Breus S. V.,
Ph. D (Economics), Associate Professor, Associate Professor of the Department of Business Economics
Khaustova Ye. B.,
Ph. D (Economics), Associate Professor, Associate Professor of the Accounting and Audit Department
Denysenko M. P.
Doctor of Economic Sciences, Professor, Professor of the Department of Business Economics
Kyiv National University of Technologies and Design (Ukraine, Kyiv)

ESTIMATION OF ECONOMIC SECURITY OF INSTITUTIONS OF HIGHER EDUCATION USING CLUSTER AND FACTOR ANALYSIS

Under current conditions, institutions of higher education (IHE) play an important role in ensuring the economic growth of the state, training highly skilled professionals that may be in demand both in the national and international labour markets. Taking into account the objective features, IHE functioning is an important element of the socio-economic system and economic entities. The main purpose is to meet the consumers' needs, which in the context of the higher education development efficiency needs to reconcile the economy needs, labour market requirements and employers to support those universities that train specialists to be used in industries that are in the 6^{th} and 7^{th} technological processes.

Amid an intensifying competition between all national IHEs and comparatively difficult conditions of institutions of higher education (compared with other Ukrainian universities), displaced from temporarily occupied territories [1], the latter have not only a decrease in places in the TOP-200 Ukraine rating, but also a decrease the values of the integral indicator in it in 2013 and 2016. According to this rating in 2013 and 2016, Table 1 was formed, in which 2013 is the period before the occupation, 2016 is the last year listed in the rating TOP-200 Ukraine. The year 2017 takes into account the year of publication of the actual ranking of universities in 2016. Hereafter, according to Table 1, a cluster analysis of institutions of higher education for 2016 was carried out. In the course of the cluster analysis, the software product Statistica was used. It involves normalization (standard value equals to the difference between the output and the mean

Table 1

Integral indicator and its rating indices in IHE moved from temporarily occupied territories* for 2013 and 2016

Integral indicator		Integral indicator indices					
		Quality of academic staff, Ias		Quality of education, Ie		International recognition, Iir	
2013 [1]	2016 [2]	2013[1]	2016[2]	2013[1]	2016[2]	2013[1]	2016[2]
Donetsk national technical university (DonNTU) – IHE place in the rating according to the data of 2013/2016– (16/25)							
39,0447749	32,08517	9,065461844	10,20566	10,37493685	9,7286763	19,6043762	12,15083
Vasyl' Stus Denetsk national university (Vasyl' Stus DonNU) – IHE place in the rating according to the data of 2013/2016 – (20/27)							
35,63946121	31,605761	7,056879082	9,7369625	10,84511634	9,7299357	17,7374658	12,13886
Volodymyr Dahl East Ukrainian national university (V. Dahl EUNU) IHE place in the rating according to the data of 2013/2016 – (27/41)							
32,82664172	27,704312	6,837252073	8,3195826	7,757488531	7,3278926	18,23190112	12,05684
Luhansk Taras Shevchenko National University (T. Shevchenko LNU) – IHE place in the rating according to the data of 2013/2016 – (25/64)							
33,00438409	23,751508	7,182745316	7,4021796	11,29338327	10,483912	14,5282555	5,865417
Donetsk national university of economics and trade named after Mykhailo Tugan-Baranovsky (DonNUET named after M. Tugan-Baranovsky) – IHE place in the rating according to the data of 2013/2016 – (52/74)							
26,51714588	22,728191	6,438785587	8,0399361	6,265623795	6,6807408	13,8127365	8,007514
Donetsk national medical university (DonNMU) (23/85)							
33,29358019	22,233915	15,25830637	13,112818	5,791133307	4,220912	12,24414051	4,900185
Donetsk state university of management (DSUM) – IHE place in the rating according to the data of 2013/2016 – (64/112)							
25,08490243	20,316815	4,065317952	6,8976174	10,17847085	6,8874561	10,84111363	6,531741
V.I.Vernadsky Taurida National University (V.I.Vernadsky TNU) (26/127)							
32,90150301	18,803581	7,088109637	6,6989468	7,300853175	6,6977635	18,5125402	5,406871
Donbas State Technical University (DonSTU) – IHE place in the rating according to the data of 2013/2016 – (115/137)							
20,24300658	18,219346	7,895774519	7,451875	4,595766723	5,024662	7,751465342	5,742809
Luhansk state medical university (SI LSMU) – IHE place in the rating according to the data of 2013/2016 – (61/154)							
25,20674524	16,773152	9,261819871	7,9050562	5,220128687	4,1891132	10,72479668	4,678983
Luhansk national agrarian university (LNAU) – IHE place in the rating according to the data of 2013/2016 – (118/162)							
20,01176147	16,036244	7,486589159	6,510627	6,733987076	5,7902171	5,791185235	3,7354
Donbas national academy of civil engineering and architecture (DonNACEA) – IHE place in the rating according to the data of 2013/2016 – (151/173)							
16,63849246	14,681291	3,741062392	5,5312438	4,077560166	4,2584225	8,819869897	4,891624

** there are not in the rating TOP-200 Ukraine during 2013-2016 - Lugansk state academy of culture and arts; Lugansk state university of internal affairs named after E.O. Didorenko; Donetsk law institute of the*

ministry of internal affairs of Ukraine; Donetsk regional institute of postgraduate pedagogical education; Gorlovka institute of foreign languages of the state higher Education Institution "Donbas state pedagogical university"; Lugansk regional institute of postgraduate pedagogical education.
1 The rating of universities of Ukraine for the III, IV accreditation levels of Top-200 Ukraine in 2014. [Electronic resource] - Access mode: http://www.euroosvita.net/index.php/?category=49&id=3282
2 Rating of Ukrainian Universities of III, IV Accreditation Levels Top-200 Ukraine in 2015 [Electronic resource] – Access mode: http://www.euroosvita.net/index.php/?category=1&id=4068

to the standard deviation) of the output data (indices of the integral index according to the data of Table 1).

