Efficiency Indicators as Management Research Tools at Scientific Institutions

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Abstract: The theme of research is topical in the present situation with management research tools at scientific institutions of agriculture, forestry, and veterinary science in Latvia. The object of the research are the management research tools of agriculture, forestry, and veterinary science at scientific institutions. The subject of the research is the comparative analysis of efficiency indicators of the involvement of academic staff and students in the formation of intellectual capital of agriculture, forestry, and veterinary science in Latvia. The objective of the research is to study efficiency indicators of academic staff and students in the formation of intellectual capital of agriculture, forestry, and veterinary science at scientific institutions in Latvia in the period from 2013 to 2018. The following tasks are set in order to reach the objective: to study the management research tools at scientific institutions; to identify the concept of efficiency indicators of the involvement of academic staff and students in the formation of intellectual capital of agriculture, forestry, and veterinary science; to calculate their efficiency indicators; and, to conduct comparative analysis of efficiency indicators of the involvement of academic staff and students in the formation of intellectual capital of agriculture, forestry, and veterinary science at scientific institutions in Latvia. Research methods used in the paper are as follow: content analysis, economic analysis, and economic experiment.

Keywords: Efficiency, Management research, Intellectual Capital, Scientific institutions

1. Introduction

Efficiency indicators are widely used for evaluation of financial and economic activities of commercial enterprises, but minimally for evaluation of the results of the work of scientific institutions. The authors therefore focused on studying efficiency indicators as a tool for managing a scientific institution across different scientific sectors.

Compared to the previous work by Spica et al (2022; 2023) this paper draws a more complete portrait of intellectual capital (IC) of agriculture, forestry, and veterinary science, and the efficiency of its formation at scientific institutions (SIs) in Latvia. Here, the same methodology as in the previous papers has been applied.

Every six years, the Ministry of Education and Science of the Republic of Latvia (MoES) organises an international evaluation of SIs registered in Latvia. The previous International Evaluation of Scientific Institutions' Activity (IESIA) in Latvia covered the period from 2006 to 2011. The last IESIA refers to the period from 2013 to 2018. In order to establish the dynamics of efficiency indicators of academic staff involved in the formation of IC in agriculture, forestry, and veterinary science at scientific institutions at SIs of Latvia (MoES, 2021), the authors used the output data of findings across the set of evaluation of SIs of agriculture, forestry, and veterinary science per period from 2013 to 2018 offered by “Technopolis-group” (TG).

TG developed the above IESIA for the period from 2006 to 2011 and from 2013 to 2018 using similar methodology. Consequently, it provides an opportunity for the authors to calculate the IC indicators in agriculture, forestry, and veterinary science at scientific institutions at SIs of Latvia and to compare their dynamics during the period from 2013 to 2018.

The comparative analysis of efficiency indicators of involvement of academic staff of agriculture, forestry, and veterinary science at SIs of Latvia in the IC formation will let them to know whether and how the business environment affects them. IESIA happened during the economic crisis caused by Covid-19. Data of the comparative analysis will help to develop support programs to increase the efficiency of involvement of the academic staff in the IC formation. In addition, the comparative analysis will reveal whether the score of agriculture, forestry, and veterinary science at SIs of Latvia in the IESIA of TG coincides with the place of SIs of Latvia in the ratings of IC indicators, and whether the overall score of SIs of Latvia also reflects the efficiency of the involvement of the academic staff of SIs of Latvia in the IC formation.

Hypothesis: The overall score of SIs shows the efficiency of the IC formation at SIs of Latvia.

2. Theoretical Background

Business and management research is systematic research to find out things about business and management. Key outcome of management researcher is academic publication (Saunders, Lewis & Thornhill, 2019). The 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. Rondeau et al (2022) remind that peer reviewed publications remain a traditional form of academic productivity. Performance can be measured by several different indicators. Spica et al (2017a; 2017b) have worked out four indicators of the efficiency of the formation of IC in the higher education establishment (HEE): (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).

3. Methodology

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.

The authors modified the above mentioned formulas for the purposes of the study. Namely, they calculate IC efficiency indicators for total numbers of full time equivalent (FTE) academic and research personnel (KIK), for FTE academic personnel (AIK), for FTE academic and research personnel (PIK) and for PhDs completed at SIs (SIK). In addition, all the said IC efficiency indicators were calculated for different forms of IC such as total number of self-reported outputs of IC (KS), articles in peer reviewed scientific edited journals and conference proceedings included in WoS or SCOPUS (WS), articles in peer reviewed edited journals, and conference proceedings not included in WoS or SCOPUS (RS), monographs (MS), and Latvian patent (LPS), and European patent and International patents (EPS). The authors calculated mutual efficiency indicators (PE) regarding involvement of the FTE academic and research personnel (PS) and the FTE academic personnel (AS) in the formation of IC in times.

