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Analysis of key factors of influence on scientometric indicators of higher educational institutions of Ukraine

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ABSTRACT

In the article, the authors set out to determine the degree of influence of factors (the university profile, the year of its foundation, the number of research and teaching staff, the population of the city in which the educational institution is located) on the indicators of the publishing activity rating of teachers of Ukrainian universities (according to the Hirsch index, which determined by the indicators of the SciVerse Scopus database). One-way analysis of variance and multiple regression models were used for this. As a result, the influence of all the proposed factors was revealed, although the degree of influence for each of them turned out to be different. The article also determines the degree of influence of these factors on the operational indicator of scientific activity of teachers - the number of citations in 2018–2019 of articles written in 2018 per one researcher or instructor. In this case, the same methods showed the influence of only two factors - the profile of the university and the number of research and teaching staff. Conclusions are drawn about the need for building university rankings using operational (rather than cumulative) indicators of scientific activity and the importance of taking into account the profile of educational institutions by introducing weighting factors.

1. Introduction

According to established practice, in April, the Ukrainian resource Osvita.ua carries out scientometric monitoring of the activities of Ukrainian universities as reflected in the SciVerse Scopus database, based on which a general rating of Ukrainian universities is compiled (Rating, 2019). The results of this rating are based on those indicators of the Scopus database, which are a tool for tracking the citation of scientific articles published by employees of higher education institutions in Ukraine.

In the rating provided by Osvita.ua (Rating, 2019), each institution of higher education is rated by three indicators: the number of publications, the number of citations, and the Hirsch index (h-index), which are determined by the SciVerse Scopus database as of April 2019. The overall rating was derived by the h-index, and in cases when the indicator value was the sasme, the rating of the institution was determined by the number of citations.

Obviously, the indicators of the Scopus database, which are taken as the main ones for assessing higher education institutions, are directly affected by the scientific activity of its research staff. The higher such activity, the higher will be the scientometric indicators of the research and teaching staff of a higher educational institution, and, as a result, the indicators in the rating of the educational institution itself will probably be higher. Although, given the discrete nature of the h-index itself, the question may arise about the degree of "relevance" of this indicator for a particular institution. After all, its value always contains a certain part of “accumulated scientific merits”, and it may happen that the actual h-index is formed mainly due to the results of studies of those scientists who already or do not work in this institution, or are not currently engaged in scientific research. And it is not always (more likely - never) from such reports it seems possible to determine the real modern scientific activity and the dynamics of development of research in a particular institution of higher education.

On the other hand, the interpretation of the index of scientific citation also raises many questions. This became the subject of scientific discussions of representatives of different areas of research - stochastics, medicine, technology, philosophy and sociology of science. And yet, what does citation index mean? Does it mean a measure of authoritativeness of the author in a certain scientific field? Assessing the scientist’s scientific productivity? The degree of influence of the scientist on the scientific community? An indicator of the researcher’s desire to enlist the support of other authors in his own research? The level and

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quality of development of a certain scientific direction? A quantitative or qualitative indicator of the presence of links between researchers? A criterion for the classification of scientific papers? Or, finally, a subject for studying the motives that guided the scientist, making references to the works of other scientists? And is it possible to draw administrative conclusions about the level of scientific research of an individual scientist by citation indicators? Participants in discussions (Zhukova, 2013) are inclined to partially positive answers to all these questions. That is, the citation index of a particular scientist can only partially characterize the measure of his/her authority, the magnitude of the assessment of the author's scientific productivity, the degree of his/her influence on the scientific society, etc. Therefore, the value of the citation index, as well as the value of the h-index, can be only one of the factors that can be taken into account when answering these questions. Unfounded are the conclusions of the article by Celâl Şengör (2014) on the negative impact of scientometrics on science. The philosophical point of view on the content of the scientific citation index is presented by Peters and Marsh (2009), which, based on the understanding of this index as a degree of influence, determine the areas of such influence for research in business and management as follows: practice, government policy, training, Social Studies. As a result, the authors propose defining criteria for the quality of research based on the mentioned spheres of influence and their interaction. Therefore, applying quantitative indicators to assess the work of individual scientists is rather difficult.