In the process of cluster analysis there has been used the method of hierarchical clustering (the method of the closest neighbour), it is used if the number of clusters is unknown in advance. The closest neighbour method involves looking for the closest values for the phenomenon under study, clusters are gradually expanding to one value. The union rule is the single-link method (there is a gradual union of objects by analyzing the maximum similarity of elements with cluster representatives), the degree of proximity is the Euclidean distance.

The merger scheme itself after completing the procedure for uniting observations in turn is given in Table 2.

Table 2

Scheme for uniting observations into clusters

(single-link method, Euclidean distance)

	Element 1	Element 2	Element 3	Element 4	Element 5	Element 6	Element 7	Element 8	Element 9	Element 10	Element 11	Element 12
0,2298784	C_1	C_2										
0,3789142	C_7	C_8										
0,5497530	C_9	C_10										
0,6731335	C_7	C_8	C_11									
0,7353658	C_5	C_7	C_8	C_11								
0,8404358	C_5	C_7	C_8	C_11	C_9	C_10						
0,9127128	C_5	C_7	C_8	C_11	C_9	C_10	C_12					
1,278808	C_1	C_2	C_3									
1,321696	C_1	C_2	C_3	C_5	C_7	C_8	C_11	C_9	C_10	C_12		
1,639280	C_1	C_2	C_3	C_5	C_7	C_8	C_11	C_9	C_10	C_12	C_4	
2,554855	C_1	C_2	C_3	C_5	C_7	C_8	C_11	C_9	C_10	C_12	C_4	C_6

Herein after, the *k*-medium method is used, it works with the average values of the studied features, for this method the element belongs to the cluster, the distance to which will be minimal (Euclidean distance to the center of gravity of a particular cluster), and

also using this method there is an ability to indicate the required number of clusters.

This method divides data into clusters, calculates the centers of gravity for each of the clusters, moves the observations (points) into the cluster closest to them, and then after the changes the values of the new centers of gravity are calculated. Such a consistent turn-on of points will continue until the stable cluster configuration is found.

The configuration of each cluster and the distance to the center of gravity are given in Table 3.

Table 3

The configuration of each cluster and the distance to the center of gravity

Cluster, distance	Observations						
Cluster 1	C_1 DonNTU	C_2 Vasyl'Stus DonNU	C_3 V. Dahl EUNU	C_4 T. Shevchenko LNU			
Distance	0,479480	0,386527	0,606224	1,004392			
Cluster 2	C_6 DonNMU						
Distance	0,00						
Cluster 3	C_5 DonNUET named after M. Tugan-Baranovsky	C_7 DSUM	C_8 V.I. Vernadsky TNU	C_9 Don STU	C_10 SI LSMU	C_11 LNAU	C_12 Don NACEA
Distance	0,596213	0,366310	0,286135	0,206771	0,482595	0,365469	0,563731

According to the received data, the first cluster includes IHEs that either have relatively retained IHE positions in the rating, or continue to occupy higher positions in comparison with other IHEs displaced from temporarily occupied territories. The second cluster includes IHE, which has the growth of the academic potential index, at the same time the other two are falling; this university has considerably worsened its rating positions. The third cluster includes such IHEs that show a decrease in all indices and they occupy lower ranking positions compared with IHEs in the cluster 1. Institutions of higher education included in the first cluster are included in the calculation of IHE economic security.

Scientific literature does not have holistic scientific achievements in ensuring the economic security of institutions of higher education. Most often, IHE economic security is viewed from the point of view of resource and protective approaches - as a condition of IHE that has sufficient available resources to prevent, weaken or protect against threats from the activities of the IHE" [2]. In accordance with the Law of

Ukraine "On Education", adopted on 05.09.2017, all higher education institutions (HEIs) have become institutions of higher education (IHEs). The interpretation of the concept "economic security of universities" is very important taking into account the role and importance of higher education in order to ensure the state's economic growth, improve the situation in higher education, eliminate the gap between education and science in the future, reconcile the needs of the labour market, the requirements of the economy and employers with the prospect of increasing the competitiveness of IHE and the state as a whole. There has been developed a methodological approach to the estimation of the economic security of institutions of higher educational as important elements of the socio-economic system.

The prospect of further research is to assess the impact of factors on the formation of the rating indicators results according to the clusters with further elaboration of methods of estimating economic security of IHE, temporarily displaced from the occupied territories, taking into account the results of cluster analysis for IHE included in the first cluster.

