[ξ] KSZI [ξ] AKTÁK

MTA KSZI műhelytanulmányok

2011/4

Research in Emerging Fields: Who takes the lead?

Wolfgang Glänzel & Bart Thijs

wolfgang.glanzel@econ.kuleuven.be

➲ http://www.mtakszi.hu/kszi_aktak/

Research in Emerging Fields: Who takes the lead?

WOLFGANG GLÄNZEL[1,2], BART THIJS[2]

Centre for R&D Monitoring (ECOOM) and Dept. MSI, Katholieke Universiteit Leuven, (Belgium)
Institute for Research Policy Studies, Hungarian Academy of Sciences, Budapest (Hungary)

ABSTRACT

In the present piece we study research performance and collaboration of the European Union and the most active countries in emerging topics that have been identified in a dynamic cluster analysis of selected Web of Science Subject Categories in the period 1999-2008.

1. INTRODUCTION

The US-EU race for world leadership in science and technology has become a favourite topic in both the US (e.g., Shelton and Holdridge, 2004) and Europe already long before the last EU extensions in 2004/2007 (e.g., REIST-2, 1997, REIST-3, 2003, Dosi et al., 2005). In Europe, more generally, competition and collaboration among the three world leaders in science and technology, the so-called 'triad' USA, EU and Japan, has come into the focus of interest. However, the spectacular growth of the emerging economies (cf. Zhou and Leydesdorff, 2006, Glänzel et al., 2008) have made this model obsolete. China's appearance among the world's leading nations has not only challenged the Triad but moved the centre of gravity in science and technology further towards the Far East. This development has already measurable effect on the balance of power as reflected by scientific production and patenting activity (cf., Glänzel et al., 2008, Rousseau, 2008). The economic growth of countries in other world regions contribute to the global changes in the scientific and technological landscape as well, although this development is somewhat overshadowed by the breath-taking growth of the economies in the Far East (Zanotti, 2002, Zitt et al., 2006, Glänzel, 2008). Several important macro-studies were placed in a broader economic context (e.g., May, 1997, King, 2004) and, therefore, based on an all-fields-combined approach that provides a somewhat undifferentiated picture concerning a nation's particular contribution to what is considered 'hot' or future-oriented in science and technology. In the present study we attempt to analyse the outcomes of a recent project that aimed at the identification of emerging topics within scientific disciplines with significant growth patterns in order to detect national contributions to these emerging disciplines and topics. Methodology will be based on previous results, above all on a recent study by Glänzel and Thijs (2012). As examples, four topics, one each from four different disciplines, have been selected. Two questions are of particular interest. Firstly, do the examples tell us anything about Europe's particular activity and competitiveness in the emerging research topics, and, secondly, what is the role of emerging economies in these disciplines with special regard to China, India and

Brazil? In order to answer these questions, scientometric standard tools for the analysis of publication activity, citation impact and co-publication analysis are applied to the selected topics.

2. DATA SOURCES AND DATA PROCESSING

The study is based on bibliographic data extracted from Thomson Reuters' Web of Science (WoS) database. All documents recorded as articles, proceedings papers or reviews indexed in the period 1999–2008 have been taken into account. The papers were assigned to countries based on the corporate address given in the by-line of the publication. All countries indicated in the address field have thus been taken into account. A full counting scheme is applied, that is, papers are assigned to each country appearing in the list of corporate addresses without fractionation. This implies that a share of x% in the world total means, that this percentage of papers has at least one (co-)author from the country in question. Since the period 1999–2008 is studied, all counts for the 15 member countries of the EU according to its constitution prior to 2004 have been counted. Duplicates caused by internal collaboration among member countries of the EU15 have been removed to avoid double counting for this world region. For the analysis of international collaboration, co-authorship links of the most active countries were broken down by country pairs and used Salton's measure was used as an indicator of collaboration strength. For the hybrid text- and citation-based cluster analysis, the reference lists of all document pairs have been processed to obtain the strength of bibliographic coupling, while the textual component is based on term frequencies. Terms have been extracted from titles and abstracts, where keyword phrases have been kept, terms have been stemmed and stop words have been removed. Both the textual and the link component have been combined into a joined similarity measure as described by Glänzel and Thijs (2011a).

3. CONCISE SUMMARY OF METHODOLOGY

The idea of combining citation-link and text based approaches aimed at pronouncing the advantages of the two components and, at the same time, at reducing the by-effects of their shortcomings (cf. Braam et al., 1991a, b, Zitt and Bassecoulard, 1994). The combination of the two methods also makes it possible to cluster documents whenever citation links are weak or even missing. This feature is, above all, important in the applied sciences, most fields of the social sciences and in the humanities. Four WoS Subject Categories with striking growth patterns have been selected from the applied and social sciences. These disciplines are *environmental sciences*; *energy & fuels; public, environmental & occupational health* and *biomedical engineering*. In a first step, these disciplines have undergone a cluster analysis in two different not overlapping periods. The clustering resulted in 6–9 topics each per field and period.

In a second step, "core documents" (Glänzel and Czerwon, 1996) have been used to label clusters and to describe their content (Glänzel and Thijs, 2011a). By definition,

core documents are those documents that have strong (hybrid text-citation) links with many other documents in the field. They can also be used to create links between clusters of the different time periods (Glänzel and Thijs, 2011b) and thus to identify emerging topics, which are expected to have already reached a certain critical mass, to form (more or less) coherent clusters, and to still have strong links to their "mother fields". Three particular cases are considered to indicate such new, emerging topics.

(I) Existing cluster with an exceptional growth with regard to the second period,
(II) Completely new cluster with its root in other clusters in the previous period and
(III) Existing cluster with a topic shift in the new time period.