In the present research, the authors used the following data from the IESIA: 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 included in WoS or SCOPUS (WS), the number of articles in peer reviewed scientific edited journals and conference proceedings not included in WoS or SCOPUS (RS), the number of monographs (MS), the number of Latvian patents (LPS), and the number of European and International patents (EPS), and total number of self-reported outputs (KS) in period from 2013 to 2018 per SI of agriculture, forestry, and veterinary science in Latvia. Authors revised the above WS, RS, MS, LPS, EPS and KS for the year.

The number of scientific publications and patents are the main results of the IC formation at SIs of agriculture, forestry, and veterinary science. TG analysed 5 SIs of agriculture, forestry, and veterinary science of Latvia. In the IESIA there were collected output data on 5 public SIs of Latvia including 1 Latvian university, and no one private SI of Latvia were collected.

During the period analysed in the IESIA, there were only 5 such SIs in Latvia: Institute of Agricultural Reources and Economics (IARE); Institute of Horticulture (IH); Latvian State Forest Research Institute “Silava” (SILAVA); Institute of Food Safety, Animal Health and Environment “BIOR” (BIOR); Latvia University of Life Sciences and Technologies Agricultural, Forestry and Veterinary Sciences (UL/LT/A).

In this study, one scientific publication or one patent 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 place in the rating was then assessed with an appropriate score, where the lowest score is 1 point, while the highest score is 5 points. Thus, the SI, which took first place in - KIK, AIK, PIK and SIK received 5 points in the ranking, took second place - received 4 points, took third place - received 3 points, took fourth place - received 2 points, and took fifth place - received 1 point.

The above mentioned assessment system allows to compare the quantitative efficiency indicators of SIs of agriculture, forestry, and veterinary science in Latvia calculated by the authors to IESIA overall assessment criterion - quality of the SI research performance. The relevant TG Panel was the score of research performance of each SI using a 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).

The score assigned to the overall assessment by the relevant TG Panel was based on the assessment of five sub elements A to E, where element A characterises the quality of the research, element B - the impact on the development of the specific field of science, element C - the economic and social impact of the research, element D - the research environment and infrastructure of the institution, element E - the institution development potential. The Panel was provided with scores against each sub-element and the overall score and was also provided with narrative descriptions of their scores, the overall score and the sub-elements (MoES, 2021).

The follow-up authors compared the results of their own estimates of SIs quantitative indicators to the qualitative indicators of the relevant TG Panel and calculated the difference between the indicators and the changes. For this purpose, the authors calculated the average score of indicators for each SI recording the efficiency of the IC formation and compared these scores to scores of the research quality of each SI and overall score developed by the TG Panel.

4. Results

It follows from the IESIA that in Latvia, 5 SIs of agriculture, forestry, and veterinary science have corresponding fields of science in agriculture, forestry, and fisheries, 3 SIs corresponding fields of science in agricultural biotechnology, and, 2 SIs corresponding fields of science in veterinary science. In turn, such corresponding fields of sciences as social and economic geography; animal and dairy science are operated by 1 SI in each field of science.

According to the authors' estimates, from the IESIA data show that the total number of self-reported outputs of SIs of agriculture, forestry, and veterinary science in Latvia is taken in the largest proportion by the WS - 60,28%, which is followed by the RS - 35,73%, the MS - 1,70%, the LPS - 1,91%, the EPS - 0,38%.

To calculate the efficiency of the involvement of academic and research staff in the WS formation, the authors used formulas that were developed and applied already before and are modified now.

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

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

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

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

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

These indicators of SIs and their place in the rating of SIs of agriculture, forestry, and veterinary science in Latvia as well as its scores are summarized in Table 1. The table of the SIs indicators, ratings, and score was drawn up by authors. The summarized indicators show that in general, in Table 1, the figure rests in the range from 51% to 547% in respect of the SIs in Latvia. The highest indicator is SIK in the IARE, while the lowest indicators are PIK and KIK in the SILAVA. Comparing the figures collected in Table 1, the authors conclude that the AIK indicator of 191% is for the UL/LT/A, and no one AIK indicator at SIs of agriculture, forestry, and veterinary science of Latvia were collected. The lowest PIK and KIK indicators of 51% are for the SILAVA, the highest PIK indicator of 338% is for the UL/LT/A also the highest KIK indicator of 122% is for the UL/LT/A; the highest SIK indicator of 547% is owned by the IARE while the lowest SIK indicator of 237% is held by the UL/LT/A. The PS of the UL/LT/A is 1,8 times more efficient in the WS formation.

