Tools for Impact Measurement of University and Scientific Institution on Innovation Development

Inese Spica, Sarmite Jegere, Kalevs Kants, Lada Kalinina and Paula Jegere
Scientific Institution Business Competence Centre, Riga, Latvia

inese.spica@gmail.com
sarmite.jegere@inbox.lv
kalev.kants@inbox.lv
ms.lada.kalinina@gmail.com
jegerepaula@inbox.lv

Abstract: Nowadays innovations are very important for entrepreneurship and economic development. In turn, academic staff and students employed in universities and scientific institutions create the knowledge needed to develop innovation. Traditionally, new knowledge generated by universities and scientific institutions is offered to the general public in the form of scientific articles, monographs or patents. It is therefore important to clarify the efficiency of the involvement of academic staff and students in the production of scientific articles, monographs and patents. The above efficiency indicators can serve as tools for measuring the impact of universities and scientific institutions on innovation development. The object of the research is the formation of peer reviewed scientific articles not included in international databases WoS or SCOPUS at universities and scientific institutions in various scientific sectors. The subject of the research is the comparative analysis of the efficiency of formation of peer reviewed scientific articles not included in WoS and SCOPUS at universities and scientific institutions in various scientific sectors of Latvia. The objective of the research is the analysis of tools for impact measurement of universities and scientific institutions in various scientific sectors of Latvia on innovation development in the period from 2013 to 2018. The following tasks were determined to reach the objective: to study the formation of peer reviewed scientific articles not included in WoS or SCOPUS at universities and scientific institutions in various scientific sectors of Latvia; to identify the concept of the efficiency of peer reviewed scientific articles not included in WoS or SCOPUS formation in various scientific sectors; to carry out the tools for impact measurement of universities and scientific institutions on innovation development in various scientific sectors in Latvia. Research methods used in the paper are content analysis, economic analysis, and economic experiment.

Keywords: Scientific Articles, Efficiency Indicators, Comparative Analysis, Universities, Scientific Institutions, Latvia

1. Introduction

Every six years, the Ministry of Education and Science of the Republic of Latvia (IZM) shall organise an international evaluation of the scientific institutions (SIs) registered in Latvia (IESI). The last IESI took place in the period from 2013 to 2018. In order to establish the dynamics of the efficiency indicators of the academic staff involved in the formation of peer reviewed scientific articles not included in international databases "Web of Science" (WoS) or SCOPUS (RS) at the SIs of Latvia (IZM, 2021), the authors used the output data of findings across the set of SIs evaluations per period from 2013 to 2018 offered by "Technopolis-group" (TG). It provides an opportunity for the authors to calculate the RS indicators at the SIs of Latvia and to compare their dynamics during the period from 2013 to 2018. The research is limited by the fact that newer data required for the study is not currently available.

Data of the comparative analysis will help to develop support and motivation programs to increase the efficiency of involvement of the academic staff in the RS formation. In addition, the comparative analysis will reveal whether the score on quality of research at the SIs of Latvia in the IESI of TG coincides with the place of the SI of Latvia in the ratings of the RS indicators, and whether the quality of research score of the SI of Latvia also reflects the efficiency of the involvement of the academic staff of the SI of Latvia in the RS formation.

Hypothesis: The quality of research scores of the SIs shows the efficiency of the RS formation in the SIs of Latvia.

2. Theoretical Background

In the past decade a significant part of scientific literature has addressed the socio-economic impacts of university-industry research and development collaboration (Lima et al., 2021).

The authors rely on research of understanding, adapting, applying intellectual capital (IC) in universities (Mercado-Salgado et al, 2016), and research of the role of human capital in educational-training process at the university (Contu, 2017) presented different aspects of IC. Spica et al (2017a) state that IC is an economic category, the spiritual value created by the human potential, and it can be accumulated and converted into the

value of other capitals. By investigating certain information about the management of education, we can increase the capacity and significance of the country's total economic capital movement.

Scientific articles, monographs, and national and international patents form the totality of the IC of each SI. From this set of IC, peer reviewed scientific articles not included in international databases WoS or SCOPUS are conventionally considered IC. Such scientific publications provide an opportunity to determine the national competitiveness of various scientists, SIs, and sectors of science in Latvia.