On the other hand, will conclusions from citation statistics that can be drawn on large data sets be justified? Namely, comparing the development of science in different countries or the scientific ratings of individual research organizations or higher education institutions in one country, ranking scientific journals (within the same discipline), etc. And further, on the basis of these conclusions, is it possible to make strategic decisions in the field of science management? And if it is possible, by what technique you need based on the data to build the Science Citation ratings of countries, organizations, agencies or magazines to strategic management decisions in the field of science have been relevant, objective and appropriate? Let us dwell in more detail on the analysis of the components of the methodology for constructing ratings of Ukrainian universities according to scientific citation.

Based on the above comments, we denote the main problem of our study. What is the degree of influence on the h-index according to the SciVerse Scopus database for higher educational institutions of Ukraine of the following factors: year of founding of the institution of higher education, population of the city where the educational institution is located, its profile and the number of teaching staff.

The main objectives of the study are defined as follows: a) determination of external factors affecting the performance of the h-index at universities in Ukraine; b) the choice and use of mathematical and statistical methods to determine the degree of influence of these factors; c) replacing the indicator of the h-index with an operational indicator of the publication activity of university teachers and determining the degree of influence of these factors on this indicator; d) formulating conclusions based on the results of the study.

2. Literature review

The problem of determining the factors of influence on the indicators of scientific productivity of individual scientists and institutional subjects is relevant for many researchers in the sociology of science and scientometrics. Let us present a brief overview of the most significant results in our opinion.

The amount of funding for scientific research in a number of publications is called one of the most significant factors influencing the effectiveness of research activity of subjects of scientific research (Benito et al., 2019; Pietrucha, 2018; Ebadi and Schiffauerova, 2016). Moreover, researchers Benito et al. (2019) determined that public funding becomes critical for 84 % of the top 300 universities selected for analysis (based on Quacquarelli Symonds, ranking 2018). In addition to the financing factor, the authors also studied the influence of geographical location, form of ownership (public / private), scale and financial resources of these universities. Pietrucha (2018) named variables that determine the position of the universities from a particular country in the world ranking: the country's economic potential, research and development costs, long-term political stability (the absence of war, occupation, coups and major changes in the political system) and institutional variables, including government effectiveness.[1] Ebadi and Schiffauerova (2016) in addition to the impact of research funding in the quality of scientific results as factors of influence paid attention to the types of financing programs, and also noted the negative effect of the career age on professional research quality. Korytkowski and Kulczycki (2019) determined that when choosing the method of calculating publications for the purpose of national assessment, it is necessary to take into account the current situation in the country in terms of the importance of research results, the level of internal, external and international cooperation and publication models in various fields of science. And Frenken et al. (2017), using regression analysis, evaluated the extent to which university variables are affected by structural variables, including its scale and age, city size, academic programs and country location. According to the results of this work, differences in research results among universities are mainly related to the size of the institution, academic programs and location of the country. Anninos (2014), using a bibliometric methodology, concluded that the results of scientific activities of universities may depend on their scientific orientation and number of staff.

As a factor of influence on indicators of scientific productivity of universities called the fact of open access publishing (Mikki, 2017; Repanovici, 2011; Holmberg et al., 2020). In addition, criticizing the one-dimensional approach to assessing the results of institution's research, López-Illescas et al. (2011) show that evaluating a university's research activity should take into account the disciplinary breadth of its publication activity and the impact of citation. Of interest is also the publication of Van Raan et al. (2011), in which the authors note the negative impact of the language effect on the scientific activity of European universities and express concern that this effect will be seriously exacerbated by expanding the coverage of WoS and Scopus journals in national languages. And in publications (Bornmann and Daniel, 2008) and (Tahamtan and Bornmann, 2019) (the second article is, in fact, a continuation of the first) using polls or interviews, the motivation for citing scientists is analyzed. The authors analyze a number of features of such motivation: citation context, semantics and language patterns in citation, places of citation in a citing document, and citation polarity (negative, neutral, positive). Finally, György Csomós (2017) demonstrated an interesting visualization of the international scientific cooperation of cities, namely the spatial scientometric approach based on Scopus data.

