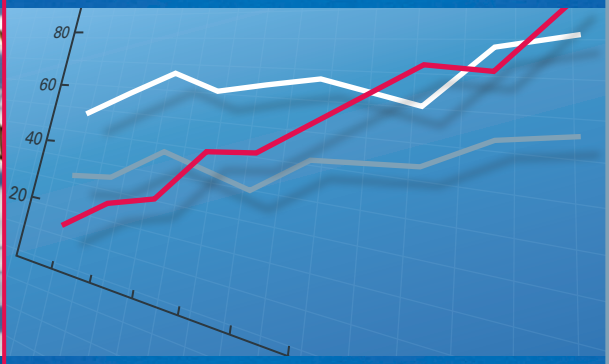
Publications of the Academy of Finland 15/06

Finnish Science in International Comparison



A Bibliometric Analysis

Annamaija Lehvo
Anu Nuutinen

Academy of Finland
Research funding and expertise

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Academy of Finland in brief

The Academy's mission is to finance high-quality scientific research, act as a science and science policy expert and strengthen the position of science and research. The Academy's activities cover all scientific disciplines.

The main focus of the Academy's development activities is on improving opportunities for professional careers in research, providing resources and facilities for high-profile research environments and making the best possible use of international opportunities in all fields of research, research funding, and science policy.

The Academy has a number of funding instruments for various purposes. In its research funding, the Academy of Finland promotes gender equality and encourages in particular women researchers to apply for research posts and research grants from the Academy.

The Academy's annual research funding amounts to more than 240 million euros, which represents some 15 per cent of the government's total R&D spending.

Each year Academy-funded projects account for some 3,000 researcher-years at universities and research institutes.

The wide range of high-level basic research funded by the Academy generates new knowledge and new experts. The Academy of Finland operates within the administrative sector of the Ministry of Education and receives its funding through the state budget.

For more information on the Academy of Finland, go to www.aka.fi/eng.

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Description

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Abstract

This report provides an international comparison of research outputs and the scientific impacts, visibility and quality of research in Finland with other EU 25 and OECD countries from 1985 to 2005. The structure and level of publishing in Finland are examined in closer detail by sector, organisation and major field of science from the mid-1990s onwards.

Bibliometric methods have become well established over the past ten years as tools for assessing the scientific impact of research. They are based on the use of publication and citation data. The Academy of Finland has used these methods since the late 1990s in its assessments of the state and quality of Finnish scientific research.

Relative to population and GDP, Finland is one of the world's biggest publishers, ahead of such traditionally strong countries in scientific research as the UK and Germany. The quality of scientific research in Finland is higher than in the OECD countries on average. The quality level in agricultural sciences and medical sciences is significantly higher than the OECD average.

The internationalisation of Finnish scientific research has progressed favourably since the 1990s. In particular, international collaboration among university researchers has expanded considerably both with foreign and domestic universities and business companies.

In many research-intensive countries such as the United States, Germany, France and the UK, the growth of scientific research was at its fastest in the 1980s. In Finland the fastest growth of scientific research was recorded in the early 1990s; since then this growth has slowed somewhat. In the early 2000s, strong growth has been seen in the smaller science countries of southern Europe such as Portugal and Turkey, as well as in the Asian countries of China and South Korea. The geography of scientific research is changing and by all accounts it will continue to change significantly over the next decades.

Key words	bibliometrics, publications, citations, Finnish science, OECD countries, quality of research, scientific impact, OECD major fields of science	
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Tiivistelmä	Tässä raportissa vertaillaan OECD-maiden tutkimuksen tuloksellisuutta sekä näkyvyyttä, tieteellistä vaikuttavuutta ja laatua viimeisen kahdenkymmenen vuoden aikana julkaisutoimintaan perustuen. Suomen julkaisutoiminnan rakennetta ja tasoa tarkastellaan tarkemmin sektoreittain, organisaatioittain ja päätieteenaloittain 1990-luvun puolivälistä lähtien. Bibliometriset menetelmät ovat vakiinnuttaneet asemansa viimeisen kymmenen vuoden aikana tutkimuksen tieteellisen vaikuttavuuden arvioinnin apuvälineenä. Ne perustuvat julkaisu- ja viittaustietojen käyttöön. Akatemia on käyttänyt näitä menetelmiä 1990-luvun lopulta lähtien Suomen tieteen tilan ja tason arvioinneissa. Asukaslukuun ja bruttokansantuotteeseen suhteutettuna Suomi on yksi suurimpia julkaisujen tuottajia maailmassa ja edellä sellaisia perinteisiä tiedemaita kuten Iso-Britannia ja Saksa. Suomalainen tiede on laadukkaampaa kuin OECD-maissa keskimäärin. Päätieteenaloista maataloustieteet ja lääketieteet ovat OECD-maiden tasoa merkittävästi ylempänä. Suomen tieteen kansainvälistyminen on jatkunut 1990-luvulta lähtien suotuisasti. Erityisesti voidaan panna merkille yliopistojen tutkijoiden huomattavasti laajentunut yhteistyö sekä ulkomaisten että kotimaisten yliopistojen ja yritysten kanssa. Monien korkean tutkimusintensiteetin maiden kuten Yhdysvaltojen, Saksan, Ranskan ja Ison-Britannian tieteen nopea kasvu ajoittuu 1980-luvulle, kun taas Suomessa se tapahtui 1990-luvun alkupuoliskolla. Sen jälkeen kasvu on ollut vähäisempää. Voimakasta kasvua on tapahtunut 2000-luvulla Euroopan eteläisissä pienissä tiedemaissa kuten Portugalissa ja Turkissa sekä Aasian maista Kiinassa ja Etelä-Koreassa. Tieteen maantiede on muuttumassa ja se tulee mitä ilmeisemmin edelleen muuttumaan merkittävästi seuraavien vuosikymmenten aikana.	
Asiasanat	bibliometriikka, julkaisut, viittaukset, Suomen tiede, OECD-maat, tutkimuksen laatu, tieteellinen vaikuttavuus, OECD:n päätieteenalat	
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Foreword
Impact assessment at the Academy of Finland

President Raimo Väyrynen
Director (Evaluation and Development) Paavo Löppönen

The Government resolution on 7 April 2005 concerning the structural development of the public research system underlines the key importance of a sustained development effort along current lines to further strengthen the quality and relevance of research and development in Finland. The main criterion specified for the collaboration among research funding agencies is to gain an increased impact for research and innovation funding. The Academy of Finland and the Finnish Funding Agency for Technology and Innovation Tekes are called upon in the resolution to develop the impact assessment of research and innovation in Finland. Furthermore, the two agencies are to work closely in assessing the impacts of the structural development of the research system.

The new University Act that took effect in 2005 creates a new task for universities in addition to their existing missions of free research and provision of education: this is to have closer exchange and interaction with the rest of society and to promote the social impacts of research results and artistic activity. This so-called third function of universities will make impact assessment an integral part of academic research, which will also have a major bearing on the Academy – after all over 80 per cent of Academy funding goes towards supporting research at universities.

Assessing the impacts of basic research

A distinction is often made between the scientific, technological-economic, cultural and social impacts of research. Most of the work to develop assessment tools has concentrated on scientific and technological-economic impacts.

The assessment of scientific impacts and the development of the necessary tools are among the Academy's basic missions. The most important assessment method used by the Academy is the peer review by scientific experts in the field concerned. Peer reviews are primarily used for *ex ante* assessments of scientific quality, but they can also be used for *ex post* assessments of the (social) impacts of research and research funding; this is known as a *modified peer review*. In this case the panel members will have the expertise and experience to assess the relevance and value of research or research funding from the vantage-point of the end-users and society at large.

Bibliometric methods have become well established over the past ten years as useful tools for assessing the scientific impact of basic research. They are based on the use of publication and citation data. The Academy has used these methods since the late 1990s in its assessments of the state and quality of Finnish scientific research.

Academy of Finland and the impact assessment of research funding 2005–2006

The ultimate aim of impact assessments conducted by the Academy of Finland is to develop the research and innovation system and to develop the Academy's own operation and its funding instruments.

The Academy works closely with the Ministry of Education and others to develop methods and procedures for effective impact assessment. Collaboration with other actors in the research and innovation system – particularly with research funding bodies, universities and research institutes – for the development of impact assessment is based on well established practices. The Academy is committed to continue with its proven practices of compiling assessments of the state and future of Finnish scientific research.

With respect to the development of its own operation, the Academy's primary goal is to integrate impact assessment more closely with the use and development of its funding instruments as well as other activities. In this way the results of impact assessments will have greater influence on key agency operations than periodic *ad hoc* assessments. The Academy is also keen to integrate assessments of past developments with foresight.

This publication is part of the SIGHT 2006 project which is concerned with diverse aspects of the state, quality and impacts of Finnish scientific research. Below is a list of all SIGHT 2006 publications.

