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ANALYSIS OF COMPETITIVE SELECTION OF ENTRANTS FOR ECONOMIC SPECIALTIES OF HIGHER EDUCATION: 2018 EIE VALIDITY SAMPLE

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ABSTRACT

The article conducts an analytical study of statistical connections between the components of the competitive selection in 2018 and the average performance of first-year students in the branch of knowledge 07 "Management and Administration" of a particular institution of higher education (HEI). It is noted that in 2018, test EIE, within one field of knowledge, for the first time applied two different, according to the list of subjects of external independent evaluation (EIE), methods of calculating the competitive score of applicants (C_S). The use of such a two-model system had a positive effect on increasing the number of students in 2018 and 2019.

The calculation of correlation coefficients showed that the two-model system of competitive selection of entrants has a fairly high level of prognostic validity (R = 0.662). However, the competitive score calculated by the second method correlates much worse with the average learning outcomes of first-year students, compared to the first model ($R_{II} = 0.564$ vs. $R_I = 0.718$). With the help of variation of weight coefficients of EIE disciplines, a more optimal alternative model of calculating the competitive score of the entrant for the II method is determined and proposed, the correlation coefficient of which $R*_{II} = 0.621$.

The analysis of the components of the competitive selection of students in this field of knowledge showed that the results of external examinations in the Ukrainian language and literature are a strong predictor of the success of freshmen in economics (R = 0.619). Instead, the EIE in the History of Ukraine correlates worst with their assessments, compared to other subjects (R = 0.364).

Keywords: prognostic validity, correlation coefficient, competitive selection, competitive score, external independent evaluation (EIE), higher education institution (HIE).

Formulation of the problem. The national system of external independent evaluation (EIE) began to take shape in Ukraine in 2004 with the support of international and public organizations, and since 2006 it has been put into operation at the official level. In such a relatively short period of time in Ukraine there has been a radical change in approaches to the final certification of graduates of secondary schools and a fundamental transformation of the rules of admission of entrants to higher educational institutions (HEI).

The set of organizational procedures for EIE at the state level is constantly being improved. After all, the purpose of high-quality, independent measurement of knowledge in selected disciplines and calculation on their basis of a single unbiased competitive score is quality ranking and selection of entrants with the best preparation for higher education.

The objective model of such competitive selection is realized by definition of the corresponding profile subject and introduction of weight coefficients of disciplines of EIE for each professional direction. In this regard, one of the urgent tasks facing higher education institutions is to build and implement the most optimal model of competitive selection of entrants. Based on the results of external independent evaluation and the average score of the certificate, the higher education institution, varying the weight, tries to make a ranking list, in which the first places will be those entrants who can better study in the specialty.

The evaluation of the applied model of competitive selection is investigated according to the indicator *of prognostic validity* of competitive score.

Prognostic validity is the correlation coefficient between the indicator in according to which the competitive selection is carried out and the results of the student's success during the first year of study. Thus, assessing the value of prognostic validity, it is possible to investigate the statistical relationships of the results of external evaluation in individual subjects or their corresponding weights with student performance and build on them based on optimal models of competitive selection. In this case, the efficiency of the system of admission to the HEI on the basis of the EIE is considered *high* if the correlation coefficient (R) is greater than 0.5; *sufficient* if the correlation coefficient is in the range [0.3, 0.5] and *low* if the correlation coefficient is less than 0.3 [1].

Formulation of the goals of the article. The purpose of this work is an analytical study of the statistical relationships between the components of the competitive selection conducted in 2018, and performance indicators of first-year students branch of knowledge 07 "Management and Administration" of a separate institution of higher education.

Analysis of recent research and publications. The study of the prognostic validity of competitive selection in the HEI due attention in many foreign coun-

tries is given [2 - 5]. Based on the results of such research, the effectiveness of existing models of selection for universities is studied and possible directions for their further improvement are identified.

