

International co-publishing in Finland

Reports of the Ministry of Education and Culture, Finland 2012:19

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Ministry of Education and Culture
Department for Education and Science Policy
P.O. Box 29
00023 Government, Finland

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Abstract

This study looks at international co-publishing in Finland and the citation counts of publications in different disciplinary groups in 1990–2009. The results presented here are based on the Thomson Reuters Web of Science (WoS) publication and citation database from 1990 to 2009.

The share of international co-publishing in all of Finland's WoS publications increased from 25 per cent to 49 per cent in 1990–2009. In tandem with international co-publishing becoming more common, there has been an increase in the relative share of national cooperation between organisations, whereas the share of publications produced in national, intra-organisational cooperation in all of Finland's international publications has declined. The trend of co-publishing in Finland can thus be described as an increase in transboundary cooperation – both between countries and between organisations.

The share of single-author publications declined in 1990–2009. As an exception to most main scientific disciplines, single authorship remained clearly the most typical form of international authorship in humanities journals in 2006–2009; 70 per cent of these publications were written by a single author. While the relative share of single authorship has decreased, the number of co-authors in a publication has gone up: in 1990–2009, the number of co-authors in national publications increased from three to four, while this number in international co-publications has gone up from five to seven authors.

In Finland's international co-publications, the co-author was most typically affiliated with an organisation in the EU15+ states¹. The second most typical participants in international publications were co-authors from North America, and third most typical were co-authors from the Nordic countries. No change took place in the order of the three most common country groups within the period of examination.

In 1990–2008, international co-publications were on average cited more times than publications produced in national cooperation. The citation counts of the former exceeded the average global level throughout the period. The more authors that were involved in a publication, the more times it was cited on average. The high citation

¹ EU15+ states = EU15 states excluding the Nordic countries + Switzerland, or Luxembourg, Ireland, Portugal, Austria, Belgium, the Netherlands, Greece, Spain, Italy, France, Germany, the United Kingdom and Switzerland.

counts of international co-publications are partly explained by the fact that, on average, they involve a higher number of co-authors than national publications.

A growing trend in international co-publishing has been cooperation involving researchers from more than one country group in addition to Finland. The more country groups that were involved in a publication, the higher its citation count on average. In the sphere of national cooperation, gauged by the citation counts, inter-organisational cooperation produced science with a higher impact than intra-organisational co-authorship.

To summarise, this study indicates that co-publishing of Finnish scientists has diversified: the share of publications produced as a result of international cooperation, involvement of several country groups, and national inter-organisational cooperation in all WoS publications increased, and the more diverse the co-authorship was, the higher the citation count.

Preface

This is a summary report on the project "International Co-authorship in Finland" funded by the Finnish Ministry of Education and Culture. The project was implemented by the Unit for Science, Engineering and Innovation Studies at the University of Tampere between April and November 2011. The principal investigator of the research project was Reetta Muhonen M.Soc.Sci. Responsibility for processing the data was assumed by Licentiate of Engineering Yrjö Leino from CSC (Tieteen tietotekniikan keskus Oy). Hanna-Mari Puuska MA took part in planning the study and provided expert support for the project. We would like to extend our thanks to the members of the Citation Index Working Group II, which acted as the steering group for the project: Olli Poropudas, Ministry of Education and Culture (chair), Otto Auranen, Federation of Finnish Learned Societies, Maija Miettinen, Academy of Finland, Anu Nuutinen, Academy of Finland, Janne Pölönen, Federation of Finnish Learned Societies.

We would also like to thank Counsellor of Education Tiina Vihma-Purovaaraa for her comments on the report.

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1 Introduction

Encouraging internationalisation has been one of the most visible objectives of Finnish science policy in the last few decades. Internationality has always been part of scientific research activities – scientific debate has not been limited to a certain geographical area, and new ideas have been sought across national boundaries (e.g. Hakala 1998). Finnish research and scientists have been encouraged towards internationalisation due to internal reasons within the field of science, including the increase in research costs, specialisation and shared, global research targets. As the travel and various forms of communication have become less expensive, faster and more diverse, international visits, cooperation projects and publications have multiplied. In addition to internal reasons, researchers have also been encouraged towards internationalisation by means of science policy decisions. In science policy debate, internationalisation discourse has gained momentum since the late 1980s. (Hakala et al. 2003, 146–147; Hakala et al. 2004.)

It has been demonstrated that international co-publications are cited more often than others (Narin et al. 1991; Katz & Hicks 1997; Glänzel 2001; Glänzel & Schubert 2001; NordForsk 2010; NordForsk 2011), and similar results have been obtained in the Finnish context (NordForsk 2010, 24; NordForsk 2011, 57). In recent years, concern has been expressed for the declining scientific impact of Finland's international publications (Academy of

Finland 2009, 41–54, 247–249). A Nordic study (NordForsk 2010, 24) indicated that as recently as in 1989–1993, citation counts of Finland's international co-publications were 53 per cent higher than the world's WoS publications on average, while in 2004–2007, this figure had decreased to 33 per cent. On the other hand, no change has been registered in the average citation counts of WoS publications only involving Finnish authors. In 1989–2004, these publications cumulated 3 per cent less citations than all WoS publications in the world on average.

In this study, the internationalisation of Finnish research is approached by looking at the trends of international co-authorship and its links to the citation counts of publications in the different disciplinary groups. For the purposes of this study, Finnish international co-authorship is limited to publications listed in the Thomson Reuters Web of Science (WoS) database.

The typicality of co-authorship can be assessed by the following research questions:

- 1 How did (national and international) co-authorship in Finland develop in 1990–2009?
- 2 What share of publications in different disciplinary groups are international co-publications?
- 3 Are there differences between disciplinary groups in terms of the number of authors in national and international co-publications?

- 4 What shares of publications in different disciplinary groups involve co-authors from the Nordic countries, the EU15 states, the country group Other European², the Baltic countries, Russia, Africa, Asia, North America, Central and South America, and Australia and Oceania?
- 5 What share of publications in different disciplinary groups have co-authors from two or more country groups?

The relationship between international cooperation and the scientific impact of publications is gauged by the following research questions:

- 6 Do international co-publications/publications involving authors from Nordic countries (and publications with co-authors from the various country groups) cumulate more citations on average than publications with Finnish authors only?
- 7 Are Finnish publications written in intra and inter-organisational cooperation cited more often than single-author publications?
- 8 Do co-publications involving several country groups cumulate more citations on average than publications that, in addition to Finnish scientists, have co-authors from a single country group only?
- 9 Are there differences in citation counts between international co-publications and other publications in all scientific disciplines?
- 10 Is there a link between the number of authors and the number of citations cumulated by the publications in different disciplinary groups?

2 Other European= Poland, the former Yugoslavia, Bulgaria, Hungary, Romania, Ukraine, Belarus, Czech Republic, Slovenia, Malta, Cyprus, Monaco, Liechtenstein, the Vatican, Albania, Croatia, Andorra, Moldova, San Marino, Bosnia-Herzegovina, Macedonia, Slovakia, Serbia, Montenegro and Kosovo.

2 Data and methodology

The results presented in this study are based on the Thomson Reuters Web of Science (WoS) database of publications and citations for 1990–2009.³ The Thomson Reuters database is compiled from three databases: the *Science Citation Index Expanded*, the *Social Sciences Citation Index* and the *Arts & Humanities Citation Index*. The coverage in the WoS data in all scientific research published in the world varies by the field, country and year of publication (Moed 2005, 126).

In this report, a Finnish publication refers to one involving at least one scientist or research team that has recorded a Finnish address for itself in the publication. Finnish publications in the data were identified on the basis of country codes given in connection with addresses. International co-publications were defined as publications contained in the Thomson Reuters Web of Science (WoS) database where, in addition to one or several Finnish organisations, at least one foreign organisation was recorded. In this study, a national publication refers to international publications involving only Finnish affiliations.