The identified topics are then validated by experts and further analysed using bibliometric methods. A set of scientometric standard indicators is used for this analysis. This set was first described in detail by Braun et al. (1985). The factual citation impact is expressed by the Mean Observed Citation Rate (MOCR), and an expected citation impact is based on the citation impact of the journals where the papers have been published. Its mean value, calculated over individual papers, is called Mean Expected Citation Rate (MECR). The ratio MOCR/MECR, called Relative citation Rate (RCR), is used to express the relation of the two values. The disciplines and topics are relatively narrow and homogeneous so that further field-normalisation is not necessary. All citation indicators are calculated on the basis of a 3-year citation window beginning with the publication year. An example for the structural-evaluative domain studies was prepared, for instance, for the field of bioinformatics (Glänzel et al., 2009).

4. RESULTS

4.1. Environmental sciences

The first Subject Category we analysed is environmental sciences. The number of clusters increased from six in 1999–2001 to eight in the second period (2008). One of the new clusters has been labelled "nano pollution". This cluster comprises 3533 documents and represents 12.6% (i.e., ca. 1/8) of the discipline. The topic, which can be considered to be of Type II according to the above typology, can be described, e.g., by the following core documents (data sourced from Thomson Reuters Web of Knowledge).

- On colloid retention in saturated porous media in the presence of energy barriers: The failure of alpha, and opportunities to predict eta
- The significance of heterogeneity on mass flux from DNAPL source zones: An experimental investigation
- C-60 colloid formation in aqueous systems: Effects of preparation method on size, structure, and surface, charge
- Individual and mixture effects of selected pharmaceuticals and personal care products on the marine phytoplankton species Dunaliella tertiolecta
- Nanomaterials as possible contaminants: the fullerene example

- Exploring e-waste management systems in the United States
- Influence of electrolyte species and concentration on the aggregation and transport of fullerene nanoparticles in quartz sands
- Toxicity of aqueous fullerene in adult and larval Fundulus heteroclitus
- Effects of particle composition and species on toxicity of metallic nanomaterials in aquatic organisms
- Precise and Accurate Compound Specific Carbon and Nitrogen Isotope Analysis of Atrazine: Critical Role of Combustion Oven Conditions

The scientometric indicators for the most active countries in the discipline and the topic are presented in Table 1. In this case, the overall picture of the topic by and large mirrors that of the discipline. Roughly one third of all papers have an author in the EU, the share of the US lies only slightly above one fourth. China is with about 10% by far the most active country after the US. The larger EU activity is somewhat contrasted by a lower citation impact as compared with that of the USA.

Table 1 Environmental sciences ("nano-pollution")
Data sourced from Thomson Reuters Web of Knowledge

Country	**ISI Category** (N=27961)					**Topic** (N=3533)				
	Papers	**Share**	**MOCR**	**MECR**	**RCR**	**Papers**	**Share**	**MOCR**	**MECR**	**RCR**
Belgium	464	1.7%	2.88	2.23	1.29	50	1.4%	1.62	1.83	0.89
Brazil	518	1.9%	2.38	2.23	1.07	57	1.6%	2.04	2.11	0.97
Denmark	384	1.4%	3.07	2.62	1.17	53	1.5%	3.23	2.81	1.15
France	1241	4.4%	2.39	2.33	1.03	143	4.0%	2.35	2.39	0.98
Germany	1629	5.8%	2.47	2.20	1.12	229	6.5%	2.68	2.36	1.14
Greece	462	1.7%	1.72	1.73	0.99	35	1.0%	1.17	1.90	0.62
India	1259	4.5%	1.97	1.88	1.05	186	5.3%	1.33	1.69	0.79
Italy	1244	4.4%	2.17	2.23	0.97	143	4.0%	2.10	2.12	0.99
Japan	1161	4.2%	2.06	2.29	0.90	144	4.1%	1.71	2.26	0.76
Netherlands	705	2.5%	2.76	2.39	1.15	63	1.8%	2.29	2.22	1.03
China	2947	10.5%	2.37	2.33	1.02	368	10.4%	2.15	2.35	0.92
Poland	603	2.2%	1.31	1.31	1.00	91	2.6%	0.69	0.98	0.71
Spain	1346	4.8%	2.64	2.34	1.13	178	5.0%	2.70	2.41	1.12
Sweden	664	2.4%	2.78	2.35	1.18	63	1.8%	2.14	2.05	1.05
UK	1802	6.4%	2.63	2.33	1.13	193	5.5%	3.39	2.57	1.32
USA	7722	27.6%	2.69	2.49	1.08	930	26.3%	2.81	2.58	1.09
EUR15	9279	33.2%	2.37	2.25	1.05	1109	31.4%	2.45	2.31	1.06