In Ukraine, too few scientific papers to this question are devoted [1, 6 - 13]. In particular, it is worth noting the scientific and practical publication [1], which conducted a thorough study of the quality of competitive selection of students of higher education institutions based on the results of external evaluation during 2008-2015. The basis of scientific work is the study of three dimensions of the quality of the admission system: the prognostic validity of the competitive score, the fairness of evaluation and their public perception. The main directions and problems of further research of the quality of the system of admission to the HEI, ways of development of the system of EIE as a tool for ensuring the quality of the education system in terms of autonomy of educational institutions are also discussed.

This paper emphasizes the high prognostic validity of EIE, although it is shown that for the Branch of knowledge 07 "Management and Administration" its value is only in the range of $0.41 - 0.54$. The authors also emphasize that the rules of the game, in the sense of using the EIE tests for admission to the HEI and final school certification, are constantly changing, and therefore the study of their statistical patterns remains relevant for researchers.

A radically opposite and critical view on the implementation of the external evaluation competition score and its low prognostic validity is given in [6]. The author believes that the system of scaling the results of external evaluation is not transparent, masks the true level of preparation of applicants and needs improvement. His observations show that the results of higher education mathematics students are weakly related to the scores of the relevant EIE certificates, and the correlation coefficient of examination grades with the EIE scores is only 0.45.

Therefore, in order to ensure the training of elite engineering personnel, the author proposes to higher education institutions to set a minimum score of at least 170 for entrants in mathematics and physics. Which, in our opinion, is significantly inflated and not statistically substantiated.

In [7], in order to determine the optimal formula for calculating the competitive score, the influence of the values of the weights of external evaluation disciplines on the prognostic validity of the competitive selection of entrants to the branch of knowledge "Health care" is investigated.

The study of correlations between the results of external evaluation and grades in higher mathematics of first-year students is devoted to [8-10].

A comparative analysis of the value of the indicator of prognostic validity of competitive selection in 2015-2018 for the specialty 151 "Automation and computer-integrated technologies" is given in [13]. The author of the article also mathematically substantiates the expediency of changing the weights used in calculating the competitive score of entrants.

Presentation of the main material of the study. This statistical study will analyze the performance of first-year students in the branch of knowledge 07 "Management and Administration" of a separate institution of higher education, which will be called a test HEI. The volume of the observation group is 60 people.

The average rating score of students (R_S) on the results of first-year education, as well as assessments in certain disciplines, was obtained on the basis of electronic data on the success of the automated control system of test HEI further in a single 100-point scale are expressed.

Competitive score (C_S) and the results of the EIE in 2018, for this sample of students, were obtained using the information system "Competition" Public Association "Center for Educational Policy" of the Ministry of Education and Science of Ukraine [15].

It should be noted that higher education institutions, independently choosing the subjects of external evaluation and their weights, influence the formation of the model of competitive selection of entrants. Therefore, it is advisable to analyze the methodology used by the test EIE when calculating the competitive score for this branch of knowledge.

In 2018, the formula for calculating C_S when entering the bachelor's degree on the basis of complete general secondary education had a unified form:

$$C_S = C_1 \cdot E_1 + C_2 \cdot E_2 + C_3 \cdot E_3 + C_4 \cdot A + C_5 \cdot O_s)$$
$$\cdot R_c \cdot B_c \cdot V_c \cdot P_c, \ (1)$$

where E_1, E_2, E_3 - points of external independent evaluation; A - the average score of the document on education; C_1, C_2, C_3, C_4, C_5 - non-negative weights, which are set by the university; O_s - a score for the successful completion of preparatory courses for admission to the specialty (specialization), which is given special support;

R_a, B_a, V_a, P_a - adjustment factors (regional, branch, rural and priority).

