ANALYSIS OF INDICATORS OF UNIVERSITY'S SCIENTIFIC ACTIVITY

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Abstract

The article is devoted to employees' scientific activity indicators analysis at Petrozavodsk State University. To this end, a database was created dealing with both recorded and processed basic indicators characterizing university staff scientific activity.

Data mining methods were used to analyze publication activity of the university faculty. In order to identify employees groups with similar indicators of scientific activity, they were clustered. As a result, teaching staff was divided into eight clusters, three of which included employees representing both present and future of science at Petrozavodsk State University, and others that would strive to get into these groups.

The presented results of indicators' statistical processing can be useful for university self-analysis. The university management could draw a conclusion on a current state of scientific activity, both of an individual employee and of the organization as a whole. This will allow to make scientifically-based management decisions in order to improve scientific performance of the organization.

Keywords: university performance, strategic management, scientific activity, higher education, scientometric indicators, h-index, number of publications, number of citations, RSCI.

1 INTRODUCTION

Currently, one of the important criteria for evaluating the effectiveness of the University as a whole are indicators of scientific activity [1]. It can be not only the amount of funds received by the University in carrying out research and developmental works, amount of grants, number of patents, but a number of scientometric indicators that allow evaluation of the effectiveness of the organization for scientific areas. They are different in nature, but they are all in one way or another depend on the teaching staff (PPS) of the organization, as they have a direct impact on their values.

Assessment data are used for monitoring research activities of universities, when making ratings at various levels (global, national, private, etc.) are taken into account in the allocation of grants and, in turn characterize the productivity of a scientist, groups of scientists, organization or country as a whole.

The aim of this work is to analyze the main indicators of scientific activities related to the publication activity of the University as a whole, for example, Petrozavodsk state University (PetrSU).

2 STRUCTURE OF THE INITIAL RESEARCH DATA

As information base of the research, data were collected and processed on the main indicators characterizing the scientific activity of the university staff, namely, the indicators of their publication activity and the distribution of their publications by years for the period 2000 - 2015, available in the bibliographic database of the Russian index of scientific Citing (RSCI) [2].

Data on publications on 798 employees of PetrSU included the Hirsch index (hereinafter referred to as HIH), the number of publications, the number of citations, the number of co-authors, the impact factor of journals and other information (more than 30 different indicators), and the distribution of their publications from 2000 to 2015 inclusive. The required information is taken from a bibliographic database of the Russian Science Citation Index on 1.12.2016, the

The employee was characterized by age, seniority, position, academic degree, academic rank, rate and type of work (main / part-time), as well as membership in PetrSU subdepartment (faculty / institute and department). In this study, educational institutions that were on 01.01.2017, namely the Institute of Biology, Ecology and Agrotechnologies (IBEA), the Institute of Foreign Languages (IFL), the Institute of Forestry, Mountain and Building Sciences (IFMBS), the Institute Mathematics and Information

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Technologies (IMIT), Institute of History, Political and Social Sciences (IHPSS), Institute of Pedagogy and Psychology (IPP), Institute of Physical Culture, Sports and Tourism (IPCST), Institute of Economics and Law (IEL), Medical Institute (MI), Institute of Philology (IP) And Physical-Technical Institute (PTI).

Thus, all the necessary information for the analysis of publication activity were collected.

3 ANALYSIS OF THE PUBLICATION ACTIVITY OF THE FACULTY OF PETRSU

One of the most important scientometric indicators used by the university's management for quantitative assessment of scientific productivity of a scientist, as well as when making personnel decisions in obtaining academic titles, etc. is the h-index (HI). This indicator was put in the basis of the assessment of the activity of teaching staff and a number of foreign universities [3]. In this connection, the analysis of the publication activity in the context of the main institutes of PetrSU and the academic degrees of employees was carried out using the h-index as an example. Table 1 shows the distribution of the total number of employees of PetrSU in terms of academic degrees, as well as the results of the grouping of the staff of the institutes on the value of the h-index.