On the contrary, there are developments in which a toolkit for localizing the problem of the influence of various factors on the indicators of scientific productivity of individual scientists and institutional subjects is proposed. Siniksaran and Satman (2020) created software for modeling the WURS ranking of universities, in which normalization or adjustment processes are applied for some indicators (for example, the revenues of institutions and research are normalized by purchasing power parity, or the normalized citation impact indicator is adjusted by country or region). Other suggestions of the toolkit for building ratings are also of interest: objectification of the criteria for selecting links in the manuscript in relation to the cited authors or journals by organizing a systematic search in the network of citations (Amancio et al., 2012); the use of a platform for assessing in relative terms the effectiveness of publications at the author level, in which there are two determining factors - the publication performance index (PPI)

[1] Government Effectiveness (2020). World Bank, Worldwide Governance Indicators. https://info.worldbank.org/governance/wgi/pdf/ge.pdf

and the publication performance block (PPB) (Simoes and Crespo, 2020); the implementation of a multidimensional approach to rating building, in which the authors tried to overcome four main problems of ratings - one-dimensionality, statistical stability, dependence on the scale of the university and subject composition, lack of accounting for input-output structure (Daraio et al., 2015). Another group of scientometric researchers has improved the tools for localizing the problem of the influence of factors on indicators of scientific productivity in the context of developing new scientometric indices based on the h-index: the study of the possibilities of using h-index derivatives (Costas and Bordons, 2008; Schreiber et al., 2011; Miroiu et al., 2015; Stovba and Stovba, 2016); a comparative analysis of the ranking of national research systems according to citation indicators using integer and fractionated methods of calculation (Aksnes et al., 2012); a scientometric index proposal, which has two components: the first describes the apparent dissemination of scientific knowledge, and the second reflects the implicit dissemination of scientific knowledge and is expressed through the number of implicit references (Shtovba and Shtovba, 2013). Finally and Moskaleva's study (2014) provides statistical information on the methods for using indicators of scientific publications to compile international university ratings, analyzes specialized publication activity ratings and the relationship between the number of national scientific journals presented in the Web of Science and Scopus databases and the representation of countries in university ratings.

3. Main research results

For a statistical analysis of the degree of influence of the factors defined by us above on the indicators of scientific citation, we consider the rating of higher educational institutions of Ukraine for the indicators of the scientiometric base SciVerse Scopus as of 01/15/2019 (Rating, 2019). The rating contains three indicators: the number of publications; number of citations; Hirsch index (h-index) (all according to the SciVerse Scopus database). The rating contains data from 163 Ukrainian universities, but for the purpose of this analysis we will use only 142, excluding institutions of higher education in the Crimea and certain areas of Donetsk and Lugansk regions, since the statistics from those institutions are not available.

Taras Shevchenko National University of Kyiv is far ahead of all universities in Ukraine with an indicator of 88. On the other end, two higher education institutions in the ranking have zero Hirsch index indicators - these are Berdyansk University of Management and Business and Kharkiv University of Technology 'Step', with a few publications in the database which have never been cited.

We use additional variables that we introduce as factors of influence on scientometric indicators of universities: a) the year the university was founded; b) the number of doctors and candidates of sciences in the university (see Examples Group 3)[2] ; c) university profile; d) the population of the city in which the university is located.

We have obtained values for quantitative variables (a) and (b) for all universities from Specialized Portal about Education in Ukraine[3], and variable (d) – from State Statistics Service of Ukraine[4] .

