

# Are we moving towards an integrated European Research Area? Some macro-level bibliometric perspectives

Robert J.W. Tijssen<sup>1</sup>

25 June 2008

## Abstract

This empirical paper addresses the question whether the European science base has become more coherent and more integrated during the years immediately prior to the EU27 expansion in 2004. Comparative quantitative indicators describe and analyze broad patterns and macro-level trends within intra-EU scientific cooperation, at various high aggregate “macro” levels, drawing on bibliometric analysis of jointly authored research articles published in the years 2001-2005.

This study provides country-level co-publication statistics describing the geographical distribution of each member state’s research partners – domestically, within the EU27 and outside the EU27. The results show signs that cooperation within the EU as a whole has increased noticeably during recent years. Some of the new EU27 member states show a relatively strong preference for EU research partnerships, but no conclusive macro-level evidence was found of structural transformations and large scale integration processes toward a highly interconnected ‘European Research Area’.

## 1 European research cooperation

The European science space is populated by a highly diversified and heterogeneous set of countries and regions. There are very signifi-

cant disparities in terms of size, research quality, effectiveness, dynamism and connectivity. The enlargement of the EU in 2004 with 10 new member states has added very significantly to this diversity. The expansion of the European Union after the turn of the century has drawn increased attention to the internal coherence of its ‘European science system’ in order to enhance its productivity and effectiveness. This system is characterized by a highly diversified and heterogeneous collection of ‘actors’ (countries, regions, organizations, facilities, networks and individuals). Research cooperation is seen as one of the main ‘top down’ organizational vehicles and ‘bottom up’ motivational factors to promote coordination and integration among those actors. The key question is to what extent the expansion of the European Union is affecting the growth of intra-European research cooperation. And are growth patterns of European scientific cooperation suggestive of integration processes? These are the two research questions that will be addressed in this paper, which reports on findings of an empirical study based on research publication outputs.

## 2 Bibliometric measurements of research cooperation

Numerous empirical studies have used bibliometric measurements to compare structural

---

<sup>1</sup> Centre for Science and Technology Studies (CWTS), Leiden University, The Netherlands, [tijssen@cwts.leidenuniv.nl](mailto:tijssen@cwts.leidenuniv.nl)

and temporal characteristics of scientific cooperation at macro levels (e.g. Glanzel, 2001; Katz, 1994; Luukkonen et al., 1993; Luwel, 2006; Moed et al., 1992; Zitt and Bassecourard, 2004). The metrics applied in this papers deals exclusively with one of the major tangible ‘outputs’ of these processes: research publications disseminated in the public domain. This particular metrics is based on information derived from group-authored research publications that involved collaborating scientists and scholars from different institutional or geographical backgrounds. The analytical strength of these co-publication measurements lies in their ability to provide detailed indicator-based comparisons within a structured ‘science systems’ framework, as well as providing a platform of empirical data for follow-up (qualitative) studies of relational patterns and trends. Very few co-publication studies have looked specifically at research cooperation within Europe, mostly at the level of individual countries (e.g. Katz, 1994; Tijssen and Van Leeuwen, 2007).

Some studies of intra-European co-publications, dealing with country-level trends during the period 1992-2001, show signals of European integration with large degrees of diversity at the level of individual member states (Frenken, 2002a; 2002b). Intra-EU cooperation patterns and trends cannot be seen in isolation from worldwide developments in research cooperation. Comprehensive studies of pan-European integration processes therefore require a broader geographical perspective and multi-level analyses; research cooperation linkages between individual member states are intricately related to globalisation and regionalisation of European science.

The statistical analysis covers hundreds of thousands of co-publications that were published between 2001 and 2005. Bearing in mind that the average time lag between research initiation and publishing research findings may take at least two years, these data refer mainly to research activities during the years 1999-2003, the period immediately prior to the EU’s enlargement on January 1st 2004 to 27 member states.

### 3 Information source and data processing

The empirical data for this study were extracted from co-authored research articles that were published in science journals indexed by the Web of Science (WoS), an electronic bibliographical database produced by ReutersThomson Scientific. Research articles in these peer-reviewed journals satisfy a certain minimum level of originality and scientific quality. The WoS, indexing some 9 000 journals worldwide, is considered to be one the most comprehensive and reliable sources of information on basic research activity across all countries and fields of science. It provides a good to excellence representation of internationally accepted high-quality ‘mainstream’ research, especially public sector curiosity-driven ‘basic’ research within the natural sciences, life sciences and medical sciences. The noteworthy limitations of the WoS are its bias in favour of English-language journals and the fairly low levels of coverage of research in the social sciences and humanities. Moreover, the WoS-indexed publications tend to include successful research only (failures are usually not published in international journals). Despite these constraints, the WoS represents a very sizable representation of European collaborative research, especially academic research within fields of the ‘hard’ sciences.

