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Comparative Analysis of University Publication Activity by Google Scholar (On Example of Leading Czech and Germany Universities)

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Abstract

With the help of the Google Scholar search engine, we have studied in detail the aggregated publication structure of the leading universities in the Czech Republic and Germany. We have also classified these structures and identified structural changes in them for German universities. These shifts have been observed in the Free University of Berlin and Humboldt University, and they all occurred within 5 years in the first decade of the 21st century when the major university publication activity moved from the sphere of medical research to the area of social sciences and humanities. Prospects for further research are in the comparative analysis of university publication activities with the help of Web of Science, Scopus and Google Scholar facilities.

Keywords

university publication activity, publication structures, Google Scholar, Czech Universities, German Universities, changes in publication structures

Introduction

Google Scholar (GS) search engine has recently been regarded as an alternative scientometric tool. One of the firsts to have noticed the possibility to use the GS for assessment of publication activity and citation were: Bauer & Bakkalbasi (2005), Jacsó (2005) and Norouzi (2005). The cluster publications consisting of scientific papers that use this tool made up 340 publications (as of July 2, 2011), this cluster having been determined by using GS advance search with the keyword "Google Scholar" being printed in the browser "with exact phrase" looking for this keyword in titles of articles (with an additional option "at least summaries"). The core publication in this cluster is a paper by Jacsó (2005), who has been cited 159 times. But in this cluster publication there is no single work on university publication activity, except an article by Moskovkin (2009). Let's note that there can be many papers about GS, still Google Scholar doesn't have to appear in the titles. (Aguillo, 2011; Bar-Ilan, Levene and Lin 2007; Kousha, Thelwall and Rezaie, 2010). In this extended publication cluster can be found articles on university publication activity (with option "anywhere in the article") which may be identified with help of operator "site:universitydomain" in GS (for example, Aguillo, 2011).

Google Scholar is still treated with suspicion by both librarians and scientists. For the former, it is a potential threat to lose a budget to buy traditional citation database in case scientists stop using them. For the latter, it is a deep-rooted tradition habit to work with those traditional citation databases, and those who do bibliometric and scientometric studies are still doing research to compare the search possibilities of GS with other databases.

In the most recent and complete review by Walters (2011), we found about 50 references to publications having Google Scholar in their titles, and most of them were about such comparisons. By the way, GS engine at the moment finds 351 papers having Google Scholar "in the title of article" ("with the exact phrase", "at least summary", as of 30 September, 2011).

One can see that all the above mentioned papers, included in the review (Walter 2011) are also part of the GS-publication cluster, generated by the term "Google Scholar".

Mayr and Walter (2007), noted "that GS provided thorough coverage of the journals covered by Social Sciences Citation Index (81%), Science Citation Index (86%), and Art and Humanities Citation Index (81%)."

Studies have shown that GS is effective not only in terms of covering ISI Web of Science, but also in terms of citation counts and ranking (Mikki, 2010; Pauly & Stergiou, 2005; Meho & Yang, 2007; Bar-Ilan, Levene & Lin, 2007). The same can be said about its use for the calculation of h-index (Vanclay, 2007; Bar-Ilan, 2008; Mikki, 2010).

An interesting example of the effectiveness of subject search in GS is given by Haya, Nygren & Widmark (2007) comparing GS with Metalib (a federated search tool representing more than 200 databases available at Stockholm University), thanks to the help of thirty two undergraduates working with them, chiefly in the social sciences. The study showed that on average, the students found more than twice as many relevant documents in GS than in Metalib. This raises the question: After this, is there a necessity for university subscription databases?

Our analysis of the GS-publication cluster, generated by the term "Google Scholar" has shown that, currently various studies have been conducted by tests with the help of GS Journals, terms, subject areas and authors. At the same time there are no articles on the testing of university names, with the exception of some of our publications (Moskovkin, 2009; Moskovkin & Delux, 2009). They show that in order to calculate the publications of university researchers, there must be a clear indication of the generally recognized name of the university and consequentially test them in line "with exact phrase" with restrictions on the time period and subject areas. Our calculations using the GS for the first nine universities in Taiwan Ranking-2007 and Moscow university in comparison with databases SCI and SSCI, showed that the GS returns between 1.6 (Moscow University) and 39.2 (Cambridge University) times more results than SCI and SSCI (Moskovkin & Delux, 2009).

We now will characterize on the university systems in Germany and the Czech Republic, basing on the data published by the scientists of

those universities.

The Czech University sector is made up of 24 institutions (321,247 students) and includes public universities only. The Czech non-university-sector is made up of 48 institutes (53,528 students). Thus, the non-university sector comprises little more than 20% of the total size of the Czech higher education in terms of student numbers (as of December 2008, cited from Pabian (2010)). Within the Czech higher education sector, the major difference between non-university and university HEIs (Higher Education Institutes) is in the level of degree programs from bachelor to doctorate level they offer, while non-university institutions offer only bachelors and master programs (Pabian, 2010). Note that the webometric rating of Czech universities cover all universities and part of the non-universities HEIs (**www.webometrics.info**).

The German higher education system currently comprises some 350 HEIs, state and state-approved, including the following types of institutions: (1) universities, (2) universities of applied sciences (UAS), (3) colleges of education, and (4) academies of fine arts. The largest groups according to the number of students are UASs (184) and universities (109). 1.4 million students study at universities and 0.5 million at UASs (Kulicke & Stahlecker, 2010). Note that the webometric ranking of German universities cover all universities and UASs.

The total expenditures of the UAS on R&D in the year of 2005 amounted to 3,673 million Euros, and expenses of universities – 8.3 billion Euros. To compare, we would like to note that between 2002 and 2006 Czech non-university institutions received 16.8 million CZK (649,000 Euros) of research public funding while public universities received more than 20 billion CZK (773 million Euros). So we can see that German university system gets one-two times more funding than the Czech university system.

