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THE QUALITY OF SCIENCE IN ESTONIA, LATVIA, AND LITHUANIA AFTER THE FIRST DECADE OF INDEPENDENCE

Jüri Allik

University of Tartu

Abstract. The main goal of this essay is to provide an analysis of bibliometric indicators of the quality of science in Estonia, Latvia, and Lithuania during the last ten years. In 2001, Estonia with 404 scientific publications per million of population was clearly ahead of Latvia (166), and Lithuania (136). Since 1992, Estonian and Lithuanian scientists more than doubled the number of articles they published in journals indexed by the *ISI Web of Knowledge*. The number of articles from Latvia has increased only 10%, which is even less than the general increase of published articles in the world. Comparing expenditures on research and development, R&D, with the number of scientific publications of each country, the cost of one published article was lowest in Estonia and only a little higher in Latvia and Lithuania. The unrealistically low cost of scientific articles suggests that a considerable amount of "hidden money" is involved, not reflected in the official expenditures. According to the *ISI Essential Science Indicators* database, Estonian scientists produced the largest number of high-impact papers (4,429) and also received the largest number of articles citing them (22,274); the Latvian contribution was the most modest, 2,610 articles and 9,192 citations. Estonia was able to produce high-impact research in 20 research areas, Lithuania in 13, and Latvia in 11 areas. It is concluded that the inadequate amount of money and the ignorance of the political elite concerning the role of science in a modern society are the most pressing problems for the further development of science in all three Baltic states, and particularly in Latvia.

Introduction

All three Baltic states – Estonia, Latvia, and Lithuania – have made a significant effort to break away from the previous Soviet structure of science. For instance, the former division between the institutes of the Academy of Sciences without teaching obligations and universities has disappeared. Scientists receive funding for their research directly from the science funding agencies, rather than from their own institutions as an aftermath of bureaucratic decisions. Funding decisions are increasingly based on scholarship and academic merits that are established by a peer review process, beside personal relations and belonging to an "old boy network" (cf. Allik 1998).

Clearly, the single most pressing problem for Baltic academia is the inadequate amount of money available for science. None of these countries come even close to the level that EU member countries on average spend on research and development (R&D). Only Estonia invests in R&D at the same level with those with the lowest R&D investments among the EU member countries such as Greece and Portugal (Key Figures, 2002). The situation is particularly demanding in Latvia where R&D intensity is one of the lowest in Europe. From the EU candidate countries only Romania and Cyprus have lower R&D percentage from the Gross Domestic Product (GDP).

The ten-year period since regaining independence is long enough to evaluate the quality of science and especially the dynamics of the quality in three Baltic states. Science administrators of Estonia, Latvia and Lithuania are often rather enthusiastic about the progress of research and scholarship in their own countries. Their main argument for these optimistic, sometimes uncritically optimistic appraisals is the existence of a few outstanding scholars or benevolent results of some international evaluations. All three Baltic states are similar in the respect of steps they took for an external evaluation of their science. In 1991, the Estonian Science Foundation applied to the Royal Swedish Academy of Sciences and the Swedish Research Councils with a request to carry out a thorough evaluation of Estonian science. The Danish Research Council carried out a similar evaluation in Latvia in 1992, and the Research Council of Norway conducted an evaluation of Lithuanian research (Martinson 1999). In all three cases, the evaluations were relatively benevolent, partly due to the evaluators' surprise to find high competence and good research at least in some areas of science.

At the same time, more rigorous bibliometric assessments of national sciences in general are very rare (see Tiits & Kaarli 2001 as an exception). Bibliometric indicators show that Estonian science in general is still less intensive than science in the rest of the world. For example, even the most advanced field of Estonian social sciences, psychology, is at least 7 times less effective than it is in Finland (Allik 1998). There are all reasons to expect that the intensity and quality of research is not much better in Latvia and Lithuania.

The main goal of this essay is to provide an analysis of bibliometric indicators of the quality of science in three Baltic states, Estonia, Latvia, and Lithuania, during the last ten years.