SIGHT 2006: Evaluations and assessments of the state, quality and impacts of Finnish scientific research

Impacts of Academy research funding
Sivistystä ei voi tuoda – tutkijapuheenvuoroja kulttuurin ja yhteiskunnan tutkimuksen vaikuttavuudesta. [Civilisation cannot be imported – Researcher commentary on the impacts of cultural and social research.] Suomen Akatemian julkaisuja 5/2006.

Suomen Akatemian rahoittama luonnontieteiden ja tekniikan alojen tutkimus: Arviointi hankkeiden vaikuttavuuksista. [Research in natural sciences and engineering funded by the Academy of Finland: Assessment of impact of projects.] Suomen Akatemian julkaisuja 6/2006.

Tutkimuksen vaikuttavuus biotieteiden ja ympäristön tutkimuksen aloilla. [The impact of research in biosciences and environmental research.] Suomen Akatemian julkaisuja 7/2006.

Strategisella rahoituksella vaikuttavampaa tutkimusta? Kolme esimerkkiä vaikutusten ja vaikuttavuuden arvioinnista terveyden tutkimuksen alalta. [Strategic funding for enhanced research impact? Three examples from the field of health research.] Suomen Akatemian julkaisuja 8/2006.

Kanninen, S. & T. Lemola: Methods for Evaluating the Impact of Basic Research Funding: an Analysis of Recent International Evaluation Activity. Advansis Ltd. Publications of the Academy of Finland 9/2006.

Suomen Akatemian tutkimusrahoituksen vaikuttavuus. Arviointiraportti. [Impact of Academy of Finland Research Funding. An evaluation report.] Suomen Akatemian julkaisuja 11/2006.

Level and structure of Finnish science
Lehvo, Annamaija & Nuutinen Anu: Finnish Science in International Comparison: A Bibliometric Analysis. Publications of the Academy of Finland 15/2006.

Impacts at the research system level
Suomen Akatemian ja Tekesin yhteinen vaikuttavuutta tutkimusjärjestelmän tasolla tarkasteleva seminaari 12.10.2005. [Joint Academy-Tekes seminar on research system level impacts, 12 October 2005.] Presentations in Finnish www.aka.fi

Changes in the level and orientation of Finnish competencies: indicator development. Academy–Tekes. Work to continue in 2007.

Foresighting: FinnSight 2015
FinnSight 2015: Tieteen, teknologian ja yhteiskunnan näkymät, 292 p., Suomen Akatemia ja Tekes, Helsinki 2006.

FinnSight 2015: Tieteen, teknologian ja yhteiskunnan näkymät (synteesiraportti), 68 p., Suomen Akatemia ja Tekes, Helsinki 2006.

FinnSight 2015: The Outlook for Science, Technology and Society (synthesis report in English), 68 p., Academy of Finland and Tekes, Helsinki 2006.

Summary and conclusions in Finnish
Yhteenveto ja johtopäätökset

Suomalaiset tutkijat tekivät vuonna 2005 8 300 julkaisua, joka on enemmän kuin koskaan aikaisemmin. Suomen julkaisumäärä on 2,5-kertaistunut 20 vuoden aikana. Nopein kasvu ajoittuu 1990-luvun alkupuoliskolle, jolloin julkaisumäärä kasvoi kahdeksan prosentin vuosivauhtia. 2000-luvulla kasvu on hidastunut muutamaan prosenttiin vuodessa.

Suomalaiset tutkijat tekevät kansainvälistä yhteistyötä eniten EU-maiden kanssa. Yhteisjulkaisujen määrä lisääntyi 85 prosenttia vuosina 1995–2004. Samaan aikaan yhteisjulkaisujen määrä Pohjoismaiden kanssa lisääntyi 78 prosenttia ja Pohjois-Amerikan maiden kanssa 42 prosenttia. Merkittävimmät yhteistyömaat ovat Yhdysvallat, Ruotsi, Iso-Britannia, Saksa, Ranska, Alankomaat ja Venäjä.

Yliopistot ovat mukana 69 prosentissa kaikista suomalaisista julkaisuista, ja valtion tutkimuslaitosten julkaisujen osuus on 17 prosenttia. Yritykset ovat mukana kuudessa prosentissa julkaisuista. Vuosina 1995–2004 ei sektoreiden suhteellisissa osuuksissa tapahtunut merkittäviä muutoksia. Kaudella yliopistojen julkaisumäärä lisääntyi kolmanneksella ja valtion tutkimuslaitosten neljänneksellä.

Suomen julkaisuprofiili painottuu luonnontieteisiin ja lääketieteisiin kuten OECD-maissa keskimäärin. Suomessa kuitenkin lääketieteiden osuus on OECD-maiden keskimääräistä osuutta suurempi. Suomessa perustutkimuksesta vastaavien yliopistojen profiilissa korostuu lääketieteiden osuus. Luonnontieteiden ja maataloustieteiden osuus on suurin valtion tutkimuslaitoksissa. Yrityksissä julkaisutoiminta painottuu soveltavalle tekniikan päätieteenalalle. Humanististen alojen julkaisutoiminta keskittyy yliopistoihin.

Suomen julkaisumäärä vastaa reilua kahta prosenttia EU 25 -maiden julkaisuista ja hieman yli prosenttia OECD-maiden julkaisuista. Suomen julkaisuosuudet ovat kasvaneet 1980-luvun lopulta alkaen, mutta pienentyneet suurimmista osuuksista vuodesta 2001 lähtien.

Kansakunnan kokoon suhteutettuna Suomen julkaisumäärä oli 1 600 julkaisua miljoonaa asukasta kohti vuonna 2005. Suomi sijoittui 30 OECD-maan vertailussa neljänneksi Sveitsin, Ruotsin ja Tanskan jälkeen. Vuonna 1995 Suomen sijoitus oli viides. Kolmen kärkimaan järjestys ei ole kymmenessä vuodessa muuttunut, sen sijaan Suomi ohitti Kanadan kivutessaan neljänneksi vuoden 2005 vertailussa.

EU 25 -maiden julkaisumäärä yli kaksinkertaistui viimeisen 20 vuoden aikana, ja samalla OECD:n julkaisumäärä 1,8-kertaistui. Suomen julkaisumäärä 2,5-kertaistui. OECD-maiden julkaisumäärien keskimääräiseen kasvuvauhtiin verrattuna Suomen julkaisumäärän muutos oli nopeaa 1990-luvun alkupuolella mutta hidastui 2000-luvun alussa. Ruotsissa, Isossa-Britanniassa, Ranskassa, Saksassa ja Tanskassa kehitys on ollut saman suuntaista.

Suomen julkaisut keräsivät keskimäärin kuusi viittausta julkaisua kohden 2000-luvun alussa ja niihin viitattiin 13 prosenttia enemmän kuin OECD-maiden julkaisuihin keskimäärin. Kaikkien OECD-maiden viittausindeksien vertailussa Suomi sijoittui kahdeksanneksi.

Viimeisen kahdenkymmenen vuoden aikana Sveitsin, Tanskan, Yhdysvaltojen, Alankomaiden, Ruotsin ja Ison-Britannian suhteellinen viittausindeksi on ollut suurempi kuin OECD-maissa keskimäärin. Suomi kuuluu niiden maiden ryhmään, joiden suhteellinen viittausindeksi ylitti OECD:n arvon 1990-luvun alkupuolella ja kasvoi nopeasti koko vuosikymmenen ajan.

Päätieteenaloittain tarkasteltuna Suomen luonnontieteiden julkaisuihin viitattiin neljä prosenttia vähemmän kuin OECD-maiden alan julkaisuihin keskimäärin 2000-luvun alkupuolella. Tekniikan alalla viittauskertymä oli prosentin suurempi kuin OECD-maissa keskimäärin. Lääketieteissä alan julkaisuihin viitattiin 25 prosenttia enemmän kuin OECD-maiden alan julkaisuihin keskimäärin. Maataloustieteissä Suomi sijoittui ensimmäiseksi. Suomen julkaisuihin viitattiin 56 prosenttia enemmän kuin OECD-maiden alan julkaisuihin keskimäärin. Yhteiskuntatieteissä Suomen julkaisut keräsivät 12 prosenttia vähemmän viittauksia kuin alalla keskimäärin ja humanististen alojen viittauskertymä oli sama kuin OECD-maissa keskimäärin.

Bibliometristen tiedeindikaattoreiden pohjalta voidaan tehdä muutama johtopäätös Suomen tieteen kehityksestä ja asemasta kansainvälisessä vertailussa. Asukaslukuun ja bruttokansantuotteeseen suhteutettuna Suomi on yksi suurimpia julkaisujen tuottajia maailmassa ja edellä sellaisia perinteisiä tiedemaita kuten Iso-Britannia ja Saksa. Suomalainen tiede on laadukkaampaa kuin OECD-maissa keskimäärin. Päätieteenaloista maataloustieteet ja lääketieteet ovat OECD-maiden tasoa merkittävästi ylempänä.

Suomen tieteen kansainvälistyminen on jatkunut 1990-luvulta lähtien suotuisasti. Erityisesti voidaan panna merkille yliopistojen huomattavasti laajentunut yhteistyö ulkomaisten yliopistojen ja tutkimuslaitosten kanssa.