Regarding the bibliometric pattern of Czech and German research, with the help of GS we were able to find only 2 publications. The first publication, published by Vanacek (2008), is a bibliometric analysis of Czech research publications from 1994 to 2005 comparing with those from Austria, Hungary, Poland, Finland, Ireland and Greece on the basis of Web of Science databases. Among these countries, the Czech Republic came the 5th and 6th in terms of publication activity and citations. Relatively the most cited were Czech papers in the field of Engineering and Mathematics ranked third, and Computer Science, Environment & Ecology and Molecular Biology ranking fourth among the 7 EU countries. Even though the Czech R&D increased more than 5 times from 106 to almost 580 million euro (Vanacek, 2008) in the given period, the lion's share of these funds went to financing the Academy of Sciences of the Czech Republic. The same situation, as it is well known, can be observed starting from 2005 up to present, which results in a fairly low publication activity of university scientists in comparison with the scientists from the Academy of Sciences.

The second publication, by Mittermaier (2010), using the Web of Science database, studied the publication activity and citing behaviour of researchers from nine German technological universities. The work was completed within FP7 and unlike the previously mentioned work, it blends well in the context of our research. In Germany the **IFQ** is in charge of publishing bibliometric reports.

The objectives of this paper is to build and classify university publication structures, as well as, to identify their structural changes by example of the leading universities in the Czech Republic and Germany.

Methods

When using GS, university publication structure is constructed as a matrix of publications **(N_{ij})** of dimension **n*m**, where N_{ij} - the number of responses (publications) for the i-th university and the j-th subject area, n - number of universities, m = 7 – number of GS subject areas.

The number of responses has been determined by tests in the advance search of all the characteristic names of the university (in a national and English languages) being printed in the browser "with exact phrase" with a restriction on the time interval except patents. In this case, it is possible to choose an option of including a citation or at least summaries.

Based on this matrix, we can clearly find a specialized subject area and the number of publications in it: $\max_j\{N_{ij}\}$, whereas the proportion of specialized publications for the i-th university is determined by the formula:

$$\rho^i_{spec} = \max_j\{N_{ij}\} / \sum_{j=1}^{7} N_{ij}$$

On the basis of these matrices it is possible to construct aggregated publication matrix **($\tilde{N}_{ij}$)** of dimension n*mtilde, where $\tilde{N}_{ij}$ - quantity of responses for the i-th university and j-th aggregated subject area, n - quantity of university, mtilde=3 - quantity of aggregated subject areas.

The way how aggregated subject areas correspond to Google Scholar subject areas is given in Table 1.

Table 1. Conformity aggregated subject areas to Google Scholar subject areas

Aggregated subject areas	Google Scholar subject areas
Science & Engineering, excluding Life Sciences (**S&E**)	Chemistry and Materials Science (**CHEM**); Engineering, Computer Science and Mathematics (**ENG**); Physics, Astronomy and Planetary Science (**PHYS**)
Life Sciences (**LS**)	Biology, Life Sciences and Environmental Science (**BIOL**); Medicine, Pharmacology and Veterinary Science (**MED**)
Social Sciences & Humanities and Economics (**SSH**)	Business, Administrations, Finance and Economics (**BUS**); Social Sciences, Arts and Humanities (**SOC**)

On the basis of the matrix **$\tilde{N}_{ij}$** we built formalized types of aggregated publication structures for the given set of universities. Mathematical description of the aggregated publication structure may be written, for example, by inequality system: $\rho_{S\&E} > \rho_{LS} > \rho_{SSH}$, where ρ - share of publications attributable to one of the aggregated subject areas. Note that this inequality system is true for the classical university with a traditional structure of scientific research. Note that the matrices (N_{ij}) and ($\tilde{N}_{ij}$) can be constructed on any bounded time interval, a multiple of one year.

GS algorithm correlates publications of the requested university with that university and the time of the publication, in the case when the publications metadata is well structured. This, first and fore most, relates to the journal entered in Web of Science and SCOPUS and placed on online platforms by their publishers. At the same time the presence of the section "Related articles" on these platforms may result in mistakes in the dates of the requested articles.

GS generates wrong responses for the sources of information, in which on the first page the author(s) is not linked with his (their) place of work. Here it is possible that it randomly takes the name of organizations mentioned in the text of the article.

The algorithm GS-sorting into subject categories is probably based on the information and search thesaurus, as mentioned in the introduction. Namely, every subject category corresponds to a set of terms (key words), which constantly increase. With each new request with specific subject areas, GS-sorting algorithm compares key words of requested articles with their (divided into subject categories) terminology set.

The reason we chose to study German and Czech universities is associated with the similar university traditions. For example, Charles University in Czech Republic is the first German university and the oldest university in Central and Eastern Europe (founded in 1348).

The publication structures were built on the entire time interval (from the appearance of the first digitized publications to the year 2010), as well as, on the yearly time interval with 5 year intervals (1990, 1995, 2000, 2005, 2010). In later case we were able to study the transformation of the publication structures in time.

Results and Discussion

On the basis of webometric Ranking of World Universities (July 2010), we selected the top 10 universities in the Czech Republic and Germany, which were tested using the search engine Google Scholar for their publication activity in the seven subjects areas (Table 1). For Czech universities to test their English and Czech names using the advanced search with the exact phrase and with a restriction on the time interval (from the beginning of the first digitized publications up to 2010 inclusive) in exclusion of patents. We used option "article plus citation".

In both cases (the authors of the positioning of names of their universities both in English and in Czech language) GS provides responses mainly on the English-language publication, whereas publication of universities in Czech names accounted for only 2,2% of publications with English names. For all Czech universities, the figure was approximately the same level, with the exception of the Technical University Ostrava: responses to the English name "Technical University Ostrava" consists of 621, and to the Czech name "Technická Univerzita Ostrava" consists of 172 responses, the share of Czech names is 27,7%. Experiments were conducted in the period from 25.10.2010 till 15.11.2010. Total responses are presented in a matrix of publications (N_{ij}) of dimension n*m = 10x7 (Table 2).

