NATIONAL REPORT
ON SCIENCE AND TECHNOLOGY POLICY

National Report on Science and Technology Policy

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CONTENTS

Introduction

Both the past and the present reveal that knowledge as a product of research provides power (intellectual as well as other forms of knowledge holders' dominance), military supremacy (providing weapons more powerful that those of the enemy's), economic power (better products that the competitor's), and ideological domination (influencing people's behaviour). At present, science and technologies have become a crucial catalyst of the global economy and knowledge-based society. In order to generate knowledge, countries spend different, yet increasing, volumes of funds, which amount to 1.8 % of GDP in the European Union, 2.7 % of GDP in the USA, and 3.1% of GDP in Japan.

This way of thinking may just bring a smile to our face in a country like Slovakia, which does not count among countries of great power neither in terms of its population nor purchasing power. Our acting in the history has so far been limited to some very cautious backstage actions and the level of socio-economic development in our country has not yet reached the level of the most developed countries. Therefore, the question arises whether it is not just a worthless luxury to devote so much attention and considerable funds to research.

The experience of Finland, Ireland, Switzerland, Sweden, New Zealand, or Australia shows that in small countries quality research can, among other things, serve as a stepping-stone to success, both material and intellectual. Research itself is by no means sufficient for ensuring economic growth, yet it often represents an important part of it. On the other hand, hardly any country lacking in successful research and science has ever managed to make the ultimate leap to join the most prosperous countries of the world.

Slovakia does have an ambition to become part of the world's elite - having confirmed this not only by its OECD membership, but also by its efforts to join the European Union. What role are Slovak researchers playing in this process? What are their outputs and their quality like? What does the state do in providing support for quality research and science? What approach in this area do small countries unable to conduct top-class research in all fields of study adopt?

The National Report on Science and Technology Policy in Slovakia seeks to provide concise answers to the above questions, to assess the condition in the field of generating knowledge in our country and the impact of pertaining policies in the area of science and technology upon the whole process.

First and foremost, we draw attention to the analysis of the condition of scientific activity in Slovakia. Chapter 1 aims to answer fundamental questions concerning the assessment of science - on what basis its condition can be evaluated and how we can avoid oversimplified use of indicators taken out of context.

Chapter 2 directly relates to the opening chapter and its findings. Based on an extensive database of facts, it presents the reader with a realistic picture of the situation in generating knowledge in Slovakia. It deals with financing and human resources issues and, in particular, their outputs. Due to their importance, it pays particular attention to scientific journals and the Slovak science in the context of the European Union.

Chapter 3 is devoted to supplementing this comprehensive view with a brief, yet more detailed overview of particular groups of scientific disciplines. These sketches do not aspire to provide a complete picture, as it is impossible due to the limitations of space.

Rather, their task is to present the general public and analysts with basic facts about the status of individual fields of research.

The closing, most extensive Chapter 4 aims at interrelating the current state and its causes, for which reason it deals with policy in the area of science and technology. It provides an analysis of state policy during the era of socialism and in the 1990's. The core of this chapter aims to provide an overview of the science and technology reform that was launched on April 1st, 2002. It analyses the starting points, results, and conditions for successful completion of the reform. In conclusion, the text contains recommendations for its adjustments and further development, which could be used to formulate science and technology policy in the next electoral term (2002 - 2006).

Prior to dealing with the very question of generating knowledge, it is, however, necessary to consider basic concepts being used in this context.

The first concept to consider here is science. Our understanding of this concept is based on a three-stage, lexicographic definition, according to which science means a systematic observation of natural phenomena and conditions with the aim of discovering facts about them and formulating laws and principles based on these facts, as well as an organised body of knowledge, which results from such observations that can be verified or tested by further research, and, at the same time, any specified branch of this general body of knowledge such as biology, physics, geology, or astronomy.

As far as science and economic advancement, innovative trends and patent agenda are concerned, the couple of terms *science and technology* is commonly used in all developed countries. Without a doubt, the equivalent term in Slovak for the English word *"technology"* is *"technológia"*, not *"technika"*. This couple of terms, science and technology, indicates the fact that new technologies result from scientific knowledge. The notion of technology is defined as the application of science mainly for industrial and commercial purposes. Technology is not an independent science with a set of its own doctrines, but is based on applying principles formulated in various natural sciences (chemistry, mechanics, mineralogy, etc.) to production processes. Technology is a practical application of science in trade and industry. The term *technika* used in our country instead of *technológia* is to a certain extent a socialist relict[1]. Technique (a rough equivalent of the Slovak term technika in this context) is defined as theory, principles or study of art or a process. It is a systematic procedure, by means of which a complex or scientific task is accomplished. Technique can also be understood as a method of handling substance, essence, for example a work of art. The process of terminological change is well under way in the former socialist countries. Poland has already given up using this term in the sense of technology; Russia and Ukraine have done so in part, only Vietnam and Bulgaria stick to the old usage. However, the terminological couple *science and technique (veda a technika)* can be used as a justifiable logical connection in the fields of museum & exhibition science, historiography, and philosophy.

[1] In English, the difference in meaning between these two words is much less clear, as *technology* can be used to denote both meanings. For the purposes of this part, we can distinguish their meaning by using *technology & technique* for the Slovak terms *technológia & technika. (Translator's note)*

A parallel concept, to a certain extent, is a couple of terms - *research and development.* Given the needs of this analysis, a definition that seems to be the most operational can be found in Frascati Manual, which states that research and experimental development incorporate creative work carried out on a systematic basis in order to increase the scope of knowledge, including the knowledge of man, culture, and society and to use this volume of knowledge for devising new applications.

For the above reasons, it would probably be more appropriate to speak of science and technology policy or research and development policy. However, the Slovak legislation, policy materials, media, and other stakeholders taking part in the dialogue on the state policy in this field, for historical reasons, stick to the old usage of this term (*vedeckotechnická politika* in Slovak). To ensure comprehensibility, we use this term in the Slovak edition of this publication as well.

We would like to invite you to read this publication and thus discover the actual meaning of this notion.

Chapter 1: How to evaluate science in Slovakia and its producers?

The question - what is the quality of Slovak scientists and their production? - is fascinating for both laymen and scientists themselves. Chapters 2 and 3 seek to find an answer to this question on the basis of numerous output indicators. Many of them, though, use so-called bibliometric analytical methods. In practice, the results of bibliometric assessment are reduced to simple, easy-to-handle figures. Without in-depth understanding of assessment principles and their pitfalls, however, one can easily make serious mistakes in decision-making. For this reason, prior to the assessment itself, we have included a chapter explaining how to make proper use of bibliometric assessment instruments. At the same time, we wish to emphasise that Chapter 2 investigates the whole area of research and development, and therefore is not limited to bibliometric indicators.

There are two approaches to the evaluation of science that have become commonly used - one is based on the assessment of a scientific product by equipollent partners (peer review) and the other makes use of bibliometric methods. These two approaches are accepted by the majority of OECD member countries (OECD (1994), OECD (1997)). The stage of disclosing the results of scientific activity is the most suitable for its evaluation - by both peer review and bibliometric assessment methods.

Bibliometrics usually assesses two basic parameters, one of which can be marked as overall productivity and the other as pertaining to the quality of the published material. It needs to be stressed that the results of bibliometric assessment also serve as an important basis for peer review assessment of a scientific product. Yet, peer review methods are often challenged and questioned, and the use of "more objective" bibliometrics is preferred instead. Grounds behind such criticism are the following: ideally, published results should be reviewed by real experts in the given area and evaluated both in a quantitative and qualitative manner according to specified rules. As common practice, however, peer reviews are often carried out by general commissions rather than specialists being able to penetrate to the very assessment of primary research data. They, therefore, tend to resort to secondary criteria such as gross numbers of publications, journals' prestige, authors and institutions' reputation, or the estimation of importance and relevance of a particular field of science. Thus, it is no surprise that there is tendency to evaluate scientific results in the form of publications by quantitative and objective indicators (Seglen (1996)).

In spite of this fact, quality peer review methods are considered to represent the fairest and most acceptable form of evaluation (Coleman (1999)). Elected members of a panel must, however, represent the whole scientific discipline and enjoy confidence of the scientific community. Also, it is necessary to take appropriate measures to prevent evaluation from being skewed due to family or amity ties. Likewise, scientific orthodoxy can by no means be evaluated better than pioneering works. In this context, there is no alternative to peer review methods. In practice, it often means that the smallest reasonable number of publications, chosen by their authors as the best examples of their work in accordance with specified evaluation criteria, is submitted for evaluation. Naturally, such an approach cannot be practically used in aggregate analyses, such as this report, for which reason we will mostly rely on bibliometric criteria.

Bibliometrics - its meaning and content

The transfer of information is a significant factor in obtaining knowledge necessary for scientific development, economic advancement and social progress. The dissemination of scientific information takes place as part of scientific communication, which is a notion we understand as making use of and disseminating information by scientists in a certain field of science by means of both formal and informal communication channels. Bibliometrics is a discipline of science based on the quantitative analysis and measurement of documents serving to store and convey scientific knowledge.

The most frequent questions to be solved in bibliometrics relate to the following areas:

- Examination of citation links in documents
- Observation of co-authorship, its graphical presentation
- Observation of the dating of literature
- Citation analysis of scientific journals
- Analysis of research workers' publication activity
- Examination of international publication trends
- Distribution of creative performance of research workers, institutions, and countries
- Examination of information needs of research workers and scientific institutions
- Determination of the thematic scatter of literature
- Retrieval of information and its evaluation
- Assessment of scientists, publications, scientific institutions, and countries in particular disciplines and science as a whole.

In our case, in order to evaluate the Slovak science and research workers, it is necessary to take a complex view of the subject, taking into account the above-mentioned applications of bibliometrics.

Scientific work is a process, which Michael Faraday, a British physicist, characterised with the following words: "Work, finish, and publish!" Publication of the results of scientific work provides others with opportunity to make use of these results, and let them reproduce and verify somebody else's achievements. The community of scientists and potential users are thus allowed to get acquainted with the results of scientific work (generated knowledge) and utilise them in a number of ways. Spending funds allocated in support of science and yet not publishing regularly, such scientists do evade oversight on how they have disposed of the entrusted funds. There is no point in claiming that somebody is an excellent scientist, as long as he or she keeps the results in a drawer (except for cases of political persecution).

The importance of publishing results also from the fact that every good investor is interested in returns that his investments can yield. As for money provided in support of science, there is often no direct relationship pointing to a final, financially quantifiable, gain. Let's mention medical sciences, as an example. Trivial, easy-to-quantify scientific solutions, such as shortening hospitalisation time, preferring outpatient to inpatient medical care, use of a more efficient therapy, or preventing the occurrence of a disease by more efficient preventative measures, are rather rare and sometimes represent the final stage of scientific activity, which could not be anticipated at earlier stages (the discovery of penicillin, for example). People are therefore in search of methods that would allow quantifying the gains of scientific activity also at stages preceding the final utilisation of a certain piece of knowledge.

Quantitative and qualitative properties of a publication

Bibliometrics seeks to assess both quality and quantity of publications.

As far as quantitative assessment is concerned, it is based on the fact that the first, highly important element of the whole process, followed at later stages by bibliometric assessment itself, is the very act of publishing. The publishers of scientific journals - universities, commercial publishing houses, public authorities, societies, and associations - are to a various extent dependent on the sale of their products (scientific periodicals) and their use by the scientific community. Editorial boards of journals, headed by editors-in-chief, are responsible for optimal accomplishment of this economic and commercial goal. The editor's task is to cover expensive space on a journal's pages with scientific information that would ensure demand for the journal. This means that every journal will only publish such contributions that exceed a certain threshold of quality, originality, and topicality. The editor's decision on publishing a contribution is based on the opinion of reviewers, who do not have the opportunity of directly inspecting primary data, though. (The issues concerning scientific journals are discussed in a separate section of the following chapter.)

In this case, a parameter to be assessed is the number of publications. Practical experience reveals that the publishing activity of research workers oscillates in a very wide range. This distribution is determined by Zipf-Mandelbrot's law: (Mandelbrot (1966))

$$a_n = \frac{K_3}{(b + n)^5}$$

where K_3 is a constant, a_n is the number of authors that publish n articles, s is a constant expressing the relationship between the number of publication per one person - author and the number of authors, and b is a parameter allowing a more precise approximation of empirical data.

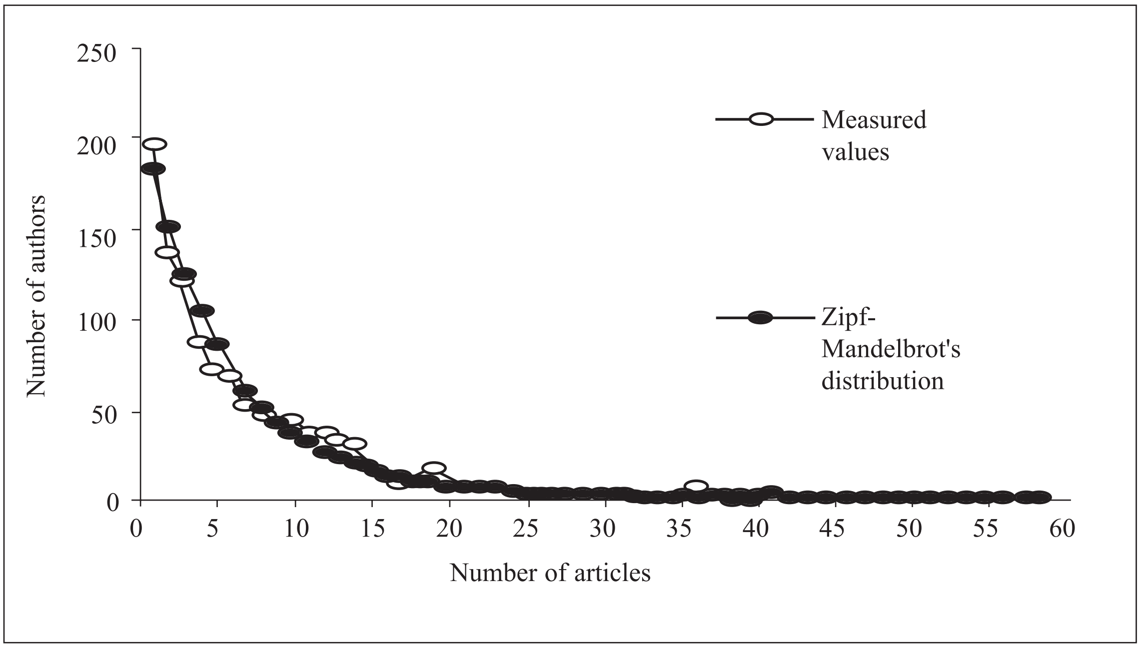
By way of illustration, we have applied this law to data on a_n authors publishing n articles at the Institute of Preventive and Clinical Medicine (IPCM) in the period 1992 - 2000. We have searched for optimal constants K_3, s, and b by means of mathematical and statistical methods, to make sure that particular laws comply as much as possible with the actual values. The Altmann - Fitter software package was used to search for the optimal values (Altmann (1997)).

Chart 1.1 shows the data from the IPCM database and their best approximation by Zipf-Mandelbrot's distribution. The publications recorded in the ISI database (see below) have been taken into consideration.

The evaluation of scientific production by the number of publications can be applied to an individual scientist, scientific team, workplace, or the whole scientific community in a particular country. However, the number of scientific works published can hardly express anything about their quality. Neither does it provide any information about their originality, level of innovation, and contribution to scientific advancement. The highest information value can be achieved at the high level of aggregation: faculties, institutes, universities, and whole countries (UNESCO (1998)).

Since the unit of evaluation is the number of publications over a period of time, there might be attempts at inflating this parameter. This can result in oversized publications or repeated publication of the same results, and following the principle of the least publishable unit.

Chart 1.1: Modelling of publication activity - IPCM example



Source: authors

Assessing the quality of published works produced by an individual scientist or a team of authors poses a far more difficult problem than determining respective quantitative parameters (number of publications). Qualitative assessment approaches are based on bibliography (references) that is cited in scientific literature. By means of citations, authors create explicit links between their current research and preceding works, which are stored in a large store of scientific literature, as well as many other relations within the scientific community. Such examination and quantification of the relations between documents, authors, scientific institutions, fields of science, etc. on the basis of citations is referred to as citation analysis. It is one of the bibliometric methods and builds on the hypothesis that any citation of an author's work always represents an important fact. The citation symbolises concepts or scientific ideas, about which authors debate (Garfield (1997)).

Knowing that the results of research are directly dependent on the quality of input data, it is necessary to take a closer look at citations and all issues related to them. To be able to use citation data for citation analysis, the following preconditions need to be met:

- The citation of a document indicates that it has been used by the citing author.
- The citation expresses credit - the quality, significance, and impact of the cited document. In order for the results of citation analysis to be trustworthy and of qualitative nature, they must, on average, comply also with this precondition.
- Citations are used to enhance the potential of scientific work. Assuming they are really used for this purpose, citations reflect the fact that out of all available documents authors choose those that they regard as the best works in a particular discipline. Thus, they serve, among other things, as an important information survey instrument.
- The cited document is content-relevant to the citing document. This assumption lays the foundation for the relevance of citation indices.

Until as late as 1963, authors could find out whether their work had been cited only accidentally in the course of their studies of literature. In the early 1960's, the most important world's citation register - Science Citation Index (SCI) - was established at the private Institute for Scientific Information (ISI) in Philadelphia, which annually covers more than 650,000 articles from more than 3,400 journals. Still, it includes only a small fraction out of an estimated number of 126,000 scientific journals in the world. The SCI/ISI database shows a nearly linear expansion over time, while there has been an exponential increase in the overall number of scientific journals worldwide since 1750. The annual rise is 7 % and the overall number of new journals doubles every 10 - 15 years (Höök (1999)). In 1965, only about 2 million citations were registered in the ISI/SCI database, whereas this number reached 16 million in 1997. Information in the register is available in printed form, on CDs, and recently can also be accessed on-line. The most interesting ISI products for us are Science Citation Index and Journal Citation Reports. Besides a large number of more sophisticated scientiometric data, the register provides information on which particular publication was cited in a given year and by whom. This information is found in Science Citation Index. It allows determining how many times and by whom all works of a given author were cited in a certain year or in the course of several years and obtaining aggregate data about a particular scientific team, institute, university, state, etc.

On the other hand, there are frequent objections against across-the-board use of the results of citation analyses. The following are the most frequently voiced (Egghe and Rousseau 1990)):

- **Self-citations** - excluding self-citations might be a solution, but can be problematic in the case of multiple authorship
- **Multiple authorship** - cited articles are listed in the citation indices under the name of the first author
- **Homographic issues** - many scientists with the same name and initials can publish in the same scientific discipline, which leads to errors
- **Synonymy** - citations can be misplaced due to an incorrect form of the author's name. For example, authors can be cited with a different number of initials, women publish under a different name after getting married, various transcription can be used, etc.

- **Type of bibliographic sources** - many studies prove that the selection of type and number of sources depends on the aim that is being pursued by an analysis. This original aim can therefore distort the results of the analysis.
- **Implicit citations** - generally known theories, instruments, or ideas are often used as self-evident, without stating the original source. For example, when speaking of SCI, only few cite its originator - Garfield.
- **Variation over time** - the use of citations often significantly changes over time, so caution needs to be exercised in the timing of research
- **Peculiarities of scientific disciplines** - this problem is related to a variant number of publications and publication practices, which much depend on particular specialisations
- **Incompleteness of ISI databases** - for various reasons, many journals are not included in the ISI databases
- **Domination of English** - language barriers - as English is the dominant language in the Western world, scientist prefer citing journals written in English
- **"American bias"** - the survey of index databases shows that, for example, as many as 95 % of American scientists cite American works; in the case of British scientists this figure is only about 40 %
- **Gender bias** - some studies indicate that scientists tend to cite authors of their own gender more frequently
- **Errors** - citation analyses, naturally, incorporate data citation indices contained in citation indices, hence with their errors as well

In spite of their limitations and problems, the results of citation analysis obtained by examining citation indices provide relatively objective data on the response to published works in a quantified form. Citation analysis cannot be used as a universal and unequivocal method for the assessment of quality or relevance of published scientific works. Recently, a tendency gains ground, according to which the results of this analysis are mostly used with the aim of comparing publication activities or the quality of works within a narrower scientific discipline.

To understand the incentives of scientists as individuals and members of a socio-cultural class, one has to perceive science not only as an aggregate of knowledge, but also as a social system, and scientists not only as lonely runners on the public stage, but as members of a distinctive community with common interests, attitudes, and opinions. There are a number of reasons why authors cite others' works. For example, Garfield lists the following reasons for citing: (Garfield (1965))

- discharging a debt of honour in recognition of the progenitor of a scientific discipline
- showing linkage to related works
- stating methodology, technical equipment, etc.
- creating a background for supplementary study
- correcting the works of others'
- correcting one's own works
- criticism of preceding works
- advising of upcoming works

- creating links to a little known, insufficiently indexed or non-cited work
- authenticity of data
- various constants etc.
- identifying an original publication or other work describing a certain fundamental concept, such Pareto's law, Lotko's law, etc.
- elaboration of the work or ideas of other authors
- negative evaluation
- issues relating to the priority of others' arguments

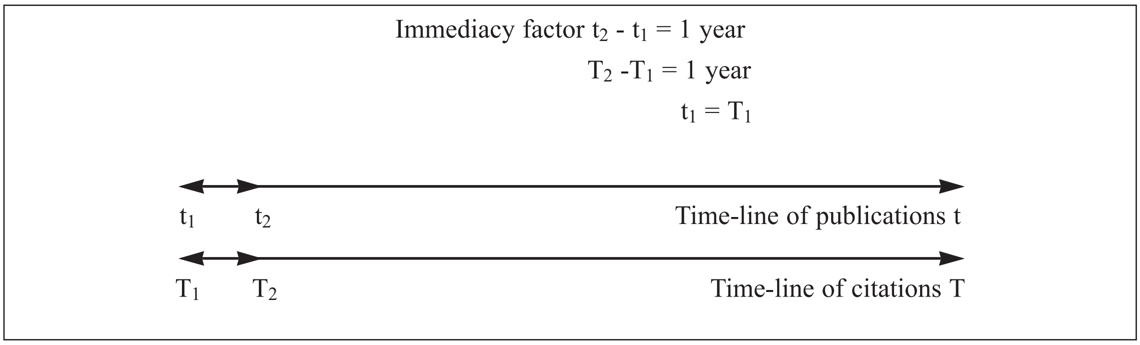
As indicated by the above facts, the citation incentives are a set of factors, which lead the author of a publication to a certain mode of citation. The most important factor is its usefulness. Citations refer to employed methodologies as well as to such works that the published work wants to carry on with, disregarding whether its results prove, question or confute (negative citations) the preceding results. Many authors feel obliged to cite the works of notable persons in a particular discipline. Sometimes, potential reviewers are cited too. Some other time, anonymous reviewers might even recommend that their own publications should be added to the bibliography. Not knowing the primary bibliographic sources, secondary sources are cited, such as overview articles (summary papers). Sometimes, bibliographic references are simply copied, which can be discovered by spotting an identical misprint in a number of duplicates. There are scientific teams citing each other (citation cartels, citation lobbying), as well as teams that ignore each other in spite of their high relevance. The citation of an article has its time dynamics. On average, articles are the most frequently cited in the second and third year after their publication, yet certain articles may show completely different dynamics over time. Middle-aged and older scientists, who had not been allowed to publish in foreign journals before 1989 and our (Czechoslovak) journals devoted to their discipline had not been excerpted in the ISI/SCI database, may be disadvantaged when evaluated in terms of citation counts (Pitterová (1999)).

In spite of the above-mentioned remarks, the number of citations still remains the parameter expressing the most information about the quality of a published work and its author, even though better assessment parameters should be more closely related to the fundamental characteristics of science, such as novelty, substantiality, and the volume of generated knowledge.

Impact factor (IF)

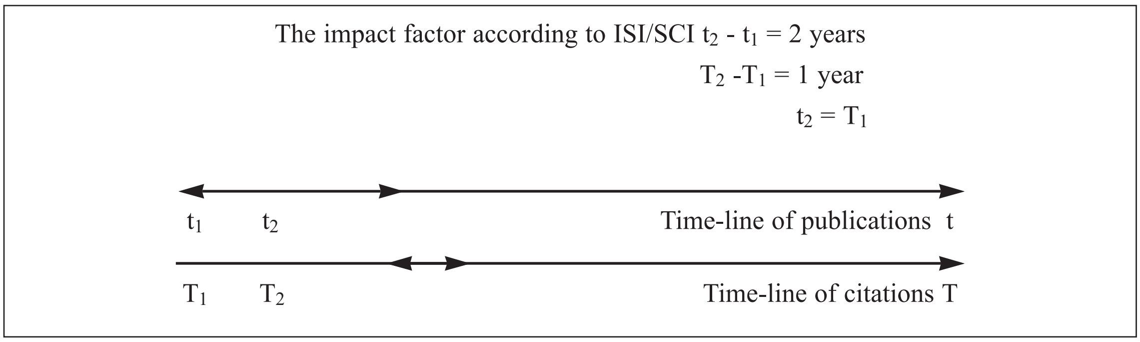
When formulating quantitative parameters that express the frequency of citations, one can arbitrarily choose a time window in which certain publications appeared and their number was recorded and, likewise, a time window in which these publications were cited and the number of their citations was recorded. The following two combinations of time windows are the most frequently used, which are expressed by the immediacy factor (Chart 1.2) and the impact factor according to ISI/SCI (Chart 1.3).

Chart 1.2: Immediacy Factor



Source: Authors

Chart 1.3: Impact factor



Source: Authors

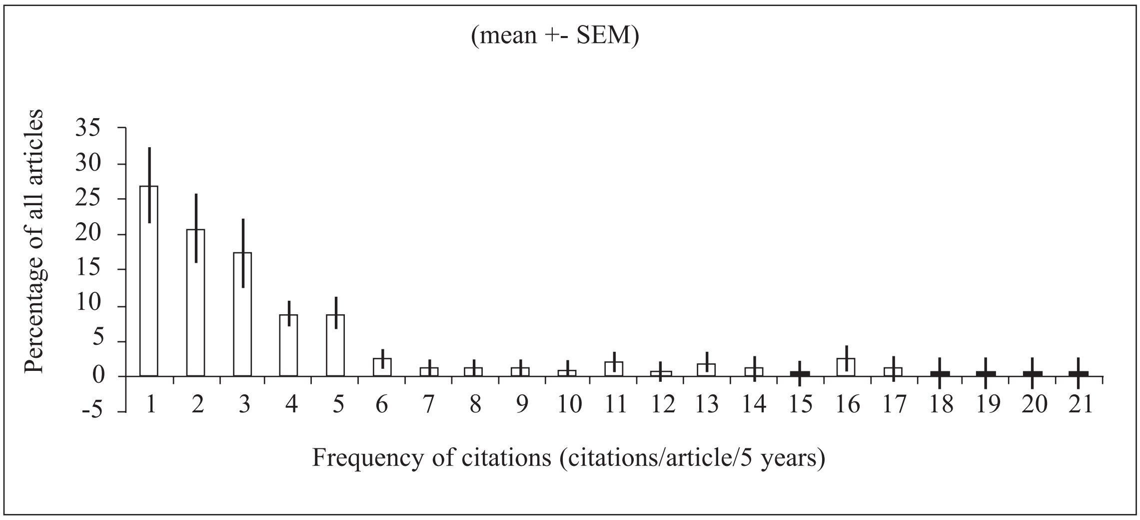
The ISI database cannot expand so as to incorporate all scientific journals, but it covers - within limits - those regarded by the authors of the database as the most significant in terms of their information value. To avoid serious mistakes in the selection of journals, they take account of, apart from other selection criteria, a so-called impact factor (IF) of a particular journal. The impact factor of a journal is calculated as a fraction in which the numerator indicates the number of recorded citations of articles during a certain year (e.g. 2000), which had been published in this journal in the previous two years (e.g. 1998 and 1999). The denominator shows the number of such articles. Let's mention the following example: a certain journal published 251 articles during the years 1998 and 1999. Consequently, these articles were cited 348 times in the year 2000. Thus, the impact factor of this journal for the year 2000 will be 348/251 = 1.39. The same calculation is used to determine the immediacy factor except that both the publication and citation time frame last one year and occupy the same period of time. The denominator only includes original articles, notes, and summary papers from the database. On the other hand, the numerator covers all types of documents (editorials, abstracts from scientific conventions and so forth). In spite of all circumstances that accompany authors in deciding whether to list a certain work in the bibliography at the end of their publication, the impact factor is regarded as an important parameter indicating not only the information value, but also the prestige of a journal. The information about the impact factor of journals is made public in Journal Citation Reports.

First and foremost, the impact factor serves as an essential parameter in decisions scientific libraries are making on obtaining a certain title, but the impact factor is also taken into consideration by authors in deciding where the results of their scientific work are to be published. They expect that publishing in a journal with a high impact factor makes it more likely for their work to be cited frequently. With such expectations in mind, they favour more general journals at the expense of highly specialised periodicals, which are not likely to show high impact factors, yet might be far better carriers of knowledge for a certain discipline of science. Still, this does not apply as a general rule, as many authors' experience was that their articles published in high-IF journals were seldom cited, whereas the articles from low-IF journals reached a very high rate of citation. Journals with a high impact factor often disclose the information that they refuse a very high percentage of articles submitted to them for publication. Indeed, a relationship between the percentage of refused manuscripts and the impact factor has been discovered (Lehrl (1999)).

The impact factor of journals is connected with a number of other factors (Seglen (1997a)). The fact that, when calculating the impact factor, the denominator only includes original articles, reports, and summary papers, whereas the numerator holds all types of documents, favours those journals that publish news on conferences, interesting editorials, and have a lively correspondence section (letters to the editors). A typical example of such journal is Lancet. A high rate of citation is often achieved by summary papers, so this is the way of improving the impact factor for journals that incline to publish them frequently. It has been proven that the articles' rate of citation is proportional to their length. An important time factor is that the impact factor calculation takes into consideration publications released over a period of two years and assesses their rate of citation as soon as in the following, third year. Thus, it favours disciplines undergoing rapid development, with a short production time of publications, and predominantly citing the newest, often ephemeral pieces of knowledge. The examples of such disciplines are molecular biology and biochemistry. The opposite category is represented by mathematics or ecology. In other words, the impact factor favours those disciplines of science in which knowledge quickly becomes obsolete. The articles publishing the results of "basic" research are cited more frequently in comparison with the results of "applied" research. The coverage of particular scientific disciplines in the ISI/SCI database is highly uneven. Chemistry's coverage is 90%, whereas biology shows only 30% coverage. It means that the journals belonging to a scientific discipline with low representation in the ISI/SCI database will have a lower impact factor compared to highly represented disciplines. The impact factor is a function of the number of works cited in one article in a particular scientific discipline. In certain disciplines, it is common practice to cite only few publications, while others may often have an extensive list of cited works. Several modifications have been proposed because of these interdisciplinary differences (Fromter (1999)). The impact factor is not adjusted for auto-citations (authors citing their own publications). A correct adjustment for auto-citations means the following: to regard a work as citing, none of its authors may be one of the authors of a cited work. The calculation of the impact factor does not take account of book publications. Journal articles written in languages other than English are less frequently cited. This is spoken of as language discrimination (97 % of reviewed journals in the ISI/SCI database are in English.) The ISI/SCI database is dominated by American journals. The composition of the database changes year after year. Excellent, narrowly specialised journals have a lower impact factor in comparison with generally-oriented journals. Most critical voices come from large European countries with developed science and lots of renowned national journals published in their own languages (Schoonbaert and Roelants (1996)). Even English-speaking Australia voices their objections, too. It is also proposed to establish a universal, Internet-based bibliographic and citation database, which would interlink every scientific work, disregarding how it was published, with every work in which it is cited (Cameron (2000)). Despite all critical voices, mostly constructive, to be heard, ISI remains to be in harmony with the globalisation of science as far as the development of informatics and scientiometrics is concerned. None of the multinational organisations (EU, UNESCO, OECD, WHO, FAO), which might be an alternative in this field, have any real chance to succeed in this respect, let alone national institutions.

The original intention of the IF authors was very pragmatic - to use the impact factor as an aid to selecting journals to be incorporated in the ISI database. That is to say that the absolute number of citations depends on the number of articles published in a given journal. To allow a mutual comparison of journals (minor and major ones) and not to favour voluminous journals, with a high absolute number of citations, at the expense of smaller journals in incorporating them in the ISI/SCI database, it was necessary to normalise the absolute number of citations by means of dividing this figure by the number of published works. The scientific community and its leaders soon got hold of this attractive figure and began using it for evaluation of many other products of scientific activity: individual publications, individual authors, authorial bodies ranging from research teams to scientific communities in individual countries. The original purpose of the IF as a factor indicating the relevance of a journal still retains its power to influence the editors and publishers of journals, librarians, and authors themselves when choosing a journal to publish their results in.

Chart 1.4: The citation of articles written by the same author



Source: Authors

Repeated analyses have shown that there are very uneven contributions of the articles published in the given journal to the resultant impact factor. As few as 15% of articles (the most frequently cited) contribute to 50% of citations, and 50% of articles contribute to 90% of citations. In other words, the more frequently cited half of articles is cited 10 times more than the less cited half. Therefore, it makes no sense to attribute the impact factor of a journal to an individual article published therein, because just that article may be found in the group with only few or no citations. The distribution of citations (a parameter of quality), like that related to the number of publications (a parameter of quantity, production), is sloping, with an analysis of a set of publications chosen at random from the ISI database showing that more than a half of the articles remain without citations (Seglen (1992)). Chart 1.4 shows the relationship between the rate of citation during 1995 - 1999 for the ISI-registered articles published during 1990 - 1999, written by 13 authors from the Institute of Preventive and Clinical Medicine (citations/article/5 years), and % of all articles. As individual authors under review differed in the total number of publications, the rate of citation was assessed in 21 citation cohorts. These were formed by multiplying the average number of citations for each author by an upper and lower bound of a respective citation cohort. Average values and their mean deviations were calculated for a percentage of all articles in respective citation cohorts. The chart shows that the rate of citation for all articles of the same author has a significantly sloping distribution, as indicated by the relatively low values of arithmetic average mean deviation. In other words, all of the authors have a high number of sparsely cited works and a low number of frequently cited works. The assessment of individual scientists thus becomes even more difficult due to this sloping distribution of the citations of their works. From this point of view, assessment over a longer period of time would be more reliable, as many scientists oscillate between more and less productive periods.

It is of significance that a similar sloping distribution, as discovered for the rate of citation for individual articles, was also traced for the rate of citation for individual journals. This is also shown by a table that is annually published in Science Citation Reports, where journals are arranged in descending order according to their impact factors. While there are only few journals in the upper part, their density is increasing with a decreasing value of the impact factor. These facts also support the proposition that it is not possible to assess individual scientists on the basis of which journals they publish their works in, because only a small fraction of publications in the given journal have a high rate of citation and a scientist under review may not be part of this group (Seglen (1997b)).

Another important fact is the incomplete coverage of journals in the ISI database. The ISI database in fact covers the most significant, yet very little fraction of the world's scientific literature. What is more, its coverage varies for individual disciplines of science.