Determining the initial data, in order to assess the IHE economic security, there have been taken into account the peculiarities of the use of one of the strategic management tools – the Balanced Score Card (BSC) [3] adapted to the needs of institutions of higher education. Taking into account the mentioned above, the output data (indicators) for assessing the IHE economic security were divided into four groups. These groups include finances (included indicators that characterize the management of financial flows of IHE); students (included indicators with the help of which it is possible to characterize the attitude of students to the IHE as a whole); internal processes (defined indicators, the increase of which will increase the effectiveness of the functioning of the IHE); development and training of the academic staff (defined indicators, by means of which it is possible to determine the main directions of improving the quality of the provided education services at the IHE).

Forming the indicators, the main systemic forms of threats [4] have been taken into account: the licensed volume and number of places for public procurement; the number of graduates of higher education institutions in general and in terms of the

number of universities; the number of students of higher education institutions as a whole and in terms of the number of universities; the expenditures on higher education in terms of Ukraine's GDP and total expenditures of the state budget; the expenditures on higher education in the total expenditures of the consolidated budget and in the total number of institutions of higher education; the expenditures on higher education in the total expenditures of the consolidated budget and in the total number of students of higher education institutions; the number of applicants to the higher education institutions in general and in terms of the licensed volume and volume of the public procurement; the number of students who studied at the expense of state and local budgets, state bodies and legal entities, individuals in general and in proportion to the total number of students of higher education institutions; the number of students in terms of the total population of Ukraine; the number of academic staff in general and in the total number of employees; the number of academic staff having a scientific degree of a doctor and a candidate of sciences as a whole and in terms of the total number of universities; the number of postgraduates and doctoral students in general and in terms of the total number of HEIs; the number of rational proposals and innovations (patents, copyright certificates, industrial designs, etc.); the number of employees after retraining, internships, trainings, advanced training, defense of dissertations; the university's place in Scopus according to *h*-index; the number of computer workplaces that have access to the Internet.

The above-mentioned system forms of threats have been adjusted taking into account the specifics of the IHE functioning as business entities and their capabilities in training competitive professionals that may be involved in further developing the economy after the de-occupation of the regions (of which they were moved).

The output data for calculating the magnitude of the variation in the groups of indicators (the period used to analyze is the period of occupation – 2014-2016) are given in Table 4. Given the heterogeneity of the indicators in the groups to bring them into a comparable form, they have been normalized. Due to the fact of absence of reference or standard values of indicators of economic security estimation, the basis for comparison has been chosen the maximum (minimum) values based on their

deviation in scope of variation (in order to avoid negative values of the integral index of IHE economic security). All indicators were to be subdivided into stimulant indicators (those classified as increasing which lead to a growth in the level of IHE economic security) and destimulant indicators (indicators whose increase leads to a decrease in its level). Use the statistic software Statistica by means of factor analysis with the method of the main components, there has been done the transformation of the output data into groups of new indicators (main components), sorted by the magnitude of their variance.

Table 4

Output data and their normalized values by groups and institutions

Years		
Finances	The correlation between the licensed volume of acceptance to studies and the volume of the public procurement for the 1st year of studying according to the training programs of bachelors and masters (disincentive)	
	The correlation between the volume of the public procurement and the number of applicants to the 1st year of training programs of bachelors and masters (disincentive)	
	The average number of academic staff per one economic contract and scientific research, financed by budget funds, per. (incentive)	
Students	The correlation between the licensed volume of acceptance to studies and the number of applicants to the 1st year of full-time study programs of bachelors and masters (disincentive)	
	The correlation between the number of students in full-time and part-time studies (disincentive)	
	The correlation between the number of students and the number of academic staff (incentive)	
	The correlation between the number of acceptance to studies to the 1st year of full-time education and the number of titles of accredited specialties for bachelor's and master's programs (incentive)	
Internal processes	The correlation between the number of titles of accredited specialties to the programs of bachelor/ masters training and the number of departments (disincentive)	
	Percentage of full-time academic staff having a doctor's degree/degree of candidate of sciences and the total number of full-time academic staff (incentive)	
	Percentage of full-time academic staff with academic rank and the total number of academic staff (incentive)	
	The correlation between the total book funds and the number of students (incentive)	
Development and training of the academic staff	The level of academic staff creative and innovative performance (incentive)	
	Index of academic staff development (incentive)	
	The coefficient of academic staff scientific recognition (incentive)	
	The coefficient of necessity of computing technology and access to network resources (disincentive)	

