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MODELING HIGHER EDUCATION INSTITUTIONS EFFECTIVENESS IN LATVIA

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Abstract

The article discusses the modelling of relative effectiveness of higher education institutions study programmes in Latvia using Data Envelopment Analysis method. The empirical research showed that there is correlation between the number of publication to academic staff a year and ratio of students to academic staff within the programme. The relation is negative (more students – less publications) at the bachelor and master level study programmes, but positive (more students – more publications). This can be explained by the bigger amount of work and accordingly more time dedicated to tuition of bachelor and master level students, as well as being co-authors in the doctoral students' publications. The research show that there is a lack of funding for patenting and supportive administrative structures at the higher education institutions are not established or are working insufficiently. The author suggests to put more emphasis on patenting issues not only in the policy planning level, but also on the level of each higher education institution by establishing supportive administrative structures. National policy should assist both financially and by enhancing prestige of the basic science, and just as a secondary objective could be the technology transfer in Latvia.

Keywords: higher education institutions effectiveness, data envelopment analysis, financing of innovation, patenting.

JEL Classification: I23, I28, O31, O34, H52.

Introduction

In order to implement measures that promote achievement of Europe 2020 strategy target of investing 3% of gross domestic product in research and development, the financing absorption capacity of research institutions, especially in higher education institutions has to be enlarged by strengthening research activities in the higher education institutions. Higher education institutions employed 60.73 % of all scientific workers in 2010 in terms of full time equivalent in Latvia (Bāliņa, 2011), it means that the most of knowledge and novelty is generated in the higher education institutions in Latvia.

Considering negative demographical tendencies and that the number of students at higher education institutions in Latvia is going to depreciate in the following decades, there is need for redesign of tertiary education system so, that the higher education institutions in Latvia gradually increase the research actions and improves its quality. In order to perform such reforms, the interconnection of tuition, academic research activities and patenting has to be evaluated.

The research focuses on analysis of empiric data and investigation of higher education institutions research potential and effectiveness.

The aim of the research is to simulate the effectiveness of higher education institutions in Latvia modelling the trade-offs of academic activities such as educating students and publishing and patenting.

To achieve the aim of the research the following tasks were set out. Firstly, accomplish revision and analysis of existing research and theoretical findings on assessment of effectiveness of higher education institutions in the world and in Latvia. Secondly, analyze empirical data on Latvian higher education institutions achievements and financing patterns. Thirdly, determine interaction between input variables – amount of financing and number of academic staff – and outputs – educated students, publications, and patents. Fourthly, to elaborate the model for testing the relative effectiveness of higher education study programmes using Data Envelopment Analysis method. Finally, to elaborate proposals and recommendations for policy makers on development of more accurate and adequate performance based financing allocation system for higher education institutions in Latvia.

The following economic research methods were used for tackling the tasks: grouping, graphic illustration, monographic descriptive method. Analysis and synthesis are used in the paper to study the problem elements and synthesize coherencies. Induction method is used for summarizing individual facts in general statements, but deduction method for theoretical explanations and logical synthesis of the empirical study. Using the quantitative data from year 2008 to 2010 on higher education institutions in Latvia, that was obtained within questionnaire organized by ongoing European Social Fund project "Evaluation of Higher Education Study Programmes and Proposals for Quality Improvement", the author performed analysis of variance (ANOVA) in order to detect the relationships among input and output variables of higher education

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institutions. The Data Envelopment Analysis method was used to construct the model for measurement of relative effectiveness of higher education study programmes.

Higher education institution role in the Triple Helix model

According to the Triple Helix model of the knowledge-based economy the main institutions are government, industry, and university (Etzkowitz & Leydesdorff, 1995). Triple Helix model defines the knowledge-based economy by three functions that are describing relations between economic system, the academic system and the political system and are relatively autonomous subsystems of society which operate with different mechanism: (1) wealth generation in the economy, (2) novelty generation by organized science and technology, and (3) governance of the interactions among these two subdynamics by policy-making in the public sphere and management in the private sphere (Leydesdorff 2010). When the Triple Helix model is working good and mutually complementary the universities are becoming more entrepreneurial, industry acts as an educator, and the government serves as a venture capitalist at times (Schalin, 2010).

These new relationships change the balance between the university's two major basic functions – education (the transfer of existing knowledge to a new generation) and research (the creation of new knowledge). The increasing emphasis on research enlarges this trade-off (Schalin, 2010).