Conclusion

Table 1.1 provides a summary of qualified possibilities of using the particular bibliometric parameters of quality, based on the total number of works published, the rate of citation, and the impact factor. The table can serve as a guideline for assessing science and scientists. In conclusion, however, we want to present a broader philosophic reflection about the assessment of science, inspired by Seglen.

Table 1.1: Possible uses of bibliometric criteria

	Parameters of quality		
	Total number of publications[1]	Rate of citation[2]	Journal impact factor (IF)
Single publication	Not applicable	Yes	No
Journal	Not applicable	Yes, with limitations	Yes, with limitations
Scientist - author	Yes	Yes	No
A body of scientists	Yes, including coefficient s	Yes	No
Authors' decisions on where to publish	Not applicable	Yes	Yes, with limitations
Librarians' decisions on which journal to order	Not applicable	Yes	Yes, with limitations

Source: Authors

A closer look at the distribution of the two basic parameters characterising a research worker from the bibliometric point of view - i.e. the number of publications and their rate of citation - has revealed that other products of ultimate human performance have identical distributions. These include, for example, extreme achievements in athletics. Seglen (Seglen (1992)) has found out that, after necessary normalisation of data, it is possible to compare extreme human performances such as running times for 100 m and 800 m races as well as for marathon races and productivity and the rate of citation for a set of research workers. The following types of activities/qualities have been divided into 7 performance cohorts of the same width (Cohort 7 represents the best performance):

- ○ Productivity of Norwegian university faculty members
- ● Individual author citations
- △ Marathon run-times for 20 % of male runners (aged 17 - 44, the Oslo Marathon, 1991)
- ▲ Height of Norwegian men (aged 25 - 29) exceeding 1.87 m
- □ World running elite, run-times for 100 m and 800 m races

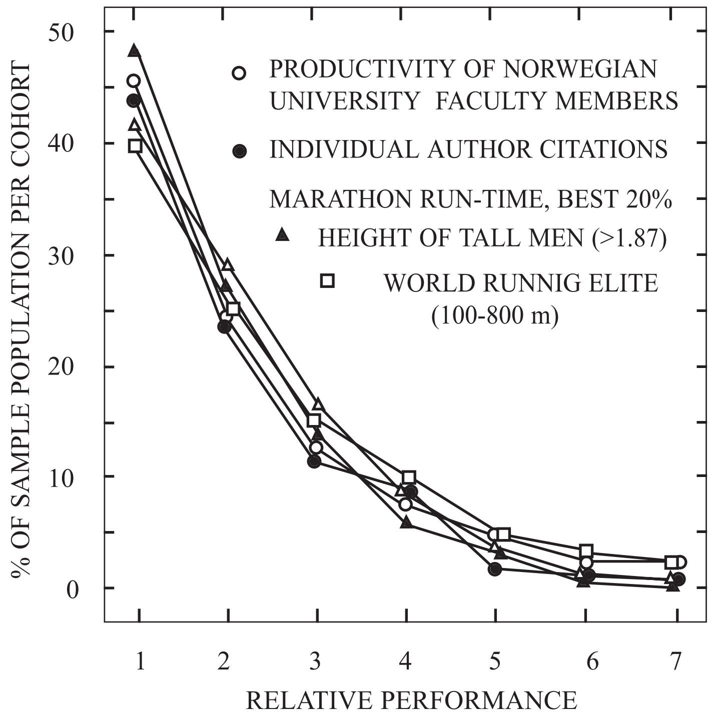
Seglen points out that "the attractive position of athletics as an analogy to science is based on its capability of illustrating that individual efforts are subject to the stochastic laws of population in a highly deterministic manner. Regardless of how hard one is

[1] for example in recognised scientific journals and other highly demanding publications
[2] for example in recognised scientific journals and other highly demanding publications

exercising, how much we are publishing, or how often we are cited, the statistical distribution we belong to still remains the same. If one is moving up in the distribution, somebody else must necessarily be falling down.

This statistics inertia is not to frustrate. The objective of scientific effort is not to change the sloping orientation of "the body of science", but to try to move it ahead. After all, sporting coaches know that, in order to train one record-breaker, a sufficiently broad sportsmen's base must be maintained. Focusing support on superior sportsmen brings no lasting effect in the long run. The same principle analogically applies to the management of science, yet scientific community is so far less aware of it than those responsible for the management of sport.

Chart 1.5 - Distribution of various human achievements



Source: Seglen (1992)

Chapter 2: The state of research and development in Slovakia

The state of Slovak research and development is frequently spoken of, mostly in connection with its widely perceived decay and misery. Yet, if we wish to discuss this matter seriously, we have to rely on data that are internationally comparable. Such an approach is often limited by lack of quality, comparable, and accessible data upon which such assessment could be based. In spite of that, it is possible, mostly thanks to the Organisation for Economic Cooperation and Development (OECD) and Institute for Scientific Information (ISI), to obtain a sufficient amount of data needed for at least a rough analysis of research and development in Slovakia.

An analysis of any area of activity is built on identifying and assessing two basic categories: inputs and outputs. The outputs allow us to recognize the quality and quantity of what is being produced in Slovakia in the area of research and development. The knowledge of inputs makes it possible to consider how efficiently the Slovak research and development community arrives at these results.

If we want to compare or evaluate the current or recent state of research and development in Slovakia, this can be performed either as assessment over time or through comparison with other countries. With regard to unavailability of long-term time series and due to socialistic deformations, we will almost exclusively focus on international comparison of the R&D state in the late 1990's. Slovakia will be compared with the following groups of countries:

- Average indicators for the EU and OECD countries as representing the wealthiest countries of the world, which Slovakia wants to level out with
- Neighbouring and other transition countries
- Poorer EU member countries (Portugal, Spain, Greece)
- The most successful small countries (such as Finland, Denmark, Ireland)

The data we are using are either taken from OECD and ISI sources (or the UN and EU as the case may be) or come from our own calculations based on available primary sources. Their interpretation is, naturally, that of the authors'. On the other hand, we have tried to list as much quantitative data as possible, so that readers could arrive at their own opinion and make own comparison.

2.1. Inputs in research and development

To start with, we will mention input indicators, which can be, in simplified terms, divided into financial and human resources indicators. Input indicators express only the volume of funds allocated for research and development, and as such have no information value concerning the quality or quantity of research and development activity.

The basic indicator shows total financial inputs into research and development, which are expressed by a GERD indicator (Gross domestic Expenditure on Research and Development). There are more ways of expressing this indicator; Table 2.1 shows a comparison taking account of the differences in countries' wealth - i.e. GERD as a percentage of the gross domestic product (average value for the years 1996 and 2000).

In comparison with wealthy economies of the OECD countries, Slovakia allocates a lower percentage of GDP for research and development, which is, however, the case of nearly all poorer economies - a share of expenditure on research and development usually rises significantly as wealth increases and structural changes in the economy are performed. Considering the mid-term average (1996 - 2000), comparison with other transition economies brings relatively positive results for Slovakia. Our country outruns not only Poland and Hungary but also Portugal and Greece.

Table 2.1: Differences in countries' wealth - i.e. GERD as a percentage of the gross domestic product (average value for the years 1996 and 2000)

GERD as % of GDP	96 - 00
Finland	2,94
OECD average	2,2
The Netherlands	2,01
EU average	1,81
Slovenia	1,46
Ireland	1,39
The Czech Republic	1,21
Spain	0,87
Slovakia	0,86
Poland	0,72
Hungary	0,71
Portugal	0,69
Greece	0,6
Romania	0,55
Turkey	0,52

Source: OECD

However, this relatively high **average** share had been significantly falling during the period in question. This drop is shown in Table 2.2 indicating an average year-on-year rise in the 1990's (based on expenditure expressed as the purchasing power parity). As shown in the table, both Slovakia and Hungary significantly reduced expenditure on research and development and, together with Italy, were the only countries to show a negative trend. On the other hand, the Czech Republic shows an average 6.5% annual rise in expenditure, and there are other countries to have experienced a rise over 5 %, such as Greece, Poland, and Portugal, which are countries whose volumes of expenditure are similar to Slovakia. So, at present, Slovakia is nearly at the tail of the above list (with 0.69% of GDP in 2000).

Table 2.2: Average year-on-year rise in 1990's (based on expenditure expressed as the purchasing power parity)

Country	Period	Average year-on-year rise
Ireland	1991-97	13,91
Mexico	1993-99	13,87
Island	1991-99	11,88
Finland	1991-99	8,79
South Korea	1991-99	8,69
Greece	1991-97	7,35
The Czech Republic	1995-99	6,52
New Zealand	1992-97	6,29
Portugal	1992-99	5,9
Sweden	1993-99	5,71
Poland	1994-99	5,22
Denmark	1991-99	4,92
Austria	1991-99	4,68
Australia	1992-98	4,08
Belgium	1993-97	3,69
Turkey	1991-97	3,68
Canada	1991-99	3,57
Norway	1995-99	3,57
The Netherlands	1994-98	3,16
USA	1991-99	3,15
Spain	1992-99	2,83
OECD average	1991-99	2,78
Japan	1996-99	2,12
France	1997-99	1,78
EU average	1991-99	1,62
Germany	1992-99	1,41
The United Kingdom	1991-99	1,24
Switzerland	1992-96	0,92
Italy	1991-99	-0,67
Hungary	1994-99	-1,81
Slovakia	1994-99	-1,95

Source: OECD

The decrease in expenditure on research and development in Slovakia is a relatively widely known fact. It is, however, caused only to a marginal extent by a drop in government spending. As indicated in Table 2.3, the Slovak government's participation in financing research and development was increasing during the whole period in question, and most of the decrease was due to cuts in business spending (this fact is proven by data on GERD (government expenditure on research and development, which are not presented here).

Table 2.3: Percentage of GERD financed by government

	1996	1997	1998	1999	2000	96 - 00
Portugal		68,2		69,7		68,95
Poland	57,8	61,7	59	58,5	63,4	60,08
Turkey	56,6	53,7	53,3	47,7		52,83
Hungary	50	54,8	56,2	53,2	49,5	52,74
Greece		53,5		48,7		51,1
Romania	54,9	42,4	52,9	46,7		49,225
Slovakia	39,5	34,5	45,3	47,9	42,6	41,96
Spain	43,9	43,6	38,7	40,8		41,75
Slovenia	43,4	37,1	39,9	36,8		39,3
The Netherlands	41,5	39,1	37,9	35,7		38,55
The Czech Republic	34,7	30,8	36,8	42,6	44,5	37,88
EU average	38,1	36,7	35,9	34,5		36,3
OECD average	32,1	31	30,6	29,6		30,83
Finland		30,9	30	29,2		30,03
Ireland	22,6	22,2				22,4

Source: OECD

On the other hand, it is also necessary to point out that the Slovak business sector had historically been financing a high, above-standard share of expenditure on research and development (see Table 2.4) compared to other countries with a similar level of wealth and economic and technological development (Hungary, Mexico, Poland, Portugal).

Table 2.4: Percentage of GERD financed by business sector

	1996	1997	1998	1999	2000	96 - 00
Ireland	68,8	69,2				69
Finland		62,9	63,9	66,9		64,57
OECD average	61,1	62,1	62,1	63,1		62,1
The Czech Republic	59,6	59,8	60,2	52,6	51,2	56,68
Slovakia	57,4	63,5	51,8	49,9	54,4	55,4
EU average	52,8	54,1	54,6	56		54,38
Slovenia	49,1	53,7	52,5	56,9		53,05
The Netherlands	48,5	45,6	48,6	49,7		48,1
Spain	45,5	44,7	49,8	48,9		47,23
Romania	41,6	52,8	42,4	50,2		46,75
Turkey	36,8	41,8	41,8	43,3		40,93
Hungary	38,9	36,6	36,1	38,5	37,8	37,58
Poland	38,9	35,1	37,8	38,1	32,6	36,5
Greece		21,6		24		22,8
Portugal		21,2		21,3		21,25

Source: OECD

In this respect, the question must be raised who actually spends funds allocated for research and development. Comparing Slovakia with the other OECD countries, several differences become visible as shown in Charts 2.5 - 2.8.

The most remarkable fact is the absolute dominance of the business sector, which, although not atypical in the EU and OECD countries, is typically the case of large countries and in part also of wealthy ones. It is evident that the business sector in smaller and poorer countries invests less in research and development, which is why it also spends less in this area - as the primary source of funds for research and development in every country is usually the business sector itself.

Table 2.5: Percentage of GERD spent by the business sector

	1996	1997	1998	1999	2000	96 - 00
Romania	73,5	81,4	76,7	74,4		76,5
Ireland	72,4	73,1				72,75
OECD average	68,2	69	69	69,3		68,88
Finland	66,2	66	67,2	68,2	71,1	67,74
Slovakia	55,8	75,6	65,8	62,6	65,8	65,12
EU average	62,5	63,3	63,6	64,7		63,53
The Czech Republic	59,9	62,8	64,6	62,9	60	62,04
The Netherlands	52,7	54,6	54,2	56,4		54,48
Slovenia	50,7	53	52	55		52,675
Spain	48,3	48,8	52,1	52	53	50,84
Hungary	43,2	41,5	38,4	40,2	44,3	41,52
Poland	40,9	39,4	41,5	41,3	36,1	39,84
Turkey	26	32,3	31,6	38		31,98
Greece		25,6		28,5		27,05
Portugal		22,5		22,7		22,6

Source: OECD

Slovakia occupies a very atypical position in the area of higher education institutions. With the exception of Romania, it shows the lowest participation of HEIs in expenditure on research and development out of all the countries under review. This is to some extent connected with Czechoslovakia' approach to research and development during the era of socialism - the Czech Republic indicates a somewhat lower share as well, but keeps increasing it rapidly.

Table 2.6: Percentage of GERD spent by higher education institutions

	1996	1997	1998	1999	2000	96 - 00
Turkey	62,1	57,2	61,1	55,3		58,93
Greece		50,6		49,5		50,05
Portugal		40		38,6		39,3
Spain	32,3	32,7	30,5	30,1	29,5	31,02
Poland	27,8	28,6	27,6	27,8	31,5	28,66
The Netherlands	28,6	27,3	27,1	26,2		27,3
Hungary	24,8	23	25,2	22,3	24	23,86
EU average	21	21	20,7	20,4		20,78
Ireland	18,9	19,2				19,05
Finland	18,1	20	19,6	19,7	17,8	19,04
Slovenia	21,6	17,4	16,6	15,9		17,875
OECD average	17,3	17	17,1	17,1		17,13
The Czech Republic	8,9	9,1	9,5	12,3	14,2	10,8
Slovakia	5,1	6,7	9,4	9,9	9,5	8,12
Romania	3,3	2,9	4,6	7		4,45

Source: OECD

Conversely, the share of the so-called public sector (i.e. the Slovak Academy of Sciences and departmental institutes) is exceptionally high, which is typical for transition economies that inherited academies of sciences and research institutions under particular ministries.

Table 2.7: Percentage of GERD spent by the public sector

	1996	1997	1998	1999	2000	96-00
Poland	31,1	32	30,8	30,8	32,2	31,38
Hungary	28,3	25,1	31,2	32,3	26,1	28,6
Slovenia	26,6	28,2	30,4	28,5		28,425
Slovakia	39,1	17,7	24,8	27,5	24,7	26,76
The Czech Republic	31,1	26,6	25,7	24,3	25,3	26,6
Portugal		24,2		27,9		26,05
Greece		23,4		21,7		22,55
Romania	23,2	15,8	18,7	18,6		19,075
The Netherlands	17,7	17,1	17,7	16,5		17,25
Spain	18,3	17,4	16,3	16,9	16,5	17,08
EU average	15,7	14,9	14,9	14		14,88
Finland	15,8	13,6	12,6	11,4	11,1	12,9
OECD average	11,8	11,2	11,1	10,8		11,23
Turkey	11,9	10,5	7,3	6,7		9,1
Ireland	7,9	7				7,45

Source: OECD

An interesting, although not surprising, phenomenon is a totally absent non-profit sector (in statistical terms at least) in expenditure on research and development. Neither do other OECD countries, except for Portugal, significantly finance research and development through this sector, yet the zero for Slovakia is a little striking. The understanding of the Slovak situation lets us assume that this is just a statistical zero, and that this figure is in reality (slightly) higher due to the existence of non-profit research institutions (think tanks) mostly financed by foreign donors.

Table 2.8: Percentage of GERD spent by the non-profit sector

	1996	1997	1998	1999	2000	96 - 00
Portugal		13,3		10,8		12,05
OECD average	2,8	2,8	2,8	2,8		2,8
Spain	1,1	1,1	1,1	1	1	1,06
Slovenia	1,1	1,4	0,9	0,6		1
The Netherlands	1	1	1	0,9		0,975
EU average		0,9	0,9	0,9		0,9
Ireland	0,8	0,7				0,75
Finland		0,5	0,6	0,7		0,6
The Czech Republic	0,1	1,4	0,2	0,5	0,5	0,54
Greece		0,4		0,3		0,35
Poland	0,1		0,1	0,1	0,1	0,1
Slovakia	0	0	0	0	0	0

Source: OECD

As mentioned above, in addition to the financial inputs, human resources are crucial just as well. Their quality will be dealt with within the analysis of outputs further in the text. From a quantitative point of view, two principal indicators will serve as a basis. One is the total number of research workers as a percentage of labour force; the other is the total number of science and technology workers as % of labour force (see Table 2.9 and 2.10).

Table 2.9: Total number of research workers as % of labour force

	1996	1997	1998	1999	96-99
Finland	n.a.	0,84	0,94	0,99	0,92
OECD average	0,58	0,59	0,6	0,64	0,6
EU average	0,49	0,5	0,52	0,55	0,52
The Netherlands	0,46	0,5	0,5	0,51	0,49
Ireland	0,45	0,51			0,48
Slovenia	0,47	0,42	0,44	0,46	0,45
Slovakia	0,4	0,4	0,4	0,36	0,39
Spain	0,32	0,33	0,37	0,37	0,35
Poland	0,31	0,32	0,33		0,32
Portugal		0,28		0,31	0,3
Greece		0,26		0,33	0,3
Hungary	0,26	0,28	0,29	0,31	0,29
The Czech Republic	0,25	0,24	0,24	0,26	0,25
Romania	0,26	0,24	0,24	0,2	0,24
Turkey	0,08	0,08	0,08	0,08	0,08

Source: OECD

Table 2.9: Total number of science and technology workers as % of labour force

	1996	1997	1998	1999	96-99
Finland		1,64	1,84	1,96	1,81
The Netherlands	1,07	1,09	1,1	1,1	1,09
EU average	0,95	0,95	0,97	1,02	0,97
Slovenia	0,94	0,83	0,85	0,89	0,88
Ireland	0,72	0,78			0,75
Slovakia	0,66	0,65	0,65	0,58	0,64
Spain	0,54	0,53	0,59	0,62	0,57
Greece		0,47		0,59	0,53
Hungary	0,49	0,52	0,51	0,52	0,51
Poland	0,48	0,49	0,49		0,49
The Czech Republic	0,45	0,45	0,44	0,46	0,45
Romania	0,51	0,46	0,45	0,38	0,45
Portugal		3,7		4,1	0,39
Turkey	0,1	0,1	0,1	0,1	0,1

Source: OECD

As for human resources in research and development, similar developments can to some extent be observed as in the case of financial resources. Slovakia has a lower number of research workers and research and development personnel (measured by the share in the country's total labour force) in comparison with the wealthy OECD countries. Our lagging behind the wealthier countries in the number of research workers and (in particular) personnel in the area of research and development is, however, much less significant than in any comparison concerning financial resources, including the share of GDP. At the same time, Slovakia can pride itself on the same or sometimes even higher number of research workers and personnel in comparison with other developed transition economies (the Czech Republic, Hungary, Poland), poorer EU countries (Greece, Portugal, Spain) and even some wealthier OECD members (Italy).

Yet, Slovakia is paying dearly for such hosts of research and development personnel. Table 2.11 shows the intensity of research workers' financing - i.e. the share of expenditure on research and development divided by the share of research workers in the country's total labour force. The higher this indicator, the more funds are spent per research worker out of the country's national wealth. It is apparent that out of the given sample, Slovakia and Greece spend the least.

Table 2.11: Intensity of research workers' financing (GERD as % of GDP/Number of research workers as % of labour force)

Turkey	6,5
The Czech Republic	4,84
The Netherlands	4,1
EU average	3,48
Slovenia	3,24
Finland	3,2
Ireland	2,9
Spain	2,49
Hungary	2,45
Portugal	2,3
Romania	2,29
Poland	2,25
Slovakia	2,21
Greece	2

Source: Authors' calculations based on OECD data

This indicator does not change much, as shown by the intensity of research personnel's financing (see Table 2.12), where there are only two countries in the sample - Rumania and Greece - which spend less than Slovakia.

Table 2.12: Intensity of research personnel's financing (GERD as % of GDP/Number of research personnel as % of labour force

Turkey	5,2
The Czech Republic	2,69
EU average	1,87
Ireland	1,85
The Netherlands	1,84
Portugal	1,77
Slovenia	1,66
Finland	1,62
Spain	1,53
Poland	1,47
Hungary	1,39
Slovakia	1,34
Romania	1,22
Greece	1,13

Source: Authors' calculations based on OECD data

For the purposes of interpreting these data, it is first necessary to take a look at the context of expenditure on research and development.

Much of the total expenditure on research and development consists of labour and related costs. These are different in each country and mostly depend on the level of country's wealth (roughly measured as GDP per capita). In other words, scientists from poorer countries should in principle earn less than their colleagues living in richer countries, but their earnings should be roughly the same in comparison with their own country's average. Due to international mobility existing within the scientific community, poorer countries should probably pay something extra in comparison with a country's average wage to retain scientists of identical quality in their home country.

Another important constituent of the expenditure is material costs. Although some materials may be produced locally, we can basically speak of a global market, where tradable goods cost the same in financial (monetary) terms, disregarding whether they are purchased by a scientist from a poorer or richer country. That's why, in order to sustain an identical level of research activity, research workers in poorer countries need a higher share of funds in the national wealth.

All in all, it means that poorer countries should have a coefficient of intensity somewhat higher than wealthier countries in order to provide for identical conditions in research and development. This is the case of the Czech Republic and Slovenia, for example. On the other hand, it is significantly lower in Rumania, Slovakia, and Hungary -Slovakia's intensity of financing is two times lower compared to the Czech Republic for both researchers and research personnel. To put it in other words, given its level of national wealth and in comparison with the neighbouring countries, Slovakia has a considerable number of researchers and research personnel, but the financing of their activities is not sufficient. This problem deepened significantly in the late 1990's.

Several conclusions concerning inputs into research and development in Slovakia can be made on the basis of the above facts. **First, given its level of national wealth,**

Slovakia has a relatively high number of researchers and personnel in the area of research and development. Its expenditure on research and development are comparable to the other transition economies, yet having shown a significant drop in recent years. Decrease in expenditure was not followed by a corresponding reduction in the number of researchers/personnel. This has further reduced the volume of funds per one researcher/worker. For example, the Czech Republic was increasing expenditure on research and development in the late 1990's by more than 6.5 % annually, and at the same time was sharply reducing employment in this area.

2.2. Outputs of research and development

Analysing outputs allows us to recognize the quality and quantity of what is being produced in Slovakia in the area of research and development. The ways of assessing the quality of scientific activity were discussed in the previous chapter. We will use its findings to assess the area of research and development in Slovakia. Since the analysis of outputs in research and development is a broader category, in our efforts to get a realistic picture we will use not only the bibliometric, but also some other criteria.

To begin with, let's mention a general indicator - the technological achievement index - elaborated by the United Nations. Its purpose is to express the rate of a country's success in developing and spreading technologies and building up quality human resources. It means that the index measures actual achievements, not technological potential or inputs in this field. It provides a good lead-in to complex understanding of research and development. According to this index, Slovakia currently ranks twenty-fifth, which is significantly better than its position in the human development index (which is mostly based on the level of GDP achieved, life expectancy, and education). This indicates that, in general, Slovakia is much more successful in the field of technological development than would be foreshadowed by its overall development. The same applies to the Czech Republic, Hungary, Singapore, but also to Finland, Poland, and Bulgaria.

Table 2.13: The technological achievement index, compared to the human development index

	Technological achievement index	Rank in the overall human development index
1 Finland	0,744	10
2 USA	0,733	6
3 Sweden	0,703	2
4 Japan	0,698	9
5 South Korea	0,666	27
6 The Netherlands	0,63	8
7 The United Kingdom	0,606	13
8 Canada	0,589	3
9 Australia	0,587	5
10 Singapore	0,585	25
11 Germany	0,583	17
12 Norway	0,579	1
13 Ireland	0,566	18
14 Belgium	0,553	4
15 New Zealand	0,548	19
16 Austria	0,544	15
17 France	0,535	12
18 Israel	0,514	22
19 Spain	0,481	21
20 Italy	0,471	20
21 The Czech Republic	0,465	33
22 Hungary	0,464	35
23 Slovenia	0,458	29
24 Hong Kong	0,455	23
25 Slovakia	0,447	36
26 Greece	0,437	23
27 Portugal	0,419	28
28 Bulgaria	0,411	62
29 Poland	0,407	37
30 Malaysia	0,396	59

Source: UN

A more concrete measurement of research and development outputs will be initially based on the bibliometric criteria - i.e. publication and citation statistics in particular. We will also pay particular attention to scientific journals, which are dealt with in section 2.3.

As far as publication statistics are concerned, worldwide comparative data are available as of 1997. It is apparent that Slovakia is lagging way behind wealthier OECD countries, yet in comparison with its neighbours as well as poorer OECD countries it enjoys a relatively good position. In comparison with the number of research workers Slovakia would, however, achieve much worse results due to their relatively high number, which is not reflected in publication activity, though.

Table 2.14: Scientific and technical publications, 1997

Country	Number of articles per one million inhabitants	% share in all publications within OECD
Switzerland	1 395	1,9
Sweden	1 190	2,1
Denmark	1 028	1,1
Finland	938	0,9
The Netherlands	879	2,7
Canada	786	4,6
The United Kingdom	767	8,9
Norway	748	0,6
Australia	735	2,7
New Zealand	728	0,5
USA	657	34,6
Belgium	641	1,3
Austria	570	0,9
EU	557	41,1
France	557	6,5
Germany	548	8,9
OECD	464	100
Ireland	401	0,3
Japan	381	9,5
Italy	354	4
Spain	348	2,7
The Czech Republic	267	0,5
Greece	258	0,5
Slovakia	246	0,3
Hungary	240	0,5
Portugal	152	0,3
Poland	143	1,1
South Korea	118	1,1
Turkey	37	0,5
Mexiko	27	0,5

Source: National Science Foundation

Realising that five years have already passed since the comparison and a more detailed breakdown is missing, we have decided to carry out our own international analysis of publications as well. It is based on articles published in ISI-listed journals (at times referred to as recognized journals). The ISI database consists of three parts:

- Science Citation Index Expanded (SCI) - deals with so-called "hard" sciences - natural, technical, agricultural, medical, and pharmaceutical sciences
- Social Science Citation Index (SSCI) - is devoted to social sciences
- Arts & Humanities Citation Index (AHCI) - deals with artistic sciences and the humanities

The number of publications per million inhabitants shown on a sample of six small European countries for each of these three databases is listed in tables 2.15 - 2.17.

Table 2.15: Number of publications per million inhabitants - Science Citation Index Expanded (SCI - EXPANDED)

	1995	1996	1997	1998	1999	2000	1995 - 2000
Finland	1 229,4	1 309,0	1 403,7	1 476,3	1 545,3	1 569,1	1 422,1
Austria	745,6	816,0	927,8	975,7	1 023,5	992,6	913,5
Slovenia	440,7	462,3	570,9	564,1	670,4	833,2	590,3
Hungary	339,6	351,9	386,3	443,4	446,7	468,3	406,0
The Czech Republic	334,5	379,3	391,2	425,0	424,8	439,5	399,0
Slovakia	355,8	378,8	362,5	385,7	368,7	351,7	367,2

Source: Authors on the basis of ISI data

Table 2.16: Number of publications per million inhabitants - Social Science Citation Index (SSCI)

	1995	1996	1997	1998	1999	2000	1995 - 2000
Finland	109,0	119,9	135,0	155,5	170,4	164,1	142,3
Austria	53,2	55,0	55,9	56,9	58,6	65,4	57,5
Slovakia	36,2	30,4	24,0	22,3	26,3	26,5	27,6
The Czech Republic	26,6	25,6	24,3	25,9	29,5	28,5	26,7
Slovenia	15,6	25,6	22,1	20,7	27,1	31,2	23,7
Hungary	18,6	16,1	12,6	13,0	15,9	16,9	15,5

Source: Authors on the basis of ISI data

Table 2.17: Number of publications per million inhabitants - Arts & Humanities Citation Index (A&HCI)

	1995	1996	1997	1998	1999	2000	1995 - 2000
Austria	20,7	20,6	25,2	28,7	26,1	26,5	24,6
Finland	16,4	17,0	19,6	17,5	23,4	21,6	19,3
Slovakia	16,0	20,9	13,9	19,1	13,3	14,1	16,2
The Czech Republic	8,6	7,7	6,0	12,6	9,8	7,7	8,7
Slovenia	8,0	6,0	7,5	7,1	7,5	9,5	7,6
Hungary	8,2	6,8	5,8	6,6	5,1	6,4	6,5

Source: Authors on the basis of ISI data

The data show that publication activity in Slovakia lags in all three areas behind the small countries of western Europe, and in the SCI-E category even behind the neighbouring countries (this gap, however, began widening only in recent years, when the Czech Republic and Hungary significantly increased the number of publications produced). In this respect, it is, however, necessary to point out to two factors questioning the unambiguous interpretation of these figures. First, it is the fact that publication activity as such is only a weak indicator of the quality of scientific work due to highly varying quality of individual scientific journals. Particularly in case of Slovakia, this is even more amplified by non-existence of its own recognised journal in some sciences. Slovakia has historically had a relatively high number of recognised journals in the area of social sciences and humanities, compared to similar European countries. This is not the case with the so-called hard sciences. On the other hand, when analysing journals in the field of social sciences and humanities, we find out that articles published in them are cited sparsely and almost exclusively in the same journal, which makes us proceed with caution in interpreting the publications data (see the section on social sciences and humanities).

An interesting piece of information is a figure indicating the percentage of published articles with foreign co-authorship, as shown in Table 2.18. Slovakia shows a very high number of such collaborations, together with Poland, the Czech Republic, Hungary, or some smaller countries of western Europe. Yet, this figure cannot be unambiguously interpreted for Slovakia without more data, as there is no way of deciding between the following two explanations of this fact:

- The Slovak science as a whole is highly integrated in the worldwide research activities.
- The majority of Slovak scientific publications in recognised journals are the products of a limited group of scientists, mostly working at scientific institutions abroad and publishing in collaboration with local scientists, who therefore have a high percentage of articles with foreign co-authorship.

Table 2.18: Percentage of published articles with foreign co-authorship, 1995 - 1997

Hungary	50,9
Portugal	50,8
Switzerland	48,1
Belgium	46,6
The Czech Republic	46,4
Poland	46,1
Denmark	44,3
Austria	43,6
Slovakia	43,2
Mexiko	42,8
Ireland	41,9
Norway	40,5
Sweden	39,4
Greece	38,3
Finland	36,1
The Netherlands	36,0
France	35,6
Italy	35,3
Germany	33,7
New Zealand	32,9
Spain	32,2
Canada	31,2
The United Kingdom	29,3
Australia	27,6
South Korea	27,6
OECD average	26,7
Turkey	22,6
USA	18,0
EU	18,0
Japan	15,2

Source: ISI

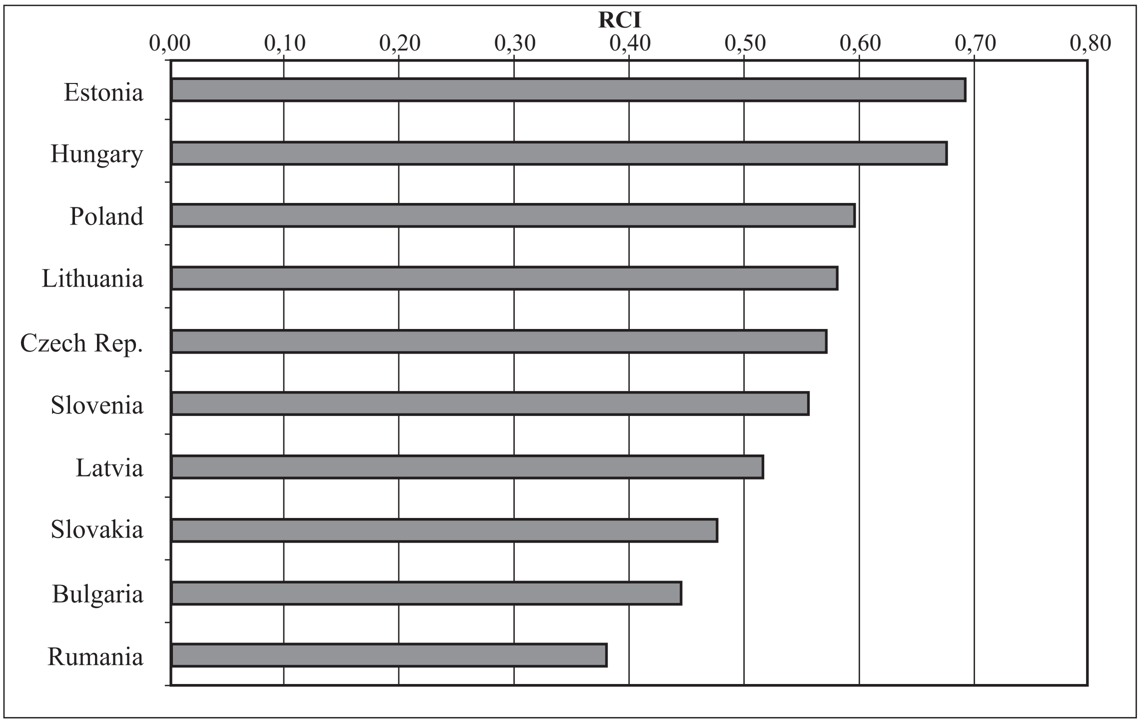
Following the analysis of publications, we will also focus on their rate of citation, a highly important category, as the response to published research results is generally regarded as one of the best criteria for assessing its significance (see the chapter on assessment of science).

In this case, a key compound indicator is a so-called relative citation impact (abbreviated RCI), which is defined as the ratio of the citation impact of publications of a given country to the citation impact of the worldwide database of publications (baseline).[1] The RCI value greater than 1 indicates that the rate of citation for a particular country is above the world's average, the RCI value below 1 shows that the rate of citation (bibliometric quality) does not reach up to the world's level.

[1] the citation impact expresses the average number of citations per one publication

As shown in the chart, Slovakia has one of the lowest values of the citation impact, except for Rumania and Bulgaria, out of the group of transition economies under review. In absolute terms, the value of this indicator is below 0.5. In other words, the works of Slovak scientists receive less than half of the response in comparison with the world's average, thus being at the tail amongst countries seeking the EU membership.

Chart 2.1: Bibliometric quality of publications from selected countries for the period 1995 - 1999



Source: Ryan Sheppard, ISI Thomson Scientific, a presentation delivered in Prague, February 2, 2001

Another instrument to measure the quality of top scientists is the ISI database on highly cited researchers (ISI highly cited). This includes 0.5% of the most frequently cited authors for the period 1981 - 1999 in 21 broadly defined disciplines in natural, medical, technical, and agricultural sciences. In this respect, they represent the absolute elite of the world's science. Table 2.19 represents the number of such top-class researchers in individual countries.