Co-authorship of a WoS-indexed research publication is used as an empirical indicator of research cooperation, where changes in co-publication output are assumed to reflect the dynamics of research cooperation connectivity. Adopting an integer counting scheme, a publication can belong to one or more geographical category depending on the countries listed in the author addresses. Three broad categories are defined: (a) an ‘intra-EU27 co-publication’ with partners exclusively from other EU27 member states, (b) an ‘international co-publication’ with at least one non-EU27 partner or (b) a ‘domestic co-publication’. The category ‘intra-EU27 co-publications’ is divided into two subcategories: (a1) ‘co-publications among EU15 member states, (a2) co-publications among

EU15 member states and new EU27 member states, and (a3) co-publications among EU15 member states and new EU27 member states.

#### 4 Research cooperation trends

This analysis of European co-publication trends focuses on three groups of countries according to their EU membership status in 2001-2005:

(a) EU15 member states ('EU15'): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, and the United Kingdom;

(b) New member states of the EU27 ('new EU27'): Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia;

(c) Acceding countries and Candidate countries ('EU-AC'): Croatia, Macedonia (FYROM), and Turkey.

Figure 1 depicts the growth rates of co-publication frequencies involving these three country blocks, broken down into six categories. The global growth rate of international co-publications is added for reference. Using

the co-publication output levels in 2001 as a statistical baseline, we find an intra-EU growth rate of 30%, which is in line with the worldwide growth rate of co-publication output between 2001 and 2005. This finding suggests that large scale institutional support within Europe to promote intra-EU research cooperation has not lead to any additionality in terms of an enhanced level of connectivity. Alternatively, it may indicate that support programmes may have been instrumental in closing the gap between the relatively low European levels of international research cooperation compared to many other non-EU countries. The EU growth rate in international co-publications is now at the same level as the US (34% growth between 2001 and 2005) and Japan (27%), but still significantly less than for example China (98%), South Korea (85%), Canada (49%), Norway (45%) and Switzerland (40%). The increase in co-publications involving two or more of 12 new member states of the EU-27 has increased by 50%. At face value, intra-European research cooperation has certainly has become a more pronounced driving force of connectivity patterns within European science.

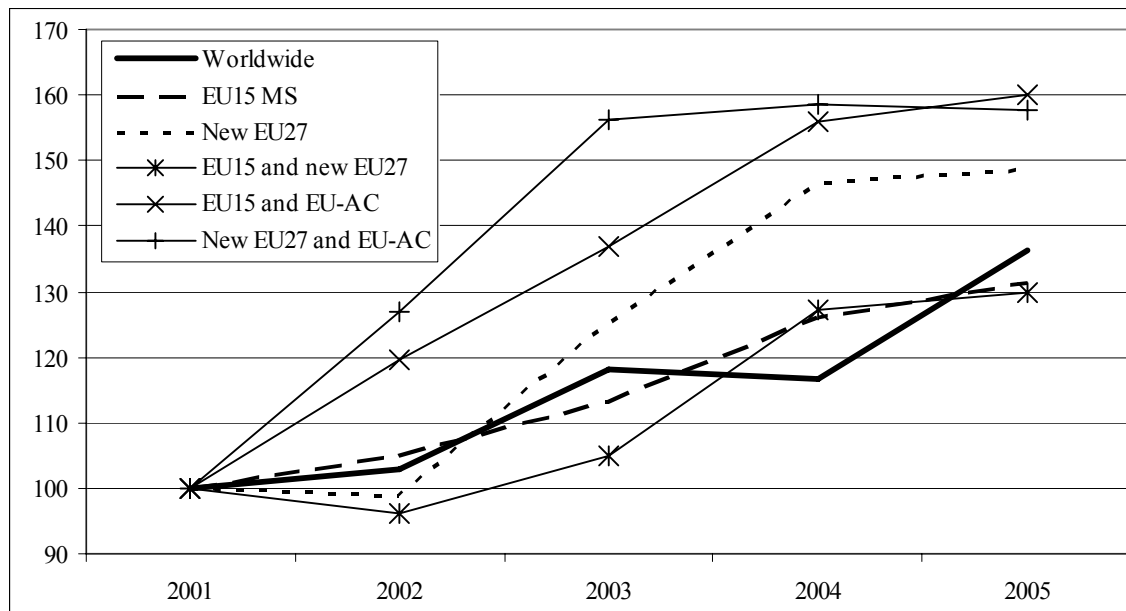


Figure 1. Growth rates of international scientific cooperation: general trends in co-publication output frequencies (%; 2001=100)

