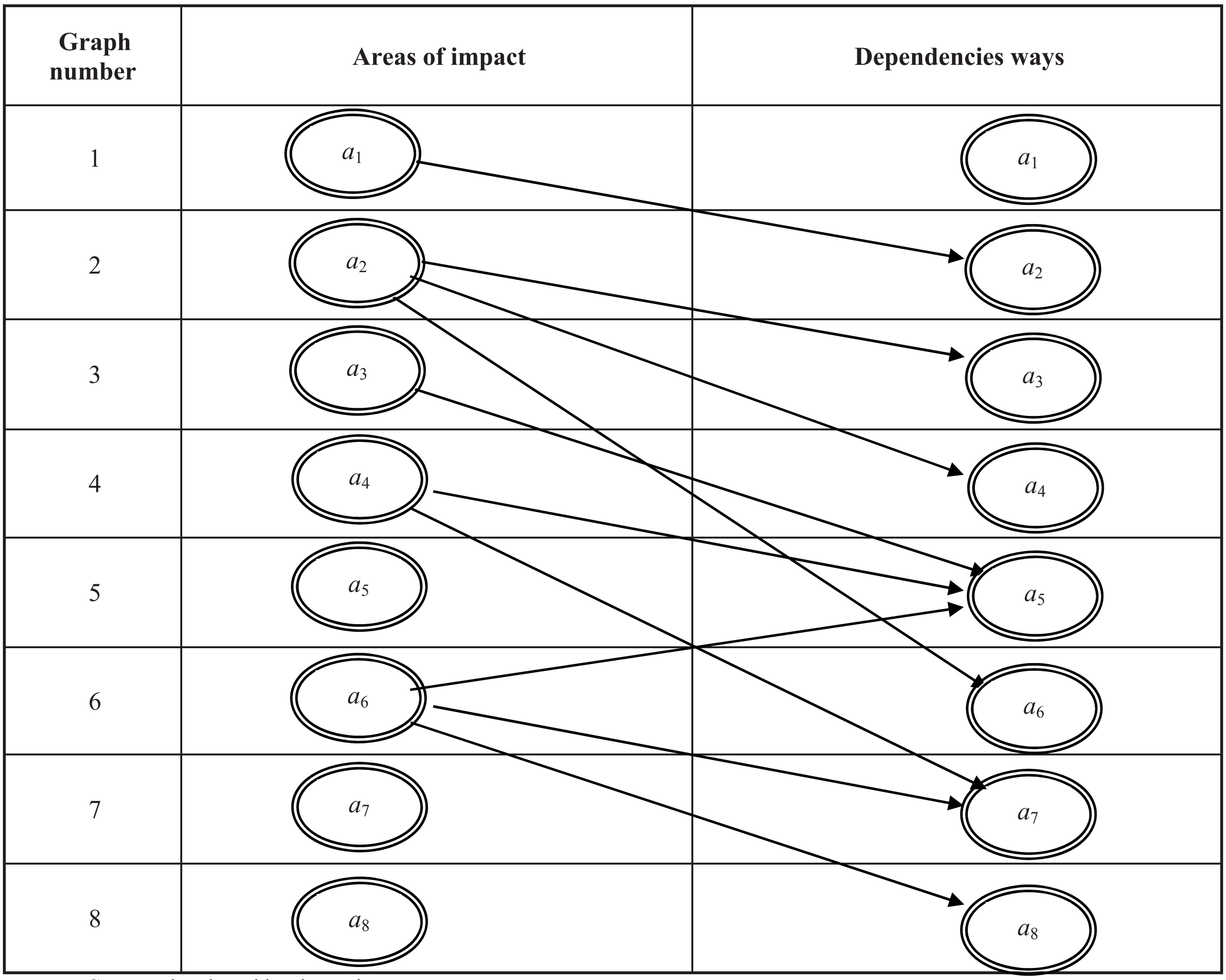
Fig. 2. **Graphs of multilevelhierarchical relationshipsbetween BPS threats**
Source: developed by the authors.

Using the graphs shown in *Fig. 2*, the scheme of interconnections between the threats of the BPS is built, thus forming a *Table 3*, which, in addition to the number of the graph, shows the directions of direct influence of each of the threats and ways of their dependence on the others.