There is no highly cited researcher in Slovakia - i.e. somebody to represent the absolute world's elite in one of these disciplines. It is observable, however, that there is no such personage in the EU candidate countries either, not even in Finland or Chile. On the other hand, Denmark, Israel, and Scotland (the countries of size comparable to Slovakia) have seven such scientists and Russia has two of them.

Table 2.19: Highly cited researchers

Bulgaria	0
The Czech Republic	0
Cyprus	0
Estonia	0
Hungary	0
Latvia	0
Lithuania	0
Malta	0
Poland	0
Romania	0
Slovakia	0
Slovenia	0
Russia	2
Scotia	7
Switzerland	22
Denmark	6
Finland	0
Ireland	2
The Netherlands	12
Sweden	16
Israel	7
Chile	0

Source: ISI

The bibliometric criteria serve as a basis to measure the quality of basic and applied research, since publication activity is not limited to basic research only. Besides these criteria, it is advisable to use some other indicators as well. One of possible measures of quality for the outputs of Slovak research and development is the rate of success within the Fifth Framework Programme of the European Union in support of research and development. Because of its significance, a separate section - 2.4 - is devoted to this topic.

An area of particular importance is that of patents. To internationally compare the outputs of research and development in this respect, so-called patent families are used, particularly what we call triadic patent families. What do these concepts denote?

A patent family is defined as a group of patents granted in several countries to protect the same invention. Triadic patent indicators relate to patents granted by the three principal patent offices - European, American, and Japanese. Such indicators are internationally comparable, because they abstract from geographic influence and apply to inventions of higher quality for which patents are filed in several countries. Figures for particular countries are listed in Table 2.20.

Table 2.20: Patents - Number of triadic patent families

	in individual years					cumulative number				
	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
OECD	30 664	30 663	34 214	36 120		30 664	61 327	95 541	131 661	131 661
EU	9 751	10 347	11 029	11 733		9 751	20 098	31 127	42 860	42 860
The Netherlands	593	582	720	722		593	1175	1895	2617	2617
Finland	248	324	282	296		248	572	854	1150	1150
Spain	71	82	86	86		71	153	239	325	325
Ireland	17	33	25			17	50	75	75	75
Hungary	24	17	23			24	41	64	64	64
The Czech Republic	8	5	8			8	13	21	21	21
Poland	11	4	4			11	15	19	19	19
Slovenia	5	3	6			5	8	14	14	14
Portugal	4	2	7			4	6	13	13	13
Greece	2	4	4			2	6	10	10	10
Slovakia	1	1	6			1	2	8	8	8
Turkey	2	1	2			2	3	5	5	5
Romania	1	0	1			1	1	2	2	2

Source: OECD

When recalculated per million inhabitants, Slovakia does not measure up to the Czech Republic, Hungary, and Slovenia (absolute figures are not listed in the table due to their very low value). On the other hand, countries such as Portugal and Poland fared even worse. All in all, the number of triadic patents in every country of eastern Europe is significantly lower than in the small countries of western Europe. It makes no difference to examine only patent applications submitted to the European patent office (see Table 2.21).

Table 2.21: Patent applications submitted to the European patent office (by priority year)

Country	in absolute terms			one million inhabitants		
	1990	1995	1997	1990	1995	1997
Switzerland	1 688	1 664	2 088	251,44	236,31	294,5
Sweden	934	1 501	2 003	109,06	170,03	226,45
Germany	11 498	12 952	17 222	181,77	158,6	209,89
Finland	431	694	990	86,42	135,84	192,69
The Netherlands	1 522	1 714	2 367	101,84	110,85	151,67
Luxembourg	41	33	53	107,42	79,56	124,95
Austria	656	671	952	85	83,4	117,93
Denmark	327	477	590	63,63	91,32	111,78
Japan	12 976	11 801	13 974	105,03	93,98	110,76
Belgium	514	795	1 120	51,59	78,41	110,04
EU	27 016	30 620	39 712	77,23	82,01	105,79
France	4 922	5 083	6 142	84,64	85,55	102,67
USA	17 396	20 579	24 129	69,59	78,23	90
OECD average	60 393	66 801	82 846	71,99	61,76	75,56
The United Kingdom	3 565	3 720	4 378	61,94	63,48	74,19
Norway	128	232	307	30,09	53,3	69,74
Island	8	10	16	30,85	38,08	57,52
Italy	2 246	2 459	3 118	39,6	42,92	54,22
Canada	552	783	1 153	19,92	26,68	38,45
Ireland	68	95	127	19,31	26,32	34,64
Australia	361	480	571	21,14	26,56	30,81
New Zealand	23	61	92	6,77	16,65	24,4
Spain	258	386	578	6,63	9,85	14,69
South Korea	118	450	597	2,75	9,99	12,98
Hungary	69	53	70	6,64	5,14	6,94
Greece	26	27	49	2,61	2,58	4,63
The Czech Republic	22	19	42	2,08	1,82	4,07
Slovakia	0	7	13	0	1,29	2,36
Portugal	8	14	23	0,78	1,41	2,29
Poland	20	13	28	0,51	0,35	0,74
Mexiko	14	23	40	0,18	0,26	0,42
Turkey	4	5	15	0,07	0,08	0,23

Source: OECD

These general figures can be further broken down for two sectors that show particular sensitivity to dynamic research and development - information technology and biotechnology. Patent applications from these two sectors submitted to the European patent office are shown in Table 2.22 and 2.23 (absolute figures are not listed in the tables due to their very low value). We can notice that during the five-year period in question Slovakia did not take out a single patent in information technology and took out only two patents in biotechnology. Both in absolute and relative terms, these figures are very low, which is, however, what we have in common with the other transition economies (except for Slovenia).

Table 2.22: Patent applications submitted to the European patent office - information technology

	in individual years					cumulative number				
	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
OECD	6 850	7 447	8 365	9 911	11 542	6 850	14 297	22 662	32 573	44 115
EU	2 077	2 390	2 654	3 444	4 262	2 077	4 467	7 121	10 565	14 827
The Netherlands	222	220	264	385	452	222	442	706	1091	1543
Finland	112	178	189	283	378	112	290	479	762	1140
Spain	21	24	10	22	30	21	45	55	77	107
Ireland	8	7	13	15	20	8	15	28	43	63
Hungary	3	4	4	1	4	3	7	11	12	16
Greece	0	3	4	1	4	0	3	7	8	12
Poland	0	1	1	0	2	0	1	2	2	4
Slovenia	0	3	0	0	1	0	3	3	3	4
Portugal	1	0	1	1	0	1	1	2	3	3
Turkey				1	2	0	0	0	1	3
The Czech Republic	0	0	0	0	2	0	0	0	0	2
Romania	0	0	0	0	1	0	0	0	0	1
Slovakia	0	0	0	0	0	0	0	0	0	0

Source: OECD

Table 2.23: Patent applications submitted to the European patent office -biotechnology

	in individual years					cumulative number				
	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
OECD	1 554	1 745	2 018	2 415	2 995	1 554	3 299	5 317	7 732	10 727
EU	487	610	679	784	1014	487	1097	1776	2560	3574
The Netherlands	43	36	57	69	90	43	79	136	205	295
Finland	11	13	19	18	12	11	24	43	61	73
Spain	4	10	4	13	11	4	14	18	31	42
Ireland	0	1	8	5	8	0	1	9	14	22
Hungary	0	1	0	2	2	0	1	1	3	5
Poland	1	0	0	1	1	1	1	1	2	3
Slovenia	1	0	1	0	1	1	1	2	2	3
Greece	1	0	0	1	1	1	1	1	2	3
Slovakia	0	1	0	0	1	0	1	1	1	2
Portugal	0	1	0	0	1	0	1	1	1	2
Turkey	0	1	0	0	0	0	1	1	1	1
The Czech Republic	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0

Source: OECD

The last area to deal with in the analysis of research and development outputs is the balance of trade and the share of the world's market in products based on sophisticated and advanced technologies. Even though the relationship between the quality and quantity of research and development and the production of such products is not straightforward, they are also to some extent the outputs of research and development. Tables 2.24 - 2.28 show the market share of goods and services produced in Slovakia in the individual areas that are highly sensitive to research and development. None of these indicators tells much by itself, for increasing specialisation in the world's economy means that no country can keep a strong position in all industries, which is particularly true for a small, open economy that seeks to make the most of the advantages of specialisation. The fact worth attention is that Slovakia has a very low market share in all industries in question, even when adjusted for its population. Likewise, it is worth noticing that Slovakia is running a trade deficit in all technologically demanding areas, except for aircraft and space industry, i.e. it imports more goods and services than it exports.

Table 2.24: Foreign trade - Aircraft industry

	1993	1996	1999	93 - 99		1993	1996	1999	93 - 99
OECD together	27 876	24 935	33 301	28 704		100,0	100,0	100,0	100
EU	6 974,5	8 999,7	-921,7	5 017,5		31,2	34,0	25,8	30,343
The Netherlands	963,9	-377,4	-428	52,833		4,24	1,54	0,83	2,2033
Spain	-52,8	-544	-1561,1	-719,3		1,43	1,48	1,03	1,3133
Ireland	-230,9	-154,5	-1071,3	-485,57		0,22	0,42	0,4	0,3467
The Czech Republic		26,3	-120,9	-47,3			0,15	0,37	0,26
Turkey	-1458,2	-1136,8	-53,5	-882,83		0,01	0,08	0,42	0,17
Poland	9,6	43,1	-32,9	6,6		0,06	0,12	0,09	0,09
Portugal	-27,8	-51,8	-394,6	-158,07		0,06	0,08	0,09	0,0767
Greece	-347	-166,9	-688,7	-400,87		0,03	0,04	0,09	0,0533
Finland	-185,7	-581	-782,7	-516,47		0,02	0,06	0,02	0,0333
Slovakia			18,3	18,3				0,02	0,02
Hungary		-55,1	-8,1	-31,6			0,01	0	0,005

Source: OECD

Table 2.25: Foreign trade - Electrical engineering

	Balance of trade (million USD, current prices)				Share in export market (%)			
	1993	1996	1999	93 - 99	1993	1996	1999	93 - 99
OECD together	5 228,3	230,4	179 674	7 808,7	100,0	100,0	100,0	100
EU	-11897	-10978	-12988	-11954	17,6	17,6	16,2	17,12
The Netherlands	77,5	121	-937,3	-246,27	4,5	3,32	3,32	3,7133
Finland	225,2	1 907,2	4 579	2 237,1	0,89	1,7	2,22	1,6033
Ireland	-700,8	264,5	1661,8	408,5	1,4	1,18	2	1,5267
Spain	-1329,8	-2851,9	-4268,9	-2816,9		1,06	1,04	1,05
Portugal	-407,2	-423,8	-690,9	-507,3	0,31	0,44	0,43	0,3933
Hungary	-211,2	-415,7	-804,8	-477,23	0,18	0,2	0,7	0,36
Poland	-639,3	-955,2	-1583,3	-1059,3	0,08	0,2	0,31	0,1967
The Czech Republic	-212	-904,9	-753,1	-623,33	0,09	0,21	0,25	0,1833
Turkey	-669,3	-1074,9	-2374,4	-1372,9	0,13	0,13	0,22	0,16
Slovakia			-204,1	-204,1			0,06	0,06
Greece	-692	-568,5	-1093,4	-784,63	0,06	0,03	0,04	0,0433

Source: OECD

Table 2.26: Foreign trade - Office appliances and computer industry

	Balance of trade (million USD, current prices)				Share in export market (%)			
	1993	1996	1999	93 - 99	1993	1996	1999	93 - 99
OECD together	-22 216	-46 078	-65 667	-44 654	100,0	100,0	100,0	100
EU	-23 787	-34 051	-44 159	-33 999	12,4	12,1	12,3	12,26
The Netherlands	-584,2	206	-2 624,8	-1 001	6,86	9,57	10,64	9,0233
Ireland	2 717,1	4 101,4	7 132,1	4 650,2	4,94	5,91	7,57	6,14
Spain	-1877,2	-2324,3	-2829,1	-2343,5	0,95	0,94	0,85	0,9133
Hungary	-411,2	-356,2	1458,6	230,4	0,02	0,03	1,58	0,5433
Finland	-197,7	-488,7	-879,7	-522,03	0,59	0,58	0,42	0,53
The Czech Republic	-564,9	-789,9	-656,5	-670,43	0,07	0,13	0,14	0,1133
Slovakia			-163,2	-163,2			0,07	0,07
Portugal	-549,7	-831,7	-1011,9	-797,77	0,04	0,04	0,05	0,0433
Poland	-566,2	-1058,4	-1504,9	-1043,2	0,01	0,04	0,04	0,03
Greece	-339,3	-388,2	-658,8	-462,1	0,02	0,01	0,03	0,02
Turkey	-577,8	-754,3	-1146,9	-826,33	0,01	0,01	0,03	0,0167

Source: OECD

Table 2.27: Foreign trade - Pharmaceutical industry

	Balance of trade (million USD, current prices)				Share in export market (%)			
	1993	1996	1999	93 - 99	1993	1996	1999	93 - 99
OECD together	4 804,4	7 161,8	7 819,9	6 595,4	100,0	100,0	100,0	100
EU	7 683	128 817	17 559	12 707	37,3	33,9	33,1	34,747
Finland	-271,8	-435,5	-468,4	-391,9	10,87	9,89	10,55	10,437
The Netherlands	-446,1	389,8	-361,5	-139,27	4,46	5,68	3,99	4,71
Ireland	1434,9	2757	5315,6	3169,2	3,11	4,59	6,35	4,6833
Spain	-875,8	-1272,7	-1789	-1312,5	1,88	1,97	2	1,95
Hungary	-53,3	-156,9	-267,3	-159,17	0,57	0,43	0,33	0,4433
Poland	-452,1	-850	-1407,5	-903,2	0,45	0,36	0,16	0,3233
The Czech Republic	-207,4	-505,3	-565	-425,9	0,25	0,29	0,21	0,25
Portugal	-391,2	-613,6	-828,9	-611,23	0,16	0,23	0,23	0,2067
Greece	-557,4	-890,9	-945,9	-798,07	0,16	0,1	0,15	0,1367
Turkey	-391,69	-650,6	-1180,8	-741,03	0,16	0,13	0,12	0,1367
Slovakia			-242	-242			0,1	0,1

Source: OECD

Table 2.28: Foreign trade - Instrumentation and equipment

	Balance of trade (million USD, current prices)				Share in export market (%)			
	1993	1996	1999	93 - 99	1993	1996	1999	93 - 99
OECD together	11 784	11 429	14 381	12 532	100,0	100,0	100,0	100
EU	-3 969,0	-266,4	-2 616,9	-2 284,1	20,5	23,1	21,6	21,73
The Netherlands	425,1	867	1593,7	961,93	5,02	4,38	4,99	4,7967
Ireland	533,2	785,7	1011,7	776,87	1,23	1,36	1,58	1,39
Spain	-1801	-2193,8	-2984,2	-2326,3	0,75	1,04	0,87	0,8867
Finland	-41,9	12	210,2	60,1	0,4	0,64	0,7	0,58
The Czech Republic	-394,9	-594,1	-444,8	-477,93	0,11	0,22	0,24	0,19
Portugal	-386,5	-478,9	-720,6	-528,67	0,15	0,19	0,14	0,16
Hungary	-211,9	-181,9	-348	-247,27	0,11	0,15	0,16	0,14
Poland	-486,8	-763,5	-777,9	-676,07	0,07	0,11	0,12	0,1
Greece	-492,6	-591,4	-651,3	-578,43	0,04	0,06	0,04	0,0467
Slovakia			-197,8	-197,8			0,04	0,04
Turkey	-754,6	-985,4	-1056,6	-932,2	0,03	0,04	0,04	0,0367

Source: OECD

2.3. Assessment of scientific journals by means of Journal Citation Reports

An investigation into the use and impact of scientific journals is an important part of the assessment of scientific productivity. The citation monitoring of journals was more extensively enabled by annually publishing (since 1976) Journal Citation Reports (JRC) by the Institute for Scientific Information (ISI) as part of SCI and SSCI. This document contains various indices and characteristics by means of which it is possible to compare the information value of journals, to determine the most influential journals, etc. It is made up of the following main sections:

- Journal Rankings
- Source Data Listing
- Journal Half-Life Listing
- Subject Category Listing
- Citing Journal Listing
- Cited Journal Listing

At present, the web-based version of the JCR is available free of charge to higher education institutions and the Slovak Academy of Sciences.

The JCR is a principal, complex, quantitative and unique guide to scientific and technical publishing. It is principal, because it brings up-to-date information about nearly 6,000 world's most important journals. It is complex due to its multidisciplinary and international substance. It covers all disciplines of science and technologies and incorporates more than 3,000 publishers from 60 countries. The JCR can provide answers to several important questions relating to journals:

- **Which journals are the biggest?** The JCR ranks journals in order of the number of articles published in a given year. This allows comparison of journals by their size and determining a group of publications that publish most articles in respective specialties or in science as a whole.
- **Which journals are the most frequently used?** The JCR also ranks journals in order of how many times per year they are cited. This indicated how often a particular journal is read and used by scientific and research workers. Once again, a group of the most highly cited journals can be determined.
- **Which journals are the most up-to-date?** The JCR also expresses how many times a particular article has been cited in the year of its publication. This immediacy index can highlight the journals that publish the latest results of research in fast-moving specialties.
- **Which journals have the highest impact?** The JCR also informs about the average number of citations for the articles from a given journal over past two years. This makes it possible to compare the impact factor of a journal with an average impact factor of all journals in a particular discipline or to the impact factor of all JCR-listed journals serving as a baseline.
- **Which publications does a journal cite and in which is it cited?** Furthermore, the JCR identifies the publications that are the most frequently cited by a given journal. Also, it retrospectively shows which publications most often cite a given journal.

Thus, citation links can disclose the orientation of a journal, discover its most closely related or competitive publications, and describe specific networks of journals.

The JCR Science Edition provides citation data from scientific journals and is composed on the basis of the whole ISI database including citations from SSCI and A&HCI as well as from the SCI database. The citations from JCR-listed journals are compiled every year from the current annual consolidated database, regardless of type of the cited article or time of its publication. Every unique link between two articles is regarded as a citation. For example, one article may have 20 references, but supposing that only 15 different articles are cited in these 20 references, it means that 15 unique citations have been registered (JCR, 2000).

Articles from JCR-listed journals include only original research articles, reviews, and technical notes. Commentaries, letters, news items and meeting abstracts are not included in the source documents, as they are not generally cited.

The ISI does not recommend that JCR users rely only on the citation data about a journal under review. These data do not substitute reviews of similar, competitive journals. What is more, special attention should be paid to various factors that can affect resultant citation data, such as language, journal's history and format, journal's issuance date, and particularly scientific discipline or branch. The users should also be aware of conditions that can influence JCR results and factors, such as the following ones:

- **Impact factors depending on article type** - the ISI uses article type codes that are assigned to every published item. It is, however, impossible to assign such a code to all 12 million records processed every year. That's why the number of citations includes articles of all types, although, as for the number of articles, the JCR only keeps track of original articles, reviews, technical letters, or other short articles. Impact factors can be distorted in this way. If a journal publishes a lot of letters in one year, it can lead to a temporary increase in the number of citations. This increase will not be proportionally reflected in the number of articles listed in the JCR. To identify and resolve such situations, detailed analyses of article-to-article relations need to be carried out.
- **Changes in journal size** - unexpected changes in the journal size can also affect the impact factor. The average number of citations falls, if one-year-old articles prevail over two-year-old ones, because the rate of citation for an article typically reaches its peak in two years from its publication. Likewise, if the number of articles falls, it can lead to a temporary rise in the impact factor. The section assessing journals - Journal Rankings - shows the number of articles not only for a given year, but also for two preceding years, which makes it possible to discover such sudden changes.
- **Journal title change and the impact factor** - in the first year after such a change, the new title is listed without its impact factor, with the number of articles for the two preceding years is zero. The old title is listed with the standard impact factor. Next year, the JCR will list separate impact factors for both the new and the old title. It might happen in this year that the impact factor of the new title will be lower than reasonably expected, as only the latest articles could be included in it. Similarly, the older journal's impact factor might be greater then expected, due to its being based on older articles only. To determine a common impact factor, one can add the total number of citations for two years and divide it by the number of articles in both titles. In the third year after the title change, the old title is no longer listed.

It also needs to be noticed that not every journal published worldwide is tracked in the ISI database. There are several factors governing the selection of journals. It is the general contents of the journals, graphics layout/format, citation data, and existing ISI coverage of scientific disciplines. The following three types of information are considered when selecting journals:

- citation data
- journal quality
- experts' opinion

The ISI monitors information on all cited references published in a journal i.e. not only cited articles, but also errata, reviews, letters, etc.

The selection of journals also takes account of several qualitative indicators. One of them is the quality of a journal. The most significant condition is to what extent a journal is capable of fulfilling its programme. This includes the editorship's requirements on abstracts, titles, and bibliography. Another indicator of a journal's quality is who the members of its editorial board are, which means that if a journal from a small country is not in some way exceptional, it is unlikely to be attractive enough to be included in the database. Another requirement is regularity of issuing. It is not permissible for a journal to be issued with a week or month's delay. The ISI decision can also be affected by the fact whether a journal in question respects international editorial conventions.

The question of language is of high importance as well. At least some brief abstract and résumé in English are required. If a journal editor wishes to ensure a broader audience for its articles within the international scientific community, it is necessary that articles, abstract, and bibliography be in English as well.

The selection of journals also depends on opinions of experts in a given discipline. The advisory board members are all specialists whose collective multidisciplinary expertise keeps the ISI informed about new and noteworthy publications. The opinions of external experts, subscribers, editors, publishers and others are taken into consideration as well. The ISI considers and looks into any criticism concerning a new journal.

After this introduction, we will take a look at journals tracked in the JCR in the year 2000, as shown in Table 2.29. We notice that in comparison with other small countries of western Europe (including non-English-speaking ones) the number of listed journals from Slovakia is lower. On the other hand, it can measure up to other transition countries quite well.

Table 2.29: Number of SCI and SSCI-monitored journals from selected countries in 2000

Country	SCI	SSCI
USA	2184	1011
Switzerland	162	22
Russia	101	7
Ireland	19	5
Finland	10	1
Germany	433	51
England	1096	354
Austria	23	2
Estonia	1	-
Lithuania	1	-
Slovenia	3	1
The Czech Republic	22	5
Slovakia	11	2

Source: JCR

Tables 2.30 - 2.32 show common data on particular SCI and SSCI-listed journals for Slovakia, the Czech Republic, and Slovenia: total number of citations in the journal in 2000, impact factor (IF), immediacy index, number of articles in the year 2000, and particularly cited half-life information in the last column. This indicator is defined as the number of publication years from the current year, which account for 50% of current citations received. A longer cited half-life generally indicates that the articles are cited even after a long time since its publication year. Thus, the lower the index, the newer citations are contained in the journal's articles. The data for both SCI and SSCI have been taken from the 2000 JCR Science Edition. As there had been no considerable differences in the previous years, we suppose that the results for 2001 should be similar.

Table 2.30: SCI and SSCI-listed journals - Slovak Republic

Title	Total number of citations	Impact factor	Immediacy index	Number of published articles	Cited half-life
ACTA PHYS SLOVACA	177	0,465	0,038	52	2,6
BIOLÓGIA	233	0,165	0,020	99	5,0
CHEM PAP-CHEM ZVESTI	239	0,154	0,062	80	5,1
COMPUT ARTIF INTELL	50	0,226	0,000	24	
DREV VYSK	30	0,069	0,000	9	
EKOL BRATISLAVA	59	0,109	0,029	70	
GEN PHYSIOL BIOPHYS	281	0,417	0,000	15	7,6
GEOL CARPATH	148	0,156	0,026	78	5,7
HELMINTHOLOGIA	147	0,526	0,220	41	4,6
KOVOVE MATER	80	0,280	0,125	32	
NEOPLASMA	491	0,579	0,027	73	6,2
EKON CAS	21	0,106	0,000	26	
STUD PSYCHOL	106	0,292	0,062	48	5,4

Source: JCR

Table 2.31: SCI and SSCI-listed journals - Czech Republic

Title	Total number of citations	Impact factor	Immediacy index	Number of published articles	Cited half-life
ACTA VET BRNO	87	0,240	0,000	41	
ACTA VIROL	495	0,558	0,122	41	8,8
CERAM-SILIKATY	37	0,167	0,000	25	
CESK SLOV NEUROL N	17	0,059	0,000	60	
CHEM LISTY	304	0,278	0,028	107	6,7
COLLECT CZECH CHEM C	2759	0,960	0,150	133	10,0
CZECH J ANIM SCI	29	0,172	0,012	80	
CZECH J PHYS	988	0,298	0,041	218	4,8
CZECH MATH J	303	0,103	0,096	73	10,0
EUR J ENTOMOL	381	0,716	0,055	73	4,6
FOLIA BIOL-PRAGUE	225	0,351	0,122	41	6,6
FOLIA GEOBOT	294	0,649	0,045	22	6,3
FOLIA MICROBIOL	624	0,752	0,093	43	5,3
FOLIA PARASIT	476	0,844	0,235	51	6,8
FOILA ZOOL	250	0,240	0,197	71	6,2
KYBERNETIKA	140	0,178	0,079	38	0,0
LISTY CUKROV	10	0,018			
PHOTOSYNTHETICA	778	0,482	0,026	39	8,0
PHYSOL RES	475	1,366	0,100	110	3,6
ROST VYROBA	173	0,256	0,037	81	5,6
STUD GEOPHYS GEOD	257	0,761	0,750	44	4,3
VET MED-CZECH	128	0,188	0,000	42	5,0

Source: JCR

Table 2.32: SCI and SSCI-listed journals - Slovenia

Title	Total number of citations	Impact factor	Immediacy index	Number of published articles
ACTA CHIM SLOV	75	0,161	0,073	41
INFORM MIDEM	15	0,120	0,000	24
STROJ VESTN-J MECH E	9	0,012	0,000	56
JAVNOST-PUBLIC	10	0,020	0,000	22

Source: JCR

When focusing attention on individual impact factors for the journals listed in the above tables, we see that nearly all of them have this figure below 0.5, with the exception of a few journals having the impact factor between 0.5 - 1.0, which are very low values altogether. An exceptional case is a Czech journal Physiol RES specialising in physiology with the impact factor of 1.366. This might point out to the fact that journals from the candidate countries, in spite of being included in the ISI indexing, are little significant for scientists and probably do not bring any substantial or latest information, or they are not attractive for scientists for a number of reasons mentioned above. It is most likely that an author wishing to publish an article with significant content will do so in a foreign journal. Therefore, the very number of monitored journals from a certain country cannot properly illustrate the quality of science in that country. This indicators needs to be assessed in conjunction with other indicators, such as the total number of publications by Slovak scientists in foreign journals, their rates of citation, etc. (which we do elsewhere). Our conclusions can be proven by their comparison with the figures for Hungary, Poland, and Baltic states, which are not listed here due to the limitations of space.

As mentioned in Chapter 1, the impact factor cannot be compared across journals from various disciplines of science. It is, however, possible to compare an average impact factor of all journals being published in a given country. Supposing that such journals altogether could at least roughly cover the whole scope of research, such comparison may have certain information value in this respect. The average figure is shown in Table 2.33. We see that Slovakia's average impact factor is way lower that the Czech Republic's or Hungary's, which implies a lower average response Slovak scientific journals receive in comparison with their neighbours. A surprising finding is the absolutely lowest average achieved by Slovenia.

Table 2.33: The average of impact factors for JCR-listed journals in a given country

Poland	0,503676
The Czech Republic	0,38264
Hungary	0,36285
Slovakia	0,272615
Slovenia	0,07825

Source: JCR

2.4. Slovak science and the European Union

Introduction and analysis of facts

The European research area is a natural basis of the Slovak science in terms of activity, competition, and comparison. This area exists not only as a sum of national activities in research and development, but also as a location where all Europe-specific research and development programmes take place. At present, the Fifth Framework Programme for Research and Technological Development is coming to its end, and the Sixth Framework Programme is being launched. In both of these programmes, Slovakia is playing the role of an active and contributing member. The analysis of our achievements in the ongoing Fifth Framework Programme thus provides an opportunity to conduct efficient comparison with a high information value. The Fifth Framework Programme does not cover all scientific disciplines and all types of activities in research and development. It is therefore not appropriate to use data resulting from this programme to assess individual scientists or disciplines. On the other hand, when analysing the Slovak science as a whole, these disadvantages diminish significantly, and we are of the opinion that such comparison is meaningful.

The Fifth Framework Programme set out the priorities of technological development and demonstration activities of the European Union for the period 1998 - 2002. The Fifth Framework Programme has two different parts: the European Community Framework Programme covering research, technological development and demonstration activities and the Euratom Framework Programme covering research and training activities in the nuclear sector.

The Fifth Framework Programme differs considerably from its predecessors. It has been conceived to help solve problems and to respond to major socio-economic challenges facing Europe. To maximise its impact, it concentrates on a limited number of research areas combining technological, industrial, economic, social, and cultural aspects.

The scientific priorities of this programme have been determined on the basis of a common set of criteria, which can be divided into three categories.

The first category includes criteria related to "value added" by the EC and the subsidiarity principle in order to select only such goals that can be efficiently accomplished at the EC level by means of scientific activities conducted at this level. It applies to the need to

- create a "critical mass" by mutually combining expertise and resources available in various member states
- considerably contribute to implementing one or several EC policies
- respond to problems ensuing at the EC level or questions related to some aspects of standardisation, or to questions in connection with the development of the European research area.

The second category includes criteria related to social goals, with the aim of strengthening principal social goals of the Community reflecting expectations and concerns of its citizens. They are concerned with:

- improving employment conditions
- improving the quality of life and health
- environmental protection.

The third category includes criteria concerning economic development and scientific and technological outlook so as to contribute to consistent and sustainable growth of the Community as a whole. It is therefore necessary to focus on:

- expanding areas with good prospects of growth
- areas where the Community's intentions can and must be more competitive
- areas where prospects are growing for considerable scientific and technological progress and where there are possibilities of spreading and utilising its results in the mid or long-term.

The Fifth Framework Programme has two main parts. One is the Fifth Framework Programme for research and technological development, consisting of four targeted thematic programmes that implement research, technological development, and demonstration activities and three broad-scope horizontal programmes. The other part is the Fifth Framework Programme (Euratom) that consists of a targeted thematic programme implementing research and training activities in the nuclear sector. Each of the framework programmes also contains a specific programme covering direct scientific activities and technological development activities to be implemented by the Common Research Centre of the European Community. They are based on research and institutional support for science and technology.

A budget of 13,700 million euros has been agreed for the implementation of the Fifth Framework Programme. Together with 1,260 million euros allocated for the Euratom programme, the overall budget for research during 1999 - 2002 totals to 14,960 million euros, which is a 4.61% rise compared to the Fourth Framework Programme.

As far as Slovakia's participation is concerned, the membership of the Fifth Framework Programme costs Slovakia considerable amounts of funds, which keep rising progressively and are determined on the basis of the GDP. The concern of each candidate country is to reclaim as much of the allocated funds as possible through grants for successful projects. A report that was part of the Association Board's decision on adopting conditions and negotiating the participation of the Slovak Republic in the EC programmes in the field of research, technological development, and demonstration activities (1998 - 2002) and which was deliberated by the Government of the Slovak Republic literally states:

- "Based on the results accomplished in the 3rd and 4th RTD Framework Programmes, it can be envisaged that the Slovak scientific and research community is capable not only of reclaiming the invested funds, but also obtaining further financial resources."
- "There is a very high degree of certainty that return on investment will be achieved."

15.96 million euros had been paid over 3 years by Slovakia in a form of contributions (1999 - 2001). The revenue as of September 15, 2001, or at the end of 2001, was 9.34 or 10.855 million euros (The Ministry of Education published two slightly different figures concerning the revenue). It is unlikely that the revenue could significantly exceed 9.34 or 10.855 million euros over the last three and a half months of 2001.

A question therefore arises: "Was a loss of 6.62 or 5.1 million euros really made? In other words, "Did Slovakia really invest in the common fund the amount exceeding by about 6 million euros what it was in fact able to reclaim?

An in-depth analysis of the Slovak participation in the Fifth Framework Programme has not yet been made public. The Ministry of Education published on its web site (in 337 words) the above brief, optimistic data, showing **significant time discrepancy between expended funds and reclaimed revenues**. The expenditure is listed for a two-year period (1999 and 2000), whereas the revenues cover a three-year period (1999 - 2001 less three months).

Table 2.34: The numbers of approved project and the EC contribution

Sector	Number of projects	EC contribution (EUR)
HEIs	19	1 369 045
Total for public sector	64	7 903 514
In that SAS	36	4 195 369
Business sector	28	1 582 369
Total	111	10 854 928

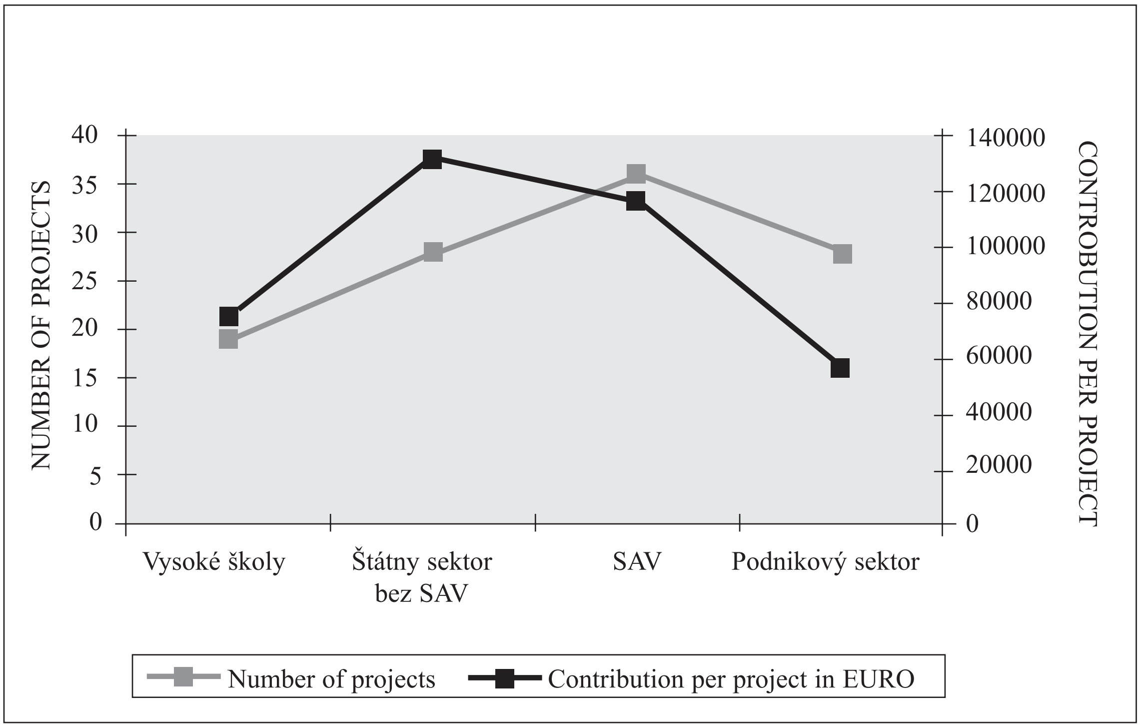
Source: Ministry of Education

On the other hand, Table 2.34 was made public, indicating the numbers of approved projects and a total contribution by the European Commission in individual sectors.