For our sample of students in the branch of knowledge 07 "Management and Administration" did not take into account the branch and priority coefficients as well as additional points for preparatory courses and therefore formula (1) takes a simplified form:

$$C_S = (0{,}45 \cdot E_1 + 0{,}25 \cdot E_2 + 0{,}2 \cdot E_3 + 0{,}1 \cdot A) \cdot R_c \cdot V_c, \ (2)$$

In (2) the weight coefficients of the EIE disciplines, which were selected by the test HEI for this branch of knowledge, are also given. The largest value of the coefficient (0.45) corresponds to the profile subject. In fig. 1 presents the distribution of the competition score calculated by formula (2) for students of test HEI according to the results of admission in 2018 and 2019.
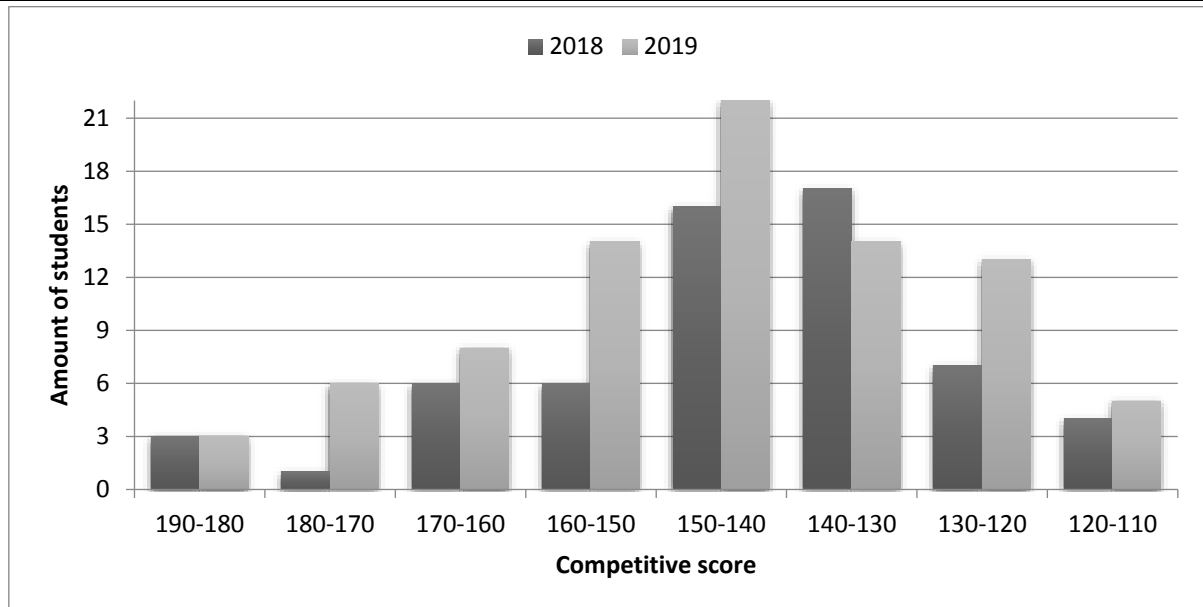
Fig. 1. Histogram of the distribution of the competitive score of students in the branch of knowledge 07 "Management and Administration" of the test HEI on the results of the accession of 2018 and 2019
Source: generated and calculated by the author based on the data given in [15]

For further analysis, it is important that in 2018, test HEI, within one specialty, was first applied two different, according to the list of subjects of external evaluation, models of calculation of C_S. In the first model, the profile subject E_1 with the highest weighting factor ($C_1 = 0.45$) was Mathematics, C_2 - Ukrainian language and literature and C_3 - at the choice of the entrant or Geography or Foreign language.

In the second model, the profile subject E_1 was the History of Ukraine, E_2 - respectively, remained the Ukrainian language and literature, a E_3 - at the choice of the entrant or Geography or Mathematics. Thus, according to this scheme, even those entrants who did not pass or did not pass the threshold of "passing / not passing" the external examination in mathematics had the opportunity to enter the university. It should be noted that enrollment in the HEI in this case took place only on a contractual basis.

