Twenty years of Czech science: A bibliometric analysis

Dalibor Fiala[1] and Yuh-Shan Ho[2]
[1]Department of Computer Science and Engineering,
University of West Bohemia, 30614 Plzeň, CZECH REPUBLIC
[2]Trend Research Centre, Asia University, Taichung 41354, TAIWAN
e-mail: ysho@asia.edu.tw (corresponding author)

ABSTRACT
To reveal the research performance and trends of the Czech Republic, this study carried out a bibliometric analysis of Czech publications during 1993 – 2012 covered in the Science Citation Index Expanded. A total of 105,103 articles were analyzed in terms of categories, publication sources (journals), contributing institutions, countries, authors, collaboration, most cited articles, as well as research emphases by the distribution of article title words, author keywords, and KeyWords Plus. The main findings include: (a) the annual numbers of Czech articles rose almost steadily during 1993-2012, with a sudden increase in 1994 due to the split of Czechoslovakia in 1993; (b) multidisciplinary materials science, physical chemistry, and multidisciplinary chemistry were the most active research categories; (c) Czech journals were more preferred to by Czech scientists compared to the foreign journals, while the top three journals were Collection of Czechoslovak Chemical Communications, Chemicke Listy, and Czechoslovak Journal of Physics; (d) Except for the Academy of Sciences of the Czech Republic, Charles University in Prague contributed the most articles and had the highest growth rate among the top seven institutions; (e) the most frequently collaborative countries were five of seven industrial countries: Germany, United States, France, United Kingdom, and Italy, as well as the other successor of Czechoslovakia, i.e. Slovakia; (f) The Czech research related to mechanical properties, Raman spectroscopy, phylogeny, and oxidative stress have come more popular in recent years.

Keywords: Czech Republic; Scientometrics; Research Productivity; Research Trends; Web of Science.

INTRODUCTION

Czechoslovakia split up into two sovereign states of the Czech Republic and Slovakia peacefully on 1 January 1993. Independent Czech science has just experienced the very first twenty years of its existence. The Czech Republic has received relatively little coverage in the scientometric literature. A few scientometric studies on the Czech Republic have been conducted, such as on Czech research publications (Vaněček 2008a; Bajerski and Siwek 2012), bibliometric analyses of patents (Vaněček 2008b), European framework programme results (Vaněček et al. 2010), and Czech bibliometric system that fosters mediocre research (Konvalinka et al. 2009). Other scientometric studies usually analyze the Czech Republic in the context of a larger group of (Central) European countries (Braun and Schubert 1996; Radosevic and Auriol 1999; Gorraiz, Reimann, and Gumpenberger 2012). The official evaluation methodology of the scientific research output in the Czech Republic has been described by Fiala (2013) and its effects on the research performance have been discussed by Vaněček (2013). Furthermore, scientometric studies of the overall research productivity of countries and groups of countries have a long tradition starting with the seminal analysis by Schubert et al. (1989) and continuing with other investigations into the scientific production of nations at a larger scale (Braun et al. 1994; Braun et al. 1995; Cole

and Phelan 1999) and at a smaller scale (Gálvez et al. 2000). Regions analyzed include Scandinavia (Glänzel 2000) and Latin America (De Moya-Anegón and Herrero-Solana 1999) and there have been general bibliometric studies on China (Zhang and Zhang 1997, Fu et al. 2011), Russia (Wilson and Markusova 2004), Cuba (Sancho et al. 1993), United Kingdom (Martin 1994), Latvia (Kristapsons and Tjunina 1995), Croatia (Bencetić Klaić and Klaić 2004), Brazil (Glänzel et al. 2006), and Mexico (Luna-Morales 2012).

Research production of scientists is related to various forms of publication authorship. Gift or honorary authorship is defined as the inclusion as author of an individual who has not contributed adequately to the project (Bennett and Taylor 2003; Singh 2009). It has been found that an increased number of authors in a paper is more likely to precipitate various unethical authorship practices including gift authorship (Slone 1996; Dotson and Slaughter 2011). There are different patterns of the author order of multi-authored papers (He, Ding and Yan 2012). It has been reported that the most important positions are the first and the last, whom very often is the corresponding author (Zuckerman 1968; Costas and Bordons 2011). The first author contributed most to the work, including conducting research and writing the manuscript (Riesenberg and Lundberg 1990). It was also noticed that the corresponding author supervised the planning and execution of the study and the writing of the paper (Burman 1982). The Y-index is related to important positions which are the first and corresponding authors (Ho 2012; 2014). In general, only one parameter was included in a bibliometric index, for example h-index (Hirsch 2005), g-index (Egghe 2006), A-index (Jin 2006), R-index (Jin et al. 2007), and AR-index (Jin et al. 2007). Y-index could alleviate the problem of increasing multi-authorship and unethical authorship, and provide one reasonable choice to characterize the size and feature of contribution by authors, institutions and countries (Fu and Ho 2014).

This study is concerned with a bibliometric analysis of the Czech Republic's research performance and trends during 1993-2012. The evolvement of Czech scientific research, discipline strength, preferred journals, contributing institutions and countries, research focuses of Czech scientists, and the most productive Czech researchers over the past twenty years was revealed.

MATERIALS AND METHOD

Data for this study were derived from the online version of Science Citation Index Expanded (SCI-EXPANDED), Thomson Reuters Web of Science database (updated on 26 June 2013). All documents with "Czech Republic" in the address field from 1993 to 2012 were found out. In total, 105,103 articles met the selection criteria. As for the document records retrieved, document information included names of authors, title, year of publication, source journals publishing the articles, and contact addresses. All the records were downloaded into Microsoft Excel spreadsheet, and additional coding was manually performed for the origin country and institute of the collaborators and impact factors of the publishing journals as well as distributions of words in title, author keywords, and *KeyWords Plus* in different periods. Besides, the reported impact factor (IF_{2012}) of each journal was obtained from the Journal Citation Reports (JCR) 2012.

The affiliation information has been normalized to reduce the error from Web of Science. Articles originating from England, Scotland, Northern Ireland, and Wales were reclassified as being from the United Kingdom (UK) (Chiu and Ho 2005). A total of 34 articles from

Czechoslovakia and one article affiliated to "Czehc Republic" were (after manual inspection) reclassified as being from the Czech Republic. Three articles from Zaire were recorded as the Democratic Republic of the Congo. Similarly, 11 articles from Hong Kong before 1997 were included in China (Fu et al. 2012). In addition, one article with a mistake in the name of the country "Bra" was checked and found to be Brazil. The contributions from institutions and countries were identified by the appearance of at least one author in the publications. Collaboration type was determined by the affiliations of the authors, where the term "internationally collaborative article" was assigned to those articles that were co-authored by researchers from outside of the Czech Republic. The term "institute independent article" was assigned if the researchers' addresses were from the same institute in the Czech Republic. The term "inter-institutionally collaborative article" was assigned if authors were from different institutes (Li and Ho 2008). In the SCI-EXPANDED database, the corresponding author is designated as the "reprint author"; this study will hereby use the term "corresponding author". In a single author article where authorship is unspecified, the single author is both first and corresponding author (Ho 2014). Similarly, in a single institutional publication, the institution is classified as the first author institution as well as the corresponding author institution.

In the analysis of the productivity of individual researchers, Y-index was used. The construction of the Y-index with two parameters (*j*, *h*) is an attempt to assess both the publication quantity and the characteristic of contribution as a single index. This index is related to the numbers of first author publications (*FP*) and corresponding author publications (*RP*), as defined by (Ho 2014):

$$j = FP + RP \qquad (1)$$

$$h = \tan^{-1}\left(\frac{RP}{FP}\right) \qquad (2)$$

where *j* is a publication performance constant related to publication quantity, and *h* is a publication characteristic which can describe the proportion of *RP* to *FP*. The greater *j* is, the more contribution the analyzed unit makes. Different values of *h* stand for different proportions of corresponding author publications to first author publications. $h > 0.7854$ means more corresponding author publications; $h = 0.7854$ means the same quantity of first author and corresponding author publications; $0 < h < 0.7854$ means more first author publications. When $h = 0$, *j* = number of first author publications, and when $h = \pi/2$, *j* = number of corresponding author publications.

RESULTS AND DISCUSSIONS

Among the 105,103 articles, the series of paper counts were increasing starting with 394 and 2,915 articles in 1993 and 1994 respectively. The annual number of Czech articles ended with 9,256 publications in 2012, with one stagnation only between 1997 and 1998, in both of which 3,722 Czech papers appeared. The sudden change between 1993 and 1994 would be very likely caused by the fact that many Czech publications were still affiliated with Czechoslovakia in 1993, a country that no longer existed at that time. There were still articles affiliated with "Czechoslovakia" appearing in 1993 – 1995 with 3,643 articles in 1993 alone but substantially fewer in 1994 and 1995 (175 and 14, respectively). If two thirds of these articles (considering the population sizes of the Czech Republic and Slovakia) had been added to our data set, they would have constituted only about 2% or

3% of all articles under study not included in our analysis. Omitting the first two years, the compound annual production growth rate was almost 7% in the period under study.