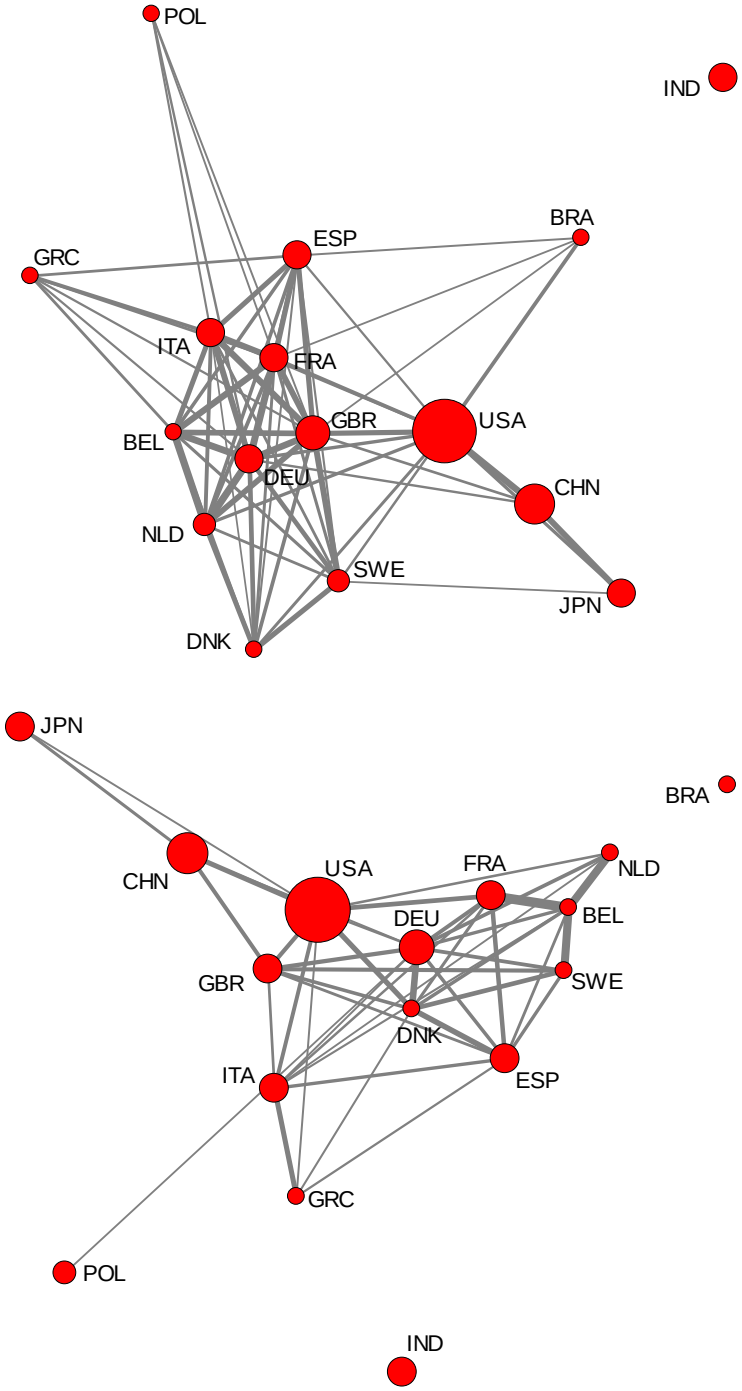

Figure 1 Environmental sciences (top: subject category; bottom: emerging topic)
Data sourced from Thomson Reuters Web of Knowledge

The MOCR of the world total in "nano pollution" amounts to 2.18. The citation impact of the US and EU are distinctly above this reference value. Furthermore, the highest impact is achieved by the UK and Denmark. This is contrasted by the surprisingly low impact of Belgium and Greece. Finally, the relatively high impact of China's publications in this emerging topic is worth mentioning (cf. Glänzel et al., 2008). Its MOCR value exceeds that of Japan and is very close to reference standard. International collaboration in "nano pollution" is quite intense. The share of internationally co-authored papers in all papers ranges between more than 60% (Denmark and Belgium) and less than 20% (Poland, Brazil and India). The median amounts to 39.4%. The share of international co-publications in the US, China and Japan is traditionally moderate (25%–27% each). The members of the EU form a strong cluster in the WoS discipline (see Figure 1). The US are connected with the EU as well as with China and Japan. In the emerging topic, the coherence of the European cluster is less pronounced and the US form the most important node in the collaboration network.

4.2. Energy & fuels

The second topic emerges from research in energy & fuels. The number of clusters increased from seven in 1999–2003 to eight in the second period (2006–2008). One of the clusters in the second period has been labelled "biofuel". This cluster comprises 7059 documents and represents 24.2% (i.e. about 1/4) of the discipline. This topic can be considered to be of Type I emerging from a former cluster on fuels. It can be described by the following selected core documents (data sourced from Thomson Reuters Web of Knowledge).

- Process optimization for biodiesel production from mahua (Madhuca indica) oil using response surface methodology
- Continuous production of biodiesel via transesterification from vegetable oils in supercritical methanol
- Temperature effects on biohydrogen production in a granular sludge bed induced by activated carbon carriers
- Biohydrogen generation from jackfruit peel using anaerobic contact filter
- Biohydrogen-production from beer lees biomass by cow dung compost
- Isolation of hydrogen generating microflora from cow dung for seeding anaerobic digester
- Fermentative hydrogen production from xylose using anaerobic mixed microflora
- Sulfate effect on fermentative hydrogen production using anaerobic mixed microflora
- Biodiesel production via non-catalytic SCF method and biodiesel fuel characteristics
- Biological hydrogen production in suspended and attached growth anaerobic reactor systems

The scientometric indicators for the most active countries in the discipline and the topic are presented in Table 2. Unlike in the previous case, the comparison of the emerging topic with the discipline reveals some interesting deviations. The EU is still responsible for slightly more than one fourth of all papers in both the topic and the domain, but US activity is rather low. In the emerging topic, it ranks even second after China. Beyond doubt, China is the most active country in biodiesel and Japan and India rank third and fourth after the US, respectively, outpacing all individual members of the EU. The MOCR of the topic "biofuel" amounts to 3.79. According to the expectation, both the EU and the US have an observed citation impact above this reference standard; however, their rather moderate MECR values implies that, on an average, neither the US nor the EU publish in journals with very high impact. The citation impact of the individual member countries reflect a quite differentiated picture with Denmark, Germany and the Netherlands at the high-end and Greece, Italy and France with indicator values somewhat above or even below the world standard. Japan, China and India are not only very active in this subject, their research is efficient as well. They outperform even several European countries in terms of citation impact (cf. Table 2). Biofuel related research apparently has become a strategic subject in these countries.