Monen korkean tutkimusintensiteetin maan kuten Yhdysvaltojen, Saksan, Ranskan ja Ison-Britannian tieteen nopea kasvu ajoittuu 1980-luvulle, kun taas Suomessa se tapahtui 1990-luvun alkupuoliskolla. Voimakasta kasvua on tapahtunut 2000-luvulla Euroopan eteläisissä pienissä tiedemaissa kuten Portugalissa ja Turkissa sekä Aasian maista Kiinassa ja Etelä-Koreassa. Tieteen maantiede on muuttumassa ja se tulee mitä ilmeisemmin edelleen muuttumaan merkittävästi seuraavien vuosikymmenten aikana.

1 Introduction

Finnish investment in research and development

Finland is one of the most research-intensive countries in the world. In 2003, national spending on research and development totalled over 5 billion euros, or 3.49 per cent of GDP. The private business sector accounts for 70 per cent of total R&D funding. Funding from public sector sources amounts to 26 per cent. The rest comes primarily from foreign sources, such as EU framework programmes in research. (Key Figures 2005.)

Finland also ranks among the most active EU member states in terms of the development of human resources in research. Finland has the EU's highest number of people working in R&D as a proportion of the employed population. In 2003, the figure stood at 16.2 person-years per 1,000 employed persons, and it is rising. (Key Figures 2005.)

This report provides an international comparison of research outputs and the scientific impacts, visibility and quality of research in Finland with other EU

Table 1. Bibliometric science indicators.

Number of publications	• Describes outcomes of research. • Publication numbers are studied by country, major field of science, discipline, sector and organisation.
Share of publications	• Number of Finnish publications as a proportion of all publications in the OECD countries, for example.
Number of publications relative to population or GDP	• Gives a rough indication of the output of research relative to the size or wealth of the nation.
Number of citations	• Number of citations received by certain publications during a certain period.
Share of citations	• Number of citations received by Finnish publications as a proportion of citations received by all OECD publications, for example.
Impact factor	• Gives a rough indication of the visibility, scientific impact and quality of research. • Number of citations / number of publications. • Average number of citations received by the publications of a certain country, organisation etc. during a certain period.
Relative citation impact	• Gives a rough indication of the visibility, scientific impact and quality of research. • Impact factor for a certain country / impact factor for OECD, while the relative citation impact for the OECD is one. • How many per cent more or less citations Finnish publications, for instance, have received in comparison with the average for the OECD countries during a certain period. • How many per cent more or less citations Finnish publications in the natural sciences, for instance, have received in comparison with the OECD average for the natural sciences during a certain period.

and OECD countries from 1985 to 2005. The structure and level of publishing in Finland are examined in closer detail by sector, organisation and major field of science from the mid-1990s onwards.

Bibliometric data, analysis and indicators

Scientific publishing is a key way of disseminating research results in the science community. The quantitative study of publishing is known as bibliometrics. Bibliometric analyses make use of various kinds of publication and citation databases. One major difficulty with the use of international databases is the overrepresentation of English-language journals. This is particularly problematic in the social sciences and humanities.

This report uses two Thomson Scientific databases. The National Science Indicators (NSI) database includes world publication and citation data for 1981–2005. The National Citation Report (NCR) database for Finland provides detailed publication and citation data at the researcher level for 1995–2004 (for further details, see Appendix 1).

Measures of scientific publishing in the form of numerical data are called bibliometric science indicators. One important use for these measures in science administration and at universities is for purposes of assessing research outcomes. The rapid growth of assessment and evaluation has also led to an increased use of various indicators describing the volume, level and impact of research. This report uses the bibliometric science indicators shown in Table 1.

Bibliometric science indicators have somewhat limited applicability, and it is rarely that their interpretation is straightforward and unproblematic (see Appendix 1 and e.g. Husso & Miettinen 2000). They do, however, provide a useful backdrop for discussion as well as for the formulation of new questions. If used uncritically, bibliometric indicators may lead to flawed conclusions.

Publication and citation practices vary among disciplines, and therefore direct comparisons are not possible. There are often marked differences between different fields of research in terms of how quickly they respond to new literature, the life-span of publications and publishing and citation practices. In medicine and molecular biology, for instance, research results may become outdated within a matter of months, whereas in the social sciences many studies may still be cited decades after their publication. These differences will also be reflected in the impact factors recorded in different disciplines.

2 Scientific publishing in Finland

2.1 The development of publishing and citation indices in Finland

Measured in terms of publishing volumes, the output of Finnish research has developed favourably over the past 20 years. In 2005, Finnish researchers produced 8,304 publications, the highest figure on record. During the period from1985 to 2005, the total volume of publications increased 2.5-fold. From 1985 to 1995, the number of Finnish publications increased by 75 per cent, over the next ten years the increase was 44 per cent (Table 2).

The total annual number of publications in Finland at 8,300 accounts for over two per cent of the total number of publications in the EU 25 countries and for just over one per cent of publications in all OECD countries (Figure 1). However, following a period of sustained growth until the turn of the millennium, Finland's share of all EU and OECD publications has begun to decline since 2001.

When the overlap due to co-publications was removed from country publication data, the number of Finnish publications in 1985 was around 2,500; in 1995 around 4,500; and in 2002 around 6,000 (Karlsson and Wadskog 2006). The numbers showed robust growth from the early 1990s onwards, increasing much more rapidly than in the other Nordic countries and in Switzerland, the UK, Germany and France, for example.

Table 2. Bibliometric indicators for Finnish publishing in 1981–2005.

PUBLICATIONS	1985	1995	2005
Number of publications	3,301	5,769	8,304
% change in number of publications to previous year under review	-	74.8	43.9
% share of EU 25[a] countries' publications	2.0	2.3	2.4
% share of OECD countries' publications	0.8	1.0	1.1
CITATIONS	1981–1985	1991–1995	2001–2005
% share of EU 25[a] countries' citations	2.0	2.4	2.9
% share of OECD countries' citations	0.7	0.9	1.3
CITATION INDICES	1981–1985	1991–1995	2001–2005
Impact factor[b]	2.75	3.59	5.60
Relative citation impact[c]	0.88	0.96	1.13

[a] EU 25 refers to the current 25 EU countries during the period under review.

[b] Impact factor = number of citations / number of publications.

[c] Relative citation impact = impact factor for Finland / impact factor for the OECD. (For example, in 2001–2005 the impact factor for Finland was 5.60 and for the OECD 4.96, i.e. the index value is 5.60/4.96 = 1.13.)

Source: Thomson Scientific, NSI 1981–2005.

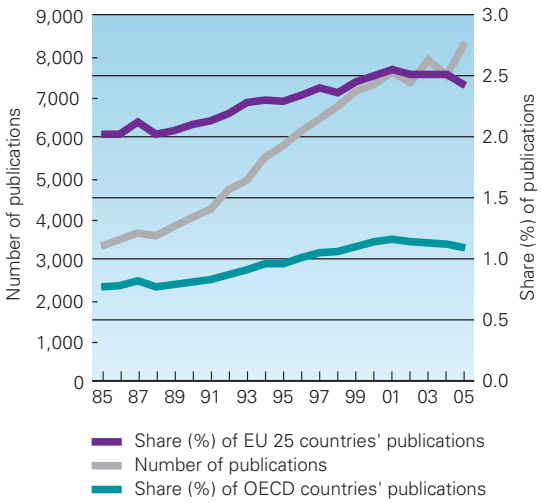

Figure 1. Number of Finnish publications and share of EU 25* and OECD publications in 1985–2005.

* EU 25 refers to the current 25 EU countries during the period under review.

Source: Thomson Scientific, NSI 1981–2005.

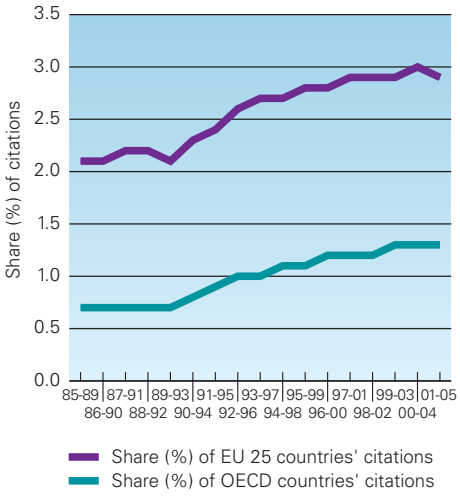

Figure 2. Finland's share of EU 25* and OECD citations in 1985–2005.

* EU 25 refers to the current 25 EU countries during the period under review.

Source: Thomson Scientific, NSI 1981–2005.

Finnish publications are cited more and more frequently. In the past 20 years, Finland's share of all citations to EU 25 publications has increased from two to almost three per cent, among OECD publications the share has increased from 0.7 to 1.3 per cent (Figure 2). The Finnish share of citations grew most rapidly in the early 1990s.