Within the Fifth Framework Programme, the European Commission had approved 111 projects, in the solving of which Slovak subjects participated, by September 15, 2001.

Chart 2.2 shows the data from Table 2.34 expressed separately for the public sector without the Slovak Academy of Sciences and the Slovak Academy of Sciences. An average contribution per one project was calculated as well. After such an adjustment, Chart 2.3 clearly shows that the lowest contribution per project was obtained by the **business sector**, which does not stand out in the number of approved projects either. The highest contribution per project was given to the public sector without the SAS. This figure was significantly increased by three projects of the Institute for Preventive and Clinical Medicine, amounting to nearly half a million euros each. The Slovak Academy of Sciences also ranked quite well, in terms of both the number of projects and contribution per project. In spite of extensive labour force, higher education institutions had a low number of projects as well as a low average contribution per project.

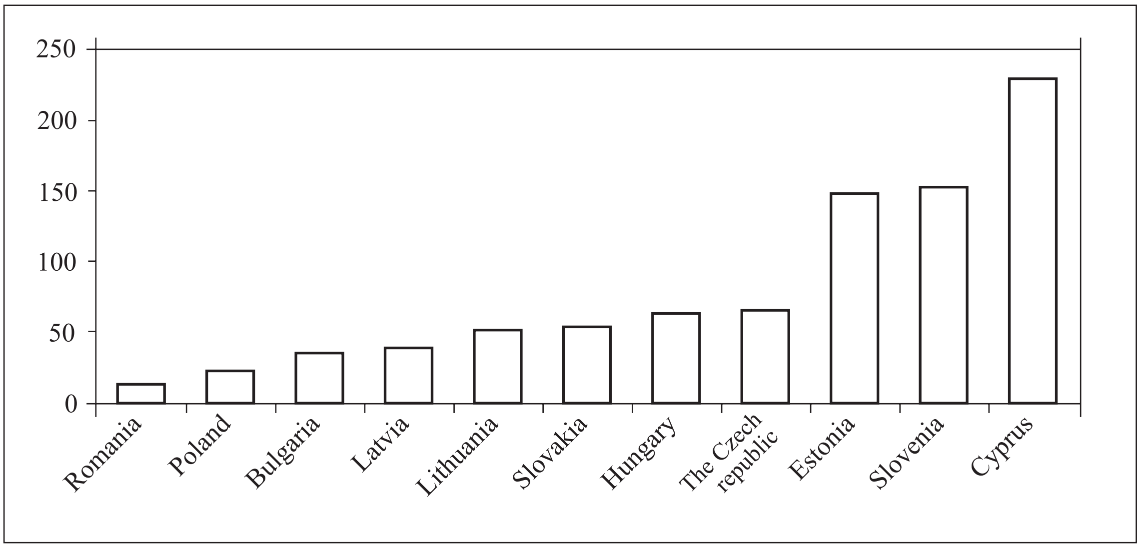
Chart 2.2: Number of projects and contribution per project



Source: Authors

Chart 2.3, based on the sources of the Slovak Republic's Mission at the European Commission, indicates a low activity of Slovak organisations in submitting project proposals. On the basis of the data adjusted for the number of inhabitants, we can see that our country was significantly outrun by the Czech Republic, Hungary, Slovenia, Estonia, and Cyprus. Our lagging behind is highly significant especially in comparison with Estonia and Slovenia.

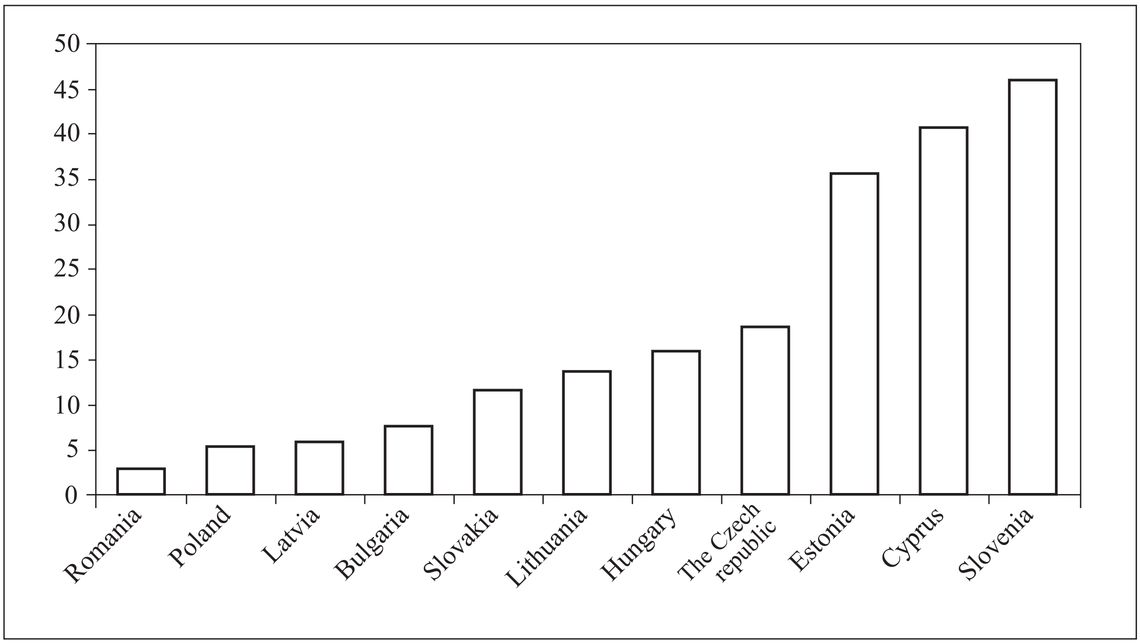
Chart 2.3: Number of submitted proposals per million inhabitants



Source: Authors

Chart 2.4 reveals that with regard to the number of projects approved within the Fifth Framework Programme, we are little successful in comparison with the other candidate countries. Slovakia ranks better than Bulgaria, Rumania, and Poland, which is not surprising given the population of these countries.

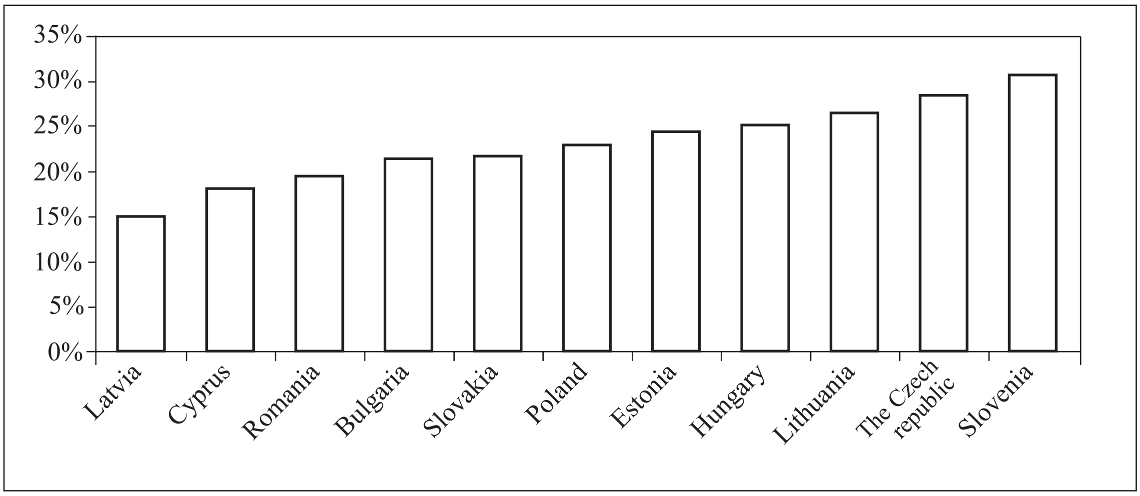
Chart 2.4: Number of approved proposals per million inhabitants



Source: Authors

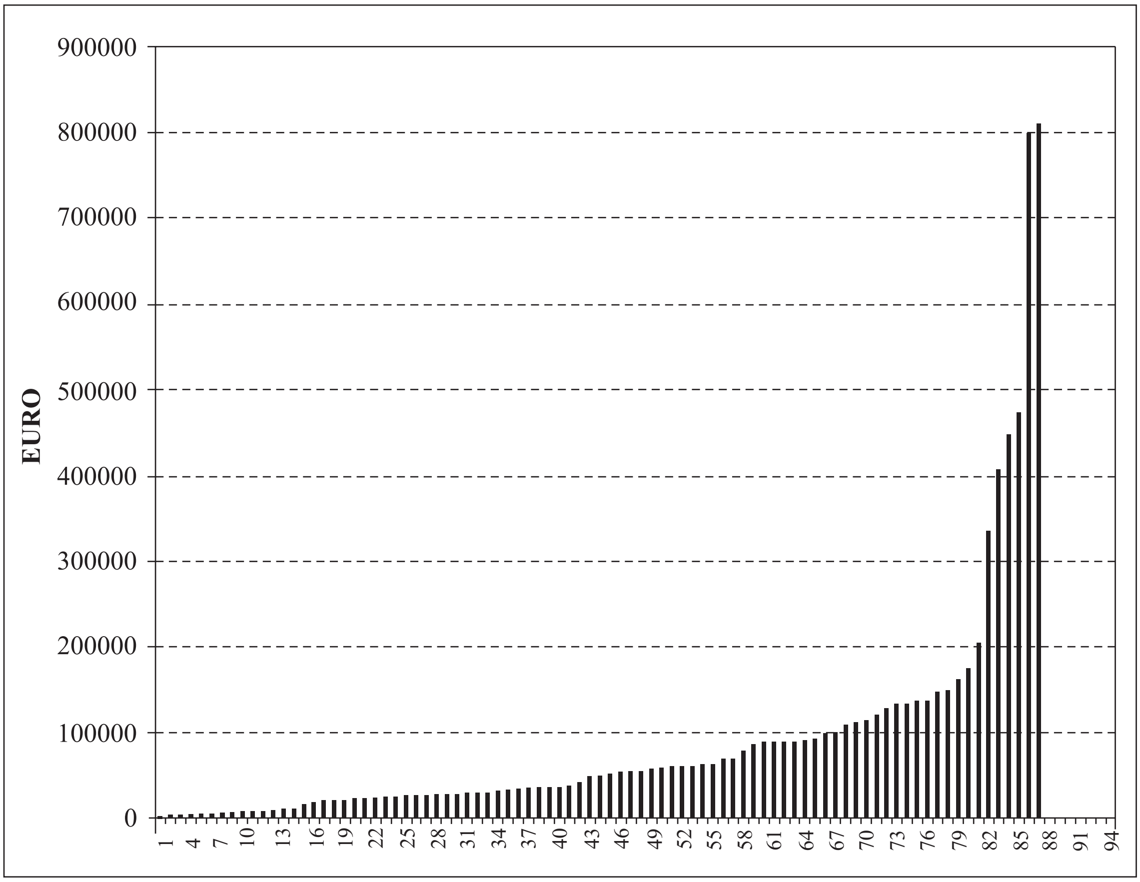
The last of these three charts - 2.5 - illustrates a lower quality of projects submitted by Slovak organisations in comparison with the other candidate countries. Only Rumania, Bulgaria, Cyprus, and Latvia show even lower rates of success (approved projects/submitted projects) than Slovakia.

Chart 2.5: Rate of success



Source: Authors

Chart 2.6: 5th FP projects - contribution (EUR)

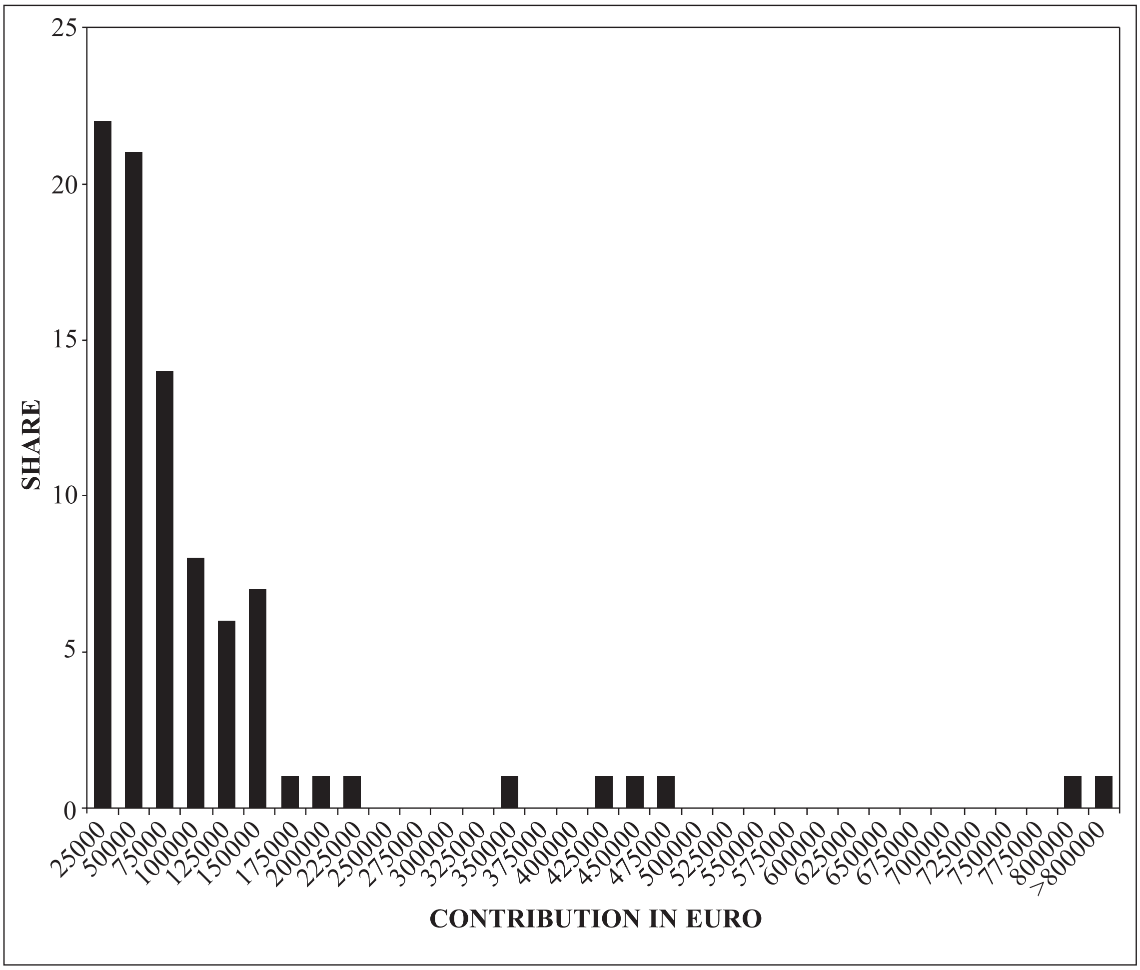


Source: Authors

Another chart - 2.6 - indicates the amount of each contribution for all approved Slovak projects. It is observable that low-contribution projects significantly dominate.

This fact is even more apparent from the following Chart 2.7, where the frequency of projects depending on the amount of contributions is presented. A scale unit was chosen 25 000 EUR. We notice that most projects have received a contribution up to 25 000 EUR. The frequency is decreasing with the increasing amount of contributions. There are only three projects within the range 175 000 - 225 000 EUR, followed by a wide gap, then there is one project in the range 325 000 - 350 000 EUR, another gap, and finally there are **three projects from the Institute of Preventive and Clinical Medicine with the contribution of 425 000 - 475 000 EUR**. The 800 000 EUR range includes support for two Slovak centres of excellence. These two cases represent a category of support different from all the other projects. Here, the funds are assigned for accompanying measures and not for direct support of scientific projects. These funds are intended to cover some costs of international conferences, workshops, and other activities, which cannot be financed through a standard budget of a scientific project. They are also used to cover relatively high scholarships for scholars from the EU countries participating in fellowships in our country. Although we do not have information about scientific contributions for other countries, a clear conclusion of this analysis is that Slovak organisations should do their best to obtain the highest possible contributions. It can be achieved through well-elaborated proposals and justified financial requirements. The feasibility of such an approach is proven by the three IPCM projects with the highest contribution in support of scientific activity of out all projects submitted from Slovakia (as of September 15, 2001).

Chart 2.7: Percentage occurrence of contributions by their amount



Source: Authors

Questions arising in connection with the Fifth Framework Programme should also include an analysis of the "functional" status of approved projects from Slovakia. Those participating in the projects can do so either as main contractors or auxiliary contractors, and each project has a coordinator. Based on the data provided by the Ministry of Education, it can be noted that there are only two scientific projects within the Fifth Framework Programme that are coordinated from Slovakia, namely Project IST-1999-20364 WEBOCRACY "Web-technologies in support of direct participation in democratic processes", coordinator Doc. Ing. Tomáš Sabol, CSc., and Project QLK4-CT-2000-00488 PCBRISK "Assessment of health hazards for people exposed to low doses of PCB in the long run", coordinator Prof. MUDr. Tomáš Trnovec, DrSc. This last fact about coordination by a Slovak entity disproves the myth that a project proposal with the coordination by a candidate country is unlikely to be approved. It would be very helpful to assess projects from the candidate countries also from the point of view of coordination and contractors, the data at our disposal do not suffice for such a task, though.

Commentary and conclusions

The low return on investment, few submitted and approved projects, and low rate of success in the Fifth Framework Programme achieved by Slovak organisations need further analysis. The Ministry of Education web page informs that a number of organisational structures have been set up in order to help Slovakia achieve the best possible results in these activities.

- **Main Coordinator - the Ministry of Education:** Main Coordinator's task in the information infrastructure of the Slovak Republic is to ensure liaison through Secretary with the Slovak Commissioner's Office at the 5th FP in Brussels (Liaison Office) within the Slovak Mission at the EU in Brussels, the Slovak government, and other central authorities of the Slovak Republic.
- **Coordinative Board of the SR for the Fifth RTD Framework Programme:** "The Coordinative Board acts as an advisory body to the Main Coordinator. **It creates and implements the national policy of participation by Slovak organisations, research and development institutions, industrial institutions, and small and medium-size enterprises in the Fifth Framework Programme.**"
- **Executive and expert coordinators:** Their task is to ensure optimal participation of organisations subordinated to particular ministries in the Fifth Framework Programme.
- **SARC and FEMIRC:** "Slovakia's success in the Fifth Framework Programme will much depend on setting up a suitable communication infrastructure and preparing our scientific and technical community to be able to succeed in a highly competitive environment. It includes providing up-to-date and correct information, searching for potential research partners, drafting proposals in an appropriate form and "convenient language", advisory services for research teams, organising workshops and conferences, and making information available both in printed and electronic form. In this area, we expect specialist assistance of the EC and rely on SARC **(Centre for Science, Technology, and Development)** - a subsidised organisation subordinated to the Ministry of Education, and FEMIRC Slovakia **(Fellow Member of the Innovation Relay Centres)**, established on the basis of BIC Bratislava (Business and Innovation Centre), which create two main nodes of the information infrastructure.
- **Information infrastructure:** An information infrastructure draft has been elaborated by the Ministry of Education and consulted with a number of central authorities of the Slovak Republic, and other institutions concerned.

It is not known how the above officials and organisations adhere to their tasks pertaining to the Fifth Framework Programme, but the results achieved by Slovakia do not make them deserve much praise. On the other hand, the IPCM's participation in the Fifth Framework Programme as **one of the two projects** coordinated from Slovakia emerged quite **separately and independently** of the activities of the above-mentioned coordinator, coordination board, executive coordinators, and bodies such as SARC and

FEMIRC and their information infrastructure. The present level of information background provided for the framework programmes by the European Commission is so high and user-friendly that the activities being performed in connection with the Fifth Framework Programme, which are described on the MoE web site, are questionable in terms of return on investments (covering business trips to Belgium, setting up the infrastructure, etc.). Besides, what we learnt by personal experience about informatics skills of one of the executive coordinators made a rather negative impression. He was unable to answer a concrete query about a method of encryption used. Successful participation in the Fifth Framework Programme is a result of the proponent's expertise, compatibility of the proposal with programme objectives and assessment criteria, its linguistic and informatics readiness, and experience of previous international cooperation and activities abroad. An organisation that is unable to draft a proposal of appropriate standard without a third party's assistance does not meet preconditions for successful scientific work within the Fifth Framework Programme.

Besides providing necessary background for such activities, the question of incentives needs to be taken into consideration as well. As far as manifestos are concerned, all political, expert, and executive officials put emphasis on the need to integrate Slovakia into the EU in all areas including science. Contrary to what they proclaim, conditions providing incentives to participate in the EU framework programmes have not in fact been created in the Slovak research community. It is due to the fact that all the EU-supported activities in the Fifth Framework Programme are based on joint participation of a particular country (contractor) and the European Commission. This is referred to as a share cost principle in EC documents. From the EC's point of view, the project is being solved by a particular national entity (contractor) and the European Commission contributes towards the project by the reimbursement of eligible costs up to an amount agreed beforehand. The amount of reimbursement depends on a bookkeeping method used. The EC documents lay emphasis on the fact that joint cost-sharing between the contractor and the EC must be transparent and identifiable independently of a chosen reimbursement method. If our state actually strives to ensure that as many Slovak organisations as possible participate in the EC framework programmes, it must be its policy and organisational task to ensure that the Slovak organisations that have succeeded in obtaining the EU contribution have no difficulty in Slovakia's participation in funding these projects. Despite a proclaimed priority concern of Slovakia and its political representatives for the integration processes, the cost-sharing principle is not being pursued in practice. It is reflected by the fact that in research organisations currently solving projects without foreign support and a few projects supported the EC framework programmes their managerial representatives use public funds to subside, both in wages and material costs, projects that failed to obtain or did not even try to obtain a foreign contribution, which is contrary to Slovakia's priorities in the area of integration and policy. This can be documented by practical examples:

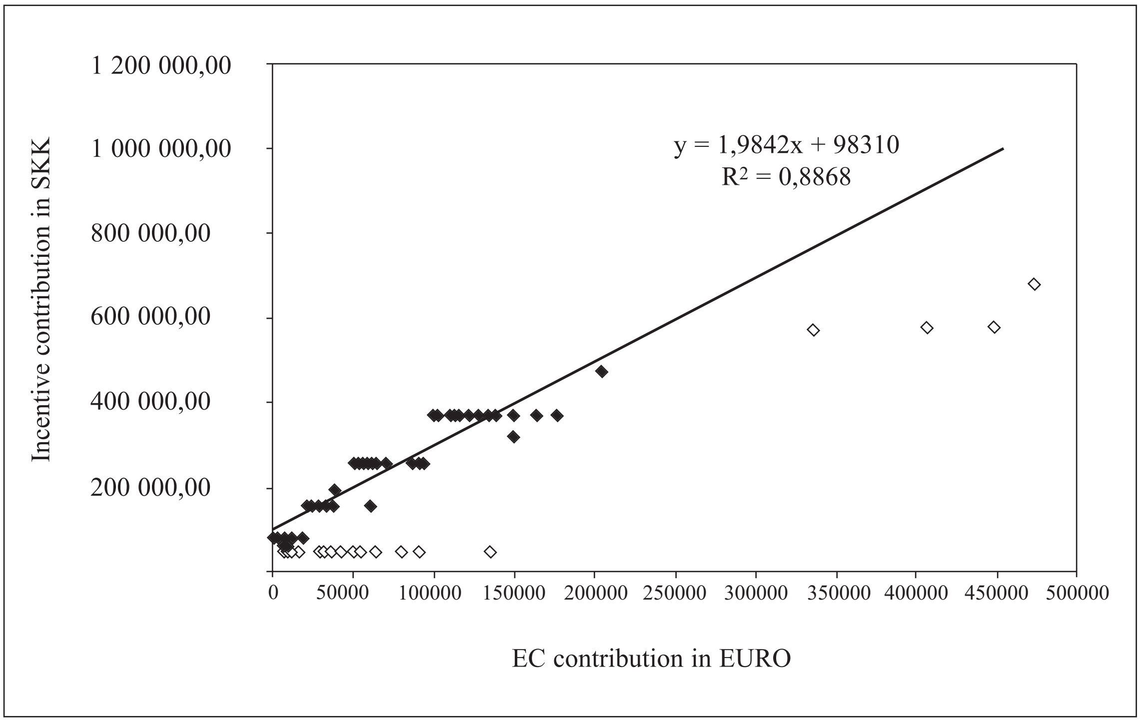
- In the case of research workers solving less demanding local projects, performance bonuses in their wages are fully covered by the state budget funds, and in the case of those working on demanding 5th FP projects, these performance bonuses are covered by the EC contribution.

- In case of need to reduce the number of employees at a particular place of work, foreign projects were the first to attract the management's attention in this respect. To keep them running, some of the employees working on these projects had to change their employment contracts into temporary ones, where wages can be covered by the EC contribution. There are hardly any priority performance bonuses for workers solving the projects within the Fifth Framework Programme.

Similar egalitarian views are reflected in determining the amount of so-called incentive contributions from the state budget for the 5th FP projects (with contracts concluded until December 29, 2000). Chart 2.8 showing the relationship between the incentive contributions from the state budget and the EC contributions reveals that less successful project have been significantly favoured by:

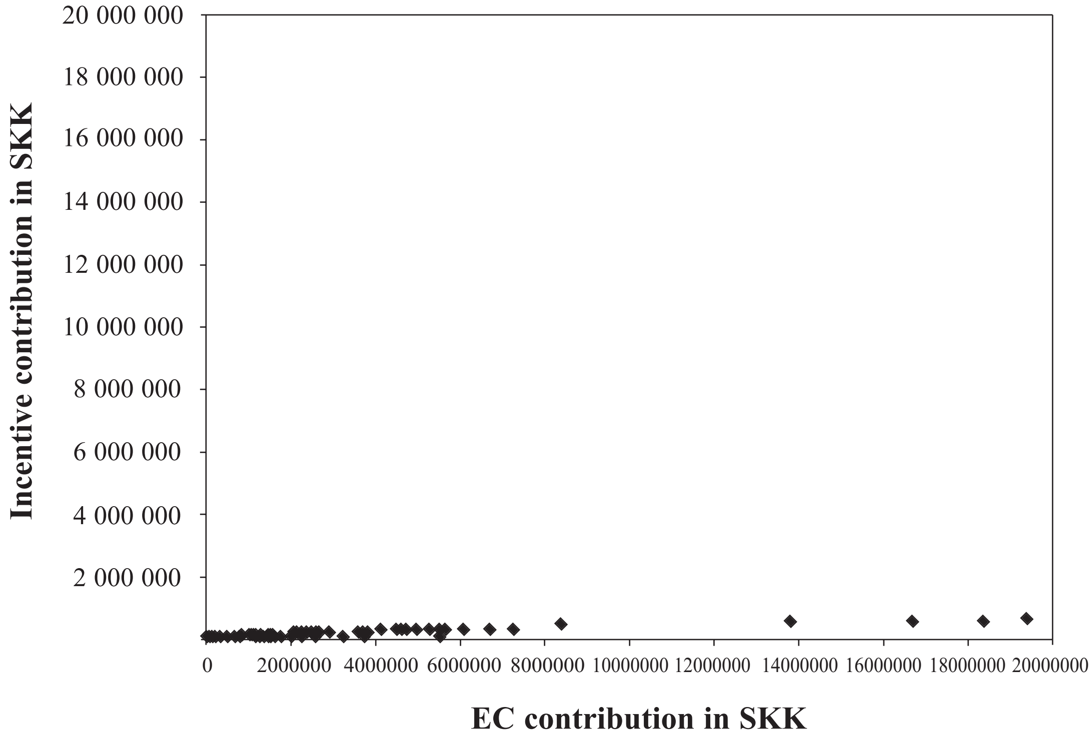
- the constant amount of "a lump-sump contribution" regardless of the total volume of reimbursed eligible costs
- the non-linear relationship between the incentive contribution and the volume of reimbursed eligible costs. Mediocrity and second-rate quality have been significantly favoured. The present trend is aimed at supporting excellence (centres of excellence). Chart 2.9 showing the relationship between the incentive contributions from the state budget and the EC contributions reveals that Slovakia's participation means covering wages and other operation costs. Slovakia's contribution to non-capital costs is negligible.

Chart 2.8: Relationship between the incentive contribution and the EC contribution



Source: Authors

Chart 2.9: Relationship between the incentive contribution from the state budget and the EC contribution in SKK



Source: Authors

The Sixth Framework Programme is being launched at present. In this respect, the conclusions of the European Board Chairmanship as of March 23 - 24, 2000 are of high importance. It has stated that measures need to be taken in order to create the European Research Area:

- To create suitable mechanisms for networking national and joint research programmes on a voluntary basis and following freely chosen goals in order to make more advantage of synergic resources for research and development in the member countries and to ensure regular reporting to the Board on progress made
- To map research and development excellence in all member countries in order to promote the spreading of excellence
- To enhance the environment stimulating investment in private research, partnerships in research and development, starting up high technologies by tax policies, innovative investments (venture capital) and support provided by the European Investment Bank
- To stimulate development of an open method of coordination in order to mutually compare national scientific and developmental policies, and to set the indicators

for assessing performance in various areas by June, 2000, with regard to human resources development in particular

- To implement the European innovative panel assessment by June, 2001
- To facilitate the establishment of a high-speed trans-European network for electronic scientific communication, with the support of the European Investment Bank, with the aim of connecting research institutes and universities, as well as scientific libraries, research centres, and schools, by the end of 2001
- To adopt measures removing obstacles to scientists' mobility in Europe by 2002, and attract and retain top-class scientific talents of Europe
- To ensure that the patent of the EC is available by the end of 2001, including the model of its utilisation, so that patent protection in the EC could be equally straightforward, inexpensive to obtain, and as consistent in its coverage as patent protection provided by its key competitors.

The organisation of research in Europe is to be significantly changed. The most important tool that has so far been used in Europe is the EC framework programme. Yet, it accounts for only about 5.4% of public funds and as such is not able to ensure better organisation of European research efforts. Reducing disintegration and ensuring better integration of the European scientific and technological area is the necessary precondition for strengthening research in Europe. Such arrangements will create a substantial "critical mass" in the main areas of scientific advancement. In this respect, a question arises how to define the European research area. The European Union responds that it should incorporate the following aspects:

- networking the existing centres of excellence in Europe and creating virtual centres of excellence by means of new and interactive communication instruments
- a common approach to the needs and resources for financing large research facilities in Europe
- a more coherent implementation of national and European activities and closer relations between various scientific and technological organisations in Europe, better use of instruments and resources to stimulate investments in research, innovative indirect-aid systems (complying with the EC rules on state subsidies), patents, and venture capital
- creating a common system for implementing R&D policies
- more extensive and mobile human resources: greater mobility of scientists, stressing the European dimension in scientists' careers, emphasising the position and role of women in science
- stimulating young people's interest in research and scientific career
- a greater European cohesion in research, based on the best experience of transferring knowledge at the regional and local level, and in the role of regions in European scientific efforts
- the unification of scientific communities, societies, and scientists of western and eastern Europe
- making Europe more attractive for scientists from other parts of the world
- support for common social and ethical values in scientific and technological matters.

The contribution of the new 6th framework programme to the creation of the European research area is based on three new instruments: networks of excellence, integrated projects, and the EC's participation in jointly implemented national programmes. As shown by the above, if we want to succeed in the 6th Framework Programme 2002 - 2006, joint efforts of the whole Slovak scientific community and its organisational units will be needed. It is also necessary to identify factors that caused Slovakia's relatively poor results in the Fifth Framework Programme and prevent reoccurrence of such faults.

Chapter 3: Analysis of individual areas of science

Chapter 2 was devoted to the aggregate analysis of the Slovak science. Yet, science is made up of many diverse disciplines, which is why we find it necessary to provide at least a brief overview of primary groups of scientific disciplines, in spite of the limited scope of this publication. Therefore, Chapter 3 is divided into five sections, in which natural, technical, medical and pharmaceutical, agricultural, and social sciences and humanities are dealt with.

When thinking of the individual groups of scientific disciplines, their mutual proportions need to be taken into consideration. As for Slovakia, these are shown in Table 3.1, where the branches of science are listed in terms of expenditure on research and development. Even though the amount of funds is not in direct proportion to either the number of research workers or the quality of research, still these figures reveal that the financial centre of the Slovak science mostly consists in natural, technical, and agricultural sciences. The purpose of this chapter is to find out more about their actual contents.

Table 3.1: Expenditure on research and development in Slovakia, 2000

	Share in R&D expenditure (%)	Index 00/99
Natural sciences	26,29	163,1
Engineering and technologies	47,07	88
Medical and pharmaceutical sciences	8,08	74
Agricultural sciences	11,81	106,3
Social sciences	5,82	79,6
Humanities	0,93	90,3

Source: Statistical Office of the Slovak Republic

3.1. Natural sciences

It is a general assumption in the Slovak scientific community that natural sciences are our strongest point in comparison with the world's science. In HEI assessments carried out by the Accreditation Board, a government advisory body, the representatives of technical and economic sciences and humanities argued that natural sciences were the easiest to publish in international recognised journals and thus achieve high citation counts. Similar arguments were used when criteria for appointing professors were stipulated. It is typical that these figures are the highest in the case of natural sciences, despite considerable differences between their various disciplines. Traditionally, the highest figures are achieved by chemistry and physics, which may be related for example to a high level of these sciences over a long period of time in the former Czechoslovakia and then in the Slovak Republic. Slovakia has historically been strong on other disciplines as well, such as biochemistry, microbiology, virology, or their sub-disciplines. The assumption about the high quality of natural sciences can be justified on the grounds that natural sciences were the least exposed to persecution during the totalitarian era. It is also argued that their representatives could travel abroad more freely, although it was the technical disciplines that offered the widest possibilities of visiting foreign countries. It is undisputable, however, that in the normalisation period many natural scientists, among others, were forced to abandon their work. Whole scientific teams of excellent quality were dismissed in those times.

More than 12 years have passed since the 1989 turnabout, which should be a sufficiently long time for such differences to level out. Besides, several branches of humanities, economic sciences, and applied technical sciences were invited to international cooperation in the past decade much more frequently than natural sciences. This is what the structure of supported projects in the 5th and 6th RTD framework programmes of the EC shows, where the support is targeted at environmental sciences, biotechnologies, molecular biology, human health and nutrition, informatics, and communications as the branches of natural sciences. On the other hand, physics and chemistry as basic scientific disciplines are not included in their priorities at all. They are only implicitly incorporated in nearly all priority programmes, for example physics in connection with the transfer of information and chemistry in environmental branches, several biological disciplines, materials development, etc. The obstacles some sciences had been facing before 1989 were removed long ago, new priorities have been set out, and new opportunities appeared. A question therefore arises whether the image of traditionally strong natural sciences can stand comparison with the world. Our comparison was based mostly on available bibliometric data, which do not suffice to get a full picture, yet we believe that they can to some extent illustrate the state of natural sciences in Slovakia.