Table 2 Energy & Fuels (biodiesel)
Data sourced from Thomson Reuters Web of Knowledge

Country	**ISI Category** (N=29160)					**Topic** (N=7059)				
	Papers	**Share**	**MOCR**	**MECR**	**RCR**	**Papers**	**Share**	**MOCR**	**MECR**	**RCR**
Belgium	198	0.7%	3.94	3.49	1.13	50	0.7%	4.14	3.82	1.08
Brazil	523	1.8%	3.50	3.82	0.91	140	2.0%	3.71	3.76	0.99
Denmark	318	1.1%	5.00	3.28	1.52	75	1.1%	10.01	3.44	2.91
France	1265	4.3%	3.27	3.23	1.01	328	4.6%	3.80	3.80	1.00
Germany	1294	4.4%	3.35	3.06	1.09	326	4.6%	4.63	3.80	1.22
Greece	462	1.6%	3.38	3.27	1.04	120	1.7%	3.59	3.13	1.15
India	1510	5.2%	4.11	3.97	1.04	421	6.0%	4.53	3.88	1.17
Italy	811	2.8%	3.40	3.44	0.99	223	3.2%	3.89	3.65	1.06
Japan	1524	5.2%	3.52	3.87	0.91	499	7.1%	4.29	4.14	1.04
Netherlands	480	1.6%	3.94	3.44	1.14	94	1.3%	4.65	3.89	1.19
China	3759	12.9%	3.68	3.58	1.03	1218	17.3%	4.12	3.78	1.09
Poland	339	1.2%	2.47	3.12	0.79	97	1.4%	3.66	3.66	1.00
Spain	1120	3.8%	3.51	3.76	0.93	262	3.7%	3.62	3.70	0.98
Sweden	568	1.9%	3.71	3.44	1.08	93	1.3%	3.66	3.64	1.00
UK	1424	4.9%	3.26	3.12	1.05	307	4.3%	3.78	3.09	1.22
USA	5136	17.6%	3.50	3.23	1.08	1036	14.7%	4.11	3.60	1.14
EUR15	7778	26.7%	3.38	3.31	1.02	1806	25.6%	4.02	3.58	1.12

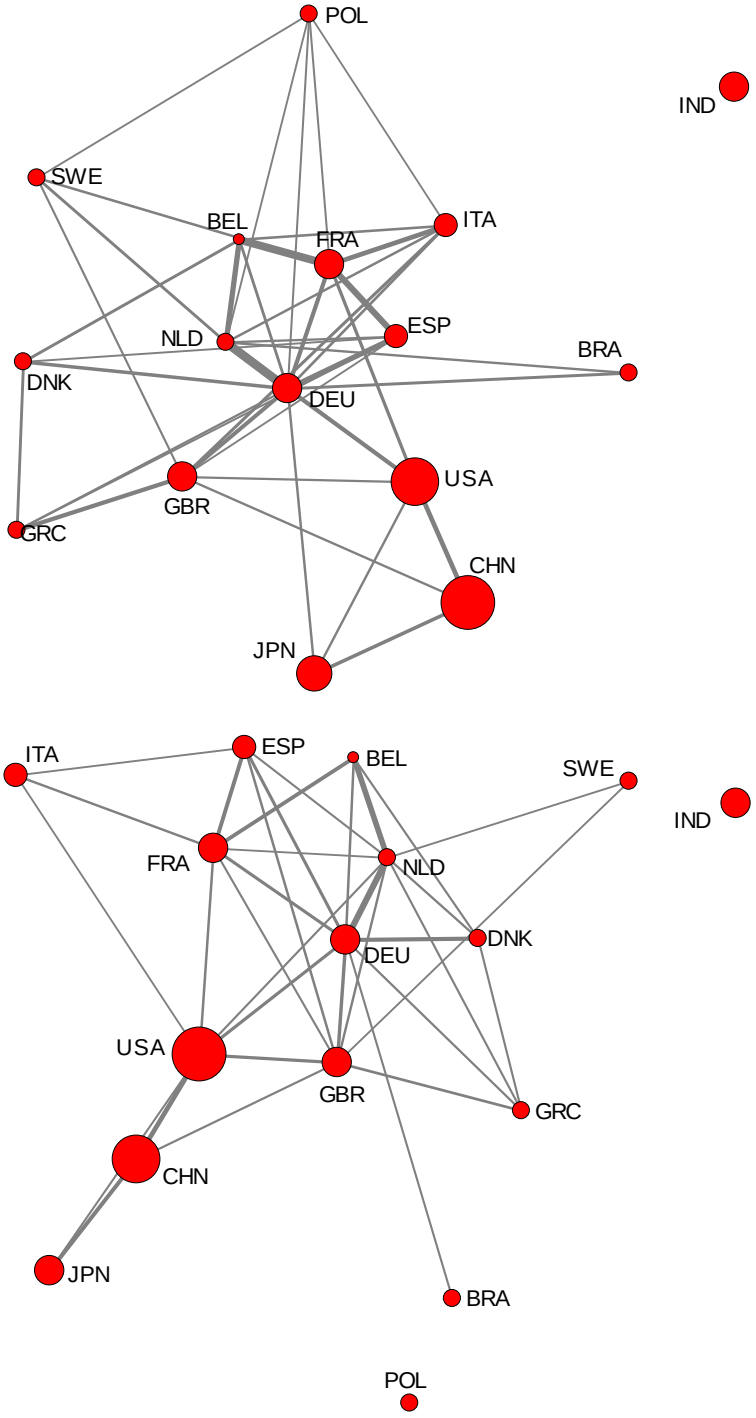

Figure 2 Energy & Fuel (top: subject category; bottom: emerging topic)
Data sourced from Thomson Reuters Web of Knowledge