Single-author publications in which the author has registered both a domestic and an international

affiliation were not defined as international cooperation. The same argument applies to the definition of domestic cooperation: a single author's affiliation with two Finnish organisations is not regarded as cooperation. Thomson Reuters categorises publications into more than 30 different types, of which three have been taken into account in this study: *Article*, *Letter* and *Review*. Of all Finnish publications found in the database, these types cover nearly 89 per cent in total. Other publication types excluded from the study include *Meeting Abstract* (8.5%), *Editorial* (1.6%) and *Book Review* (0.9%).

In the analysis conducted for this report, each publication was classified as belonging to one or several disciplinary groups in multiple steps. The scientific discipline of an individual publication was directly determined by the journal in which the publication appeared. The Thomson Reuters data was collected by journal, with the publisher having determined one to six scientific disciplines for each journal. A publication may thus belong to between one and six scientific disciplines. Thomson Reuters classifies dozens of journals in the category "Multidisciplinary Sciences". This

³ This study was conducted in parallel with a study of the Citation Index Working Group II appointed by the Ministry of Education and Culture, and the starting points and definitions used for producing the data are thus to a great extent similar in both studies (for more information, see the Citation Index Working Group II, 2011).

category includes journals in such fields as Nature and Science, the articles in which cumulate citation counts that clearly exceed the average. In this report, publications appearing in such multidisciplinary journals are treated as a class of their own.

As the basis for determining the scientific discipline of a publication is the journal and not the author, the division of the journals into scientific disciplines is indicative and does not fully match the divisions into fields of education and research prevailing in research organisations. In addition to examination by scientific discipline, the report also discusses results compiled by organisation type. The organisation type of a publication is determined by the author's affiliations.

Relative citation index

In this report, citation counts of Finnish publications are compared to the world average citation counts. As the citation practices in different disciplinary groups may vary considerably, the number of citations cumulated by each publication was normalised by comparing it with the average citation counts of all publications in the relevant subject field which were published in that year and which represent the same WoS article type (Article, Review or Letter). In this report, the citation counts of Finnish publications have been put into proportion with all publications in the world in each of the 260 scientific disciplines used in Thomson Reuters. The accumulation period of the citations was not limited; articles published in the early part of the period under scrutiny thus had more time to cumulate citations, but as publications of an individual year are always compared to all WoS article types in the world published in that year and in the relevant subject field, this sets the publications on an equal footing, regardless of their year of publication.

When we calculate average citation counts normalised in terms of the scientific discipline, we obtain a *field-based relative citation index*, which describes the average *scientific impact* of Finnish publications compared to other publications in the same scientific discipline. If the value of this index exceeds 1, the impact is higher than the world

average, whereas an index of less than 1 indicates an impact lower than the average. As publications that came out in 2009 have not had time to cumulate statistically significant citation counts, all indicators based on citation counts were only calculated for those publications published in or before 2008.

When calculating absolute citation counts, *self-citations*, i.e citations from publications whose authors included some of the same names as the cited publication, were discarded. Self-citations do not specifically describe the scientific impact of publications, and self-citations have thus been excluded from the data in this study.

Fractional counting of publication numbers

When looking at the trends in and impact of authorship, we can either use the actual publication numbers, or fractional numbers obtained on the basis of organisations or number of co-authors involved (see for example Citation Index Working Group II 2011). The publication numbers given in this report are based on whole counts. The purpose of the study is to find out how typical international and national co-authorship is, rather than looking at the productivity of various forms of cooperation. As international co-publications always involve other countries, fractional counting by the countries or organisations involved in the publications, for example, would distort the number of international co-publications as compared to publications that were not written in cooperation with organisations in other countries. If the publication involves authors from more than one country group, the publication is thus counted for each group. As a single publication can belong to several country groups, the sum of country groups exceeds 100 per cent (see e.g. Table 3.3).

3 Results

3.1 Trends in co-authorship, 1990–2009

The share of Finnish international co-publications in all Finnish Web of Science publications has been increasing during 1990–2009 (Figure 3.1). In 1990–1993, this share was one fourth of all publications, and in 2006–2009 almost one half (49%) of all publications were already co-authored with foreign scientists. In addition to a dramatic increase in the share of international co-publications over the last twenty years, in proportion to her size, Finland stands out among other OECD countries for her total volume of WoS publications: in 2006–2009, more scientific publications entered in the WoS database per capita appeared in Finland than in any other OECD country (Citation Index Working Group II, 2011, 20).

Of the main scientific disciplines, the greatest increase in international co-authorship in 1990–2009 was recorded for journals in agriculture and forestry, or from 10 per cent to 40 per cent (Figure 3.2). The lowest share of international co-publications was found in humanities journals, while this field showed a relatively strong internationalisation trend with the share of international publications going up from 4 to 13 per cent. While the share of international co-publications increased in journals of all fields in 1990–2009, the majority of publications in the main scientific disciplines in 2006–2009 (excluding natural

science journals) were those only involving scientists affiliated with domestic organisations.

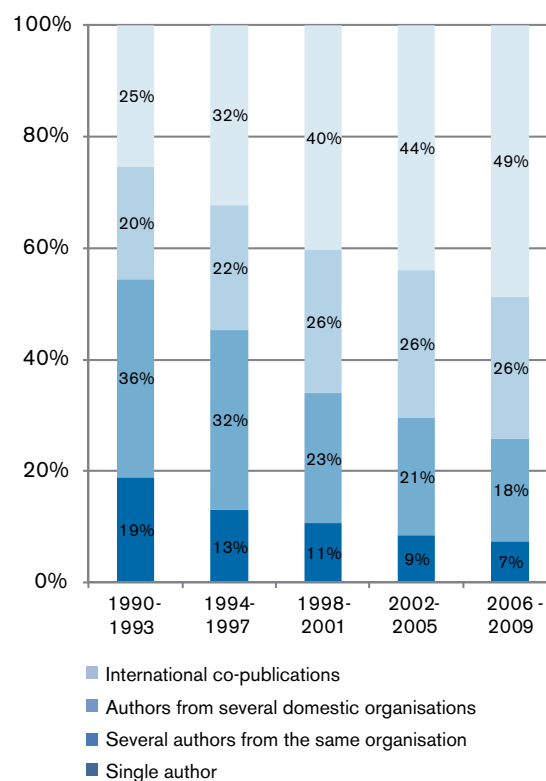


Figure 3.1. Typicality of cooperation in 1990–2009.

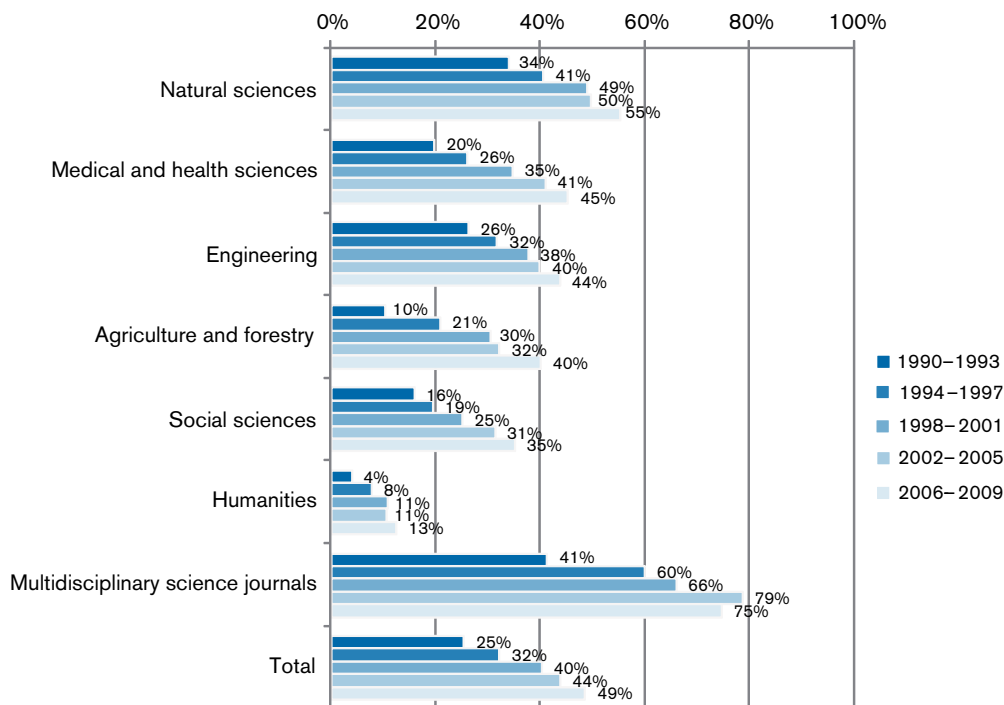


Figure 3.2. Share of international co-publications by main scientific discipline in 1990–2009