Spica et al (2017a; 2017b) have worked out four indicators of the efficiency of the formation of IC in the higher education establishment: (1)The efficiency of the involvement of academic staff in the formation of IC per year in percentages (AIK); (2)The efficiency of the involvement of academic staff with a Doctorate degree in the formation of IC per year in percentages (DIK); (3)The efficiency of the involvement of students in the formation of IC per year in percentages (SIK); (4)Mutual efficiency of the involvement members of the academic staff with Doctorate degrees and the academic staff without Doctorate degrees in the formation of IC per year in times, (DE).

In order to calculate the AIK, DIK, SIK, and DE of the HEE Spica et al (2017a; 2017b) have worked out four formulas: (1) AIK = (ZPS : AS) x 100; (2) DIK = (ZPS : DS) x 100; (3) SIK = (ZPS : SS) x 100; (4) DE = DIK : AIK. Where: ZPS represents the number of scientific publications of the HEE per year; AS represents the number of academic staff in full-time jobs per year; DS represents the number of academic staff with Doctorate degrees holding in full-time jobs per year; SS represents the number of students per year.

3. Methodology

In their study, the authors will conduct a comparative analysis of SIs involved in the formation of RS in various sectors of science in Latvia. It comprised evaluation of SIs of six sectors of science: 1)Engineering and Computer Sciences (E&CS); 2)Natural Sciences (NS); 3)Medical and Health Sciences (M&HS); 4)Agriculture, Forestry, and Veterinary Sci-ences (A&F&VS); 5)Social Sciences (SS); 6)Humanities and Art Sciences (H&AS).

The authors modified the above mentioned formulas for the purposes of the study. Namely, calculate RS efficiency indicators for total numbers of full time equivalent (FTE) academic and research personnel (KIK), for FTE academic personnel (AIK), for FTE academic research personnel (PIK) and for PhDs completed at the SI (SIK). In addition, all the authors of the above-mentioned RS efficiency indicators were calculated for total number of self-reported outputs of articles in peer reviewed scientific edited journals and conference proceedings not included in WoS or SCOPUS (RS). The authors calculated mutual efficiency indicators (PE) regarding involvement of the FTE academic research personnel (PS) and the FTE academic personnel (AS) in the formation of RS in times.

In the present research, the authors used the following data from the IESI: output data on the number of FTE academic personnel (AS), the number of FTE academic and research personnel (PS), the total number of FTE academic and research personnel (KS), the number of PhDs completed (SS), the number of articles in peer reviewed scientific edited journals and conference proceedings not included in WoS or SCOPUS (RS) in period 2013-2018 per SI in Latvia. Authors revised the above RS for the year. TG analysed 62 SI of Latvia.

In this study, one RS are accepted as one unit of IC. Further, using the modified formulas 1; 2; 3; and 4, were calculated: KIK, AIK, PIK, SIK, PE. Then, according to the results obtained through the author's calculations, a corresponding rating place was assigned to each SI of Latvia per year and each of the above indicators KIK, AIK, PIK and SIK.

Each rating location was then assessed with an appropriate score, where the lowest score is 1 point, while the highest score is 5 points. The above mentioned assessment system makes it possible to compare the quantitative efficiency indicators of SI of various scientific sectors in Latvia calculated by the authors with IESI overall assessment criterion - quality of the research performance of the SI. The relevant Panel of the TG was a score of the research performance of each SI using the scale, where score 5 means outstanding level of research, score 4 means very good level of research, score 3 means good level of research, score 2 means adequate level of research, score 1 means poor level of research (IZM, 2021).

Next, the unified overview of all six sectors of science in Latvia was created. Here, the SIs were arranged according to the obtained rank in their sector of science. Furthermore, indicators of the efficiency of the involvement of academic staff of each SI in the formation of RS were added. The authors then selected one SI with the highest efficiency indicator of the involvement of academic staff in the formation of RS from the unified

review of the sectors of science in Latvia, accepted it as the basic indicator, and equated it to 100%. Further, the authors calculated the proportion of the efficiency of the involvement of academic staff of each SI in the base indicator.