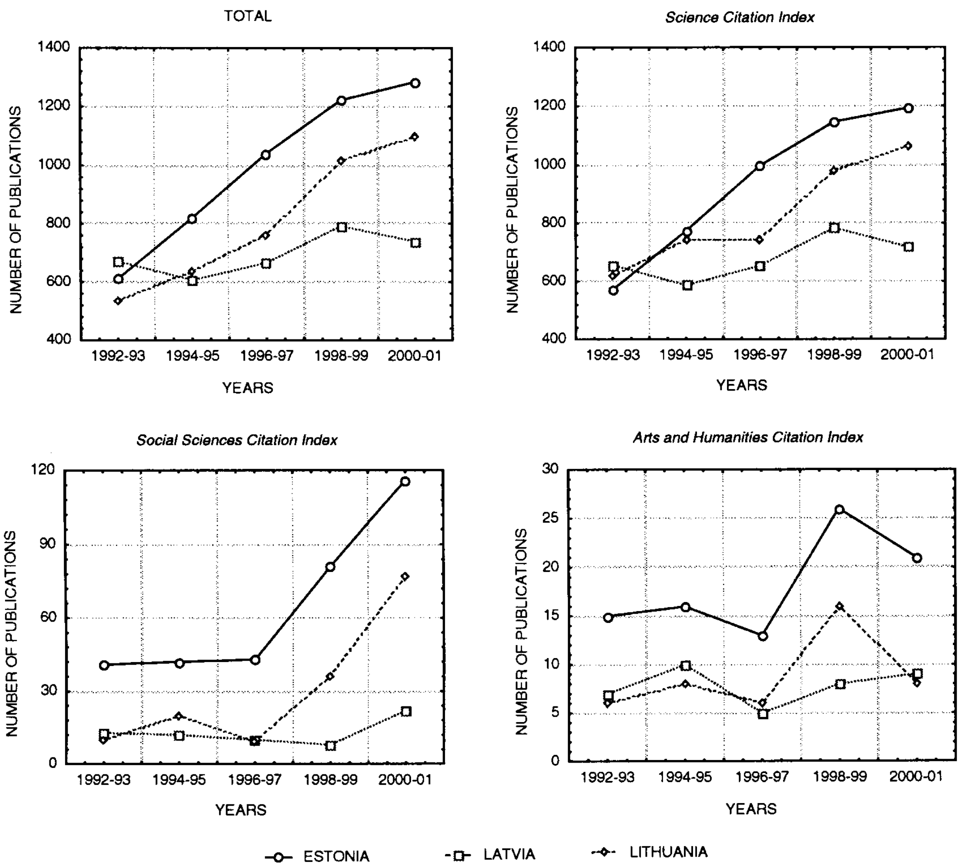
Bibliometric indicators

The *Institute for Scientific Information* (ISI), founded by Eugene Garfield more than 45 years ago, created the world's three largest databases of scientific information – *Science Citation Index* (SCI), *Social Sciences Citation Index* (SSCI), and *Arts and Humanities Citation Index* (AHCI). Every year, more than a million new articles are added to this database. For example, in 2001 999,618 (SCI), 149,672

(SSCI), and 105,236 (AHCI) new entries were added to the three databases. In total, it is more than 1.25 million new articles per year. Currently, ISI and the citation indices are owned by the *Thomson Corporation*, a company that in 2001 had revenues of US $7.2 billion. Since 2001, all three databases are available through a single Web-based platform, *ISI Web of Knowledge*.

Figure 1 demonstrates the growth of scientific publications during the last 10 years from 1992 to 2001. In order to avoid random fluctuations, the whole range was divided into 5 two-year periods. The search was done in the *ISI Web of Science* database separately for three indices, SCI, SSCI, and AHCI, with the authors' affiliation country as a key for the search. The search was done in November, 2002.

Figure 1. The number of papers published in journals indexed in SCI, SCCI, and AHCI



By the absolute number of publications, Latvia was the most productive of the three Baltic states in 1992/93. In total, across all three indices, Latvian scientists published 672 articles in journals indexed in one of three databases included in the

