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Bibliometrik Maps of Scientific Collaboration of EU Countries in Science and Social Science¹

The paper presents bibliometric analysis of the international scientific collaboration of 27 EU countries in the field of science and social sciences. The object of the paper is the joint publications of authors from the 27 EU member-states in the fields of science and of social sciences. Material for this analysis was drawn from DBs WOS: SCiex 2006 and SSCI 2006. The states as wholes are considered here as participants of collaboration. If a paper has two or more authors from different countries, it belongs to the material of the present study. The discovery of specific country-to-country links is based on the comparison of actual collaboration figures with theoretical values, calculated on the assumption of mutual statistical independence. The results are presented with the help of two maps showing those specific links.

Key words: map of science, bibliometric analysis, international collaboration, EU countries, Web of Science, SSCI CDE.

Dedicated to Vladislav Kelle

Introduction

Scientific collaboration is becoming a significant issue in bibliometric and webometric studies of science. Only some of them should be mentioned in the context of this study: Lamirel et al. presented a new approach for evaluation of collaboration between European universities (Lamirel, 2005). Science collaboration of in the field of social sciences was discussed by the present author at Collnet 2006 in Nancy (Marshakova-Shaikevich 2006, 2007), bibliometric perspectives of an integrated EU research was presented by Robert J.W. Tijssen at Collnet 2008 in Berlin (Tijssen, 2008). An attempt at visualization of international collaboration of 27 EU countries in science and social sciences is made here. The resulting maps could serve for better understanding of structure of scientific cooperation in Europe.

The main object of the present study is international scientific collaboration within the EU countries. However, lest essential information should be lost, the data for some countries outside European Union were also included into material of this study. Those countries are — USA, Japan, People's Republic of China, Canada, Australia, India, Russia, Switzerland, Israel, Norway, Iran, Croatia and Iceland. The statistics of academic publications of 40 states under study are given in Table 1.

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Table 1. Research activity in science and social sciences: 2006

Country	Social Sciences: Total N = 150th		Science: World Total N= 1218 th	
	SSCI 2006 Num- ber publications	Weight in world total, %	SCIex 2006 Number of publi- cations	Weight in world total, %
Austria	722	0.48	10750	0.88
Belgium	1465	0.98	15471	1.27
Denmark	998	0.66	11047	0.91
Finland	1111	0.74	9556	0.78
France	2934	1.96	61899	5.08
Germany	6928	4.62	89306	7.33
Greece	593	0.39	10463	0.86
Ireland	654	0.44	7067	0.56
Italy	2441	1.63	50886	4.18
Luxembourg	0		265	0.02
Netherlands	4725	3.15	28315	2.32
Portugal	405	0.27	7488	0.61
Spain	2855	1.90	37808	3.10
Sweden	2290	1.53	19466	1.60
UK	19691*	13.13	100575*	8.52
CzR	270	0.18	7203	0.59
PL	403	0.27	17021	1.40
Hu	317	0.21	5974	0.49
SK	151	0.10	2305	0.19
Slovenia	124	0.08	2225	0.18
Estonia	88	0.06	874	0.07
CYPRUS	57	0.04	364	0.03
Lithuania	107	0.07	1213	0.10
MALTA	14	0.01	72	0.01
LA	20	0.01	343	0.03
Romania	70	0.05	3219	0.26
Bulgaria	51	0.03	1863	0.15
USA	74567	49.7	376833	30.94
Australia	6676	4.45	32718	2.69
Canada	8951	5.97	51725	4.25
Russia	530	0.35	23188	1.90
Croatia	334	0.22	2118	0.17
Israel	1669	1.11	14310	1.17
Japan	1828	1.21	88851	7.29
Norway	1148	0.76	7712	0.63
Switzerland	1808	1.20	21055	1.73
Iceland	82	0.05	574	0.05
Peoples-R-China	1965	1.3	86025	7.06

*The sum of UK publications adjusted for “internal collaboration”.

The EU countries contribute some 40 % to the world output in science proper and 33 % in social sciences.

Bibliographic data were drawn from DBs WOS SCiex 2006 and SSCI 2006.

The source data call for some modifications for our purpose. The tradition of British authors to indicate parts of UK (England, Scotland, Wales, Northern Ireland) rather than the kingdom as a whole gives those parts undue prominence. The figures of that “internal collaboration” should be subtracted from the sum of four parts to give the true result for UK.

Methodology

To calculate specific collaboration relatedness of two countries the following formula was used :

$$S_{ij} = (C_{ij} - m) / \sqrt{m}$$

C_{ij} — real number of joint publications of countries i and j

m — mathematical expectation of number of joint publications of countries i and j

The mathematical expectation of the number of joint publications, entirely due to chance, was calculated as

$$m = N_i \times P_j,$$

with N_i — total collaboration publications of country i ,

$P_j = N_j / \sum N$ — the weight of country j in the total number of publications of the world.