Table 1 shows the quantitative distribution of students of test HEI between different methods of

calculating the competitive score. This table, for comparison, also presents the results of the introductory campaign in 2019, because then used a similar approach to determine the C_S of this branch of knowledge. As can be seen from table 1 the number of students who chose the second method of calculating the C_S in 2019 has increased significantly. If in 2018 their share was 36.7%, then in the next year - almost half of the students enrolled in the test HEI.

It is worth noting that in 2019 the number of enrolled students who did not have an EIE Mathematics certificate also doubled. In general, the use of a two-model method of calculating the C_S, allowed the test HEI to significantly increase the contingent of students in 2019. This approach proved to be attractive especially for those entrants who did not have an external examination in mathematics, or it was too small to successfully participate in the general competition.

Table 1.

Quantitative distribution of students in the branch of knowledge 07 "Management and Administration" between different methods of calculating the competitive score, used by test HEI in 2018 and 2019

	Total number of students	Used the I-st model calculation of C_s		Used the II-nd model calculation of C_s		Did not pass the external examination in mathematics	
		number of people	%	number of people	%	number of people	%
According to the results of the 2018 accession	60	38	63,3	22	36,7	14	23,3
According to the results of the 2019 accession	85	43	50,6	42	49,4	28	32,9

Source: generated and calculated by the author based on the data given in [15]

Table 2 presents descriptive statistics of indicators of competitive selection of students in the branch of knowledge 07 "Management and Administration" test

HEI with different methods of calculating C_S. In the given characteristics it is possible to pay attention that in 2018 the average competitive score calculated by the

I method is much higher than the corresponding indicator of the II method and the total sample size. Thus, we can conclude that students with potentially higher EIE scores chose the first method for calculating the C_S.

Table 2.

Descriptive statistics of indicators of competitive selection of students in the branch of knowledge 07 "Management and Administration" of test HEI

Indicator	Year of entry	Sample size	Arithmetic mean	The standard deviation	Asymmetry	Kurtosis
General competitive score	2018	60	143,4	16,26	0,596	0,167
	2019	85	145,8	17,64	0,315	-0,704
Competitive score, which is calculated for the I method	2018	38	144,2	17,24	0,781	0,062
	2019	43	149,97	17,28	0,084	0,669
Competitive score, which is calculated for the II method	2018	22	140,7	15,03	-0,071	-0,392
	2019	42	141,5	17,16	0,62	0,284
EIE, Mathematics	2018	46	127,02	22,45	0,747	0,235
	2019	57	131,25	22,30	0,372	0,969
EIE, Ukrainian language and literature	2018	60	150,55	20,82	-0,261	-0,435
	2019	85	146,02	22,3	-0,093	-0,945
EIE, History of Ukraine	2018	22	129,1	17,6	0,24	0,258
	2019	42	135,3	19,1	0,302	0,167

Source: generated and calculated by the author based on the data given in [15]

This correspondence is also observed for the indicators of 2019, but their values have significantly increased compared to last year. This is especially true for the average C_S, determined by the first method (149.97 in 2019 vs. 144.2 in 2018).

It should also be noted that the average score of the EIE in Mathematics in 2018 (127.02) was significantly lower than the corresponding indicator of the EIE in Ukrainian language and literature (150.55). This situation is typical, mostly, for students of economic specialties and corresponds to the general trend of decreasing the level of physical and mathematical education of school graduates, which has been observed recently in Ukraine. In 2019, the difference between the average EIE scores for these subjects becomes less significant. The average score of the EIE in mathematics increased slightly (131.25), and the average score of the EIE in the Ukrainian language and literature decreased (146.02).

Also noteworthy is the low average indicator of external evaluation in history of Ukraine (129.1 in 2018), which was used as a profile subject for the second method of calculating the C_S. Taking into account also the lower average competitive score for this group of students, it is expedient to further evaluate their results of success in the HEI.