After that, a rating scale of the results obtained was created on five-score system, where the highest rating is five score, and the lowest rating is one score. The new efficiency rating system for the involvement of academic staff of SIs in the formation of RS created by authors provides for granting of one score for the obtained efficiency indicators from 1% to 20%, 2 scores - for the obtained efficiency indicators from 21% to 40%, 3 scores - for the obtained efficiency indicators from 41% to 60%, 4 scores - for the obtained efficiency indicators from 61% to 80%, and 5 scores - for the obtained efficiency indicators from 81% to 100%,

The follow-up authors compared the results of their own estimates of SI quantitative indicators to the relevant Panel of the TG's results of qualitative indicators, calculated the difference between the indicators and the changes. For this purpose, the authors calculated for each SI score of indicators recording efficiency of RS and average score of each scientific sector. After that, authors compared these scores with scores of quality of the research of each SI developed by Panel of the TG.

4. Results

To calculate the efficiency of the involvement of academic staff in the formation of RS the authors used formulas that were developed and approbated already before and now modified.

$$AIK = (RS : AS) \times 100 \quad (1)$$

$$PIK = (RS: PS) \times 100 \quad (2)$$

$$KIK = (RS : KS) \times 100 \quad (3)$$

$$SIK = (RS: SS) \times 100 \quad (4)$$

$$PE = PIK : AIK \quad (5)$$

Table 1: Performance indicators of the involvement of academic personnel of SIs in the formation of RS in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

AIK rating	E&CS AIK (%)	E&CS AIK (%) of base indicator	E&CS AIK score	NS AIK (%)	NS AIK (%) of base indicator	NS AIK score	M&HS AIK (%)	M&HS AIK (%) of base indicator	M&HS AIK score	A&F&VS AIK (%)	A&F&VS AIK (%) of base in-dicator	A&F&VS AIK score	SS AIK(%)	SS AIK (%) of base indicator	SS AIKscore	H&AS AIK (%)	H&AS AIK (%) of base indicator	H&AS AIK score
1	829	100	5	116	14	1	165	20	1	200	24	2	468	56	3	527	64	4
2	547	66	4	97	12	1	99	12	1	0	0	0	233	28	2	309	37	2
3	393	47	3	82	10	1	40	5	1	0	0	0	228	28	2	201	24	2
4	267	32	2	68	8	1	39	5	1	0	0	0	212	26	2	186	22	2
5	248	30	2	0	0	0	0	0	0	0	0	0	182	22	2	143	17	1
6	219	26	2	0	0	0	0	0	0				161	19	1	57	7	1
7	174	21	2	0	0	0	0	0	0				137	17	1	55	7	1
8	159	19	1				0	0	0				118	14	1	20	2	1
9	150	18	1										117	14	1	4	0	0
10	95	11	1										100	12	1	0	0	0
11	71	9	1										82	10	1	0	0	0
12	16	2	1										69	8	1			
13	0	0	0										0	0	0			

AIK rating	E&CS AIK (%)	E&CS AIK (%) of base indicator	E&CS AIK score	NS AIK (%)	NS AIK (%) of base indicator	NS AIK score	M&HS AIK (%)	M&HS AIK (%) of base indicator	M&HS AIK score	A&F&VS AIK (%)	A&F&VS AIK (%) of base in-dicator	A&F&VS AIK score	SS AIK(%)	SS AIK (%) of base indicator	SS AIKscore	H&AS AIK (%)	H&AS AIK (%) of base indicator	H&AS AIK score
14	0	0	0										0	0	0			
15	0	0	0										0	0	0			
16	0	0	0															
Average	207	25	2	145	17	1	164	20	1	283	34	2	144	17	1	98	12	1

According to Table 1 the highest AIK indicator in the formation of RS in a year is 829% and was accepted by the authors as the basic indicator or 100%. The above indicator has been achieved by a SI representing the E&CS. Consequently, the efficiency indicator of the SIs of other sectors of science in Latvia were attributed to this higher efficiency indicator in order to determine their proportion as a percentage. Then, according to the new rating system developed by the authors, each SI was assigned a certain number of scores.