Web of Science Category

Articles matching the search criteria could be found in 175 out of 249 Web of Science subject categories. The most productive categories were multidisciplinary materials science, physical chemistry, and multidisciplinary chemistry, which included more than 5% of all articles each. After these materials science and chemistry categories come biochemistry and molecular biology and condensed matter physics with slightly less than 5% of all articles each. On the other hand, there were categories each of which included less than 0.02% of all articles in our data set – nursing, andrology, robotics, medical ethics, ocean engineering, and primary health care. Most of the top 20 categories in Table 1 had the ratio of $\%TP_{CR}/\%TP$ greater than one, indicating that Czech played a more active publishing role than the rest of the countries in the world in these categories, especially for analytical chemistry, multidisciplinary physics, mathematics, plant sciences, applied mathematics. In summary, the Czech Republic's publications are primarily concerned with "hard" sciences such as materials science, chemistry, and physics, as depicted in Table 1.

Table 1: Top 20 Web of Science Categories of 105,103 Czech Republic's Publications

Web of Science category	TP_{CR}	$\%TP_{CR}$	$\%TP_{CR}/\%TP_{W}$
multidisciplinary materials science	6,734	6.4	1.4
physical chemistry	5,649	5.4	1.4
multidisciplinary chemistry	5,409	5.1	1.5
biochemistry and molecular biology	5,013	4.8	0.90
condensed matter physics	4,786	4.6	1.6
analytical chemistry	4,331	4.1	2.3
multidisciplinary physics	4,165	4.0	1.7
applied physics	4,102	3.9	1.0
Mathematics	3,507	3.3	1.7
plant sciences	3,298	3.1	1.8
applied mathematics	3,091	2.9	1.7
neurosciences	2,714	2.6	0.86
astronomy and astrophysics	2,648	2.5	1.5
atomic, molecular and chemical physics	2,543	2.4	1.5
environmental sciences	2,370	2.3	1.0
oncology	2,232	2.1	0.89
biotechnology and applied microbiology	2,107	2.0	1.0
electrical and electronic engineering	2,091	2.0	0.53
inorganic and nuclear chemistry	2,074	2.0	1.6
polymer science	2,066	2.0	1.3

TP_{CR}: number of total articles in Czech Republic; $\%TP_{CR}$: the percentage of the number of articles of the analyzed category to the total 105,103 Czech Republic articles; $\%TP_{W}$: the percentage of the number of articles of the analyzed category to the total articles in SCI-EXPANDED; $\%TP_{CR}/\%TP_{W}$: the ratio of $\%TP_{CR}$ to $\%TP_{W}$.

From the timeline in Figure 1, all of the top six categories grew with local ups and downs between 1993 and 2012. What is very striking is the decline of multidisciplinary chemistry in the 2000s after its success in the 1990s, contrasted with its revival since 2010. On the other hand, publications on condensed matter physics have declined since 2007.

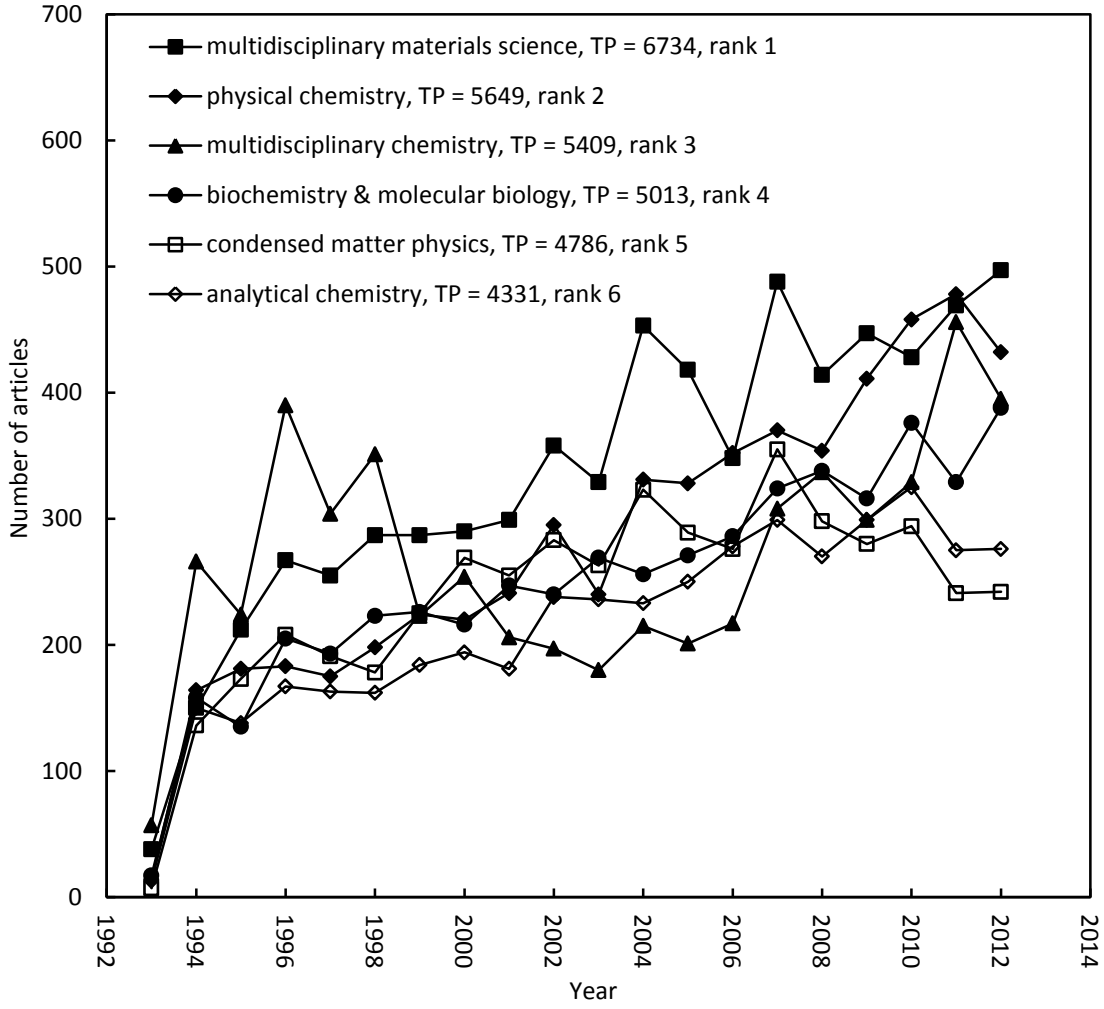

Figure 1: Top Six Web of Science Categories with the Most Published Articles by Czech Republic (TP > 4,300)

Journals

The top 20 journals along with total numbers of papers, percentage shares, and impact factors are listed in Table 2. Nine of the top 20 journals are published in countries other than the Czech Republic – four of them in the Netherlands (*Journal of Chromatography A*, *Physics Letters B*, *Nuclear Instruments & Methods in Physics Research Section A*, *Journal of Magnetism and Magnetic Materials*), two in the United States (*Physical Review B* and *Physical Review Letters* with the highest impact factor of 7.943), and one in France (*Astronomy & Astrophysics*), Sweden (*Neuroendocrinology Letters*), and Slovakia (*Biologia*). However, the top three journals were from Czech, and contributed to 3.5% of all the Czech Republic's publications. These journals are *Collection of Czechoslovak Chemical Communications*, *Chemicke Listy* and *Czechoslovak Journal of Physics* (which was merged

with another journal in 2007). Excluding three of the 11 "Czech" journals having no impact factor, the average impact factor of the other eight Czech journals is 0.767, while the average impact factors of the nine "international" journals is 3.376. As for the rank quartiles of their respective subject categories based on the impact factors, the Czech journals are placed at the boundary of quartiles Q3 and Q4 on average, but the international journals are located within quartile Q2 on average. Thus, with regards to the journals in which the most Czech articles were published, more papers appear in lower-impact Czech journals than in higher-impact international journals.