In Table 1, we presented the ranking of Ukrainian cities by population number. Further on, we will not use the population of the city in which the university is located, but rather its rating by size.

Variable item (c) - University profile - categorical. Note that the categorical (i.e., qualitative, rather than quantitative) measurement scale is characterized by the fact that each value defines a separate category into which the values of the variable fall (each category differs from the other, but this difference cannot be quantified).

Table 1
The gradation of cities by population.

City population (people)	City population rating
More than 1 000 000	1
500 000–1 000 000	2
250 000–500 000	3
100 000–250 000	4
50 000–100 000	5

Define the values of the categorical variable "university profile" as shown in Table 2.

Let us find out the effect of each of the four named factors on the h-index. As the first studied influence factor, we choose a variable – "University Profile". For this task we use one-way analysis of variance. To apply it, the independent variable must be categorical, as in our case. When conducting a factor experiment (treatment) in the analysis of variance, a specific combination of categories (levels) of the factor is used. The factor levels in us will be categorical values of university profiles (Table 3).

The analysis results show that *Sig.* = 0,000, that is, the difference between the average value of the h- index in the groups by the profiles of universities is statistically significant (<0,05). Thus, the factor "university profile" affects the performance of the h-index on (7879,363/29018,120) · 100 % =27,2 %. Since the effect of the categorical variable "university profile" is very significant, in the future we will conduct research both for all educational institutions and within groups according to their profiles.

Let us determine the dependence of the h-index on quantitative variables (Table 4).

Two correlations are significant at 0.01. The "older" the educational institution, the higher the h-index, and the more staff of candidates and doctors of science, the higher the h-index. City population rating is not a significant separate factor, but it is close to a significant one at the level of 0.05 and we will consider it, since for certain types of universities it will be a significant factor.

In order to clarify the results of determining the influence of quantitative factors on the h-index of universities for each block by university profiles:

1) Let us analyze the bivariate correlations between the Hirsch index and quantitative variables (the year the university was founded; the number of doctors and candidates of science; the population of the city (city population rating) in which the educational institution is located);
2) construct a multiple linear regression model for each university block (with the same conditions: h- index is a dependent variable, the remaining quantitative variables are independent).

The use of multiple regression allows us to answer the question of how well the estimated equation approximates the data, whether there is a significant linear relationship, and also what are the estimated

Table 2
The values of the categorical variable "university profile".

University Profile	Value
classical	1
technical	2
economical	3
medical	4
pedagogical	5
agricultural and environmental	6
other	7

[2] OECD/Eurostat/UNESCO Institute for Statistics (2015), "ISCED 2011 Level 8: Doctoral or equivalent level", in *ISCED 2011 Operational Manual: Guidelines for Classifying National Education Programmes and Related Qualifications*, OECD Publishing, Paris. DOI: https://doi.org/10.1787/9789264228368-13-en

[3] https://www.education.ua/ua/universities/

[4] http://database.ukrcensus.gov.ua/PXWEB2007/ukr/publ_new1/2019/zb_chnn2019.pdf

Table 3
The results of the one-way analysis of variance of the impact of the university profile on the h- index.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7879,363	6	1313,227	8,387	,000
Within Groups	21138,757	135	156,583		
Total	29018,120	141			

h-index.

Table 4
Matrix of Bivariate correlations between the h-index and quantitative factors (variables).

		Year of foundation	Number of doctors and candidates of science	City population rating
h_index	Pearson Correlation	-,346**	,740**	-,132
	Sig. (1-tailed)	,000	,000	,059
	N	142	142	142

** Correlation is significant at the 0.01 level (1-tailed).

values of the coefficients for the best prediction equation. In addition, the relative importance of the independent variables in predicting the dependent variable can be determined. All intermediate calculations we performed in the statistical package SPSS.