The comparison with selected EU countries (Finland, the Netherlands, and Austria and some candidate countries (the Czech Republic, Hungary, and Slovenia) during the period 1995 - 2001 is shown in Table 3.2. Countries with the population similar to Slovakia have been chosen for comparison. Table 3.2 shows SCI-listed publications of all types and languages. The comparison gives clear evidence that we are significantly lagging behind the other countries under review as far as the number of publications per 100 000 inhabitants is concerned. When adjusted for population, the scientific production of Slovak institutions for 2001 only reaches 34% of Austria's production and less than 25% of Finland's production. It is only 78 - 79% of the production in the Czech Republic and Hungary. Should we take into account only publications in English and only articles in scientific journals, the productivity proportions for 2001 would remain more or less the same.

Table 3.2: SCI-listed publications of all types and languages (calculated per 100 000 inhabitants)

Year	The Czech Republic	Finland	The Netherlands	Austria	Slovakia	Slovenia
1995	33,54	120,81	34,40	73,19	35,31	46,16
1996	38	128,88	35,50	80,21	37,66	48,42
1997	39,12	138,75	38,82	91,30	36,11	59,79
1998	42,46	146,21	44,39	96,15	38,50	58,79
1999	42,40	153,63	44,53	100,98	36,87	70,21
2000	43,83	156,31	46,46	98,05	35,16	87,26
2001	48,59	160,17	47,84	111,00	37,96	87,26
Together 1995 - 2001	287,93	1004,77	291,94	650,88	257,59	457,89

Source: Science Citation Index

Trends in the production of publications are even more pessimistic. While all the countries have been showing a significant rise over time, the Slovak production keeps stagnating. Compared to the state as of 1995, the Czech Republic, Hungary, and Austria experienced an increase by 40 - 50% in 2001. It is noteworthy that only 7 years ago, in 1995, our production of publication was even higher than that of the Czech Republic's, as proven by SCI data. Over a few years, the situation has significantly changed to our disadvantage.

The low scientific productivity of Slovak institutions is not caused by a lower share of research workers in overall labour force. Note that the Czech Republic has used a slightly different methodology for scientific productivity assessment, where they only compare annual productivity adjusted per number of research workers. As the Slovak scientific community is not underestimated in this indicator, no significant changes would be expected in the comparison.

The contribution of natural sciences to the scientific productivity of Slovakia in comparison with other scientific areas is shown in Table 3.3.

Table 3.3: Scientific publications from Slovakia in international journals

Branch of science	**1995**	**1996**	**1997**	**1998**	**1999**
Physics a astronomy	336	357	358	368	348
Chemistry	400	459	429	532	339
Technical sciences	256	207	249	163	177
Biomedicine and pharmaceutical sciences	195	178	172	137	165
Clinical medicine and health's sciences	96	108	84	97	104
Biology	255	311	267	246	228
Mathematics and statistics	86	79	66	72	79
Agricultural sciences	101	92	55	71	58
Geological and environmental sciences	39	54	50	40	46
Computer sciences	29	27	22	23	38
Multidisciplinary publications	4	8	23	10	2
Nature sciences together	1 156	1 260	1 170	1 258	1 040
All scientific areas together	1 837	1 880	1 775	1 761	1 584

Source: ISI

The high percentage of natural science publications (66.6% over the reviewed period) clearly proves their dominance over technical, biomedical, clinical, health, IT, and agricultural sciences, which all account for less than 34% of Slovakia's scientific production over the reviewed period. The most important long-term contributors are chemistry and physics (according to this database, they altogether account for 40 - 44% of Slovakia's scientific production) with a significant lead against the others. On the other hand, the share of R&D employees in natural sciences is only 25%. Table 3.3 allows us to deduce reasons behind the stagnation of Slovakia's scientific production. It seems that reserves of natural sciences have been used up, as neither physics nor chemistry show any significant rise over time. The reality is that the production of the Slovak science is unlikely to grow as long as it keeps facing difficulties due to out-of-date equipment, shortage of chemicals, and little financial support by the state, and also due to the fact that none of the two basic disciplines are sufficiently supported in the 5th and 6th RTD framework programmes. It is unfortunate that even the production of engineering and agricultural sciences has been falling in the period under review, where there is significantly greater support for these sciences from the state budget.

An indicator more important than the extensive production of publications is their quality. One of the measures that are used for large sets of publications, for example the assessment of publication activity in the Slovak Republic, is the "impact factor" of publications produced. The impact factor expresses the average number of citations per one publication over a certain period. The impact factor for particular countries is shown in Chart 2.1 in Chapter 2, which we are now referring to again from the viewpoint of natural sciences.

The chart shows that, out of the ten candidate countries, Slovakia is behind the Baltic countries, Hungary, Poland, the Czech Republic, and Slovenia, and only slightly ahead of Bulgaria and Rumania. This lagging is expressed by the so-called relative citation impact (abbreviated RCI), which is defined as the ratio of the citation impact of publications of a given country to the citation impact of the worldwide database (baseline). The RCI value greater than 1 indicates that the rate of citation for a particular country is above the world's average, the RCI value below 1 shows that the rate of citation (bibliometric quality) does not reach up to the world's level. In the case of Slovakia, this factor was less than 0.5 over the period 1995 - 1999, which is dramatically below the world's level. Similar figures concerning the candidate countries and their comparison with developed countries were first made public in a renowned scientific journal Science to cover the period 1994 - 1997 and were highly negative for Slovakia. It seemed at that time that Slovakia's ranking might have been aggravated by some methodological error due to misplacement of publications after the partition of Czechoslovakia, when some of them were still considered to belong to the former federation and were not computer registered. Unfortunately, this phenomenon is persistent. On the other hand, the Czech Republic has achieved not only increase in the production of publications, but also increase in the impact factor by significant 10 per cent. At present, the Czech Republic belongs to the group of countries featuring RCI greater than 0.5, even though it is not only behind Hungary and Poland, but also Lithuania and Estonia. Conversely, Latvia, Slovakia, Bulgaria, and Rumania have a cumulative (average) value of RCI below 0.5.

Since the citation of works not listed in the SCI and other databases is unlikely to occur, it is nearly certain that it is again natural sciences that are the dominant contributors to RCI. At the same time, it proves that even these sciences do not occupy the top positions compared to the world's elite, although it is difficult to estimate to what extent this is due to (non-)productivity of other disciplines, whose contributions to the ISI-registered production are inadequately low.

In conclusion, it holds that despite natural sciences still keep their traditionally strong position in the Slovak science according to available, rather limited indicators, their position is much weaker from the viewpoint of international comparison. While comparable countries are experiencing a rise not only in scientific productivity, but also in its quality, Slovakia is rather showing signs of stagnating.

3.2. Technical sciences

High technology, innovations, and resulting quality services and competitive production are what significantly stimulate countries' economic growth at present. To become an equipollent partner to the world's developed economies, it is essential - especially for a country not rich in natural resources - to prioritise these processes in particular.

Technical sciences cover the following areas of research:

- electrical engineering
- information and communication technology
- engineering
- civil engineering, architecture, and urbanism
- (in part) chemistry

They are concerned with research and development in relation to technical disciplines and processes. Technical sciences require close connection with basic scientific disciplines making part of the knowledge base - i.e. mathematics, physics, biology, etc. on the one hand, and with an application environment on the other. The capability to efficiently and quickly interconnect research results with their applications is a basic condition for their development, socio-economic growth, and the competitiveness of society.

At the present time, the key worldwide trends, which advance many other areas apart from technical sciences, include the development of information and communication technology and an interdisciplinary approach. This approach is often directed at the areas of miniaturisation, even as far as to a highly favoured branch of today - nanotechnology. These branches represent the interdisciplinary connection of natural and technical sciences and advance the world's science towards new frontiers of knowledge.

The advancement of **electrical engineering and information technology** is at present characterised by the development of made-to-measure solutions for customers, be it in the area of chips, circuits, systems, or software solutions. Great emphasis is being laid upon the development of information and communication networks and signal processing.

Technical sciences in **engineering** deal with examining new material solutions, implementing information technology into design processes and production itself. The multidisciplinary approach and miniaturisation are important catalysts of progress in this area.

Research in the field of **civil engineering** focuses on safety and reliability of building constructions, their resistance against natural disasters, more extensive use of computer simulation in order to solve complicated static and dynamic problems, and intelligent buildings. The area of building operations is concerned with new technologies with low energy consumption, the area of building materials and substances focuses on new composite materials, and utilisation of recyclable local resources with required physical and mechanical properties. **Architecture and urbanism** fully support sustainable growth, quality of life, or preservation of cultural heritage.

Chemistry, which cannot be expressly included in technical sciences, is dominated by search for new environmental solutions promoting the development of such procedures and materials that would ensure the world's sustainable growth.

Until 1989, **research and development in technical sciences** had been adversely affected by the partition of the world and resulting limited access to information, equipment, and applications or to the latest results of research, development, and applications (embargo on new technologies by industrial countries).

Although our scientists often made significant achievements and achieved a high international status, their applications were not always directed at potential customers.

There was often a wide gap between research and its application, which made it impossible to efficiently use the results of research in order to stimulate the overall socio-economic growth of society.

Research and development in technical sciences - particularly in case of "progressive technical sciences" - were often supplanted by reproducing already invented facts. This was particularly apparent in those areas of technical sciences that were focused on progress towards new technologies presently referred to as "high-tech".

Based on the statistical analyses of data provided by the Ministry of Education and the Statistical Office of the Slovak Republic, the number, period of service, and percentage of all pieces of equipment older than 8 years out of all pieces of equipment in the individual areas of research and development is in all cases more than 60%. This figure is alarming, as technological renovation in the world is much faster.

Table 3.4: Number, average period of service, and percentage of obsolete pieces of equipment in the individual branches of technical sciences

Branch of science	Business sector in research and development			Public sector in research and development: Total			Public sector in research and development: In that SAS			HEIs			Total		
	Number	Average period of service	Percentage of obsolete pieces	Number	Average period of service	Percentage of obsolete pieces	Number	Average period of service	Percentage of obsolete pieces	Number	Average period of service	Percentage of obsolete pieces	Number	Average period of service	Percentage of obsolete pieces
		years	%		years	%		years	%		years	%		years	%
Equipment and technology	184	9,9	60,3	147	9,8	63,9	71	11,2	80,3	285	11,7	64,9	616	10,7	63,3

Source: Ministry of Education

Note: The share of obsolete pieces of equipment is a percentage of all pieces of equipment older than 8 years out of all pieces of equipment.

The following table shows that at present there are 234 R&D laboratories in Slovakia whose equipment is above standard. At first sight, this number seems very optimistic. The statistics does not, however, state what percentage of equipment in these laboratories is obsolete.

Table 3.5: R&D laboratories with above-standard equipment - by sectors

Sector	Above-standard equipped R&D laboratories			
	Total number	Providing services for other organisations	Accredited	
			Total	In that those providing services for other organisations
Business sector in R&D	39	37	25	25
Public sector in R&D	84	61	20	20
- in that SAS	33	25	5	5
HEI sector	111	75	20	16
Total	234	173	65	61

Source: Ministry of Education

At present, there are 147 R&D laboratories in Slovakia whose equipment is above standard in the area of technical sciences.

Table 3.6: R&D laboratories with above-standard equipment - technical sciences

Branch of science	Sector				
	Business	Public		HEIs	Total
		Total	In that SAS		
Equipment and technology	29	43	20	75	147

Source: Ministry of Education

Table 3.7: The structure of expenditure on research and development in technical sciences in 2000

Indicator	Unit	Value	Trend 00/99 %
Total R&D expenditure in engineering and technologies	million SKK	2 864,3	96,4
Share of R&D expenditure in engineering and technologies	%	47,07	88,0

Source: Ministry of Education

The share of current and capital R&D expenditure in total R&D expenditure in 2000 changed significantly in comparison with the 1999 share due to an absolute as well as relative increase in current expenditure and an absolute and relative decrease in capital expenditure. A negative phenomenon is a persisting reduction in capital expenditure, which is contrary to the requirements for modernising the equipment and infrastructure in research and development organisations.

The structure of current expenditure on research and development by basic types of science and research shows that in 2000 there was both an absolute and relative decrease in expenditure on basis research (by 2.6%) and a relatively significant increase in expenditure on applied research (by 23.3%) and development (by 10.9%) in comparison with 1999. This is because of an absolute as well as relative increase in R&D expenditure coming from business sources, which is a positive trend for technical research.

The structure of expenditure in technical sciences indicates its decrease in 2000 compared to 1999. The above facts are of high relevance and prove that the volume of funds from businesses has the essential effect upon financing research and development.

Comparison of patent activity with other OECD countries

As far as patent activity is concerned, the situation in Slovakia is appalling. It is, however, similar to that of the other V4 countries. The OECD patent activity survey can serve as an example (OECD (2001)). During 1991 - 1997, 11,542 patents related to information technology were filed, whereas not a single patent was filed from Slovakia over the same period. In the field of "triadic patents", which applies to patents filed in Europe, the USA, and Japan, 36,120 patents were filled, in that 10 from Slovakia. Other V4 countries were experiencing similar, or just slightly better, development. Strong economies have a significantly higher number of submitted patents, often exceeding 1000 in the field of information technology in the Netherlands, Sweden, or Finland.

Citations in technical sciences

One of the criteria for assessment of science and research is the publications' rate of citation in the SCI in particular. Significant attention is paid to this issue in Slovakia, too. Scientists in technical sciences are often shown in a bad light as far as the rate of citation of their works in recognised journals is concerned.

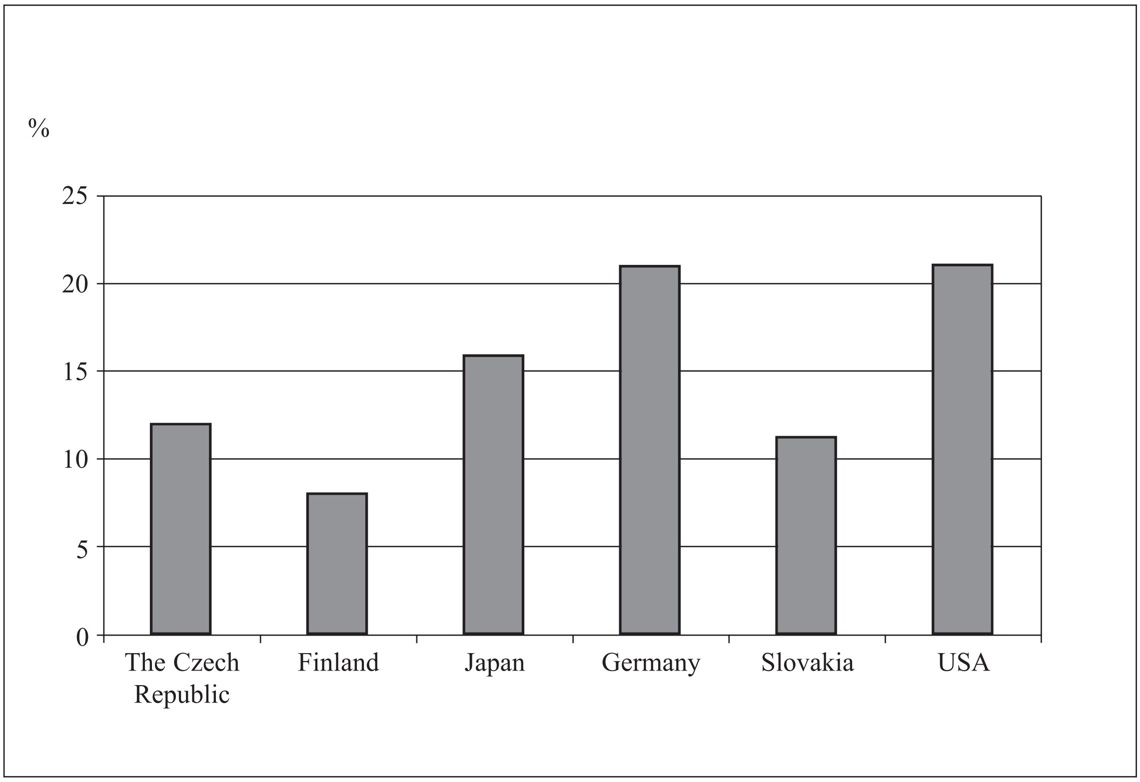
Out of the overall number of 7,567 journals listed in the "WEB of SCIENCE" 1,106 of them are registered in section "Engineering, Computing &Technology", which accounts for 14.6%. On the basis of a representative survey, an analysis of the WEB of SCIENCE database has shown that the number of citations in section "Engineering, Computing & Technology" out of all citations in selected countries over the previous years is as follows:

Table 3.8: Numbers and percentages of citation occurrences from section "Engineering, Computing & Technology" in recognised journals in selected countries in 2000, based on the WEB of SCIENCE analysis

Country	Numbers and percentages of citation occurrences from section "Engineering, Computing & Technology" in recognised journals in selected countries in 2000		
	Total number of citations under review in all areas	Number of unique citation occurrences in section "Engineering, Computing & Technology"	Percentage value
The Czech Republic	500	57	11,4
Finland	500	37	7,4
Japan	500	77	15,4
Germany	500	102	20,4
Slovakia	500	53	10,6
USA	500	102	20,4

Source: Authors on the basis of ISI data

Chart 3.1: Percentages of citation occurrences from section "Engineering, Computing & Technology" in recognised journals in selected countries (2000)



Source: Authors on the basis of ISI data

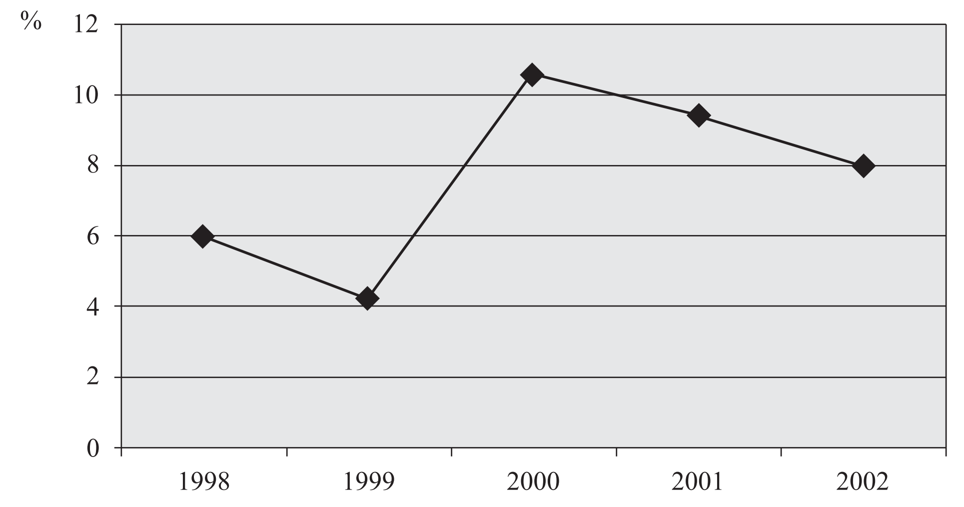
The occurrence of citations from Slovakia over past five year is shown in the following table and chart.

Table 3.9: Numbers and percentages of citation occurrences from section "Engineering, Computing & Technology" in recognised journals in selected countries in 2000, based on the WEB of SCIENCE analysis

Year	Numbers and percentages of citation occurrences from section "Engineering, Computing & Technology" in recognised journals by Slovak authors in 1998 - 2002		
	Total number of citations under review in all areas	Number of unique citation occurrences in the area of technical sciences	Percentage value
1998	500	30	6
1999	500	21	4,2
2000	500	53	10,6
2001	500	47	9,4
2002	500	40	8

Source: authors on the basis of ISI data

Chart 3.2: Percentages of citation occurrences from section "Engineering, Computing & Technology" in recognised journals by Slovak authors in 1998 - 2002, based on the WEB of SCIENCE analysis



Source: Authors on the basis of ISI data

Achievements in technical sciences should also consist in good technical solutions, projects, and particularly innovation.

At present, great attention is being paid to supporting research in technical sciences, especially in economically strong countries. In these countries, research is often accelerating thanks to support by manufacturing enterprises and service establishments, with an increasing share of funding from these sources.

It is just this kind of support that is lacking in technological development and innovations in our country, especially because our industry is not sufficiently oriented towards innovations. Rather, it is "hired labour" that is dominating today. It cannot, however, provide for long-term socio-economic growth. Such a mode of production is making use of the instant advantage of Slovakia's cheap labour force and still moderate costs of energy or tenancy. After the costs of labour, energy, tenancy, and land no longer present a comparative advantage for investors, they will move production to where the comparative advantage will still exist - to the world's poorer economies.

This kind of research will be flourishing at technical universities in particular, which may bring opportunities of revival. At the same time, it is necessary to create conditions for transfer of knowledge and technologies by means of establishing **incubators for emerging innovative firms and technological zones**. From the viewpoint of both education and science, debates on **"innovative universities"** are gaining ground in the world, which are universities that get accustomed to the above-mentioned trends.

Technological zones, incubators for emerging innovative firms, and spin-offs create conditions for efficient and quality transfer of knowledge from universities to the business environment. This provides support for quality development of universities, but especially new, highly important stimuli to the development of the economy. **The issues of outputs from science and research activity and their more efficient utilisation are closely related to their rapid transfer to the business environment, where such outputs can be materialised.** We know from experience that this transfer is not working properly in our conditions. It is rather foreign firms that take concern in application of new knowledge, not local ones, despite it is a basis for their further growth. A successful model of transferring technologies, which is, by the way, one of the priorities for the growth of universities in developed countries, is based on establishing technological zones. **Technological zones, built in cities with significant potential for education and science, provide guaranties for a rapid development of the city, region, and state, positively affecting not only employment, but also the development of universities themselves.** One of the important functions of a technological zone is founding **business incubators with the aim of supporting job creation**. This function has been in recent years receiving a lot of support by the European Commission, which has stressed on several occasions the importance of research for technological development and job creation. Those involved in founding technological zones have to face obstacles resulting from insufficient legislation in this area.

In technical sciences, we have inherited very poor equipment and only little has changed over the past decade. Often, the situation is often even worse than before. The EU-based funding does not provide for the infrastructure, which we have to build on our own. Neither do we seek to solve the deficit in human resources, young people in particular, in science, research, and education. This makes a very bad starting position for Slovakia in a competitive environment of the emerging European research and education area.

The function of publicly supported research in the future economic and social development is often misunderstood and neglected. On the other hand, the experience, often that of the USA rather than the EU countries, shows that a generous funding of efficient technological research can be a source of technological opportunities as well as a catalyst of new business activities in the globalised world. The entry to the world of quality technological research is costly, yet necessary so as to be able to endure in complex processes, in which it is just high technologies that significantly contribute to successful socio-economic development of society.

Priority trends in technical research for the coming years

The following areas will attract particular attention in technical research in the coming years:

- **Development of digital global communication**
  - man - machine communication
  - communication mobility
  - transfer and control of data streams, their secure processing and storage
- **Solutions to new production and corporate structures**
  - reality and virtual reality
  - development of services
  - administration of the future
- **New production tools and operating procedures**
  - laser - a universal working instrument
  - rapid prototyping
  - new oversight procedures
- **Adaptable and recyclable materials**
  - adaptive materials
  - integrated variability
  - polymers with new and outstanding properties
  - surface treatment
  - high-performance ceramics
- **Intelligent systems - networked systems - micro-system technology and data networks**
  - products for the mobility of the immobile
  - robots as providers of services
- **Health - medicine and technology**
  - medicine via the Internet
  - genic technology
  - medical biotechnologies as the driving force behind pharmaceutical research
- **Sustainable growth and energy**
  - innovations and ecology
  - chipless working
  - the use of solar energy
  - intelligent buildings
  - climatic changes - recommendations for the economy, society, and policy needed

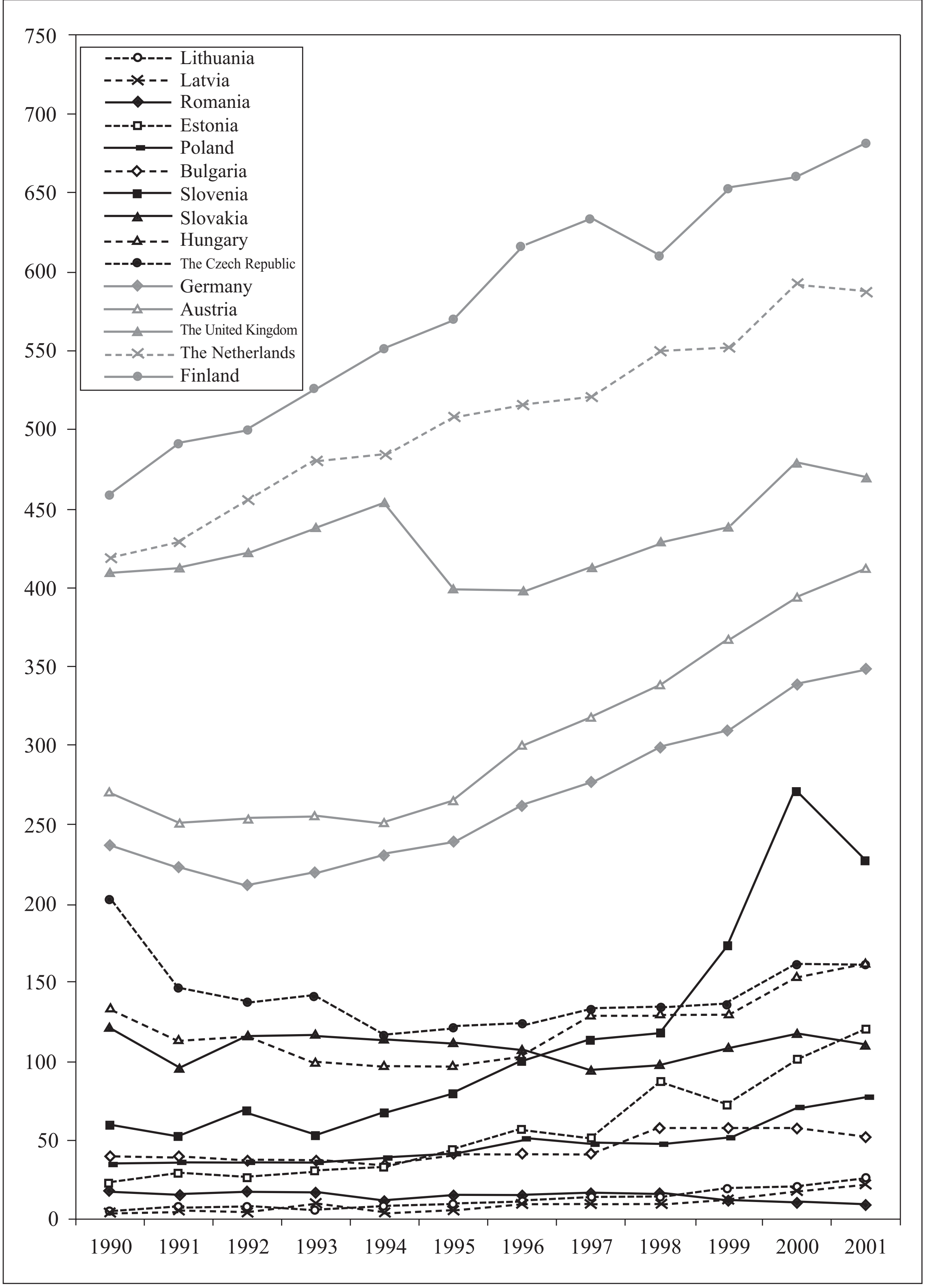
Slovakia has very good conditions for many of the above research areas, particularly as far as human resources are concerned. This fact is not to be wasted, as it is a principal condition for its successful development in the future, even after Slovakia's accession to the European Union.

3.3. Medical and pharmaceutical sciences

A vision of development of medical sciences in Slovakia has to be clearly formulated and measures proposed to make them more efficient on the basis of an analysis of the present state of their creative potential. The rate and trends of scientific productivity can be measured by means of scientiometrics. The information about the rate and trends of productivity in national medical sciences is based on data obtained from the PubMed database. This database is maintained by the US National Medical Library and provides access to more than 11 million citations in reviewed journals since 1960. The bibliometric analysis has been carried out as follows: we entered the names of particular states or cities, which had been in advance identified as centres of medical research, under the affiliation item in the search window for individual years and a sum of several years, and this search yielded results indicating the number of database entries for a particular state and period of time.

Charts 3.3 and 3.4 show the number of PubMed entries for individual years, normalised on the basis of the population of each country under review, besides Slovakia. Taking account of all the limitations of such an assessment (see Chapter 1), the bibliometric data obtained in this way are a relatively reliable indicator of scientific production in the particular branch of science over a specific period of time. Slovakia is being compared with the other candidate countries (NAS - Newly Associated States) and selected EU member countries. Chart 3.3, which contains summary information about the productivity of medical sciences over past 11 years, shows that all the candidate countries including Slovakia have been significantly lagging behind the group of the selected EU member countries. What is more, the latter group also shows a permanently upward trend and also proves the fact that scientific performance is indirectly proportional to the population of the countries in question. This phenomenon can be clearly noticed when comparing, for example, Germany with Finland, the Netherlands, or other smaller EU states. It is also apparent in the case of Poland compared to the other candidate countries.

Charts 3.3: The number of the PubMed database entries for individual years, normalised per one million inhabitants

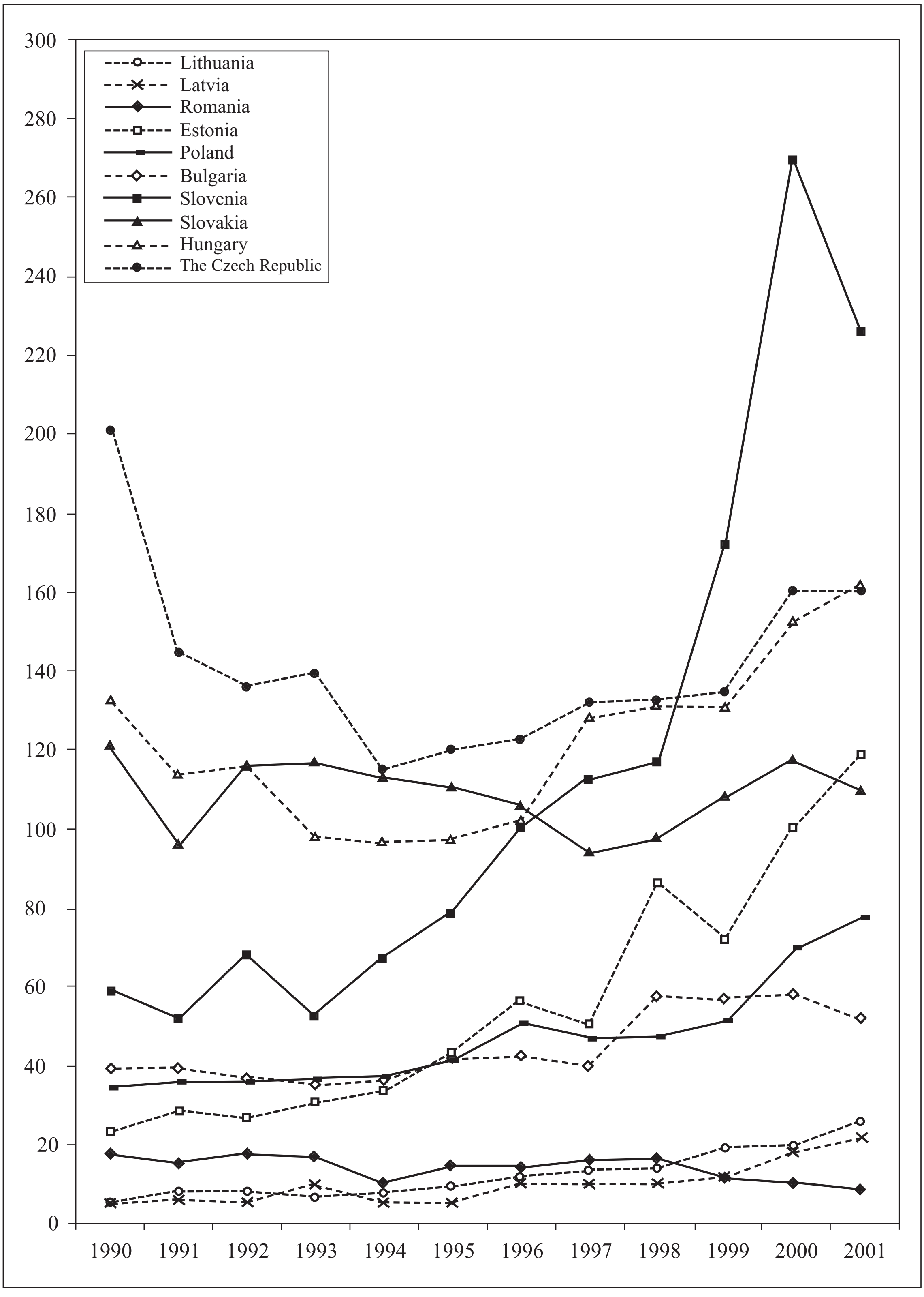


Source: Authors on the basis of PubMed data

Chart 3.4 shows the same data as are found in Chart 3.3, but providing more details about the candidate countries.

- When analysing the chart, we will first focus on general trends. Slovenia, Poland, the Czech Republic, Hungary, and Estonia show an upward trend in the number of published scientific works. Unlike these countries, Slovakia's production is stagnating and should this trend of recent years prevail in the future, we would be soon outrun even by Poland, considering data normalised per one million inhabitants, in spite of its large population.
- As for the absolute values for the last two closed years - 1999 and 2000 (the PubMed database for 2001 was not fully closed at the time of processing these results), the chart clearly shows that Slovakia is significantly lagging not only behind Slovenia, but also Hungary and the Czech Republic. It is just a question of time when we are outrun by Estonia and Poland. Slovakia still ranks better than the two Baltic states - Latvia and Lithuania and the two Balkan states - Rumania and Bulgaria.