Table 2 Matrix of publications of the leading Czech universities in subject areas (experiments with search engine Google Scholar, 25.10.2010-15.11.2010)

University	BIOL	BUS	CHEM	ENG	MED	PHYS	SOC	Total	%
Charles University	7,249	3,139	8,977	10,170	13,451	10,118	8,587	61,691	52.45%
Masaryk University	2,819	932	2,956	3,816	3,536	1,782	7,025	22,866	19.44%
Czech Technical University	212	324	1,343	7,543	194	3,226	542	13,384	11.38%
University of West Bohemia	24	95	425	1,901	36	231	264	2,976	2.53%
University of Technology Brno	50	20	142	498	58	65	30	863	0.73%
Palacky University	1,379	78	928	1,237	1,698	974	698	6,992	5..95%
University of Economics Prague	5	1,300	2	308	7	3	249	1,874	1.59%
University of South Bohemia	2,399	84	231	59	222	99	230	3,324	2.83%
Technical University Ostrava	9	59	283	284	2	103	53	793	0.67%
Institute of Chemical Technology Prague	562	29	1,889	117	56	140	53	2,846	2.42%
Sum	**14,708**	**6,060**	**17,176**	**25,933**	**19,260**	**16,741**	**17,731**	**117,609**	**100%**

As we can see from the matrix, more than 50% of the publications of the ten leading Czech universities accounted for Charles University - the oldest and the best Czech university.

The most significant areas reflected in publications at this university are Science & Engineering, and therefore the most research is done in the sphere of Science & Engineering. Based on this matrix, we can determine some aggregated publication structures in Czech universities (Table 3).

Table 3. Aggregated publication structures of the leading Czech universities

University	BIOL+MED		CHEM+ENG+PHYS		BUS+SOC		Total	
Charles University	20,700	33.55%	29,265	47.44%	11,726	19.01%	61,691	100.00%
Masaryk University	6,355	27.79%	8,554	37.41%	7,957	34.80%	22,866	100.00%
Czech Technical University	406	3.03%	12,112	90.50%	866	6.47%	13,384	100.00%
University of West Bohemia	60	2.02%	2,557	85.92%	359	12.06%	2,976	100.00%
University of Technology Brno	108	1.51%	705	81.69%	50	5.79%	863	100.00%
Palacky University	3,077	44.01%	3,139	44.89%	776	11.10%	6,992	100.00%
University of Economics Prague	12	0.64%	313	16.70%	1,549	82.66%	1,874	100.00%
University of South Bohemia	2,621	78.85%	389	11.70%	314	9.45%	3,324	100.00%
Technical University Ostrava	11	1.39%	670	84.49%	112	14.12%	793	100.00%
Institute of Chemical Technology Prague	618	21.71%	2,146	75.40%	82	2.88%	2,846	100.00%
Sum	33,968	28.88%	59,850	50.89%	23,791	20.23%	117,609	100.00%

As we can see from this table, Science & Engineering, except Life Sciences, are the most substantially represented in all technical universities and the University of West Bohemia (more than 75% of publications). More than 35% of the publications of this profile were prepared in classical universities, such as Charles, Masaryk and Palacky universities. Over 30% of publications in the field of biomedical research were recorded at Charles and Palacky universities, as well as at the University of South Bohemia, where the percentage of such publications reached 79%. Among classical universities, the biggest number of socio-economic and humanitarian publications was prepared at Masaryk University (34.8%). Formalized types of aggregated publication structures obtained on the basis of the above table are presented in Table 4.

Table 4. Formalized types of aggregated publication structures of the leading Czech universities

No.	Mathematical description of the aggregated publication structures	Czech Universities
1.	$\rho_{S\wedge E}>\rho_{LS}>\rho_{SSH}$	Charles University
2.	$\rho_{S\wedge E}>>\rho_{LS}>\rho_{SSH}$	University of Technology Brno, Institute of Chemical Technology Prague
3.	$\rho_{S\wedge E}>>\rho_{SSH}>\rho_{LS}$	University of West Bohemia, Czech technical University, Technical University Ostrava
4.	$\rho_{S\wedge E}>\rho_{SSH}>\rho_{LS}$	Masaryk University
5.	$\rho_{S\wedge E}\approx\rho_{LS}>\rho_{SSH}$	Palacky University
6.	$\rho_{LS}>>\rho_{S\wedge E}>\rho_{SSH}$	University of South Bohemia
7.	$\rho_{SSH}>>\rho_{S\wedge E}>0$	University of Economics Prague

Notes: ρ- share of publication in the relevant aggregated subject area; >> - for 75%; ≈ - the approximate equality with 1% accuracy; 0 - with 1% accuracy.

From Table 4, we can see that for classical universities, for which the first type of aggregated publication type is customary, only Charles University was included in this structure type. We have determined quite a large variety of aggregated publication structure types. Very specific types of such structures have been recorded at the classical University of South Bohemia (with biomedical publications prevailing) and Palacky University (the number of S&E (except Life Sciences) publications equaling biomedical publications).

Now let's look at the publication dynamics of the universities under study since 1990, with a five-year step. This dynamics has been

observed thanks to the experiments with the GS (advanced search with an exact phrase containing an English name of a university) (Table 5).

We have determined the total (total number of responses in seven subject areas) and specialized (the number of responses in the leading subject area) number of publications, as well as their increase in twenty-year period. This increase for an i-university is determined by the formula

$$k=N_{i2010}/N_{i1990}$$

where $N_{i1990}\neq 0$. If $N_{i1990}=0$, then we considered the earliest year when the number of publications was above zero.