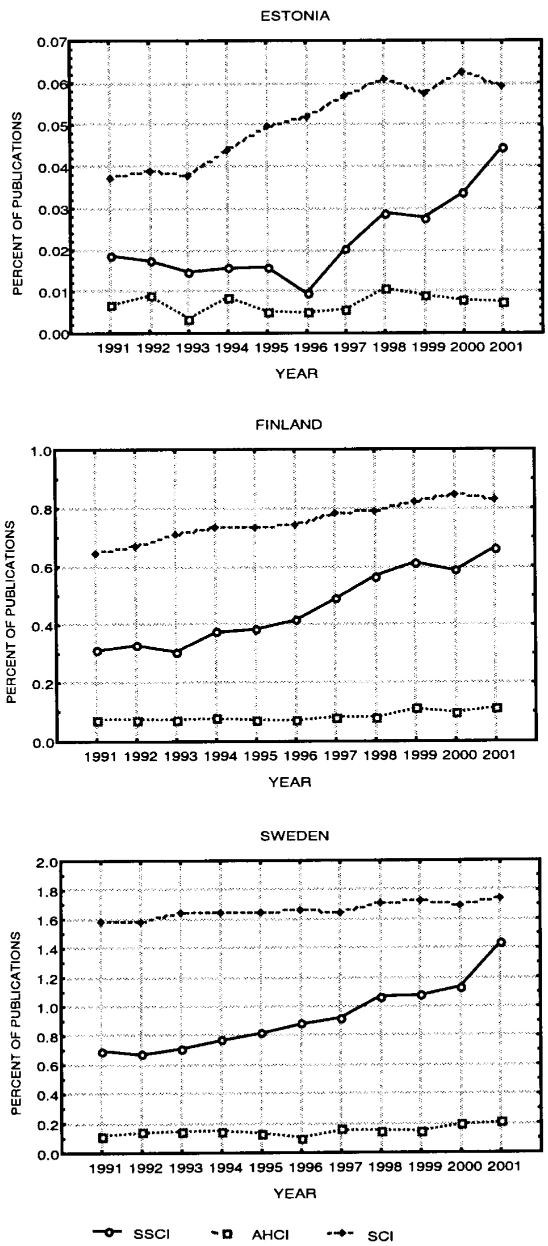
ISI Web of Science. After 8 years, in 2000/01, they published 739 articles, which is only 10% more than at the beginning of the observation period. At the same time, the increase of Estonian and Lithuanian publications has been 110% and 105% respectively. At variance from Latvia, the productivity of Estonian and Lithuanian scientists has increased with a steady pace of approximately 50–60 additional publications each year. This increase is salient in natural and exact sciences (SCI) already only a few years after regaining independence. In social sciences (SSCI), however, there was a 5–6 year lag before the number of articles published in SSCI journals started to increase.

However, from this figure alone it is difficult to say what is the publication rate of the Baltic states in relative terms. The total number of indexed articles has also increased during the last decade. For example, in 1991 there were 695,688 articles indexed in the SCI. In 2001, the number of articles indexed by SCI increased to 999,618, which is about one third (30.4%) more than in 1991. Thus, it is possible that the increase of publications simply reflects the general increase of journals and published articles that has taken place during the last decade. Therefore, it is more informative to examine the percentage of articles published by a given country from the total number of indexed articles in that year. Figure 2 presents the percentage of articles published by Estonian researchers in SCI, SSCI, and AHCI from 1991 to 2001. For comparison, similar statistics are presented for Finland and Sweden who are among the leaders of scientific publications both by the number of publications and their citations.

Two points are of particular interest. First, the growth rate of scientific publications from Estonia in SCI and SSCI has been faster than the general increase of publications in these two indices. Second, similar trends of development can be recorded in two Scandinavian countries, Finland and Sweden, with whom Estonia has the closest scientific contacts. One characteristic feature of all three countries is the closing of the gap between SCI and SSCI. In the early nineties, the contribution of social scientists (SSCI) in all three countries was approximately two times smaller than the percentage of publications contributed by natural and exact scientists (SCI). In 2001, the handicap of social sciences remains 10–20% and if the observed trends will continue the gap will be finally closed during the next 3–4 years. At variance from other fields of scholarship, the relative contribution of the humanities has remained virtually constant at their particular percentage in all three countries. It is, however, unjust to blame scholars in humanities in Estonia, Finland, and Sweden for the lack of progress. It is more likely that differently from other research areas, sources covered by AHCI are not representative to arts and humanities as a whole.