International collaboration is less intense than in the previous case. Only Belgium has more than 50% internationally co-authored papers in its publication output. The corresponding share amounts to less than 20% each in Poland, China and India. The share of international co-publications of most countries in the selection fluctuates in a wide range around the median of 31.3%. Also the network is "looser" than was in nano pollution; the European cluster is less coherent, more scattered and it forms kind of an agglomerate of local clusters (see Figure 2). The USA form the bridge between the Far Eastern and the Europe groups.

4.3. Public, environmental & occupational health

The third Subject Category is *public, environmental & occupational health*. This discipline is covered by both the Science Citation Index Expanded (SCIE) and the Social Sciences Citation Index (SSCI). The first period chosen for this subject category is 1999-2001 and because of the size of this discipline, about 40% of papers in the period 2004-2008 were selected for the second period. The number of clusters changed from six in the first period to seven in the second one. A new cluster comprises 5945 documents and represents 20.5% (i.e. about 1/5) of the discipline. Since many documents are related with the effects of global warming and air pollution, it has been labelled "environmental factors". We have selected ten core documents for the description (data sourced from Thomson Reuters Web of Knowledge).

- Mortality in 13 French cities during the August 2003 heat wave
- Ambient carbon monoxide may influence heart rate variability in subjects with coronary artery disease
- Temperature and mortality among the elderly in the United States - A comparison of epidemiologic methods
- Effects of air pollution on heart rate variability: The VA Normative Aging Study
- Association of air pollution with increased incidence of ventricular tachyarrhythmias recorded by implanted cardioverter defibrillators
- The estimation of SARS incubation distribution from serial interval data using a convolution likelihood
- Mortality displacement of heat-related deaths - A comparison of Delhi, Sao Paulo, and London
- Multipoint linkage analysis for a very dense set of markers
- Association of ventricular arrhythmias detected by implantable cardioverter defibrillator and ambient air pollutants in the St Louis, Missouri metropolitan area
- Focused exposures to airborne traffic particles and heart rate variability in the elderly

Table 3 Public, environmental & occupational health (environmental factors)
Data sourced from Thomson Reuters Web of Knowledge

Country	**ISI Category** (N=29044)					**Topic** (N=5945)				
	Papers	**Share**	**MOCR**	**MECR**	**RCR**	**Papers**	**Share**	**MOCR**	**MECR**	**RCR**
Belgium	335	1.2%	3.79	3.08	1.23	106	1.8%	4.27	3.39	1.26
Brazil	1049	3.6%	1.90	1.95	0.97	282	4.7%	2.20	2.49	0.88
Denmark	515	1.8%	5.22	3.86	1.35	107	1.8%	5.58	3.82	1.46
France	963	3.3%	3.91	3.43	1.14	344	5.8%	4.07	3.51	1.16
Germany	1131	3.9%	4.18	3.17	1.32	265	4.5%	4.69	3.56	1.32
Greece	184	0.6%	4.55	3.63	1.25	50	0.8%	6.14	3.74	1.64
India	404	1.4%	2.34	2.61	0.90	148	2.5%	2.20	2.71	0.81
Italy	759	2.6%	3.77	3.29	1.15	209	3.5%	3.55	3.26	1.09
Japan	773	2.7%	2.69	2.99	0.90	186	3.1%	3.09	3.16	0.98
Netherlands	1046	3.6%	4.29	3.86	1.11	245	4.1%	4.44	4.00	1.11
China	709	2.4%	3.17	3.15	1.01	193	3.2%	2.85	3.19	0.89
Poland	210	0.7%	2.79	2.85	0.98	53	0.9%	2.96	3.01	0.98
Spain	728	2.5%	3.25	2.89	1.13	193	3.2%	3.28	2.92	1.13
Sweden	983	3.4%	4.08	3.39	1.20	163	2.7%	4.11	3.45	1.19
UK	3387	11.7%	4.23	3.52	1.20	697	11.7%	4.65	3.70	1.26
USA	13349	46.0%	4.44	3.97	1.12	2279	38.3%	4.89	4.09	1.19
EUR15	9088	31.3%	3.77	3.33	1.13	2126	35.8%	4.01	3.47	1.16

Table 3 shows the indicators for the most active countries. Beyond any doubt, the US is the most important contributor although the EU has a similar large share in the emerging topic. In this topic, the UK is ranking second after the US in terms of activity, followed by France and Brazil; this is remarkable since China's contribution is low although SARS was one of the issues studied in the literature of this cluster. Also Germany's contribution is strikingly moderate.

The MOCR of the complete topic "environmental factors" amounts to 3.82. The observed citation impact of the EU and the US are again above this reference standard but the values are clearly in favour with the United States. Within the EU, Denmark, the UK, Germany and the Netherlands attract most citations on an average. Most strikingly, Greece has the highest impact with MOCR=6.14 but this is based on a rather small set of papers (cf. Table 3). Also, 60% of the Greek papers in this topic have a co-author in the US and/or another EU country. The citation impact of Brazil and the Asian countries remain distinctly below the reference standard of 3.82.