Table 1.

Subdivision	Number of employees			Number of employees on the h-index				
	Total	Candidates of Sciences	Doctor of Sciences	0	1 - 2	3 - 5	6 - 10	>10
IBEA	74	50	18	21	26	20	7	0
IFL	65	23	2	46	14	5	0	0
IFMBS	91	67	17	21	31	18	14	7
IMIT	71	42	8	19	31	16	5	0
IHPSS	68	45	9	19	35	13	1	0
IPP	69	44	3	29	36	4	0	0
IPCST	55	17	2	34	13	7	1	0
IEL	53	33	7	32	12	5	2	2
MI	106	63	27	34	35	28	7	2
IP	80	41	8	47	28	5	0	0
PTI	66	45	11	13	25	19	5	4
PetrSU	**798**	**470**	**112**	**315**	**286**	**140**	**42**	**15**

The most numerous units are the Medical Institute and the Institute of Forestry, Mining and Building Sciences. They comprise 13.3% and 11.4% of the total number of employees, respectively. The share of teaching staff in the remaining educational institutions ranges from 6.6% to 9.3%. The structure of the number of employees of the institutes in terms of academic degrees, sorted in descending order of the proportion of the number of employees with a scientific degree is presented in Figure 1. The largest number of graduated (92%) in the structure of educational institutions is observed in IBEA and IFMBS, least in IFL (38%) and IPCST (35%).

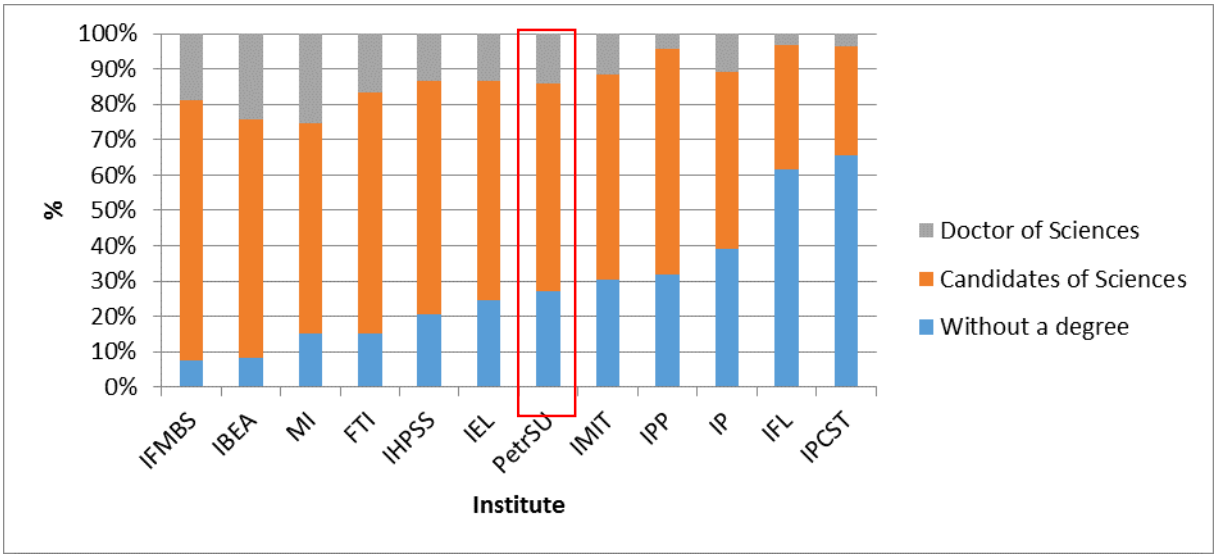

Fig.1. Structure of the number of employees of institutes in the context of academic degrees

The average values of the h-index in the staff of PetrSU in the context of academic degrees are shown in Fig. 2. The highest values of the index are the doctors of technical sciences (IFMBS, FTI), the least - humanitarian directions (IF, IHPSS). It should be noted that among the doctors of sciences and employees who do not have a scientific degree, there is a wide spread of the values of HI (the coefficient of variation is 61% and 76% respectively), among candidates of science it is 44%. From Figure 2, we can thus conclude that if the unit of conditional effectiveness is taken by employees who do not have a degree, then it turns out that the scientific activity of candidates of sciences is four times more effective than non-degree ones, and the scientific activity of doctors of science is three times more effective, than for candidates (or 12 times more effective than non-degree).