In tandem with international co-authorship becoming more common, there has been an increase in the relative share of national cooperation between organisations (Table 3.1), whereas the share of publications produced in national, intra-organisational cooperation in all international publications in Finland has declined. The trend in co-authorship in Finland can thus be described as an increase in transboundary cooperation – both between countries and between organisations. In the early years of the period under scrutiny, publications appearing as a result of either intra or inter-organisational national cooperation were

a more common type of WoS publications than international co-authorship. Not before the four-year period between 2006 and 2009 did Finnish international co-publications outnumber the total share of articles created in national cooperation (49% and 44% respectively).

The share of single-author publications declined in 1990–2009 in all main scientific disciplines (appendix 1). As an exception to most main scientific disciplines, single authorship remained clearly the most typical form of international authorship in humanities journals in 2006–2009; 70 per cent of publications were by a single author.

Table 3.1. Typicality of co-authorship in 1990–2009.

Number of publications	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Single author	3,316	19%	3,139	13%	3,221	11%	2,798	9%	2,829	7%
Several authors from the same organisation	6,218	36%	7,716	32%	7,036	23%	6,947	21%	6,935	18%
Authors from several domestic organisations	3,522	20%	5,384	22%	7,761	26%	8,707	26%	9,705	26%
International co-publications	4,452	25%	7,725	32%	12,164	40%	14,422	44%	18,438	49%
<i>Total</i>	17,508	100%	23,964	100%	30,183	100%	32,874	100%	37,908	100%

3.2 Trends in international co-authorship by organisation type

The share of international co-publications in all WoS publications increased for all organisation types. In 2006–2009, international co-authorship accounted for slightly over one-half of publications in universities, state research institutes and university hospitals (Figure 3.3).

3.3 Trends in author numbers

The average number of co-authors in Web of Science publications increased from three to four authors in national publications and from five to seven in international co-publications in 1990–2009 (Figures 3.4. and 3.5).

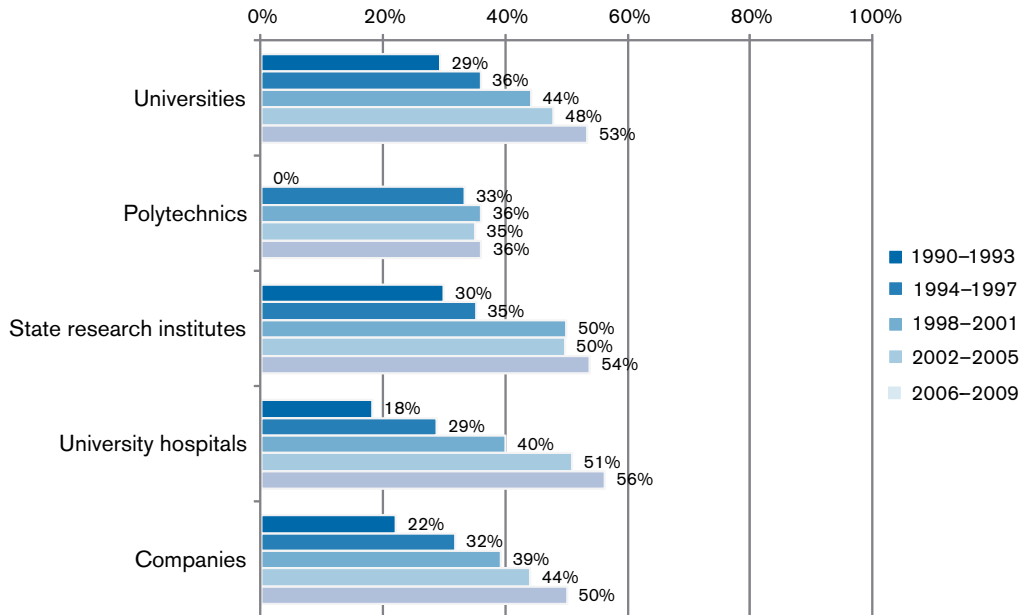


Figure 3.3. Share of international co-publications in all publications by organisation type in 1990–2009.

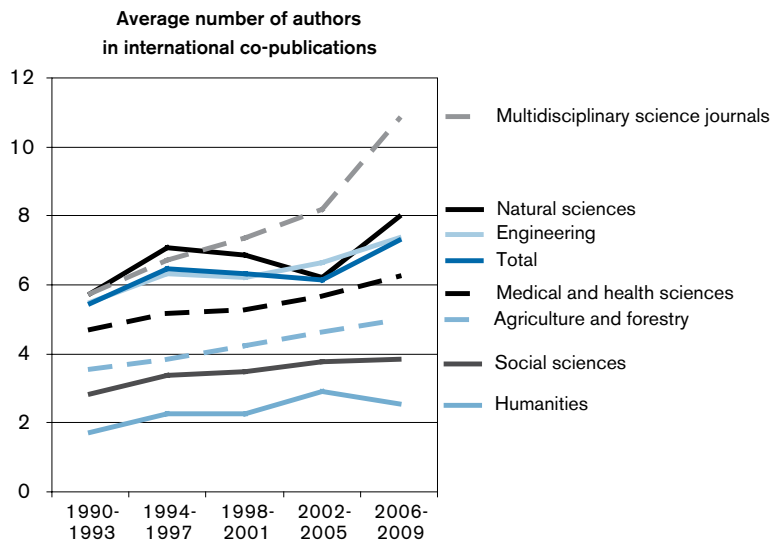


Figure 3.4. Trends in author numbers of international co-publications in 1990–2009 by main scientific discipline.

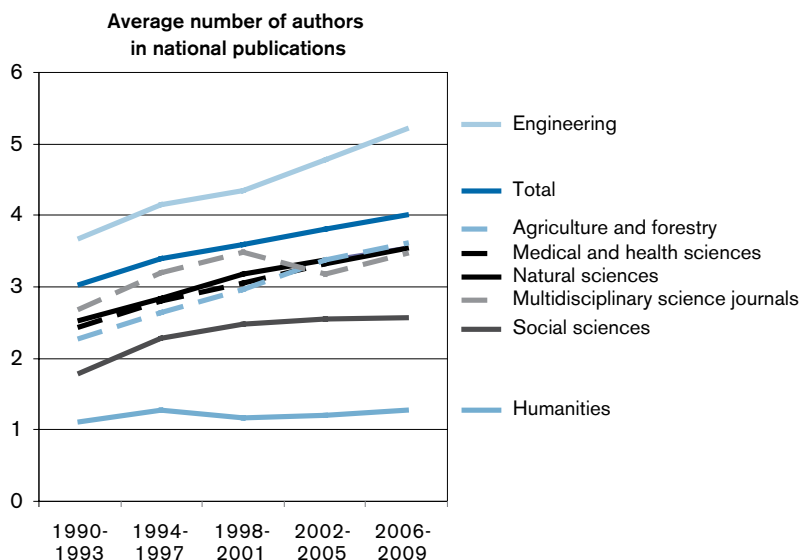


Figure 3.5. Trends in author numbers of national publications by main scientific discipline in 1990–2009.