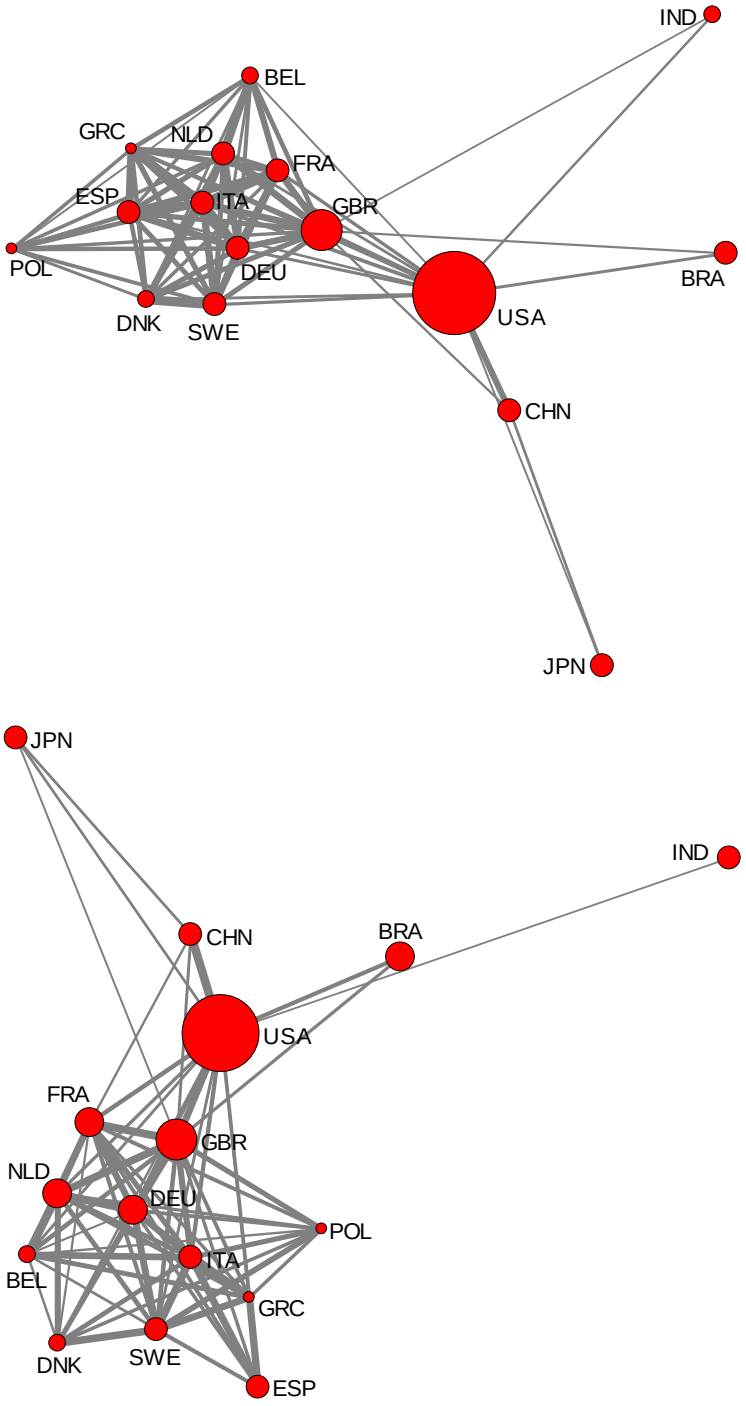

Figure 3 Public health (top: subject category; bottom: emerging topic)
Data sourced from Thomson Reuters Web of Knowledge

"Environmental factors" is apparently a global topic; international collaboration is intense and the network has two important nodes, namely the US (globally) and the UK (locally) in Europe (see Figure 4). Three countries (Greece, Belgium and Denmark) have 60% or more internationally co-authored papers in its publication output and only India has a percentage of international papers below 25%. The median (51.2%) of the selection is pronouncedly high. Almost one third (31.9%) of the US papers in the emerging topic have a foreign co-author

4.4. Biomedical engineering

The last Subject Category, which has been selected, is *biomedical engineering*. Here the number of clusters increased from eight (1999-2003) to nine (2004-2008). The cluster labelled "brain-machine interface" existed already in the first period but it has considerably grown: The growth rate amounts to 35.4%. In the second period the cluster comprises 5632 documents and thus represents 19.4% (i.e. almost 1/5) of the discipline. The topic has been labelled "brain-machine interface". Typical core documents are listed below (data sourced from Thomson Reuters Web of Knowledge).

- "Virtual keyboard" controlled by spontaneous EEG activity
- Planar gradiometer for magnetic induction tomography (MIT): theoretical and experimental sensitivity maps for a low-contrast phantom
- Adaptive BCI based on variational Bayesian Kalman filtering: An empirical evaluation
- Model-based neural decoding of reaching movements: A maximum likelihood approach
- Ascertaining the importance of neurons to develop better brain-machine interfaces
- Anasynchronously controlled EEG-based virtual keyboard: Improvement of the spelling rate
- Boosting bit rates in noninvasive EEG single-trial classifications by feature combination and multiclass paradigms
- Support vector channel selection in BCI
- Classification of single-trial electroencephalogram during finger movement
- BCI2000: A general-purpose, brain-computer interface (BCI) system

Scientometric indicators for the most active countries in BCI and related issues are shown in Table 4. Nearly 40% of all papers have an author in the EU. The US has a distinctly lower share. Within the European Union, we find by and large the usual balance of productivity: UK, Germany, France and Italy are the most active members, where, in this case, Italy is even more active than France.