An example of seven European countries is given in Table 2 and Table 3 to illustrate the calculation. In Table 2 the figures below the main diagonal indicate mathematical expectations (m) and those above the main diagonal are real numbers of joint publications (C).

Table 2

Countries	France	Belgium	Netherlands	Germany	Switzerland	Austria	Italy
France	XXXX	1876	1742	4536	2251	588	3383
Belgium	784	XXXX	1478	1433	608	354	940
Netherlands	1437	358	XXXX	3168	912	370	1402
Germany	4535	1133	2067	XXXX	3572	2200	3434
Switzerland	1069	268	490	1547	XXXX	599	1523
Austria	551	135	247	790	186	XXXX	634
Italy	2583	646	1183	3732	882	449	XXXX

The resulting measure of specific collaboration relatedness (S) is given below the main diagonal of Table 3.

Table 3

Countries	France	Belgium	Netherlands	Germany	Switzerland	Austria	Italy
France	XXXX	1876	1742	4536	2251	588	3383
Belgium	39	XXXX	1478	1433	608	354	940
Netherlands	8	58	XXXX	3168	912	370	1402
Germany	0	8	22	XXXX	3572	2200	3434

Switzerland	36	20	19	51	XXXX	599	1523
Austria	1	10	7	50	30	XXXX	634
Italy	15	8	6	-4	21	8	XXXX

One can see that the of French and German joint publications corresponds exactly to what might be expected as a null-hypothesis, i.e. those countries are statistically independent as far as international collaboration is concerned. $S = 0$ here. The number of German and Italian joint publications is even less than expected ($S = -4$), which might be interpreted as the effect of a very weak factor hindering the collaboration between the two countries. On the other hand, all other cells are positive deviations from mathematical expectation. In the pair “France-Austria” this association is negligible, in all other pairs it is significant or highly significant.

A matrix of 27 x 27 would be too cumbersome. A graphic representation is easily visualized and gives better ground for interpretation.

Discussion and conclusion

In Fig. 1 a map of international collaboration in science is given. The four degrees of thickness of the lines reflect values of S as follows:

- $S - 50$ and more (e.g. UK — Ir, CzR — Sk, Au — Ge),
- $S = 25-49$ (e.g. Fr — Swt, De — Ic, Fi — Es, Sl — Cr),
- $S = 15-24$ (e.g. Fr — It, Ge — Ru, CzR — Pl, Hu — Ro),
- $S = 10-11$ (e.g. UK — M, Sp — It, Bu — Gr, Sw — Li).