3.4 Geographical orientation of international co-authorship

In Finnish international co-publications, the co-author most typically came from a research organisation in one of the EU15+ countries⁴ (Table 3.3). The second highest number of co-authors in international publications were from North America, and the third most common co-authorship partner came from the Nordic countries. No change took place in the order of the three most common country groups involved in co-authorship, but their shares in Finland’s international co-authorship have undergone different development

patterns. During the period under scrutiny, the share of EU15+ countries increased from 38 to 54 per cent, while the share of North America decreased from 35 to 30 per cent. The share of the Nordic countries in Finnish co-publications showed a slight increase from 24 to 26 per cent, whereas Asia increased its share in Finnish co-authorship from 8 to 14 per cent. When we look at the authors’ geographical background by the main scientific discipline, the top three remain the same, with changes in the order of the country groups only (appendix 2). Compared to other main scientific disciplines, Russia is an important partner in natural sciences, and Asia in the field of engineering.

⁴ EU15+ states= EU15 states excluding Nordic countries + Switzerland, or Luxembourg, Ireland, Portugal, Austria, Belgium, the Netherlands, Greece, Spain, Italy, France, Germany, the United Kingdom and Switzerland.

Table 3.3. The number of Finnish co-publications with authors from various country groups and their share in international co-authorship.

Number of publications*	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Nordic countries	1,052	24%	1,943	25%	3,100	25%	3,611	25%	4,806	26%
EU15+Switzerland	1,691	38%	3,075	40%	5,675	47%	7,227	50%	9,925	54%
Other European	483	11%	838	11%	1,311	11%	1,425	10%	2,260	12%
Baltic countries	32	1%	249	3%	390	3%	472	3%	659	4%
Russia	415	9%	735	10%	1,109	9%	1,132	8%	1,509	8%
Africa	69	2%	101	1%	140	1%	187	1%	294	2%
Asia	346	8%	746	10%	1,229	10%	1,612	11%	2,638	14%
Australia & Oceania	92	2%	191	2%	403	3%	503	3%	896	5%
North America	1,577	35%	2,816	36%	3,989	33%	4,521	31%	5,590	30%
Central and South America	96	2%	233	3%	280	2%	357	2%	481	3%
1 country group	3,586	81%	5,842	76%	8,775	72%	10,030	70%	11,987	65%
2 country groups	632	14%	1,285	17%	2,406	20%	3,106	22%	4,200	23%
Min. 3 country groups	234	5%	598	8%	983	8%	1,286	9%	2,251	12%
<i>Total</i>	<i>4,452</i>	<i>100%</i>	<i>7,725</i>	<i>100%</i>	<i>12,164</i>	<i>100%</i>	<i>14,422</i>	<i>100%</i>	<i>18,438</i>	<i>100%</i>

*Publications involving several country groups were included in the total number of publications of each country group, producing a total of over 100 per cent.

3.5 Relationship between international cooperation and scientific impact

In 1990–2008, international co-publications were on average cited more often than publications produced in domestic cooperation. The citation counts of the former

exceeded the average world level throughout this period. This study indicates that no great changes took place in the relative citation index of international co-publications during the period under scrutiny: in 1990–1993, the relative citation index was 1.29, while in 2006–2008 it was 1.31 (Table 3.9; cf. NordForsk 2010, 24).

Table 3.9. Co-authorship and the relative citation index in 1990–2008* (calculated if the number of publications was 50 or over)

Relative citation index	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Trend 1990–1993 -> 2006–2008
	Single author	0.73	0.78	0.71	0.79	0.81
Several authors from the same organisation	0.92	1.01	0.96	1.00	1.00	0.08
Authors from several domestic organisations	1.18	1.11	1.11	0.99	1.00	-0.18
International co-publications	1.29	1.30	1.33	1.23	1.31	0.01
Nordic countries	1.44	1.37	1.40	1.44	1.55	0.11
EU15+Switzerland	1.22	1.36	1.47	1.35	1.49	0.27
Other European	0.73	1.01	0.95	0.99	1.20	0.47
Baltic countries	-	1.01	1.12	1.03	1.06	0.05*
Russia	0.82	0.73	0.74	0.72	0.90	0.08
Africa	0.84	0.97	1.45	1.00	1.24	0.40
Asia	1.20	1.23	1.19	1.19	1.32	0.12
Australia & Oseania	1.85	1.55	1.86	1.71	1.95	0.10
North America	1.68	1.69	1.74	1.55	1.68	0.00
Central and South America	0.87	0.94	1.33	1.18	1.70	0.83
1 country group	1.28	1.25	1.29	1.19	1.21	-0.07
2 country groups	1.40	1.56	1.46	1.45	1.54	0.14
Min. 3 country groups	1.75	2.03	2.42	2.02	2.49	0.74

*trend 1994–1997 -> 2006–2008

Of Finnish international co-publications, the highest relative citation index was displayed by publications co-written with authors from Australia and Oceania, which cumulated 85 per cent more citations in 1990–1993 and 95 per cent more in 2006–2008 than the world's publications on average (Table 3.9). These publications are relatively unimportant in Finnish international co-authorship, as their numbers were very low (see Table 3.3). Measured by citation counts, Finnish scientists achieved their second highest impact in cooperation with North American organisations. The scientific impact resulting from cooperation with Nordic countries ranked third when gauged by citation counts. Co-publications with the most typical co-authors for Finnish scientists, or those from EU15+ countries, also cumulated more citations than the average world level throughout the period under scrutiny, but the relative citation index remained slightly lower than that for co-publications with scientists from Nordic countries. An analysis by the main scientific discipline produces similar results (appendix 3).

The impact of co-publications with Central and South American scientists improved the most in relative terms (Table 3.9). In 2006–2008, the citation counts of these publications were on average 70 per cent higher than those of other WoS publications in their field. In the final years of the period under scrutiny in particular, or in 2006–2008, the impact of Finland's co-publications has exceeded the world average in nearly all country groups. An exception to this is co-publications with Russia, the relative citation index of which has remained below the world level throughout the period.

A growing trend in international co-authorship has been cooperation involving researchers from more than one country group in addition to Finland (Table 3.3). The more groups of countries that were involved in the publication, the higher its citation count on average: publications with at least three country groups cumulated nearly 2.5 times more citations in 2006–2008 than the world's WoS publications on average (Table 3.9).

As regards national cooperation, cooperation between organisations has produced science with a

higher impact when gauged by the citation counts than intra-organisational cooperation (Table 3.9). The lowest numbers of citations were cumulated by single-author publications in all main scientific disciplines (appendix 3). Single-author publications in social science journals were cited significantly less often than similar publications in other main scientific disciplines.

In a nutshell, we can say that when gauged by the citation counts, science with the highest impact has been the result of co-authorship across organisational or national boundaries. In this study, differences in citation counts between national and international co-publications were found in all main scientific disciplines (appendix 3; cf. Persson 2010). In natural science journals, differences between the relative citation indices of national and international co-publications were minor compared to other main scientific disciplines, and in the field of engineering, greater than in other main fields.

3.6 International co-authorship and scientific impact by organisation type

Both in this and the following subsection 3.7, Finnish Web of Science publications are not categorised as above into publications produced in intra and inter-organisational cooperation and single-author publications, but are rather examined as a uniform category of national publications, comparing them with publications produced as a result of international co-authorship.

The citation counts of international co-publications are, on average, higher than the counts of national publications for all organisation types in all four-year periods (Table 3.17; for more information, see Citation Index Working Group II, 2011.)