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

Table 3

Scheme of the relation between BPS threats



Source: developed by the authors.

After receiving the data (see *Fig. 2* and *Table 3*), the total weight values of direct and indirect effects of threats and their integral dependence on other threats will be calculated. To do this, we introduce the following notation.

Though k_{ij} — numberofimpacts (i = 1 — direct, i = 2 — indirect) or dependencies (i = 3 — direct, i = 4 — indirect) for j-th threat (j = 1,…, n); w_i — weight i-th type. For calculations, the following conditional values for the weights in terms of units are assumed:

$w_1 = 10$, $w_2 = 5$, $w_3 = –10$, $w_3 = –5$.

Total weight values are to be marked through S_{ij}.

The following formula is received:

$$S_{ij} = k_{ij} w_i (i = 1, 2, 3, 4; j = 1,\dots, n), \tag{2}$$

where n — threat number.

For the specific graph shown in *Fig. 2*, given the expression (2) we have:

$$S_{ij} = \sum_{i+1}^{4} k_{ij} w_i, (j = \overline{1,8}). \tag{3}$$

Note that in the absence of one threat to one of the connection types, the corresponding k_{ij} value in expression (3) will be zero.

The above formula is a basis for obtaining weighted ranking of threats, taking into account the different types of relationships between them. Insert the obtained results in *Table 4*.

Table 4

BPS Threat Ranking Results

Threat a_j	k_{1j}	k_{2j}	k_{3j}	k_{4j}	S_{1j}	S_{2j}	S_{3j}	S_{4j}	S_{Fj}
a_1	1	3	0	0	10	15	0	0	60
a_2	3	3	1	0	30	15	–10	0	70
a_3	1	0	1	1	10	0	–10	–5	30
a_4	2	0	1	1	20	0	–10	–5	40
a_5	0	0	3	1	0	0	–30	–5	0
a_6	3	0	1	1	30	0	–10	–5	45
a_7	0	0	2	1	0	0	–20	–5	10
a_8	0	0	1	1	0	0	–10	–5	20

Source: calculated by the authors.

Table 4 is constructed using the data of *Fig. 2* and *Table 3*. In the column «Directions of influence» *Table 3*, for each of the threats, we select direct effects, the number of which is fixed by the coefficients k_{1j}. Column «Paths of dependence» *Table 3* provides k_{3j} coefficients. Due to the dependence of some threats on others (see *Table 3*), we obtain the value of k_{2j}, and indirect effects (influence or through other threats) from *Fig. 2* is the value of k_{4j}.

It should be noted that $S_{3j} < 0$ and $S_{4j} < 0$, since under the given initial conditions $w_3 < 0$ and $w_4 < 0$. Therefore, to bring the total weight values of the threats to the origin, so positive values, we transform the formula (3) as follows :

$$S_{ij} = \sum_{i+1}^{4} k_{ij} w_i + \max\left|S_{3j}\right| + \max\left|S_{4j}\right|, (j = \overline{1,8}). \tag{4}$$

Summarizing these data, the *Table 4* for establishing threat rankings will be obtained.

As can be seen from the *Table 4*, $\max|S_{3j}| = 30$, $\max|S_{4j}| = 5$. The indicated values according to (4) are added in each row to the sum of the values in columns S_{1j}, S_{2j}, S_{3j} і S_{4j}. Finally, (4) we obtain the resulting threat weight, which is the basis for establishing the level of priority of the BPS threats:

$$S_{F1} = [10 + 15 + 0 + 0] + [30 + 5] = 60;$$

$$S_{F2} = [30 + 15 - 10 + 0] + [30 + 5] = 70;$$

$$S_{F3} = [10 + 0 - 10 - 5] + [30 + 5] = 30;$$

$$S_{F4} = [20 + 0 - 10 - 5] + [30 + 5] = 40;$$

$$S_{F5} = [0 + 0 - 30 - 5] + [30 + 5] = 0;$$

$$S_{F6} = [30 + 0 - 10 - 5] + [30 + 5] = 45;$$

$$S_{F7} = [0 + 0 - 20 - 5] + [30 + 5] = 10;$$

$$S_{F8} = [0 + 0 - 10 - 5] + [30 + 5] = 20.$$

By defining the severity of S_{Fj} threats (see *Table 4*), hierarchy of priority for the impact of the isolated BPS threats is built.