For ease of presenting the results, we present them in the form of Table 5, which introduced the main characteristics for bivariate correlations (their values and significance) and multiple linear regression equations (determination coefficient, multiple correlation coefficient, model significance level, standardized regression equation coefficients). Let us analyze the results.

In the Table 5, the cells in which the significant bivariate correlations are located, as well as the cells in which the significant multiple linear regression models are located, are highlighted in gray.

Significance is the probability that the result is random. By default, significance should be less than

0.05. The lower the probability of error, the greater the confidence that the selected factors *X* together affect the dependent variable *Y*. The standardized coefficient of the regression equation determines the strength of the influence of the variation x_j on the variation of the productive attribute y while abstracting from the concomitant influence of the variations of other factors included in the regression equation. The standardized coefficient is calculated in the range from -1 to +1. Standardization allows you to compare variables with different sizes and units of measure. The higher the value of the Beta coefficient modulo, the stronger the given factor *X* affects the dependent variable *Y*. The sign of the coefficient indicates the direction of the connection: a positive coefficient indicates a directly proportional relationship (with an increase in *X*, the value of *Y* increases), and a negative coefficient indicates an inverse proportional relationship (with increasing *X*, the value of *Y* decreases). If the Beta coefficient is close to 0, then with the growth of *X* the value of *Y* remains constant (that is, *X* practically does not affect *Y*).

The multiple correlation coefficient for the model for all 142 universities is 0.757 and the model is significant. And this suggests that the three selected factor variables have a significant joint effect on the h-index. This model does not include a categorical variable "university profile," which we discussed above. When constructing a quantitative-categorical regression model taking into account the "university profile" factor, the multiple correlation coefficient is 0.823, which indicates a significant joint effect of all the selected factors.

Let us briefly analyze which factors are more significant in each of the groups of educational institutions. We note right away that in two groups of universities - "pedagogical" and "others" - no factors are separately significant and general regression models are not significant.

In classical, technical, economic, medical and agricultural universities, the most important factor in influencing the Hirsch index is the "number of doctors and candidates of science." In classical and agricultural educational institutions, the second most important factor was the "population of the city", and in technical - the "year of foundation." These factors also have an effect in general models for other types of universities.

Note that in international university rankings such as Academic Ranking of World Universities (ARWU, or Shanghai Ranking), Times Higher Education World University Ranking (THE WUR) and QS World University Ranking (QS), indicators related to publication activity are from a third to two- thirds of the final rating score. This indicates the extreme importance of scientific publications for evaluating the activities of the university. Different methods are used to evaluate publication activity: for example, the number of citations received by university articles over 5 years according to the Scopus database per 1 teacher; the number of highly cited scientists from among university employees; the number of articles published in the journals Nature and Science over the past five years and others. Note that in none of the cases known to us is the general indicator of the h-index of the university used.

Let's try to find out the degree of influence of the factors highlighted above on one of the accepted methods of measuring publication activity, for example, on the number of citations received by university articles over 2 years according to the Scopus database per one research and teaching worker (we limit the number of articles to those published by teachers of Ukrainian universities in 2018, and citation period - 2018–2019 years).

When conducting a one-way analysis of variance of the degree of influence of the factor variable "university profile" on the number of citations per one research and teaching worker for 2018, we obtained such results (Table 6).

As a result of the analysis, we see that the factor "university profile" affects the indicator "Number of citations per one researcher/instructor", although the level of its influence has become lower. It is equal 14,4 %.

Let us determine the dependence of the number of citations per teacher on quantitative variables. Consider the matrix of bivariate correlations of the influence of quantitative factor variables (the year the university was founded; the number of doctors and candidates of sciences; the population of the city (city population rating) in which the educational institution is located) on the indicator "Number of citations per one researcher/instructor" (Table 7).

From this matrix we see that only one factor - "the number of doctors and candidates of sciences" - is weak, but still affects the Number of citations per one researcher/instructor. But the other two factors - "the year the university was founded" and "the population of the city" - completely lost their influence on the citation rate.