The MOCR of the world total in "brain-machine interface" amounts to 2.67. As in the previous case, the MOCR values of the EU and the US are above this reference standard and the US MOCR exceeds that of the EU. The distribution within the EU somewhat differs from that of the discipline as well as of the previous emerging topics. Spain, the

Netherlands and Italy attract, on an average, more citations than Denmark, the UK and Germany.

International collaboration is relative intense. Denmark has more than 60% internationally co-authored papers in its publication output and only two countries (India and USA) have a percentage of international papers below 25%. The median of 36.7% is in line with the expectations. However, the network differs from the previous ones as there is no distinct EU cluster. Europe, the US, Asia and Brazil form one large cluster. Only India remains somewhat isolated (cf. Figure 4).

Table 4 Biomedical engineering (BMI)
Data sourced from Thomson Reuters Web of Knowledge

Country	**ISI Category** (N=29071)					**Topic** (N=5632)				
	Papers	**Share**	**MOCR**	**MECR**	**RCR**	**Papers**	**Share**	**MOCR**	**MECR**	**RCR**
Belgium	401	1.4%	4.33	3.61	1.20	83	1.5%	2.96	2.67	1.11
Brazil	466	1.6%	2.54	3.21	0.79	95	1.7%	2.00	2.68	0.75
Denmark	269	0.9%	3.97	3.82	1.04	94	1.7%	2.51	2.98	0.84
France	1165	4.0%	3.94	3.98	0.99	241	4.3%	2.95	2.95	1.00
Germany	2244	7.7%	4.07	3.86	1.05	338	6.0%	2.69	2.67	1.01
Greece	341	1.2%	2.60	3.00	0.87	98	1.7%	2.19	2.72	0.81
India	301	1.0%	3.02	3.44	0.88	48	0.9%	1.98	2.23	0.89
Italy	1617	5.6%	3.58	3.61	0.99	296	5.3%	3.05	2.88	1.06
Japan	1994	6.9%	3.87	4.34	0.89	221	3.9%	2.38	2.95	0.80
Netherlands	1103	3.8%	4.63	4.38	1.06	196	3.5%	3.53	3.17	1.11
China	1751	6.0%	4.17	4.15	1.00	256	4.5%	2.01	2.68	0.75
Poland	279	1.0%	1.91	2.52	0.76	71	1.3%	1.82	2.34	0.78
Spain	736	2.5%	3.39	3.64	0.93	207	3.7%	3.13	2.91	1.08
Sweden	535	1.8%	3.75	3.95	0.95	119	2.1%	2.63	2.83	0.93
UK	2553	8.8%	4.10	3.91	1.05	546	9.7%	3.00	3.04	0.98
USA	10278	35.4%	4.61	4.20	1.10	1990	35.3%	3.09	3.36	0.92
EUR15	10772	37.1%	3.80	3.81	1.00	2227	39.5%	2.84	2.88	0.98

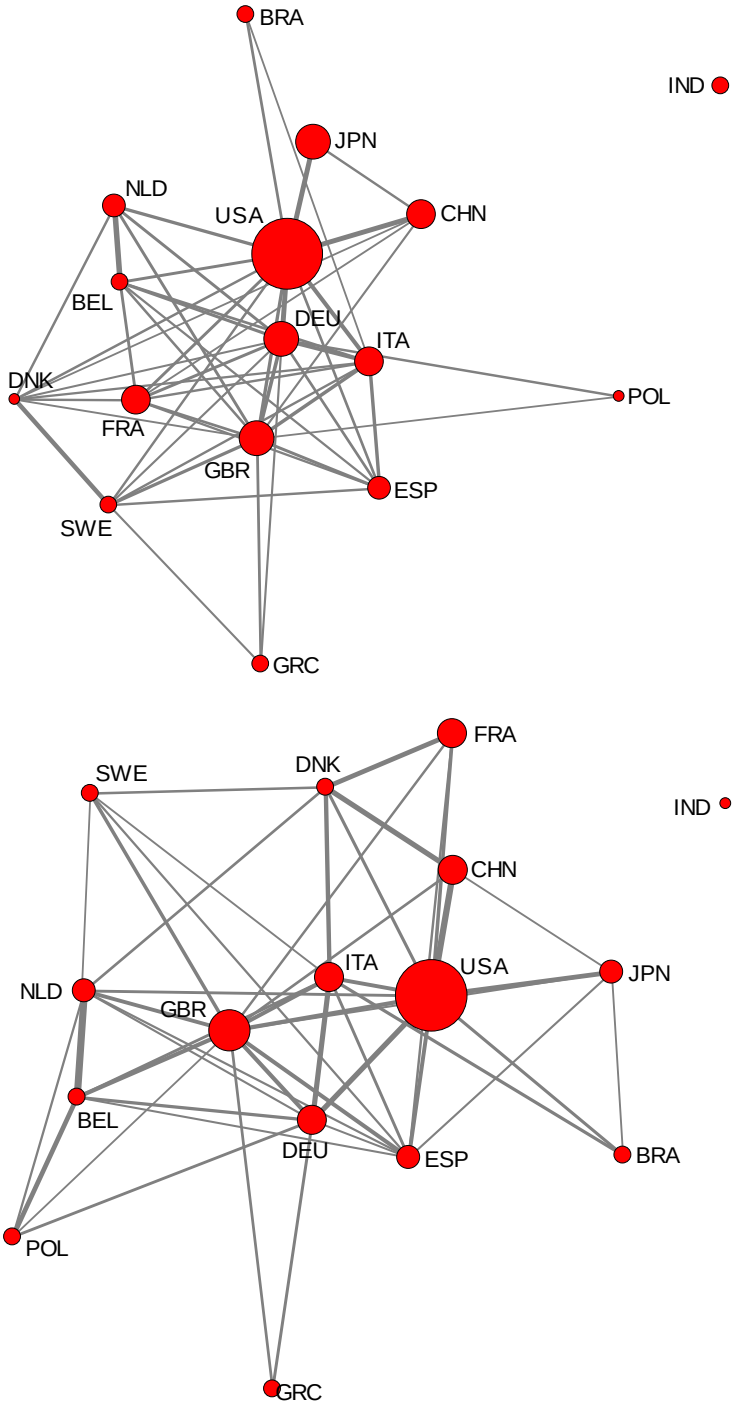

Figure 4 Biomedical research (top: subject category; bottom: emerging topic)
Data sourced from Thomson Reuters Web of Knowledge