Returning to the evaluation of science in the Baltic states at the beginning of the new millennium, Estonia, Latvia, and Lithuania have reached the level of 641, 369, and 550 publications per year respectively. The number of publications per capita is often used as an indicator of the research capacity and growing knowledge pool of a given country. When we take into account the size of population, Estonia with 404 scientific publications per one million of population is clearly

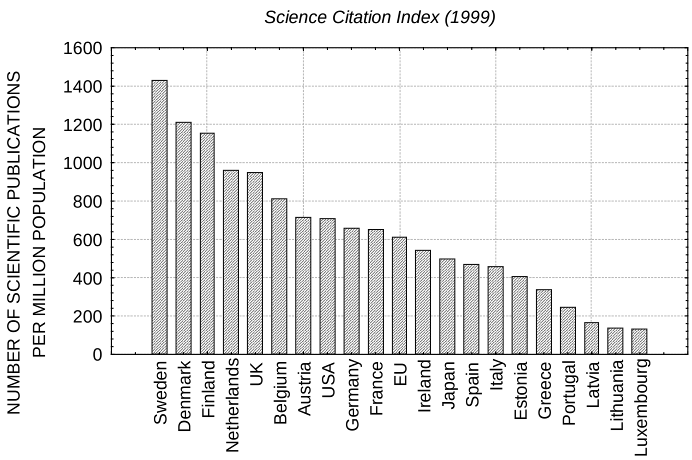
Figure 2. Percent of scientific publications from Estonia, Finland, and Sweden indexed by SCI, SSCI, and AHCI



ahead of Latvia (166), and Lithuania (136). According to the latest statistical figures, there were 3002, 2626 and 7777 researchers in 1999 in Estonia, Latvia, and Lithuania respectively (Key Figures 2002, p. 70). Thus, the productivity of researchers is not particularly high in the Baltic states. There was one published article per approximately 5, 7, and 14 researchers in Estonia, Latvia, and Lithuania respectively.

The European Commission recently published an analysis of scientific productivity based on SCI data in 1999 (Key Figures 2001, Figure 3.2.1). I modified this figure by adding data from Estonia, Latvia, and Lithuania. Figure 3 demonstrates the ranking list of EU countries (but also US and Japan) according to their publication performances. This figure shows that the Scandinavian countries (Sweden, Denmark, and Finland), Netherlands, United Kingdom, Belgium, and Austria are not only above EU-average, but also above the US and Japan.

Figure 3. Number of scientific publications in journals indexed by SCI per million population



Rather surprisingly, Estonia's publication rate, the best of three Baltic states, is not so bad at all – 67% of the EU-average (Latvia 27% and Lithuania 22%), even above Greece and Portugal. Latvia and Lithuania are approximately on the same level with Luxembourg.[1]

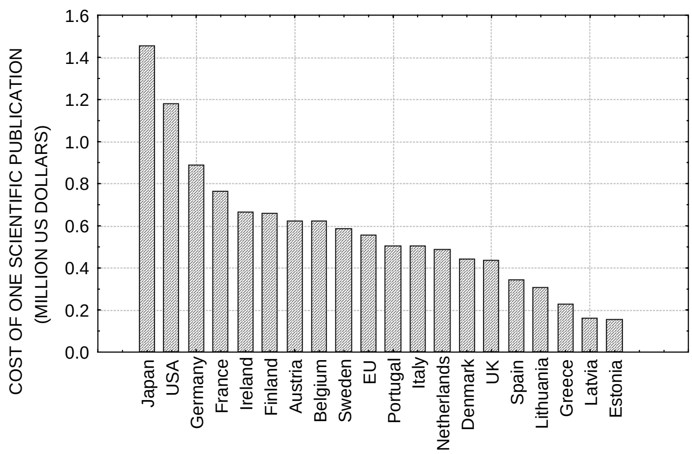
Cost of publication

It is obvious that different countries spend unequal amounts of money on research and development (R&D) and, consequently, there is an unequal amount

[1] These results are comparable to data reported recently by the European Commission (Key Figures 2002, Table 5.2.2) where publications in 11 fields were counted (social sciences were not included). According to this table, EU average in 1999 was 755 publications per million population. Comparably, Estonia had 330 publications (44% of the EU mean level), Latvia 143 (19%), and Lithuania 127 (17%). From other EU candidate countries Slovenia had the best publication record – 577 (76%) publications per million population. See also Tiits and Kaarli (2001).