The use of two different models of competitive selection of entrants for one branch of knowledge, is of interest in assessing their indicators of prognostic validity, even with small sample sizes. Table 3 shows the Spearman correlation coefficients between the grades obtained by students during their studies in the test HEI, and the indicators that were used as criteria for selecting students for admission. A higher correlation coefficient means a greater prognostic validity of the criterion.

As can be seen from Table 3, use by the test HEI two-model system of competitive selection of entrants, for one branch of knowledge, has a fairly high level of prognostic validity (R > 0.5). In fig. 2 also shows the correlation field of dependence between the average score of students of test HEI and their competitive score.

It is significant that the values of C_S are better correlated with the average student performance, calculated from the results of the second session. And this is typical for all, without exception, the indicators listed in table 3. One of the main reasons for this pattern may be the problem of psychological adaptation of freshmen in the autumn (first) semester to new, unfamiliar to them methods of teaching and assessment.
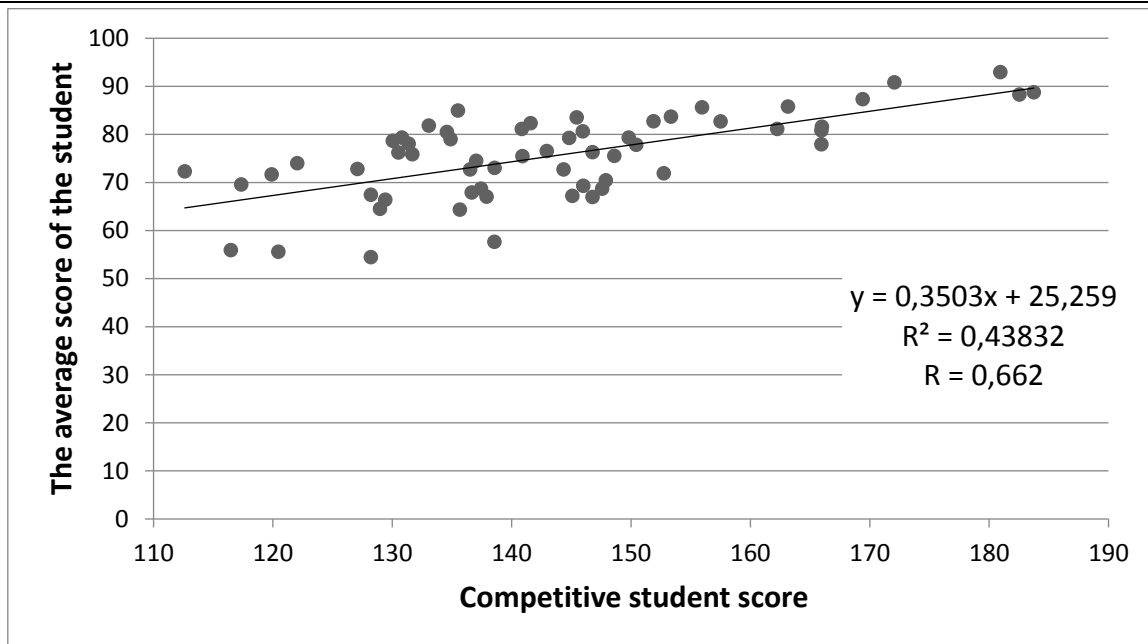
Fig. 2. Correlation field of dependence of the average score of the success of freshmen in the branch of knowledge 07 "Management and Administration" on their competitive score, obtained according to the EIE 2018. The sample size is 60 people
Source: generated and calculated by the author based on the data given in [15]

Analysis of the data shown in table 3 shows that the highest prognostic validity is the I method of calculating the competitive score. We will remind that in this method Mathematics is a profile subject with the highest weighting factor. But, as it turned out, the results of the EIE only in this discipline are less correlated with the average scores of students of the test

HEI (R = 0.421 for the first semester and R = 0.541 for the second). Therefore, the improvement of the forecast function of competitive selection is achieved through the use of an integrated model of calculation of the C_S with a successful combination of EIE subjects with their corresponding weights (1).