Table 2: Performance indicators of the involvement of academic research personnel of SIs in the formation of RS in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

PIK rating	E&CS PIK (%)	E&CS PIK (%) of base indicator	E&CS PIK score	NS PIK (%)	NS PIK (%) of base indicator	NS PIK score	M&HS PIK (%)	M&HS PIK (%) of base indicator	M&HS PIK score	A&F&VS PIK (%)	A&F&VS PIK (%) of base indicator	A&F&VS PIK score	SS PIK (%)	SS PIK (%) of base indicator	SS PIK score	H&AS PIK (%)	H&AS PIK (%) of base indicator	H&AS PIK score
1	416	5	1	43	1	1	7992	100	5	354	4	1	900	11	1	1615	20	1
2	317	4	1	41	1	1	469	6	1	40	1	1	675	8	1	1228	15	1
3	265	3	1	34	0	0	150	2	1	27	0	0	596	7	1	647	8	1
4	187	2	1	20	0	0	98	1	1	12	0	0	438	5	1	567	7	1
5	166	2	1	12	0	0	90	1	1	5	0	0	404	5	1	382	5	1
6	148	2	1	12	0	0	35	0	0				401	5	1	198	2	1
7	106	1	1	1	0	0	3	0	0				272	3	1	165	2	1
8	101	1	1				3	0	0				248	3	1	148	2	1
9	99	1	1										208	3	1	96	1	1
10	90	1	1										175	2	1	90	1	1
11	88	1	1										124	2	1	52	1	1
12	70	1	1										122	2	1			
13	58	1	1										71	1	1			
14	38	0	0										39	0	0			
15	16	0	0										0	0	0			
16	0	0	0															
Average	128	2	1	21	0	0	58	1	1	57	1	1	256	3	1	170	2	1

Comparing the figures collected in Table 2, the authors conclude that the highest PIK indicator of 7992% is for the SI of the M&HS, while the lowest PIK indicator of 1% is for the SI of the NS. It follows that only one SI get the highest rating of 5 score, fourteen SIs get 0 score, but other forty five SIs get 1 scores.

Table 3: Performance indicators of the involvement of PhDs completed at SIs in the formation of RS in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

SIK rating	E&CS SIK (%)	E&CS SIK (%) of base indicator	E&CS SIK score	NS SIK (%)	NS SIK (%) of base indicator	NS SIK score	M&HS SIK (%)	M&HS SIK (%) of base indicator	M&HS SIK score	A&F&VS SIK (%)	A&F&VS SIK (%) of base indicator	A&F&VS SIK score	SS SIK (%)	SS SIK (%) of base indicator	SS SIK score	H&AS SIK (%)	H&AS SIK (%) of base indicator	H&AS SIK score
1	450	27	2	165	10	1	195	12	1	311	18	1	814	48	3	1683	100	5
2	392	23	2	135	8	1	182	11	1	248	15	1	767	46	3	1167	69	4
3	283	17	1	128	8	1	138	8	1	119	7	1	600	36	2	779	46	3
4	248	15	1	109	6	1	66	4	1	108	6	1	325	19	1	531	32	2
5	198	12	1	57	3	1	50	3	1	20	1	1	260	15	1	451	27	2
6	180	11	1	32	2	1	24	1	1				257	15	1	140	8	1
7	172	10	1	11	1	1	14	1	1				225	13	1	138	8	1
8	154	9	1				12	1	1				178	11	1	121	7	1
9	138	8	1										150	9	1	110	7	1
10	128	8	1										123	7	1	31	2	1
11	104	6	1										58	3	1	0	0	0
12	100	6	1										56	3	1			
13	87	5	1										24	1	1			
14	65	4	1										0	0	0			
15	55	3	1										0	0	0			
16	0	0	0															
Average	156	9	1	48	3	1	75	4	1	187	11	1	112	7	1	222	13	1

In Table 3, according to the SIK indicators the first place and highest score 5 is taken by the SI of the H&AS, while the lowest SIK indicator of 11% is for the SI of the NS. Only one SI gets the 4 score, three SIs get the 3 score, two SIs get 2 score, but other SIs get 1 score.