The most even distribution of publications among subject areas in 2010 was observed at Charles University and Palacky University (the lowest percentage of specialized publications), and the highest percentage of specialized publications was recorded for technical universities: the Economic University in Prague and the University of South Bohemia. The names of the specialized subject areas correspond to $\mathbf{max_j\{N_{ij}\}}$ in the matrix of publications of the leading Czech universities in subject areas (Table 2). For example, for Charles University $max_j\{N_{ij}\}=N_{15}=13,451$, for the University of South Bohemia $max_j\{N_{ij}\}=N_{81}=2,399$. In the first case, these specialized areas were medicine, pharmacology and veterinary science, in the second case they were biology, life sciences and the environmental science. By analyzing the absolute growth of total and specialized publications in all universities (Table 5), we can notice the following **regularity**:

$$k_{spec}>k_{tot} <=> (\rho_{spec})_{1990}<(\rho_{spec})_{2010}$$

$$k_{spec}<k_{tot} <=> (\rho_{spec})_{1990}>(\rho_{spec})_{2010}$$

where k_{spec}, k_{tot} are calculated using the following formula

$$k=N_{i2010}/N_{i1990}$$

where N is the total and specialized number of publications

If $(\rho_{spec})_{1990}=0$, then we consider the earliest year when the number of specialized publications was above zero.

Table 5. Dynamics of the publication of the leading Czech universities (experiments with search engine Google Scholar, March 30, 2011)

University	1990			1995			2000			2005			2010			Absolute Growth (%)	
	Total	Specialised		Total	Specialised		Total	Specialised		Total	Specialised		Total	Specialised		Total	Specialised
		Amount	%		Amount	%		Amount	%		Amount	%		Amount	%		
Charles	834	163	19.5%	1,250	182	14.6%	2,260	585	25.9%	3,540	910	25.7%	4,830	1,240	25.7%	5.79	7.61
Masaryk	91	19	20.9%	404	133	32.9%	1,120	207	18.5%	1,490	426	28.6%	2,180	636	29.2%	23.96	33.47
Czech Technical	60	30	50.0%	267	137	51.3%	502	289	57.6%	981	597	60.9%	1,330	615	46.2%	22.17	20.50
West Bohemia	0	0	0.0%	27	15	55.6%	102	68	66.7%	214	135	63.1%	382	216	56.5%	14.15	14.40
Technology Brno	0	0	0.0%	0	0	0.0%	12	6	50.0%	67	40	59.7%	117	68	58.1%	9.75	11.33
Palacky	109	40	36.7%	100	26	26.0%	370	162	43.8%	443	132	29.8%	735	165	22.4%	6.74	4.13
Economics Prague	1	1	100.0%	9	6	66.7%	120	102	85.0%	164	105	64.0%	197	125	63.5%	197.00	125.00
South Bohemia	1	1	100.0%	27	20	74.1%	122	89	73.0%	289	200	69.2%	459	334	72.8%	459.00	334.00
Technical Ostrava	0	0	0.0%	10	5	50.0%	24	13	54.2%	48	21	43.8%	63	24	38.1%	6.30	4.80
Chemical Technology	36	13	36.1%	46	21	45.7%	68	48	70.6%	128	90	70.3%	289	203	70.2%	8.03	15.62
Sum	1,132	267	23.6%	2,140	545	25.5%	4,700	1,569	33.4%	7,364	2,656	36.1%	10,582	3,626	34.3%	9.35	13.58

Considering Charles University, we can see that the growth rate of specialized publications exceeded the growth rate of the total number of publications: $k_{spec}=7.64 > k_{tot}=5.79$, which implies that the share of specialized publications in 1990 was below the level of 2010: $(\rho_{spec})_{1990}=19.5\% < (\rho_{spec})_{2010}=25.7\%$.

In general, for all the universities under study, the share of specialized publications for the twenty-year period rose from 23.6% to 36.1%. Thanks to the calculations made and recorded in Table 5, we can clearly observe the stabilization time for the share of specialized publications with a five-year interval accuracy. For Charles University it was 2000, for Masaryk University - 2005, for The Technological University of Brno - 2005, for The Economic University of Prague - 2005, for The University of South Bohemia - 1995, for The Institute of Chemical Technology (Prague) - 2000. For other universities, stabilization time of the share of specialized publications is hard to be determined.

Now we can turn to the webometric analysis of publication activity for the top ten universities in Germany. These universities have been tested using GS for three names for each university – one in German and two in English (e.g., The University of Hamburg and Hamburg University) (Table 6). In contrast to the leading Czech universities, where the share of responses to the Czech names of universities was very low, the share of responses to the German names of German universities was 42.8%. For individual universities, such responses prevailed for the Free University of Berlin, Universities of Münich and Münster. In contrast to the leading Czech universities, where more than 50% of the publications accounted for only one university (Charles University), the distribution of German universities according to their publication activity is more evenly distributed. Indeed, the leading University of Hamburg alone accounted for only 17.36% of the publications of the total number of publications of the top ten universities in Germany (Table 6).

On the basis of the matrix of publications of leading universities in Germany, aggregated publication structures for these universities have been determined (Table 7). The Table shows the names of universities from Table 6 with the maximum contribution to the overall publication activity.

In contrast to the Czech universities, where seven out of ten universities had more than 75% of publications in one of the aggregated subject areas, among German universities only Chemnitz University of Technology was recorded to have a similar situation (with 82.58% of the publications in the sphere of S&E, except Life Sciences). The leader in the field of biomedical research (with 50.01% of the publications in this sphere) is Heidelberg University, and the leader in publication activity in Social Sciences & Humanities and Economics (52.21%) is the University of Trier.