In order to compare the results obtained by different methods for determining the publication activity of teachers of Ukrainian universities, we made a comparative analysis of the h-index (on the graph it is ranked by university profiles) and "Number of citations per one researcher/instructor" (Fig. 1).

Having made the necessary calculations, we found that the correlation coefficient between the h-index and the number of citations per one researcher/instructor for 2018–2019 publications for 2018 for all universities is significant and equal to 0.522. The highest correlation coefficient for these indicators in the group of "medical universities" is 0.71, further: "classical universities" - 0.64, "technical universities" - 0.57, "pedagogical universities" and "agricultural universities" – 0.38, "economic universities" - 0.26, "other universities" - (−0.36).

4. Discussion

The problem of determining factors of influence on the results of the publication activity of the research and teaching staff of higher education institutions is relevant not only for Ukraine. And this can be seen in scientometrics publications (we presented in this article a brief overview

Table 5
Results of bivariate correlations and multiple regression models.

Indicator	Classic	Technical	Economic	Medical	Pedagogical	Agricultural	Other	Overall
Number of Universities blocks	25	43	11	15	18	16	14	142
Bivariate correlations of factor variables with the h-Index and their significance								
Year of foundation	-,235	-,563	-,459	-,295	-,367	,061	,136	-,346
The number of doctors and candidates of sciences	,834	,786	,589	,686	,035	,632	,240	,740
City population rating	-,435	-,225	,415	-,306	,058	-,472	-,050	-,132
Parameters of multiple linear regression models								
R-squared	,721	,632	,663	,595	,192	,522	,180	,573
Multiple correlation	,849	,795	,814	,772	,438	,722	,424	,757
Model significance	,000	,000	,044	,016	,379	,027	,558	,000
Standardized Regression Equation Coefficients								
Year of foundation	-,087	-,120	-,463	-,164	-,520	-,046	,108	-,165
The number of doctors and candidates of sciences	,759	,703	,507	,685	-,209	,556	,418	,695
City population rating	-,156	-,055	,366	-,253	,144	-,366	-,053	-,012

Table 6
The results of a one-way analysis of variance of the impact of the university profile on the number of citations per one researcher/instructor.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,275	6	,213	3,793	,002
Within Groups	7,566	135	,056		
Total	8,841	141			

Number of citations per one researcher/instructor.

Table 7
Matrix of bivariate correlations between the "Number of citations per one researcher/instructor" and quantitative factors (variables).

		Year of foundation	Number of doctors and candidates of science	City population rating
Number of citations per one researcher/ instructor	Pearson Correlation	-,062	,248*	-,115
	Sig. (1-tailed)	,231	,001	,086
	N	142	142	142

the indicators of the "Consolidated Rating of Ukrainian Universities" (Rating, 2019a), which in turn affects the decisions of educational managers (regarding the distribution of the state order for training specialists[5]), employers (regarding the choice of graduates to fill vacancies), and applicants (in part of the choice of university to teach certain programs). Consequently, the results of scientometric monitoring of the activities of Ukrainian universities have a solid political weight for the latter. And this means that the methodology for conducting such monitoring should take into account, first of all, the relevant (or operational) indicators of publication activity of educational institutions for a specific period of time.

Determining the degree of influence of the university profile on the h-index (according to the indicators of the SciVerse Scopus database) gives an answer to this question. Is it necessary to introduce weight coefficients for universities of different profiles when determining the indicator of publication activity of the research and teaching staff of a university?