But According to Washburn, universities now hope to gain much more financially from applied research and therefore tend to put basic research on the back burner. Researchers tend to take fewer risks, preferring topics that promise immediate rewards instead of more speculative subjects that might eventually be of greater benefit (Washburn, 2005).

Nelson presents a more complete model of university research production and diffusion (Nelson, 2012), entrepreneurial effectiveness of European universities is studied by Van Looy, et.al., 2011, while Hicks analyses the Performance-based research funding systems are national systems of research output evaluation used to distribute research funding to universities, with the aim to increase the excellence of a nation's research. Institutional, professional and individual autonomy are important values in the academic community and the effects of Performance-based research funding systems on autonomy are much discussed (Hicks, 2012). Organizational control theory as helpful method to manage the university's technology development is analysed by Johnson (2011).

There are several authors in Latvia that have been writing about higher education institutions as stakeholder of national innovation system and knowledge based economy (Boļšakovs, 2008; Dimza, 2003), higher education institution's role in regional economic development (Sloka & Vilciņa, 2009; Vīksne, 2010), and the efficiency of higher education institutions as educational institutions (Paniņa, 2011).

Research capacity at higher education institutions in Latvia

Council of Higher Education in Latvia is implementing a European Social Fund project "Evaluation of Higher Education Study Programmes and Proposals for Quality Improvement" from 9 May 2011 to 30 April 2013. The aim of the project is to evaluate higher education programme quality and overlapping, sufficiency of resources, and sustainability. To achieve the aim the Council of Higher Education in Latvia, organized questionnaire of higher education institutions by field of science and education programme. The author of the article selected quantitative data obtained within the questionnaire about 10 different field of science (Table 1.).

The data in the Table 1 show that average programme funding to academic staff varies from 4113,75 lats (mathematics) to 12 506,66 lats (biology). Such bias among study programmes can be explained by the differences in number of academic staff, additional funding attracted to study programme and different study costs depended from field of science.

Analysing the outputs of scientific action in the selected education programmes – number of publications, number of patents, and the author discovers even higher differences among the education programmes in the specific field of science. The average number of patents, licences, design samples, computer programmes during the year 2008-2010 is highest in the chemistry (28.25), veterinary medicine (15.33), agriculture (11.00) and biology (10.20), while there are no patents within the forestry research and philology education programmes.

Table 1. Average data on higher education institutions education programme performance in Latvia by the field of science (2008-2010)

Field of science	Total programme funding 2010./2011. to academic staff, LVL	Total number of scientific publications	Number of scientific publications in internationally cited editions	Number of scientific publications in other international editions	Number of scientific publications in other Latvian editions	Patents, licences, design samples, computer programmes
Geography, Geology	4 468.00	150.67	43.00	70.17	37.50	0.50
Philology	4 566.90	103.88	2.63	65.79	35.46	-
Veterinary medicine	7 187.00	333.00	125.67	112.67	94.67	15.33
Environmental science	4960.79	240.89	40.00	111.67	89.22	9.38
Mathematics	4 113.75	123.43	58.14	47.14	18.14	1.14
Physics	9 127.72	167.20	138.20	22.00	7.00	2.80
Biology	12 506.66	183.40	109.60	28.80	45.00	10.20
Agriculture	4 855.15	520.00	195.20	160.40	164.40	11.00
Forestry research	4 207.30	230.33	44.17	74.83	111.33	-
Chemistry	8 308.37	338.00	153.38	103.50	81.13	28.25

The highest average total number of scientific publications during the year 2008-2010 is in the field of agriculture (520), chemistry (338) and veterinary medicine (333). Although it is important to analyse the quality of publications: most scientific publications in internationally cited editions have physics (83% of all publications), biology (60% of all publications), mathematics (47% of all publications), chemistry (45% of all publications), and veterinary medicine (38% of all publications), while number of scientific publications in other Latvian editions (except internationally cited editions and international editions) have forestry research (48% of all publications), environmental science (37% of all publications), philology (34% of all publications).

This means that both – the number and the quality of scientific publications, and number of patent licences, design samples, computer programmes have to be increased in order to improve the performance of scientific action of higher education institutions in Latvia.