Table 2: Top 20 Journals Publishing the Czech Republic's Research

Journal Title	TP (%)	IF_{2012}
Collection of Czechoslovak Chemical Communications	1.446 (1.4)	1.000
Chemicke Listy	1.194 (1.1)	0.453
Czechoslovak Journal of Physics	1.008 (1.0)	N/A
Physical Review B	986 (0.94)	3.767
Physiological Research	925 (0.88)	1.531
Ceska A Slovenska Neurologie A Neurochirurgie	924 (0.88)	0.366
Acta Veterinaria Brno	697 (0.66)	0.393
Astronomy & Astrophysics	677 (0.64)	5.084
Physical Review Letters	677 (0.64)	7.943
Folia Microbiologica	646 (0.61)	0.791
Rostlinna Vyroba	605 (0.58)	N/A
Czech Journal of Animal Science	581 (0.55)	0.922
Journal of Chromatography A	549 (0.52)	4.612
Veterinarni Medicina	542 (0.52)	0.679
Listy Cukrovarnicke A Reparske	540 (0.51)	N/A
Physics Letters B	509 (0.48)	4.569
Nuclear Instruments & Methods In Physics Research Section A-Accelerators Spectrometers Detectors and Associated Equipment	486 (0.46)	1.142
Journal of Magnetism and Magnetic Materials	480 (0.46)	1.826
Neuroendocrinology Letters	411 (0.39)	0.932
Biologia	395 (0.38)	0.506

TP: number of total articles; N/A: not available in 2012

Figure 2 presents the evolution of published papers in the top six journals in the last 20 years. The journals could be classified into two main groups. In the first group, there are journals with a relatively stable slight growth (*Physical Review B*, *Physiological Research*, and *Ceska A Slovenska Neurologie A Neurochirurgie*) and in the second group, there are two journals declining in an oscillating way (*Czechoslovak Journal of Physics* and *Collection of Czechoslovak Chemical Communications* are not listed in SCI-Expanded after 2007 and 2012, respectively) and one growing in an oscillating manner (*Chemicke Listy*).

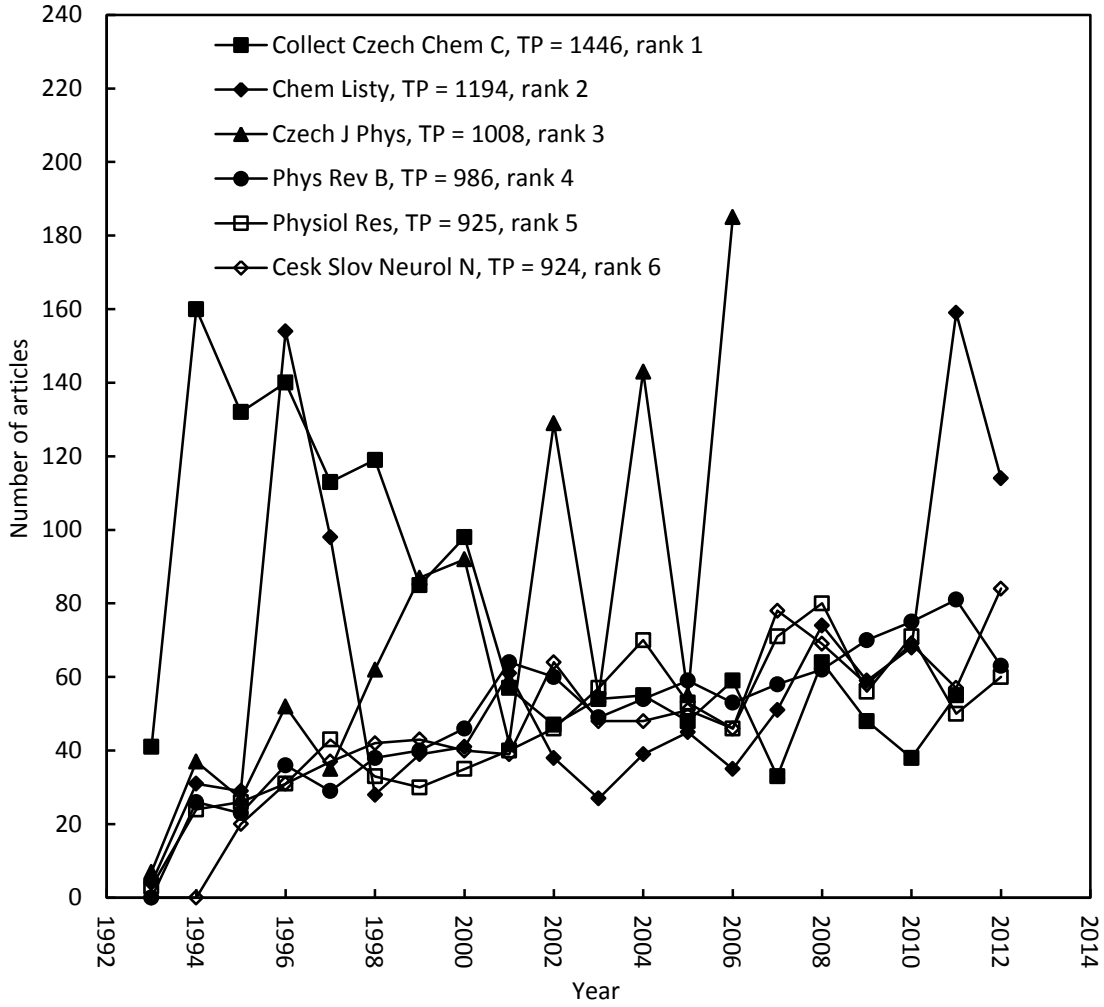

Figure 2: Top Six Journals with the Most Published Articles (TP > 900)

Institutional Contributor

The most productive Czech research institutions in the past 20 years are presented in Table 3. Far and away the best performer is the Academy of Sciences of the Czech Republic with 41,530 publications and a 40% share in the Czech Republic's publications, followed distantly by Charles University in Prague with 26,301 (25%) publications, and Masaryk University in Brno with 7,252 (6.9%) publications. However, the institutions downwards after Masaryk University come much closer to each other and the difference between the university ranked third and the one ranked 20th is only about six percent difference in the production share. Although some basic name unification merged frequently occurring name variants into one (e.g. "Czech Univ Agr", "Czech Univ Life Sci", and "Czech Univ Life Sci Prague" were all considered as the Czech University of Life Sciences), the absolute production numbers may still be inaccurate and prefer referring to the relative shares instead. (Even the "Organization-Enhanced" feature of Web of Science does not help much in this respect because it also contains many errors.) In addition to the overall production of institutions, it is interesting to identify their independent papers (IP), collaborative papers (CP), first author papers (FP), corresponding (or reprint) author papers (RP), and single author (also single affiliation) papers (SP). These absolute numbers along with the corresponding shares in the total production of each institution can be seen in Table 3. A remarkably high share of independent articles (almost 43%) and a complementarily low

share of collaborative articles (about 57%) can be observed with Brno University of Technology. This institution is thus relatively self-sufficient.

On the other hand, the National Institute of Public Health (a non-academic institute) and the University of South Bohemia are not very independent (and very collaborative), because their shares of independent articles are only about 9% and 11%, respectively. Of course, this may relate to the specialties of these institutions as it is well known that medicine and biology fields generally require greater numbers of authors and institutions involved in the production of research papers. This high level of collaboration is further reflected in low percentages of first author articles (about 29% for the National Institute of Public Health and roughly 40% for the University of South Bohemia), corresponding author articles (around 27% and 39%), and (to a smaller extent) single author articles (approx. 1% and 2%), but this last indicator is also very small for some other institutions such as the Institute of Clinical and Experimental Medicine (less than 1%) or the Veterinary Research Institute, the University of Veterinary and Pharmaceutical Sciences, and the Institute of Chemical Technology (always about 2% of single author articles). In contrast, there are two universities, the University of Ostrava and Brno University of Technology, which both have 12% - 13% of single author articles indicating a higher capacity of researching independently.

As far as the most productive universities are concerned, it seems that Charles University is slightly more collaborative than Masaryk University (80% compared to 75%), which, in turn, results in slightly smaller proportions of first author papers, corresponding author papers, and single author papers. As for the research productivity in the individual years, it is visualized in Figure 3 for the top seven institutions. The most notable features are the absolute production growth of almost all institutions, the catching up of Charles University with the Academy of Sciences in recent years, and the relatively slow catching up of the smaller institutions with the top two performers. However, a bias appeared because the Academy of Sciences of the Czech Republic has over many branches in different cities. The branches of Academy of Sciences of the Czech Republic could lead to different results. Similar phenomenon could be found in previous studies, such as Chinese Academy of Sciences (Fu et al. 2011).