Karlsson and Wadskog (2006) studied the top one per cent of world publications that received the most citations in 1982–1984 and 2000–2002. By the beginning of the 2000s almost one per cent of Finland's publications was among the top one percent of world publications. At this point Finland ranked 12th in the world. The Finnish percentage has increased since the early 1980s. At the same time the corresponding proportions for the United States, the UK, Sweden and Canada have declined. Of the US publications almost two per cent was among the top one percent and accounted for the largest proportion.

Karlsson and Wadskog (2006) also studied self-citation by individual researchers. In 1985 self-citations accounted for 36 per cent of all citations to Finnish publications, in 1995 for 33 per cent and in 2002 for 28 per cent. In 2002 the figures for Norway, Denmark and Sweden were at around the same level as Finland's. The lowest self-citation rate was recorded for the United States, but even here the figure was over 20 per cent.

Furthermore, Karlsson and Wadskog (2006) conducted an analysis of publications that received no citations at all within two years of publication (self-citations were excluded). Finland fared very well in this comparison as its number of non-cited publications as a proportion of all publications (around 38% in 2000–2002) was higher than in just five other countries: Denmark, the Netherlands, Switzerland, Sweden and the United States. Denmark recorded the lowest figure of all at about 33 per cent.

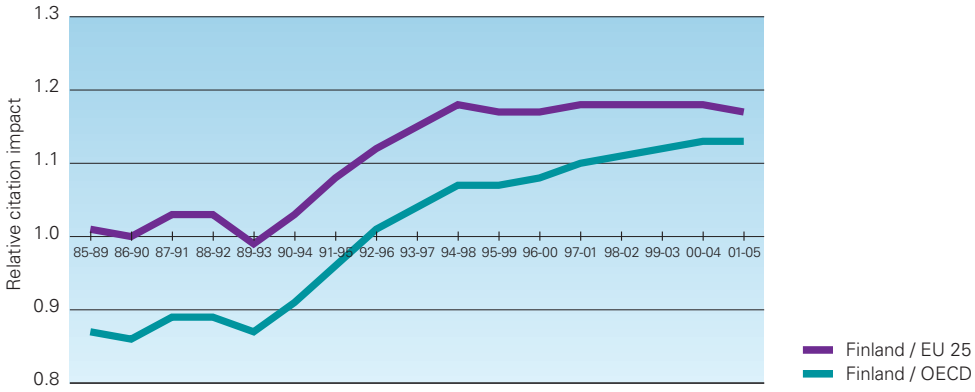

Figure 3. Development of Finland's citation impact[a] compared to EU 25[b] countries and OECD countries in 1985–2005.

[a] Relative citation impact = impact factor for Finland (number of citations / number of publications) / impact factor for e.g. EU 25.

[b] EU 25 refers to the current 25 EU countries during the period under review.

Source: Thomson Scientific, NSI 1981–2005.

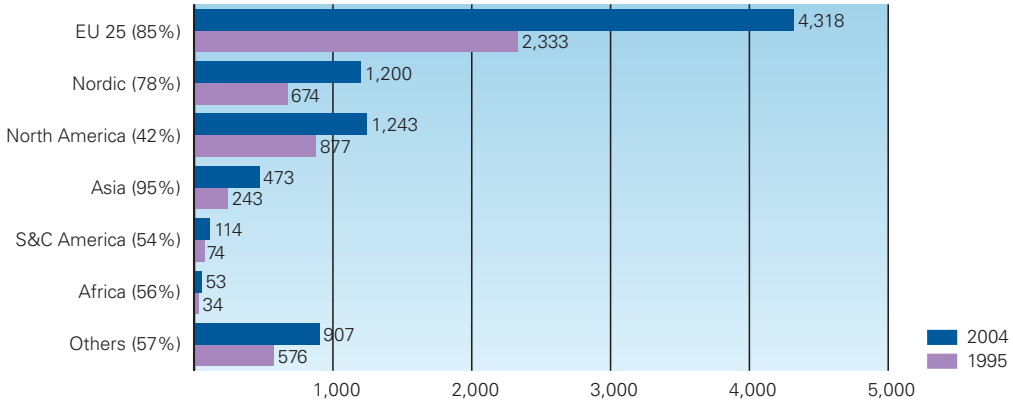

Figure 4. Number of international co-publications by Finnish researchers in 1995 and 2004. Year-on-year change (%) is given in parentheses after each region. Numbers refer to the number of publications co-authored with a country, and these numbers are not fractionalised according to the numbers of countries involved in a publication.

Source: Thomson Scientific, NCR 1995–2004.

The relative citation impact provides a rough indication of the visibility and scientific impact of research. During the period under review the number of citations received by Finnish publications reached the average OECD level (relative citation impact = 1) in the early 1990s (Figure 3), when the figure increased very sharply. During 1992–1996, Finland's relative citation impact was 1.01, i.e. Finnish publications received one per cent more citations than publications in the OECD countries on average.

On average, Finnish publications received almost six citations per publication (impact factor = 5.6) during 2001–2005. During this same period, publications

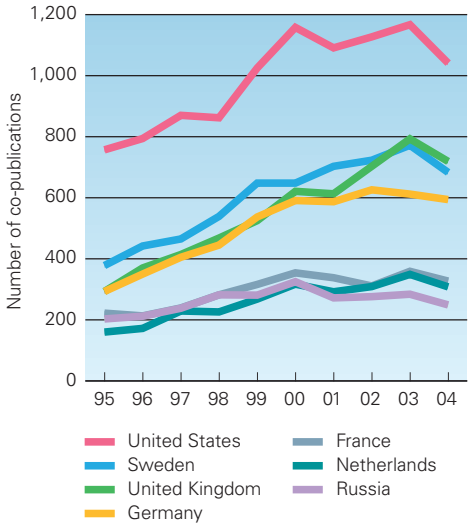

Figure 5. Number of international co-publications by Finnish researchers in 1995–2004 with most important partner countries (more than 2,500 co-publications). Numbers refer to the number of publications co-authored with a country, and these numbers are not fractionalised according to the numbers of countries involved in a publication.

Source: Thomson Scientific, NCR 1995–2004.

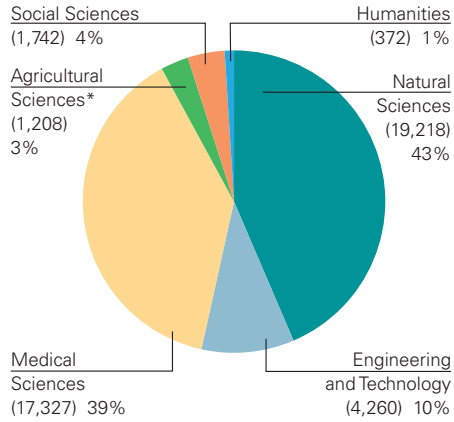

Figure 6. Breakdown of Finnish publications by major field of science in 2001–2005. Total number of publications in each major field during the five-year period given in parentheses.

* Forestry sciences not included in agricultural sciences as they are divided in the NSI database between different natural sciences.

Source: Thomson Scientific, NSI 1981–2005.

in OECD countries received on average five citations. In other words, Finnish publications were cited 13 per cent more often (relative citation impact = 1.13) than OECD publications on average. In the early 2000s, the number of citations received by Finnish publications was 17 per cent higher than the corresponding figure for EU 25 publications.

2.2 International collaboration in publishing

The involvement of Finnish researchers in international publishing collaboration has increased significantly since the mid-1990s (Figure 4). The largest number of joint publications are produced with researchers from other EU countries. In 1995–2004, the number of joint publications went up by 85 per cent. At the same time the number of joint publications with colleagues from the Nordic countries increased by 78 per cent. The corresponding increase for co-publications with North American (US and Canada) researchers was 42 per cent.

The most important partner countries for Finnish researchers are the United States, Sweden, the UK, Germany, France, the Netherlands and Russia (Figure 5). The sharpest increase in the number of co-publications in 1995–2004 has been recorded for the UK (145%), Germany (102%) and the Netherlands (93%). The most important partners listed by Persson et al. (2000) for 1986–1998 are exactly the same. The only difference is that the number of co-publications with Russian researchers has now surpassed the number of co-publications with Danish colleagues.

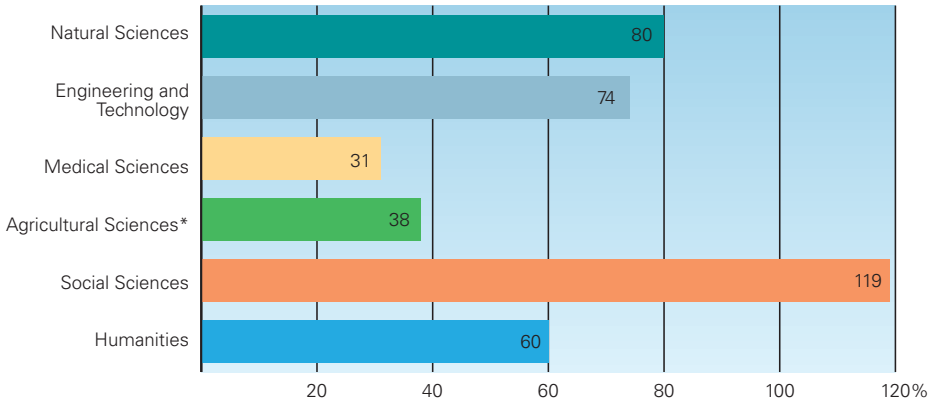

Figure 7. Change (%) in the number of publications in Finland by major field of science from 1991–1995 to 2001–2005.