Table 1: The efficiency of the involvement of academic and research staff in the WS formation at SIs of agriculture, forestry, and veterinary sciences in Latvia per year in period from 2013 to 2018

SI	AIK (%)	AIK rating	AIK score	PIK (%)	PIK rating	PIK score	KIK (%)	KIK rating	KIK score	Average of AIK & PIK score	PE in times	SIK (%)	SIK rating	SIK score	Average of AIK & PIK & SIK score
IARE	0	0	0	70	4	2	70	4	2	1,0	0	547	1	5	2,3
IH	0	0	0	80	2	4	80	2	4	2,0	0	354	3	3	2,3
SILAVA	0	0	0	51	5	1	51	5	1	0,5	0	477	2	4	1,7
BIOR	0	0	0	77	3	3	77	3	3	1,5	0	303	4	2	1,7
UL/LT/A	191	1	5	338	1	5	122	1	5	5,0	1,8	237	5	1	3,7
Average	478			96			80				0,2	316			

In Table 1, the authors created the rating and score of the SIs of agriculture, forestry, and veterinary science in Latvia based on the AIK, PIK, KIK, SIK indicators of the efficiency of the academic research personnel and PhDs involvement in the WS formation. According to the AIK indicator, the first and single place, and highest score is taken by the UL/LT/A; according to the PIK and KIK indicators, the first place and highest score is taken also by the UL/LT/A; and according to the SIK indicator the first place and highest score is taken by the IARE.

On the other hand, when comparing the average KIK without SIK, the highest score is obtained by the UL/LT/A, and the comparison of the average KIK with the SIK shows that the highest score goes to the IARE.

The authors compared the SIK indicators of all students of HEE in Latvia to SIK indicators of PhDs students of SIs of agriculture, forestry, and veterinary science in Latvia, and found that SIK indicators of the PhDs students were considerably higher. It follows from the study by Spica et all (2018) that the highest SIK indicators were held by Daugavpils University (1,45% in 2013) and the University of Latvia (1,82% in 2014). Meanwhile, between 2013 and 2018, the highest annual SIK indicator for PhDs students of SIs of agriculture, forestry, and veterinary science in Latvia was held by the IARE and represented 547%.

When analysing the results obtained by SIs in the IC formation in the field of agriculture, forestry, and veterinary science, the same methodology was used as in the fields of social sciences, and humanities and art sciences. Thus, the quantitative results of SIs in these fields can be compared. One of the main criteria for the quantitative evaluation of SIs is the efficiency of the involvement of the SIs staff in the formation of WoS and SCOPUS publications.

The comparison of the results of the three fields of science leads to conclusion that the highest score of the KIK indicator in the field of social sciences is 278% (Spica et al, 2022) while the highest score of the KIK indicator in field of agriculture, forestry, and veterinary science is 122%, and, the highest score of the KIK indicator in field of humanities and art sciences is 53% (Spica et al, 2023). In addition, it should be noted that the highest score of the KIK indicator in the field of humanities and art sciences is a little higher than 51% received by the SILAVA, which is the lowest score in the field of agriculture, forestry, and veterinary science.

A similar trend is observed when comparing the efficiency of the involvement PhD degree holders in the formation of WoS and SCOPUS publications in the three above-referred fields of science. Here, the highest rate of the SIK indicator in social sciences is 667% (Spica et al, 2022) while in agriculture, forestry, and veterinary science the highest rate is 547%, and, the highest rate of the SIK indicator in humanities and art science is 450% (Spica et al, 2023). In turn, the lowest rate of the SIK indicator in the field of agriculture, forestry, and veterinary science is 237%; the lowest rate of the SIK indicator in the field of social sciences is 58% (Spica et al, 2022); the lowest rate of the SIK indicator in the field of humanities and art science is 13% (Spica et al, 2023). This means that the lowest rate in the field of agriculture, forestry, and veterinary science, however, is almost 18 times

higher than the lowest rate in the field of humanities and art science, and, almost 4 times higher than the lowest rate in the field of social science.

In Table 2 authors calculate efficiency of the involvement of academic and research staff in the RS formation, the authors used formulas 6; 7; 8; 9; 10.