Table 3: Top 20 Most Productive Institutions of 105,103 Czech Republic Articles

Rank	Institution	TP (%)	IP (%)	CP (%)	FP (%)	RP (%)	SP (%)
1	Academy of Sciences of the Czech Republic	41,530 (40)	9,214 (22)	32,316 (78)	22,201 (53)	21,588 (52)	2,454 (5.9)
2	Charles University	26,301 (25)	5,186 (20)	21,115 (80)	12,999 (49)	12,366 (47)	1,206 (4.6)
3	Masaryk University	7,252 (6.9)	1,811 (25)	5,441 (75)	3,893 (54)	3,702 (51)	468 (6.5)
4	Czech Technical University	5,691 (5.4)	1,653 (29)	4,038 (71)	2,897 (51)	2,793 (49)	472 (8.3)
5	Institute of Chemical Technology	5,022 (4.8)	1,569 (31)	3,453 (69)	2,984 (59)	2,866 (57)	107 (2.1)
6	Palacky University	4,497 (4.3)	1,163 (26)	3,334 (74)	2,484 (55)	2,478 (55)	305 (6.8)
7	University of South Bohemia	3,404 (3.2)	384 (11)	3,020 (89)	1,369 (40)	1,312 (39)	82 (2.4)
8	Brno University of Technology	2,483 (2.4)	1,059 (43)	1,424 (57)	1,576 (63)	1,563 (63)	297 (12)
9	University of Pardubice	2,463 (2.3)	836 (34)	1,627 (66)	1,608 (65)	1,580 (64)	75 (3.0)
10	University of Veterinary and Pharmac. Sciences	1,716 (1.6)	470 (27)	1,246 (73)	1,076 (63)	1,012 (59)	37 (2.2)
11	Mendel University	1,515 (1.4)	527 (35)	988 (65)	994 (66)	957 (63)	129 (8.5)
12	Czech University of Life Sciences	1,506 (1.4)	500 (33)	1,006 (67)	982 (65)	908 (60)	90 (6.0)
13	University of West Bohemia	1,316 (1.3)	399 (30)	917 (70)	837 (64)	814 (62)	129 (9.8)
14	Technical University of Ostrava	1,304 (1.2)	433 (33)	871 (67)	822 (63)	804 (62)	109 (8.4)
15	Institute of Clinical and Experimental Medicine	906 (0.86)	195 (22)	711 (78)	458 (51)	410 (45)	7 (0.80)
16	Veterinary Research Institute	888 (0.84)	239 (27)	649 (73)	556 (63)	551 (62)	18 (2.0)
17	Czech Geological Survey	752 (0.72)	102 (14)	650 (86)	332 (44)	322 (43)	45 (6.0)
18	University of Ostrava	716 (0.68)	186 (26)	530 (74)	378 (53)	367 (51)	90 (13)
19	National Institute of Public Health	699 (0.67)	64 (9.2)	635 (91)	204 (29)	191 (27)	7 (1.0)
20	Technical University of Liberec	592 (0.56)	178 (30)	414 (70)	315 (53)	308 (52)	49 (8.3)

TP: number of articles; TP%: share in 105,103 articles; IP: institutionally independent articles; CP: inter-institutionally collaborative articles; FP: first author articles; RP: corresponding author articles; SP: single author articles (also single affiliation); IP%, CP%, FP%, RP%, SP%: share in TP in each institution.

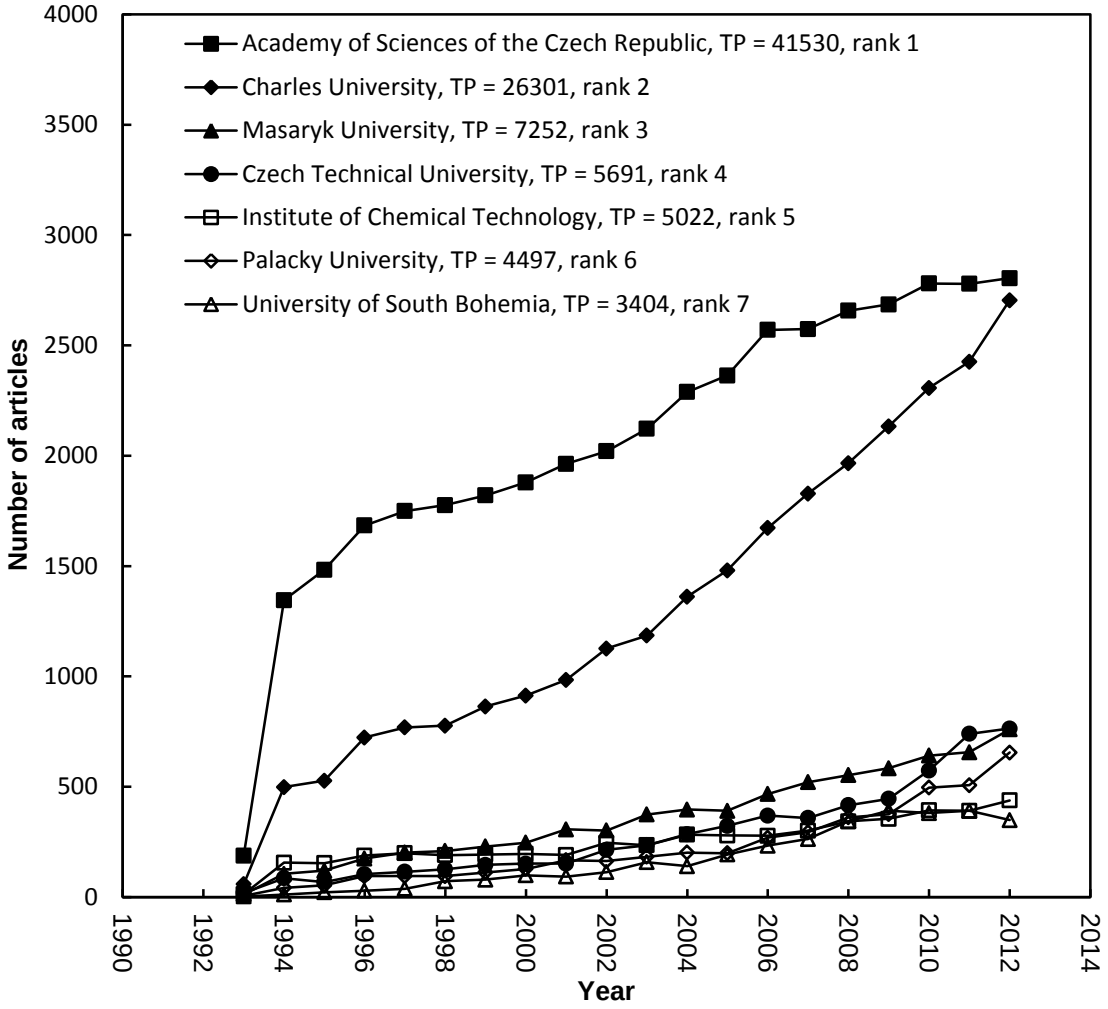

Figure 3: Top Seven Most Productive Institutions in the Czech Republic (TP > 3,000).

National Contributors

The countries most collaborating with the Czech Republic from 1993 to 2012 are shown in Table 4. The top collaborators with more than 5,000 publications are Germany (participating in 12,528 joint publications), United States, and France, followed by the United Kingdom, Italy, and Slovakia, the other successor state of Czechoslovakia. The seven major industrial countries (Canada, France, Germany, Italy, Japan, the UK, and the USA) were ranked in the top 20 countries. Researchers from the first three countries co-authored about 30% of the total Czech scientific production, but each of the further three countries had a substantial share in the research output of the Czech Republic (between 5.0% and 7.0%). Apart from Slovakia, whose presence in the top 20 international collaborators could be expected, there are also three other Eastern European countries including Russia (ranked 7th), Poland (8th), and Hungary (18th). Besides total papers, first author papers and corresponding author papers may both indicate the strength of collaboration. Regarding the first four countries there is no change with Germany retaining its first position having more than 4.0% of its collaborative articles written by a "German" first author or corresponding author, but Italy ranked 5th by total papers drops below Slovakia with nearly 2.0% of its articles authored by its first author or corresponding

author. Similarly, Spain previously ranked 9th falls out of the top 10 and is superseded by Austria and Japan considering the number of first author and corresponding author articles. There are also some other changes in the top 20 rankings by the three indicators, but they do not differ significantly in general.

Table 4: Top 20 International Collaborators for 105,103 Czech Republic's Publications

Rank	Country	TP	TPR (%)	FPR (%)	RPR (%)
1	Germany	12,528	1 (12)	1 (4.2)	1 (4.1)
2	USA	10,990	2 (10)	2 (3.9)	2 (3.8)
3	France	8,460	3 (8.0)	3 (2.3)	3 (2.2)
4	UK	7,365	4 (7.0)	4 (1.9)	4 (1.9)
5	Italy	5,450	5 (5.2)	6 (1.5)	6 (1.5)
6	Slovakia	5,081	6 (4.8)	5 (1.8)	5 (1.9)
7	Russia	4,683	7 (4.5)	7 (1.1)	7 (1.0)
8	Poland	4,603	8 (4.4)	8 (1.0)	8 (1.0)
9	Spain	3,736	9 (3.6)	11 (0.84)	11 (0.84)
10	Netherlands	3,523	10 (3.4)	12 (0.67)	12 (0.65)
11	Switzerland	3,382	11 (3.2)	14 (0.60)	14 (0.61)
12	Austria	3,328	12 (3.2)	9 (0.90)	10 (0.86)
13	Sweden	3,200	13 (3.0)	16 (0.58)	16 (0.55)
14	Japan	3,100	14 (2.9)	10 (0.89)	9 (0.87)
15	Belgium	2,772	15 (2.6)	15 (0.59)	15 (0.58)
16	Canada	2,563	16 (2.4)	13 (0.65)	13 (0.65)
17	China	1,831	17 (1.7)	23 (0.26)	21 (0.27)
18	Hungary	1,813	18 (1.7)	19 (0.31)	20 (0.31)
19	Greece	1,802	19 (1.7)	22 (0.26)	23 (0.25)
20	Finland	1,741	20 (1.7)	17 (0.35)	18 (0.37)

TP: total collaborative articles with Czech Republic; TPR (%): rank of total collaborative articles and percentage of 105,103 articles; FPR (%): rank of first author articles and percentage of 105,103 articles; RPR (%): rank of corresponding author articles and percentage of 101,737 articles (there are 101,737 Czech Republic articles with corresponding author information).