Thus, as a result of applying the selected ranking method [12, p. 33—41] a model of prioritization of the impact of isolated BPSthreats was synthesized (*Fig. 3*), which can be used to calculate alternative options for overcoming them.

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

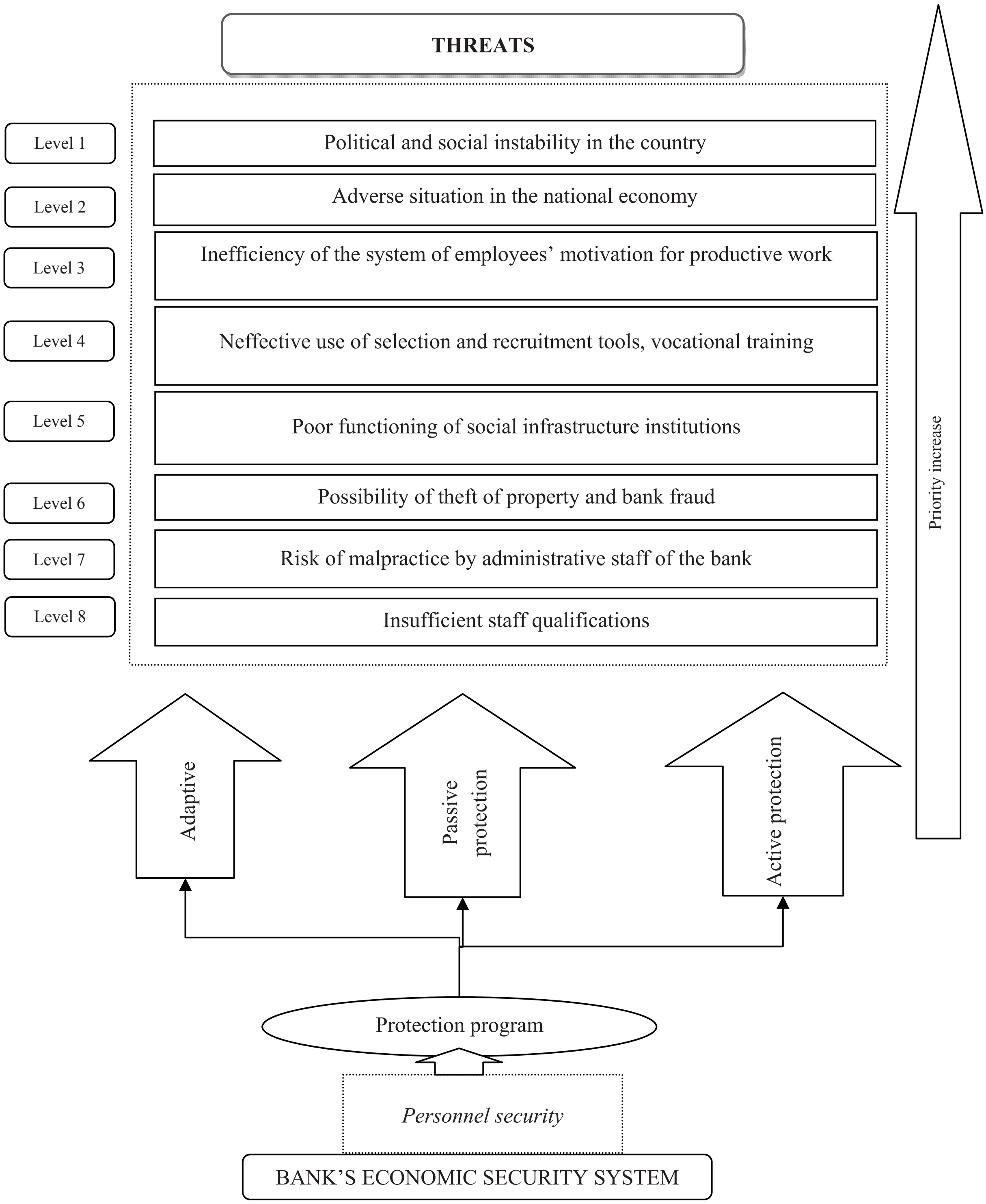


Fig. 3. **The model for prioritizing the impact of isolated BPS threats**
Source: compiled by the authors.