* Forestry sciences not included in agricultural sciences as they are divided in the NSI database between different natural sciences.

Source: Thomson Scientific, NSI 1981–2005.

2.3 Finnish publishing and publishing cooperation by major fields of science

Measured in terms of the number of publications, the two dominant fields of science in the Finnish publishing profile are the natural sciences (43%) and medical sciences (39%) (Figure 6). Publications in the engineering and technology field account for ten per cent, the rest are divided between publications in the social sciences (4%), agricultural sciences (3%) and the humanities (1%).

The number of publications in the natural sciences increased by 80 per cent from 1991–1995 to 2001–2005 (Figure 7). The growth figure for engineering and technology was 74 per cent, for agricultural sciences 38 per cent and for medical sciences 31 per cent. International publishing has also increased significantly in the social sciences and humanities (up by 119% and 60%, respectively). In these fields of science, monographs as well as publications in the Finnish and Swedish language play a particularly important part. For reasons that have to do with the structure of the database the figures for the social sciences and for the humanities in particular give only a very rough indication of the development of publishing in these major fields.

Figure 8 provides a more detailed analysis of the major field of natural sciences, which comprises a wide variety of disciplines such as biosciences, ecology and environmental sciences, chemistry, mathematics, earth sciences and physics. In these disciplines the increase in the number of publications from the early 1990s to the early 2000s ranges from 193 per cent in earth sciences to 52 per cent in biosciences.

We move on now to consider the international collaboration of Finnish researchers in the natural sciences and medical sciences, which together account for 83 per cent of all Finnish publications. In the natural sciences, the number of joint international publications is highest with colleagues from the United States, Germany, the UK, Sweden and Russia (Figure 9). The sharpest increase in the

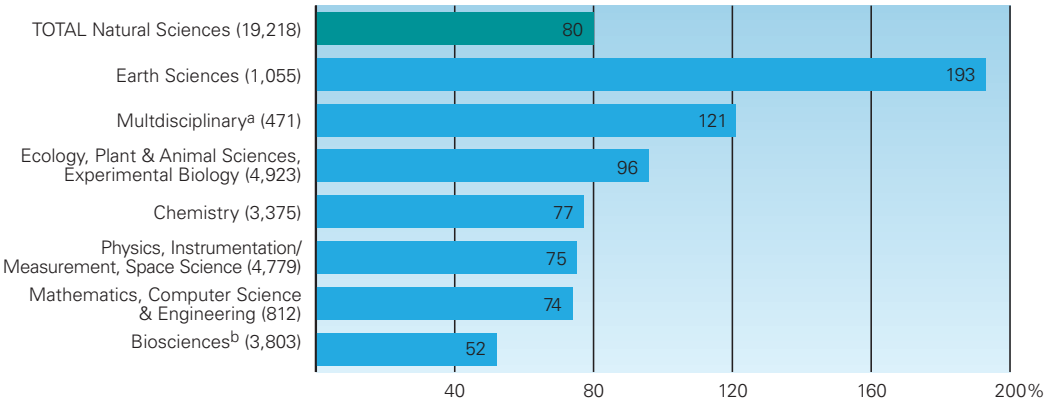

Figure 8. Change (%) in the number of publications in the natural sciences in Finland from 1991–1995 to 2001–2005. Number of publications for the most recent period indicated in parentheses.

[a] Multidisciplinary field excludes articles from Science, Nature and PNAS. Articles from these journals have been reassigned to specific categories.

[b] Includes Microbiology, Molecular Biology & Genetics, Biochemistry & Biophysics, and Biology.

Source: Thomson Scientific, NSI 1981–2005.

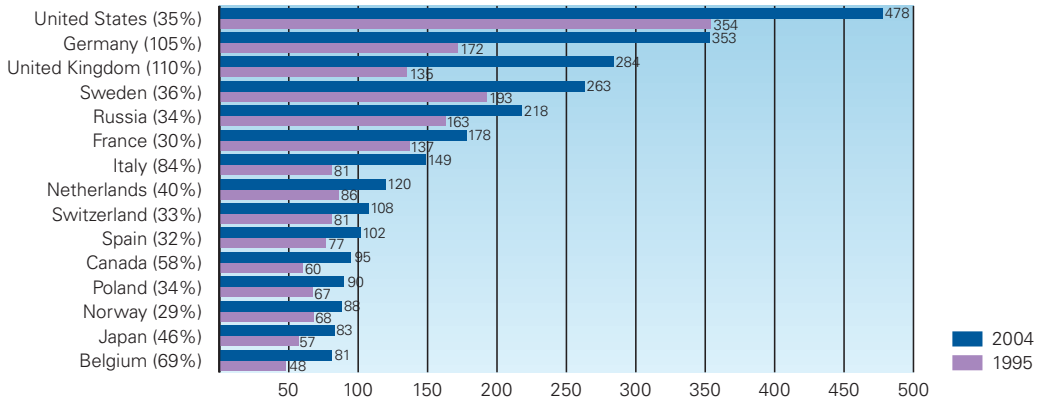

Figure 9. Finnish publishing cooperation in the major field of natural sciences. Top 15 countries in 1995–2004 are listed in order of number of publications for 2004. Numbers refer to the number of publications co-authored with a country, and these numbers are not fractionalised according to the numbers of countries involved in a publication. Year-on-year change (%) is given in parentheses after each country.

Source: Thomson Scientific, NCR 1995–2004.

number of co-publications in this major field is recorded for collaborations with the UK (110%) and Germany (105%).

In the medical sciences, there is most publishing cooperation with the United States, Sweden, the UK, Germany and the Netherlands (Figure 10). The number of co-publications in this major field has increased by more than 150 per cent with Australia, Germany, Spain, Belgium and Norway.

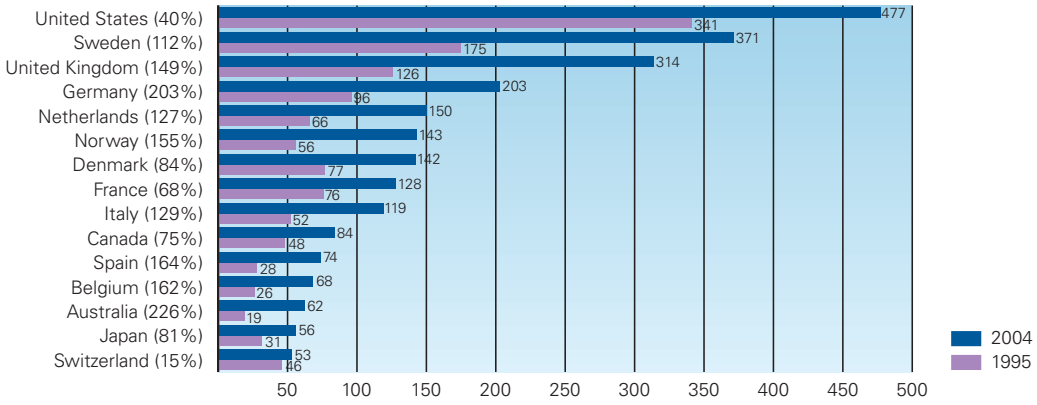

Figure 10. Finnish publishing cooperation in the major field of medical sciences. Top 15 countries in 1995–2004 are listed in order of number of publications for 2004. Numbers refer to the number of publications co-authored with a country, and these numbers are not fractionalised according to the numbers of countries involved in a publication. Year-on-year change (%) is given in parentheses after each country.

Source: Thomson Scientific, NCR 1995–2004.

2.4 Publishing in Finland by sector

In this report Finnish publications are grouped into seven sectors according to the author's affiliation (i.e. address):

- universities and university hospitals,
- polytechnics,
- government research institutes,
- other government organisations, e.g. Social Insurance Institution, Finnish Defence Forces, Bank of Finland
- business companies, including publications by Finnish-based units of international corporations
- municipal organisations, e.g. hospital districts (excluding university hospitals) and municipalities
- other organisations, e.g. foundations and associations

This analysis by sector shows that universities are involved in 69 per cent of all publications in Finland (Figure 11). Government research institutes account for 17 per cent and business companies for six per cent of all publications. There have been no marked changes in the relative shares of different sectors during the period from 1995 to 2004.

Persson et al. (2000) compared four sectors: universities and other institutions of higher education, research institutes, business companies and other organisations. The most noteworthy change in the relative contribution of these sectors was that the share of publications by research institutes increased in 1986–1998 from nine to 14 per cent.