In Figure 4, how the collaboration with the top six collaborative countries evolved over time is illustrated. The collaborative publication with each country has been almost continuously growing since 1993. For Germany alone, the number of publications increased from a few dozens to more than 1,300 between 1993 and 2012. Country ranks remained very stable as well, except for some exchanges between Italy and Slovakia. After revealing publication contributors and sources, a closer look was taken at the contents of these Czech Republic publications and discussed in the following sections.

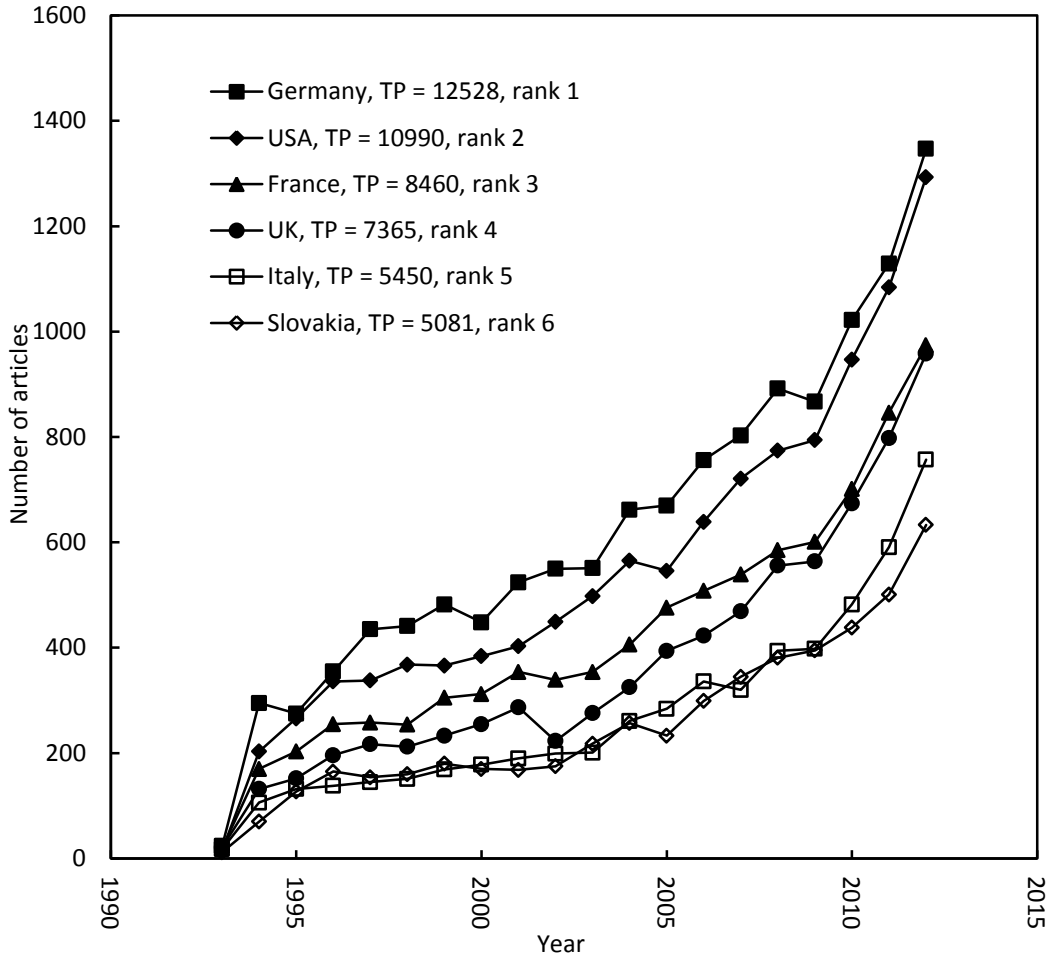

Figure 4: The Czech Republic Collaborative Publication Trends with Top Six Countries (TP > 5,000)

Distribution of title words, author keywords, and *KeyWords Plus*

The title, along with the author keywords, provides a reasonably detailed picture of the article's theme; *KeyWords Plus*, generated independently of the title or author keywords go into far more detail, describing the article's contents with greater depth and variety than only title and author keywords (Garfield 1990). First, the publication titles of Czech articles in the context of the words used in the titles during the whole 20-year period are shown in Table 5. The most frequently used words were "properties", "Czech", "Republic", "structure", "patients", and "determination", which occurred in more than 2,000 (or more than 2% of) article titles each. Further, the whole period was divided into four five-year intervals, and the ranks of title word occurrences were identified to find out how they evolved over time. The question was whether there were clearly visible trends that could reveal something about the topics of Czech Republic articles.

The growing importance of keyword "patients" ranked 42nd in 1993 – 1997, 18th in 1998 – 2002, fifth in 2003 – 2007, and finally third in 2008 – 2012 when it occurred in about 3% of article titles. Similarly, "species" gained significance and climbed from rank 37th in 1993 – 1997 to rank fifth in 2008 – 2012. A spectacular rise and fall can be observed with "films",

which climbed from rank 64th in 1993 – 1997 to rank 12th in the both intervals between 1998 and 2007 but dropped again by 28 places in 2008 – 2012. This fall of articles with "films" in their titles at the turn of the century may be related to the decline of condensed matter physics papers in later years presented in Figure 1.

Table 5: Top 20 Words in Article Titles (out of 105,103 Czech Republic's Publications)

Words in title	TP	93-12 R (%)	93-97 R (%)	98-02 R (%)	03-07 R (%)	08-12 R (%)
properties	3,553	1 (3.4)	1 (2.8)	1 (3.4)	1 (3.4)	2 (3.6)
Czech	3,411	2 (3.2)	7 (1.8)	2 (2.8)	2 (3.4)	1 (3.8)
Republic	2,558	3 (2.4)	20 (1.2)	6 (2.0)	3 (2.6)	4 (2.9)
structure	2,553	4 (2.4)	2 (2.6)	3 (2.8)	4 (2.5)	6 (2.1)
patients	2,414	5 (2.3)	42 (0.93)	18 (1.6)	5 (2.4)	3 (3.0)
determination	2,053	6 (2.0)	3 (2.4)	4 (2.4)	6 (2.0)	14 (1.6)
synthesis	1,995	7 (1.9)	4 (1.9)	5 (2.0)	7 (1.9)	8 (1.8)
model	1,985	8 (1.9)	8 (1.8)	16 (1.6)	8 (1.8)	7 (2.1)
activity	1,882	9 (1.8)	6 (1.8)	9 (1.8)	9 (1.8)	9 (1.8)
species	1,880	10 (1.8)	37 (1.0)	30 (1.2)	10 (1.8)	5 (2.3)
influence	1,850	11 (1.8)	5 (1.9)	11 (1.8)	14 (1.8)	11 (1.7)
cells	1,773	12 (1.7)	13 (1.5)	10 (1.8)	15 (1.7)	13 (1.7)
system	1,743	13 (1.7)	9 (1.6)	12 (1.7)	16 (1.6)	12 (1.7)
magnetic	1,699	14 (1.6)	16 (1.4)	8 (1.8)	12 (1.8)	18 (1.5)
human	1,626	15 (1.5)	18 (1.4)	17 (1.6)	18 (1.6)	15 (1.6)
plasma	1,594	16 (1.5)	27 (1.1)	15 (1.7)	11 (1.8)	20 (1.4)
acid	1,578	17 (1.5)	11 (1.5)	7 (1.9)	19 (1.5)	29 (1.3)
characterization	1,561	18 (1.5)	15 (1.4)	21 (1.5)	17 (1.6)	19 (1.4)
treatment	1,548	19 (1.5)	35 (1.0)	24 (1.4)	24 (1.4)	10 (1.7)
films	1,486	20 (1.4)	64 (0.76)	12 (1.7)	12 (1.8)	36 (1.2)

TP: number of total articles; R: rank

By analogy, the top 20 author keywords in the whole period and the four sub-periods with the occurrence of author keywords, ranks, and shares are listed in Table 6. The most frequent author keywords in the Czech articles from the past 20 years are "Czech Republic", "taxonomy", "rat", "new species", "apoptosis", and "X-ray diffraction", each of which was included in at least 0.5% of articles with author keywords. The ranks of "Czech Republic", "taxonomy", "apoptosis", and "X-ray diffraction" remained quite stable over the years. "Rat" decreased its share from 1.3% to 0.33% of articles and dropped by 20 places from the first position between 1993 – 1997 and 2008 – 2012 and "new species" lost importance between the first two sub-periods with a low of rank 57 in 1998 – 2002 but was finally ranked third in 2008 – 2012. Several of the top 20 author keywords experienced steep growth between the beginning and the end of the 20-year period under study. "Mechanical properties" climbed from rank 253rd to seventh; "Raman spectroscopy" rose from rank 345th to the fourth position; "phylogeny" increasing its rank from 345th to tenth;

and particularly “oxidative stress” gaining over a thousand places to rank eighth and increasing its share by an order of magnitude to 0.46% of articles in 2008 – 2012. Czech scientist, J. Čejka, from the National Museum at Czech, has collaborated with R.L. Frost from the Queensland University of Technology at Australia on the topic related to Raman spectroscopy since 2004, while R.L. Frost was the corresponding author of 63 collaborated articles. This might be one of the reasons for the increasing articles related Raman spectroscopy. Charles University published only one article with oxidative stress as author keywords in 1993-1997, and published 109 articles during the next three sub-periods. Charles University contributed a lot to the higher rank of Oxidative stress in recent years. “Oxidative stress” has also been listed as top author keywords in drinking water field in the past two decades (Fu et al. 2012).

