

The Application of Research Methods in Practice for the Efficiency of the Involvement of Academic Staff in the Formation of Intellectual Capital

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Abstract: The application of research methods in practice for the efficiency of the involvement of academic staff in the formation of intellectual capital at scientific institutions is highly topical. The object of the research is the application of research methods in practice for the efficiency of the involvement of academic staff in the formation of intellectual capital at scientific institutions in various branches of science while the subject of the research is the comparative analysis of the efficiency indicators of intellectual capital formation at scientific institutions in various branches of science in Latvia. The objective of the research is the application of research methods in practice for the efficiency of the involvement of academic staff in the intellectual capital formation at scientific institutions in various branches of science in Latvia in the period from 2013 to 2018. The following tasks were set to reach the objective: (1) to study the application of research methods in practice for the efficiency of the involvement of academic staff in the formation of intellectual capital at scientific institutions in various branches of science; (2) to calculate the main efficiency indicators thereof; and, (3) to carry out the comparative analysis of indicators characterising the efficiency of intellectual capital formation at scientific institutions in various branches of science in Latvia. Research methods used in the paper are as follow: content analysis, economic analysis, and economic experiment.

Keywords: Research Methods, Efficiency Indicators, Intellectual Capital, Academic Staff, Practice

1. Introduction

Efficiency indicators are widely used for evaluation of financial and economic activities of commercial enterprises, but these insufficient use for evaluation of the results of the work of scientific institutions. The authors therefore focused on studying the application of research methods and its quantitative indicators to the practice for the efficiency analysis of the involvement of academic staff in the formation of intellectual capital across different scientific sectors.

Nowadays different scientific institutions (SIs) have different amount and types of intellectual capital (IC) that their produce. One type of intellectual capital are an inventions that usually have be protected with different patents. These patented inventions can be commercialized on the market and therefor to attract more financial resource for new research in different scientific sectors.

In practice the Latvian scientific institutions only analyze the numbers of Latvian Patents (LPS) but the efficiency of the involvement of academic staff on the formation of Latvian Patents are not measured.

Specific economic indicators are needed to assess the performance of the SIs. Qualitative data is required for the calculation of economic indicators. For this purpose, the results of the international evaluation of scientific institutions (IESI) can be used.

Every six years, the Ministry of Education and Science of the Republic of Latvia (MoES) shall organise the IESI registered in Latvia. The last IESI took place for the period from 2013 to 2018. In order to establish the dynamics of the efficiency indicators of academic staff involved in the formation of LPS at SIs in Latvia (MoES, 2021), the authors used the output data of findings across the set of SIs evaluations in the period from 2013 to 2018 offered by "Technopolis-group" (TG). It provides an opportunity for the authors to calculate the LPS indicators at Latvian SIs and to compare their dynamics during the period from 2013 to 2018.

Data of the comparative analysis will help to develop support and motivation programs to increase the efficiency of involvement of academic staff in the LPS formation. In addition, the comparative analysis will show whether the score on the research quality at Latvian SIs in the IESI by TG coincides with the place of the relevant Latvian

SI in the ratings of the LPS indicators, and whether the score on the research quality of the Latvian SI also reflects the efficiency of the involvement of the academic staff of the Latvian SI in the LPS formation.

Hypothesis: The score of the research quality of SIs shows the efficiency of the LPS formation in Latvian SIs.

2. Theoretical Background

The authors rely on the research on understanding, adapting, and applying intellectual capital (IC) in universities (Mercado-Salgado et al, 2016); and the research on the role of human capital in educational-training process at a university (Contu, 2017) which 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 types of capital. 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 IC of each SI. Rondeau et al (2022) remind that peer reviewed publications remain a traditional form of academic productivity. From this set of elements forming IC, national patents can be considered as country scientific and technological development indicator that characterise usefull of national science and technologies for identification and solution different problems in national economics.

The analysis of the number of Latvian Patents (LP) and its efficiency indicators provide an opportunity to determine the national competitiveness of various scientists, SIs, and branches of science in Latvia on the area of national inventions.

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

In order to calculate the AIK, DIK, SIK, and DE of a HEE, Spica et al (2017a; 2017b) developed four formulas:

(1) $AIK = (ZPS:AS) \times 100$; (2) $DIK = (ZPS:DS) \times 100$; (3) $SIK = (ZPS:SS) \times 100$; (4) $DE = DIK:AIK$; where: ZPS represents the number of scientific publications of HEE per year; AS represents the number of academic staff in full-time jobs per year; DS represents the number of academic staff in full-time jobs holding Doctorate degrees per year; and, 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 LPS formation in various branches of science in Latvia. It will comprise evaluation of SIs in six branches 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 Sciences (A&F&VS); 5)Social Sciences (SS); 6)Humanities and Art Sciences (H&AS).