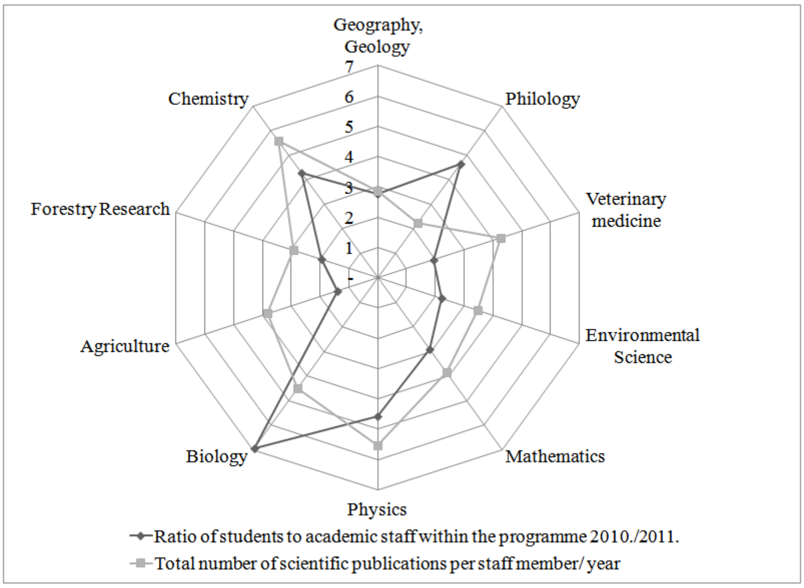

Figure 1. Average ratio of students to academic staff within the programme 2010./2011. and the mean of total number of scientific publications per staff member a year in higher education institutions education programme by the field of science in Latvia

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The analysis of ratio of students to academic staff within the education programme 2010./2011. and total number of scientific publications per staff member a year show that there could be the negative correlation between those variables in some education programmes (see Figure 1).

The proportion students to academic staff is the lowest in the education programme agriculture (1.40 students/academic staff), but the highest biology (6.94 students/academic staff), while scientific publications per staff member a year varies from 2.24 philology to 5.59 chemistry and 5.53 physics.

The scientific question is how to facilitate the increase the output of higher education institutions scientific action. In order to answer this question the interaction between input and output variables of higher education institution scientific and educational processes have to be analysed.

Interaction between input and output variables of higher education institution scientific processes

For explanation of higher education institution interactions among variables, the author of the article raises three hypotheses:

1) The higher ratio of students to academic staff, the less scientific publications per staff member a year;
2) The higher total education programme funding 2010./2011. to academic staff, the more patents, licences, design samples, computer programmes (since 2008) per staff member a year;
3) The higher total education programme funding 2010./2011. to academic staff, the more scientific publications per staff member a year.

Using the same quantitative data as in the previous section of the article, with an exception that now each case was taken into the calculations, not average data for education programme by science field, the author performed analysis of variance (ANOVA) in order to test the three hypotheses mentioned above.

1) The higher ratio of students to academic staff, the less scientific publications per staff member a year, hypothesis could not be denied if all the cases were included (α=0.05, Sig=0.023, R^2=0.066, y=4.181-0.107x), but if the educational programmes at doctoral level were selected, than hypothesis should be rejected (α=0.05, Sig=0,442, R^2=0.037, y=5.477+0.413x). According to this there is correlation between the number of publication to academic staff a year and ratio of students to academic staff within the programme. The relation is negative (more students – less publications) at the bachelor and master level study programmes, but positive (more students – more publications). This can be explained by the bigger amount of work and accordingly more time dedicated to tuition of bachelor and master level students, as well as being co-authors in the doctoral students' publications. Therefore doctoral students are considered as an input variable, while other students (including doctoral students) are counted as output variable.

2) The higher total education programme funding 2010./2011. to academic staff, the more patents, licences, design samples, computer programmes (since 2008) per staff member a year, hypothesis can be rejected (α=0.05, Sig=0.068, R^2=0.044, y=3180+0.001x). Explanation of this could be that there is not enough financing for patenting, or supportive administrative structures at the higher education institutions are not established or are working insufficiently. The author suggests to put more emphasis on patenting issues not only in the policy planning level, but also on the level of each higher education institution by establishing supportive administrative structures.

3) The higher total education programme funding 2010./2011. to academic staff, the more scientific publications per staff member a year, hypothesis cannot be rejected (α=0.05, Sig=0.003, R^2=0.107, y=2.48+x). This means that sufficient amount of funding helps to generate more publications per academic staff member a year. According to Glenna *et.al.*, strong incentives for public-science research along with adequate public-research funds to preserve the university's vital role in conducting basic and non-proprietary research are needed to complement private-sector research investments at universities (Glenna *et.al.*, 2011).