Table 6: Top 20 Author Keywords in Various Periods (70,542 Articles had Author Keywords)

Author keywords	TP	93-12 R (%)	93-97 R (%)	98-02 R (%)	03-07 R (%)	08-12 R (%)
Czech Republic	810	1 (1.1)	2 (0.70)	1 (0.98)	1 (1.2)	1 (1.3)
taxonomy	661	2 (0.94)	3 (0.67)	4 (0.61)	2 (0.78)	2 (1.2)
rat	397	3 (0.56)	1 (1.3)	2 (0.81)	5 (0.54)	20 (0.33)
new species	392	4 (0.56)	19 (0.34)	57 (0.23)	19 (0.35)	3 (0.87)
apoptosis	377	5 (0.53)	16 (0.35)	5 (0.53)	3 (0.66)	6 (0.49)
X-ray diffraction	372	6 (0.53)	14 (0.40)	3 (0.66)	4 (0.60)	11 (0.45)
morphology	324	7 (0.46)	8 (0.51)	25 (0.30)	7 (0.46)	5 (0.51)
crystal structure	298	8 (0.42)	12 (0.43)	7 (0.49)	9 (0.43)	14 (0.39)
mechanical properties	290	9 (0.41)	253 (0.11)	39 (0.27)	6 (0.50)	7 (0.47)
Raman spectroscopy	283	10 (0.40)	345 (0.10)	101 (0.18)	8 (0.46)	4 (0.52)
mass spectrometry	266	11 (0.38)	67 (0.21)	27 (0.29)	13 (0.38)	12 (0.44)
NMR	249	12 (0.35)	34 (0.27)	8 (0.48)	10 (0.42)	37 (0.27)
pig	246	13 (0.35)	6 (0.54)	10 (0.40)	16 (0.37)	35 (0.27)
flow cytometry	246	13 (0.35)	40 (0.26)	14 (0.35)	13 (0.38)	18 (0.34)
oxidative stress	246	13 (0.35)	1052 (0.048)	96 (0.19)	17 (0.36)	8 (0.46)
phylogeny	241	16 (0.34)	345 (0.10)	76 (0.21)	22 (0.33)	10 (0.45)
HPLC	235	17 (0.33)	21 (0.32)	52 (0.24)	17 (0.36)	16 (0.35)
fish	230	18 (0.33)	59 (0.22)	69 (0.22)	23 (0.33)	13 (0.39)
diffusion	215	19 (0.30)	21 (0.32)	23 (0.31)	12 (0.39)	44 (0.24)
microstructure	215	19 (0.30)	253 (0.11)	43 (0.26)	13 (0.38)	22 (0.31)

TP: number of total articles; R: rank

An extension of Table 6 is Table 7, which presents an analysis of *KeyWords Plus* that are associated with 87,918 articles. The most frequent ones in the entire interval from 1993 to 2012 were “expression”, “growth”, and “model”, all of which retained very stable ranks and shares over the years. Some other *KeyWords Plus* occurred more frequently in later years such as “evolution”, “disease”, and “in-vitro”, which were ranked fifth, ninth, and

12th in 2008 – 2012, respectively. Czech science was not statically concerned with some specific topics throughout the past 20 years but evolved based on some patterns shown to some extent in the previous tables.

Table 7: Top 20 *KeyWords Plus* (87,918 articles had *KeyWords Plus*)

KeyWords Plus	TP	93-12 R (%)	93-97 R (%)	98-02 R (%)	03-07 R (%)	08-12 R (%)
expression	2,100	1 (2.4)	4 (1.7)	1 (2.5)	1 (2.5)	1 (2.4)
growth	1,908	2 (2.2)	2 (1.9)	3 (2.3)	2 (2.1)	2 (2.2)
model	1,897	3 (2.2)	1 (2.0)	2 (2.3)	3 (2.0)	3 (2.2)
identification	1,549	4 (1.8)	11 (1.3)	8 (1.4)	4 (1.9)	4 (1.9)
behavior	1,480	5 (1.7)	7 (1.5)	5 (1.6)	5 (1.7)	6 (1.8)
system	1,337	6 (1.5)	10 (1.3)	9 (1.3)	7 (1.6)	7 (1.7)
systems	1,273	7 (1.4)	5 (1.6)	7 (1.5)	9 (1.4)	8 (1.4)
evolution	1,260	8 (1.4)	41 (0.7)	20 (1.0)	8 (1.5)	5 (1.8)
spectroscopy	1,259	9 (1.4)	6 (1.6)	6 (1.6)	10 (1.4)	10 (1.4)
cells	1,214	10 (1.4)	3 (1.8)	4 (1.7)	14 (1.3)	15 (1.2)
derivatives	1,208	11 (1.4)	9 (1.3)	13 (1.1)	6 (1.6)	11 (1.4)
water	1,073	12 (1.2)	21 (1.0)	15 (1.1)	12 (1.3)	14 (1.3)
dynamics	1,055	13 (1.2)	37 (0.77)	10 (1.3)	11 (1.3)	16 (1.2)
temperature	1,037	14 (1.2)	25 (0.88)	15 (1.1)	18 (1.1)	12 (1.3)
disease	1,011	15 (1.1)	59 (0.57)	22 (0.93)	16 (1.2)	9 (1.4)
in-vitro	999	16 (1.1)	190 (0.24)	19 (1.0)	13 (1.3)	12 (1.3)
protein	942	17 (1.1)	12 (1.2)	10 (1.3)	19 (1.1)	24 (0.93)
films	910	18 (1.0)	16 (1.0)	14 (1.1)	21 (1.0)	20 (1.0)
crystal-structure	904	19 (1.0)	54 (0.59)	32 (0.82)	15 (1.2)	17 (1.1)
gene	886	20 (1.0)	28 (0.83)	12 (1.2)	17 (1.2)	28 (0.87)

TP: number of total articles; R: rank

Individual Researchers

In this section, the production of individual researchers was investigated. As for the author analysis, only 101,737 articles with the information of both first author and corresponding author were evaluated by Y-index (Ho 2014). Only 25,715 of the 150,395 authors had both first author and corresponding author articles. In total, 116,488 authors (77% of 150,395 authors) had no first author articles ($h = \pi/2$), 3,240 (2.2%) authors had $\pi/2 > h > 0.7854$, 18,539 (12%) authors had $h = 0.7854$, 3,946 (2.6%) authors had $0.7854 > h > 0$, and 8,192 (5.4%) authors had $h = 0$. Figure 5 displays the distribution of the top 19 authors with $j \geq 160$ (j Cos h and j Sin h are chosen as the x and y coordinate axes). It may be interesting to see which international authors are the most frequent collaborators of Czech researchers. Four of the authors do not seem to be Czech scientists such as V.M. Abazov from Russia, P. Abreu from Portugal, G. Aad from Germany, and S. Chatrchyan from Armenia. Unlike these top international authors, the most productive Czech researcher in terms of all published

papers is not shown in Fig. 5 (M. Lokajicek with a total of 574 articles), because his sum of first author and corresponding author papers is not sufficiently large. The publication characteristic *h* could help obtain the different proportion of corresponding author articles (*RP*) to first author articles (*FP*). Each dot represents one value of Y-index (*j*, *h*) that could be one author or many authors. The authors who contributed the most were V.M. Abazov (*j* = 569) followed by F. Moravec (*j* = 434), E. Makrlik (*j* = 390), P. Abreu (*j* = 379), and G. Aad (*j* = 363).