The output data for normalisation (DonNTU)*														
2014	2,9021	0,6798	26,6667	1,973	2,0964	22,475	44,214	4,12	0,525	0,4292	15,055	0,175	0,0458	16,0	0,8333
2015	10,2499	1,8791	21,5556	19,26	1,8137	22,031	17,952	4,0	0,6495	0,5309	19	0,0619	0,0927	20,0	0,5154
2016	70,7038	0,3232	20,2222	22,852	1,2746	18,159	29,892	2,6	0,6978	0,5604	28,442	0,011	0,2637	22,0	0,5495
	The output data for normalisation (Vasyl' Stus DonNU)**														
2014	4,425	0,3535	53,5714	1,5641	3,8835	8,048	174,902	0,9273	0,7667	0,7667	0,2981	0,0693	0,1573	19,0	0,4213
2015	15,6349	0,4009	26,5714	6,2685	3,3369	10,831	71,9412	0,9273	0,8468	0,8064	4,4676	0,0081	0,1344	24,0	1,0
2016	9,9923	0,116	36,4615	1,1593	2,2993	11,395	337,982	1,0181	0,5591	0,5211	3,3327	0,0105	0,057	34,0	0,5359
The output data (V. Dahl EUNU)***															
2014	5,2437	1,4634	86,6000	7,6738	1,1996	13,9746	12,9832	3,6060	0,6570	0,5161	1,0742	0,1328	0,0878	7,0	0,6259
2015	26,5630	0,4210	53,7000	11,1818	1,2671	13,2128	13,2689	3,6060	0,6797	0,5773	1,8529	0,0018	0,1322	8,0	0,3964
2016	19,0653	0,3952	55,5714	7,5344	1,3723	12,8432	15,8380	4,3030	0,7532	0,6841	26,3759	0,1825	0,1620	12,0	0,1671
The output data (T. Shevchenko LNU)****															
2014	28,4952	0,3046	54,5	8,6809	1,3317	24,312	95,116	0,9772	0,6193	0,4445	0,6604	0,0298	0,0734	4,0	0,4954
2015	45,8653	0,236	42,556	10,826	1,5497	17,935	105,33	0,9772	0,6084	0,3916	1,0192	0,1828	0,0836	7,0	0,4256
2016	37,0649	0,086	91,0	3,186	1,4654	14,874	104,23	1,6818	0,6538	0,4808	1,2929	0,0247	0,0742	7,0	0,3956

** Report of the acting rector of DonNTU Lyashko Ya.O. about performance of duties for 2015. – Krasnoarmiysk. – 2016. – 114 p. [Electronic resource]. – Mode of access: http://donntu.edu.ua/2016/publ/zvit_rektor2015.pdf; Report of the acting rector of DonNTU Lyashko Ya.O. about performance of duties for 2016. – Pokrovsk. – 2016. – 111 p. [Electronic resource]. – Access mode: http://donntu.edu.ua/wp-content/uploads/2015/04/zvit_rektor2016.pdf.*

*** Report of the rector of Vasyl Stus DonNU Grinyuk R.F. about the university team's work for 2016 and the perspective tasks for development. – Vinnitsa. – 2016 – 216 pp. [Electronic resource]. – Access mode:*

http://www.donnu.edu.ua/uk-ua/prozorist-ta-informatsiyna-vidkritist/Pages/default. aspx; Report of the rector of Vasyl Stus DonNU Grinyuk R.F. about the university team's work for 2017 and the perspective tasks for development. - Vinnitsa. – 2017 – 176s. [Electronic resource]. – Mode of access: http://www.donnu.edu.ua/uk-ua/prozorist-ta-informatsiyna-vidkritist/Pages/default.aspx.

**** Report of the rector of V. Dahl EUNU, O. V. Porkoyan - Severodonetsk – 2016 – 23 p. [Electronic resource]. – Access mode: https://snu.edu.ua/wp-content/uploads/2017/01/Zvit2016.pdf.*

***** Report of the rector of SI "Lugansk Taras Shevchenko National University" Savchenko S.V. for the period from January 2016 to January 2017: information materials / S.V. Savchenko; State institution "Luhansk Taras Shevchenko National University" – Starobilsk: Publ. SI "T.Shevchenko LNU", 2017. – 139 p.*

The calculation of integral indices by groups of criteria and the integral index as a whole for IHE included in the cluster 1 as a result of the cluster analysis has been carried out by determining the criteria's importance by groups in the process of conducting a factor analysis (by the method of the main components) according to the results of the factor loadings' research for each IHE and for each group of indicators (Table 5).

Table 5

Defined weight of indicators by groups

Criteria	Factor 1	Factor 2	Maximum value (loading)	Product	Weight
DonNTU					
Group "Finance"					
The correlation between the licensed volume of acceptance to studies and the volume of the public procurement for the 1st year of studying according to the preparation programs of bachelors and masters (X 1)	0,8244	0,5660	0,8244	0,6986	0,4398
The correlation between the volume of the public procurement and the number of applicants to the 1st year of training programs of bachelors and masters (X 2)	-0,9405	0,3397	0,3397	0,0518	0,0326
The average number of academic staff per one economic contract and scientific research, financed by budget funds, per. (X 3)	0,9889	-0,1488	0,9889	0,8380	0,5276
Total dispersion	2,5421	0,4579	–	–	–
The share of total dispersion	0,8474	0,1526	–	–	–
Sum	–	–	–	1,5884	1,0
Group "Students"					
The correlation between the licensed volume of acceptance to studies and the number of applicants to the 1st year of full-time study programs of bachelors and masters (X 1)	0,9706	-0,2405	0,9706	0,7265	0,3195
The correlation between the number of students in full-time and part-time studies (X 2)	-0,9561	-0,2930	0,9561	0,7156	0,3147
The correlation between the number of students and the number of academic staff (X 3)	0,853	0,5219	0,853	0,6385	0,2808
The correlation between the number of acceptance to studies	0,6404	-0,768	0,768	0,1932	0,0849