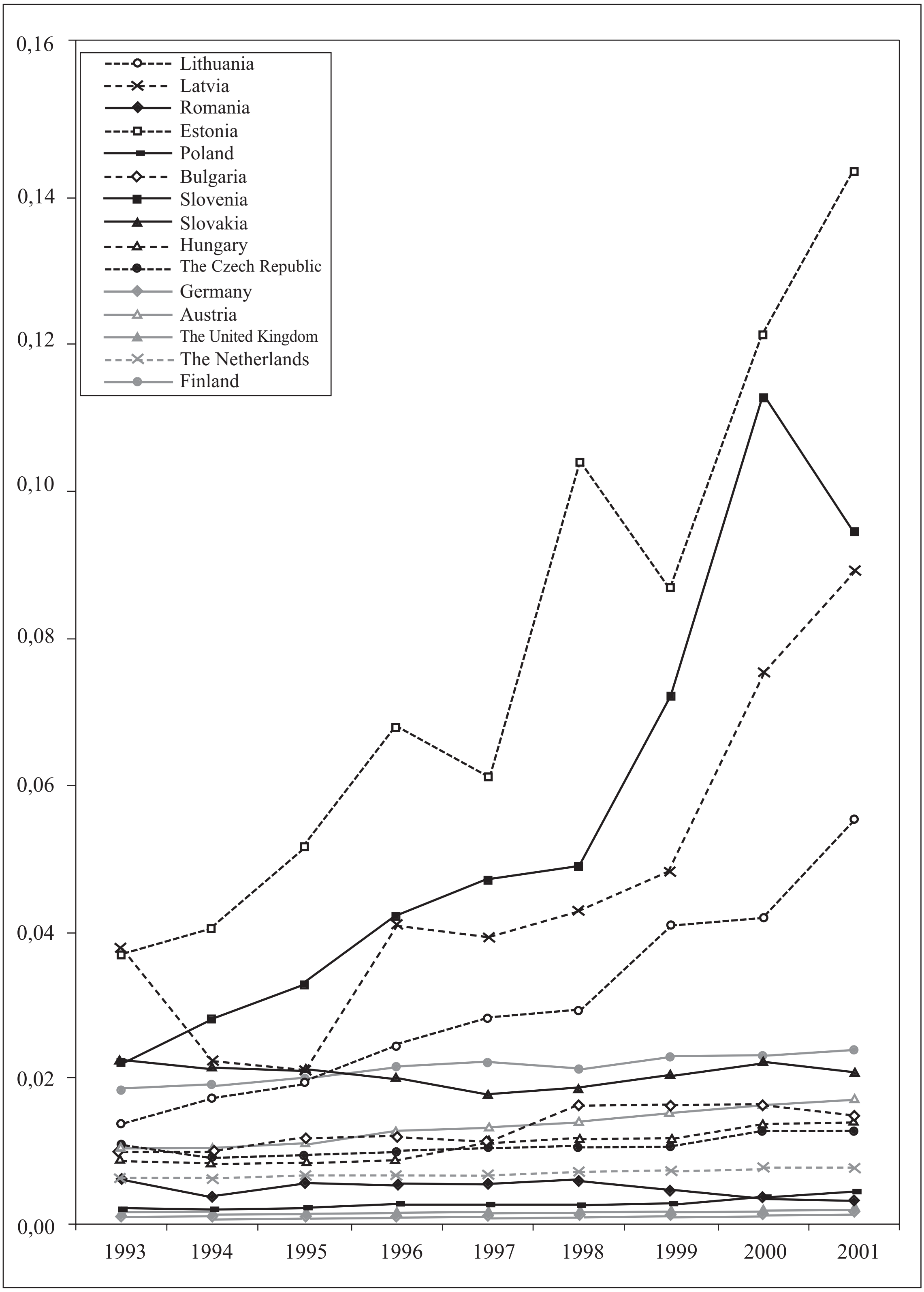
Charts 3.4: The number of the PubMed database entries for individual years, normalised per 1 million inhabitants. Details about selected candidate countries.



Source: authors on the basis of the PubMed data

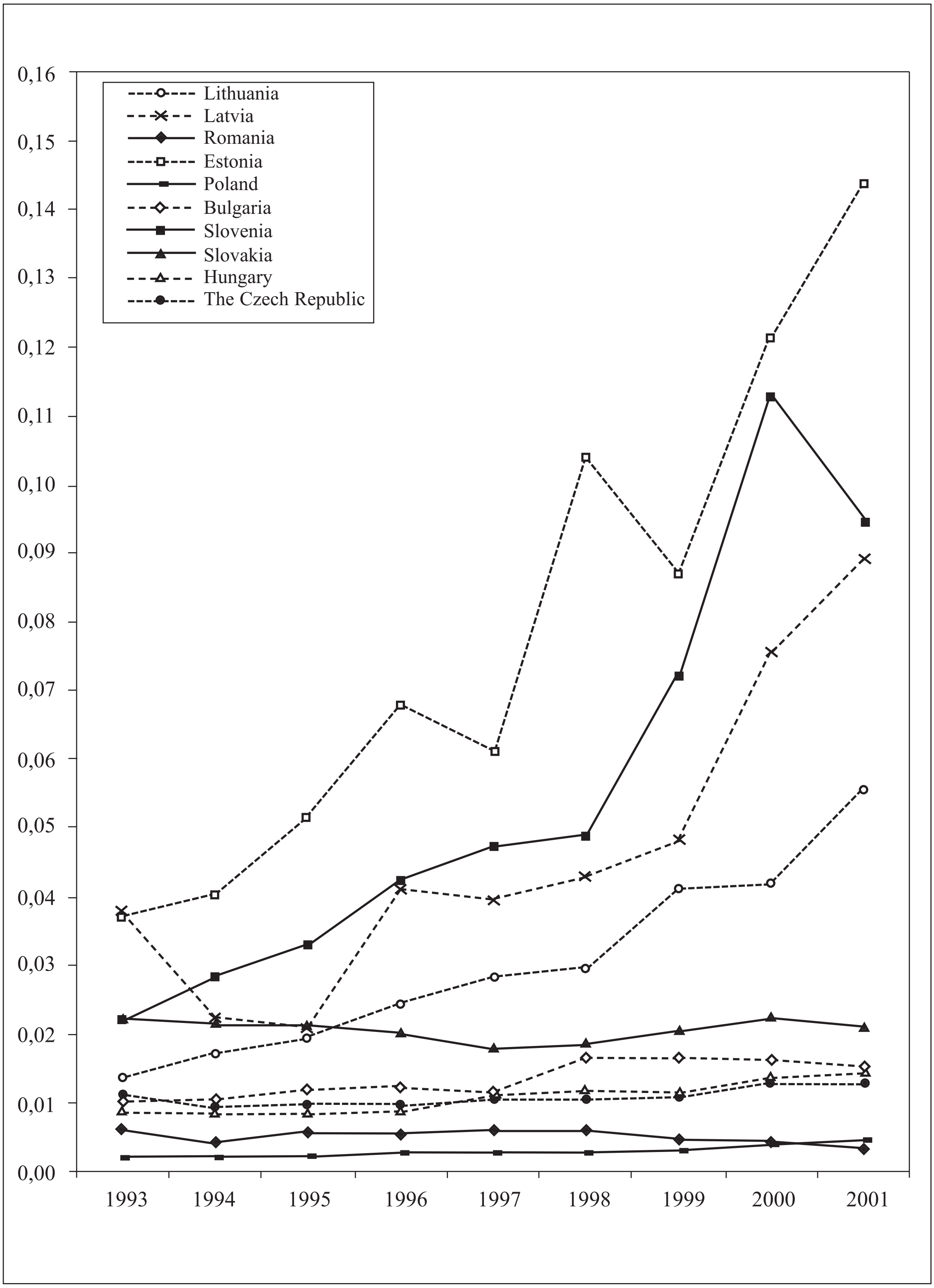
Charts 3.5 and 3.6 have been plotted so as to express the data that is normalised not only per population, but also per the total number of entries over the period 1993 - 2001. Such presentation of results provides even clearer information about trends over time than the previous charts; it does not say anything about the scope of production, though. Chart 3.5 in fact shows that there is only a slightly upward trend in the production of medical sciences in the developed EU member countries under review. The detailed record of newly associated countries (Chart 3.6) illustrates a sharply upward trend for recently emerging countries such as Slovenia, Estonia, Lithuania, and Latvia, but a significant decrease for Rumania and Slovakia.

Charts 3.5: The number of the PubMed database entries for individual years, normalised per 1 million inhabitants and per number of records in 1993 - 2001



Source: authors on the basis of the PubMed data

Charts 3.6: The number of the PubMed database entries for individual years, normalised per 1 million inhabitants and per number of records in 1993 - 2001 Details about selected candidate countries.



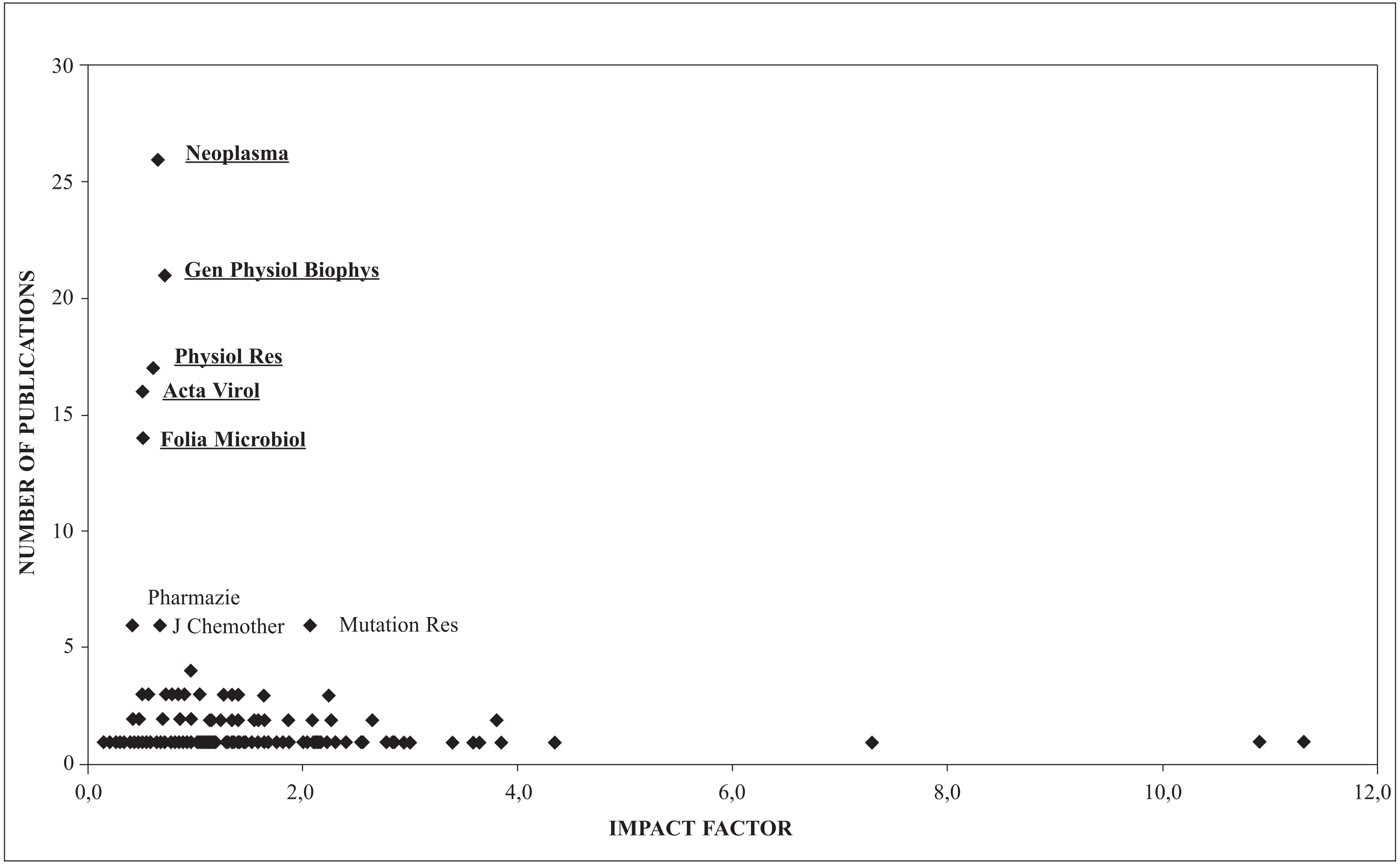
Source: authors on the basis of the PubMed data

The figures indicating poor performance of the Slovak medical research in comparison with the other candidate countries are not sporadic in broader context either. Participation in EU framework programmes is regarded by the candidate countries as a matter of prestige. Based on the statistical indicators showing Slovakia's achievements in the Fifth RTD Framework Programme published by the Slovak Mission at the EC in 2000, it is apparent that Slovakia was outdone by a number of candidate countries in all indicators in question (the number of submitted projects, number of successful projects normalised per population, and the rate of success as the successful to submitted projects ratio), which corresponds to the above data about medical sciences.

The status from the viewpoint of the quality of journals publishing Slovak contributions

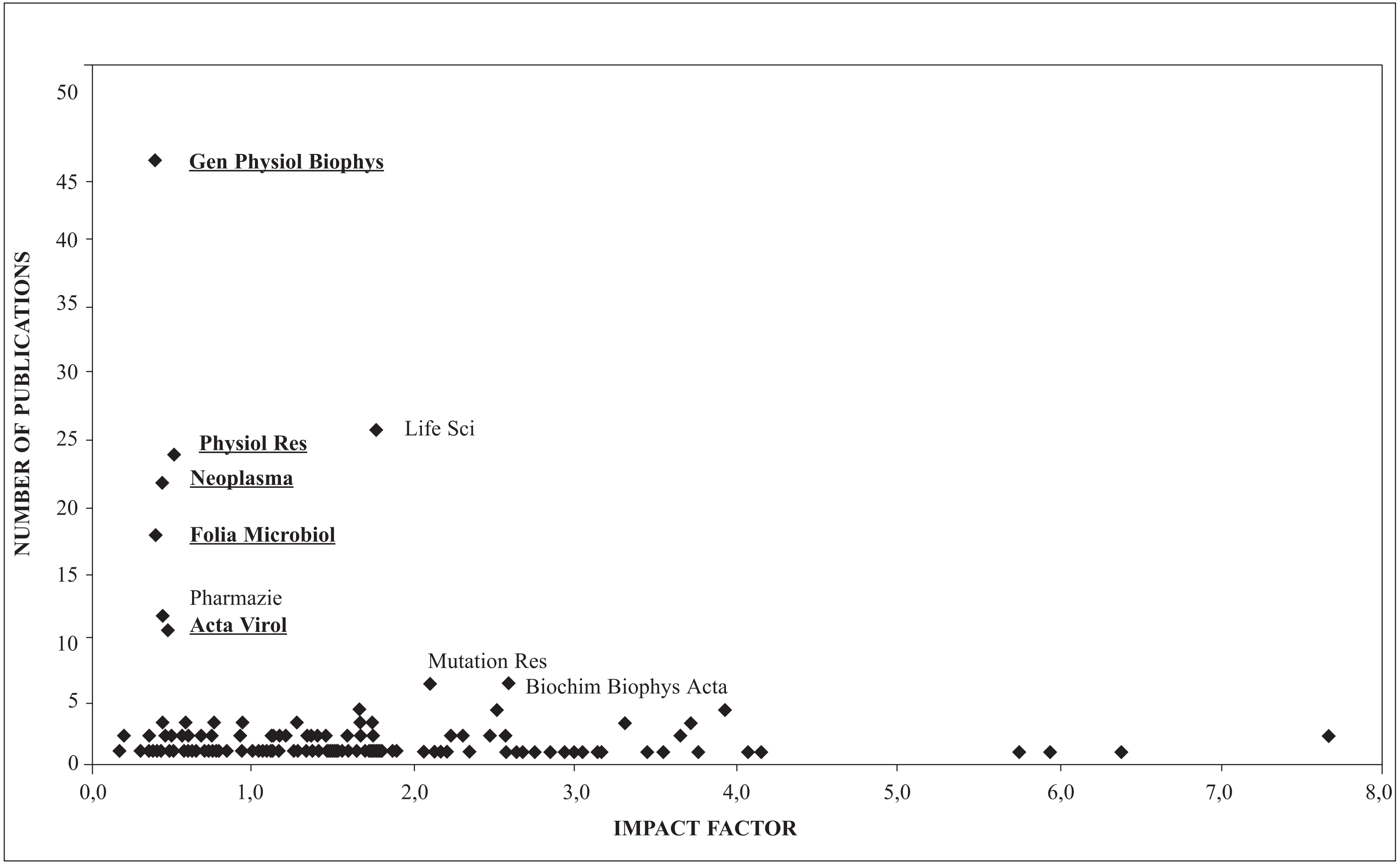
We have also analysed scientific journals in which Slovak authors publish, separately considering journals listed in the Current Contents and those not listed there. The Current Contents are published by a commercial organisation, the Institute for Scientific Information (ISI), whose decisions on including/excluding a particular journal into/from the CC are directed by their policies, which take account of commercial goals of the ISI as well as the quality of journals (for more information, see Trnovec, T., Zahumenská, Ľ., Wimmerová, S., Porubská, Z.: How to evaluate medical science in Slovakia and its producers? Med. Monitor, 2001, Issue 3, pp. 24-29, or Chapter 1 in this Report. Charts 3.7 - 3.9 inform in which CC-listed journals and how many times Slovak authors published over the period 1998 - 2000 and what was the impact factor (see Chapter 1) of these journals in a specific year. It is observable that Slovak scientists favour publishing in Slovak or Czech "recognised" journals (those listed in the Current Contents). In the following charts, the titles of these journals are printed in bold and underlined. The charts also indicate that these journals closely related to us typically show lower impact factors. The occurrence of publications in foreign recognised journals is much lower.

Chart 3.7: The impact factors of the CC-listed journals in which Slovak scientists published and were included in the PubMed database for 1998. Slovak and Czech journals are marked in bold and underlined.



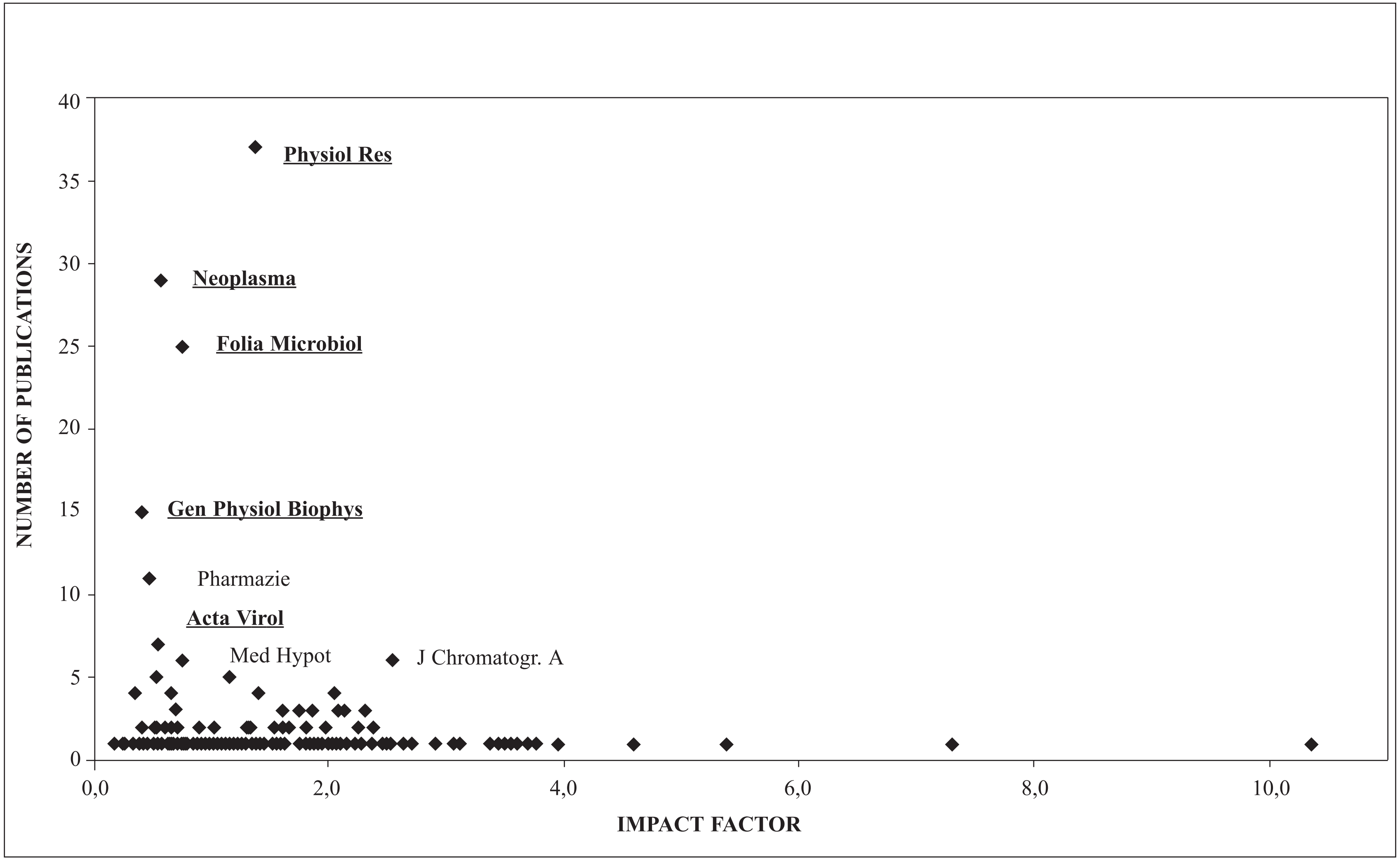
Source: authors on the basis of ISI and PubMed data

Chart 3.8: The impact factors of the CC-listed journals in which Slovak scientists published and were included in the PubMed database for 1999. Slovak and Czech journals are marked in bold and underlined.



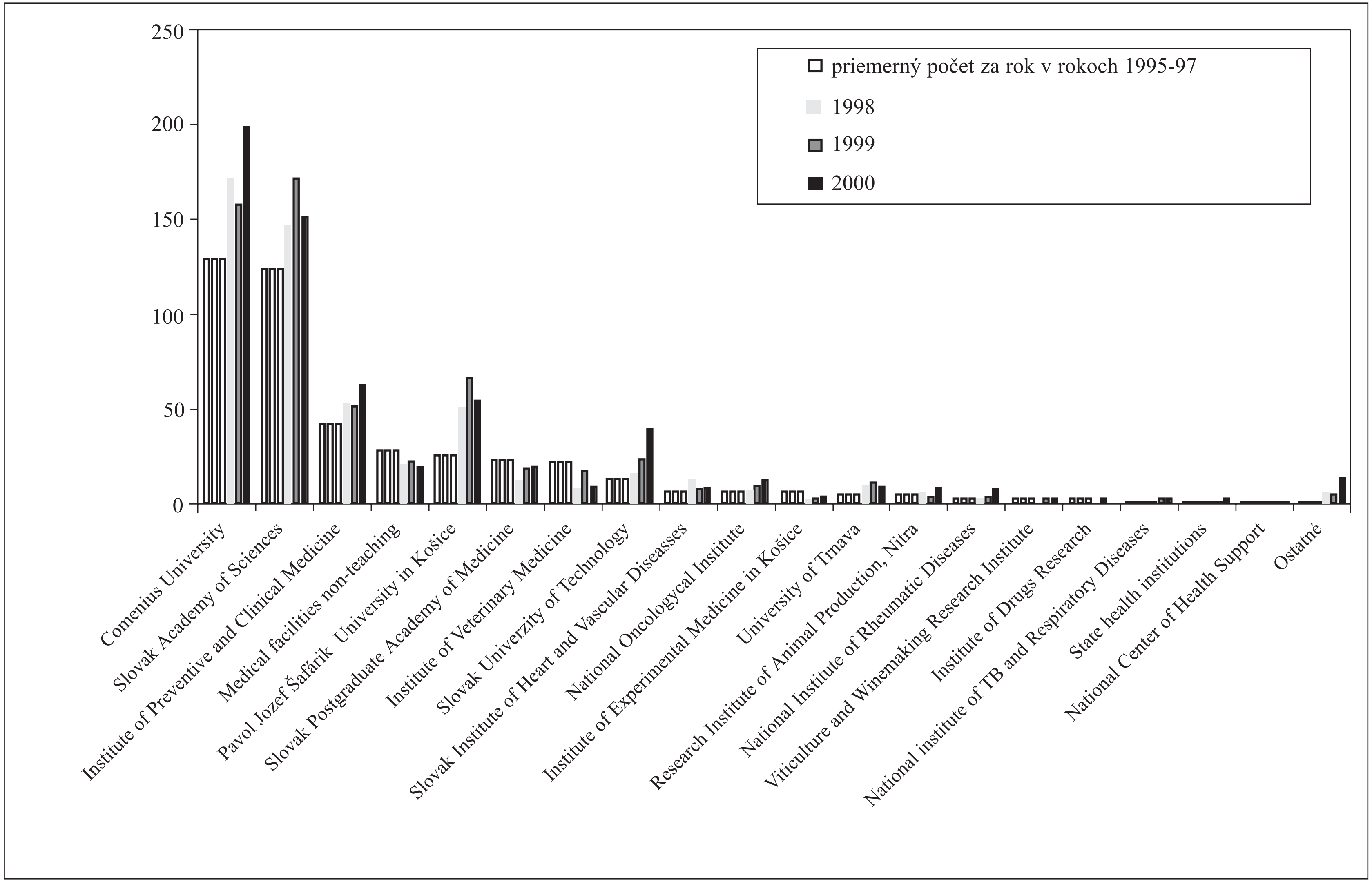
Source: authors on the basis of ISI and PubMed data

Chart 3.9: The impact factors of the CC-listed journals in which Slovak scientists published and were included in the PubMed database for 2000. Slovak and Czech journals are marked in bold and underlined.



Source: authors on the basis of ISI and PubMed data

Chart 3.10: Absolute numbers of publications from the PubMed database by Slovak institutions



Source: authors on the basis of the PubMed data

According to affiliations shown for individual Slovak entries in the PubMed database, we have assessed the participation of individual institutions in the overall production over 1995 - 2000. Chart 3.10 shows that the greatest number of such PubMed entries come from Comenius University and the Slovak Academy of Sciences. These are followed by the Institute of Preventive and Clinical Medicine based in Bratislava and the P.J. Šafárik University based in Prešov. All institutions that annually contributed by at least publications were included in the chart. Institutions that did not reach this limit were classified as "others".

Also, it is very interesting to observe the share of non-CC-listed journals, in which Slovak authors published, and their language. As shown by Table 3.10, scientific works are preferably published in a journal called *Bratislavské lekárske listy* (Bratislava

Table 3.10: The frequency of Slovak publications in non-CC-listed journals over 1998 - 2000 (journals in which 2 or more works were published in at least one of the given years have been taken into consideration)

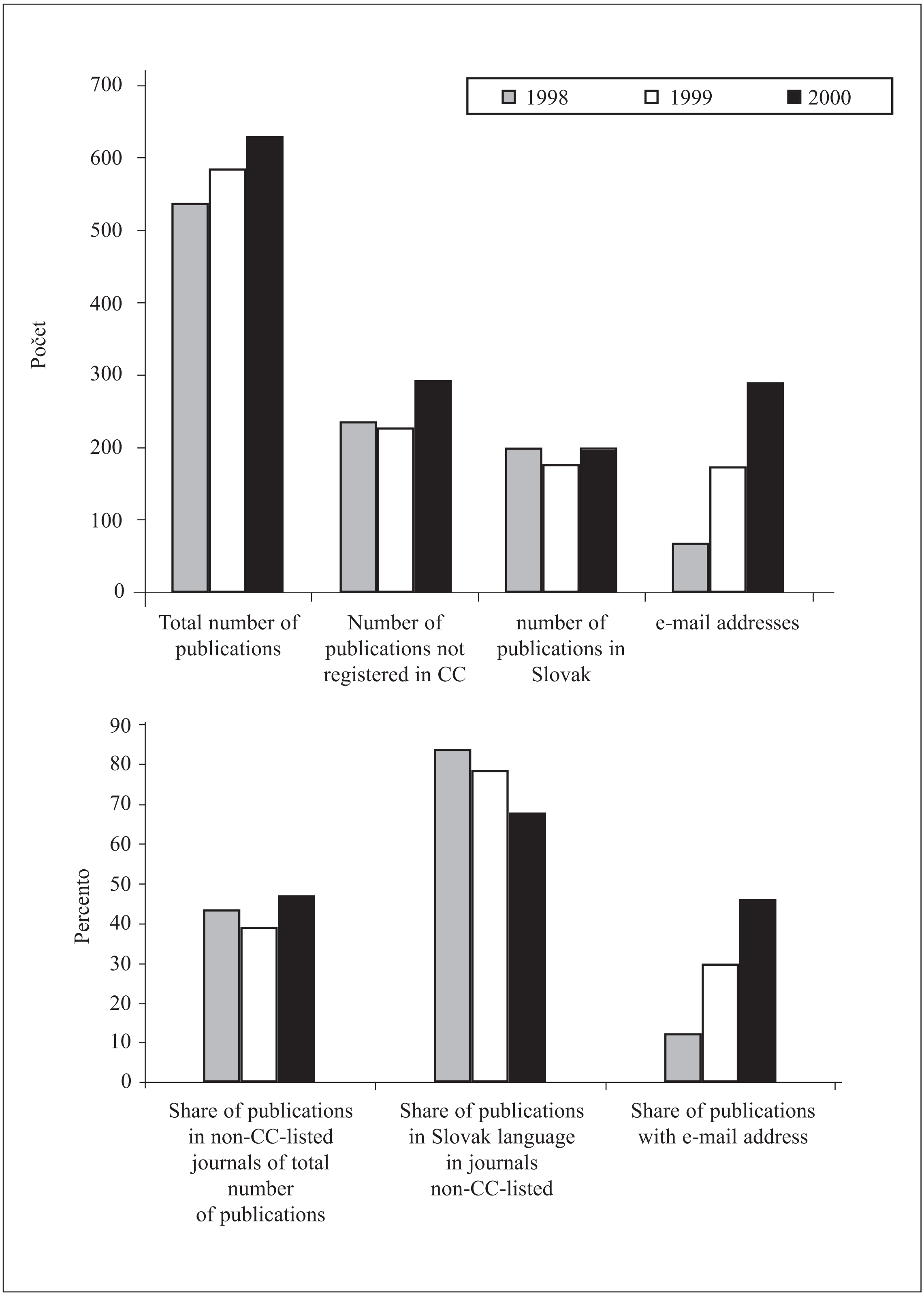
Journal title	Years		
	2000	1999	1998
Bratisl Lek Listy	119	90	108
Rozhl Chir	28	24	15
Ceska Slov Farm	24	13	8
Vnitr Lek	15	20	27
Cesk Slov Oftalmol	13	11	18
Cent Eur J Public Health	12	3	4
Cesk Patol	10	7	1
Endocr Regul	9	7	4
Cas Lek Cesk	6	10	3
Epidemiol Mikrobiol Imunol	5	8	7
Biochim Biophys Acta	5	-	3
Sb Lek	4	-	5
Electrophoresis	4	-	-
Ceska Gynekol	2	5	5
Cesk Fysiol	2	3	3
Acta Univ Palacki Olomuc Fac Med	2	-	-
Bioelectrochemistry	2	-	-
Eur J Intern Med	2	-	-
J Manag Med	2	-	-
J Infect Chemother	1	5	-
Acta Chir Plast	1	1	2
Acta Pol Pharm	1	-	3
Biofactors	-	2	-
Bull Environ Contam Toxicol	-	1	3
Arch Tierernahr	-	1	2
J Health Adm Educ	-	-	3
MAGMA	-	-	2

Source: Authors on the basis of PubMed data

Medical Letters) and in the Slovak language. A question therefore arises to whom such scientific works are addressed and how they can contribute to the internationalisation of Slovak medical science.

The language of publications allows identifying addressees for whom a published work is intended. Globalisation and internationalisation, which are movements in which the Slovak science has to be increasingly engaged, require publishing in one of the world's most widely used languages, particularly in English. Chart 3.11 clearly proves that the Slovak medical science does not respond to the need of internationalisation. It is also illustrated by the fact that a percentage of PubMed-listed Slovak works published in the Slovak language during 1998 - 2000 was still very high and did not change in fact. What is positive is only an increasing percentage of affiliated Internet addresses. This analysis confirms our previous findings that as many as two thirds of works produced by professors and doctors at our three faculties of medicine in 1966 - 1998 were published in the Slovak language. This figure was 25% for departments of the Slovak Academy of Sciences and 42% for departmental institutes of the Ministry of Health.

Chart 3.11: Data on publishing Slovak scientific works in worldwide-spoken languages, based on the PubMed database



Source: Authors on the basis of PubMed data

A vision on the future of Slovak medical sciences from the perspective of bibliometric analysis

As far as medical research is concerned, Slovakia is presently standing at the crossroads. It can either follow:

- the way of the EU members such as Finland, the Netherlands, Austria, or Ireland and countries aspiring after membership of the European union such as Slovenia or Estonia, and V4 members such as the Czech Republic and Hungary, and other countries that yield provably better results in the development of science than Slovakia
- or the way of many other countries with GDP comparable to Slovakia's, still little productive in medical sciences, or the way of two Balkan states, Rumania and Bulgaria, which are seeking the EU membership, but their GDP is lower than that of Slovakia and there is a stagnating or even downward trend in the development of medical sciences in these countries.

In this respect, it must be stressed that the decision on the future course of the Slovak medical science is not in the hands of scientific community, but rather respective policy makers.

Financing of medical science under the Ministry of Health of the Slovak Republic

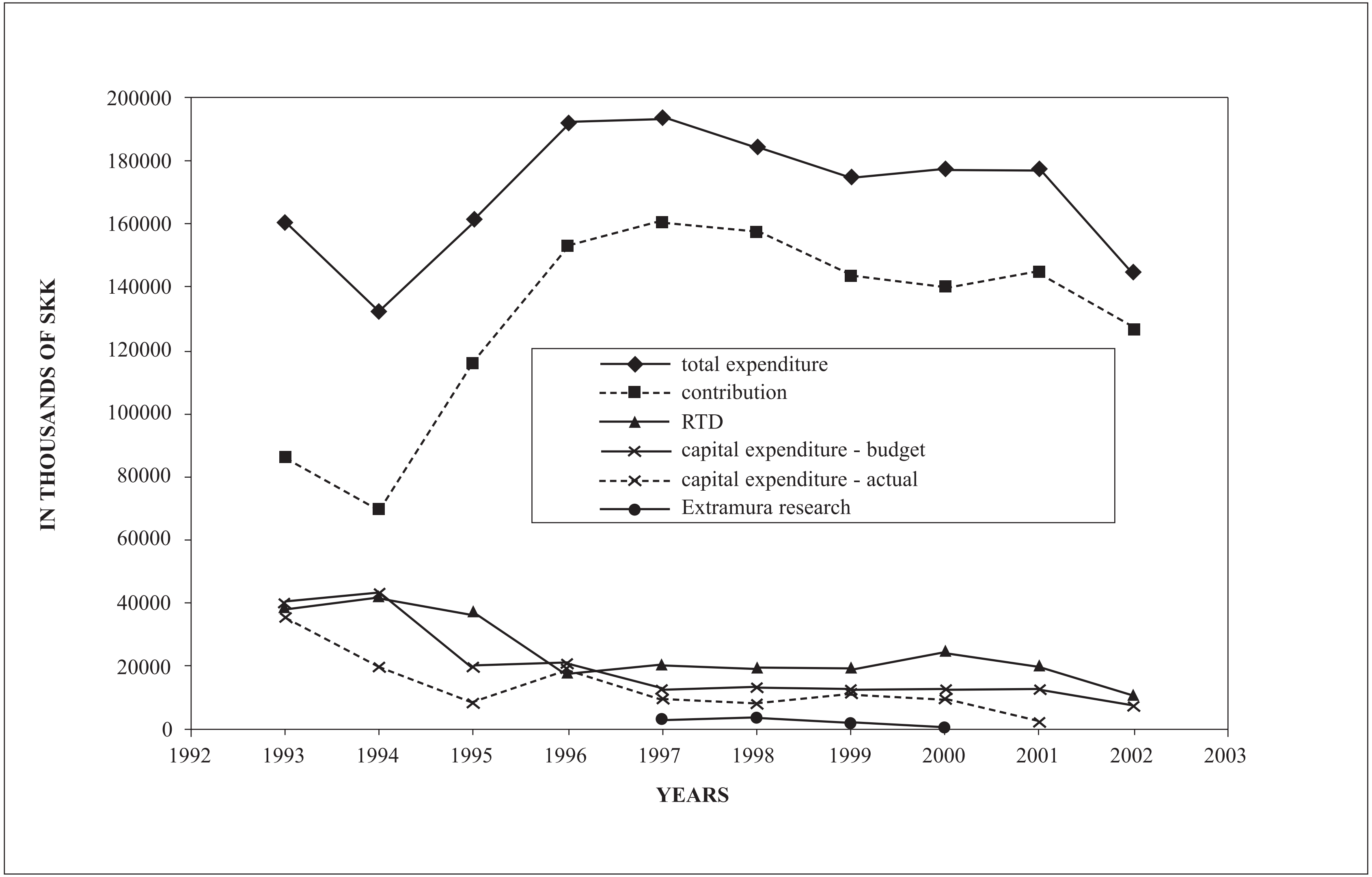
Chart 3.12 illustrates the financing of science under the Ministry of Heath in the given years. As shown in the chart, the budget distinguishes three types of resources:

- subsidies
- government contracts and RTD tasks approved by the government
- capital expenditure

The chart shows a sharp decrease in expenditure on medical science under the Ministry of Health over past years and extrapolation can prove that if the present trend should persist, the support for departmental medical research would cease in 2005, which is the anticipated time of Slovakia's accession to the EU.