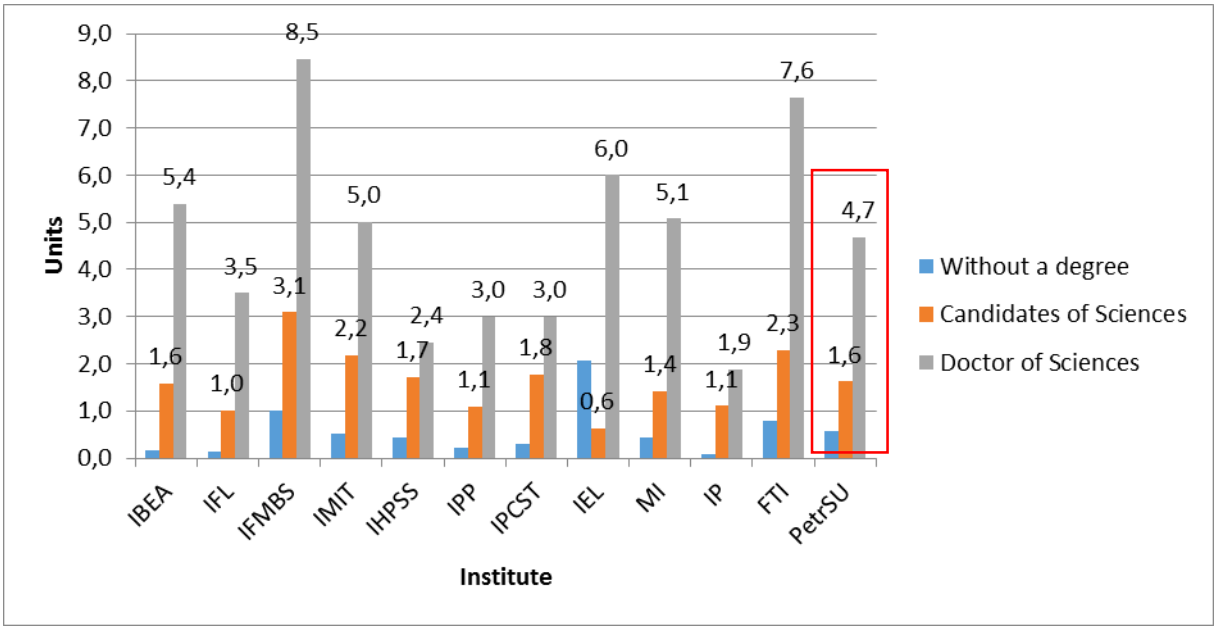

Fig. 2. The average value of the h-index among PetrSU employees in terms of academic degrees

Figure 3 shows the distribution of the number of employees of institutions with the value of the h-index, broken into ranges. Sorting is made in the order of increasing the proportion of the number of employees with a zero value of HI. From the data presented, it can be seen that the majority of employees in all institutes have the value of HI in the range from 0 to 2, which is about 75% of the total number of teaching staff. Also, about 40% of PetrSU employees have a zero h-index. These include

employees who, according to the RSCI, have a total of zero publications or those with a number of publications, but they are not quoted.