3.7 Relationship between number of authors and scientific impact

The more authors that were involved in a publication, the higher its citation count on average (figure 3.6). The high citation counts cumulated by

Table 3.17. Trends in the relative citation index for national publications and international co-publications by organisation type in 1990–2008 (calculated if the number of publications was 50 or over)

Relative citation index (discipline-based)	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008
Universities					
National publications	0.91	0.99	1.00	0.98	0.99
International co-publications	1.20	1.20	1.24	1.17	1.26
Polytechnics					
National publications	-	-	-	0.70	0.63
International co-publications	-	-	-	-	-
State research institutes					
National publications	0.98	1.03	0.99	1.00	0.99
International co-publications	1.49	1.39	1.45	1.28	1.37
University hospitals					
National publications	1.02	1.01	0.99	0.93	0.95
International co-publications	1.57	1.66	1.58	1.51	1.49
Companies					
National publications	0.88	1.00	0.78	0.82	0.80
International co-publications	1.41	1.33	1.34	1.22	1.15

international co-publications are partly explained by the fact that, on average, they have a higher number of authors than national publications (Figures 3.4 and 3.5). While international co-publications cumulated more citations than national publications on average, the citation counts of national co-publications with more than five authors were higher than the counts of international publications with

two or three co-authors, and national publications with more than ten authors similarly had higher citation counts than international publications with ten authors or less (Figure 3.6). In the field of engineering in particular, the citations counts are explained not only by the international character of a publication but also the number of its co-authors (appendix 4.c).

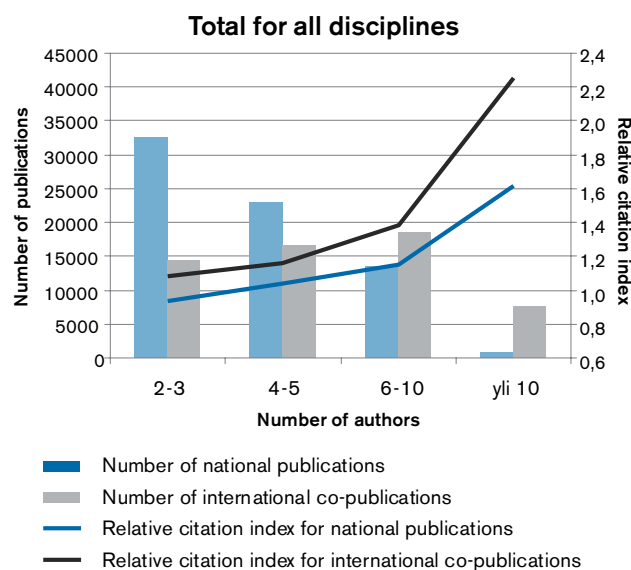


Figure 3.6. Number of publications and relative citation index by number of authors in 1990–2008 (calculated if the number of publications was 50 or over)

4 Conclusions

This study indicates that the internationalisation policy of Finnish science has been productive: in 2006–2009, the share of international co-publications was nearly one-half of all Web of Science publications. At the beginning of this report, a reference was made to the concern felt in science policy debate for the declining scientific impact of Finland's international publications in comparison with other OECD countries. This study indicates that no great changes took place in the relative citation index of international co-publications during the period under scrutiny. The scientific impact of publications produced in cooperation between domestic organisations, however, did show a decline (Cf. NordForsk 2010, 24).

Based on the study results we can say in a nutshell that co-authorship has diversified: the share of publications appearing as a result of international cooperation, involvement of several country groups, and domestic inter-organisational cooperation in all WoS publications increased, and the more diverse the co-authorship was, the higher the citation counts. The average number of co-authors involved in a publication similarly increased. The share of international co-authorship increased regardless of the fact that the funding allocation model of the Ministry of Education and Culture, for example, does *not* comment on international co-authorship, nor does the Working Group on Funding Models in its opinion on the new funding allocation model for universities to be applied from 2013 (Ministry of Education and

Culture 2011a). In the eligibility criteria for external funding applications, particularly in funding provided by the Academy of Finland and European Union Framework Programmes, however, international cooperation is significant, even if international co-authorship is not an explicitly stated objective.

In impact studies, international co-authorship has been found more useful for countries located in the so-called scientific periphery, and this phenomenon has been described by the concept of periphery effects (Glänzel et al. 1999; Goldfinch et al. 2003, 328). In the results of this project, from the perspective of European cooperation networks the periphery effect is most clearly reflected in the co-publications of Finland – described as being situated in the middle ground between the centre and the periphery – with Russia, a country located in the scientific periphery (see European Commission 2008, 99–101). The citation counts of Finland's international co-publications with Russia were lower than the counts of Finnish publications on average. However, compared to Russia's own WoS publications (Citation Index Working Group II, 2011), these co-publications have cumulated considerably higher numbers of citations; in other words, gauged by the citation counts, cooperation with Finland has been lucrative for Russia. In the citation counts of Finnish co-publications with North America, on the other hand, the position of the United States as a hub of science is reflected as higher average citation counts than those for other country groups, and gauged by

the number of citations, cooperation is also beneficial for the United States.

The report of the Citation Index Working Group II (2011) describes the trend in the impact of publications of the OECD countries. In 1990–2008, differences in citation counts between various OECD countries have levelled out: in relative terms, the citation counts for the publications of countries that have done less well in the citation index were higher than before, while the relative citation counts of publications of the stronger countries were lower (Citation Index Working Group II, 2011, 22–23). The results of this study point to the same finding: the groups whose relative citation index increased the most were Finnish scientific co-publications involving research organisations from Central and South America, the country group Other European or Africa (Table 3.9), while publications involving research organisations from North America are the only type of publications whose citation counts did not increase in 1990–2009.

Citation counts are an established and relatively easy-to-gauge method for measuring the trends in scientific impact – but they only offer one perspective to assessing the quality of research (cf. e.g. JUFO 2011). In addition to internationalisation, expectations of regional and social impact are placed on scientific work (Ministry of Education 2004; 2005; Ministry of Education and Culture 2011). Stressing internationality in science policy has clearly overshadowed another policy goal, or the social impact of research, at least when examining the publication profiles of universities. While the third mission of the universities was incorporated in the Finnish Universities Act in 2004, it is not reflected in the development of the universities' publication profiles: the share of international scientific publications in all Finnish publications has shown a strong increase over the last twenty years, while during this period, the share of domestic non-scientific publications has been declining (Puuska 2011; see also Muhonen, Auranen & Talola 2009).

While based on the results discussed in this report, cooperation with certain country groups rather than others appears to make more sense in the light of citation counts, the basic setting for

cooperation in a scientist's everyday work is also affected by other factors, including shared research interests and funding providers' criteria for desired partners (e.g. Nordic and European cooperation). The most desirable partners may also vary in different fields of research.

This study examines the trends of international co-authorship and its relationship with the citation counts of publications. While we could state that international co-authorship and, in particular, co-publications with several country groups on average result in publications with a higher scientific impact than national authorship on the basis of these results, they do not permit us to directly draw the conclusion that it is precisely international cooperation in itself that influences the citation counts. Typically, it is scientists whose research themes and degree of establishment are likely to differ from average research in general who engage in international cooperation. For example, publications involving three country groups in addition to Finland are likely to have highly established research activities and research settings of a certain type in their background, and the high citation counts cumulated by these publications are an indication of other causes besides the significance of cooperation. It would make an interesting theme for further study to establish who the co-authors of Finnish scientists are in these multinational publications; for example, to what extent the publications are produced in internal or external European cooperation. Qualitative data and bibliometric analyses at an individual level could also broaden our understanding of international co-authorship of scientists and its motives. Even if the data used is limited to certain types of authorship, the analysis that was completed in this study offers the most comprehensive picture of trends in Finnish international co-authorship so far.