For the purposes of the study, the authors modified the above formulas. Namely, they calculated LPS efficiency indicators for total numbers of full time equivalent (FTE) of academic and research personnel (KIK), for FTE academic staff (AIK), for FTE academic research personnel (PIK) and for PhDs completed at the SI (SIK). In addition, all of the above LPS efficiency indicators were calculated for total number of self-reported outputs of Latvian Patents. The authors calculated mutual efficiency indicators (PE) regarding involvement of FTE academic research personnel (PS) and the FTE academic staff (AS) in the LPS formation in times.

In the present research, the authors have used the following data from the IESI: output data on the number of FTE academic staff (AS), the number of FTE academic research personnel (PS), the total number of FTE academic and research personel (KS), the number of PhDs completed (SS), the number of Latvian Patents (LPS) in the period from 2013 to 2018 per SI in Latvia. The authors revised the above LPS for one year. TG analysed 62 SIs of Latvia.

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

Each place in rating was then assessed with an appropriate score, where the lowest score is 1 point, and the highest score is 5 points. This assessment system enables comparing the quantitative efficiency indicators of SIs in various scientific branches in Latvia calculated by the authors with the IESI overall assessment criterion - the research quality of the SI. The relevant Panel of the TG was a score of the research quality of each SI using the scale where score 5 means an outstanding level of research, score 4 means a very good level of research, score 3 means a good level of research, score 2 means an adequate level of research, and score 1 means a poor level of research (MoES, 2021).

Next, a unified overview of all six branches of science in Latvia was created. Here, all SIs were arranged according to the rank obtained in their branch of science. Furthermore, indicators of the efficiency of the involvement of academic staff of each SI in the LPS formation were added. The authors then selected one SI with the highest efficiency indicator of the involvement of academic staff in the formation of LPS from the unified review of the branches of science in Latvia, accepted it as the basic indicator, and equated it to 100%. Subsequently, the authors calculated the proportion of the efficiency of the involvement of academic staff of each SI in the base indicator.

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

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

4. Results

To calculate the efficiency of the involvement of academic staff in the LPS formation, the authors used formulas that were elaborated and approbated already before and then modified by the authors:

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

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

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

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

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

According to Table 1 the highest AIK indicator in the LPS formation in a year is 45% 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 SIs of other branches 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 points.

Table 1: Performance indicators of the involvement of academic staff of SIs in the LPS formation in a year and the comparative analysis thereof in various branches of science in Latvia in the period from 2013 to 2018

AIK ra- ting	E& CS AIK (%)	E& CS AIK (%) of ba- se in- di- ca- tor	E& CS AIK sco- re	NS AIK (%)	NS AIK (%) of ba- se in- di- ca- tor	NS AIK sco- re	M& HS AIK (%)	M& HS AIK (%) of ba- se in- di- ca- tor	M& HS AIK sco- re	A& F&V S AIK (%)	A& F& VS AIK (%) of ba- se in- di- ca- tor	A& F& VS AIK sco- re	SS AIK (%)	SS AIK (%) of ba- se in- di- ca- tor	SS AIK sco- re	H& AS AIK (%)	H& AS AIK (%) of ba- se in- di- ca- tor	H& AS AIK sco- re
1	45	100	5	39	87	5	17	38	2	7	16	1	3	7	1	15	33	2
2	39	87	5	9	20	1	3	7	1				3	7	1			
3	32	71	4	2	4	1	2	4	1				1	2	1			
4	28	62	4				1	2	1									
5	24	53	3															
6	20	44	3															
7	17	38	2															
8	16	36	2															
9	12	27	2															
10	4	9	1															
11	1	2	1															
Ave- rage	25	56	3	15	33	2	22	49	3	15	33	2	0	0	0	15	33	2

Having compared the numbers collected in Table 2 the authors conclude that the highest PIK indicator of 256% is for a SI representing the M&HS, and the lowest PIK indicator of 0% is for five SIs in various branches of science. It follows that only one SI gets the highest score of 5 points, only one SI gets score of 2 points, twenty-nine SIs gets 1 points, and the rest of SIs gets 0 points.