Determining the degree of influence of the university's age ("old", "experienced") on the h-index indicator allows us to determine whether it is advisable to take into account the influence on the political decisions in the field of higher education of the accumulated value of the h-index for all years of the university's existence (or the total number of

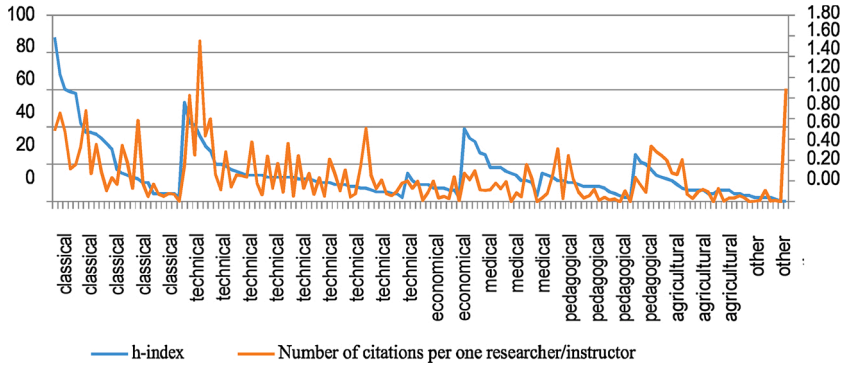

Fig. 1. h-index and the Number of citations per one researcher/instructor.

of the most significant ones). One of the main questions is how objective are the political conclusions of science managers, which are drawn from the analysis of the publication activity of university teachers. What does the solution of this issue look like for higher education institutions in Ukraine?

Recall that scientometric monitoring of subjects of scientific activity of Ukrainian universities is carried out according to the indicators of the SciVerse Scopus database, based on which, depending on the h-index of each university, a general rating of Ukrainian higher education institutions is compiled (Rating, 2019). This rating is further used as one of

citations). In addition, the study of the degree of influence of the population of the city in which the institution of higher education is located on the indicators of publication activity makes it possible to determine

[5] CABINET OF MINISTERS OF UKRAINE. DECREE "On the state order for the training of specialists, scientific, researcher/instructor and working personnel, for advanced training and retraining in 2020". 08/07/2020. № 616. Kyiv. https://www.kmu.gov.ua/npas/pro-derzhavne-zamovlennya-na-pidgotovku-fahivciv-naukovih-naukovo-pedagogichnih-ta-robitnichih-t80720

whether in this case it is necessary to introduce weights for universities depending on the population of their cities.

Finally, determining the degree of influence of the university scale on the Hirsch index indicator allows, in the presence of such an influence, to confirm the truth: the larger the educational institution, the higher its publication activity in the absolute values of the indicators. To characterize the scale of the university, we chose the number of doctors and candidates of sciences. Considering that in Ukraine there is a clear correlation between the number of teachers and the number of students (through a coefficient approved at the state level), as well as per capita funding (according to the standards for financing student training), all of these indicators can be considered multicollinear.

To determine the degree of influence of the profile, year of foundation, scale and location of universities on a more relevant (or operational) indicator of the publication activity of educational institutions for a particular period of time, we chose as the last indicator the "Number of citations per one researcher/instructor" over the past 2 years, according to the Scopus database. This made it possible to determine recent scientific activity and the dynamics of the research development in a particular institution of higher education. As a result, there have been changes in the ranking of universities by the h-index.

In the group of classical universities, the first 5 universities by rating behind the h-index in the rating of "Number of citations per one researcher/instructor" have lost their positions (in parentheses we indicate the place in the rating by h-index and place in the rating of "Number of citations per one researcher/instructor"): Taras Shevchenko National University of Kyiv (1(1)–9)[6] ; V. N. Karazin Kharkiv National University (2(2)–5); Ivan Franko National University of L'viv (3–10); Yuriy Fedkovych Chernivtsi National University (4(4)–35); Odessa I.I. Mechnikov National University (5(5)–31). In the group of technical universities National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute has lost its position (6(6)–33). But Ukrainian State Chemical Technology University was the first in the ranking by the "Number of citations per one researcher/instructor".

In the block of economic universities, Odessa National Economic University has moved down from 97(83) to 130, but Kyiv National University of Trade and Economics (112(96)-59) and Banking University–Kyiv (125(107)-50) almost doubled their positions in the new ranking.