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Typicality of co-publishing in 1990–2009 by scientific discipline

Number of publications	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Natural sciences										
Single author	1,443	20%	1,472	14%	1,414	10%	1,345	8%	1,250	7%
Several authors from the same organisation	2,417	33%	3,249	30%	3,415	24%	3,897	24%	3,778	20%
Authors from several domestic organisations	983	13%	1,648	15%	2,472	17%	3,056	19%	3,418	18%
International co-authorship	2,508	34%	4,353	41%	7,006	49%	8,206	50%	10,491	55%
<i>Total</i>	7,351	100%	10,722	100%	14,306	100%	16,504	100%	18,938	100%
Medical and health sciences										
Single author	1,017	12%	914	8%	812	6%	531	4%	415	3%
Several authors from the same organisation	3,392	40%	3,777	34%	2,705	21%	1,909	15%	1,726	12%
Authors from several domestic organisations	2,439	29%	3,484	32%	4,945	38%	5,093	40%	5,493	39%
International co-authorship	1,693	20%	2,884	26%	4,497	35%	5,235	41%	6,341	45%
<i>Total</i>	8,541	100%	11,059	100%	12,960	100%	12,768	100%	13,976	100%
Engineering										
Single author	458	24%	474	16%	502	12%	438	9%	383	6%
Several authors from the same organisation	648	34%	999	34%	1,223	29%	1,520	30%	1,726	28%
Authors from several domestic organisations	301	16%	553	19%	872	21%	1,074	21%	1,345	22%
International co-authorship	502	26%	944	32%	1,574	38%	2,022	40%	2,688	44%
<i>Total</i>	1,909	100%	2,970	100%	4,171	100%	5,054	100%	6,141	100%
Agriculture and forestry										
Single author	256	30%	193	18%	204	13%	147	8%	105	5%
Several authors from the same organisation	363	42%	447	41%	522	33%	545	31%	540	26%
Authors from several domestic organisations	156	18%	216	20%	377	24%	502	28%	588	29%
International co-authorship	90	10%	226	21%	482	30%	569	32%	826	40%
<i>Total</i>	865	100%	1,082	100%	1,585	100%	1,763	100%	2,059	100%
Social sciences										
Single author	379	46%	425	32%	528	28%	519	23%	737	22%
Several authors from the same organisation	195	24%	343	26%	420	22%	462	21%	639	19%
Authors from several domestic organisations	118	14%	307	23%	459	24%	552	25%	780	23%
International co-authorship	131	16%	260	19%	472	25%	702	31%	1 169	35%
<i>Total</i>	823	100%	1,335	100%	1,879	100%	2,234	100%	3,324	100%
Humanities										
Single author	193	87%	161	79%	267	76%	275	74%	436	70%
Several authors from the same organisation	16	7%	14	7%	30	9%	37	10%	60	10%
Authors from several domestic organisations	5	2%	14	7%	16	5%	22	6%	50	8%
International co-authorship	9	4%	16	8%	38	11%	40	11%	78	13%
<i>Total</i>	223	100%	205	100%	351	100%	374	100%	624	100%
Multidisciplinary science										
Single author	19	22%	14	11%	15	8%	11	7%	17	6%
Several authors from the same organisation	22	25%	23	18%	32	16%	13	8%	32	11%
Authors from several domestic organisations	10	11%	15	12%	19	10%	12	7%	22	8%
International co-authorship	36	41%	78	60%	128	66%	133	79%	209	75%
<i>Total</i>	87	100%	130	100%	194	100%	169	100%	280	100%

The number of Finnish co-publications involving authors from various country groups and their share in international co-authorship by scientific discipline

Table 2 a. Natural sciences: the number of Finnish co-publications with authors from different country groups and their share in international co-authorship.

Number of publications*	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Nordic countries	521	20.8%	968	22.2%	1,569	22.4%	1,714	20.9%	2,331	22%
EU15 + Switzerland	1,070	42.7%	1,847	42.4%	3,416	48.8%	4,300	52.4%	5,779	55%
Other European	375	15.0%	649	14.9%	980	14.0%	987	12.0%	1,570	15%
Baltic countries	18	0.7%	153	3.5%	268	3.8%	320	3.9%	374	4%
Russia	320	12.8%	643	14.8%	1,007	14.4%	999	12.2%	1,303	12%
Africa	38	1.5%	33	0.8%	67	1.0%	93	1.1%	119	1%
Asia	204	8.1%	444	10.2%	767	10.9%	930	11.3%	1,586	15%
Australia & Oceania	39	1.6%	82	1.9%	175	2.5%	222	2.7%	378	4%
North America	750	29.9%	1,430	32.9%	2,038	29.1%	2,227	27.1%	2,915	28%
Central and South America	66	2.6%	166	3.8%	208	3.0%	233	2.8%	253	2%
1 country group	1,979	78.9%	3,207	73.7%	4,971	71.0%	5,690	69.3%	6,796	64.8%
2 country groups	385	15.4%	780	17.9%	1,411	20.1%	1,800	21.9%	2,407	22.9%
Min. 3 country groups	144	5.7%	366	8.4%	624	8.9%	716	8.7%	1,288	12.3%
<i>Total</i>	2,567	100%	4,425	100%	7,173	100%	8,342	100%	10,610	100%

*Publications involving several country groups were included in the total number of publications for each country group, producing a total of over 100 per cent.

Table 2 b. Medical and health sciences: the number of Finnish co-publications with authors from various country groups and their share in international co-authorship.

Number of publications*	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Nordic countries	484	28.6%	881	30.5%	1,360	30.2%	1,641	31.3%	2,106	33%
EU15 + Switzerland	554	32.7%	1,058	36.7%	1,949	43.3%	2,471	47.2%	3,327	52%
Other European	89	5.3%	170	5.9%	280	6.2%	386	7.4%	590	9%
Baltic countries	12	0.7%	94	3.3%	125	2.8%	140	2.7%	215	3%
Russia	73	4.3%	65	2.3%	87	1.9%	115	2.2%	158	2%
Africa	29	1.7%	53	1.8%	65	1.4%	80	1.5%	141	2%
Asia	130	7.7%	249	8.6%	407	9.0%	545	10.4%	783	12%
Australia & Oceania	41	2.4%	97	3.4%	198	4.4%	239	4.6%	405	6%
North America	675	39.9%	1,203	41.7%	1,659	36.9%	1,980	37.8%	2,173	34%
Central and South America	20	1.2%	56	1.9%	66	1.5%	94	1.8%	185	3%
1 country group	1,409	83.2%	2,205	76.5%	3,263	72.6%	3,549	67.8%	4,036	63.7%
2 country groups	204	12.1%	457	15.8%	939	20.9%	1,171	22.4%	1,494	23.6%
Min. 3 country groups	80	4.7%	222	7.7%	295	6.6%	515	9.8%	811	12.8%
<i>Total</i>	1,706	100%	2,910	100%	4,541	100%	5,266	100%	6,361	100%

*) Publications involving several country groups were included in the total number of publications for each country group, producing a total of over 100 per cent.

Table 2 c. Engineering: the number of Finnish co-publications with authors from various country groups and their share in international co-authorship.

Number of publications*	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Nordic countries	106	21.1%	186	19.7%	356	22.6%	463	22.9%	571	21%
EU15 + Switzerland	175	34.9%	409	43.3%	708	45.0%	977	48.3%	1,398	52%
Other European	52	10.4%	92	9.7%	180	11.4%	196	9.7%	263	10%
Baltic countries	1	0.2%	28	3.0%	59	3.7%	70	3.5%	93	3%
Russia	32	6.4%	47	5.0%	73	4.6%	124	6.1%	168	6%
Africa	4	0.8%	20	2.1%	23	1.5%	20	1.0%	37	1%
Asia	39	7.8%	94	10.0%	180	11.4%	246	12.2%	456	17%
Australia & Oceania	15	3.0%	24	2.5%	49	3.1%	84	4.2%	119	4%
North America	190	37.8%	315	33.4%	496	31.5%	583	28.8%	742	28%
Central and South America	18	3.6%	20	2.1%	20	1.3%	41	2.0%	61	2%
1 country group	416	82.9%	735	77.9%	1,206	76.6%	1,491	73.7%	1,864	69.3%
2 country groups	65	12.9%	158	16.7%	258	16.4%	382	18.9%	578	21.5%
Min. 3 country groups	21	4.2%	51	5.4%	110	7.0%	149	7.4%	246	9.2%
<i>Total</i>	512	100%	947	100%	1,602	100%	2,048	100%	2,705	100%

*) Publications involving several country groups were included in the total number of publications for each country group, producing a total of over 100 per cent.