AIK = (RS : AS) x 100 (6)

PIK = (RS : PS) x 100 (7)

KIK = (RS : KS) x 100 (8)

SIK = (RS : SS) x 100 (9)

PE = PIK : AIK

Table 2: The efficiency of the involvement of academic and research staff in the RS formation at SIs of agriculture, forestry, and veterinary sciences in Latvia per year in period from 2013 to 2018

SI	AIK (%)	AIK rating	AIK score	PIK (%)	PIK rating	PIK score	KIK (%)	KIK rating	KIK score	Average of AIK & PIK score	PE in times	SIK (%)	SIK rating	SIK score	Average of AIK & PIK & SIK score
IARE	0	0	0	40	2	4	40	2	4	2,0	0	311	1	5	3,0
IH	0	0	0	27	3	3	27	3	3	1,5	0	119	3	3	2,0
SILAVA	0	0	0	12	4	2	12	4	2	1,0	0	108	4	2	1,3
BIOR	0	0	0	5	5	1	5	5	1	0,5	0	20	5	1	0,7
UL/LT/A	200	1	5	354	1	5	128	1	5	5,0	1,8	248	2	4	3,0
Average	283			57			47				0,2	187			

In Table 2, in respect of SIs of agriculture, forestry, and veterinary science in Latvia, the figure rests in the range from 5% to 354%. The highest indicator is the PIK in the UL/LT/A but the lowest indicators are the PIK and the KIK in the BIOR.

The AIK indicator of 200% is for the UL/LT/A, and no one AIK indicator at SIs of agriculture, forestry, and veterinary science of Latvia were collected; the highest PIK indicator of 354% is held by the UL/LT/A, while the lowest PIK indicator of 5% belongs to the BIOR; the highest KIK indicators of 128% is held by the UL/LT/A, while the lowest KIK indicator of 5% is held by the BIOR; the highest SIK indicator of 311% is held by the IARE, while the lowest SIK indicator of 20% belongs to BIOR. The PS of the UL/LT/A is 1,8 times more efficient in the RS formation.

In Table 3 authors calculate efficiency of the involvement of academic and research staff in the formation of MS, the authors used formulas 11; 12; 13; 14; 15.

AIK = (MS : AS) x 100 (11)

PIK = (MS : PS) x 100 (12)

KIK = (MS : KS) x 100 (13)

SIK = (MS : SS) x 100 (14)

PE = PIK : AIK (15)

Table 3: The efficiency of the involvement of academic and research staff in the MS formation at SIs of agriculture, forestry, and veterinary sciences in Latvia per year in period from 2013 to 2018

SI	AIK (%)	AIK rating	AIK score	PIK (%)	PIK rating	PIK score	KIK (%)	KIK rating	KIK score	Average of AIK & PIK score	PE in times	SIK (%)	SIK rating	SIK score	Average of AIK & PIK & SIK score
IARE	0	0	0	3	3	3	3	2	4	1,5	0	25	1	5	2,7
IH	0	0	0	2	4	2	2	4	2	1,0	0	8	4	2	1,3
SILAVA	0	0	0	2	5	1	2	5	1	0,5	0	15	2	4	1,7
BIOR	0	0	0	3	2	4	3	1	5	2,0	0	14	3	3	2,3
UL/LT/A	3	1	5	5	1	5	2	3	3	5,0	1,8	4	5	1	3,7
Average	13			3			2				0,2	9			

In Table 3 the figure rests in the range from 2% to 25% in respect of the SIs in Latvia. The highest indicator is SIK in the IARE, but the lowest indicators are PIK and KIK in the SILAVA.

Table 4: The efficiency of the involvement of academic and research staff in the LPS formation at SIs of agriculture, forestry, and veterinary sciences in Latvia per year in period from 2013 to 2018

SI	AIK (%)	AIK rating	AIK score	PIK (%)	PIK rating	PIK score	KIK (%)	KIK rating	KIK score	Average of AIK & PIK score	PE in times	SIK (%)	SIK rating	SIK score	Average of AIK & PIK & SIK score
IARE	0	0	0	1	5	1	1	5	1	0,5	0	6	4	2	1,0
IH	0	0	0	4	2	4	4	2	4	2,0	0	17	2	4	2,7
SILAVA	0	0	0	2	3	3	2	3	3	1,5	0	18	1	5	2,7
BIOR	0	0	0	1	4	2	1	4	2	1,0	0	5	5	1	1,0
UL/LT/A	7	1	5	12	1	5	5	1	5	5,0	1,8	9	3	3	4,3
Average	15			3			3				0,2	10			

In Table 4 authors calculate efficiency of the involvement of academic personnel and research personnel in the formation of LPS, the authors used formulas 16; 17; 18; 19; 20.