of money that is needed to get a scientific article published. One possibility how to estimate the cost of one published article is to compare the number of published articles with expenditures on R&D. Not mentioning tiny Luxembourg, the most prosperous member of EU in 1999 was Ireland whose GDP per capita equals $25,918. The least affluent among EU members was Greece with $15,414 per capita (Human Development Report 2001). Although on average EU members spend 1.9% of their GDP on R&D, there is a great diversity among the member states. In particular, Sweden and Finland have a significantly higher R&D expenditure than other EU members, 3.7% and 3.3% respectively. On the lower end of the scale are Portugal and Greece with 0.78% and 0.51%, respectively (Key Figures, 2001). Obviously, there is a great diversity in how much money each country is spending on R&D. For example, Sweden was spending $838 and Greece only $78 per capita for the research and development. Comparing expenditures of each country with the number of scientific publication it is possible to find the cost of one published article. Figure 4 shows the mean R&D expenditure on an article published in journals indexed by SCI in 1999. The most "expensive" articles were in USA and Japan where the cost of a single scientific article was over one million dollars. The cheapest production costs of a scientific article were in Estonia, only about $157,000 per article. Thus, there is an obvious discrepancy between results presented in Figure 3 and Figure 4. By the output of scientific research Estonia is comparable with EU member states like Italy and Greece but this status is achieved by considerably smaller expenditures on R&D.

Figure 4. The mean R&D expenditure per published article in journals indexed by SCI in 1999



Notes: Luxembourg was not included in the EU average.

The quality of scientific research

The number of publications shows quantity not quality of scientific research. In order to estimate the quality of scientific research in the three Baltic states, I made a search in the *ISI Essential Science Indicators* database at the end of November, 2002. This database is an analytic tool that enables to conduct quantitative analyses of research performance of institutions and countries. Covering a multi-disciplinary selection of 8,500 journals from around the world, this tool offers data for ranking scientists, institutions, and countries. Table 1 provides information about the number of papers and their citation rates that passed the threshold of the

Table 1. Number of high-impact papers and their citations in the ISI Essential Science Indicators database (November, 2002)

	Estonia			**Latvia**			**Lithuania**		
RESEARCH AREA	**Papers**	**Citations**	**Impact**	**Papers**	**Citations**	**Impact**	**Papers**	**Citations**	**Impact**
CHEMISTRY	**538**	3 318	6.17	**780**	2 157	2.77	**652**	1 823	2.80
CLINICAL MEDICINE	**524**	3 008	5.74				**255**	1 736	6.81
PHYSICS	**659**	2 624	3.98	**695**	3 544	5.10	**937**	4 269	4.56
BIOLOGY & BIOCHEMISTRY	**281**	2 181	7.76	**151**	857	5.68	**265**	1 786	6.74
PLANT & ANIMAL SCIENCE	**408**	1 822	4.47	**101**	380	3.76	**136**	461	3.39
SPACE SCIENCE	**169**	1 384	8.19				**77**	344	4.47
NEUROSCIENCE & BEHAVIOR	**143**	1 291	9.03				**34**	311	9.15
ENVIRONMENT/ ECOLOGY	**234**	1 239	5.29						
GEOSCIENCES	**416**	1 074	2.58						
MOLECULAR BIOLOGY & GENETICS	**107**	991	9.26	**49**	421	8.59	**84**	1 077	12.82
PHARMACOLOGY & TOXICOLOGY	**78**	704	9.03	**17**	254	14.94			
MICROBIOLOGY	**98**	681	6.95	**51**	423	8.29			
MATERIALS SCIENCE	**130**	476	3.66	**401**	545	1.36	**336**	482	1.43
ENGINEERING	**246**	439	1.78	**310**	375	1.21	**373**	824	2.21
IMMUNOLOGY	**64**	407	6.36						
PSYCHIATRY/ PSYCHOLOGY	**79**	271	3.43				**13**	51	3.92
SOCIAL SCIENCES, GENERAL	**112**	158	1.41						
MATHEMATICS	**103**	151	1.47				**161**	169	1.05
COMPUTER SCIENCE	**33**	28	0.85	**50**	112	2.24	**41**	36	0.88
MULTI-DISCIPLINARY	**7**	27	3.86	**5**	124	24.80			
TOTAL	**4 429**	22 274	5.03	**2 610**	9 192	3.52	**3 364**	13 369	3.97

high-impact papers in the respective areas. The relative order of countries – Estonia, Lithuania, and Latvia – was preserved: in total, Estonian scientists produced the largest number of high-impact papers (4,429) and also received the largest number of citations (22,274); the Latvian contribution was the most modest (2,610 articles and 9,192 citations). Also the impact factor was highest in Estonia (5.03) followed by Lithuania (3.97), and Latvia (3.52). Estonia was able to produce high-impact research in all 20 research areas, Lithuania in 13, and Latvia in 11 areas. Perhaps the most indicative factor is that neither Latvia nor Lithuania were able to produce high-impact research in social sciences.