Countering the negative impact of threats involves the implementation of a certain protection program, which in terms of bank personnel security may have the following options:

- adaptive, that is, focused on adapting to the effects of threats;
- passive protection — the implementation of passive protective measures aimed at minimizing the losses from the negative impact of threats (reactive measures), which presuppose the preservation of the workforce with minor organizational measures, maintaining the discipline, etc.;
- active protection — implementation of active actions aimed at counteracting the emergence, development and impact of threats by introducing changes in the organizational

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

structure of the bank (personnel restructuring), improving resource and social security, implementing training and retraining programs, restructuring of the PS subsystem, lobbying interests local and state authorities, etc.

Each program should contain a set of operational, tactical and strategic management decisions aimed at achieving priority interests in the field of security of BPS.

We believe that in the next phase, it is advisable to solve a task that should involve choosing the best option for counteracting BPS threats.

In the process of solving this problem, the methods [2; 3; 13], which were already used in solving similar problems [4; 14].

To solve our problem, we need to specify a set of valid security program options that are used in the BPS guarantee process, from which the choice x_i, (i = 1, n = 3) (*Table 5*).

Table 5

Options for a security program in the process of BPS guaranteeing

Anti-crisis solution options	x_i
Adaptive	x_1
Passive protection	x_2
Active protection	x_3

Source: compiled by the authors.

The following criteria were determined by which the most appropriate protection program захисту x_i, – g_j (j = 1, m = 4)would be selected (*Table 6*).

Table 6

Criteria for selecting options for a security program during the BPS guarantee process

Criteria for selecting options	g_j
Resources for the implementation of the security program	g_1
Time taken to develop and implement an appropriate security program	g_2
Performance of similar programs in the past	g_3
Willingness to change	g_4

Source: compiled by the authors.

For certain security options, the following preference ratios are set for many alternatives:

$$g_1: x_2 \succ x_1, x_2 \approx x_3, x_3 \succ x_1; \quad (5)$$

$$g_2: x_1 \succ x_2, x_2 \approx x_3, x_1 \succ x_3; \quad (6)$$

$$g_3: x_1 \approx x_2, x_3 \succ x_2, x_3 \succ x_1; \quad (7)$$

$$g_4: x_2 \succ x_1, x_2 \approx x_3, x_3 \succ x_1. \quad (8)$$

It is necessary to find the best protection program for a set of defined criteria. We are faced with the problem of rational choice of a variant of a set X, on which some fuzzy relation of the preference g_1, g_2,... g_m with the membership functions is given: $\mu_{gj}: X \times X \to [0, 1]$.

To determine ω_i — the weight of the i-th criterion, a matrix of paired comparisons was formed on the basis of expert surveys (*Table 8*) using a special scale of relative importance of objects (*Table 7*).

Table 7

The scale of the relative importance of the criteria by which options are selected for the security program during the BPS guarantee process

Importance assessment	**Explanation of choice**
1	g_1 and g_2 criteris are equivalent
3	g_1 criterion slightly override the criterion g_2
5	g_1 criterion override criterion g_2
7	g_1 criterion significantly override criterion g_2
9	g_1 criterion absolutely override criterion g_2
2, 4, 6, 8	intermediate values

Source: formed based on [15; 16].

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

Table 8

Matrix of paired comparisons of the criteria by which the protection program options are selected during the BPS guarantee process

g_j, g_m	g_1	g_2	g_3	g_4
g_1	1	3	5	7
g_2	1/3	1	3	5
g_3	1/5	1/3	1	3
g_4	1/7	1/5	1/3	1

Source: developed by the authors.

For the two criteria that are compared, depending on the degree of their impact on the process of choosing options for the security program in the process of guaranteeing the BPS, we will have an assessment of the importance, which is the corresponding element of the matrix of pairwise comparisons in position (g_j, g_m). The set of importance assessments, as a result of comparison of criteria, will be placed in a matrix, designed as a table (see *Table 8*). According to the chosen method of determining the importance of the criteria [8], the diagonal elements of the matrix are equal to one, and the lower part of the matrix (see *Table 8*) is filled with inverted values.

To establish a measure of consistency of numerical values of pairwise comparisons of the criteria by which the choice given in the *Table 8* matrix, calculate the priority vector of the matrix E_n (*Table 9*), the eigenvalue of the matrix λ_{max}, the *IU* consistency index and the consistency ratio *WU* (*Table 10*).