Publication numbers in different sectors vary so widely that they are shown in Figure 12 on a logarithmic scale. The number of publications by universities has increased by one-third and that of publications by government research institutions by one-quarter from 1995 to 2004. International publishing by polytechnics has rapidly accelerated, but the overall volumes remain modest.

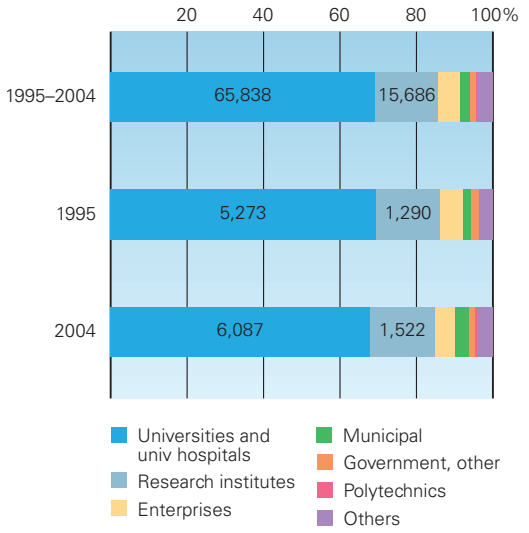

Figure 11. Publishing in Finland (%) by sector in 1995 and 2004. Values in bars indicate the number of publications in which the organisations of each sector are involved. Joint publications by organisations from the same sector are excluded to eliminate overlap. Includes organisations with five or more publications.

Source: Thomson Scientific, NCR 1995–2004.

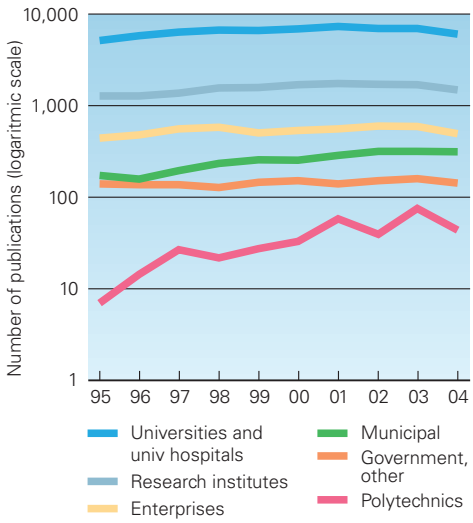

Figure 12. Development of the number of publications in different sectors in 1995–2004, described on a logarithmic scale. Joint publications by organisations in the same sector are excluded to eliminate overlap. Includes organisations with five or more publications. Values indicate the number of publications in which the organisations of each sector are involved.

Source: Thomson Scientific, NCR 1995–2004.

The number of joint publications by universities, the single biggest publishing sector in Finland, has increased in 1995–2004 both with international and domestic organisations (Figure 13).

An examination of publishing in different sectors by OECD major fields of science shows that the medical sciences are very prominent in the publishing profile of universities that are responsible for basic research (Figure 14). The share of natural sciences and agricultural sciences is the highest in government research institutes. In business companies the main emphasis in publishing is on applied engineering and technology. Universities account for the bulk of publishing in the humanities.

The number of publications by universities and government research institutes, the two biggest sectors in volume terms, has increased in all major fields of science from 1995 to 2004 (Figure 15). The only exception is the trend for engineering and technology publications at research institutes. Publication numbers at universities have increased most of all in agricultural sciences and least in medical sciences. Publication numbers for government research institutes have increased most sharply in the social sciences and the medical sciences.

2.5 Publishing in Finland by organisation

The NCR database includes figures for 256 Finnish organisations (including a few Finnish-based units of international corporations) that came out with ten publications or more in 1995–2004. These include 18 universities and 14 polytechnics, 16 government research institutes, 30 other government organisations,

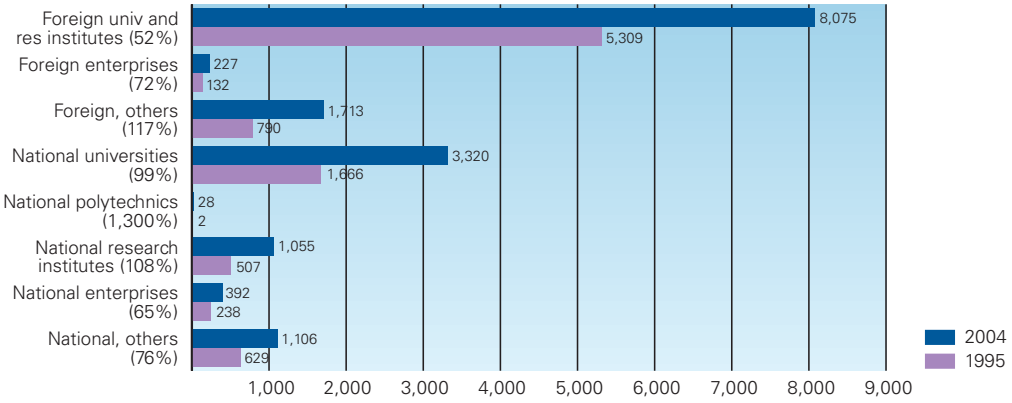

Figure 13. Collaboration by the university sector with other sectors in 1995 and 2004. Change (%) in the number of co-publications indicated after each sector in parentheses. Numbers refer to the number of publications co-authored with an organisation, and these numbers are not fractionalised according to the numbers of organisations involved in a publication. Number of publications for domestic universities includes publications by university hospitals.

Source: Thomson Scientific, NCR 1995–2004.

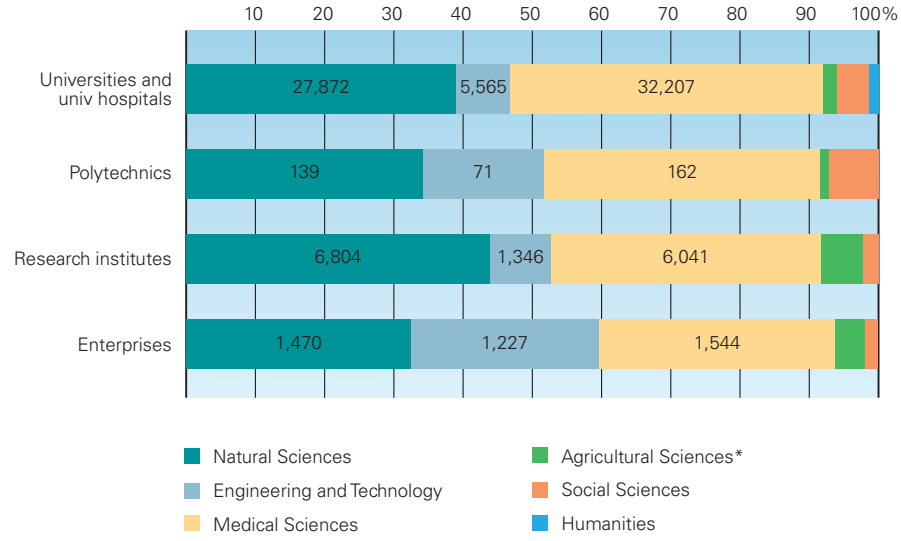

Figure 14. Publishing in different sectors (%) in 1995–2004 by the OECD's six major fields of science. Values in bars indicate the number of publications in which the organisations of each sector are involved. Includes organisations with five or more publications.

* Forestry sciences not included in agricultural sciences as they are divided in the NCR database between different natural sciences.

Source: Thomson Scientific, NCR 1995–2004.

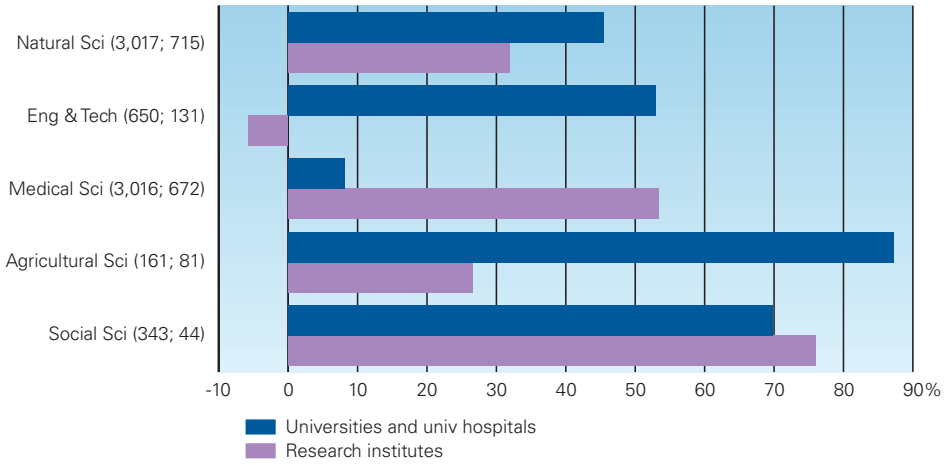

Figure 15. Change (%) in number of publications at universities and research institutes from 1995 to 2004 by major fields of science*. Number of publications in 2004 for universities and research institutes indicated after each major field of science in parentheses.