5. CONCLUSIONS

Patterns of publication activity and citation impact, on one hand, and international collaboration, on the other hand, reflect important characteristics of emerging topics. Several topics might require intense international collaboration like the "environmental factors" in public health. Here, of course, regional aspects play an important part as well. Factors might, for instance, differ in individual world regions but the fundamental phenomenon remains a global one. By contrast, BCI related research might be a truly global issue since here we have not found any sub-clusters or polarisation. The loose networks in biofuel shows that national issues might be in the foreground here. The differentiation in industry between sugarcane in Brazil, corn in the US and rice straw in Japan might illustrate this regional aspect. "Nano pollution" is phenomenon of the industrialised world. Nevertheless, through environmental factors it becomes, in a sense, a global issue again.

The "scientific productivity" of the EU is except for "environmental factors" in public health distinctly higher than that of the USA. However, the US somewhat outperforms Europe in terms of citation impact in all selected topics, although the deviation between the US and EU indicator values is not dramatic. Several European countries achieved an outstanding citation impact, which, in particular, exceeded the European and the US standard by far.

Finally, the essential contribution of the emerging economies in Asia and South America to the research in the topics "nano pollution" and "biofuel" is worth mentioning. The high citation impact substantiates the efficiency of their efforts.

ACKNOWLEDGEMENT

Methodology has partially been developed in the context of the ERACEP project within the Coordination and Support Actions (CSAs) of the European Research Council (ERC) work programme. The authors wish to acknowledge this support.

REFERENCES

Braam, R.R., Moed, H.F., van Raan, A.F.J. (1991a). Mapping of science by combined cocitation and word analysis, Part 1: Structural aspects. *Journal of the American Society for Information Science*, 42 (4), 233–251.

Braam, R.R., Moed, H.F., van Raan, A.F.J. (1991b). Mapping of science by combined cocitation and word analysis, Part II: Dynamical aspects. *Journal of the American Society for Information Science*, 42 (4), 252–266.

Braun, T., Glänzel, W., Schubert, A. (1985), *Scientometric Indicators. A 32-Country Comparison of Publication Productivity and Citation Impact*. World Scientific, Singapore – Philadelphia.

Dosi, G., Llerena P., Sylos Labini, M. (2005), *Science–Technology–Industry Links and the "European Paradox": Some Notes on the Dynamics of Scientific and Technological Research in Europe*. LEM Working Paper Series, 02/2005.

Glänzel, W., Debackere, K., Meyer, M. (2008), 'Triad' or 'Tetrad'? On global changes in a dynamic world. *Scientometrics*, 74 (1), 71–88.

Glänzel, W., Janssens, F., Thijs, B. (2009), A comparative analysis of publication activity and citation impact based on the core literature in bioinformatics. *Scientometrics*, 79 (1), 109–129.

Glänzel, W., Thijs, B. (2011a), Using 'core documents' for the representation of clusters and topics. *Scientometrics*, 88 (1), 297–309.

Glänzel, W., Thijs, B. (2011b), *Using 'core documents' for detecting new emerging topics*. Noyons, E., Ngulube, P. Leta, J. (Eds), Proceedings of ISSI 2011 – The 13th International Conference on Scientometrics and Informetrics, Durban, South Africa, 04-07 July 2011, University of Zululand, 224–235.King, D.A. (2004), The scientific impact of nations. *Nature*, 430 (6997), 311–316.

May, R.M. (1997), The scientific wealth of nations. *Science*, 275 (5301), 793–796.

REIST-2 (1997), *Second European Report on S&T Indicators 1997*. EUR 17639, Brussels – Luxembourg.

REIST-3 (2003), *Third European Report on S&T Indicators 2003*. EUR 20025, Brussels – Luxembourg.

Rousseau, R. (2008), Triad or Tetrad: another representation. *ISSI Newsletter*, 4 (1), 5–7.

Shelton, R.D., Holdridge, G.M. (2004), The US-EU race for leadership of science and technology: Qualitative and quantitative indicators. *Scientometrics*, 60 (3), 353–363.

Zanotto, E.D. (2002) Scientific and technological development in Brazil. The widening gap. *Scientometrics*, 55 (3), 411–419.

Zhou, P., Leydesdorff, L. (2006), The emergence of China as a leading nation in science. *Research Policy*, 35 (1), 83–104.

Zitt, M., Bassecoulard, E. (1994), Development of a method for detection and trend analysis of research fronts built by lexical or cocitation analysis. *Scientometrics*, 30 (1), 333–351.

Zitt, M., Thèves, J., Laurens, P., Ramanana-Rahary, S., Bassecoulard, E., Filliatreau G. (2006), *Assessing international visibility of nations in science: citations performances of large emerging actors (BRIC)*. Poster presented at the 9th Science & Technology Indicators Conference, 7-9 September Leuven (Belgium).