AIK = (LPS : AS) x 100 (16)

PIK = (LPS : PS) x 100 (17)

KIK = (LPS : KS) x 100 (18)

SIK = (LPS : SS) x 100 (19)

PE = PIK : AIK (20)

In Table 4 the figure rests in the range from 1% to 18% in respect of the SIs in Latvia. Comparing the figures collected in Table 4, the authors conclude that the highest AIK, PIK, and KIK score is held by the UL/LT/A, while the lowest PIK and KIK score belongs to the IARE. The comparison of the SIK, shows that the highest SIK score is held by the SILAVA, while the lowest SIK score belongs to the BIOR.

In Table 5 authors calculate efficiency of the involvement of academic personnel and research personnel in the formation of EPS, the authors used formulas 21; 22; 23; 24; 25.

AIK = (EPS : AS) x 100 (21)

PIK = (EPS : PS) x 100 (22)

KIK = (EPS : KS) x 100 (23)

SIK = (EPS : SS) x 100 (24)

PE = PIK : AIK (25)

Table 5: The efficiency of the involvement of academic and research staff in the EPS formation at SIs of agriculture, forestry, and veterinary sciences in Latvia per year in period from 2013 to 2018

SI	AIK (%)	AIK rating	AIK score	PIK (%)	PIK rating	PIK score	KIK (%)	KIK rating	KIK score	Average of AIK & PIK score	PE in times	SIK (%)	SIK rating	SIK score	Average of AIK & PIK & SIK score
IH	0	0	0	3	1	5	3	1	5	2,5	0	15	1	5	3,3
SILAVA	0	0	0	0	2	4	0	2	4	2,0	0	3	2	4	2,7
Average	3			1			0,5				0,2	2			

Of the 5 Latvian SIs in the field of agriculture, forestry, and veterinary sciences, only the IH and the SILAVA have the EPS. In Table 5 the figure rests in the range from 0% to 15% in respect of the SIs in Latvia. In all tables, the average indicators PE are the same, and the average SIK indicators are the highest, while the average KIK indicators.

Table 6: The Comparison of the results of qualitative and quantitative evaluation of Latvian SIs in the field of agriculture, forestry, and veterinary sciences using the IC form for period from 2013 to 2018

SI	Quality score by TG (QTG)	Overall score by TG (OTG)	Total average score of AIK & PIK using IC form (TAAP)	Difference of score (QTG-TAAP)	Difference of score (OTG-TAAP)	Total average score of AIK & PIK & SIK using IC form (TAAPS)	Difference of score (QTG-TAAPS)	Difference of score (OTG-TAAPS)
IARE	2	3	1,5	0,5	1,5	2,7	-0,7	0,3
IH	3	3	2,0	1,0	1,0	2,3	0,7	0,7
SILAVA	4	4	0,5	3,5	3,5	1,7	2,3	2,3
BIOR	4	4	1,0	3,0	3,0	1,0	3,0	3,0
UL/LT/A	3	2	5,0	-2,0	-3,0	2,3	0,7	-0,3

Table 7: The Comparison of the results of qualitative and quantitative evaluation of Latvian SIs in the field of agriculture, forestry, and veterinary sciences using the overall IC for period from 2013 to 2018

SI	Quality score by TG (QTG)	Overall score by TG (OTG)	Total average score of KIK using IC overall (TAKO)	Difference of score (QTG-TAKO)	Difference of score (OTG-TAKO)	Total average score of KIK & SIK using IC overall (TAKOS)	Difference of score (QTG-TAKOS)	Difference of score (OTG-TAKOS)
IARE	2	3	2,2	-0,2	0,8	2,8	-0,8	0,2
IH	3	3	3,6	-0,6	-0,6	3,5	-0,5	-0,5
SILAVA	4	4	2,2	1,8	1,8	3,0	1,0	1,0
BIOR	4	4	2,2	1,8	1,8	1,8	2,2	2,2
UL/LT/A	3	2	3,6	-0,6	-1,6	2,7	0,3	-0,7

5. Conclusions

The study of the authors did not result in confirmation of their hypothesis. When comparing the qualitative ratings of TG group to the quantitative assessments performed by the authors, it can be concluded that they differ from minus 3,0 points to plus 3,5 points in total. The hypothesis is accepted *pro tem* for other branches of SIs of Latvia.

The study shows that the KIK, AIK, PIK, and SIK of SIs of agriculture, forestry, and veterinary sciences in Latvia were lower than the results compiled by the relevant TG Panel except for one to two SIs of agriculture, forestry, and veterinary sciences.

The authors concluded from comparison of the qualitative indicators analysed by the TG Panel with the quantitative efficiency indicators developed by the authors that they differ significantly. Therefore, it is encouraged to supplement the methodology for international evaluation of scientific institutions with efficiency indicators in order to improve the quality of the evaluation.

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