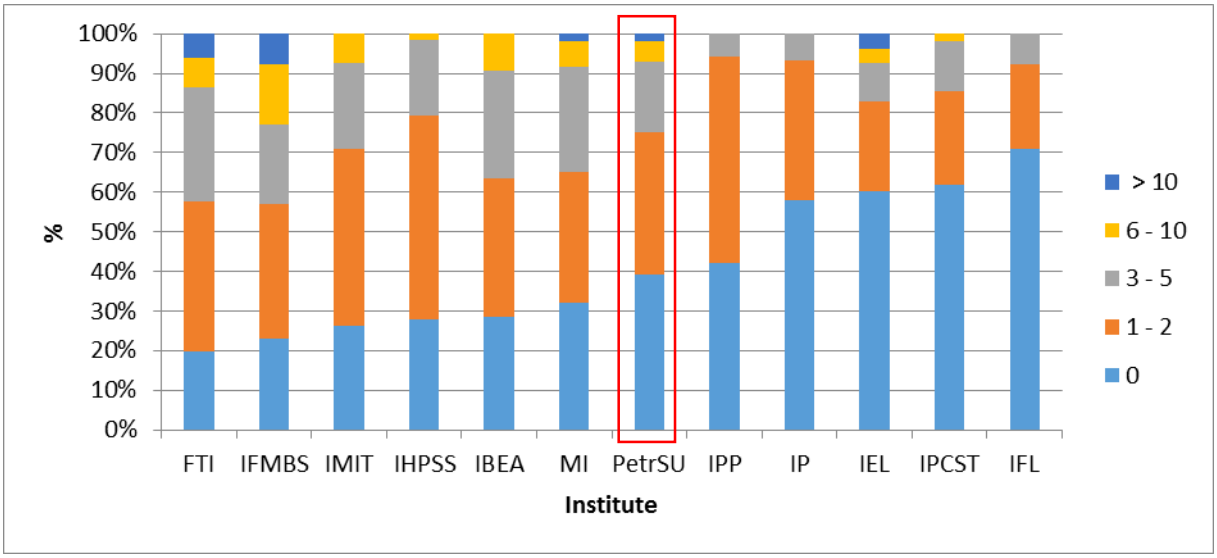

Fig. 3. The structure of the number of employees of institutions with different values of the h-index

Figure 4 shows its average values of the HI from the employees of PetrSU by institutes in descending order. Leaders are teachers IFMBS - their average value is twice the average for the university as a whole. Among the lagging behind - IFL, perhaps this is due to the low rate of gradualization among the PPS.