Table 2: Performance indicators of the involvement of academic research personnel of SIs in the LPS formation in a year and the comparative analysis thereof in various branches of science in Latvia in the 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	69	27	2	16	6	1	256	100	5	12	5	1	8	3	1	17	7	1
2	22	9	1	6	2	1	19	7	1	4	2	1	3	1	1			
3	22	9	1	2	1	1	10	4	1	2	1	1	1	0	0			
4	17	7	1	1	0	0	7	3	1	1	0	0						
5	12	5	1	1	0	0	5	2	1	1	0	0						
6	12	5	1				3	1	1									
7	11	4	1				2	1	1									
8	10	4	1				2	1	1									
9	9	4	1															
10	9	4	1															
11	6	2	1															
12	5	2	1															
13	2	1	1															
14	2	1	1															
Average	15	6	1	2	1	1	8	3	1	3	1	1	1	0	0	17	7	1

In Table 3, according to the SIK indicators, the first place and highest score of 5 points is taken by a SI in the M&HS, while the lowest SIK indicator of 1% is received by a SI representing the M&HS, and a SI representing the SS. It follows from Table 3 that only one of SIs in the E&CS gets score of 4 points, and only one of SIs in the NS gets score of 4 points, two of SIs in the E&CS gets score of 3 points, one of SIs in the E&CS, and one of SIs in the NS gets score of 2 points. The rest of SIs gets 1 point.

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

SIK ra- ting	E& CS SIK (%)	E& CS SIK (%) of ba- se in- di- ca- tor	E& CS SIK sco- re	NS SIK (%)	NS SIK (%) of ba- se in- di- ca- tor	NS SIK sco- re	M& HS SIK (%)	M& HS SIK (%) of ba- se in- di- ca- tor	M& HS SIK sco- re	A& F& VS SIK (%)	A& F& VS SIK (%) of ba- se in- di- ca- tor	A& F& VS SIK sco- re	SS SIK (%)	SS SIK (%) of ba- se in- di- ca- tor	SS SIK sco- re	H& AS SIK (%)	H& AS SIK (%) of ba- se in- di- ca- tor	H& AS SIK sco- re
1	59	64	4	61	66	4	92	100	5	18	20	1	3	3	1	-	-	-
2	51	55	3	23	25	2	11	12	1	17	18	1	2	2	1	-	-	-
3	40	43	3	5	5	1	7	8	1	9	10	1	1	1	1	-	-	-
4	22	24	2	3	3	1	6	7	1	6	7	1				-	-	-
5	17	18	1	2	2	1	4	4	1	5	5	1				-	-	-
6	17	18	1				3	3	1							-	-	-
7	16	17	1				3	3	1							-	-	-
8	14	15	1				1	1	1							-	-	-
9	12	13	1													-	-	-
10	9	10	1													-	-	-
11	6	7	1															
12	5	5	1															
13	5	5	1															
14	2	2	1															
Ave- rage	19	21	2	5	5	1	10	11	1	10	11	1	0	0	0	-	-	-

According to Table 4, the highest KIK indicator is 256% and it represents a SI in the M&HS. In the six branches of science no SI gets 4 points, 3 points, or 2 points, but twenty-five SIs get 1 point, and ten SIs get 0 points. It follows that the total academic staff of SIs in various branches of science in Latvia in the period from 2013 to 2018 did not compete in the LPS formation in the national scientific environment.

Table 4: Performance indicators of the involvement of total academic staff of SIs in the LPS formation in a year and the comparative analysis thereof in various branches of science in Latvia in the 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	27	11	1	11	4	1	256	100	5	5	2	1	2	1	1	8	3	1
2	22	9	1	6	2	1	19	7	1	4	2	1	1	0	0			
3	17	7	1	2	1	1	7	3	1	2	1	1	0	0	0			
4	12	5	1	1	0	0	6	2	1	1	0	0						
5	8	3	1	0	0	0	3	1	1	1	0	0						
6	7	3	1				1	0	0									
7	7	3	1				1	0	0									
8	7	3	1				1	0	0									
9	7	3	1															
10	5	2	1															
11	3	1	1															
12	3	1	1															
13	2	1	1															
14	1	0	0															
Average	10	4	1	2	1	1	6	2	1	3	1	1	0	0	0	8	3	1

In Table 5, the PE indicators rest in the range from 0,2 to 3,8 in respect of SIs in Latvia. The highest PE is held by a SI in the M&HS while the lowest PE belongs to two SIs in the E&CS and one SI 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 1,1 in the H&AS. It follows that academic research personnel of SIs in the SS and the H&AS is more efficient in the LPS formation than their academic staff. The lowest average rate of the PE indicators is 0,2 in the NS and the A&F&VS. It means that academic staff of the above branches of science is more efficient in the LPS formation than academic research personnel at SIs in the NS and the A&F&VS.

The comparison of QTG scores by TG to the new total quantity KIK scores calculated by the authors leads to conclusion that the difference between them forms 1 to 4 points in total. The assessment of the QTG scores and the new KIK scores of each SI in various branches of science in Latvia results in a deduction that new KIK scores were lower, except for the one SI in the M&HS, where new KIK scores were highest.