Table 2

Prognostic validity of components of competitive selection of students in the branch of know-ledge 07 "Management and Administration" of test HEI according to the results of EIE 2018

Indicator	Sample size	Average score of the first session	Average score of the second session	Average score of first-year students
Correlation of the competitive score with the assessments of first-year students of the total sample size	60	0,573	0,674	0,662
Correlation of the competitive score calculated according to the first method with the assessments of first-year students	38	0,643	0,728	0,718
Correlation of the competitive score calculated according to the II method with the estimations of first-year students	22	0,417	0,581	0,564
Correlation of the competition score with the grades of first-year students who passed the external examination in mathematics	46	0,597	0,699	0,682
Correlation of external evaluation results in mathematics and grades of first-year students	46	0,421	0,541	0,509
Correlation of external evaluation results in Ukrainian language and literature with the assessments of first-year students	60	0,577	0,600	0,619
Correlation of external evaluation results in history of Ukraine and assessments of first-year students	22	0,324	0,329	0,364

Source: generated and calculated by the author based on the data given in [15]

To assess the impact of the results of the external examination in mathematics on the prognostic validity of the two-model system of competitive selection of students, from the general sample were excluded persons who did not have a certificate in this subject and redefined correlation coefficients (Table 3). The result of the calculation was slightly better than the corresponding indicator of the total sample size. Thus, despite the fact that the external examination in mathematics is not a strong predictor of the success of freshmen, its mandatory inclusion in the two-model calculation formula C_S leads to an increase in the prognostic validity of competitive selection of students in the branch of knowledge 07 "Management and Administration" test HEI.

Table 3

Average success rates of first-year students in the branch of knowledge 07 "Management and Administration" test HEI according to the results of the 2018-2019 academic year

Indicator	Sample size	Average score of the first session	Average score of the second session	Average score of first-year students
The average score of first-year students in the total sample	60	77,5	73,4	75,5
The average score of freshmen, for whom the index of C_S was calculated by the I method	38	77,4	73,2	75,3
The average score of freshmen, for whom the index of C_S was calculated by the II method	22	77,9	73,8	75,9
The average score of freshmen who had a certificate of external examination in mathematics	46	78,2	73,9	76,1
The average score of freshmen who did not have a certificate of external examination in mathematics	14	75,2	71,7	73,5

In the II method of calculating the C_S as a profile subject used the results of external evaluation of the History of Ukraine. Thus, this discipline had the highest weighting factor (0.45) and the greatest influence in determining the competitive score by formula (2). But, as can be seen from Table 3, the external evaluation of the History of Ukraine is the worst correlated with the success of first-year students in economics, compared to other subjects (R = 0.324 in the first semester, R = 0.329 in the 2nd semester and R = 0.364 for the academic year) .

The consequence of this is also a much lower prognostic validity of the second model of competitive selection relative to the first model (R_{II} = 0.564 against R_I = 0.718 on the average performance of students during the first year of study).

Instead, EIE of the Ukrainian language and literature, as shown by the calculations given in table. 3, is a strong predictor of success of first-year students in economics.

The above analysis of the prognostic validity of the components of competitive selection, which is used in the II method of calculating the C_S, allows, varying the weights of the disciplines of external evaluation, to obtain a more optimal model for calculating the competitive score. Since the highest indicators of the forecast were the assessments of the External Evaluation of Ukrainian Language and Literature, their weighting in the structure of the competition score should be the highest. Therefore, it is advisable to use this subject as a profile with a weighting factor C_1 = 0.45 instead of the external evaluation of the History of Ukraine. Thus, the formula for calculating C_S (2) in this case remains unchanged, and only subjects change places: E_1 - History of Ukraine and E_2 - Ukrainian language and literature.