Table 6. Matrix of publications of the leading Germany universities on subject areas (experiments with search engine Google Scholar, 15.11.2010-05.12.2010)

University	BIOL	BUS	CHEM	ENG	MED	PHYS	SOC	Total	%
Freie Universität Berlin	5,710	1,510	6,620	4,200	6,230	7,300	7,290	38,860	8.45%
Free University of Berlin	1,780	1,250	1,450	1,010	5,030	891	4,900	16,311	3.55%
Berlin Free University	45	80	33	44	191	46	378	817	0.18%
Total	**7,535**	**2,840**	**8,103**	**5,254**	**11,451**	**8,237**	**12,568**	**55,988**	**12.17%**
Ludwig Maximilians Universität München	3,540	1,010	2,960	2,240	6,980	3,630	2,400	22,760	4.95%

Ludwig Maximilian University of Munich	71	35	131	91	358	77	133	896	0.19%
Munich University	625	669	392	2,530	871	660	1,550	7,297	1.59%
Total	**4,236**	**1,714**	**3,483**	**4,861**	**8,209**	**4,367**	**4,083**	**30,953**	**6.73%**
Ruprecht Karls Universität Heidelberg	403	128	759	364	1140	798	703	4,295	0.93%
University of Heidelberg	8,380	1,490	4,640	3,640	20,100	5,000	9,540	52,790	11.47%
Heidelberg University	972	303	681	749	2,020	1190	3,020	8,935	1.94%
Total	**9,755**	**1,921**	**6,080**	**4,753**	**23,260**	**6,988**	**13,263**	**66,020**	**14.35%**
Universität Trier	140	244	125	805	52	181	1,020	2,567	0.56%
University of Trier	290	364	127	1,150	421	171	2,170	4,693	1.02%
Trier University	81	112	26	186	44	34	277	760	0.17%
Total	**511**	**720**	**278**	**2,141**	**517**	**386**	**3,467**	**8,020**	**1.74%**
Humboldt Universität zu Berlin	3,020	1,810	2,660	3,950	3,330	4,490	3,390	22,650	4.92%
University of Humboldt	6	11	1	9	5	1	46	79	0.02%
Humboldt University	5,040	3,830	2,440	3,750	12,000	2,440	7,800	37,300	8.11%
Total	**8,066**	**5,651**	**5,101**	**7,709**	**15,335**	**6,931**	**11,236**	**60,029**	**13.05%**
Universität Leipzig	1,470	465	4,110	1,890	3,440	3,270	3,480	18,125	3.94%
University of Leipzig	2,650	740	3,080	2,270	8,830	1,530	6,460	25,560	5.56%
Leipzig University	314	180	552	494	1,060	536	1,680	4,816	1.05%
Total	**4,434**	**1,385**	**7,742**	**4,654**	**13,330**	**5,336**	**11,620**	**48,501**	**10.54%**
Universität Hamburg	5,280	1,090	5,820	4,650	2,140	9,900	3,830	32,710	7.11%
University of Hamburg	6,350	2,010	4,750	5,440	6,190	5,180	7,320	37,240	8.09%
Hamburg University	1,080	1,040	934	1,840	1,060	1,750	2,230	9,934	2.16%
Total	**12,710**	**4,140**	**11,504**	**11,930**	**9,390**	**16,830**	**13,380**	**79,884**	**17.36%**
Technische Universität Chemnitz	11	91	695	850	15	408	196	2,266	0.49%
Chemnitz University of Technology	12	234	680	1,310	28	333	333	2,930	0.64%
Technical University of Chemnitz	4	36	152	438	3	102	85	820	0.18%
Total	**27**	**361**	**1,527**	**2,598**	**46**	**843**	**614**	**6,016**	**1.31%**
Universität Münster	2,920	1,160	5,950	2,810	5,080	4,000	3,150	25,070	5.45%
University of Münster	2,100	509	1,670	1,090	5,240	997	1,640	13,246	2.88%
Münster University	162	89	163	149	401	155	223	1,342	0.29%
Total	**5,182**	**1,758**	**7,783**	**4,049**	**10,721**	**5,152**	**5,013**	**39,658**	**8.62%**
Universität Freiburg	5,890	802	5,730	3,420	4,510	4,280	3,120	27,752	6.03%
University of Freiburg	5,390	1,110	3,800	3,880	10,100	2,290	5,760	32,330	7.03%
Freiburg University	531	197	338	595	1,340	390	1,530	4,921	1.07%
Total	**11,811**	**2,109**	**9,868**	**7,895**	**15,950**	**6,960**	**10,410**	**65,003**	**14.13%**
Sum	**64,267**	**22,599**	**61,469**	**55,844**	**108,209**	**62,030**	**85,654**	**460,072**	**100%**

Table 7. Aggregated publication structures of the leading Germany universities

University	BIOL+MED		CHEM+ENG+PHYS		BUS+SOC		Total	
Freie Universität Berlin	18,986	33.91%	21,594	38.57%	15,408	27.52%	55,988	100%
Ludwig Maximilians Universität München	12,445	40.21%	12,711	41.07%	5,797	18.73%	30,953	100%
University of Heidelberg	33,015	50.01%	17,821	26.99%	15,184	23.00%	66,020	100%
University of Trier	1,028	12.82%	2,805	34.98%	4,187	52.21%	8,020	100%
Humboldt University	23,401	38.98%	19,741	32.89%	16,887	28.13%	60,029	100%
University of Leipzig	17,764	36.63%	17,732	36.56%	13,005	26.81%	48,501	100%
University of Hamburg	22,100	27.67%	40,264	50.40%	17,520	21.93%	79,884	100%
Chemnitz University of Technology	73	1.21%	4,968	82.58%	975	16.21%	6,016	100%
Universität Münster	15,903	40.10%	16,984	42.83%	6,771	17.07%	39,658	100%
Universität Freiburg	27,761	42.71%	24,723	38.03%	12,519	19.26%	65,003	100%
Sum	172,476	37.49%	179,343	38.98%	108,253	23.53%	460,072	100%

Formalized types of aggregated publication structures are shown in table 8. Designation to it is the same as the table 4.