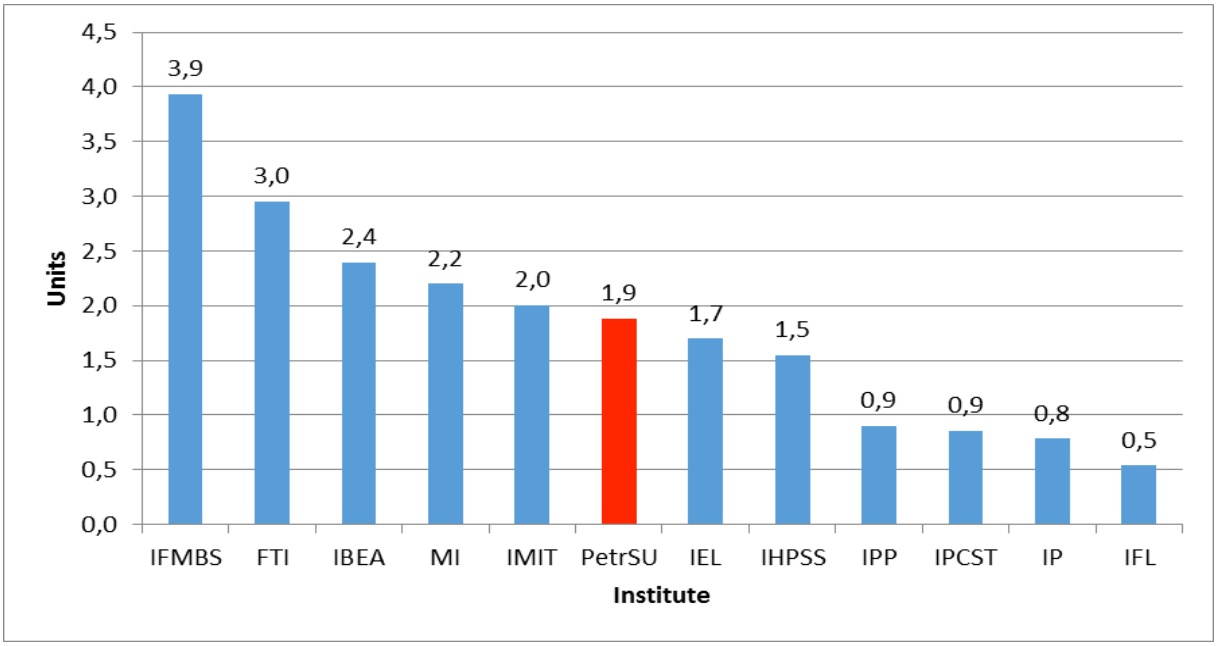

Fig. 4. The average value of the h-index for employees of PetrSU for institutes

Figure 5 reflects the contribution of each institution to the university-wide Hirsch index (HI = 1.9) in descending order of the contribution from the bottom to the top. It can be seen that the largest contribution is made by IFMBS, the smallest is IFL. IFMBS, MI and FTI give a total of more than half of the total value of PetrSU.

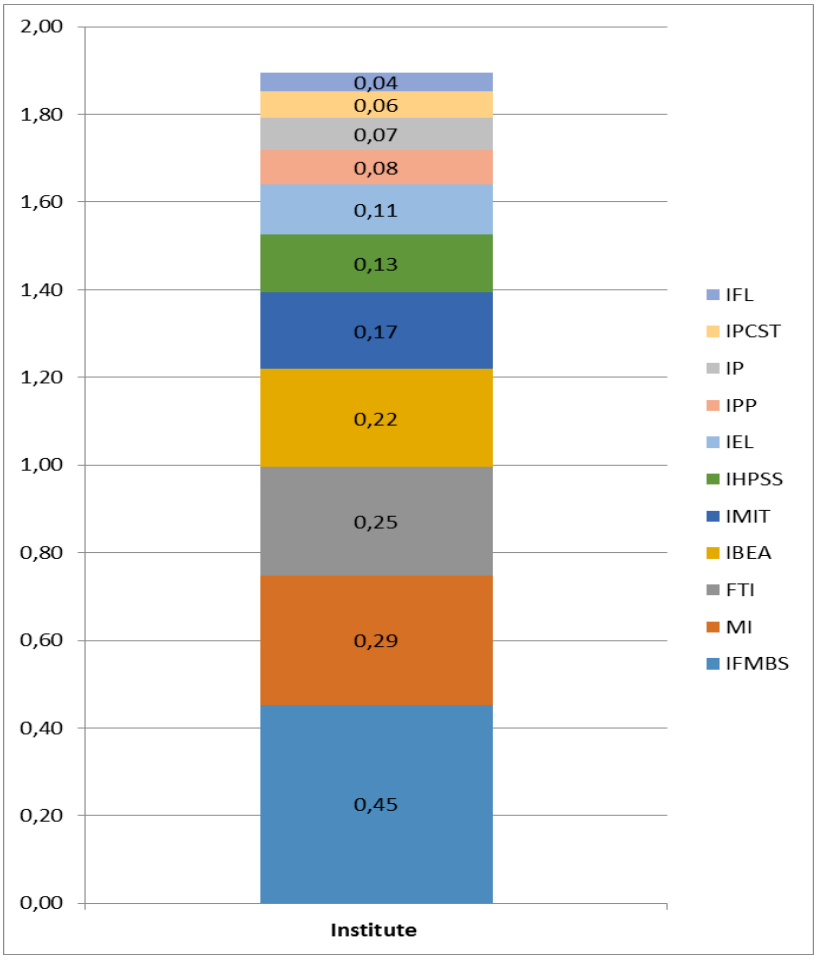

Fig. 5. The contribution of educational institutions to the university h-index

The existing indicators, in particular the h-index, allow one to compare the effectiveness of scientists' activity by means of a quantitative analysis of publications and their citations. As a result of the comparative analysis, a great differentiation of the publication activity was revealed in the context of educational institutions. Similar differences are observed between staff without a degree and candidates and doctors of sciences [4].