Another, alternative option for calculating the C_S by the II method, you can consider a model for which all subjects of external evaluation have the same weighting factor $C_1 = C_2 = C_3 = 0.3$. Then the formula for its calculation takes the following form:

$$C_S = (0.3 \cdot E_1 + 0.3 \cdot E_2 + 0.3 \cdot E_3 + 0.1 \cdot A) \cdot R_c \cdot V_c, \quad (3)$$

where E_1 - EIE History of Ukraine, E_2 - EIE Ukrainian language and literature, E_3 - at the choice of the entrant or Geography or Mathematics.

To evaluate and compare the proposed methods of calculating the C_S, the competitive score of entrants in this sample was listed according to the chosen method, and the correlation indicators were determined (Fig. 3).

As expected, the best result of the forecast of the average success of first-year students (R = 0.621) is the model in which the EIE Ukrainian language and literature has the highest weighting factor $C_1 = 0.45$, and the worst (R = 0.564) - used by the test HEI in 2018. In other words, this means that the change of places of objects EIE E_1 and E_2 in the II model of calculation of C_S, leads to a significant increase in its prognostic validity, and as a result there is an increase of the correlation coefficients in the total sample size (Table 4).
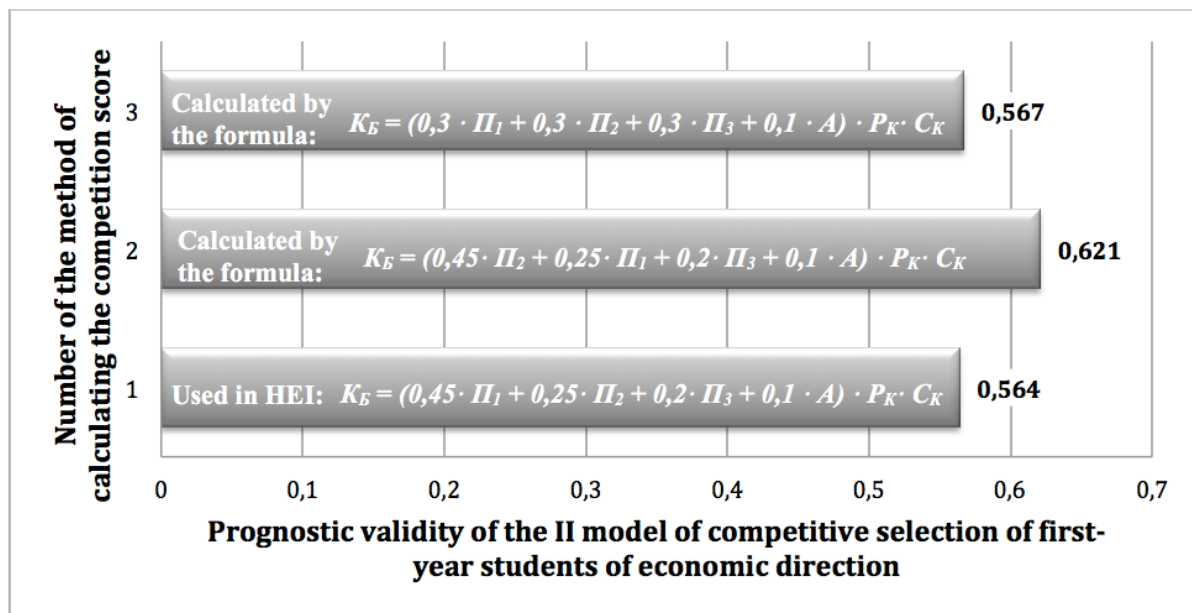
Fig. 3. Prognostic validity of the II model of competitive selection of first-year students of economic direction with different calculation methods of C_S

Note also that the use of formula (3) for the calculation of C_S has little effect on the change in the value of the correlation coefficient.