* Forestry sciences not included in agricultural sciences as they are divided in the NCR database between different natural sciences. Number of publications in the humanities not sufficient to be included in the analysis.

Source: Thomson Scientific, NCR 1995–2004.

95 business companies, 36 municipal organisations and 47 other organisations. We now turn our attention to publishing by organisations with the largest number of publications and to how those numbers have changed in general and within different major fields of science.

Appendix Table 1 in this report shows the number of citations received by the publications of different organisations relative to their total number of publications (= impact factor) in 2000–2004. Breakdowns are also provided by major fields of science and for the natural sciences by the classification of disciplines used by Statistics Finland. In comparing the impact factors of different organisations we need to bear in mind the differences in the relative weight of various disciplines in their publishing profiles (see also Figures 1 and 2 in Appendix 1).

The number of publications issued by universities increased in 1995–2004 (Figures 16a and 16b). Publications by the University of Helsinki account for 34 per cent, by the University of Turku for 14 per cent and by the University of Oulu for eleven per cent of all publications by Finnish universities.

Seven government research institutes account for 85 per cent of all publications by this category (Figure 17). Publications from the National Public Health Institute and VTT Technical Research Centre of Finland account for 52 per cent of all publications by government research institutes.

The publication numbers of the ten biggest corporate publishers show some fluctuation year on year (Figure 18). The biggest publisher is Nokia Group, which accounts for 15 per cent of all publications by business companies.

Publishing figures for organisations by major fields of science are shown in Figure 19. The natural sciences account for more than 60 per cent of publications by the Finnish Forest Research Institute and by the universities of Joensuu and Jyväskylä. The Nokia Group, Tampere University of Technology, VTT Finland and

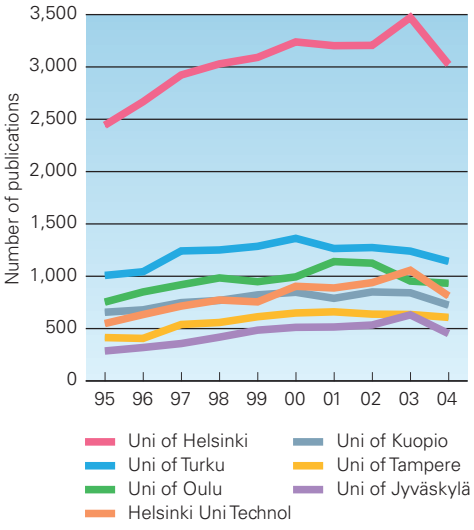

Figure 16a. Number of publications by universities (and university hospitals)* in 1995–2004. Figures shown for universities with more than 4,000 publications in 1995–2004.

* Excluded from the data are 192 publications by the Turku Centre for Computer Science and 30 publications by the Helsinki Institute for Information Technology which it has not been possible to allocate between different universities.

Source: Thomson Scientific, NCR 1995–2004.

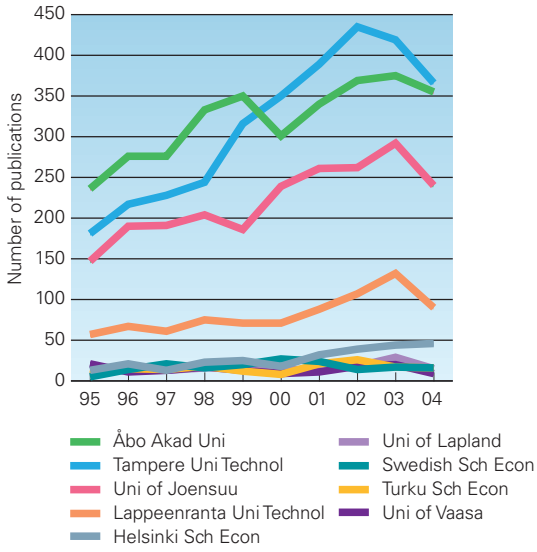

Figure 16b. Number of publications by universities (and university hospitals) in 1995–2004. Figures shown for universities with more than 100 publications in 1995–2004.

Source: Thomson Scientific, NCR 1995–2004.

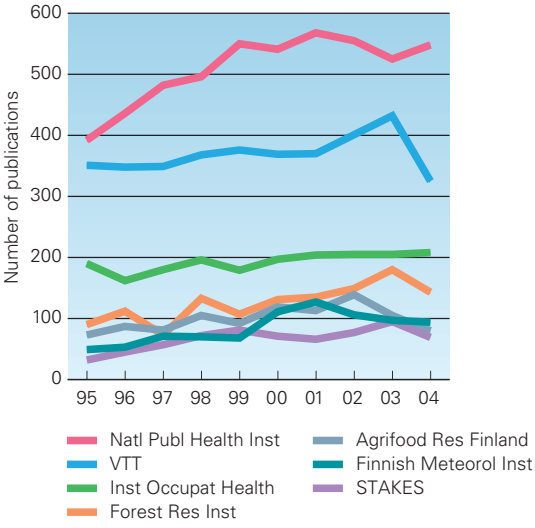

Figure 17. Number of publications by government research institutes in 1995–2004. Figures shown for research institutes with more than 600 publications in 1995–2004.

Source: Thomson Scientific, NCR 1995–2004.

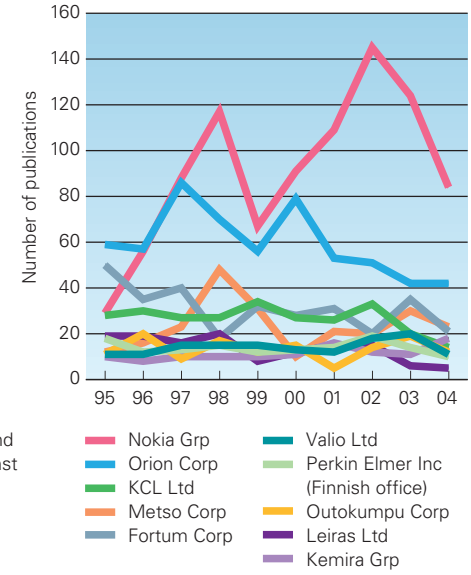

Figure 18. Number of publications by business companies in 1995–2004. Figures shown for companies with more than 100 publications in 1995–2004.

Source: Thomson Scientific, NCR 1995–2004.

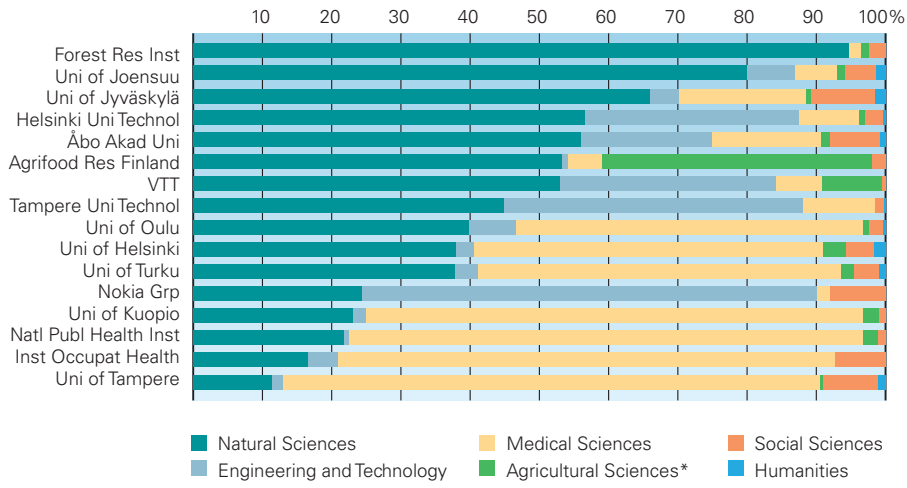

Figure 19. Share (%) of total publications in major fields of science by organisations with largest number of publications in 1995–2004. Organisations listed in order of their share of publications in the major field of natural sciences. Publication numbers for universities include publications by university hospitals.

* Forestry sciences not included in agricultural sciences as they are divided in the NCR database between different natural sciences.

Source: Thomson Scientific, NCR 1995–2004.