In this regard, an interesting task is to split the entire set of PPSs into stable groups of employees with similar characteristics of the publication activity

4 CLUSTERING

To determine the existence of links between different indicators (information about employees and their scientometrics), Excel Add-Ins Analysis Services MS SQL Server was used. These technologies allow you to find in large volumes of data hidden and nontrivial patterns that are not detectable at first sight. The work used the following analysis methods: Highlight Exceptions, Analysis of key influence factors, Goal Seek and Clustering. The input data for clustering was taken most of the results obtained during the procedure for analyzing the key influencing factors on the h-index. Such significant factors were the academic degree, academic title, institution, age, length of service, number of publications by the author at RSCI, number of citations of the author's publications at the RSCI, h-index and number of articles in Russian journals from the Higher Attestation Commission list. As a result, all employees were divided into eight clusters. The corresponding results are shown in Figure 6.

Variables	State	Total	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 6	Cluster 5	Cluster 7	Cluster 8
size		798	275	94	90	86	82	79	65	27
age	average mean	49	48,68	49,84	35,09	53,29	38,94	59,9	59,93	60,76
age	deviation	14,26	15,1	8,03	6,05	13,78	6,46	11,35	11,76	12,36
h-index	average mean	2	0	1,43	0,91	5,46	2,74	2,66	0,79	11,98
h-index	deviation	2,99		0,56	0,59	2,05	1,02	0,95	0,53	7,17
experience	average value	19	18,79	19,23	9,75	20,45	10,94	29,2	27,84	23,19
experience	deviation	13,05	13,35	8,81	5,72	15,09	7,14	11,51	12,16	15,92
academic degree	candidates of sc.	470	46 %	94 %	47 %	44 %	90 %	62 %	80 %	12 %
academic degree	no	216	53 %	5 %	53 %	0 %	10 %	0 %	15 %	7 %
academic degree	doctor of sc.	112	2 %	2 %	0 %	56 %	0 %	38 %	5 %	81 %
academic title	no	405	73 %	31 %	97 %	21 %	67 %	1 %	24 %	9 %
academic title	docent	323	26 %	69 %	3 %	46 %	33 %	80 %	71 %	29 %
academic title	pofessor	70	2 %	0 %	0 %	34 %	0 %	19 %	5 %	63 %
Insirute	MI	106	10 %	9 %	9 %	21 %	14 %	24 %	13 %	19 %
Insirute	IFMBS	91	7 %	8 %	7 %	22 %	15 %	13 %	16 %	27 %
Insirute	IP	74	14 %	8 %	10 %	0 %	11 %	11 %	2 %	0 %
Insirute	IBEA	74	7 %	16 %	3 %	16 %	10 %	9 %	6 %	15 %
Insirute	IPP	69	9 %	18 %	10 %	0 %	0 %	8 %	16 %	0 %
Insirute	IMIT	69	6 %	10 %	14 %	13 %	11 %	5 %	8 %	7 %
Insirute	IHPSS	68	6 %	12 %	13 %	6 %	12 %	11 %	8 %	0 %
Insirute	FTI	66	5 %	5 %	12 %	15 %	14 %	8 %	2 %	21 %
Insirute	...	...	...	...	...	...	...	...	...	...
Number of publications in RSCI	average mean	16	0,19	8,81	7,19	44,31	20,08	20,78	5,51	130,19
Number of publications in RSCI	deviation	32,24	0,65	3,99	4	19,47	8,31	9,59	3,68	98,95
Number of articles in IIAC	average mean	6	0	2,25	2,02	19,21	6,32	7,55	0,77	64,51
Number of articles in IIAC	deviation	15,43		1,93	1,57	9,65	4,23	4,56	0,86	45,15
Number of citations of publications in RSCI	average mean	41	0	7,09	2,65	118,57	25,12	28,6	1,85	613,84
Number of citations of publications in RSCI	deviation	181,41		4,83	2,75	71,17	17,22	18,81	2,27	759,73