to the 1st year of full-time education and the number of titles of accredited specialties for bachelor's and master's programs (X 4)					
Total dispersion	2,9941	1,0059	–	–	–
The share of total dispersion	0,7485	0,2515	–	–	–
Sum	–	–	–	2,2738	1,0
Group "Internal processes"					
The correlation between the number of titles of accredited specialties to the programs of bachelor/ masters training and the number of departments (X 1)	-0,9112	0,4119	-0,9112	0,0899	0,0334
Percentage of full-time academic staff having a doctor's degree/degree of candidate of sciences and the total number of full-time academic staff (X 2)	-0,9618	-0,2738	-0,9618	0,8670	0,3222
Percentage of full-time academic staff with academic rank and the total number of academic staff (X 3)	-0,9442	-0,3294	-0,9442	0,8511	0,3163
The correlation between the total book funds and the number of students (X 4)	-0,9791	0,2033	-0,9791	0,8826	0,3280
Total dispersion	3,6056	0,3944	–	–	–
The share of total dispersion	0,9014	0,0986	–	–	–
Sum	–	–	–	2,6905	1,0
Group "Development and training of the academic staff"					
The level of academic staff creative and innovative performance (X 1)	0,9995	-0,0316	0,9995	0,8967	0,2643
Index of academic staff development (X 2)	-0,8768	-0,4808	-0,8768	0,7866	0,2318
The coefficient of academic staff scientific recognition (X 3)	-1,0	0,0062	-1,0	0,8971	0,2644
The coefficient of necessity of computing technology and access to network resources (X 4)	0,9058	-0,4237	0,9058	0,8126	0,2395
Total dispersion	3,5882	0,4118	–	–	–
The share of total dispersion	0,8971	0,1029	–	–	–
Sum	–	–	–	3,3929	1,0
Vasyl' Stus DonNU					
Group "Finance"					
The correlation between the licensed volume of acceptance to studies and the volume of the public procurement for the 1st year of studying according to the preparation programs of bachelors and masters (X 1)	1,0	0,0026	1,0	0,6670	0,4032
The correlation between the volume of the public procurement and the number of applicants to the 1st year of training programs of bachelors and masters (X 2)	0,1617	-0,9868	0,9868	0,3287	0,1987
The average number of academic staff per one economic contract and scientific research, financed by budget funds, per. (X 3)	0,9873	0,1590	0,9873	0,6585	0,3981
Total dispersion	2,0009	0,9991	–	–	–
The share of total dispersion	0,6670	0,3330	–	–	–
Sum	–	–	–	1,6541	1,0
Group "Students"					
The correlation between the licensed volume of acceptance to studies and the number of applicants to the 1st year of full-time study programs of bachelors and masters (X 1)	-0,5695	0,822	0,822	0,3189	0,1808

The correlation between the number of students in full-time and part-time studies (X 2)	-0,9368	-0,3499	-0,9368	0,5734	0,3251
The correlation between the number of students and the number of academic staff (X 3)	-0,6215	-0,7834	-0,7834	0,3039	0,1723
The correlation between the number of acceptance to studies to the 1st year of full-time education and the number of titles of accredited specialties for bachelor's and master's programs (X 4)	-0,9276	0,3736	-0,9276	0,5678	0,3219
Total dispersion	2,4486	1,5514	–	–	–
The share of total dispersion	0,6121	0,3879	–	–	–
Sum	–	–	–	1,7639	1,0
Group "Internal processes"					
The correlation between the number of titles of accredited specialties to the programs of bachelor/ masters training and the number of departments (X 1)	-0,9803	-0,1977	0,9803	0,9590	0,2478
Percentage of full-time academic staff having a doctor's degree/degree of candidate of sciences and the total number of full-time academic staff (X 2)	-0,9973	0,074	0,9973	0,9757	0,2521
Percentage of full-time academic staff with academic rank and the total number of academic staff (X 3)	-0,9975	-0,0702	0,9975	0,9759	0,2521
The correlation between the total book funds and the number of students (X 4)	0,9811	-0,1936	0,9811	0,9598	0,2480
Total dispersion	3,913	0,087	–	–	–
The share of total dispersion	0,9783	0,0217	–	–	–
Sum	–	–	–	3,8704	1,0
Group "Development and training of the academic staff"					
The level of academic staff creative and innovative performance (X 1)	-0,908	-0,419	0,908	0,6015	0,2792
Index of academic staff development (X 2)	-0,909	0,4167	0,9090	0,6021	0,2795
The coefficient of academic staff scientific recognition (X 3)	0,9505	-0,3108	0,9505	0,6296	0,2923
The coefficient of necessity of computing technology and access to network resources (X 4)	-0,3088	-0,9511	0,9511	0,3211	0,1490
Total dispersion	2,6496	1,3504	–	–	–
The share of total dispersion	0,6624	0,3376	–	–	–
Sum	–	–	–	2,1543	1,0
V. Dahl EUNU					
Group "Finance"					
The correlation between the licensed volume of acceptance to studies and the volume of the public procurement for the 1st year of studying according to the preparation programs of bachelors and masters (X 1)	0,9741	0,226	0,9741	0,9487	0,3290
The correlation between the volume of the public procurement and the number of applicants to the 1st year of training programs of bachelors and masters (X 2)	-0,9892	0,1467	0,9892	0,9634	0,3341
The average number of academic staff per one economic contract and scientific research, financed by budget funds, per. (X 3)	0,9972	-0,0753	0,9972	0,9712	0,3368
Total dispersion	2,9217	0,0783	–	–	–
The share of total dispersion	0,9739	0,0261	–	–	–