Table 8. Formalized types of aggregated publication structures of the leading German universities

No.	Mathematical description of the aggregated publication structures	German Universities
1.	$\rho_{S\wedge E}>\rho_{LS}>\rho_{SSH}$	Freie Universtität Berlin, University of Hamburg
2.	$\rho_{LS}>>\rho_{S\wedge E}>\rho_{SSH}$	University of Heidelberg, Universität Freiburg
3.	$\rho_{S\wedge E}\approx\rho_{LS}>\rho_{SSH}$	Ludwig Maximilians Universität München, University of Leipzig, Universität Münster
4.	$\rho_{LS}>\rho_{SSH}>\rho_{S\wedge E}$	Humboldt University
5.	$\rho_{S\wedge E}>>\rho_{SSH}>\rho_{LS}$	Chemnitz University of Technology
6.	$\rho_{SSH}>\rho_{S\wedge E}>\rho_{LS}$	University of Trier

The types of aggregated publication structures Nos. 1, 3 and 5 were observed in Czech universities. If the types of structures Nos. 1 and 3 merge into one: $\rho_{S\wedge E}\geq\rho_{LS}>\rho_{SSH}$, then this combined type of the aggregated publication structure would account for five German universities out of ten. By "≥" we mean "greater than or approximately equal". Czech and German universities with the same types of aggregated publication structures are shown in Table. 9, which is based on Tables 4 and 8.

Table 9. Czech and German universities with the same types of aggregated publication structures

Mathematical description of the aggregated publication structures	Czech Universities	German Universities
$\rho_{S\wedge E}>\rho_{LS}>\rho_{SSH}$	Charles University	Freie Universität Berlin, University of Hamburg
$\rho_{S\wedge E}\approx\rho_{LS}>\rho_{SSH}$	Palacky University	Ludwig Maximilians Universität München, University of Leipzig, Universität Münster
$\rho_{S\wedge E}>>\rho_{SSH}>\rho_{LS}$	University of West Bohemia, Czech Technical University, Technical University Ostrava	Chemnitz University of Technology

In Table 9, we can see that the last type of publication structure with a minimum share of biomedical publications is typical for technical universities. The average aggregated publication structures for all ten German universities (Table 7) corresponds to the first type of aggregated publication structures (Table 8), with S&E publications taking a slight lead, unlike the average aggregated publication structures of Czech universities (Table 3). This can be explained by the fact that among the ten Czech universities under study four universities were technical ones, and among German universities, only one was a technical university.

We can now look at the dynamics of the publication activity at German universities since 1990, with a five year-step. This dynamics has been observed thanks to the experiments with the GS (advanced search with an exact phrase containing an English name of a university) (Table 10). We have calculated the number of total and specialized publications, as well as their growth rate for the twenty-year period of

time, just the way we did for Czech universities (Table 5). For all the universities during that period of time, there can be clearly observed a certain regularity of decline in the share of specialized publications:

$$k_{spec}<k_{tot} <=> (\rho_{spec})_{1990}>(\rho_{spec})_{2010}$$

In general, for all German universities under study, the share of specialized publications for the twenty-year period fell from 36.6% to 26.5%. As our research has shown, Czech universities demonstrated the reverse situation (the growth of specialized publications from 23.6% to 36.1%). If we consider the change of the indicator for individual universities, we can see that the smallest share of specialized publications in 2010 was recorded for the universities of Münster, Freiburg, Münich and Hamburg, and the highest - for the University of Heidelberg and Chemnitz University of Technology (Table 10).

For some universities, there has been clearly determined time stabilization of the share of specialized publications. For the Free University of Berlin it was 2000, for the University of Münich - 2005, for Humboldt University - 2005, for the University of Leipzig - 2000, for the University of Hamburg - 2000. For other universities such time is hard to be determined.

Table 10. Dynamics of the publication of the leading German universities (experiments with search engine Google Scholar, 23.04.2011)

University	1990			1995			2000			2005			2010			Absolute Growth (%)	
	Total	Specialised		Total	Specialised		Total	Specialised		Total	Specialised		Total	Specialised		Total	Specialised
		Amount	%		Amount	%		Amount	%		Amount	%		Amount	%		
Freie Berlin	1,212	402	33.2%	1,610	458	28.4%	2,590	647	25.0%	3,135	806	25.7%	3,077	835	27.1%	2,.54	2.08
München	418	192	45.9%	572	241	42.1%	1,253	369	29.4%	2,092	416	19.9%	2,580	545	21.1%	6.17	2.84
Heidelberg	1,033	472	45.7%	1,478	617	41.7%	2,683	1,055	39.3%	4,724	2,141	45.3%	5,281	1,982	37.5%	5.11	4.20
Trier	80	51	63.8%	162	90	55.6%	377	258	684%	574	258	44.9%	659	198	30.0%	8.24	3.88
Humboldt	657	256	39.0%	1,007	258	25.6%	3,401	1,217	35.8%	4,251	1,065	25.1%	3,798	948	25.0%	5.78	3.70
Leipzig	447	159	35.6%	653	184	28.2%	1,929	652	33.8%	3,177	1,050	33.1%	3,352	1,024	30.5%	7.50	6.44
Hamburg	1,133	250	22.1%	1,703	428	25.1%	3,149	652	20.7%	4,366	849	19.4%	4,914	1,042	21.2%	4.34	4.17
Chemnitz	8	4	50.0%	98	43	43.9%	294	120	40.8%	509	130	25.5%	638	250	39.2%	79.75	62.50
Münster	521	231	44.3%	678	230	33.9%	1,777	676	38.0%	2,527	783	31.0%	2,613	522	20.0%	5.02	2.26
Freiburg	799	292	36.5%	1,181	355	30.1%	2,654	780	29.4%	3,518	998	28.4%	3914	812	20.7%	4.90	2.78
Summary	6,308	2,309	36.6%	9,142	2,904	31.8%	20,107	6,426	32.0%	28,873	8,496	29.4%	30,826	8,158	26.5%	4.89	3.53

We can now show in which subject areas the specialization of each university research has been recorded since 1990. For this purpose we have constructed the matrix of the leading subject areas (Table 11), which marked the years with peaking publications in a particular subject area.