Fig. 6. Results of clustering employees of PetrSU

The first cluster (275 people) includes employees who have a zero h-index, the average number of author's publications in the RSCI is 0.19, and the number of citations of the author's publications in the RSCI is 0. The academic degree and academic title is predominantly not. At the same time, the average age is about 50 years and half of them are candidates of science. This cluster consists of those who reduce the average value of the h-index as a whole for the university. If you remove from the database those employees whose total number of publications in the RSCI is zero, then the average value of the Institute of PetrSU will increase by 1.4 times and will be equal to 2.74. For the second cluster (94 people) with the same average age of employees of about 50 years, but the h-index for which an average of 1.43, is characterized by an average number of publications by the author at the RSCI equal to 8.81, the average number of citations of the author's publications at RSCI is 7.09. Qualitative composition - mostly candidates of science with a scientific title associate professor. For an average of 20 years, such a number of publications is insignificant. Most likely, this group consists of employees who have ceased to actively publish after the defense of the candidate's thesis. In the third cluster (90 people) are relatively young employees, half of them are candidates of science, whose average age is about 35 years and the length of service is 10 years, the degree and academic title are mostly absent. The average value of the number of publications of the author in the RSCI is 7.19, the number of citations of the author's publications in RSCI is 2.02, and the number of them is 0.91. This group includes low-active young scientists who, probably, in the near future do not plan to receive a scientific degree or rank. In the fourth cluster (86 people) included employees with a degree and about 80% of them - academic rank, whose average age is 53 years. The average value of the h-index is 5.46, the number of the author's publications in the RSCI is 44.31 and the number of citations of the author's publications in the RSCI is 118.57. These indicators show that this group of employees is actively conducting its publication activities, the results of which are interesting to others. This cluster is the support of the university. Their average age coincides with the average for the university, they are actively engaged in science and can make a good substitute for the current honorary professor. The fifth cluster (79 people) consists of elderly employees (average age is 60 years) and experience of 30 years, most of which have a scientific degree of a candidate or doctor of science, but in rank - associate professors. The h-index averaged 2.66, the number of publications of the author in the RSCI - 20.78, the number of citations of the author's publications in the RSCI is 28.6. This cluster includes scientists who, having both a scientific degree and academic title, continue their publication activities. The sixth cluster (82 people) is characterized by an average age of 39 years and an experience of 11 years, consisting mainly of candidates of sciences without academic title. The h-index averaged 2.74, the number of publications of the author in RSCI C is 20.08, the number of citations of the author's publications in the RSCI is 25.12. This cluster includes quite young employees who are actively engaged in scientific activities, and, possibly, are preparing to apply for academic status. The seventh cluster (65 people) included employees who had average age and seniority of 60 and 28 years, respectively, mainly candidates of science with academic title as associate professor. The average number of publications of the author in the RSCI is 5.51, and the number of citations of

the author's publications in the RSCI is 1.85. Unlike the fifth cluster, the average value of HI is 0.79. It seems that they conducted an active publication activity before obtaining an academic title, after which they ceased to deal with it. For the eighth cluster (27 people), the smallest, the average age is 61 years, the experience is 23 years. Basically, this group consists of doctors of sciences with academic title. Their h-index averaged 11.98, the number of the author's publications in RSCI is 130.19 and the number of citations of the author's publications in the RSCI is 613.84. This cluster includes honorary professors who, despite age, are still engaged in science and actively publish their results. More young employees should take an example from them.

Obtained eight clusters can be ordered by average age and the level of scientific activity of employees, linking them to the matrix structure. Figure 7 shows a three-level graph of the possible transitions of employees from the cluster to the cluster, depending on their publication activity and the increase in the number of years. The highest level is occupied by employees, actively leading scientific activity, medium – low-activity, and, accordingly, lower - not active. It should be noted that the most probable transitions from one state to another, provided that the ratio of PPS to publications remains the same, are marked in Figure 7 by bold arrows. Such transitions occur within the same level.