Sum	–	–	–	2,8832	1,0
Group "Students"					
The correlation between the licensed volume of acceptance to studies and the number of applicants to the 1st year of full-time study programs of bachelors and masters (X 1)	0,2421	0,9702	0,9702	0,2801	0,1643
The correlation between the number of students in full-time and part-time studies (X 2)	-0,9963	0,0854	0,9963	0,7087	0,4156
The correlation between the number of students and the number of academic staff (X 3)	-0,9178	0,3971	0,9178	0,6528	0,3829
The correlation between the number of acceptance to studies to the 1st year of full-time education and the number of titles of accredited specialties for bachelor's and master's programs (X 4)	0,9755	0,22	0,9755	0,0635	0,0372
Total dispersion	2,8453	1,1547	–	–	–
The share of total dispersion	0,7113	0,2887	–	–	–
Sum	–	–	–	1,7051	1,0
Group "Internal processes"					
The correlation between the number of titles of accredited specialties to the programs of bachelor/ masters training and the number of departments (X 1)	0,988	0,1544	0,988	0,9658	0,2498
Percentage of full-time academic staff having a doctor's degree/degree of candidate of sciences and the total number of full-time academic staff (X 2)	-0,9974	0,0726	0,9974	0,9750	0,2522
Percentage of full-time academic staff with academic rank and the total number of academic staff (X 3)	-0,9774	0,2115	0,9774	0,9554	0,2472
The correlation between the total book funds and the number of students (X 4)	-0,9918	-0,1276	0,9918	0,9695	0,2508
Total dispersion	3,9099	0,0901	–	–	–
The share of total dispersion	0,9775	0,0225	–	–	–
Sum	–	–	–	3,8656	1,0
Group "Development and training of the academic staff"					
The level of academic staff creative and innovative performance (X 1)	-0,4723	0,8814	0,8814	0,2085	0,0857
Index of academic staff development (X 2)	-0,9442	-0,3293	0,9442	0,7208	0,2963
The coefficient of academic staff scientific recognition (X 3)	-0,9938	0,1108	0,9938	0,7587	0,3119
The coefficient of necessity of computing technology and access to network resources (X 4)	-0,9753	-0,2209	0,9753	0,7445	0,3061
Total dispersion	3,0536	0,9464	–	–	–
The share of total dispersion	0,7634	0,2366	–	–	–
Sum	–	–	–	2,4326	1,0
T. Shevchenko LNU					
Group "Finance"					
The correlation between the licensed volume of acceptance to studies and the volume of the public procurement for the 1st year of studying according to the preparation programs of bachelors and masters (X 1)	0,0694	0,9976	0,9976	0,3811	0,2428
The correlation between the volume of the public procurement and the number of applicants to the 1st year of training programs of bachelors and masters (X 2)	-0,9726	-0,2325	0,9726	0,6011	0,3830

The average number of academic staff per one economic contract and scientific research, financed by budget funds, per.. (X 3)	-0,9505	0,3108	0,9505	0,5874	0,3743
Total dispersion	1,8541	1,1459	–	–	–
The share of total dispersion	0,618	0,382	–	–	–
Sum	–	–	–	1,5696	1,0
Group "Students"					
The correlation between the licensed volume of acceptance to studies and the number of applicants to the 1st year of full-time study programs of bachelors and masters (X 1)	0,2979	-0,9546	0,9546	0,2846	0,1736
The correlation between the number of students in full-time and part-time studies (X 2)	-0,9013	-0,4332	0,9013	0,6326	0,3859
The correlation between the number of students and the number of academic staff (X 3)	-0,9641	0,2657	0,9641	0,6767	0,4128
The correlation between the number of acceptance to studies to the 1st year of full-time education and the number of titles of accredited specialties for bachelor's and master's programs (X 4)	0,9884	0,1519	0,9884	0,0453	0,0276
Total dispersion	2,8074	1,1926	–	–	–
The share of total dispersion	0,7019	0,2981	–	–	–
Sum	–	–	–	1,6392	1,0
Group "Internal processes"					
The correlation between the number of titles of accredited specialties to the programs of bachelor/ masters training and the number of departments (X 1)	0,9959	0,0902	0,9959	0,8218	0,2756
Percentage of full-time academic staff having a doctor's degree/degree of candidate of sciences and the total number of full-time academic staff (X 2)	-0,990	0,1413	0,99	0,8169	0,2740
Percentage of full-time academic staff with academic rank and the total number of academic staff (X 3)	-0,8575	0,5144	0,8575	0,7076	0,2373
The correlation between the total book funds and the number of students (X 4)	-0,7703	-0,6376	0,7703	0,6357	0,2132
Total dispersion	3,3007	0,6993	–	–	–
The share of total dispersion	0,8252	0,1748	–	–	–
Sum	–	–	–	2,9820	1,0
Group "Development and training of the academic staff"					
The level of academic staff creative and innovative performance (X 1)	-0,8179	-0,5753	0,8179	0,5630	0,2472
Index of academic staff development (X 2)	-0,8708	-0,4917	0,8708	0,5995	0,2632
The coefficient of academic staff scientific recognition (X 3)	-0,8949	0,4463	0,8949	0,6160	0,2705
The coefficient of necessity of computing technology and access to network resources (X 4)	-0,7249	0,6888	0,7249	0,4990	0,2191
Total dispersion	2,7536	1,2464	–	–	–
The share of total dispersion	0,6884	0,3116	–	–	–
Sum	–	–	–	2,2776	1,0

Hereafter there has been carried out the calculation of integral indices of economic security of institutions of higher education in the groups of indicators. To

calculate them, an approach was used to construct a relationship between integral and basic indices – additive convolution [5-7], the value of integral indices by groups of indicators and the general range from 0 to 1. This corresponds to the basic idea of determining the level of economic security of institutions of higher education.