Table 1 also demonstrates the research areas that are particularly strong in each state. For example, Estonia was especially productive in chemistry (the impact factor 6.17), Latvia in pharmacology and toxicology (14.94), and Lithuania in molecular biology and genetics (12.82).

What happened to Latvia?

This study clearly reveals the obvious signs of stagnation of Latvian science. Only ten years ago, Latvia was the most productive among the Baltic states in terms of the number of scientific publications. Now, a decade later Latvia produces considerably less scientific articles than Estonia and Lithuania. While Estonia and Lithuania have almost doubled their number of scientific papers, Latvia has remained approximately on the same absolute level of productivity as at the beginning of 1990s. In fact, this denotes a decline of the relative contribution to the world science as the total number of articles published each year has also increased over the past ten years.

There are several plausible reasons that alone or in combination with others could explain this stagnation in Latvian science. They can be grouped into three main factors: organization, people, and money (cf. Stradins 2001; Ekmanis 2002):

(1) There were mistakes in the reform of Latvian science. One obvious strategic miscalculation was the introduction of 100% grant system, which virtually destroyed the existing scientific infrastructure.

(2) As a result of the reforms, the number of scientists dropped several times. Currently Latvia has the smallest number of scientists per 1000 residents – 11.1. Comparable numbers for Lithuania (21.6) and Estonia (21.2) are approximately two times higher (cf. Key Figures 2002, Table 5.2.1). Besides those who simply lost their jobs, about 1000 scientists from Latvia currently work abroad. According to some estimations the cost of this brain drain is about 100 million US dollars (Ekmanis 2002). At the same time, the natural increase of researchers with required academic qualification is dangerously low. In the year 2000, only 22 persons in Latvia received a PhD degree (Ekmanis 2002), which is many times less than necessary to preserve even *status quo* in the Latvian science.

(3) Finally, allocations from the state budget to science are not increasing but decreasing. In 2000, the Gross Domestic Expenditure on R&D (GERD) in Latvia

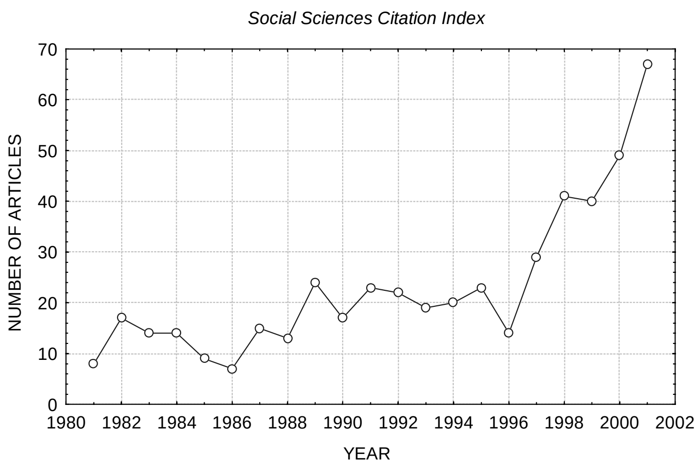
was only 0.41%. In Estonia it was 0.75% and in Lithuania 0.60% (Key Figures 2002, Table 5.2.1.).

The reduction of the number of scientists and a relatively small percentage from GDP allocated for R&D are common to all three Baltic states. Latvia, however, has suffered to the largest extent. These two reasons, together with the mistakes in organization, drained Latvian science not only of required resources but incentives as well.

The quality of social sciences in Estonia revisited

In a previous article in this journal, I pointed out a strange paradox that freedom was not so inspiring for Estonian social sciences after all. Contrary to expectations that the liberation from the stagnation of the Brezhnev era, the start of Gorbachev's perestroika in 1985, the Estonian Declaration of Sovereignty in 1988, and the restoration of independence after the failed August coup in Moscow in 1991, will dramatically increase the productivity of Estonian social scientists, the number of publications by Estonian social scientists only slightly increased in early nineties (Allik 1998, Figure 1). At the time of the previous article, data for years from 1981 to 1995 were available. Now, a few years later, I can extend the observation period up to 21 years. Figure 4 demonstrates the number of published articles in scientific journals indexed by SSCI which were authored or co-authored by Estonian scientists from 1981 to 2001.

Figure 5. The number of articles in the SSCI source index authored by Estonian scientists from 1981 to 2001.