Table 9

Sums of elements of columns of the matrix of pairwise comparisons of criteria by which the choices of the security program in the process of BPS provision are made

g_j	g_1	g_2	g_3	g_4
E_n	0,055	0,117	0,263	0,563

Source: calculated by the authors.

Table 10

Determination of the level of inconsistency of the matrix of paired comparisons, which is presented in the form of *Table 8*

Indicator	**Actually the matrix, λ_{max}**	**Consistency Index, *IU***	**Consistency ratio, *WU***
Calculation results	7,195	0,032	0,025

Source: calculated by the authors.

The results of paired comparisons (see *Table 8*) can be considered satisfactory, since $WU \leq 0{,}1$. Therefore, we have a sufficient degree of convergence of the process and a proper consistency of expert judgment regarding the weighted values of the criteria by which to choose among the options for the protection program in the process of guaranteeing the BPS.

The weight of the criteria by which the choice of protection program in the process of BPS guaranteeing is made for:

- resource support for the implementation of the selected security program $\omega_1 = 0{,}055$;
- the time allotted for the development and implementation of an appropriate security program, $\omega_2 = 0{,}117$;
- performance of similar programs in the past $\omega_3 = 0{,}263$;
- readiness for change $\omega_4 = 0{,}563$, $\sum_{j=1}^{n} \omega_j = 1$.

To solve the formulated problem of multicriteria selection, an appropriate method of convolution of a vector criterion into a scalar one was chosen [13].

The first method of convolution $Q_1 = \bigcap_{j=1}^{m} g_j$ is the intersection of given preference ratios.

The second way is to minimize the initial relations g_j as a sum

The best alternative for both convolutions should be found.

The problem is solved as follows.

We construct the function of the membership of the given preference relations μ_{gj} (x_i, x_n) (*Table 11—14*). There are four alternatives to each of the $g_j$criteria. The results were assessed as follows:

$$\mu_{g_j}(x_i, x_n) = \begin{cases} 1, \text{ if } x_i \succ x_n \text{ or } x_i \approx x_n \\ 0, \text{ if } x_i \prec x_n \end{cases}. \quad (9)$$

Table 11

The relationship matrix for the resource implementation of the selected security program

	x_i/x_n	x_1	x_2	x_3
$\mu g_1(x_i, x_n) =$	x_1	1	0	0
	x_2	1	1	1
	x_3	1	0	1

Source: calculated by the authors.

Table 12

The relation matrix for the time allotted for development and implementation of an appropriate security program

	x_i/x_n	x_1	x_2	x_3
$\mu g_2(x_i, x_n) =$	x_1	1	1	1
	x_2	0	1	1
	x_3	0	0	1

Source: calculated by the authors.

Table 13

Relationship matrix for implementation performance similar programs in the past

	x_i/x_n	x_1	x_2	x_3
$\mu g_3(x_i, x_n) =$	x_1	1	1	0
	x_2	0	1	0
	x_3	1	1	1

Source: calculated by the authors.

Table 14

Relationship matrix for readiness for change

	x_i/x_n	x_1	x_2	x_3
$\mu g_4(x_i, x_n) =$	x_1	1	0	0
	x_2	1	1	1
	x_3	1	0	1

Source: calculated by the authors.

Data are presented as $\mu g_1(x_i, x_n)$, $\mu g_2(x_i, x_n)$, $\mu g_3(x_i, x_n)$, $\mu g_4(x_i, x_n)$matricesthat meet the criteriag_j.

The convolution of relations g_1, g_2, g_3, g_4 in the form of the intersection $Q_1 = g_1 \cap g_2 \cap g_3 \cap g_4$ with the membership function should be built (*Table 15*):

$$\mu_{Q1}(x_i, x_n) = \min\{\mu g_1(x_i, x_n), \mu g_2(x_i, x_n), \mu g_3(x_i, x_n), \mu g_4(x_i, x_n)\}. \quad (10)$$

Table 15

$\mu_{Q1}(x_i, x_n)$ matrix of minimum elements x_i, x_n among abtained matices $\mu_{gj}(x_i, x_n)$

	x_i/x_n	x_1	x_2	x_3
$\mu_{Q1}(x_i, x_n) =$	x_1	1	0	0
	x_2	0	1	0
	x_3	0	0	1

Source: calculated by the authors.