The integral indicator of economic security is determined hierarchically on the basis of the additive convolution in accordance with the approach [7], which involves the calculation of integral indicators for each group (Formula 1) and the integral indicator in general (Formula 2).

$$I_m = \sum_{i=1}^{n} d_i \times y_i, \quad (1)$$

where I_m is an aggregate indicator (integral indicator for the group of indicators) / sub-index of the mth group of indicators of IHE economic security, where m = (1, 2, 3, 4); d_i is weight of the indicator, which determines the degree of contribution of the i^{th} indicator to the integral index of the component (groups of indicators) of IHE economic security; y_i is a normalized value of the i^{th} indicator; n is the number of indicators used to evaluate the i^{th} indicator in the aggregated indicator (integral indicator in the group of indicators) / sub-index of the m^{th} group of indicators of IHE economic security; $\sum d_i = 1$; $0 \le d_i;\ y_i \le 1$.

The integral indicator of IHE economic security as a whole is calculated by the Formula 2.

$$II_{ES\,IHE} = \sum_{m} d_m \times I_m, \quad (2)$$

where $II_{ES\,IHE}$ is an integral indicator of IHE economic security; d_m is weight coefficient, which determines the degree of contribution of the index / subindex of the m^{th} group of economic security to the integral index of economic security of institutions of higher education; I_m is an aggregate index / subindex of the m^{th} group of economic security, where m = (1, 2, 3, 4); $\sum d_m = 1$; $0 \le d_m;\ y_m \le 1$.

Basing on the Formulas 1 and 2, according to normalized indicators and Table 5 (factor weight), there has been carried out the calculation of aggregated indicators

(integral indicators by groups) for IHE, which, as a result of the cluster analysis, was included in the first cluster (Table 6).

Table 6

Aggregated indicators (integral indicators) by groups and years

Years	Aggregated indicator of IHE economic security in the group "Finance"	Aggregated indicator of IHE economic security in the group "Students"	Aggregated indicator of IHE economic security in the group "Internal processes"	Aggregated indicator of IHE economic security in the group "Development and training of academic staff"
DonNTU				
2014	0,9925	0,6853	0,0000	0,5038
2015	0,5339	0,4151	0,5767	0,3082
2016	0,0326	0,3534	1,0	0,5219
Vasyl' Stus DonNU				
2014	0,8344	0,2910	0,6467	0,7077
2015	0	0,2554	1,0000	0,3131
2016	0,5475	1,0	0,1805	0,4227
V. Dahl EUNU				
2014	0,6659	0,9565	0,2498	0,0621
2015	0,3261	0,3820	0,4071	0,3928
2016	0,4690	0,2015	0,7502	1,0
T. Shevchenko LNU				
2014	0,3351	0,8475	0,4821	0,0080
2015	0,1202	0,1615	0,3965	0,9341
2016	0,8802	0,3475	0,7244	0,5102

In order to find out exactly which indicators (variables) have a significant effect on the dispersion level explanation, factor loading analysis is performed without the rotation procedure for all IHEs included in the first cluster as a result of the cluster analysis (Table 7). According to Table 7, the first factor in V. Dahl EUNU and T. Shevchenko LNU is essential and can fully explain the dependence and overall variance. In other cases, the dependence is not significant.

As a result of factor analysis, in particular, in the process of factor loadings calculations, there is a complex factor structure that complicates the identification of uncorrelated variables (main components) and data interpretation in the context of determining the level of IHE economic security. The search for a factor structure in which the factor loading is approaching 1 or 0 has been carried out taking into account the research [5-7] using the quartimax rotation procedure (involves the rotation of the factor axes to increase the values of factor loadings taking into account the structure quality of all components). Quartimax normalized has been chosen

among the most common approaches to this procedure implementation.

After rotation (with the help of the quartimax normalized procedure), the obtained aggregated indices are generalized, but not the main components. Factor loadings exceed the value of 0.7. The results of calculations are given in Table 7.