This matrix clearly shows that on the whole research specialization of the leading Germany universities is observed in the fields of medicine, pharmacology and veterinary medicine. At the same time, for the Free University of Berlin and Humboldt University, there have occurred structural changes in publication structures towards social sciences and humanities. For the former university it happened after 2000, for the latter - after 2005. This trend is reflected in the cumulative (total for all years) aggregated publication structures of these universities (Table 7), in which the share of socio-economic and humanitarian publications exceeded those for other universities, except the University of Trier, which during the period under study majored in social sciences and humanities.

Table 11. Matrix of leading subject areas of German universities

University Name	Chemistry and Materials Science	Engineering, Computer Science, and Mathematics	Medicine, Pharmacology, and Veterinary Science	Physics, Astronomy, and Planetary Science	Social Sciences, Arts, and Humanities
Freie Universität Berlin			1990-2000		2005-2010
Ludwig Maximilians Universität München			1990-2010		
University of Heidelberg			1990-2010		
University of Trier					1990-2010
Humboldt University			1990-2005		2010
University of Leipzig	1995		1990, 2000-2010		
University of Hamburg				1990-2010	
Chemnitz University of Technology	2005	1990, 2000-2010			
Universität Münster			1990-2010		
Universität Freiburg			1990-2010		

In the conclusion of this work we will discuss about issues of quality and efficiency of the GS-algorithm, which we have encountered during our current and previous researches.

Walters (2011) referring to O'Leary (2005) and GS ("About Google Scholar") notes that "GS gets its bibliographic records from three sources":

1. Freely available web documents "Look scholarly" in their content or format;

2. Articles or documents supplied be Google scholar's partner agencies: journal publishers, scholarly societies, database vendors, and academic institutions;

3. Citations extracted from the references lists of previous indexed documents.

We can add here one more point:

4. Articles or documents in the OA-repositories and OA-Journals, which are indexed automatically thanks to the OAI-PMH interface (Open Archives Initiative Protocol for Metadata Harvesting).

This is a considerable amount of quality papers with good metadata. Our experience of working with Russian and Ukrainian OA-repositories and Journals show that within a month all the articles from them get indexed by GS. It can be considered as a contribution to the debate about the linguistic coverage by GS. For example, Walker et al. (2004) find citations in at least seven other languages apart from English. Peter Jacsó (2008) states that GS indexes French, Spanish, Portuguese, German, Japanese, Chinese, Korean and Russian language collection of academic works. Such a wide coverage of most languages of the world is promoted by GS having now free access to all OA-Repositories and OA-Journals. The availability of a vast array of quality academic papers from OA-Repositories and OA-Journals does not allow us to agree with the opinion of Walters (2011) that: "Only the records supplied by Google Scholar's partner agencies are likely to provide consistent coverage of particular journals". He also referred to six other articles, which stated that "GS does not index every article available through partner agencies' web sites". But all those articles go back to 2004 – 2005 when GS only came into operation, three of those articles having been written by the most outspoken critic of GS, Peter Jacsó. We should note that most of his early complaints about CS are no longer valid, as the GS search engine is rapidly evolving, partly thanks to the numerous comments and remarks made by Peter Jacsó himself. Unfortunately his older publications are still cited as evidence of the ineffectiveness of the GS search engines, which in turn keeps track of this scientist's articles from the University of Hawaii (as of the end of September 2011 - 138 articles, "at least summaries"),

as well as references to those papers, marking his paper written in 2005 and published in the Current Science Journal as one of the leaders of citation (with 167 citations) in the GS-publication cluster generated by the term "Google Scholar".

We assume that for some time to come, critics will go on finding and publishing senseless results towards the performance of the GS search engine, while its team time and again will do its best to eradicate those defects. For example, Peter Jacsó (2008) found that "F. Password" was not only the most productive, but also a very highly cited author. After which the GS-team removed this ambiguity, but today you can apply the GS search engine to find out that "M.Noise" (also a non-existing author) has published 1210 papers. You can make up a host of such examples, it's all nit-picking, which does not in any way diminish the grandeur and significance of the GS-project.

Studies on the effectiveness of GS' search engine are considerable complicated by the fact that for us it is a "black box". But is it really important for an ordinary researcher to know how it works, if all he ever sees are the journals from the top part of the recall list, that were included in ISI Web of Science and SCOPUS.

But GS does not only re-direct us to publishing online platforms, where we are required to pay $30-40 for each article, but often returns author's PDF-files of those articles placed in OA-Repositories, institutional and personal sites. The rate of posting author's PDF-files in Open Access is increasing every month. At the same time, this positive process creates a problem of an increase in the duplication of documents returned by the GS, which is becoming increasingly difficult for the search engine to handle. In this regard, Jacsó (2005) says that "the number of duplicate, triplicate and quadruplicate records for the same source documents (which Google scholar cannot detect reliably) has increased.

Our experience shows that the GS is unique not only for scientific information retrieval, but also for building publication clusters and for the identification of research fronts.

For it to become a valuable and valid tool used for scientometric and bibliometric analysis, it is necessary to count citations with the option "cited by" on an annual basis (Dewly, 2010) and for any arbitrary period of time (Moskovkin, 2009).

Additionally, it necessary to be able to extract the book counts, as is done with respect to [CITATION] and [PATENTS]. We would like to note that there are separate tools used to search for books and patents: Google Books and Google Patents.