Table 4: Performance indicators of the involvement of total academic staff of SIs in the formation of RS in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

KIK rating	E&CS KIK (%)	E&CS KIK (%) of base indicator	E&CS KIK score	NS KIK (%)	NS KIK (%) of base indicator	NS KIK score	M&HS KIK (%)	M&HS KIK (%) of base indicator	M&HS KIK score	A&F&VS KIK (%)	A&F&VS KIK (%) of base indicator	A&F&VS KIK score	SS KIK (%)	SS KIK (%) of base indicator	SS KIK score	H&AS KIK (%)	H&AS KIK (%) of base indicator	H&AS KIK score
1	277	3	1	43	1	1	7992	100	5	128	2	1	217	3	1	273	3	1
2	130	2	1	30	0	0	469	6	1	40	1	1	175	2	1	259	3	1
3	105	1	1	24	0	0	61	1	1	27	0	0	161	2	1	198	2	1
4	100	1	1	17	0	0	47	1	1	12	0	0	147	2	1	162	2	1
5	99	1	1	12	0	0	31	0	0	5	0	0	129	2	1	117	1	1
6	86	1	1	10	0	0	19	0	0				111	1	1	96	1	1
7	77	1	1	1	0	0	3	0	0				105	1	1	62	1	1
8	76	1	1				3	0	0				101	1	1	49	1	1
9	73	1	1										80	1	1	40	1	1
10	51	1	1										67	1	1	18	0	0
11	42	1	1										54	1	1	4	0	0
12	40	1	1										49	1	1			
13	38	0	0										44	1	1			
14	16	0	0										39	0	0			
15	14	0	0										0	0	0			
16	0	0	0															
Average	79	1	1	19	0	0	43	1	1	47	1	1	92	1	1	62	1	1

According to Table 4, the highest KIK indicator is 7992% and representing the SI of the M&HS. In the six scientific sectors forty SIs get 1 score, but the other twenty one SIs get 0 score. It follows that total academic staff of SIs in various sectors of science in Latvia in period from 2013 to 2028 did not competitive in the formation of RS on national scientific environment.

Table 5: Performance indicators of the mutual efficiency indicators regarding involvement of total academic research personnel and total academic personnel of SIs in the formation of RS in times a year, quality of research (QTG) scores by TG, new total quantity KIK scores of SIs, and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

KIK rating	E&CS PE	E&CS QTG score	E&CS KIK score	NS PE	NS QTG score	NS KIK score	M&HS PE	M&HS QTG score	M&HS KIK score	A&F&VS PE	A&F&VS QTG score	A&F&VS KIK score	SS PE	SS QTG score	SS KIK score	H&AS PE	H&AS QTG score	H&AS KIK score
1	0,5	3	1	0	4	1	0	2	5	1,8	3	1	0,9	3	1	1,1	2	1
2	1,5	3	1	0,4	3	0	0	3	1	0	2	1	0	4	1	5,2	3	1
3	1,5	2	1	0,4	2	0	0,6	4	1	0	3	0	3,2	2	1	0	4	1

KIK rating	E&CS PE	E&CS QTG score	E&CS KIK score	NS PE	NS QTG score	NS KIK score	M&HS PE	M&HS QTG score	M&HS KIK score	A&F&VS PE	A&F&VS QTG score	A&F&VS KIK score	SS PE	SS QTG score	SS KIK score	H&AS PE	H&AS QTG score	H&AS KIK score
4	0,7	3	1	0,2	4	0	0,9	4	1	0	4	0	1,7	3	1	6,6	4	1
5	0	2	1	0	4	0	3,8	1	0	0	4	0	2,4	3	1	4,5	2	1
6	0,2	2	1	0,2	3	0	0,9	3	0				4,4	3	1	0	4	1
7	0,9	2	1	0	3	0	0	5	0				7,6	2	1	0,5	3	1
8	0,4	3	1				0	4	0				1,7	2	1	6,8	3	1
9	0,2	3	1										2,1	2	1	2,7	3	1
10	2,6	2	1										2,1	3	1	8,4	4	0
11	0,4	3	1										0,3	3	1	11,6	4	0
12	0,7	2	1										1,5	1	1			
13	0	3	0										1,8	2	1			
14	0	4	0										0	1	0			
15	5,5	1	0										0	1	0			
16	0	1	0															
Average	0,6	-	1	0,2	-	0	0,4	-	1	0,2	-	1	1,8	-	1	1,7	-	1

In Table 5, the PE indicators rests in the range from 0,2 to 11,6 in respect of the SIs in Latvia. The highest PE is held by the SI in the H&AS, while the lowest PE belongs to two SI's in the E&CS, and, to two SI's in the NS.