Table 7

Factor loadings without rotation and after rotation

Variables	Factor loadings (without rotation)		Factor loadings and weight of each indicator (after rotation)				
	Factor 1	Factor 2	Factor 1	Factor 2	Maximum value (loading)	Product	Weight
DonNTU							
Aggregated indicator of IHE economic security in the group "Finance" (X 1)	0,9814	-0,1919	0,9900	-0,1409	0,1409	0,0378	0,0216
Aggregated indicator of IHE economic security in the group "Students" (X 2)	0,9838	0,1795	0,9731	0,2302	0,9731	0,7123	0,4071
Aggregated indicator of IHE economic security in the group "Internal processes"(X 3)	-0,9969	0,0790	-0,9996	0,0273	0,9996	0,7317	0,4182
Aggregated indicator of IHE economic security in the group "Development and training of academic staff" (X 4)	0,0909	0,9959	0,0392	0,9992	0,9992	0,2678	0,1531
Total dispersion	2,9330	1,0670	2,9280	1,0720	–	–	–
The share of total dispersion	0,7332	0,2668	0,7320	0,2680	–	–	–
Sum	–	–	–	–	–	1,7496	1,0
Vasyl'Stus DonNU							
Aggregated indicator of IHE economic security in the group "Finance" (X 1)	0,8862	0,4633	-0,3161	-0,9487	0,9487	0,4712	0,2421
Aggregated indicator of IHE economic security in the group "Students" (X 2)	0,6462	-0,7632	-0,9949	0,1006	0,9949	0,5008	0,2573
Aggregated indicator of IHE economic security in the group "Internal processes"(X 3)	-0,8932	0,4497	0,9550	0,2965	0,955	0,4807	0,2470
Aggregated indicator of IHE economic security in the group "Development and training of academic staff" (X 4)	0,6127	0,7903	0,1078	-0,9942	0,9942	0,4937	0,2537
Total dispersion	2,3760	1,6240	2,0135	1,9865	–	–	–
The share of total dispersion	0,5940	0,4060	0,5034	0,4966	–	–	–
Sum	–	–	–	–	–	1,9465	1,0
V. Dahl EUNU							
Aggregated indicator of IHE economic security in the group "Finance" (X 1)	0,6962	-0,7179	-0,4041	0,9147	0,9147	0,2426	0,1028
Aggregated indicator of IHE economic security in the group "Students" (X 2)	0,9905	-0,1373	-0,8815	0,4721	0,8815	0,6477	0,2745
Aggregated indicator of IHE economic security in the group "Internal	-0,9337	-0,3580	0,9999	0,0121	0,9999	0,7347	0,3114

processes"(X 3)							
Aggregated indicator of IHE economic security in the group "Development and training of academic staff" (X 4)	-0,9481	-0,3179	0,9995	-0,0304	0,9995	0,7344	0,3113
Total dispersion	3,2366	0,7634	2,9394	1,0606	-	-	-
The share of total dispersion	0,8091	0,1909	0,7348	0,2652	-	-	-
Sum	-	-	-	-	-	2,3595	1,0
T. Shevchenko LNU							
Aggregated indicator of IHE economic security in the group "Finance" (X 1)	-0,7843	0,6204	0,9979	0,0654	0,9979	0,5046	0,2534
Aggregated indicator of IHE economic security in the group "Students" (X 2)	-0,6355	-0,7721	-0,0459	0,9989	0,9989	0,4938	0,2480
Aggregated indicator of IHE economic security in the group "Internal processes" (X 3)	-0,7695	0,6386	0,9991	0,042	0,9991	0,5052	0,2537
Aggregated indicator of IHE economic security in the group "Development and training of academic staff" (X 4)	0,7823	0,6230	-0,1629	-0,9866	0,9866	0,4877	0,2449
Total dispersion	2,2231	1,7769	2,0226	1,9774	–	–	–
The share of total dispersion	0,5558	0,4442	0,5057	0,4943	–	–	–
Sum	–	–	–	–	-	1,9913	1,0

Table 8

Generalized index integral indicators for groups and integral indicator over the years

Years	Aggregated indicator (integral indicator) in the group "Finance"	Aggregated indicator (integral indicator) in the group "Students"	Aggregated indicator (integral indicator) in the group "Internal processes"	Aggregated indicator (integral indicator) in the group "Development and training of academic staff"	Integral indicator of economic security
DonNTU					
2014	0,0214	0,2790	0,0000	0,0771	0,3775
2015	0,0115	0,1690	0,2412	0,0472	0,4689
2016	0,0007	0,1439	0,4182	0,0799	0,6427
Vasyl' Stus DonNU					
2014	0,2020	0,0749	0,1597	0,1795	0,6161
2015	0,0000	0,0657	0,2470	0,0794	0,3921
2016	0,1325	0,2573	0,0446	0,1072	0,5416
V. Dahl EUNU					
2014	0,0685	0,2626	0,0778	0,0193	0,4282
2015	0,0335	0,1049	0,1268	0,1223	0,3874
2016	0,0482	0,0553	0,2336	0,3113	0,6484
T. Shevchenko LNU					
2014	0,0849	0,2101	0,1223	0,0020	0,4193
2015	0,0305	0,0400	0,1006	0,2288	0,3999
2016	0,2231	0,0862	0,1838	0,1249	0,6180

Basing on Formulas 1 and 2 and according to tables 6 and 7 there have been done the calculations of the integral indicator of IHE (entered into the first cluster over the years) economic security (Table 8). The range of characteristic values of

IHE economic security levels is based on the Guidelines for calculating the level of economic security of the Ministry of Economic Development and Trade of Ukraine [7], according to which the absolutely safe level is in the range from 0-0,2; critical – from 0.2 to 0.4; dangerous – from 0,4-0,6; unsatisfactory – from 0.6-0.8; optimal – from 0.8-1, respectively. The data in Table 8 generally indicates the unsafe condition of economic security of IHE included in the first cluster as a result of cluster analysis during 2014-2016.

The estimation results of IHE economic security provide grounds for concluding the appropriateness of developing measures at all management levels to increase their economic security, which in the long run will have a positive impact on the level of economic development of the state, its economic security and national security in general.

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