However, there are several factors and outputs that influence the effectiveness of scientific work at the universities; therefore the author decided use more powerful method that can display relative efficiency of education programmes by scientific field – Data Envelopment Analysis.

Modelling relative efficiency of higher education institutions scientific performance using Data Envelopment Analysis

In the previous section of the article three hypotheses were tested to find out whether there are any correlations among higher education institutions scientific performance variables of education programmes

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by scientific field and what is the nature of these correlations. The author considers that the most appropriate method to test relative efficiency of higher education institutions scientific performance is Data Envelopment Analysis, because provides this sophisticated analysis that can be used in order to perform a number of tasks including:

- Resource allocation: reallocating from the inefficient to the efficient
- Identification of "best practice"
- Identification of "poor practice"
- Target setting
- Monitoring efficiency changes over time
- Calculation of conditions for Performance-based research funding systems

The article focuses on modelling of relative efficiency of education programmes scientific performance in higher education institutions in Latvia.

Higher education institution scientific process has input variables:

- number of academic staff
- number of doctoral students
- amount of financing

and output variables:

- educated students
- scientific publications
- patents.

Doctoral students are included in the input variables because they are already working as scientists – performing research and writing scientific publications together with their scientific supervisor or other colleagues. Having a great number of doctoral students increases the ratio scientific publication per academic staff. Another aspect why doctoral students can be seen as input variable is the findings of research performed by Prodan and Drnovsek (2010), which shows that greater numbers of years spent at an academic institution hinder the formation of academic-entrepreneurial intentions. Because tenured professorships guarantee academics basic socioeconomic status, they are less motivated to endanger their research by redirecting interest and energy to business matters (Prodan, Drnovsek, 2010).

The model would be more complete if there would be any data on prior accumulated knowledge, because current researchers "stand on the shoulders" of previous researchers (Guan & Chen, 2012). The author suggests to include this variable in the model as input variable.

The mathematical formulation of the model is:

$$\min_{\theta, s_i^-, s_i^+} \left(\theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)\right) \qquad (1)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \quad \text{i=1,...,m} \qquad (2)$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{i0} \quad \text{r=1,...,s} \qquad (3)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad \text{j=1,...,n} \qquad (4)$$

$$\lambda_0 = 0 \qquad (5)$$

$$\lambda_j \geq 0, \forall j \in J \qquad s_r^+ \geq 0, s_i^- \geq 0, \forall i, j, r \qquad (6)$$

Where:

x_{ij} – the i-input of DMU j

y_{rj} – the r-output of DMU j

θ – the efficiency score of considered DMU

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$\sum_{j=1}^{n} \lambda_j = 1$ – is the constraint of convexity (BCC model)

s_i^- – input slack parameter

s_r^+ – output slack parameter

$\lambda_0 = 0$ – constraint for applying the superefficiency measure

The adequate software, that is able to draw the efficiency graph, displaying relative efficiency of units, could be used to determine relatively the most efficient (generally having greater outputs per researcher and per unit of investment) higher education institution in Latvia and also indicate institutions that should measure up.

Conclusions

The number and the quality of scientific publications, and number of patent licences, design samples, computer programmes have to be increased in order to improve the performance of scientific action of higher education institutions in Latvia.

In order to answer scientific question – how to facilitate the increase the output of higher education institutions scientific action – the interaction among input and output variables of higher education institution scientific and educational processes have to be analysed.

Funding for patenting is lacking and supportive administrative structures at the higher education institutions are not established or are working insufficiently. The author suggests to put more emphasis on patenting issues not only in the policy planning level, but also on the level of each higher education institution by establishing supportive administrative structures.

Empirical research showed that there is positive correlation between funding and amount of publications per academic staff member in the higher education institutions in Latvia.

The policy makers are mainly focusing on activities that support the technology transfer, but the higher education institutions can be a driving force of economy only if they are a great centre for science, not if they are a great centre for technology transfer. Also Hewitt-Douglas research findings from the United Kingdom case demonstrate that universities' approach to knowledge transfer is shaped by institutional and organisational resources, in particular their ethos and research quality, rather than the capability to undertake knowledge transfer through a Technology Transfer Office (Hewitt-Douglas, 2012). Lam (2011) searching answers to question what motivates academic scientists to engage in research commercialization, concludes that policy to encourage commercial engagement should build on reputational and intrinsic rather than purely financial motivations (Lam, 2011). If the policy planners are considering to address the doctoral students as new generation of scientists, have to take into account that the doctoral students who prefer industrial employment show a weaker "taste for science", a greater concern for salary and access to resources, and a stronger interest in downstream work compared to doctoral students who prefer an academic career (Roach & Sauermann, 2010).