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

Let's determine the ratio of strict preference for the first convolution, construct the membership function (*Table 16*):

$$\mu^{s}_{Q_1}(x_i, x_n) = \max\{0; \mu_{Q_1}(x_i, x_n) - \mu_{Q_1}(x_n, x_i)\}. \quad (11)$$

Table 16

Matrix $\mu^{s}_{Q1}(x_i, x_n)$

$\mu^{s}_{Q1}(x_i, x_n)$	x_1	x_2	x_3
x_1	0	0	0
x_2	0	0	0
x_3	0	0	0
$\mu^{нд}_{Q1}(X)$	1	1	1

Source: calculated by the authors.

Define the set of non-dominant alternatives $Q_1^{нд}$ in the set (X, Q_1), and construct the membership function (see *Table 16*):

$$\mu^{нд}_{Q1}(X) = 1 - \max \mu^{s}_{Q1}(x_n, x_i). \quad (12)$$

Therefore, it cann be seen from the *Table 16* the following $\mu^{нд}_{Q1}(X) = [1;\ 1;\ 1]$.

Using the criteria convolution as a sum $Q_2 = \sum_{j=1}^{m} \omega_j g_j$, a fuzzy relation of the advantage of Q_2 with the membership function is built (*Table 17*):

$$\mu_{Q2}(x_i, x_n) = \sum_{j=1}^{n} \omega_j \mu_{gj}(x_i, x_n). \quad (13)$$

Table 17

Matrix $\mu_{Q2}(x_i, x_n)$

$\mu_{Q2}(x_i, x_n)$	x_1	x_2	x_3
x_1	1	0,380	0,117
x_2	0,618	1	0,735
x_3	0,881	0,263	1

Source: calculated by the authors.

The ratio of strict preference for the second Q_2^{s} convolution is to be defined and the membership function constructed (*Table 18*):

$$\mu^{s}_{Q2}(x_i, x_n) = \max\{0; \mu_{Q2}(x_i, x_n) - \mu_{Q2}(x_n, x_i)\}. \quad (14)$$

Table 18

Matrix $\mu^{s}_{Q_2}(x_i, x_n)$

$\mu^{s}_{Q_2}(x_i, x_n)$	x_1	x_2	x_3
x_1	0	0	0
x_2	0,238	0	0,472
x_3	0,764	0	0

Source: calculated by the authors.

The non-dominant alternatives by the second $Q_2^{нд}$ convolution is to be defined and the membership function constructed:

$$\mu^{нд}_{Q_2}(X) = 1 - \max \mu^{s}_{Q2}(x_n, x_i). \quad (15)$$

Therefore, there is a fuzzy subset of non-dominant alternatives to the relation Q_2:

$$\mu^{нд}_{Q_2}(X) = [0{,}236;\ 1; 0{,}528].$$

The common set of non-dominant alternatives for both convolutions (*Table 19*) is to be found $Q^{нд}(X) = Q_1^{нд}(X) \bigcap Q_2^{нд}(X)$ with membership function

$$\mu_{Q^{нд}}(X) = \min\{\mu_{Q_1^{нд}}(X); \mu_{Q_2^{нд}}(X)\}. \quad (16)$$

Table 19

Identifying a non-dominant alternative by both convolutions

	x_1	x_2	x_3
$\mu_{Q1}^{нд}(X)$	1	1	1
$\mu_{Q_2}^{нд}(X)$	0,236	1	0,528
$\mu_{Q^{нд}}(X)$	0,236	1	0,528

Source: calculated by the authors.

A non-dominant alternative for both convolutions is identified:

$$\mu_{Q_2}^{нд}(X) = [0{,}236;\ 1; 0{,}528].$$

The best alternative is to consider the alternative x_i, for which the degree of immunity in both convolutions is maximum $\mu_Q^{нд}(Xi) = \max\mu_Q^{нд}$`. It is found that x_2 is the implementation of the passive protection program. The degree of non-dominance of this alternative is equal to one, that is, it is a clearly non-dominant alternative. A high degree of malnutrition also has an alternative to x_3 — the use of an active protection program.