The values of the indicator of prognostic validity of the two-model competitive selection system for the above proposed alternative methods of calculating C_S are given in table 4.

As can be seen from the data in table. 4, for alternative methods, the mentioned above tendency to increase the correlation of the competitive score with the average scores of the second semester is stored, compared with the scores of the first semester. And the

use of EIE Ukrainian language and literature as a profile subject of the II model, contributes to the increase of its forecast indicators and the total sample size. The correlation equation, which allows with some error to predict the average performance of a freshman, in this case, is:

$$Y = 0.3489 \cdot C_S + 24.986 , \qquad (4)$$

where Y is the average score of the student in the branch of knowledge 07 "Management and Administration" according to the results of the first year.

Table 4

Predictive validity of alternative two-model systems of competitive selection of students branch of knowledge 07 "Management and administration" test HEI according to the results of EIE 2018

Type of model	Indicator	Sample size	Average score of the first session	Average score of the second session	Average score of first-year students
Two-model competitive selection system used in the HEI	Predictive validity of the total sample size	60	0,573	0,674	0,662
	Prognostic validity of the II method of calculation of C_S	22	0,417	0,581	0,564
An alternative two-model system, in which the objects of external evaluation E_1 and E_2 are changed in places when calculating the C_S of the II method	Predictive validity of the total sample size	60	0,584	0,688	0,676
	Prognostic validity of the II method of calculation of C_S	22	0,459	0,640	0,621
An alternative two-model system in which the C_S II method is calculated by formula (3)	Predictive validity of the total sample size	60	0,564	0,681	0,662
	Prognostic validity of the II method of calculation of C_S	22	0,378	0,608	0,567

Preliminary calculations (Table 2) also showed that the average competitive score calculated by the first method is much higher than the corresponding indicator of the second method and the total sample size. Therefore, it is advisable to compare the average performance of students in these groups during the first year of study in the HEI (Table 5).

Analysis of the data given in table 5 shows that the average student performance is almost the same for each group, and therefore, they are independent of the method of calculating the competitive score. This is in favor of a two-model C_S calculation system, as its application does not lead to a general decrease in the level of average success of freshmen.

It should also be noted that students who have not submitted certificates of external examination in Mathematics have slightly lower learning rates compared to other persons.

Table 5

Average success rates of first-year students in the branch of knowledge 07 "Management and Administration" test HEI according to the results of the 2018-2019 academic year

Indicator	Sample size	Average score of the first session	Average score of the second session	Average score of first-year students
The average score of first-year students in the total sample	60	77,5	73,4	75,5
The average score of freshmen, for whom the index of C_S was calculated by the I method	38	77,4	73,2	75,3
The average score of freshmen, for whom the index of C_S was calculated by the II method	22	77,9	73,8	75,9
The average score of freshmen who had a certificate of external examination in mathematics	46	78,2	73,9	76,1
The average score of freshmen who did not have a certificate of external examination in mathematics	14	75,2	71,7	73,5

Conclusions. A statistical study of the correlations between the components of the competitive selection in 2018, and the average performance of first-year students in the branch of knowledge 07 "Management and Administration" indicates that:

1) the two-model system of calculating the competitive score used by the test HEI has a fairly high prognostic validity (R = 0.662) and has a positive effect on increasing the contingent of students in 2018 and 2019;

2) the highest prognostic validity ($R_I = 0.718$) has the first method of calculating the competitive score, in which Mathematics is a profile subject with the highest weighting factor;

3) EIE Ukrainian language and literature, in comparison with other disciplines, is a relatively strong predictor (R = 0.619) of the success of first-year students in economics, and for EIE assessments in the History of Ukraine this indicator is the lowest (R = 0.364);

4) the use of external evaluation Ukrainian language and literature, as a profile subject of the second method of calculating the competitive score, allows to increase its prognostic validity ($R_{II} = 0.621$) and improve the correlation indicators of the total sample size (R = 0.676).

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