The first national policy should assist both financially and by enhancing prestige of the basic science, and just as a secondary objective could be the technology transfer in Latvia.

The development of model that takes into account diversity of input/output data and their relative importance, dependence, and correlation is part of the research agenda.

References

1. Bāliņa, S. (2011). Development of Science and Technology in Latvia, 2011. Ministry of Education and Science, 1-143.
2. Boļšakovs S. (2008). Inovatīvā darbība Latvijā (Innovative activities in Latvia). J.L.V. Ltd., Ogre, 1-323.
3. Cooper, W.W., Seiford L.M., Tone K. (2006). Data Envelopment Analysis-A Comprehensive Text with Models, Applications, References and DEA-Solver Software, 2nd edition, Springer, 1-439.
4. Dimza V. (2003). Inovācijas pasaulē, Eiropā, Latvijā (Innovation in the World, in Europe, in Latvia). Institute of Economics, Latvian Academy of Sciences Ltd., Riga, 205.
5. Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix---University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development. EASST Review 14, 14-19.

ISSN 2029-9338 (ONLINE)
ISSN 1822-6515 (CD-ROM)

6. Glenna, L.L., Welsh, R., Ervin, D., Lacy, W.B., Biscotti, D. (2011). Commercial science, scientists' values, and university biotechnology research agendas. Research Policy, 40, 957–968.
7. Guan, J. & Chen, K. (2012). Modeling the relative efficiency of national innovation systems. Research Policy, 41, 102–115.
8. Hewitt-Douglas, J. (2012). Research intensity and knowledge transfer activity in UK universities. Research Policy, 41, 262–275.
9. Hicks, D. (2012). Performance-based university research funding systems. Research Policy, 41, 251– 261.
10. Johnson, H. A. W. (2011). Managing university technology development using organizational control theory. Research Policy, 41, 842– 852.
11. Lam, A. (2011). What motivates academic scientists to engage in research commercialization: 'Gold', 'ribbon' or 'puzzle'? Research Policy, 40, 1354–1368.
12. Leydesdorff, L. (2010). The Knowledge-Based Economy and the Triple Helix Model, Annual Review of Information Science and Technology, Blaise Cronin (Ed.); 44 (2010) 367-417. http://www.leydesdorff.net/arist09/arist09.pdf Accessed: 10.01.2012.
13. Nelson A. J. (2012). Putting university research in context: Assessing alternative measures of production and diffusion at Stanford. Research Policy, 41 (4), 678–691.
14. Paniņa, L. (2011). Higher Education Institutions Effectiveness in Latvia. The Doctoral dissertation, University of Daugavpils.
15. Prodan I., Drnovsek M. (2010). Conceptualizing academic-entrepreneurial intentions: An empirical test. Technovation, 30 (5-6), 332-347.
16. Roach M., Sauermann H. (2010), A Taste for Science? PhD Scientists' Academic Orientation and Self-selection into Research Careers in Industry. Research Policy 39, pp. 422–434.
17. Schalin, J. (2010). State Investment in Universities: Rethinking the Impact on Economic Growth, John W. Pope Center for Higher Education Policy, www.popecenter.org
18. Sloka B., & Vilciņa A. (2009). Contribution of Regional Higher Education Institutions for Regional Development. Proceedings of the International Scientific Conference Economic science for rural development. Primary and secondary production, consumption. Jelgava: Latvia University of Agriculture, 19, 58-63.
19. Van Looy, B., Landon, P., Callaert, J., Van Pottelsberghe, B., Sapsalis, E., Debackere, K. (2011). Entrepreneurial effectiveness of European universities: An empirical assessment of antecedents and trade-offs, Research Policy, 40, 553–564.
20. Vīksne D. (2010). Assessment and Development Perspectives of Regional Higher Education Institutions of Latvia. (Summary of the Doctoral dissertation. Latvia University of Agriculture) [online] [retrieved 2010-08-26]. Available from: http://llufb.llu.lv/dissertation-summary/education/Dace_Viksne_promocijas_darba_kopsavilkums_2010_LLU_EF.pdf.
21. Washburn, J. (2005). University Inc. New York: Basic Books.