Conclusions. Theoretical and analytical research has led to the development of oriented graphical models and appropriate access matrices that reflect the link between threats and served as a basis for hierarchical ordering of key threats to the bank's personnel security.

Література

1. Ареф'єва О. В., Сеньківський В. М., Штангрет А. М., Мельников О. В. Побудова моделей ключових загроз на шляху до економіки знань в Україні. *Наукові записки*. 2011. № 2 (35). С. 52—68.
2. Штангрет А. М., Мельников О. В. Загрози на шляху України до економіки знань: стан та ключові проблеми освіти. *Формування ринкових відносин*. 2011. № 3. С. 24—31.
3. Штангрет А. М. Моделювання загроз для економічної безпеки підприємств авіаційної галузі. *Ефективна економіка*. 2011. № 5. URL : http://www.economy.nayka.com.ua/?op=&z=562.
4. Живко З. Б. Методологія управління економічною безпекою підприємства. Львів : Ліга-Прес, 2013. 472 с.
5. Барилюк М.-М. Р. Організаційно-економічний механізм забезпечення фінансової безпеки комерційного банку : автореф. дис. на здобуття наук. ступеня канд. екон. наук : спец. 08.00.08. Київ, 2018. 22 с.
6. Леонова Г. Г., Озаріна О. В. Досвід моделювання економічної безпеки зарубіжних підприємств. URL : http://nauka.krushir.mk.ua/?p=1032.
7. Лямец В. И., Тевяшев А. Д. Системный анализ. 2-е изд., перероб. и доп. Харьков : ХНУРЕ, 2004. 448 с.
8. Саати Т. Принятие решений. Метод анализа иерархий : пер. с англ. Москва : Радио и связь, 1993. 278 с.
9. Заде Л. А. Понятие лингвистической переменной и его применение к принятию приближенных решений : пер. с англ. Москва : Мир, 1976. 165 с.
10. Сенейко Ю. Сучасні підходи до трактування категорії «ризик». *Регіональна економіка*. 2006. № 1. С. 206—211.
11. Корж М. А. Інституційні обмеження прямого іноземного інвестування та напрями їх подолання. *Наукові праці НДФІ*. 2014. № 3 (68). С. 77—88.
12. Сеньківський В. М., Піх І. В., Мельников О. В. Метод ранжування факторів впливу на якість технологічних процесів. *Поліграфія і видавнича справа*. 2013. № 1—2 (60—61). С. 33—41.
13. Зайченко Ю. П. Дослідження операцій : підручник. 7-ме вид., перероб. та доповн. Київ : Слово, 2006. 816 с.
14. Караїм М. М., Мельников О. В. Багатофакторний вибір альтернативних варіантів оптимального антикризового рішення в процесі гарантування економічної безпеки підприємства на основі нечіткого відношення переваги. *Науковий вісник Національного лісотехнічного університету України*. 2013. Вип. 23.3. С. 355—362.
15. Методика ідентифікації українських високотехнологічних промислових підприємств : затверджено наказом Міністерства промислової політики України від 08.02.2008 № 80. URL : http: //zakon/rada.gov.ua/rada/term/v0080581-08.
16. Грунин О. А., Грунин С. О. Экономическая безопасность организации. Санкт-Петербург : Питер, 2002. 160 с.

Статтю рекомендовано до друку 19.05.2021

ISSN 2306-4994 (print); ISSN 2310-8770 (online)