Table 2 d. Agriculture and forestry: the number of Finnish co-publications with authors from various country groups and their share in international co-authorship.

Number of publications*	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Nordic countries	29	32.2%	63	27.9%	167	34.6%	176	30.9%	243	29%
EU15 + Switzerland	20	22.2%	53	23.5%	170	35.3%	258	45.3%	385	47%
Other European	6	6.7%	14	6.2%	13	2.7%	26	4.6%	58	7%
Baltic countries	2	2.2%	7	3.1%	17	3.5%	20	3.5%	46	6%
Russia	1	1.1%	4	1.8%	13	2.7%	20	3.5%	35	4%
Africa	4	4.4%	8	3.5%	4	0.8%	18	3.2%	17	2%
Asia	5	5.6%	22	9.7%	47	9.7%	62	10.9%	92	11%
Australia & Oceania	3	3.3%	11	4.9%	25	5.2%	19	3.3%	37	4%
North America	26	28.9%	67	29.6%	127	26.3%	114	20.0%	158	19%
Central and South America	2	2.2%	8	3.5%	7	1.5%	15	2.6%	34	4%
1 country group	84	93.3%	202	89.4%	412	85.5%	450	79.1%	624	75.5%
2 country groups	6	6.7%	21	9.3%	56	11.6%	94	16.5%	149	18.0%
Min. 3 country groups	0	0.0%	3	1.3%	14	2.9%	25	4.4%	53	6.4%
<i>Total</i>	92	100%	226	100%	490	100%	577	100%	830	100%

*) Publications involving several country groups were included in the total number of publications for each country group, producing a total of over 100 per cent.

Table 2 e. Social sciences: the number of Finnish co-publications involving authors from various country groups and their share in international co-authorship.

Number of publications*	1990–1993		1994–1997		1998–2001		2002–2005		2006–2009	
Nordic countries	36	27.5%	66	25.4%	124	26.2%	137	19.5%	302	26%
EU15 + Switzerland	27	20.6%	69	26.5%	232	49.1%	350	49.9%	627	54%
Other European	11	8.4%	10	3.8%	20	4.2%	28	4.0%	51	4%
Baltic countries	2	1.5%	4	1.5%	8	1.7%	11	1.6%	43	4%
Russia	7	5.3%	9	3.5%	11	2.3%	20	2.9%	29	2%
Africa	0	0.0%	2	0.8%	7	1.5%	9	1.3%	24	2%
Asia	6	4.6%	22	8.5%	34	7.2%	65	9.3%	92	8%
Australia & Oceania	1	0.8%	8	3.1%	12	2.5%	26	3.7%	92	8%
North America	78	59.5%	122	46.9%	189	40.0%	266	37.9%	370	32%
Central and South America	1	0.8%	3	1.2%	4	0.8%	7	1.0%	20	2%
1 country group	113	86.3%	227	87.3%	368	78.0%	555	79.1%	875	74.8%
2 country groups	16	12.2%	28	10.8%	82	17.4%	121	17.2%	228	19.5%
Min. 3 country groups	2	1.5%	5	1.9%	22	4.7%	26	3.7%	66	5.6%
<i>Total</i>	149	100%	275	100%	505	100%	727	100%	1.219	100%

*Publications involving several country groups were included in the total number of publications for each country group, producing a total of over 100 per cent.

Co-publishing and the relative citation index in 1990–2008 by different disciplines

Table 3 a. Natural sciences: co-publishing and the relative citation index in 1990–2008
(calculated if the number of publications was 50 or over)

Relative citation index	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Trend 1990–1993 ->2006–2008
Single author	0.77	0.80	0.80	0.83	0.77	0.00
Several authors from the same organisation	0.84	1.00	0.95	1.00	1.01	0.17
Authors from several domestic organisations	0.94	0.96	1.01	0.99	0.96	0.02
International co-authorship	1.10	1.07	1.08	1.08	1.21	0.11
Nordic countries	1.16	1.16	1.20	1.25	1.34	0.18
EU15+Switzerland	1.09	1.16	1.22	1.14	1.34	0.25
Other European	0.69	0.94	0.85	0.95	1.08	0.39
Baltic countries	-	1.02	0.94	0.97	1.11	0.09*
Russia	0.89	0.66	0.71	0.69	0.85	-0.04
Africa	-	-	1.53	0.79	1.19	-0.34**
Asia	1.03	1.05	1.01	1.10	1.32	0.29
Australia & Oceania	-	1.37	1.45	1.43	1.85	0.48*
North America	1.36	1.38	1.46	1.34	1.51	0.15
Central and South America	1.03	0.78	1.09	1.09	1.31	0.28
1 country group	1.08	1.03	1.05	1.08	1.18	0.10
2 country groups	1.10	1.28	1.22	1.19	1.33	0.23
Min. 3 country groups	1.49	1.53	1.73	1.26	1.72	0.23

*) Trend calculated for the four-year period 1994–1997 as the number of cases was less than 50 in the preceding four-year period

***) Trend calculated for the four-year period 1998–2001 as the number of cases was less than 50 in the preceding four-year periods

Table 3 b. Medical and health sciences: co-publishing and the relative citation index in 1990–2008
(calculated if the number of publications was 50 or over)

Relative citation index	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Trend 1990–1993 ->2006–2008
Single author	0.74	0.76	0.62	0.77	0.77	0.03
Several authors from the same organisation	0.98	1.01	0.92	0.96	0.94	-0.04
Authors from several domestic organisations	1.24	1.19	1.14	0.99	1.02	-0.22
International co-authorship	1.57	1.54	1.64	1.45	1.38	-0.19
Nordic countries	1.67	1.57	1.59	1.70	1.75	0.08
EU15+Switzerland	1.47	1.54	1.86	1.71	1.61	0.14
Other European	1.00	1.42	1.32	1.26	1.53	0.53
Baltic countries	-	0.98	1.44	1.15	0.94	-0.04*
Russia	0.68	1.48	1.05	0.96	1.13	0.45
Africa	-	0.78	1.44	1.28	1.50	0.72*
Asia	1.50	1.45	1.38	1.36	1.32	-0.18
Australia & Oceania	-	1.60	2.10	1.94	2.03	0.43*
North America	2.08	1.93	1.99	1.80	1.72	-0.36
Central and South America	-	1.35	1.99	1.30	2.53	1.18
1 country group	1.57	1.46	1.61	1.33	1.25	-0.32
2 country groups	2.06	1.93	1.80	1.89	1.68	-0.38
Min. 3 country groups	2.24	2.66	3.12	3.01	3.14	0.90

***) Trend calculated for the four-year period 1994–1997 as the number of cases was less than 50 in the preceding four-year period.