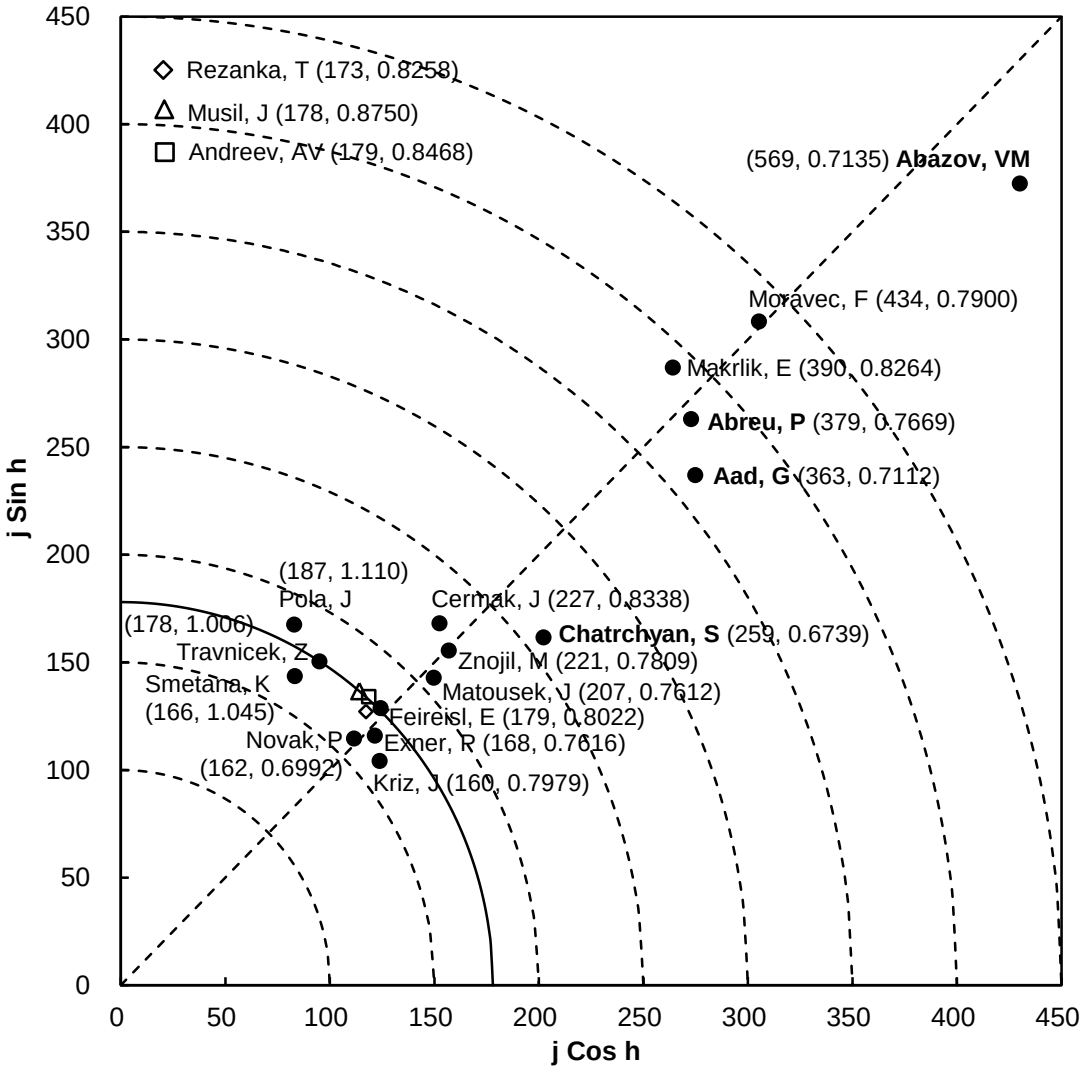

Figure 5: Top 19 Productive Authors with Y-index ($j \geq 160$)

The 1st ranked Abazov published 311 articles including 305 first author articles and 264 corresponding author articles with 11 corresponding affiliations, such as “Joint Inst Nucl Res” in Russia (n = 185), “Univ Buenos Aires” in Argentina (n = 51), “Joint Nucl Res Inst” in Russia (n = 16), “Dubna Joint Nucl Res Inst” in Russia (n = 4), “Joint Inst Nucl Res Dubna” in Russia (n = 2), “Inst Nucl Res” in Russia (n = 1), “Brookhaven Natl Lab” in the USA (n = 1), “Univ Estado Rio de Janeiro” in Brazil (n = 1), “Univ Michigan” in the USA (n = 1), “Univ Alberta” in Canada (n = 1), and “Radboud Univ Nijmegen” in the Netherlands (n = 1). In the 311 articles of V.M. Abazov, the average author number was found to be 499, ranging from

330 to 1,041 authors. Abazov not only published the most articles, first author articles, and corresponding author articles with authors who are in the Czech Republic but also published with a big group of authors from 29 countries in the 311 articles. Abazov has been evolved in group authors of D0 Collaboration, Dzero Collaboration, Tevatron Electroweak Working Group, and ASSIA Collaboration. The 2nd ranked F. Moravec (j = 434) from the Academy of Sciences of the Czech Republic published 276 articles including 216 first author articles and 218 corresponding author articles, 22 of which were written by him as a single author. The 3rd ranked E. Makrlik (j = 390) from the University of West Bohemia in the Czech Republic published 292 articles including 187 first author articles and 203 corresponding author articles, seven of which were single author papers.

The publication characteristic constant h that can help obtain the different proportion of corresponding author articles to first author articles is very helpful, especially when j of authors is the same, to distinguish the different performance of authors. For example, the j of A.V. Andreev and E. Feireisl were both the same of 179. However, h of Andreev was 0.8468 but h of Feireisl was 0.8022. Andreev had a greater proportion of corresponding author articles to first author articles than Feireisl. Similarly, the j of Z. Travnicek and J. Musil were both the same of 178 while h of Travnicek (h = 1.006) was much higher than Musil's (h = 0.8750). Within these 19 authors in Figure 5, there are 11 authors with h > 0.7854, for example J. Pola (h = 1.110), K. Smetana (h = 1.045), and Z. Travnicek (h = 1.006). These authors had more corresponding author articles than first author articles indicating that authors contributing to the articles were more likely to be designated as the corresponding authors. The top productive authors probably contributed more to the initial conception and supervision of research. Eight authors (h < 0.7854) had more first author articles than corresponding author articles, for example S. Chatrchyan (h = 0.6739) and P. Novak (h = 0.6992). These first authors contributed most to the work and writing of the article (Gaeta 1999). A potential bias in the analysis of authorship might occur when different authors have the same name or authors used different names over the time in their publications. One possibility to establish an unambiguous association of each author with his/her articles would be to create an "international publication identity number" that is assigned to each author on the publication of his/her first paper in a Web of Science-listed journal (Chiu and Ho 2007).

CONCLUSIONS AND FUTURE WORK

Independent Czech science has just experienced the first twenty years of its existence after the peaceful breakup of Czechoslovakia in January 1993. However, there have been rather few scientometric studies analyzing the outputs of Czech science and none of them has dealt with the whole 20-year period of the existence of an independent Czech Republic. This study has filled in this gap and bibliometrically investigated the Czech' research performance and trends during the past two decades. Evidence from these 105,103 bibliographic records showed that the annual Czech Republic articles have an increasing trend from the early of 1990s to 2012. The fluctuation of annual production during 1993-1994 could be due to the split of Czechoslovakia in 1993. Czech played more active publication role in materials science, chemistry, and physics, and mathematics. The most productive journals were *Collection of Czechoslovak Chemical Communications*, *Chemicke Listy*, *Czechoslovak Journal of Physics* from Czech, while more than a half of top ten journals were issued from Czech. The contributing Czech journals have higher impact factors than the contributing journals from other countries on average. The most

productive institution was the Academy of Sciences of the Czech Republic with many branches in Czech, while Charles University in Prague followed with a roughly one fourth share in all articles. Czech researchers were more likely to collaborate with Germany, United States, France, United Kingdom, Italy, and Slovakia. “Czech Republic”, “taxonomy”, “apoptosis”, and “X-ray diffraction” were the most frequently used author keywords, while the articles related to “mechanical properties”, “Raman spectroscopy”, “phylogeny”, and “oxidative stress” received an increasing attention. Y-index could measure the proportion of first author and corresponding author papers to all papers published by an individual researcher and graphically presented the productivity of leading Czech researchers based on this indicator. Even though the most prolific Czech author in absolute terms was M. Lokajicek overall, in terms of Y-index the most contributing Czech researchers were F. Moravec, E. Makrlik, and J. Cermak, respectively.

In our future work, we would like to concentrate on the citation analysis of Czech publications indexed in the Science Citation Index Expanded in 1993 – 2012, and on the analysis of science in Slovakia in the first twenty years of its independence. It would also be interesting to compare Czech and Slovak science and their different development in those recent twenty years after the dissolution of Czechoslovakia.

ACKNOWLEDGEMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

Bajerski, A. and Siwek, T. 2012. The bibliometric analysis of Czech geography in the Scopus database. *Geografie*, Vol.117, no.1: 52-71.