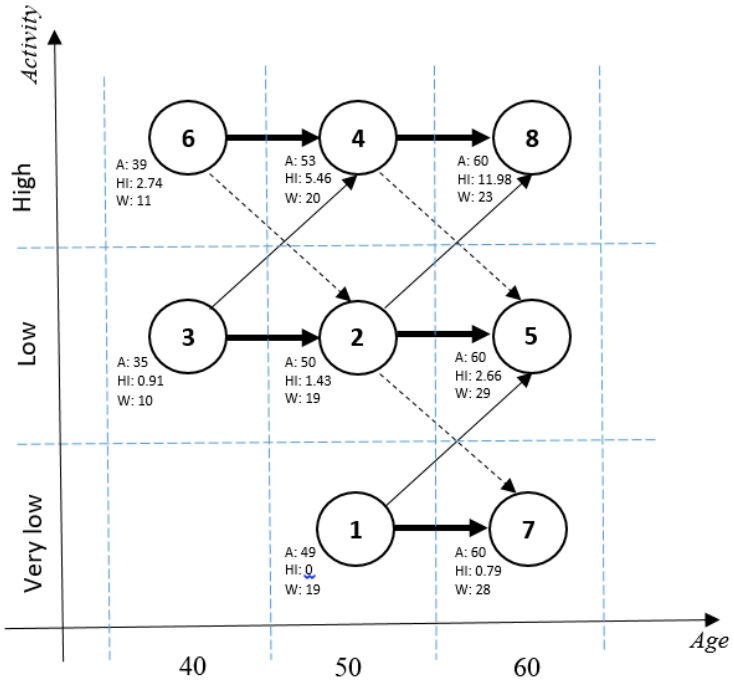

Fig. 7. The graph of possible transitions between clusters (A-average age, HI-average h-index, W-experience)

For example, those young scientists who are actively publishing will strengthen their positions, be able to obtain academic degrees or titles (6 -> 4) and subsequently become the mainstay of the university (4 -> 8). Similarly, you can describe the process for those who are not particularly going to change their attitude to the publication activity. In the best case, a transition of 3 -> 2 -> 5 or 1 -> 7 will be possible. It is interesting that if for some reason an employee devotes more time to science and takes an active publication position, then in due course he can move to a cluster, to a level, or even two, higher than he was. The transitions corresponding to this situation are marked in Figure 7 by thin arrows. In the opposite case, the employee has every chance to reduce his positions and move to the level below, which is indicated by the dotted arrows.

Thus, we can distinguish three types of transitions that connect the cluster:

- bold arrow - traditional script;
- thin arrow - optimistic scenario;
- dotted arrow - negative scenario.

5 CONCLUSION

The proposed toolkit will allow institutions to carry out self-analysis. The analysis results could be used as a basis for administrative decision-making aimed at values increasing of scientometric indicators of the institution, for example, the h-index [5].

The most interesting interpretation is obtained via analysis results of university employees clusters in terms of their publication activity indicators. In all clusters, institutions are represented equally, this means that in each educational institution there are employees who either actively engaged in publishing activities, or are not engaged at all, or there was a period of time when they were engaged. It is interesting that in the first cluster all those who had a zero value of the h-index for various reasons were singled out. This group needs more detailed research to understand the reasons of the current situation (unwillingness to work, database errors etc.). Teachers who entered the fourth, sixth and eighth clusters are shaping both present and future of the university science. They deserve leadership support, additional incentive payments, mini-grants support and initiative projects. The rest clusters require more stringent measures application, and in some cases it is possible to run with some punishment in the form of bonuses deprivation etc., but there will be also those with whom it is better not to extend labor contract or even cancel it beforehand.

The university management shall motivate top-level clusters employees to stay on that level and to encourage lower clusters employees to switch to the upper level.

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