The highest average rate of the PE indicators is 1,8 in the SS, the second highest average rate of the PE indicators is 1,7 in the H&AS. It follows that academic research personnel of the SIs of the SS and the H&AS is more effective as their academic personnel in the formation of RS. Lowest average rate of the PE indicators is 0,2 in the NS, and the A&F&VS. It follows that academic personnel of above scientific sectors is a bit effective in the formation of RS to compare with academic research personnel at the SIs of the NS, and the A&F&VS.

When comparing QTG scores by TG to new total quantity KIK scores calculated by authors, it can be concluded that they differ from 1 score to 5 scores in total. The assessment of the QTG scores and new KIK scores of each SI in various sector of sciences in Latvia results in a conclusion that new KIK scores were too lower, and, except for the one SI in the M&HS, where KIK score highest, and, one SI in the SS, where QTG, KIK scores coincided.

Table 6: The summary of performance indicators of the involvement of total academic staff of SIs in the formation of RS in a year and their total margins of AIK, PIK, SIK, and KIK indicators comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

Scores	Total margins of AIK (%)	Total margins of PIK (%)	Total margins of SIK (%)	Total margins of KIK (%)	Total average margins of AIK (%)	Total average margins of PIK (%)	Total average margins of SIK (%)	Total average margins of KIK (%)
0	4 - 4	1 - 39	-	1 - 39	-	21 - 21	-	19 - 19
1	16 - 165	40 - 1615	11 - 325	40 - 469	98 - 164	57 - 256	48 - 222	43 - 92
2	174 - 309	-	392 - 600	-	207 - 283	-	-	-
3	393 - 468	-	767 - 814	-	-	-	-	-
4	527 - 547	-	1167 - 1167	-	-	-	-	-
5	829 - 829	7992 - 7992	1683 - 1683	7992 - 7992	-	-	-	-

From the results summarised in the tables 6, authors conclude that for all AIK, PIK, SIK, KIK indicators whose

score is 1, the total margins of PIK indicators and total average margins of PIK indicators are the highest. They are followed total margins of KIK indicators and total average margins of SIK indicators. Total margins for all indicators whose score is 5, belongs to AIK, PIK, SIK and KIK indicators. Total margins for all scores from 1 to 5, which find only for AIK indicators.

5. Conclusions

The study of the authors did not result in confirming hypothesis. The quality of research scores of the SIs do not shows the efficiency of the RS formation in the SIs of Latvia. When comparing the QTG scores of TG group to the new KIK scores by the authors, it can be concluded that they differ from 1 to 5 scores in total.

The study shows that new performance indicators KIK of the involvement of total academic staff of SIs in the formation of RS in various sectors of sciences in Latvia in period from 2013 to 2018 were lower as shown by the results compiled by the relevant Panel of the TG, except for the one SI of the M&HS, where the KIK score was highest per 3 scores, and, except for one SI in the SS, where QTG, KIK scores coincided

The authors are encouraged to supplement the methodology for international evaluation of scientific institutions with four efficiency indicators AIK, PIK, SIK, KIK of the involvement of academic staff and PhDs completed at the SIs in the formation of RS per year in percentage, and, PE in times, and performance indicators of their comparative analysis in various sectors of sciences in country.

The novelty of the research is that methodology allows comparison of the efficiency of the involvement of SIs in the formation of scientific articles in the country, determination for indicators of the AIK, PIK, SIK, KIK total limits, in conformity with them, clarification of the score evaluation system for IESI.

Ethical Declaration

The authors declares that there are no ethical issues related to the research presented in this paper.

AI Declaration

The authors declares that no significant AI tools or technologies were used in the conduct the research for this paper.

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