Table 3 c. Engineering: co-publishing and the relative citation index in 1990–2008
(calculated if the number of publications was 50 or over)

Relative citation index	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Trend 1990–1993 ->2006–2008
Single author	0.86	0.91	0.83	0.92	0.87	0.01
Several authors from the same organisation	1.00	1.02	1.05	1.02	0.99	-0.01
Authors from several domestic organisations	1.49	1.12	1.03	0.97	0.88	-0.61
International co-authorship	1.13	1.45	1.35	1.19	1.44	0.31
Nordic countries	1.35	1.33	1.25	1.24	2.04	0.69
EU15+Switzerland	1.11	1.46	1.41	1.32	1.78	0.67
Other European	0.44	0.86	0.72	0.78	1.29	0.85
Baltic countries	-	-	1.21	1.19	1.11	-0.10**
Russia	-	-	0.74	0.79	1.03	0.29**
Africa	-	-	-	-	-	- ***
Asia	-	1.31	1.29	1.10	1.37	0.06*
Australia & Oceania	-	-	-	2.07	2.19	0.12
North America	1.28	1.97	1.67	1.43	2.27	0.99
Central and South America	-	-	-	-	1.24	- ****
1 country group	1.11	1.38	1.26	1.11	1.15	0.04
2 country groups	1.06	1.81	1.61	1.45	2.15	1.09
Min. 3 country groups	-	1.92	1.66	1.93	4.26	2.34*

*) Trend calculated for the four-year period 1994–1997 as the number of cases was less than 50 in the preceding four-year period

**) Trend calculated for the four-year period 1998–2001 as the number of cases was less than 50 in the preceding four-year periods

***) The number of cases less than 50 in each four-year period

****) The number of cases is 50 or more only in 2006–2008

Table 3 d. Agriculture and forestry: co-publishing and the relative citation index in 1990–2008
(calculated if the number of publications was 50 or over)

Relative citation index	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Trend 1990–1993 →2006–2008
Single author	0.79	1.04	0.65	0.93	1.11	0.32
Several authors from the same organisation	0.74	1.05	1.12	1.13	1.25	0.51
Authors from several domestic organisations	1.07	1.28	1.56	1.14	1.17	0.10
International co-authorship	1.59	1.29	1.73	1.52	1.47	-0.12

Table 3 e. Social sciences: co-publishing and the relative citation index in 1990–2008
(calculated if the number of publications was 50 or over)

Relative citation index	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Trend 1990–1993 →2006–2008
Single author	0.53	0.63	0.61	0.65	0.63	0.10
Several authors from the same organisation	0.65	0.84	0.95	0.90	0.77	0.12
Authors from several domestic organisations	1.11	0.80	1.03	0.82	0.98	-0.13
International co-authorship	1.18	1.28	1.39	1.25	1.23	0.05

Relative citation index for national and international co-publications by number of authors in 1990–2008

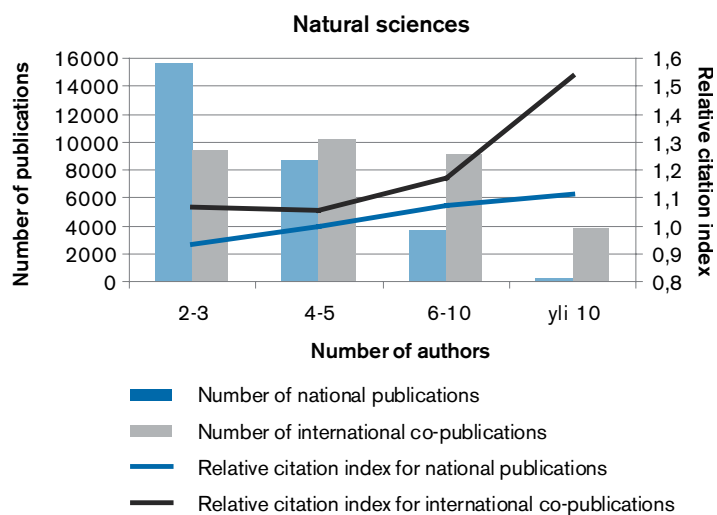


Figure 4 a. Natural sciences: number of publications and relative citation index by number of authors in 1990–2008 (calculated if the number of publications was 50 or over)

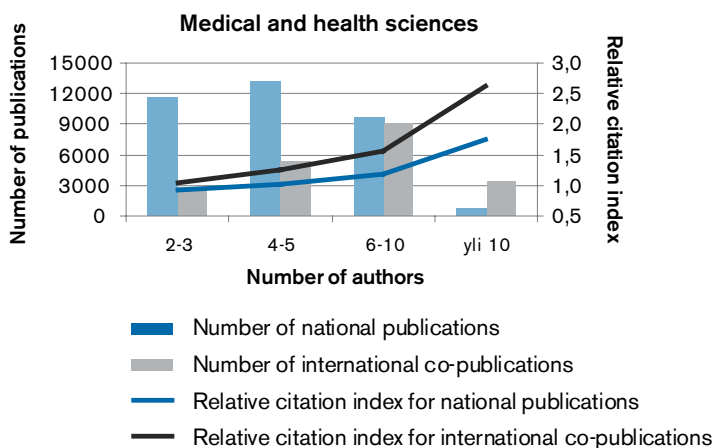


Figure 4 b. Medical and health sciences: number of publications and relative citation index by number of authors in 1990–2008 (calculated if the number of publications is 50 or over)

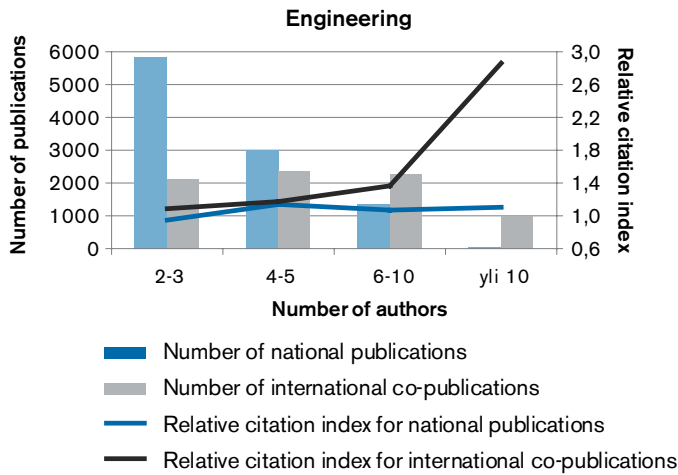


Figure 4 c. Engineering: number of publications and relative citation index by number of authors in 1990–2008 (calculated if the number of publications was 50 or over)

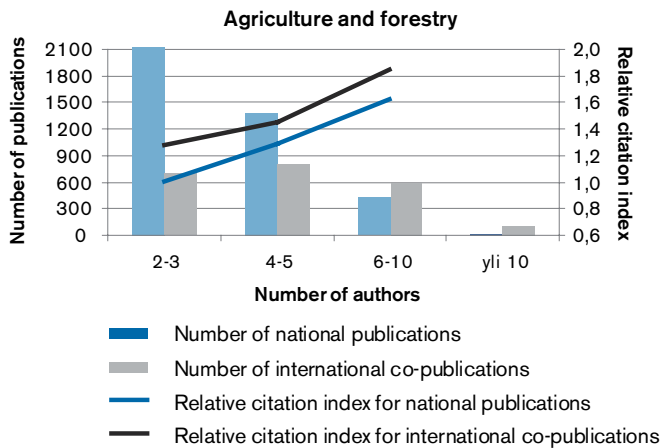


Figure 4 d. Agriculture and forestry: number of publications and relative citation index by number of authors in 1990–2008 (calculated if the number of publications is 50 or over)

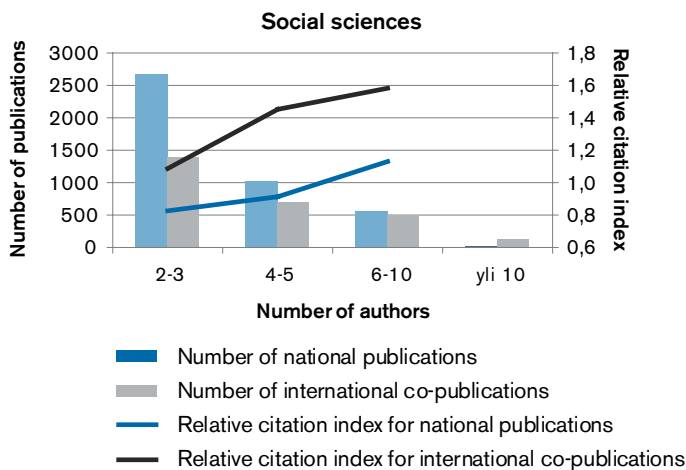


Figure 4 e. Social sciences: number of publications and relative citation index by number of authors in 1990–2008 (calculated if the number of publications is 50 or over)

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