During the last 5 years the productivity has increased with the rate of approximately 10 additional articles each year. To some extent, this rather impressive increase inclines me to revise my previous pessimistic forecast that it would take more than a hundred years to equal Finland in the number of social science publications normalized by the number of inhabitants in both countries (Allik 1998). If the progress will continue at the same pace, it will take only 10–15 years to reach the same relative level of productivity. Provided that the productivity of social scientists will continue to increase unaltered, only few years will be needed to get level with the productivity of the Estonian “hard” science, which is currently producing about 0.06% of all publications indexed in SCI.

Conclusions

Local politicians and journalists, especially in Estonia, are eager to repeat any praise they have heard from the IMF, the World Bank, or any eminent political figure concerning the success of the reforms in their country. Sometimes there are even talks about an “economic miracle”, at least in Estonia. There is no doubt that the relative economic success and building a new society has been a remarkable success story in all three countries. However, if we think about a truly modern society, which is characterized first and foremost by the capacity to produce, exploit, and propagate new knowledge, then all three Baltic states who spend less than 0.7% on R&D from their national wealth, look neither very advanced nor far-sighted. In a recent report of the European Commission its authors write: “The share of R&D expenditure in GDP expresses a country’s relative efforts to create new knowledge, to disseminate and to exploit the existing knowledge bases both in the public and in the business sector. R&D expenditure represents one of the major drives of economic growth in a knowledge-based economy. High levels and strong dynamics of R&D intensity positively support the future growth dynamics of a country” (Key Figures 2001, p. 17). It seems that the ignorance concerning the role of science in a modern society is a common trait of the political elite in all three Baltic states. A very simple idea that the concern about the quality of sciences in their countries is not just the private matter of those who are directly involved but one of the key elements of a modern society is very hard to absorb. It is clear that the future of Estonia, Latvia, and Lithuania, as of any other contemporary country is primarily dependent on its intellectual resources and the quality of education that must be provided to its people. It may sound like an axiom, but high-quality university education is simply impossible without high-quality science. Data presented in this essay indicate that at least in some fields high-quality education is already difficult if not an impossible task in the Baltic states.

The results of this bibliometric analysis also revealed a puzzle. Everyone who has even a bare knowledge about what is modern science could understand that the money Estonian, Latvian, and Lithuanian governments spend on R&D each year is too small to expect the output of that quantity and quality. For this money it is simply impossible to produce such a number of scientific publications as all Baltic states are producing. The cost of an article is unrealistically low in all three countries. The only reasonable explanation is that there is some "hidden money" involved, not taken into account in expenditures on R&D. There are several candidate sources from which I would like to mention only one. My wild guess is that a substantial amount of foreign money is involved. Beside foreign grants, a great number of studies are conducted as collaborative projects with partners from some other scientifically more advanced countries. Typically, these collaborative projects are chiefly financed by wealthy Western partners and domestic contribution is primarily a qualified but still cheap labor. There is some indication for this kind of network. For example, from all articles published by Estonian scientists in 1996–1999 more than 50% were written in collaboration with partners from Western countries; Sweden, Finland, Germany, and the US were most frequent affiliations of the co-authors (Must & Lewinson 2001). Everyone who has an intimate knowledge about life of the scientists in the Baltic states, has also heard endless stories about chemists, for instance, who after visiting a laboratory abroad carry in his or her private luggage expensive reactive substances that are absolutely vital for the continuation of their work. Or some refined analysis carried out in some other place with the help of an equipment the cost of which puts it beyond the reach of any domestic laboratory. Or we know colleagues who invariably spend all their summer vacations working in research laboratories of their Western colleagues who abandoned them for summer holidays. At the present moment I have nothing more but anecdotic evidence. However, my educated guess is that the amount of this kind of "hidden money" is significant.

Probably there is some rationale in talking about Estonian or even a larger Baltic "economic miracle". However, in the light of the presented evidence it would be more appropriate to talk about a "scientific miracle" in these countries. I think more investigation is needed to explain how sciences were able to survive and even advance in Estonia, Lithuania, and somewhat less in Latvia in conditions of a severe diet prescribed by their parliaments.

Address:
Jüri Allik
Department of Psychology
University of Tartu
Tiigi 78
50410 Tartu, Estonia
Tel: + 372 7375 905
Fax: + 372 7375 900
E-mail: jyri@psych.ut.ee

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