Bencetić Klaić, Z. and Klaić, B. 2004. Croatian scientific publications in top journals according to the Science Citation Index for the 1980-2000 period. *Scientometrics*, Vol.61, no.2: 221-251.

Bennett, D.M. and Taylor, D.M. 2003. Unethical practices in authorship of scientific papers. *Emergency Medicine*, Vol.15, no.3: 263-270.

Braun, T. and Schubert, A. 1996. Indicators of research output in the sciences from 5 Central European countries, 1990-1994. *Scientometrics*, Vol.36, no.2: 145-165.

Braun, T., Glänzel, W. and Grupp, H. 1995. The scientometric weight of 50 nations in 27 science areas, 1989-1993. Part I. All fields combined, mathematics, engineering, chemistry and physics. *Scientometrics*, Vol.33, no.3: 263-293.

Braun, T., Glänzel, W., MacZelka, H. and Schubert, A. 1994. World science in the eighties. National performances in publication output and citation impact, 1985-1989 versus 1980-1984: Part I. All science fields combined, physics, and chemistry. *Scientometrics*, Vol.29, no.3: 299-334.

Burman, K.D. 1982. Hanging from the masthead - Reflections on authorship. *Annals of Internal Medicine*, Vol.97, no.2: 602-605.

Chiu, W.T. and Ho, Y.S. 2005. Bibliometric analysis of homeopathy research during the period of 1991 to 2003. *Scientometrics*, Vol.63, no.1: 3-23.

Chiu, W.T. and Ho, Y.S. 2007. Bibliometric analysis of tsunami research. *Scientometrics*, Vol.73, no.1: 3-17.

Cole, S. and Phelan, T.J. 1999. The scientific productivity of nations. *Minerva*, Vol.37, no.1: 1-23.

Costas, R. and Bordons, M. 2011. Do age and professional rank influence the order of authorship in scientific publications? Some evidence from a micro-level perspective. *Scientometrics*, Vol.88, no.1: 145-161.

De Moya-Anegón, F. and Herrero-Solana, V. 1999. Science in America Latina: A comparison of bibliometric and scientific-technical indicators. *Scientometrics*, Vol.46, no.2: 299-320.

Dotson, B. and Slaughter, R.L. 2011. Prevalence of articles with honorary and ghost authors in three pharmacy journals. *American Journal of Health-System Pharmacy*, Vol.68, no.18: 1730-1734.

Egghe, L. 2006. Theory and practise of the g-index. *Scientometrics*, Vol.69, no.1: 131-152.

Fiala, D. 2013. Science Evaluation in the Czech Republic: The Case of Universities. *Societies*, Vol.3, no.3: 266-279.

Fu, H.Z. and Ho, Y.S. 2014. Top cited articles in adsorption research using Y-index. *Research Evaluation*, Vol. 23 (1), no.: 12-20.

Fu, H.Z., Chuang, K.Y., Wang, M.H. and Ho, Y.S. 2011. Characteristics of research in China assessed with Essential Science Indicators. *Scientometrics*, Vol.88, no.3: 841-862.

Fu, H.Z., Wang, M.H. and Ho, Y.S. 2012. The most frequently cited adsorption research articles in the Science Citation Index (Expanded). *Journal of Colloid and Interface Science*, Vol.379, no.1: 148-156.

Fu, H.Z., Wang, M.H. and Ho, Y.S. 2013. Mapping of drinking water research: A bibliometric analysis of research output during 1992-2011. *Science of the Total Environment*, Vol.443, no.: 757-765.

Gaeta, T.J. 1999. Authorship: "law" and order. *Academic Emergency Medicine*, Vol.6, no.4: 297-301.

Gálvez, A., Maqueda, M., Martínez-Bueno, M. and Valdivia, E. 2000. Scientific publication trends and the developing world. *American Scientist*, Vol.88, no.6: 526-533.

Garfield, E. 1990. KeyWords Plus: ISI's breakthrough retrieval method. Part 1. Expanding your searching power on Current Contents on Diskette. *Current Contents*, Vol.32, no.: 5-9.

Glänzel, W. 2000. Science in Scandinavia: A bibliometric approach. *Scientometrics*, Vol.48, no.2: 121-150.

Glänzel, W., Leta, J. and Thijs, B. 2006. Science in Brazil. Part 1: A macro-level comparative study. *Scientometrics*, Vol.67, no.1: 67-86.

Gorraiz, J., Reimann, R. and Gumpenberger, C. 2012. Key factors and considerations in the assessment of international collaboration: A case study for Austria and six countries. *Scientometrics*, Vol.91, no.2: 417-433.

He, B., Ding, Y. and Yan, E.J. 2012. Mining patterns of author orders in scientific publications. *Journal of Informetrics,* Vol.6**,** no.3: 359-367.

Hirsch, J.E. 2005. An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America*, Vol.102, no.46: 16569-16572.

Ho, Y.S. 2012. Top-cited articles in chemical engineering in Science Citation Index Expanded: A bibliometric analysis. *Chinese Journal of Chemical Engineering*, Vol.20, no.3: 478-488.

Ho, Y.S. 2014. Classic articles on social work field in Social Science Citation Index: A bibliometric analysis. *Scientometrics*, Vol.98, no.1: 137-155.

Jin, B.H. 2006. h-index: An evaluation indicator proposed by scientist. *Science Focus*, Vol.1, no.1: 8-9.

Jin, B.H., Liang, L.M., Rousseau, R. and Egghe, L. 2007. The R- and AR-indices: Complementing the h-index. *Chinese Science Bulletin*, Vol.52, no.6: 855-863.

Konvalinka, J., Illnerova, H., Hobza, P., Horejsi, V., Holy, A., Jungwirth, P., Paces, V., Martasek, P. and Zlatuska, J. 2009. Czech bibliometric system fosters mediocre research. Nature, Vol.460, no.7259: 1079

Kristapsons, J. and Tjunina, E. 1995. Changes in Latvia's science indicators in the transformation period. *Research Evaluation*, Vol.5, no.2: 151-160.

Li, Z. and Ho, Y.S. 2008. Use of citation per publication as an indicator to evaluate contingent valuation research. *Scientometrics*, Vol.75, no.1: 97-110.

Luna-Morales, M.E. 2012. Determinants of the maturing process of the Mexican research output: 1980-2009. *Interciencia*, Vol.37, no.10: 736-742.

Martin, B.R. 1994. British science in the 1980s - has the relative decline continued? *Scientometrics*, Vol.29, no.1: 27-56.

Radosevic, S. and Auriol, L. 1999. Patterns of restructuring in research, development and innovation activities in Central and Eastern European countries: An analysis based on S&T indicators. *Research Policy*, Vol.28, no.4: 351-376.

Riesenberg, D. and Lundberg, G.D. 1990. The order of authorship – Who's on first. JAMA-*Journal of the American Medical Association*, Vol.264, no.14: 1857

Sancho, R., Bernal, G. and Gálvez, L. 1993. Approach to the Cuban scientific activity by using publication based quantitative indicators (1985-1989). *Scientometrics*, Vol.28, no.3: 297-312.

Schubert, A., Glänzel, W. and Braun, T. 1989. Scientometric datafiles. A comprehensive set of indicators on 2649 journals and 96 countries in all major science fields and subfields 1981-1985. *Scientometrics*, Vol.16, no.1-6: 3-478.

Singh, S. 2009. Criteria for authorship. *Indian Journal of Dermatology*, Vol.75, no.2: 211-213.

Slone, R.M. 1996. Coauthors' contributions to major papers published in the AJR: Frequency of undeserved coauthorship. *American Journal of Roentgenology*, Vol.167, no.3: 571-579.

Vaněček, J. 2008a. Bibliometric analysis of the Czech research publications from 1994 to 2005. *Scientometrics*, Vol.77, no.2: 345-360.

Vaněček, J. 2008b. Patenting propensity in the Czech Republic. *Scientometrics*, Vol.75, no.2: 381-394.

Vaněček, J. 2013. The effect of performance-based research funding on output of R&D results in the Czech Republic. *Scientometrics*, Vol.98, no.1: 657-681.

Vaněček, J., Fatun, M. and Albrecht, V. 2010. Bibliometric evaluation of the FP-5 and FP-6 results in the Czech Republic. *Scientometrics*, Vol.83, no.1: 103-114.

Wilson, C.S. and Markusova, V.A. 2004. Changes in the scientific output of Russia from 1980 to 2000, as reflected in the Science Citation Index, in relation to national politico-economic changes. *Scientometrics*, Vol.59, no.3: 345-389.

Zhang, H. and Zhang, Y. 1997. Scientometric study on research performance in China. *Information Processing and Management*, Vol.33, no.1: 81-89.

Zuckerman, H.A. 1968. Patterns of name ordering among authors of scientific papers: A study of social symbolism and its ambiguity. *American Journal of Sociology*, Vol.74, no.3: 276-291.