In the block of medical universities, all educational institutions, except the Ukrainian Medical and Dental Academy and I. Horbachevsky Ternopil State Medical University, are characterized by significant drop in the new ranking. This is clearly seen from the graph (Fig. 1).

In the block of pedagogical universities, K. Ushynsky South Ukrainian Pedagogical University (46(40)-117) and Ternopil V. Hnatiuk National Pedagogical University (57(50)-96) have decline their positions in the new ranking. On the contrary, Lviv State University of Physical Culture (83(70)-18) and Kryvyi Rih State Pedagogical University (89 (76)-22) greatly improved their positions in the new ranking.

In the block of agricultural universities, the situation is similar to the previous blocks of educational institutions. The first three universities in the rankings according to the Hirsch index, National University of Life and Environmental Sciences of Ukraine (28(24)-52), Odessa National Academy of Food Technologies (30(25)-69) dropped significantly in the ranking of "Number of citations per one researcher/instructor". On the contrary, other universities in this block have maintained / improved their positions.

In the "other universities" block, all institutions, with the exception of Open International University of Human Development Ukraine, improved their positions in the new ranking, but the "improvement" indicator is very different for each university.

[6] 1st number denotes the place of the university in the rating by h-index; 2nd number, in brackets, denotes the place of the university in the rating by h-index, excluding universities in the occupied territory of Donetsk and Luhansk regions; 3rd number denotes the place of the university in the rating of "Number of citations per one researcher/instructor"

5. Conclusion

Having analyzed the degree of influence of the selected factors (the year the university was founded, the population of the institution's location, its profile and the number of academic staff) on scientific citation indicators that are used to build the ratings of higher educational institutions of Ukraine (according to the SciVerse Scopus database, the number of citations and h-index), we came to the following conclusions.

1 The h-index (and, accordingly, the general citation indicators) for all universities in Ukraine is seriously affected by the profile of the educational institution, as well as the year of its foundation and the number of research and teaching staff. The influence of the population of the city where the university is located does not appear to be significant for all universities. Nevertheless, this influence on the general indicators of scientific activity of teachers of Ukrainian universities (in the context of the general h- index) cannot be ignored. At the same time, we consider it necessary to note that our study did not reveal the influence of quantitative factors (the year of foundation, the number of teachers, the population of the city) on the h-index indicators of universities of two categories - "pedagogical" and "others". This can be explained by the fact that most teachers of these universities specialize in pedagogical, humanities or law sciences, which are presented in the SciVerse Scopus database in a very limited number of journals. Therefore, in this case it can be argued that the pedagogical, humanitarian and legal profile of these educational institutions has a strong influence on the indicators of the h-index.
2 We replaced the university-wide Hirsch index with a more operational indicator of the publication activity of teachers of higher educational institutions - by the number of citations for the last 2 years according to the Scopus database (2018–2019) received by the publications of university teachers in 2018 divided by the number of university researchers and instructors (that is, the "Number of citations per one researcher/instructor"). The same methods determined the degree of influence on the new indicator by the four factors indicated above. As a result, the influence on the new indicator for all universities in Ukraine is best revealed by the factors "University profile" and "Number of doctors and Candidates of science". Two other factors have completely lost their influence on the changed indicator of scientific activity of researchers and instructors.
3 When constructing national university ratings using operational indicators of the academic activity of the research and teaching staff, it is necessary to take into account the profile of a higher educational institution by introducing weighting factors for the universities with different professional programs. The factor "Number of Doctors and Candidates of science", which actually determines the scale of the university, should remain the most important factor in influencing the publication activity indicators of teachers of an educational institution.

CRediT authorship contribution statement

K.S. Akbash: Conceptualization, Formal analysis, Investigation, Data curation, Validation, Visualization. **N.O. Pasichnyk:** Supervision, Writing - review & editing, Conceptualization, Investigation. **R.Ya. Rizhniak:** Writing - review & editing.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijedudev.2020.102330

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