Furthermore, it is necessary to improve GS search engine in order to eliminate the duplication& of documents. It is easier to do this applying an additional option of searching for academic papers only by structured data sources with well-presented metadata (information sources presented above, numbered 2 and 4), and pdf-files of the papers that are found (source number 4) should be attached only once to the core document (source number 2).

Besides the duplication of documents, questions were raised, in relation to how GS search engine works in sorting out documents by subject areas and time periods. Empirically, we found that GS sorting is associated with up-to-date dictionaries and thesaurus, where each term (keywords) is divided into seven subject areas. Classifications of journals by subject areas are not used here because we noticed that articles from the same journal can be placed in deferent subject areas.

On earlier experiments done by us, the given sorting was satisfactory (visual view of hundreds of first responses).

With regard to restrictions on the time interval, we noticed that all responses to old articles up to about 1990, which were not placed on the platforms, archives and sites in a structured way should be checked visually, since there are many cases where a publication date of GS takes a four-digit number, corresponding to the ISSN, page numbers, etc. This also applies to the contemporary collections and databases of academic documents. Jacsó (2008) also wrote about this. Therefore, it would be advisable to adhere to a certain standard of metadata for all electronic databases of scientific information, as was done for OA-Repositories, operating under the OAI-PMH.

Working with these two restrictions (subject areas, time intervals), as well as with the option of "at least summary" can largely reduce the number of non-relevant recall and information noise in general.

In the end we note that there is no problem with the fact that GS gives only he first thousand responses, because all the responses can be viewed if looked at in small (yearly) time intervals.

Conclusions:

Building of university publication structures

This study has shown that the Google Scholar search engine allows you quickly and effectively to construct specialized and aggregated publication structures for universities, and based on this you can determine their types. For building such structures it's important to know the whole spectrum of the commonly recognized names of the universities (current and old names in english and national languages) and consequentially test them in line "with exact phrase" with restrictions on the time period and subject areas.

In creating such publication structures using a certain time step, you can study the dynamics of such structures. Such a study can reveal structural changes in university publication structures. For example, for German leading universities, such shifts have been revealed for the Free University of Berlin and Humboldt University, which occurred within a five-year period in the first decade of the 21st century, the shift being from medical research to social and humanitarian studies.

In the future, a comparative analysis of university publication activity in order to be reliable will need to combine all three tools - Web of Science, SCOPUS and Google Scholar. But we would like to note that, the advantage that Google Scholar has over Web of Science and Scopus, is its fully open (free unlimited access) to anyone who wishes to use it.

University OA-Repositories (Institutional and Personal Sites)

First of all, GS retrieves articles from leading journal publishers, because they are most cited.

In the event if one article placed on the publisher's online platform and in the University OA-repository (or on institutional and personal sites) then GS gives priority to the article placed on the publisher's online platform, but takes the University OA-repository's (institutional or personal sites) pdf-file and displays it with the link of the publisher's online platform version of the article.

Priority given to the publisher's online platform in comparison with University OA-repository (institutional or personal sites) is exclusively associated with the option "by cited" and placement of more cited articles on the first pages of GS recalls. Here GS algorithm regularly works on emitting duplicates (triplicates etc.) of the same article.

In addition, documents from University OA-repository (institutional or personal sites) that according to GS algorithm rule do not fit the status of a scientific articles, are not taken into account.

All of the above we will illustrate on the example of Universidad de Granada (University of Granada).

According to our methodology with restrictions on subject areas and time intervals and taking into account the option "at least summary" name "Universidad de Granada" gives 29,000 responses and the name "University of Granada" – 17,100 responses (26.01.2012). On this date DSpace OA-repository of this university contained 16,580 documents and GS on the site of this OA-repository (operator: site:digibug.ugr.es) found 4,000 documents.

The first 1,000 GS responses, available for viewing, from the requests of the name of reviewed university were cited no less than 5-10 times and among them there were no articles from DSpace OA-Repository, which is consistent with our past conclusion. The same goes for

the first 1,000 responses for 2011. Large discrepancies between the numbers of documents that were placed in DSpace OA-Repository (16,580) and found in it with the help of GS (4,000), speaks about the large amount of documents, that do not correspond with the status of a scientific articles, of which we spoke of earlier. In this repository we found 340 documents, dated from 1302 to 1500, as well as, approximately 2,000 documents dated from 1302 to 1700. At the same time, the option of "time interval" in GS for the name "Universidad de Granada" begins giving responses from the year 1700. Note that the oldest document corresponds to Arabic sources, connected with sales, transfer of inheritance and others. Thus, the large Web- presence of reviewed university is not connected with its OA-Repository.

GS as an information source of articles with well-structured metadata

Our experience shows that in the case of articles with well structured metadata (a good example of this is the metadata with publisher's online platforms) GS quite accurately connects the authors of the articles with the name of the university. If the authors of the articles work at different universities, then that article is credited to both universities.

In the case of inclusion in its recall list, books and other documents but not journal articles, and that have another type of metadata, GS cannot strongly correlate authors with their places of work. This is due to the fact that places of work of the authors is absent from the document's metadata. In such a case, the relation of documents to the requested university name is random, by finding the name of the university in preface or in the text of the document (for example, books). Our experience shows that the proportion of these inconsistencies is so not large.

If the publications metadata is well structured, then GS algorithm does well in correlating dated publications of the requested university with the requested time of publication. If the metadata is poorly organized for the desired publication date, GS can take the "four-place" parts of ISSN (for articles) and ISBN (for books), "four-place" page number and others.

GS-sorting algorithm

This algorithm is obviously based on the informational search thesaurus with regular increasing term reserve (key words). With every new request with restrictions on subject areas, GS-sorting algorithm compares key words in requested articles with their structured (divided into subject categories) terminology set. In the case of the emergence of new terms, it is difficult for GS to correlate these new terms with specific subject areas.

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