The chart also shows the data on a so-called extramural research at the Institute of Preventive and Clinical Medicine (IPCM), which was directed by the Medical Sciences Board of the Ministry of Health. The Extramural research (IPCM) was terminated in 2000 due to lacking support by the Ministry of Health.

Chart 3.12: Financing of science in the Ministry of Health budget



Source: Authors

In the context of the extramural research, some commentary is needed to explain the financing of government contracts and RTD tasks approved by the government. During the existence of "IPMC extramural research", a total of 9 million SKK were allocated for at least 50 quality scientific projects solved by research institutions from different regions of Slovakia, whereas 83.77 million SKK were allocated to only 7 privileged institutions for as few as 16 projects during the same period through government contracts and RTD tasks approved by the government. During 1993 - 2000, this amounted to 241.29 million SKK, and this model of distribution of funds was used until 2001. From the point of view of developed democracies, such mechanisms for distribution of funds and assessment of scientific gains from thus allocated funds were at least non-standard. It is necessary that research institutions, responsible for government contracts and RTD tasks that fall under the Ministry of Health and were subsided by nearly a quarter of billion SKK, should submit publicly available reports, statements of expended funds, and detailed information on where they published their original results and where they filed patents for them, how many times their works were cited, in which areas they were applied, and what was their gain for our health care system.

The procedure described above, with regard to current or capital expenditure, is not used in the European Commission, EU countries, or states with developed science, as administrative workers of respective bodies (equivalent to our ministries) act as the coordinators of administrative agenda or as the trustees of funds, but responsibility for deciding on their use is solely in the hands of expert boards made up of prominent domestic and foreign specialists (peer reviews). Non-compliance with the above principles has significantly contributed to the low performance of Slovak medical science, as shown in sections 2.1 and 2.2.

Several parameters are assessed as far as the financing of medical sciences in comparison with support for other branches of science is concerned. The most important ones are as follows:

- Health related % GBAORD (Government Budget Appropriation or Outlays on Research and Development)
- Health related % GERD (Gross Domestic Expenditure on Research and Development)
- Health related % BERD (Expenditure on Research and Development in the Business Enterprise Sector) and
- Health related % BERD in the Pharmaceutical Industry
- All of them can be expressed as a percentage of GDP as well.

The above-mentioned OECD study states that international comparison of these parameters is rather uncertain as their value differ considerably, which is often due to inconsistent reporting methodologies. These parameters for several OECD countries are approximately within the following bounds:

- Health related % GBAORD: 1-19% (0.01-0.16 % GDP)
- Health related % GERD: 12-24% (0.2-0.4 % GDP)
- Health related % BERD: 5-20% (0.03-0.28 % GDP)
- Health related % BERD in the Pharmaceutical Industry: 2-43% (0-0.40 % GDP)

It would be interesting to determine the position of Slovakia within these bounds. If Slovakia's GBAORD can be estimated as 3.3 billion SKK per annum, GERD about twice that amount, and total government budget expenditure on medical science as a sum of 0.14 billion SKK per annum (the Ministry of Health) plus 0.14 billion SKK (SAS institutes), then Health related % GBAORD will be approximately 0.28x100/ 3.3 = 8.5 % and Health related % GERD 0.28x100/6.6 = 4.2 %. This estimation has not taken account of financing research at Pharmaceutical Research Institute based in Modra. Although rather uncertain, the estimation concerning the above parameters in case of Slovakia shows that our country is situated near or below the lower bounds of these intervals for the other OECD countries.

3.4. Agricultural sciences

The focus of agricultural sciences is determined by the need to more efficiently utilise and protect natural resources of Slovakia, land, water, forest ecosystems, and productive biological materials, while respecting environmental requirements at the same time. It is necessary to constantly monitor and analyse the productive potential of the Slovak territory and anticipated changes in terms of needs and real possibilities of its economic utilisation and social and environmental functions. This poses qualitatively new requirements on production systems and technological procedures in the whole food-processing chain as well as in the production of biological, technological, and energy raw materials, for which our science and research have to create solutions tailored to the concrete conditions of Slovakia and, at the same time, using worldwide knowledge. The present task is to transform technology so as to use economical non-renewable energy and material inputs, thus gradually increasing the share of renewable sources produced by the agriculture sector itself. An important task for research and development is to respond in advance to the possible impacts of global and local climate changes.

This goal requires that research and development in the agriculture sector focus on the following priorities:

- to create a productive, efficient, stable, market-flexible, and competitive agricultural sector that would provide for food security, healthy nutrition, required production of biological raw materials and environmental tolerance while rationally making use of natural conditions and inputs
- to provide for rational utilisation and protection of land with sustaining its productive and other functions
- to deepen and increase the efficiency of protecting population from consuming lower quality, potentially hazardous foods with health-related risks, in compliance with the latest European legislation proposals concerning foodstuffs
- to more rationally use forest ecosystems, improve their protection, and enhance their social, landscape and water-related functions
- to improve protection and functioning of Slovakia's hydrosphere, supplying of drinking water to the population, sewerage and purification of sewage water in compliance with the European Union, and protection of the territory against harmful effects of water

- to eliminate the adverse impacts of anticipated local and global changes in climate and extreme climatic phenomena upon water systems, productive potential of soils, agricultural crops, forest ecosystems
- to create a knowledge base aimed at improving the protection and creation of ecological and aesthetical quality of the Slovak land, and conditions for the development and stabilisation of rural settlements and their economic, social, and societal functions
- to create economic and legislative conditions for transformation of the Slovak agriculture sector into an equipollent and acceptable counterpart to these sectors in developed countries of the European Community, while retaining its regional individuality

There has recently been a growing criticism of the present intense agriculture, partly due to environmental concerns, but mostly resulting from too great an extent of chemical, particularly petroleum-based, products serving as agricultural inputs, i.e. those made of non-renewable sources. For example, American authors claim that as much as 60 % of the costs of production of food and nutritive materials are the costs of petroleum-based inputs.

New trends in agricultural science and research are particularly based on the following functions this sector should fulfil:

- increasing production of non-food raw materials for technological and energy use, full utilisation of available land, for example by means of developing processing industries on the basis of the above raw materials
- developing agricultural production in order to use reproduced and reproducible sources of agriculture itself
- generating knowledge necessary for a sustainable development of productive, environment-friendly, and landscape-developing forms of agriculture
- the above changes should eliminate economic isolation of agriculture due to concentrated producers and suppliers of inputs to this industry, thus resulting in higher socio-economic independence of agriculture.

Development in agricultural sciences in Slovakia

Until 1948, there had been no institutions in Slovakia that would have systematically dealt with agricultural research on a professional basis. Only some organisations focusing on inspection and testing activities were in operation, in which some research was carried out mostly on an individual basis or as a hobby. After 1948, a complex scientific and developmental base was established including materials, equipment, and human resources in the areas of soil science, animal and vegetal husbandry, veterinary medicine, food-processing, agricultural mechanisation and technology, agricultural economy, forestry, water management, and agricultural informatics (21 research organisations altogether). Several disciplines could measure up to the international level and some of its scientific personages were highly esteemed in other developed countries.

An advantage was that 4 to 5-year research programmes and tasks with secured funding were used, which is highly important for agricultural research due to the length of production and reproduction cycles. The departmental RTD (research and technical development) base benefited from the fact that several scientific workers came to work there after they were expelled from universities or otherwise discriminated after the year 1968.

However, the development of institutions was often extensive, isolation from the most developed countries had adverse effects resulting in delayed raising of current research problems, there was no system for assessment of scientific institutions, a competitive environment and freer movement of workforce (especially if working abroad was the case) were missing. The possibilities of obtaining top-class foreign equipment, instruments, and materials were also limited.

After 1990, a gradual transformation of the departmental RTD base in agriculture was taking place.

Out of the original number of 21 research organisations, 9 were transformed on a commercial basis, in that 8 became joint stock companies through privatisation. In the course of the 1990's, human resources in the departmental RTD base were reduced by 34.5% (from 3, 121 to 2,044 employees), in that the number of research workers fell by 45% (from 1,311 to 723 employees).

Despite the significant drop in human resources over the past decade, the personnel and qualifications structure of the RTD base still has a qualified scientific and engineering potential capable of solving scientific and research tasks at the cutting edge of present knowledge. The sector experienced the most significant drop in the number of employees by 1995, in which time rationalisation measures were taken in order to ensure more efficient operation of the RTD base, formerly significantly overstaffed in some sectors. After 1995, the numbers of employees were falling less sharply due to financial constraints on the funding of departmental research.

The age structure of RTD employees is becoming a serious problem. As for research workers, the category of 35 to 55 years of age is relatively sparsely represented. This is due to several factors, particularly lacking interest of young employees in research owing to low wages, which is the most frequently stated reason why even older employees leave this profession. The employees' mobility is insufficient and usually means a single-sided process of "a brain drain" with our scientists leaving for better-paid sectors or abroad.

The persistent reduction in research activity funding causes lack of motivation, where employees insist on more clearly stated goals, financial constraints limit the scope of research activities, state-of-the-art technical and technological equipment is missing, the possibilities of professional growth of researchers at their own places of work are limited, and so are study programmes abroad. Despite these problems, there are attempts - within limits - at creating proper conditions at all research institutes. Younger workers are offered possibilities of improving qualifications, mostly through doctoral courses, postgraduate studies at universities, or research fellowship programmes in domestic and, funds permitting, foreign institutions. Emphasis is being laid upon employees' language competence.

The present state of human resources in this sector is approximately at the level recommended by a foreign audit, which has taken account of various indicators compared to selected EU countries of comparable size. According to the audit, the recommended total number of employees for Slovakia is 1,550 in 11 institutes, in that 650 employees with higher education. At the end of 2001, these RTD institutes had 1,587 employees altogether, of which 645 employees with higher education qualifications. The qualifications structure of employees provides a certain picture of the level of the agricultural RTD base. At the end of 2001, there were 1,635 employees in 12 state-subsidised institutes, of which 366 with higher education. 659 employees (40%) were involved in research, in that 267 (40.5%) had scientific qualifications: DrSc. 17 (21 in the year 2000), PhD. (or CSc.) 250, and 8 professors (14 in the year 2000) and 26 associate professors at HEIs. 119 postgraduate students were involved in scientific education.

The departmental RTD base incorporates several research institutes, whose quality is comparable to similar institutions in the most developed countries of the European Union.

The Institute of Pedology and Soil Protection based in Bratislava participates in international scientific, research, expert, and organisation activities in the area of protection and utilisation of soil. It is involved in 13 international programmes and organisations as a member, coordinator, and chairman. Top-class departments at the institute deal with a soil geographical system, remote earth prospecting, and running an internationally accredited laboratory for the pollution and condition of soil. 5 excellent specialists highly esteemed even abroad work at the institute.

The Institute of Vegetal Husbandry based in Piešťany is involved in 6 international scientific projects, participates in prominent foreign and international scientific organisations, and 10 of its employees can be regarded as excellent in terms of citation of their works in foreign scientific journals. The departments of cell and molecular biology, genetic resources of crops, genetics, and cytology of cereals can be regarded as excellent as well.

The Institute of Animal Husbandry based in Nitra is involved in solving one project within the Fifth RTD Framework Programme and in seven other international scientific and research projects. Its staff are actively participating in 40 important international non-governmental organisations in the area of science and development. In 2001, they published 25 original scientific works in foreign journals listed in the Current Contents with the impact factor of 44.4. 12 scientific workers can be regarded as excellent. The departments that can be considered excellent from the point of view of international scientific cooperation are engaged in the areas of biochemistry and animal nutrition physiology, embryonic and genetic manipulations, reproductive processes, animal products quality, breeding procedures, and animals ethology used to diversify breeding systems.

The Institute of Food-Processing based in Bratislava is involved in solving five projects within the Fifth RTD Framework Programme. The Food and Agriculture Organisation is going to designate the institute as "Centre of Excellence" in the area of food databases. The department of food composition databases with its original software can be regarded as excellent as well as other departments specialising in determining the origin and authentication of foods, molecular biology, identification of unknown substance in food, and development of unique methods for processing food raw materials. The institute's employees are actively participating in a lot of international scientific and expert organisations and coordinators of internationals projects and heads of workgroups. At least 5 of its employees can be considered excellent and internationally esteemed.

The Institute of Veterinary Medicine based in Košice is a member of twelve international scientific and interest organisations, with which it is working on a basis of active cooperation. The laboratory of gnotobiology and offspring diseases and the laboratory of genic manipulations can be regarded as excellent departments within the institute. The institute is participating in important international projects. Four of its scientific workers can be deemed excellent and internationally recognised.

The Institute of Forestry based in Zvolen acts as a member, coordinator, and chairman in several international scientific, expert, and interest organisations and in the FAO. It represents Slovakia in a FAO executive body for forestry, participates in two international research projects, and acts as a national OECD arbiter for forest materials and as a national centre for forest condition monitoring. At present, it is solving twelve tasks in cooperation with foreign scientific organisations. 5 excellent specialists highly esteemed even abroad work at the institute.

In addition to the above, the following institutions work in this sector: the Institute of Economy of Agriculture and Food-Processing (economic monitoring, analyses, interpretations, forecasting, and recommendations for the field of agriculture and food-processing), the Institute of Meadows and Upland Agriculture, the Institute of Water Management, the Regional Institute of Agricultural Ecology, a branch company Hydrological Meliorations, the Institute of Viticulture and Viniculture, and the Institute for Scientific and Technical Information on Agriculture.

3.5. Social sciences and humanities

Having embarked on analysing research in the area of social sciences and humanities, we have been faced with a serious problem, which is probably less apparent in other branches of science. It is due to a combination of inner differentiation and diversity of these disciplines and difficulties in quantitative bibliometric assessment resulting from a low degree of citation and publication activity in internationally monitored journals. The assessment issues are less significant in the case of social sciences. A very high degree of inner diversity in the area of humanities (a very high number of highly diverse fields of study with an extensive research and education base) precluded a sufficiently detailed analysis of research in humanities[1], which we regard as a weak spot of this publication. As it would be unjustifiable to entirely exclude humanities from the text, we have decided after considering all the pros and cons that the common chapter devoted to both social sciences and humanities will also provide an overview of basic common characteristics of humanities.

[1] In compliance with the classification of sciences in the present Science and Technology Act, artistic sciences come under humanities.

Development until 1989 and during the 1990's

Before November 1989, development in social sciences in Slovakia was significantly differentiated. For example, political science did not exist in Slovakia and, unlike in some other post-communist countries[2], had to begin from nothing after September 1989. Coming back to the interwar period, some traces of political science ideas and activities can be found only in the deeds of individuals - Štefan Osuský, Ján Papánek, Milan Hodža - not as an autonomous scientific discipline. Initiatives to entrench political science after 1945 and in the late 1960's were rather ephemerals for well-known reasons.[3] In the like manner, we can mention absence of any real research in the area of international relations and foreign policy.

On the other hand, sociology, economics, and humanities joined the situation after the social turnabout of 1989 as formally well-established disciplines. This is particularly true in the case of economics, which was represented by a large-scale institution - College of Economics based in Bratislava. Similarly, humanities were then represented by Comenius University and P.J. Šafárik University and together with their departments within the Slovak Academy of Sciences played a quantitatively significant role. Yet, in all these cases, their existence was possible only at the cost of serious ideological and other deformations. Sociology, in the normalisation era officially referred to as "Marxist and Leninist", was a well-established scientific disciplines of several appearances. The sociological mainstream was subdued to the position set for it by the regimented society. Sociology acted as "a minion" of the normalisation regime, solved unauthentic problems, and at all costs struggled to avoid naming the actual problems of society. A similar development could be observed in economics, where only little attention was paid to real economic research and the absolute majority of education and research activities were subject to ideology or directed at issues that were not in fact what economic research normally focuses on, or only to a marginal extent. Humanities are difficult to be generalised; some branches of them were slightly less affected, but most departments were rather heavily hit by personnel reshuffles after 1968.

After the 1989 turnabout, almost all social sciences and several humanities experienced relatively rapid quantitative and to a different extent qualitative development.

The key personage of institutionalisation of political science in Slovakia was Professor Miroslav Kusý, one of a few Slovak dissidents and signatories of Charta 77, who published in samizdat even during the normalisation era. Professor Kusý became a founder and head of the first political science department - The Department of Political Science at Faculty of Arts, Comenius University, which emerged from the Department of Scientific Communism, as well as the first chairman of the Slovak Association for Political Sciences at the Slovak Academy of Sciences (both originated in 1990). The headmastership of the department was later taken over by Professor Soňa Szomolányi.

2 Professor Kusý mentions two positive exceptions besides Yugoslavia - Poland and Hungary, which retained or constituted political science in the times when the normalisation period was reaching its climax in Slovakia (Kusý 2001, p.8).

3 Students that began studying political science at Comenius University in 1966 were awarded a degree in scientific communism at the end of their studies.

Political science was being constituted as it went along, in a very "tough" political time. Specialists of other social sciences, mostly sociologists, supplemented a lack of professionally qualified political scientists. Over the twelve years of its existence, political science has, however, developed a solid institutional base. The departments of political science can be found not only at the two traditional universities - Comenius University and University of Prešov, but also at the four newly established universities - University of Trnava, Matej Bel University in Banská Bystrica, University of Constantine the Philosopher, and University of Constantine and Methodus. Since 1991, the Institute of Political Sciences (the former Political Science Cabinet at SAS) has been acting within the Slovak Academy of Sciences. This institute is dominated by historians. Non-governmental think tanks also contribute to activities of political sciences and supplement the overall institutional base of these sciences. In particular, the Institute for Public Affairs and Slovak Association for Political Sciences can be regarded as having focus on political sciences.

Conversely, science and applied research in the area of international relations and foreign policy remain rather undeveloped. Instructional activities and educational programmes are dominant in these areas. They began gradually developing after originating the independent Slovak Republic and in connection with building up a foreign policy background for the country. In autumn 1991, the Institute of International Relations and Approximation of Law was founded at Comenius University in Bratislava, which has been functioning ever since at its Faculty of Law. The institute offers a two-year postgraduate programme for prospective diplomats and experts in international relations and foreign policy. At most Slovak universities, international relations are taught at the existing departments of political science. The following important institutions specialising in political science can be mentioned here: the Department of Political Science at Faculty of Arts (FoA), Comenius University (CU); European Studies Centre, FoA, University of Constantine the Philosopher in Nitra, the Department of Political Science, FoA, University of Prešov, and the Department of Political and Social Sciences at Faculty of International Relations, University of Economics, Bratislava.

During the coalition government headed by V. Mečiar (1994 - 1998), Faculty of Political Sciences and International Relations was formed at Matej Bel University in Banská Bystrica.

In addition to university departments, the Slovak Institute of International Studies is in operation as well. It originated in the spring 1993 and, after temporary inclusion in the Ministry of Foreign Affairs, it became independent again from January 1st, 1999. In practice, its primary task is to organise workshops and lectures in cooperation with the Ministry of Foreign Affairs. In an overwhelming majority of case, its editorial and scientific activities do not go beyond publishing conference proceedings.

The Slovak Academy of Science (SAS) is also active in the area of international relations. The Political Science Cabinet of SAS is involved in a project aimed at mapping and development of Slovakia's foreign policy. Based on the work of Štefan Šebesta, a specialist at the SAS Institute of State and Law, an edition of primary documents dealing with security issues is being published.

Non-governmental organisations are also engaged in research into foreign policy and international relations. The Slovak Foreign Policy Association was established in 1993 as an open, non-partisan discussion forum on issues relating to international affairs and foreign policy of the Slovak Republic. In addition to SFPA, its Research Centre (RC SFPA) was formed in Bratislava and Prešov in 1995 and three years later, in 1998, in Banská Bystrica. SFPA Research Centre is involved in applied research directed at the four key aspect of Slovakia's foreign policy: security policy, European integration, Eastern policy, and regional cooperation. The SFPA regularly participates in international research projects. Its publications, policy recommendations, and analyses are distributed in Slovakia as well as abroad.

As far as economics is concerned, we have already mentioned that this branch of science had a relatively extensive capacity even prior to 1989, although its contents of education and research often only partially matched what standard economics was believed to contain. At present, it can be stated that in addition to the specialised, Bratislava-based University of Economics, almost every higher education institution in Slovakia has a faculty or department of economics and offers one or more economic fields of study. Considering the more broadly defined area of economic science in Slovakia, there are thousands of individuals that devoted themselves to research and education in this area.

There are two institutes operating within the Slovak Academy of Sciences that focus on economic research in particular - the Institute of Forecasting and the Institute of Slovak and World Economics. A recent output of their work is, for example, an impact study analysing Slovakia's entry into the European Union.

Like in some other social sciences, non-governmental think tanks play a highly important role in economics as well. This applies to organisations such as MESA 10, Centre for Economic Development, Institute for Economical and Social Reforms (INEKO), and Slovak Governance Institute. The two above-mentioned institutions - SFPA and IPA - are to a limited extent focused on economic research as well, even though they are primarily aimed at political science or sociology. We can speak of their above-standard function, for comparable institutions in other countries rarely produce original and quality research, as is the case in Slovakia. If we examine the number of citations in foreign journals listed in the Current Contents, very high figures have been achieved by some NGO workers.

In respect of sociology, the first fundamental change was spinning off the SAS Institute of Sociology from the joint SAS Institute of Philosophy and Sociology, with gradual reduction in its staff. The activities of sociologists and sociology diversified into various directions: into the business sector specialising in public opinion surveys, marketing, and related research (the founders, owners, statutory representatives, and leading experts of several renowned agencies, such as FOCUS, Markant, or MVK, are sociology graduates), into non-state non-governmental research and analytical organisations (such as the SPACE foundation established in 1992, or the Institute for Public Affairs where 50% of analysts are sociologists), or educational activities (Academia Istropolitana Nova), and many former sociologist were absorbed by the newly appearing political science.

At present, sociology has a solid "scientific infrastructure" and "has all institutional constituents needed for its development" (Macháček (1998), p. 413). It is chiefly represented by its basic academic institutes - the Institute of Sociology and the Institute of Social Sciences in Košice, both falling under the Slovak Academy of Sciences. Besides the Department of Sociology, FoA Comenius University, which became a guarantor of postgraduate courses in sociology in 1998, there are also other education institutions[4] offering courses in sociology.

During the 1990's, the area of humanities experienced not only consolidation of the existing institutional capacities, but also their expansion. Several higher education institutions in Slovakia have a significant share of departments specialising in humanities, such as faculties of arts at Comenius University, University of Constantine the Philosopher, University of Prešov, not to mention schools of arts (namely College of Fine Arts) that are also involved in research activities. Within the Slovak Academy of Sciences, there are more than ten departments of humanities, such as the Institute of Archaeology, the Institute of Ethnology, the Institute of Philosophy, and three departments specialising in literature studies.

Unlike in social sciences, organisations directly subordinated to the Ministry of Culture play an important role in humanities-related research. A role of particular importance is that of the Institute of Drama, which, together with Faculty of Drama and Puppetry at College of Fine Arts, represents a nearly complete scientific base in this area due to its longer history and research tradition. On the other hand, non-governmental or business organisations do not practically take interest in humanities, which may be related to shortage of funds for non-state organisation in this field.

Scientific journals

Scientific journals are a key scene where the development of research in a particular area can be examined. This applies to social sciences and humanities as well.

A scientific journal, however, remains a weak spot of political science. The fact is that a quarterly called Political Sciences has been published since 1998 at Matej Bel University, this journal, however, publishes non-reviewed contributions and has become a forum only for a part of scientific community. The works of prominent Slovak political scientists are published in journals of other branches of science, foreign journals, or periodicals that are journalistic rather than scientific.

A similar problem is apparent in the area of international relations and foreign policy, where there is no journal among specialised periodicals that would publish peer-reviewed contributions. The Slovak Institute of International Studies publishes a quarterly journal called *International Issues* that has been issued in the Slovak language since 1992. Since 2000, the Slovak Foreign Policy Association has been publishing a journal *Slovak Foreign Policy Affairs* (twice a year, in English), which has a circulation of 1,000 copies and is distributed to foreign subscribers, partnership institutions and Slovak embassies. SFPA publishes a monthly journal in the Slovak language titled *SFPA's Letters*. The Institute of State and Law publishes a journal titled *Právny obzor* (85-year tradition), which from time to time deals with selected aspects of international law.

The SAS Institute of Sociology publishes a scientific journal called *Sociology* (every two months, published since 1969). The journal is issued four times a year in Slovak and twice

[4] Department of Sociology at University of Trnava, sociological courses are taught also by several departments at the faculties of pedagogy, arts, and economics at universities in Bratislava, Prešov, Nitra, and Banská Bystrica.

a year in English titled *Slovak Sociological Review*. The journal is internationally recognised - i.e. indexed by the Institute for Scientific Information (ISI). Like in the case of sociology, the longer existence of economics is also reflected in the fact that it has its own journal listed in the Current Contents tilled *Ekonomický časopis* (Economic Journal, published by the SAS Institute of Slovak and World Economics). There are also some other journals - for example *Ekonomické rozhľady* (Economic Outlooks, published by University of Economics).

As far as humanities are concerned, the overall number of periodicals can be expressed in tenths and most likely is higher than one hundred - the SAS Institute of History alone has five periodicals. However, only two of them are internationally recognised i.e. listed in the Arts and Humanities Science Citation Index maintained by the ISI - *Filozofia* (Philosophy, published by the Institute of Philosophy) and *Historický časopis* (Historical Journal, published by the Institute of History). The journal *Philosophy* publishes the results of basic research not only in philosophy, but also in related disciplines such as metaphysics, ethics, epistemology, history of philosophy, and social and political philosophy. *Historical Journal* has been published since 1953 and presents itself as a journal of all historians dealing with Slovak history and of all Slovak historians examining Slovak or international history.

Problems and challenges

Every discipline of social sciences is faced with its own problems and challenges. Due to limited space, we will aim only at those that they all have in common. It is natural that in recent years, social sciences have almost exclusively focused on Slovakia and transition issues in particular. We can hardly speak of an integral paradigm - published studies and articles chiefly represent empiric descriptions of what has been happening in Slovakia.

Many problems are due to overcoming the legacy of the past. They are often connected with insufficient specialised and systematic training of older and middle-aged scientists, who could partially supplement their education only after 1989. This condition is to some extent reproduced towards the future, because new graduates in humanities are taught by these pedagogues and scientists.

The present state of humanities is also conditional upon great demand for social science information and analyses, which come from domestic or foreign sources. On the one hand, the demand acts as a stimulus (both specialised and financial), its dark side is rapidly appearing products with a high information value, but low analytical value.

In some areas - for example international relations - many primary documents are missing and the terminology of basic concepts is inconsistent. Altogether, the pedagogical and scientific background of political sciences is undersized on the overall scale. Some other branches, particularly economics and sociology, have already developed a certain standard of description and handling empirical data. However, an explanatory paradigm is missing to some extent, as well as interconnection of quantitative data and theoretical and analytical views. This has several reasons - one of them is that, with a few exceptions, no dissidents or scientist from emigration came to social sciences after 1989. Other reasons behind insufficient dynamism is the long-term monopoly of Marxist and Leninist views on society in theory, research, and education, non-existence of full-scale platforms for acquisition and development of other theoretical specialisations, lack of foreign literature, and poor command of other languages (for specific details on sociology, see Sopóci (1995)).

Another issue is to what extent Slovak social sciences are integrated into international research, where the analysis of Slovak scientists' publications in recognised journals shows that their publications in journals other than Slovak are minimal. Another fact that is equally serious is the use of somebody's research results by other scientists is very low in Slovakia and practically non-existent abroad, with some individual exceptions.

The above problem is even more significant in the case of humanities. Generalising problems and challenges is very difficult and misleading for individual branches of science too. This is especially true for such a diverse group of disciplines as humanities. In spite of it, certain issues and views have a more general value and validity. We provide a brief overview of the above here.

Due to their subject matter, many disciplines of humanities have a natural tendency towards certain parochialism and a local approach. Anywhere in the world, artistic or historical research shows a significantly lower degree of globalisation than natural sciences, for example. Yet, in our opinion, a large part of humanities is rather too isolated. Objective quantification is hindered by the fact that there are only two journals listed in the Current Contents. There is hardly any publication activity of Slovak authors in foreign recognised journals.

The significance of this problem can be demonstrated by analysing the two recognized periodicals in the area of humanities - *Philosophy* and *Historical Journal*. An analysis of publications and citations from these two journals over the period 1998 - 2000 was carried out[5] and yielded the following results:

- The rate of citation for the articles published therein is low and, excluding self-citations, represents 1 citation per 5 - 20 publications.
- The highest rate of article citation is 1 citation (except for one discussion in Philosophy, where the authors cited each other). In other words, no article but one invited more significant response even in Slovakia.
- What is even more important, all citations appeared in the journal of original publication and represent citations by other Slovak authors. To put it simply, these journals made up an autonomous world with no links to other monitored journals during the period in question.

As mentioned above, this problem is not limited to Slovakia only and is highly acute in other transition countries too. Still, such comparison with other countries is not favourable for our country. Let's mention Hungary, as an example. Two most highly cited Hungarian articles listed in Arts and Humanities Citation Index and published in 1998 invited 10 citations (self-citations excluded) in a broad spectrum of journals . The most highly cited Slovenian article listed in AHCI in 1998 was cited five times, but in renowned journals such as Cultural Studies or Yale Journal of Criticism. This is not to make a fetish of publications or citations in recognised journals, but to lay emphasis on another indicator showing a high degree of isolation, as proven by the above examples. This is a real problem for the Slovak science as a whole, but also for social sciences and humanities in particular.

[5] not listed here due to the large extent of primary data

[6] This applies to the following journals (abbreviations as used by the ISI): J Logic Comput, Econ Theor, Lect Notes Comput SC, Lect Notes Artif Int, Ann Pure Appl Logic, J Symbolic Logic, Language, Can J Ling/Rev Can L, Lingua, Linguist Inq, Linguistics

Chapter 4: Science and technology policy in Slovakia and other countries

4.1. Introduction

Science and technology policy is understood as a set of legislative measures and financial instruments provided by the state in the area of science and technology.

The following chapter is aimed at analysing science and technology policy in Slovakia as well as in other selected countries and searching for recommendations for further improvements.

For the purposes of this text, we have set out the division of time periods according to which measures and instruments of the Slovak science and technology policy will be evaluated:

- in a period preceding the transformation: 1948 - 1989
- in an initial transformation period: 1990 - 1997
- and a special section will be devoted to a later transformation period: 1998 - 2002.

In addition to the above, this chapter also deals with science and technology policies in other countries, with particular focus on the neighbouring V4 countries.

4.2. Pre-transformation period in Slovakia

The pre-transformation period is tersely described in a document titled *The Overview of Science and Technology Policy of the CSFR*, drawn up by the OECD in 1992.

During the era of socialism, science and technology policy was formulated on a centralised basis of state authorities in charge of science and technology, which were subject to frequent reorganisation and renaming. Since constituting the federation in 1968, the area of science and technology had been jointly administered by federal and state authorities, with key powers in the hands of the federal authorities.

A set of legislative measures for science and technology from the period in question is partially described in a handbook *Legal Regulations for Science and Technology Development*, published in 1979 by the Research Institute of Culture based in Bratislava.

The fundamental instrument of science and technology policy was the **State Plan for Science and Technology Development**, which consisted of

- State Plan for Basic Research
- State Plan for Technological Development
- State Plan for Economic Research

These plans were drawn up for 1-year and 5-year periods and constituted a set of individual tasks that were being solved, without deeper mutual links. In the early 1970's, they were transformed into a set of state programmes. In addition to the State Plan for

Technological Development, there were also departmental plans for technological development drawn up by particular ministries and directorates of manufacturing economic units as well as enterprise plans implementing enterprise technological policies.

A basic structure of research and development

In 1951, only 14,000 workers were employed in research and development institutions, while this figure was about 147,000 in 1970 and reached about 200,000 at the end of 1988. However, only 57% of these workers were in fact involved in research and development.

Following the Soviet model, basic research was concentrated in academies of sciences - the Czechoslovak Academy of Sciences founded in 1952 and the Slovak Academy of Sciences founded in 1953. An extensive network of scientific institutes was created within these organisations. Unlike in western countries, Academies did not exist only as scholarly societies, but took over exclusive responsibility for the development of basic research from higher education institutions.

A significant decline in the research potential of HEIs can be dated back to this period, which has persisted ever since and represents a significant deformation of the Czech and Slovak research and development. Although research was part of 5-year state plans for research and development, HEIs treated it as marginal activity. This is why very limited funds were allocated for research and science at HEIs - approximately one fifth of all expenditure allocated for the two Academies of Sciences mentioned above. Despite these limitations, HEIs were actively participating in solving basic research tasks stipulated by the State Plan over the whole of this period, where they provided for about 40% of research capacities. The cooperation of the Academies of Sciences and HEIs was taking place within this framework. In addition to that, HEIs also participated in solving tasks stipulated by the State Plan for Technological Development and State Plan for Economic Research.

The links of applied research to production within the so-called departmental or enterprise sector were enervated as a result of forming a network of interdependent research institutes in the early 1950's. In connection with the implementation of a so-called "new framework of management and restructuring of the manufacturing and technological base" at the end of this decade, applied research was again incorporated into production enterprises - in manufacturing economic units established at that time. Manufacturing economic units were monopolies that naturally were not interested in innovative programmes. That's why they were unable to create a stimulating environment for these research institutes. Neither did the reform in the late 1980's called "a restructuring of the economic mechanism" (perestroika) strengthen relationships and links between research and production, which were vehemently called for in that period and which were to connect central planning with some concepts of a market economy. The monopolistic structure of the economy remained the same and attempts at implementing a "real" market mechanism failed. Legislative measures were taken to strengthen the independent position of state-run research enterprises. They were still owned by the state, but had to rely on self-financing and were bound by the same requirements and tax duties as manufacturing enterprises. Therefore, state-run research enterprises had to divert from research activities and focus on providing services, own production, or other activities though which they could make profit.