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

KIK ra- ting	E& CS PE	E& CS QTG sco- re	E& CS KIK sco- re	NS PE	NS QTG sco- re	NS KIK sco- re	M& HS PE	M& HS QTG sco- re	M& HS KIK sco- re	A& F& VS PE	A& F& VS QTG sco- re	A& F& VS KIK sco- re	SS PE	SS QTG sco- re	SS KIK sco- re	H& AS PE	H& AS QTG sco- re	H& AS KIK sco- re
1	1,5	2	1	0,4	2	1	0	2	5	1,8	3	1	2,7	3	1	1,1	2	1
2	0	2	1	0	4	1	0	4	1	0	3	1	1,0	3	0			
3	0	4	1	0,2	4	1	0	3	1	0	4	1	1,0	3	0			
4	0,9	2	1	0	4	0	0,6	4	1	0	4	0						
5	0,4	3	1	0,4	3	0	0	5	1	0	2	0						
6	0,2	3	1				0,9	3	0									
7	0,7	3	1				0,9	4	0									
8	0,7	2	1				3,8	1	0									
9	0,5	3	1															
10	0,2	2	1															
11	0,4	3	1															
12	2,6	2	1															
13	0	3	1															
14	1,5	3	0															
Ave- rage	0,6	-	1	0,2	-	1	0,4	-	1	0,2	-	1	1,8	-	0	1,1	-	1

Following the results summarised in Tables 6, the authors conclude that for all AIK, PIK, SIK, KIK indicators with score 1, the total margins of PIK indicators, total margins of KIK indicators and total average margins of PIK indicators are the highest ones. They are followed by the total margins of SIK indicators, total margins of AIK indicators, and total average margins of SIK indicators, total average margins of KIK indicators. The total margins for all indicators with score 5, belong to KIK, AIK, PIK, and SIK indicators. The total margins for all scores from 1 to 5, were found only in AIK indicators.

Economic indicators are needed to ensure the LPS management in order to measure the efficiency of the involvement of academic staff of SIs in the LPS formation. Thus, the annual total efficiency indicator margins and total average efficiency indicator margins of all SIs in various branches of science in Latvia summarised in Table

6 and their conformity with a specific IESI on five-point scale may serve as the basis for improvement of LPS management in the future.

Table 6: Summary of performance indicators of the involvement of total academic staff of SIs in the LPS formation in a year and the comparative analysis of their total margins of AIK, PIK, SIK, and KIK indicators in various branches of science in Latvia in the 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	0 - 0	1 - 1	-	1 - 1	-	1 - 1	-	0 - 0
1	1 - 9	2 - 22	1 - 18	2 - 27	-	2 - 17	5 - 10	2 - 10
2	12 - 17	69 - 69	22 - 23	-	15 - 15	-	19 - 19	-
3	20 - 24	-	40 - 51	-	22 - 23	-	-	-
4	28 - 32	-	59 - 61	-	-	-	-	-
5	39 - 45	256 - 256	92 - 92	256 - 256	-	-	-	-

5. Conclusions

The study of the authors did not result in confirming the hypothesis. The scores of SIs research quality do not show the efficiency of the LPS formation in Latvian SIs. When comparing the QTG scores of TG group to the new KIK scores by the authors, it can be concluded that they differ by 1 to 4 points in total.

The study shows that new performance indicators KIK of the involvement of total academic staff of SIs in the LPS formation in various branches of science in Latvia in the period from 2013 to 2018 were lower as presented by the results compiled by the relevant Panel of the TG except for the one SI in the M&HS, where the KIK score was higher for 3 points.

The authors are encouraged to supplement the methodology for international evaluation of scientific institutions with quantitative efficiency indicators AIK, PIK, SIK, KIK of the involvement of academic staff and PhDs completed at SIs in the LPS formation per year in percentage and PE in times, and performance indicators of the comparative analysis thereof in various branches of science in the country developed by the authors.

The methodology developed by the authors included five phases: (1) according to formulas previously developed by the authors, the efficiency indicators of each SI were calculated for AIK, PIK, KIK, SIK; (2) efficiency indicators for AIK, PIK, KIK, SIK were ranked from the highest indicator to the lowest one, and each SI was given the rating in its branch of science; (3) the comparative analysis of the individual efficiency indicators of each SI was carried out for the AIK, PIK, KIK, SIK between all branches of science, and the highest efficiency indicators of the AIK, PIK, KIK, SIK as a whole in the science were found out; (4) the highest efficiency indicators for AIK, PIK, KIK, SIK were accepted as base indicator and

equated to 100%, and the proportion of the efficiency indicator of each SI in the base indicator was calculated; (5) according to the rating scale developed by the authors, each SI was awarded an appropriate score based on the previously calculated efficiency indicators of the proportion of AIK, PIK, KIK, SIK in the science as a whole.

The methodology provides an opportunity to identify more efficient SIs in the country and to distribute public funding to SIs representing various branches of science more efficiently in accordance with these results. Efficiency indicators can serve as a basis for comparative analysis, planning, management, control, and future improvement of the SIs performance.

Ethics 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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