The large growth rates between the current EU member states (EU15 as well as EU27) and acceding/candidate countries (i.e. Croatia, Macedonia, and Turkey) is particularly interesting; it points at ‘catching up’ processes within international science, which may have occurred for a number of reasons other than an enhanced preference for European partners, notably an above average growth rate in knowledge production in conjunction an increased emphasis on international cooperation in general, or a larger propensity to publish research in WoS-indexed international journals in which these co-publications tend to be disseminated.

These growth patterns may also partly arise from structural changes in publication habits and strategies of researchers in the central European countries, where many now opt for publishing their (co-authored) research

articles in English-language WoS-indexed journals rather than publishing in other (local language) outlets.

## 5 Co-publication characteristics of EU member states

Regardless of which specific factors are driving these changes in research cooperation and co-publication activity, and how they affect each other, the social environment and cognitive framework in which European researchers operate nowadays is shifting towards a more international orientation. But what exactly is European contribution in this trend? More specifically, does the increase of co-publications involving other EU27 member states exceed a country’s growth of international WoS-indexed research articles?

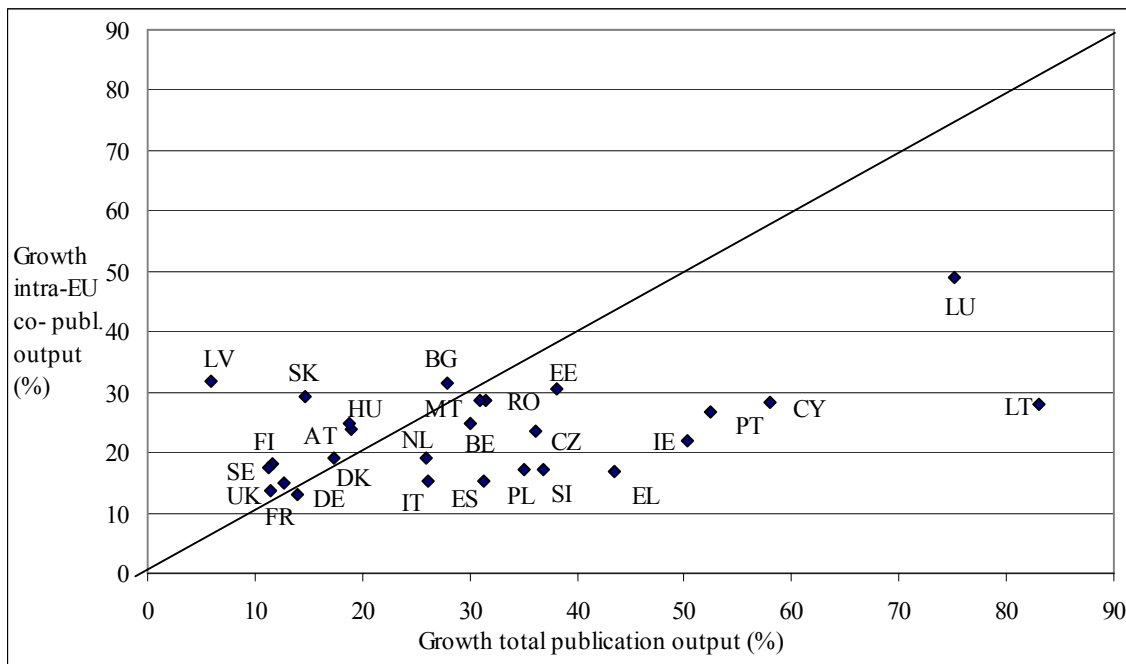


Figure 2. Growth in science versus growth in intra-EU research cooperation (% increase in publication output and % increase in intra-EU co-publication output, 2001-2005)

Table 1. Classification of EU27 countries by spatial distribution of co-publication partners - share in total publication output in 2005 (percent) and average annual change in share 2001-2005 (percent).