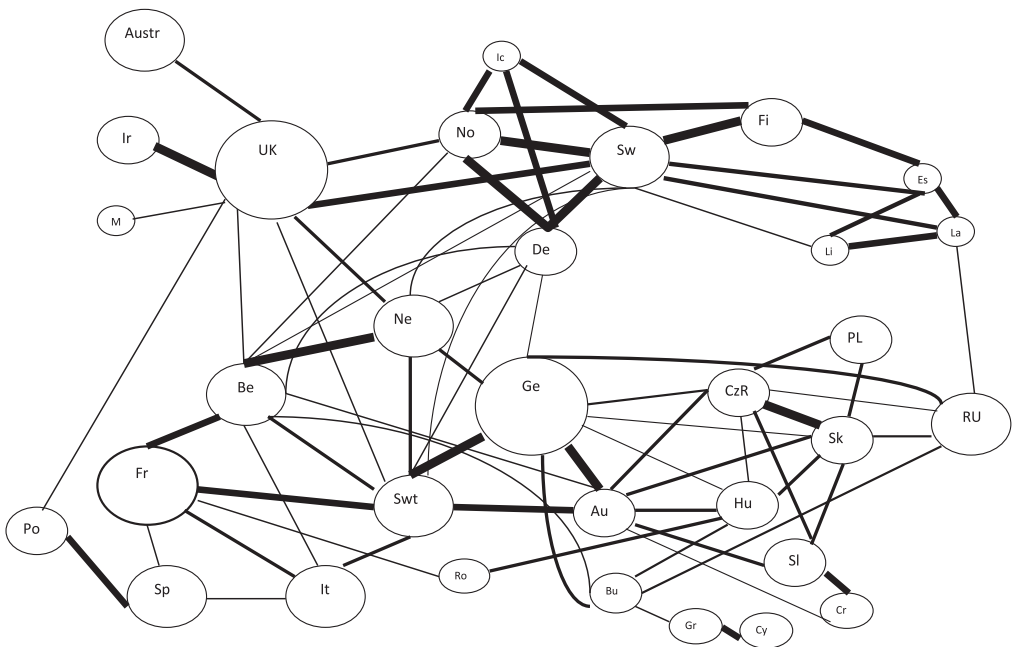


Fig. 1. Map of collaboration in science

A very compact cluster of countries is seen in the upper part of the map: it comprises five Scandinavian countries with three small Baltic states. One bridge to the rest of Europe is formed by United Kingdom with three states: Australia, Ireland and Malta. Another bridge (of weaker S) connects Scandinavia with Germany, Netherlands and Belgium. Specific links of the countries of Romance languages are manifest in the left part of the map. Switzerland with its languages and its scientific tradition is a virtual hub of the map. It has strongest ties with Germany and Austria, who show various specific links with the states of Central and Eastern Europe (Russia include). Some of those countries (especially Hungary and Bulgaria) are apt to participate in international collaboration to an uncommon degree. In addition to the links of the map we can mention Hungary's links with Finland, Sweden and Poland, or Bulgaria's ties with France, Italy, Austria and Romania. On the contrary, Poland's involvement this cluster is not so great, although its weak ties ($S = 6-8$) with Austria, Germany, Russia and Lithuania might be mentioned.

No specific links were observed outside Europe (with the single exception of 'UK-Australia' pair).

In Fig. 2 a map of the international collaboration in social science is given Specific links in social sciences to some extent resemble the outlines of Fig. 1 on a lesser scale. The output

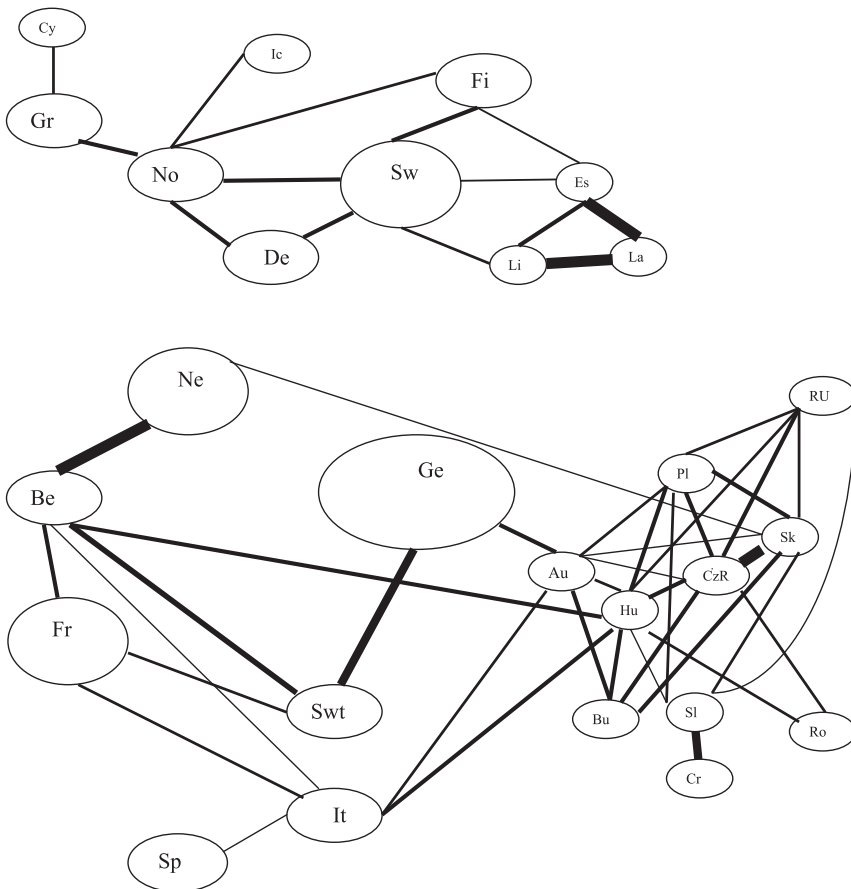


Fig. 2 Map of collaboration in social science

of publications in social sciences is eight times less than that in science proper. Accordingly the values of S are much lower. The four degrees of thickness of the lines reflect values of S as follows:

S — 20 and more (e.g. Be — Ne, CzR — Sk, Es — La),

S = 15–19 (e.g. Ge — Swt, Li — Es, Sl - Cr),

S = 9–14 (e.g. Sw — No, Ge — Au, CzR — Pl, Hu — Bu),

S = 4–8 (e.g. De — Fi, Sp — It, Fr — Swt Sw — Li).

United Kingdom disappears from the map altogether. Scando-Baltic cluster remains intact. The linguistic preponderances are evident in Western Europe (with German and Romance languages very active as cultural factor). But East European cluster with its Soviet and more ancient Austro-Hungarian traditions is alive.

In conclusion I'd like to add that there is no connection between USA and EU countries, USA only have a weak links with Norway (S=6) and Israel (S=3). China appears quite isolated. It does not show any links to the countries under study.

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