References

1. Arefieva, O. V., Senkivskyi, V. M., Shtanhret, A. M., & Melnykov, O. V. (2011). Pobudova modelei kliuchovykh zahroz na shliakhu do ekonomiky znan v Ukraini [Building models of key threats to the knowledge economy in Ukraine]. *Naukovi zapysky — Proceedings, 2* (35), 52—68 [in Ukrainian].
2. Shtanhret, A. M., & Melnykov, O. V. (2011). Zahrozy na shliakhu Ukrainy do ekonomiky znan: stan ta kliuchovi problemy osvity [Threats on the way of Ukraine to the knowledge economy: the state and key problems of education]. *Formuvannia rynkovykh vidnosyn — Formation of market relations, 3,* 24—31 [in Ukrainian].
3. Shtanhret, A. M. (2011). Modeliuvannia zahroz dlia ekonomichnoi bezpeky pidpryiemstv aviatsiinoi haluzi [Modeling of threats to the economic security of aviation enterprises]. *Efektyvna ekonomika — Efficient economy, 5.* Retrieved from http://www.economy.nayka.com.ua/?op=&z=562 [in Ukrainian].
4. Zhyvko, Z. B. (2013). *Metodolohiia upravlinnia ekonomichnoiu bezpekoiu pidpryiemstva [Methodology of economic security management of the enterprise]*. Lviv: Liha-Pres [in Ukrainian].
5. Baryliuk, M.-M. R. (2018). Orhanizatsiino-ekonomichnyi mekhanizm zabezpechennia finansovoi bezpeky komertsiinoho banku [Organizational and economic mechanism of financial security of a commercial bank]. *Extended abstract of candidate's thesis*. Kyiv [in Ukrainian].
6. Leonova, H. H., & Ozarina, O. V. (n. d.). *Dosvid modeliuvannia ekonomichnoi bezpeky zarubizhnykh pidpryiemstv [Experience in modeling the economic security of foreign enterprises]*. Retrieved from http://nauka.krushir.mk.ua/?p=1032 [in Ukrainian].
7. Lyamec, V. I., & Tevyashev, A. D. (2004). *Sistemnyj analiz [System analysis]*. Kharkiv: HNURE [in Russian].
8. Saati, T. (1993). *Prinyatie reshenij. Metod analiza ierarhij [Decision-making. Method of analysis of hierarchies]*. Moscow: Radio i svyaz' [in Russian].
9. Zade, L. A. (1976). *Ponyatie lingvisticheskoj peremennoj i ego primenenie k prinyatiyu priblizhennyh reshenij [The concept of a linguistic variable and its application to the adoption of approximate decisions]*. Moscow: Mir [in Russian].
10. Seneiko, Yu. (2006). Suchasni pidkhody do traktuvannia katehorii «ryzyk» [Modern approaches to the interpretation of the category «risk»]. *Rehionalna ekonomika — Regional economy, 1,* 206—211 [in Ukrainian].
11. Korzh, M. A. (2014). Instytutsiini obmezhennia priamoho inozemnoho investuvannia ta napriamy yikh podolannia [Institutional constraints on foreign direct investment and ways to overcome them]. *Naukovi pratsi NDFI — RFI scientific papers, 3* (68), 77—88 [in Ukrainian].
12. Senkivskyi, V. M., Pikh I. V., & Melnykov, O. V. (2013). Metod ranzhuvannia faktoriv vplyvu na yakist tekhnolohichnykh protsesiv [Method of ranking factors influencing the quality of technological processes]. *Polihrafiia i vydavnycha sprava — Printing and publishing, 1—2* (60—61), 33—41 [in Ukrainian].
13. Zaichenko, Yu. P. (2006). *Doslidzhennia operatsii [Research operations]*. Kyiv: Slovo [in Ukrainian].
14. Karaim, M. M., & Melnykov, O. V. (2013). Bahatofaktornyi vybir alternatyvnykh variantiv optymalnoho antykryzovoho rishennia v protsesi harantuvannia ekonomichnoi bezpeky pidpryiemstva na osnovi nechitkoho vidnoshennia perevahy [Multifactorial choice of alternatives for optimal anti-crisis solution in the process of guaranteeing the economic security of the enterprise on the basis of a fuzzy advantage ratio]. *Naukovyi visnyk Natsionalnoho lisotekhnichnoho universytetu Ukrainy — Scientific Bulletin of the National Forestry University of Ukraine, Vol. 23.3,* 355—362 [in Ukrainian].
15. Ministerstvo promyslovoi polityky Ukrainy. (2008). *Metodyka identyfikatsii ukrainskykh vysokotekhnolohichnykh promyslovykh pidpryiemstv: nakaz vid 08.02.2008 № 80 [Methods of identification of Ukrainian high-tech industrial enterprises: order dated 08.02.2008 № 80]*. Retrieved from http://zakon/rada.gov.ua/rada/term/v0080581-08 [in Ukrainian].
16. Grunin, O. A., & Grunin, S. O. (2002). *Ekonomicheskaya bezopasnost' organizacii [Economic security of the organization]*. Saint Petersburg: Piter [in Russian].

The article is recommended for printing 19.05.2021