Category of EU27 countries**	International EU27 % share	– intra	International % share	– other	Domestic % share	
<b>All EU27 countries</b>	<b>23</b>	<b>(10)</b>	<b>24</b>	<b>(10)</b>	<b>20</b>	<b>(14)</b>
<b>EU27 orientation</b>	<b>32</b>	<b>(13)</b>	<b>23</b>	<b>(13)</b>	<b>12</b>	<b>(26)</b>
Luxembourg	49	(17)	23	(24)	6	(53)
Latvia	32	(1)	27	(20)	8	(-3)
Bulgaria	31	(9)	24	(10)	14	(11)
Estonia	31	(10)	21	(6)	16	(11)
Slovakia	29	(6)	20	(5)	15	(8)
Romania	29	(9)	23	(11)	18	(12)
Malta	29	(45)	17	(16)	10	(43)
Cyprus	28	(14)	35	(16)	5	(56)
Lithuania	28	(10)	20	(10)	14	(40)
<b>Mixed orientation</b>	<b>21</b>	<b>(9)</b>	<b>24</b>	<b>(9)</b>	<b>23</b>	<b>(10)</b>
Portugal	27	(10)	23	(15)	24	(17)
Belgium	25	(9)	26	(10)	19	(10)
Hungary	25	(7)	26	(4)	22	(9)
Austria	24	(9)	25	(8)	21	(6)
Czech Republic	23	(10)	23	(9)	23	(14)
Ireland	22	(10)	22	(19)	19	(13)
Denmark	19	(6)	30	(6)	22	(6)
Netherlands	19	(8)	25	(8)	27	(8)
Finland	18	(7)	24	(5)	31	(3)
Sweden	17	(5)	29	(6)	25	(3)
Slovenia	17	(15)	22	(11)	22	(8)
Poland	17	(7)	22	(8)	21	(13)
Greece	17	(8)	18	(11)	27	(16)
<b>Non-EU27 orientation</b>	<b>14</b>	<b>(8)</b>	<b>24</b>	<b>(8)</b>	<b>26</b>	<b>(6)</b>
Italy	15	(8)	21	(8)	35	(8)
Spain	15	(10)	20	(11)	28	(8)
France	15	(6)	27	(8)	27	(5)
United Kingdom	14	(7)	25	(8)	19	(3)
Germany	13	(8)	27	(7)	22	(6)

*Notes:* The categories of co-publication partners are mutually exclusive. There is no multiple counting of publications classified within the same category.

EU27 oriented (>40% of total co-publication output involves EU27 countries, including domestic co-publications); Non-EU27 oriented (<25% of total co-publication output involves EU27 countries, including domestic co-publications).

Figure 2 compares the growth rates for each member state.<sup>2</sup> If so, research cooperation within their science base is becoming more EU27-oriented. A minority fraction of 10 EU27 member states, six of which are EU15 member states, actually satisfy this criterion. Only two member states exhibit a comparatively strong focus on EU27 cooperation: Latvia and Slovakia. This result clearly suggests a trend toward increased levels of intra-European connectivity, but with large variation across countries. It also emphasizes the need for a broader perspective to examine how the co-publications of these countries are distributed geographically, primarily because these trends within intra-EU27 co-authorship relationships between countries cannot be seen in isolation from trends in research partnerships in general. More specifically, is the preference for EU27 partnerships becoming larger or smaller relative to domestic partners and/or non-EU27 partners?

The statistics presented in Table 1 provide data on the geographical orientation for research partnerships as well as the corresponding of growth rates. The patterns and trends vary by member state. Almost half of Luxembourg's research publications are intra-EU co-publications, a large difference compared to Germany's 13%; Malta shows a 45% average annual increase of intra-EU co-publications, while Latvia has barely increased its low share (1%). Basically, a dichotomy is found between the nine smallest or least developed European member states, which are predominantly focused on European partners, and Europe's five largest scientifically advanced nations with a preference for domestic cooperation and/or partners outside the EU.

<sup>2</sup> Country acronyms: AT-Austria, BE-Belgium, BG-Bulgaria, CY-Cyprus, CZ-Czech Republic, DE-Germany, DK-Denmark, EE-Estonia, EL-Greece, ES-Spain, FI-Finland, FR-France, HU-Hungary, IE-Ireland, IT-Italy, LT-Lithuania, LU-Luxembourg, LV-Latvia, MT-Malta, NL-Netherlands, PL-Poland, PT-Portugal, RO-Romania, SE-Sweden, SI-Slovenia, SK-Slovakia, UK-United Kingdom.