The financing of research and development

The amount of expenditure on research and development depended on fulfilling production plans. The financing of tasks specified in the state research plans was either full or partial i.e. with some joint participation of users. Foreign currency funds needed for scientific instruments and equipment were allocated to research institutes and sometimes even to research users from the central budget. The state provided funds for the operation of budgetary and subsidised organisations, capital construction of research, testing, and auxiliary facilities, specialised scientific and technological information centres, purchases of foreign technical and specialised literature and licences. Also, the state granted scholarships for research fellowships abroad, but almost exclusively limited to the former socialistic countries. In addition to the state budget, funds from the enterprise sector contribute to financing research and development to a significant extent. Loanable funds and borrowings were sparsely used to finance research and development. For well-known reasons, there were no funds available from foreign sources and foundations.

From 1965 till 1989, the share of overall expenditure on science and technology in GDP was 4% in current prices. This was accompanied by a significant decrease in the share of state budget funds in total expenditure on science and technology from 58.8% in 1960, 47.4% in 1970 to 40% in 1980, which remained unchanged till the end of the 1980's.

In 1989, the share of overall expenditure on research and development in the generated GDP was 4% in current prices, which was the same level as in 1965. This high share was due to isolation of the Czechoslovak economy and resulting needs to focus on its own research potential. It had to provide for primary needs of the Czechoslovak industry characterised by a wide range of production and dependence on import and export. It is particularly the efficiency of spending these funds that is questionable, together with the extent to which they were spent on activities that would be at present regarded as research and development.

International cooperation

Since 1948, the entire international cooperation had been preferably focused on RVHP member countries (Mutual Economic Aid Council). The focus of such cooperation was targeted at a bilateral exchange of technical documentation and mutual consultations of scientific and technological workers. In the course of time, some other forms of cooperation came into use, such as bilateral and multilateral coordination of scientific and technological research, contractual cooperation, establishment of international scientific and technological teams, joint laboratories, and institutes - for example the Institute of Nuclear Research based in Dubno near Moscow. In general, however, such cooperation was little efficient when assessed in terms of growth of progressive products and technological procedures.

Cooperation with western countries was generally limited and mostly focused on the sale and purchase of licences. Bilateral agreements concluded with the governments of these countries constituted a basic framework for scientific contacts. In the 1980's, production collaborations became an important form of transfer of technologies from western countries. 250 cooperation contracts of this kind were registered at the end of 1988. A total annual turnover of such cooperation was more than 2 billion CSK.

Cooperation with developing countries provided a platform for increasing economic support for the pro-communistic regimes of Cuba, Mozambique, Angola, and other countries.

During 1970 - 1989, Slovakia used to purchase about fifty licences per annum, thirty of which were from non-socialistic countries and the rest from the RVHP members. In 1986 - 1987, total foreign currency expenditure on purchase and implementation of licences was about 5.9 billion CSK, which accounted for 1.4% of Czechoslovakia's total imports. In 1970 - 1989, Czechoslovakia was annually selling about forty licences on average, twenty of them to the RVHP countries. The total balance of licence trade was passive over the entire period in question.

The impact of the pre-transformation period upon the present condition

The negative tendencies of the pre-transformation period became deeply rooted in the whole structure and contents of research and development and left traces in the following initial periods of transformation particularly due to the fact that during the 1990's:

- the creative activity and overall potential of research and development kept weakening due to administrative and directive management methods
- a competitive environment was missing, which led to levelling out and equal misery of all research workers regardless of their performance
- there was an increasing degree of our lagging behind developed countries and the present V4 countries from the point of view of industry, access to information, and technology
- the disproportional financing of science and technology from the state budget was persisting, which favoured academies and enterprises at the expense of HEIs.

4.3. Transformation period in Slovakia

An initial transformation period during the Czechoslovak Federative Republic

In the first two years of the initial transformation period (1990 - 1991), science and technology policy was formulated at the level of federation and individual republics. Political measures that were progressively taken not only had to rectify the shortcomings of the past in science and technology, but also had to start focusing on relevant experience of market economies. A significant reduction in research and development workers took place: their number fell from about 200,000 in 1989 to fewer than 160,000 in 1990. In October 1990, the government of the Czechoslovak Federative Republic adopted a policy document titled *The Principles of State Research and Development Policy*. This document guaranteed freedom of research, respecting of autonomous development of science, creation of plurality in financial support for research with the aim of reinstating the close connection between research and education as well as research and economy. At the same time, these principles specified the following measures to be taken in the near future:

- adaptation of the institutional structures of research and HEIs to their forms used in western countries
- creating favourable conditions for the development of scientific and research potential, including research at HEIs
- implementation of a new system for the financing of research with regard to transition from institutional to targeted financing
- ensuring unlimited access to financial resources, particularly to special-purpose funds for all applicants through a public tender
- implementation of a grant-based financing system at the Czechoslovak Academy of Sciences, Slovak Academy of Sciences, and HEIs

In the course of social changes in 1989, both Academies of Sciences abandoned their monopolistic position in the area of science and basic research. In May 1990, the Higher Education Act No. 172/1990 was enacted, under which higher education institutions were described as ultimate educational, scientific, and artistic institutions, whose mission was to provide higher education on the basis of creative scientific research and artistic activity.

The initial transformation period in Slovakia

During the first two years of the initial transformation period, favourable conditions were created in Slovakia in order to speed up the process of transformation in the area of science and technology policy. *The Principles of State Science and Research Policy* were adopted by the government in November 1990, and in December 1991 the government approved, in compliance with the opinions of the whole scientific community, the following priorities for science and technology policy:

- the development of basic disciplines of science and education
- improving the standards of health and nutrition
- increasing concerns for environmental protection
- the development of microelectronics and informatics
- supporting the development of new materials
- the rationalisation of production and energy savings
- the economic utilisation of domestic raw materials and support for recycling technologies

In the same year, **the Government Science and Technology Council** was established as an advisory body headed by a deputy prime minister. The Council was entrusted with the following powers:

- to judge proposals of science and technology policies in the Slovak Republic
- to judge proposals concerning priority areas in science and technology and put forward new ones

- to deliberate on principal issues related to ensuring research and development activities and proposals for legislative amendments in this area
- to deliberate on principal issues related to international cooperation in science and technology and propose measures ensuring the coordination of activities in this area
- to comment on proposals concerning the overall volume and allocation of funds in support of science and technology from the state budget

An important step made in the first two years of the initial transformation period in Slovakia was a nearly concurrent establishment of grant agencies for science at HEIs and the Slovak Academy of Sciences. Both agencies were formed upon a motion made by self-governing bodies representing the scientific community, and their activity was based on a peculiar and nowhere-else-to-be-found mechanism of annual transformation of institutional funds into targeted funds coming from the science and technology budget of the Ministry of Education and the Slovak Academy of Science. Subsequently, HEIs and the SAS founded in 1992 a joint grant agency for science (GAV), later renamed to VEGA. Projects submitted there have since been judged by commissions made up of HEI and SAS representatives. Outlays on these projects still come separately from the budget sections of each institution. It is noteworthy that the most funds for the operation of GAV (presently VEGA) were provided from the state budget just in 1991 - 187 million SKK from the SAS budget and 97 million SKK from the MoE budget, which accounted for 40% of their expenditure in current prices on basic research. In later years, the budget was less generous and about 60 million SKK, on average, were transferred each year from the MoE budget upon the Board of HEIs' recommendation.

The most important legislative measure in this area was a draft bill on organisation and state support for science and technology. The submitted draft bill was to stipulate legal guarantees for free, state-supported development of science and technology in Slovakia and create conditions for research and development activities. It was intended to create a model based on a unified system of state financing based on the assessment of specialised capacity of research and development institutions. Emphasis was laid upon the cooperation of central authorities of state administration and advisory bodies made up of scientific and technological experts and representatives of the business sector, financial sector, and state administration. A special objective of the submitted draft bill was to ensure close interconnection of research and development with the general system of education. A change in financing science and technology was also proposed, with gradual transition from the institutional to targeted financing of research projects. The targeted financing was to be conducted on a competitive basis. An independent authority should be set up by law, which would be responsible for enforcing a solid scientific competition, called the Science and Technology Foundation - the today's Science and Technology Support Agency, which originated 11 years later. Based on the resolution of the Slovak National Council's chairmanship as of April 12, 1992, the draft bill was submitted to the 24th SNC session, but a subsequent vote in the plenum did not put in into the session's agenda. The same situation reoccurred in 1994 with a slightly modified draft bill on state support for science and technology. This time, the draft bill was incorporated in the NC agenda, but was not deliberated, as it was the last on the list. These two failures to enact a law governing primary aspects of research and development policy had a crucial impact on prolonging the initial transformation period and thus delaying the whole process of transformation by more than six years. During this period, the government set up the **Office for the Strategy of Development of Society, Science, and Technology**. Unclearly defined powers in science and technology policy gave rise to permanent controversies between the Office and the Ministry of Education, which had formerly been called the Ministry of Education and Science. However, the government did not approve a single principal legislative document relating to science and technology policy and all the transformation process including financing and international cooperation issues ended in deadlock - and even represented a step backwards in some fundamental aspects. For example, the Government Council on Science and Technology was cancelled and the self-governing constituent was excluded from decision-making in this area for a long time.

The lost six year left deep traces manifested in our legislation's lagging behind the V4 countries, in international cooperation, but most of all in the total stagnation of targeted financing. The whole research and development community sank into a lethargy and despair resulting from endless postponing of necessary legislative changes in all areas of science and technology policy.

4.4. Science and technology policy in Slovakia nowadays

Introduction

After the 1998 elections, the Ministry of Education began to work intensely on a reform to science and technology policy. The reform consisted of three stages:

1. drafting and adoption of policy materials
2. drafting and adoption of a new legislative framework
3. implementing the new legislative and financial framework

In the first stage, the Ministry of Education gradually drew up and submitted to the government (or to the National Council in the case of some documents) the following documents:

- The Principles of State Science and Technology Policy (Government resolution No. 727/1999)
- A New Model of Science and Technology Financing (Government resolution No. 561/2000)
- The Conception of State Science and Technology Policy (Government resolution No. 727/1999 and National Council resolution No. 1228/2000)

On the basis of the above, four new acts were drawn up in order to put these policy documents into practice:

- Science and Technology Support Agency Act
- Science and Technology Act

- Slovak Academy of Sciences Act
- Higher Education Act

The third stage was launched after these acts came into force - which was from April 1, 2002, except the law on the Agency, which became effective from 2001.

The whole process was considerably influenced by "the Audit of financing and activities of central authorities of state administration and their subordinated organisations" (thereinafter only the Audit of central state administration or the Audit) carried out by Deputy Prime Minister Ivan Mikloš. The Government of the Slovak Republic approved the Audit on August 30, 2000 by its Resolution No. 694/2000 and ordered that 53 tasks should be carried out in order to implement its findings. The following ones were of particular importance for the area of science and technology:

- Tasks C.5, C.7, and C.8, according to which more that 50 state budgetary and subsidised organisations were to use only targeted financing from January 1, 2001 and to undergo transformation of their ownership from January 1, 2002. This applied to a significant number of departmental research and development institutions
- Task C.22, on the basis of which the existing legislative framework for provision of public services was to be extended in order to allow for performing various public services including research and development through non-profit organisations
- Task C.46, which obliged the minister of education to incorporate the recommendations from the Audit concerning the financing of applied research into a new law governing the financing of science and technology

Task C.22 eventually resulted in adopting:

- a law stipulating the conditions for transformation of some budgetary and subsidised organisations into non-profit organisations
- an amendment to Act No. 213/1977 Coll. concerning non-profit organisations providing public services

The mutual interaction of the concepts presented by the MoE and the Audit eventually led to a significant impact of the Audit ideas upon the drafting of the above four laws. Therefore, the analysis of the preparation and especially results of the science and technology policy reform has to be based on the investigation of:

- the goals and philosophy of the MoE concept
- the goals and philosophy of the Audit
- their mutual relation and agreement/disagreement
- the impact of these factors on drafting and final versions of the above laws
- the impact of the final wording of these laws upon science and technology in Slovakia

The results that these analyses yielded can be summarised as follows:

- ❍ Both concepts have similar goals.
- ❍ There are significant discrepancies in how to fulfil these goals.
- ❍ The final wording of all the relevant laws is a compromise between both of these concepts.
- ❍ In spite of several weak spots of such a compromise, it provides a lot of opportunities for the development of research and development in Slovakia.
- ❍ This is, however, contingent upon significant pressure exerted by the scientific community on the government, the Ministry of Education, the Science and Technology Support Agency when the laws are being put into practice in the areas of the allocation of funds, decisions on human resources, and transparency.

The Ministry of Education vs. the Audit viewpoints

The Ministry of Education drafted the above-mentioned documents that dealt at length with the goals of science and technology reform. Many of them are so vague, though, or expressed in such general terms that the real intent of these documents is nearly impossible to trace. For example, the Conception of State Science and Technology Policy states the following principal goals:

1. consistent coordination of state science and technology policy and departmental policies in the areas of industry, power engineering, agriculture, transport, telecommunications, interior and exterior security of the state, defence, education, health care, and social, cultural, environmental, foreign, and other policies
2. creating conditions for the approximation of the Slovak science and technology to the standards of comparable countries of the European Union by 2005
3. creating conditions for broadening and improving international scientific cooperation
4. increasing the performance and efficiency of research and development particularly by means of:

   - new and amended laws in compliance with EU standards
   - systemic measures to ensure more efficient support for science and technology
   - systemic measures to ensure an efficient application of science and technology results in the economy and society
   - constant support for the training of a new generation of research and development specialists at HEIs, professional growth, and improving scientific qualifications of these specialists in compliance with developed countries' standards
   - creating conditions for improving the career prospects of employees with appropriate qualifications and management skills in the management of research and development
   - implementation of a system of evaluation, accreditation, and certification of R&D organisations and departments, which would be compatible with corresponding systems in the EU countries

5. increasing the level of interconnection (interoperation) between the state sector, HEIs, and the business sector with regard to R&D institutions and departments with the focus on developing production and non-production branches
6. speeding up the transfer of R&D results as part of the development and restructuring process in the economy and society

In our search for goals, we will therefore focus on two more specific groups of goals contained in these documents. One of them is based on the new model of science and technology financing and contains:

- priority financing for state R&D programmes and government R&D contracts
- priority support for complex solutions to the development of science and technology requiring the cooperation of several R&D sectors (HEIs, government, and businesses)
- a new approach to institutional R&D financing, which would ensure that state budget funds are more efficiently utilised and R&D workers are more directly involved in the results of their solutions
- support and creation of conditions to implement the result of industrial and applied research, which can have a gradual or immediate economic effect
- the principle of cumulating budgetary and extra-budgetary funds in order to provide targeted support through the Science and Technology Support Agency
- the need to create conditions for more efficient diversification of resources to ensure direct support for science and technology

Another set of goals ensues from The Conception of State Science and Technology Policy by the year 2005. These are partial goals resulting from attempts at creating the common European research area:

- networking the existing centres of excellence in Europe and creating virtual centres of excellence by means of new and interactive communication instruments
- a common approach to the needs and resources for financing large research facilities in Europe
- a more coherent implementation of national and European research activities and closer relations between various R&D organisations in Europe
- better use of instruments and resources to stimulate investments in research and innovation: such as indirect-aid systems (within the EC rules on state subsidies), patents, and venture capital
- creating a common system for the assessment of implementation of science and technology policies
- more support for human resources with higher mobility
    - greater mobility of scientists and stressing the European dimension in scientists' careers.
    - increasing the importance of women in research and development
    - providing incentives for young people to work in research and build a scientific career

- a greater European cohesion in research, based on the best experience of transferring knowledge at the regional and local level, and in the role of regions in European scientific efforts
- joining research communities, companies, and research workers from western and eastern Europe
- making Europe more attractive for research workers from other countries of the world
- support for common social and ethical values in science and technology matters.

The Audit's objective was to improve central state administration (formally incorporating all state budgetary and subsidised organisation including those involved in research) in the following three areas:

- increasing efficiency
- increasing quality
- eradicating corruption

The Audit recommendations distinguished between so-called commercial and non-commercial activities. The commercial activities represent the provision of goods or services that is or can be performed by non-profit and/or commercial organisations. The non-commercial activities are those that are not commercial by nature and public institutions normally perform them on an in-house basis. Some of their inputs can be ordered from and provided by the private sector. Research and development are part of commercial activities, for which the Audit recommendations are particularly as follows:

- ensuring the transparency of activities, financing, and costs
- transition from direct control over providers of goods and services to the provision of goods and services on the basis of agreements i.e. contractual relationships
- increasing competition and liberalisation of providing goods and services
- gradual change of ownership in the case of providers of goods and services that are owned by the state at present[1]
- liberalisation of remuneration, structural, and budgetary regulations for providers of these services
- creating a new legal framework for the provision of those commercial activities for which there are no corresponding legal forms at present

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[1] Change of ownership means the following:

- transformation to some other legal form: an independent public organization, public utility corporation, non-governmental public utility organization
- integration with another organisation from the central public sector that is not directly controlled by central authorities (universities, or alternatively the Slovak Academy of Sciences).
- transferring their control to regional authorities
- transferring their control to other subjects that have institutional interest in development of activities of the relevant institutions (for example professional associations, unions, church, etc.)

In cooperation with a group of researchers from HEIs, SAS, and departmental research organisations, these goals were later translated into the following seven principles focusing on research and development in particular:

- **To provide financial support from public funds only for R&D activities meeting at least one of the following criteria:** First, research and development at **international level**. Second, research and development whose relevance is proven by **co-financing** secured by another domestic or foreign **entity including businesses and the European Union**. Third, research and development reflecting **priorities of the state**. Fourth, research and development covering **the area of public goods and national heritage**. Fifth, activities supporting the development of human resources in science.
- **To distribute** both returnable and non-returnable **funds** for research and development by means of an open competition, this including not only funds for R&D activities, but also those for institutional development and other activities related to science
- **To invigorate** the system for allocation of funds to make it respond to new trends in science, and incorporate in it mechanisms ensuring the **continuity** of financing for quality research in the longer run and straightforward rules for **termination of unsuccessful projects**
- **To publish and adhere to clear rules** ensuring a **competitive environment** for the allocation of funds and opportunities of effective **oversight** of their efficient utilisation. The competitive environment can only exist when there are actually equal opportunities of obtaining funds for quality research for all applicants without apparent or hidden preferences. **To support the environment for multiple-source financing** of research and **to remove ministerialism** as a closed fund-allocation system dominated by administrative staff at particular central authorities of state administration and other state budget administrators.
- **To separate political, administrative, and specialised decision-making** on allocation of funds for research and development and to create a proper legal and organisational framework for specialists making decisions on allocated funds. Political decisions (but based on expert opinions by the scientific and business community) should be taken on the allocation of funds for individual areas of research and development. **On the other hand, decisions on the allocation of funds for particular projects within these areas and programmes have to be made only by a commission of experts made up of excellent domestic and foreign research workers in a given area, not representing particular institutions, ministries, or associations.** The only task the administrative staff has to fulfil is ensuring efficient organisation of the fund-allocation process.
- To create an effective framework for a code of ethics and resolution of conflicts of interest concerning all participants of the fund-allocation process so as to ensure that the system can be trusted by the scientific and business community.
- To adopt a legal framework for public R&D institutions ensuring the protection of public interest and respecting the needs of these organisations at the same time. The present legal forms for budgetary and subsidised organisations do not

provide such a framework. In this respect, it is also necessary to define clear rules for the establishment of public R&D organisations as well as for the termination of unsuccessful ones.

The following common aspects could be found between the conceptions of the Ministry of Education and the Audit:

- the need for real priorities in science and technology policy
- the need for diversification of funds for research and development
- laying emphasis on greater competition and incentives for both institutions and individuals
- laying emphasis on research and development based on actual demand
- the need for the European research area in science and technology
- laying emphasis on the quality of R&D institutions and departments
- laying emphasis on ethical conduct and development of human resources

However, several significant differences can also be found, which will be dealt with in more detail in the text below.

The organisation of research

The Ministry of Education did not regard this as a priority issue and the new system brought no significant change to the environment in which most institutions were to operate as budgetary or subsidised organisations founded according to the Budgetary Rules Act (departmental research institutes upon a particular ministry's decision, SAS institutes upon the SAS management's decision, and faculties or other parts of HEIs upon a decision made by a public higher education institution).

The philosophy of the Audit aimed to enforce the following changes:

- Most departmental research institutes should be privatised and transformed into non-profit organisations of private law or, alternatively, could come under HEIs or the SAS where appropriate.
- The remaining R&D organisations (the SAS in particular) should undergo transformation similar to HEIs when transformed into public HEIs.

In the case of the Slovak Academy of Sciences, this would bring a significant change in the present federative model in favour of a confederative one, where the SAS management would have limited powers and individual institutes would become almost fully autonomous. Depending on a decision about the system of financing, the SAS as a whole would be transformed either into an internal grant agency or an association of institutes.

In connection with changes in financing, such transformation would bring a so-called "assurance of poverty" to an end, which means that long-term existence of organisations was guarantied, although with a minimal budget. Allocation of funds on a competitive basis might result in the insolvency of unsuccessful ones, but possibly provide others with a much higher budget than before. To ensure flexibility of such a system, it would likewise have to allow entry into this branch of activity. Therefore, such a system would require defining clear rules for establishment of public R&D organisations as well as for termination of unsuccessful ones.

This would be also connected with new labour relations under which most employees could not enjoy job security with permanent labour contracts. To maintain flexibility, a high percentage of research workers, particularly at postgraduate level, would be hired to work on concrete projects or only for a limited period of time, and only a narrow group of employees constituting the "core" of an institute would have security of tenure.

Such an approach integrally comprises support for consortia, ad hoc association as well as support for the integration of institutions. Both instances imply a high number of R&D organisations in Slovakia, but do not propose their integration at all costs. Rather, the objective is to create an environment in which many organisations make their own decisions on getting integrated.

Financing

As far as financing is concerned, the Audit aimed to lay greater emphasis on targeted financing and introduce certain minimal qualitative requirements for institutional financing (periodical assessment, or accreditation and certification). The proposed system, however, leaves most of real decision-making up to ministries and does not provide equal opportunities for individual types of institutions, because:

- periodical assessment would be conducted by ministerial commissions (accredited by a central commission) and what's more, their criteria would not be primarily focused on the quality of research and development activities
- in other cases, relevant decision-making bodies would be made up of delegated representatives of central authorities and the R&D community
- institutional financing would cover only state-run organisations, would be subject to ministries' decision-making, and provide funds for the operation of budgetary and subsidised organisations
- state programmes would be administered by ministries with minimal legislative regulation
- there would be no limits on government contracts created and assigned by ministries

Having a similar intention, the philosophy of the Audit led to some more radical steps:

- the quality of decisions on allocation of funds would be ensured by explicit and demanding criteria for membership of any of these relevant bodies where their members would not act on behalf of any institution and a significant number of foreign scientists would participate in these bodies
- institutional financing would cover only specific projects aimed at improving the operation of institutions, these funds would be allocated on a competitive basis, and the share of institutional funds in the overall expenditure on science and technology would be gradually decreasing

- the main instruments for the financing of science and technology would be state programmes, but with a different structure of decision-making bodies (see below), co-financing of all research activities as well as support for research and development in the field of public goods (health care, education) and national heritage, and cross-cutting programmes (for example the financing of scientific mobility)
- political, administrative, and specialised decision-making on allocation of funds for research and development would be separated in the case of state programmes (see the above seven principles)
- emphasis would be laid upon co-financing of activities whose relevance is proven by some other sources of funds - in practice provided mostly by businesses and the European Union
- government contracts would be terminated, except scientific works required by ministries and security and defence issues
- maximum emphasis would be laid upon establishment and financial strengthening of the Science and Technology Support Agency
- unlike the MoE concept, significant emphasis would be placed upon the issues of ethic and transparency, particularly by publishing as much information about projects, members of bodies, etc. as possible, as well as controlling the conduct of decision-making bodies and their members with regard to the conflict of interests (for example holding a vote on a project in which an individual or his organisation participates etc.)

The clash of these two concepts, together with their partial agreement, resulted in adoption of the above-mentioned laws defining the legal framework for research and development. The following text provides a summary of the final wording of these legal norms.

Science and Technology Act

The greatest compromises were made and longest debates took place in connection with the Science and Technology Act. They led to a compromise, which in many cases significantly shifted the meaning of the law, but sometimes suffered from unclear conception where there was a clash between both of the parties.

The following are the most significant changes:

A. adopting criteria for membership in the boards of state programmes, subordinated programmes, and periodical assessment commission as well as publicity of staffing these bodies. Every member has to meet at least three of the following criteria:

- extensive publication activity, particularly in internationally recognised periodicals, monographs published by foreign publishing houses, and invitations to deliver lectures at international congresses
- several domestic and foreign citations of their works
- participation in important international projects in the area of science and technology

- founding a generally recognised scientific school of thought, documented by internationally recognised followers complying with the requirements under A)
- granting patents in the Slovak Republic or their granting on the basis of an international application, with particular focus on their industrial utilisation
- participation in accomplishing significant technical works and projects
- significant technical and economic results in practical implementation of the results of their own research and development
- successful management of economic or R&D institutions with the same orientation as particular areas of the state programme in question

On the other hand, this case makes it possible to stress some drawbacks of such a compromise, in which, unlike in the original proposal ensuing from the Audit, the last two criteria were added that to some extent diluted the strictness of these requirements and allowed less-quality staffing of these bodies - as these criteria are not much related to the quality of an individual's research and development work.

B. change in the composition of decision-making bodies - the boards of programmes and subordinate programmes - from which the formerly dominant representatives of central authorities of state administration were excluded and the share of business representatives was reduced to level out with the other participating sectors. For extensive programmes, such boards can now be staffed with one fourth to one third of foreign members.

C. the scope of government contracts was limited to 20% of the scope of state programmes

D. there were significant changes to the system of periodical assessment, which is to serve as the key to allocating institutional funds. The original criteria were as follows:

- the results of R&D activities of an organisation or department
- the state and growth of a human resources and material potential
- an efficient utilisation of resources including finance
- performing management tasks to ensure the quality of work, safety, and environmental protection over a period under review
- the results of accreditation and certification of organisations and departments

The new criteria are the following:

- publication activity and citations in Slovakia and abroad
- patents granted in Slovakia
- a high success rate in obtaining state and non-state funds for research and development
- participation in important international projects in the area of research and development
- training of research workers

Departmental commissions for periodical assessment have been abandoned and only one extra-departmental commission will exist. Criteria for membership of this commission were stated, which are the same as for membership of the boards. The commission is open to foreign members' participation.

Periodical assessment is a voluntary activity of an organisation, without passing it, however, it is not eligible for institutional financing.

At the same time, periodical assessment as a prerequisite to entering a contest for targeted funds was terminated.

E. so-called thematic state programmes were introduced that should not focus on scientific disciplines but rather on certain types of activities to provide targeted funds for specific purposes such as the development and mobility of human resources, building of a technological and institutional infrastructure for research and development and international scientific cooperation. The first instance is a programme in support of young scientists up to 35 years of age. The advantage of these financial contributions is that they represent long-term targeted funds which can be competed for in transparent tenders through projects submitted by individuals and institutions, with scientists themselves deciding on their allocation.

In addition to the above, four other smaller modifications can be noticed:

- introduction of a code of ethics regulating the conduct of all bodies, which is of crucial importance in the Slovak environment
- a better definition of science and technology services, which would prevent inappropriate use of public funds for science and technology
- the parts of the law governing individual R&D sectors with representative or statistical functions were significantly reduced. Potential risks resulting from vagueness and broad formulations were thus eliminated.
- to select tasks within state programmes, public procurement will not be used to allow for a broader range of applicants and higher involvement of specialised bodies

Slovak Academy of Sciences Act

Even though there were significant amendments made to the Slovak Academy of Sciences Act, little will in fact change in the operation of the Academy and its departments. Besides relatively smoother running of the Academy, this fact reflects lack of will to make significant changes to the status of departments and institutions through their transformation into a form of existence other than a budgetary and subsidised organisation. Without such changes, the hierarchical "federative" model of the Slovak Academy of Sciences cannot be resolved, under which the SAS establishes and closes departments and allocates funds for them, and transformed into a decentralised "confederation" allowing a greater degree of differentiation within and between these organisations.

Higher Education Act

The Higher Education Act has a significant indirect impact on science and technology particularly due to the principle of per-capita financing for educational activities of HEIs. i.e. allowing equal funds per students in the same fields of study. On its own, such a model would lead to a decrease in the quality of research and intellectual capacity of HEIs due to a so-called "race to the bottom" - there would be competition between HEIs not for higher quality but rather for providing education as cheaply as possible. It is therefore supplemented by the financing of research and development activity in connection with science and technology. What is important in this respect is not so much the actual wording of the law but rather the ratio according to which available funds are divided between both of the activities. If HEIs should receive more than 80% of funds from the per-capita education system, we can speak of an acute threat to the quality of HEIs as a whole and for their research and intellectual capacity in particular. Practical experience has so far been confirming the urgency of this threat.

Science and Technology Support Agency Act

The Science and Technology Support Agency Act creates a standard framework for the extra-departmental financing of R&D projects based on mutual oversight and decision-making by the scientific community. The key to success is the manner of its implementation. In 2002, the Agency has announced the first two grant-awarding rounds, with the closing dates for applications on April 30 and September 30. At the moment, it is too early to assess how successful its operation will be.

Civil Service Act

Like the Slovak Academy of Sciences Act, the Civil Service Act brings, in our opinion, little change to the practical functioning of research and development organisations, and it would therefore be more appropriate to point out to what this law does not cover. It does not seek to adjust the special status of research and development institutions by allowing longer-term limited labour contracts and repeated labour contracts, and it impedes more flexible modes of remuneration by keeping to the rigid pay scales.

4.5. Recommendations and Conclusion

The basic structure of research and development, its financing, lack of international cooperation and resulting negative tendencies in the pre-transformation period (1948 - 1989) were very similar or even identical in all the totalitarian countries of eastern Europe. In the initial transformation period, Slovakia was experiencing quite a dynamic development during the first two years of the Czechoslovak Federative Republic, which is proven by the fact that in this period a draft bill on state support for science and technology was submitted to parliament for enactment. In the second half of the initial transformation period that lasted for nearly six years, however, the government did not approve a single principal legislative document relating to science and technology policy. This left our legislation behind the other V4 countries, adversely affected international scientific cooperation, and led to the total stagnation of targeted financing.

In the later transformation period (1998 - 2002), our principal legislative norms have been adopted over last two years. In connection with "the big bang" that took place on April 1st, 2002, when the Science and Technology Act, the Higher Education Act, the Slovak Academy of Sciences Act, and the Public Service Act came into force, we can speak of potential for crucial change in research and development in Slovakia. Whether five years from now it will have been dated as a turning point and whether in positive or negative terms depends on these two major factors:

- to what extent individual scientists and their institutions will take charge of the regulation of the whole process - to what extent they will make use of the new laws, oversee their enforcement, actively participate in public debate on the science and technology policy of the state, and exert pressure on the government and the Ministry of Education
- to what extent there will be continuous adjustment of those provisions of the legal framework that will be proven in practice to create obstacles to transparent and competitive functioning of the whole area

In this respect, four cross-cutting themes may be recommended that the scientific community should be particularly concerned with:

A. First, it is necessary to exert pressure upon a gradual, yet sharp increase in the amount allocated on a competitive basis for specific projects within the Agency and state programmes and stagnation or decrease in funds allocated for institutional financing.
B. Second, activities of individuals as well as representative associations in connection with nominating, disclosing and debates on staffing relevant bodies such as the boards of state programmes and subordinate programmes and periodical assessment commissions. The quality of these bodies will eventually depend on particular people they are staffed with. The law stipulates minimum qualifications and other requirements, yet in reality it is necessary to oversee their fulfilment and staff these posts only with the most excellent representatives of the scientific community.
C. Third, pressure needs to be exerted upon setting up well-elaborated, quality, and innovative state programmes. The law now allows collecting funds for an infrastructure or mobility, which can then be obtained on the basis of free and open competition. Also, the law makes it possible to define actual thematic priorities of the state in the area of research and development and then invite scientists to put forward proposals for their solution. It is, however, necessary that the most excellent part of the scientific community be involved in the process.

D. The operation of the Agency will be a real trial of the resolution and ability of the Slovak scientific community to contribute to managing public affairs in this area. It will be where the community's representatives will have decisive policy-making powers.

The assessment of early experience of these four areas gives rise to scepticism so far. The activism of individuals and groups is very limited. This is in part due to the reluctance of the Ministry of Education to actively consult on steps ready to be taken.

At the same time, we can even today point out to some changes that will need to be made to these laws, the number of which is likely to grow in the future as a result of further practical experience. It applies to the following areas:

E. It can be recommended to carry out a reform of the SAS legal framework that would lead to greater decentralisation and internal differentiation of the Slovak Academy of Sciences and change in the legal status of SAS departments in favour of autonomous public institutions. However, such a change can only be carried out when winning support by the majority of SAS research workers.
F. At the same time, criteria of membership in decision-making bodies need to be modified so as to permit only quality researchers from both basic and applied research to participate in them (particularly the criterion of successful management has to be excluded). Furthermore, the parts of the law defining the mutual relationship between the boards of programmes and subordinate programmes and public authorities are confusing and need clarification.
G. Access of small and medium-size businesses to public co-financing of R&D expenditure needs to be simplified, thus motivating them to raise more funds for research and development in Slovakia.
H. The provision of institutional funds needs to be defined in more detail where the present system can be misused easily due to insufficient definition of the competition for these funds (unlike in the Czech Republic), which allows central authorities to grant such funds even without a periodical assessment certificate, just on the basis of a so-called certificate of management providing no information about the quality of research and development.
I. The structure of financial flows into higher education needs to be significantly changed in favour of funds for research and development, otherwise a significant drop in the quality of research at HEIs and the quality of HEIs as such can be anticipated. Funds for research and development at HEIs should be allocated either on a competitive basis or on the basis of strict quality assessment of individual departments.
J. It is necessary to expressly set basic salaries as minimum levels according to the Civil Service Act and introduce better pays for projects of significantly high quality (for example within state R&D programmes and the Science and Technology Support Agency).
K. It is necessary to make use of the framework provided by the Science and Technology Act for using state programmes and draft proposals for state programmes aimed at financing centres of excellence and joint cooperation centres made up of research organisations and businesses. The financing of

centres of excellence on a competitive basis - by means of allocating funds for existing departments or creating new ones - is a basis for stimulating top-class scientific work and establishing laboratories with state-of-the-art equipment. Explicit allocation of funds for joint cooperation centres of research institutions and business can more than anything else increase the motivation to look for a practical application of research work.

L. It is equally important to make use of the framework provided by the Science and Technology Act for using state programmes and draft the proposal of a state programme to finance access to scientific literature by means of strengthening the existing capacity of libraries and particularly by setting up a virtual electronic library available for the whole R&D community.

M. And thirdly, it can be recommended to make use of the framework provided by the Science and Technology Act for using state programmes and draft the proposal of a state programme to finance joint projects of HEIs, the SAS, and departmental institutions, thus removing barriers between ministries.

N. On the condition that many of these measures are put into practice, it is recommended that public expenditure on research and development be increased, as their efficient utilisation will thus be guaranteed.

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