## 6 European expansion and integration

The small member states are not homogeneously moving toward higher levels of EU orientation or integration. In fact, in many cases, their growth rates of domestic co-publications exceed those of intra-EU co-publications. It appears that these countries are expanding research collaboration and connectivity in all directions, signaling a process of expansion rather than integration. The largest countries are expected to be more domestically oriented because of their scale advantages; they have more research performing organizations and specialized research infrastructures within the national borders and thus more opportunities to cooperate with local partners. Interestingly, most of their growth rates in domestic cooperation are slightly less in 2001-2005 than the intra-EU growth rates suggesting a gradual shift toward European partnering. The large group of medium-sized member states comprise of a diversity of profiles in between these extremes. As a group, they exhibit a more equally spread distribution of cooperation partners across the three categories, with fairly similar annual growth rates.

The summary statistics for the EU27 as a whole, presented in the top row of Table 1, show that almost half of the EU research publication output involves international cooperation, either with other EU27 member states exclusively (23%), or with at least one non-EU27 country involved. Overall, these aggregate data also suggest a gradually evolving European integration: the average annual growth of intra-EU27 co-publications measured some 10% during the years 2001-2005. However, cooperation with countries outside the EU27 also grew by 10%, while domestic cooperation increased with an average of 14% each year. In other words, the intra-EU27 co-publication growth rate seems to be an integral part of global processes in modern-day science. Nonetheless, part of the increased interconnectivity within the European science system can be attributed to "Europeanization", especially within the group of small member states. However, no macro-level

evidence is found of all EU27 countries gradually becoming more focused on collaborating with fellow member states and thus moving in the same direction toward a more homogeneous ERA. In fact, some trends indicate that existing patterns of divergence seem to persist, for example in Italy and Greece where domestic cooperation clearly continues to take preference over working with foreign partners.

## 7 Concluding general remarks

Co-publication indicators obviously constitute only a partial and incomplete description of research cooperation characteristics. Although such 'simplistic' co-publication indicators of research cooperation can be more controversial than qualitative measures, they provide comparative empirical evidence that is more compelling and politically acceptable. The strength of the co-publication measurements lies in their ability to provide detailed comparison within a structured 'science systems' framework as well as being a highly versatile analytical approach for follow-up studies to gather further information beyond the broad patterns presented in this paper. First and foremost, it also enables longitudinal views - both backwards and forwards in time. In the latter case, the recent evolutionary developments described in this paper may serve as a baseline to gauge the current state of affairs (in 2006-2008) and examine the entry effects of the new EU27 member states on research cooperation trends within their own country and the European Union as a whole.

The macro-level trends and broad patterns described in this paper reveal a mix of globalization, Europeanization and localization processes occurring within European collaborative research. In most cases the trend data fail to show any significant increases in preferences for research partners located in other EU member states other than what one would expect in view of ongoing globalization processes. The new member states of the EU27 appear to be more EU-focused compared to the old EU15 member states, and their intra-EU connectivity is growing faster.

## Acknowledgement

The author wishes to thank Thed van Leeuwen, Erik van Wijk and Suze van de Luijt for data handling and research assistance.

## References

- Frenken, K., 2002a. A new indicator of European integration and an application to collaboration in scientific research. *Economic Systems Research* 14, 345-361.
- Frenken, K., 2002b. Europeanisation of science. *Tijdschrift voor Economische en Sociale Geografie* 93, 563-569.
- Glanzel, W., 2001. National characteristics of international scientific co-authorship. *Scientometrics* 66, 231-240.
- Katz, J.S., 1994. Geographical proximity and scientific cooperation. *Scientometrics* 31, 31-43.
- Luukkonen, T., Tijssen, R.J.W., Persson, O., Sivertsen, G., 1993. The measurement of international scientific collaboration. *Scientometrics* 28, 15-36.
- Luwel, M., 2006. Benchmarking the European Research Area's integration, Presentation at the 9th International Conference on Science & Technology Indicators, 7-9 September 2006, Leuven, Belgium.
- Moed, H.F., De Bruin, R.E., Nederhof, A.J., Tijssen, R.J.W., 1991. International scientific co-operation and awareness within the European Community: problems and perspectives. *Scientometrics* 21, 291-311.
- Tijssen, R.J.W., Van Leeuwen, T.N., 2007. Research Cooperation within Europe: Bibliometric views of Geographical Trends and Integration Processes, In: Torres-Salinas, D., Moed, H. (Eds.), *Proceedings of the ISSI 2007 (Volume II)*, CINDOC-CSIC, Madrid, pp. 740-744.
- Zitt, M., Bassecouard E., 2004. Internationalisation in science in the prism of bibliometric indicators: Journals, collabora-

tion and geographical distribution. In: Moed, H., Glänzel, W., Schmoch, U. (Eds.), *Handbook of Quantitative Science and Technology Research*. Kluwer Academic Publishers, Dordrecht, pp. 665-694.