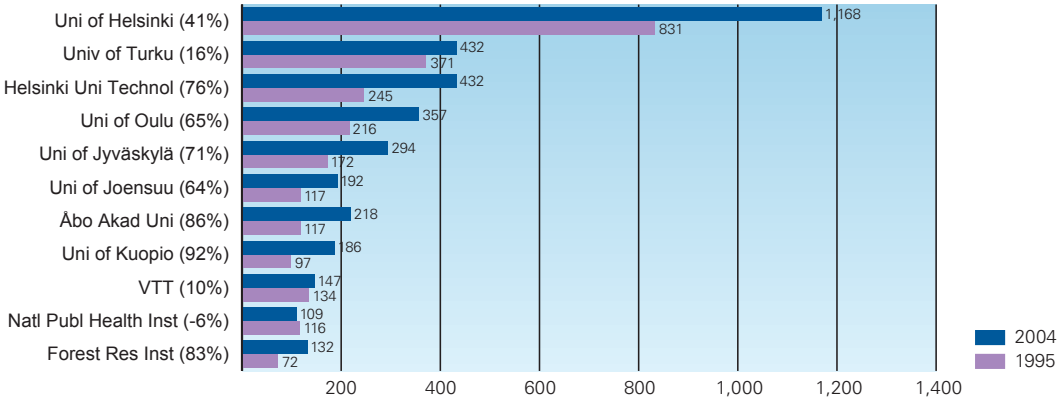

Figure 20. Organisations with the largest number of publications in the major field of natural sciences in 1995–2004, listed in order of the number of publications in 2004. Publication numbers for universities include publications by university hospitals. Year-on-year change (%) is given in parentheses after each organisation.

Source: Thomson Scientific, NCR 1995–2004.

Helsinki University of Technology show the strongest engineering and technology orientation. The medical sciences have a prominent role in the publishing profiles of the University of Tampere, the Finnish Institute of Occupational Health, the National Public Health Institute and the University of Kuopio.

The biggest publishers in the natural sciences are the University of Helsinki, the University of Turku and Helsinki University of Technology (Figure 20). The number of publications in this field has increased most at the University of Kuopio, Åbo Akademi University and the Finnish Forest Research Institute.

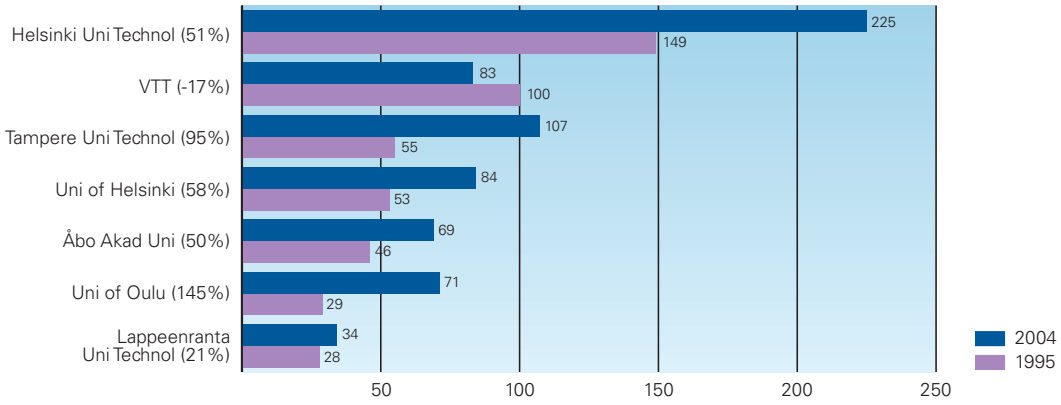

Figure 21. Organisations with the largest number of publications in the major field of engineering and technology in 1995–2004, listed in order of the number of publications in 2004. Publication numbers for universities include publications by university hospitals. Year-on-year change (%) is given in parentheses after each organisation.

Source: Thomson Scientific, NCR 1995–2004.

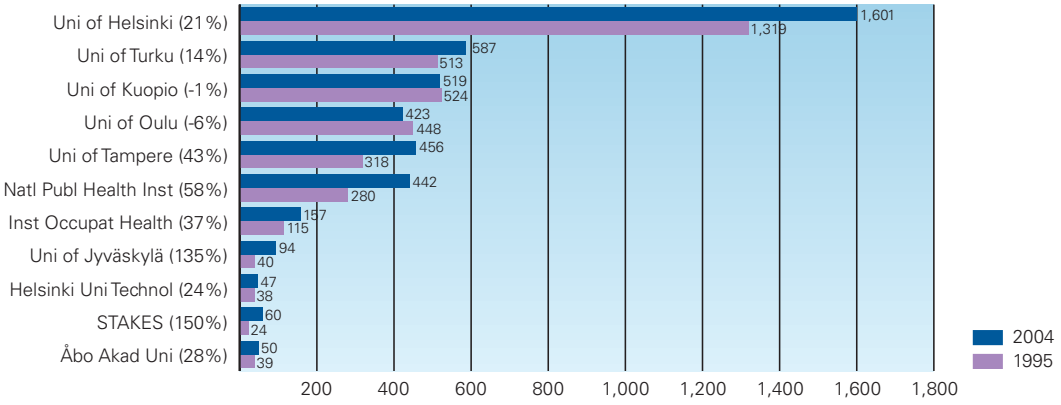

Figure 22. Organisations with the largest number of publications in the major field of medical sciences in 1995–2004, listed in order of the number of publications in 2004. Publication numbers for universities include publications by university hospitals. Year-on-year change (%) is given in parentheses after each organisation.

Source: Thomson Scientific, NCR 1995–2004.

In the engineering and technology field the largest number of publications is recorded for Helsinki University of Technology, VTT Finland and Tampere University of Technology (Figure 21). Publications numbers have increased most for the University of Oulu and Tampere University of Technology.

The biggest publishers in the major field of medical sciences are the universities of Helsinki, Turku and Kuopio (Figure 22). The sharpest increase in publication numbers has been recorded for the National Research and Development Centre for Welfare and Health (STAKES), the University of Jyväskylä and the National Public Health Institute.

3 International comparison of publishing in OECD countries

3.1 Comparison of publishing and citation impacts in OECD countries

Relative publishing indicators

US publications accounted for around one-third of all publishing in OECD countries in 2005 (Figure 23). The figure has dropped from 38 per cent in 1995 to 33 per cent in 2005. The combined share of the UK, Japan and Germany in 2005 was around one-quarter. Appendix 2 provides an overview of the development of publishing in China, India and Russia.

Relative to population numbers, the Finnish number of publications in 2005 was 1,600 per one million population (Figure 24). In this comparison Finland ranks fourth in the OECD group after Switzerland, Sweden and Denmark. In 1995

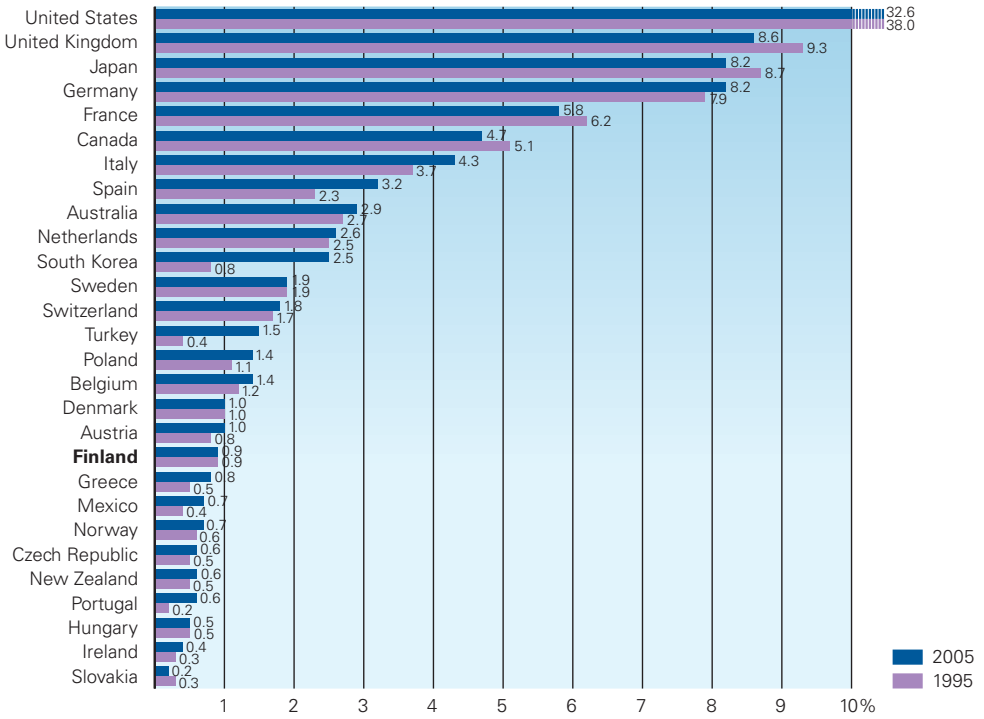

Figure 23. OECD countries' shares (%) of all OECD publications[a] in 1995 and 2005. Countries[b] listed in order of their share of publications in 2005.

[a] According to Table 2 and Figure 1 Finland's share of OECD publications in 1995 was 1.0 and in 2005 1.1. The shares indicated in Figure 23 are lower because rather than being drawn directly from the NSI database, the total number of OECD publications is here calculated as the sum total of publications from different countries, which because of co-publications between researchers from different countries involves some overlap (see also Appendix 1).

[b] Data for Iceland and Luxembourg missing because of the small total number of publications.

Source: Thomson Scientific, NSI 1981–2005.

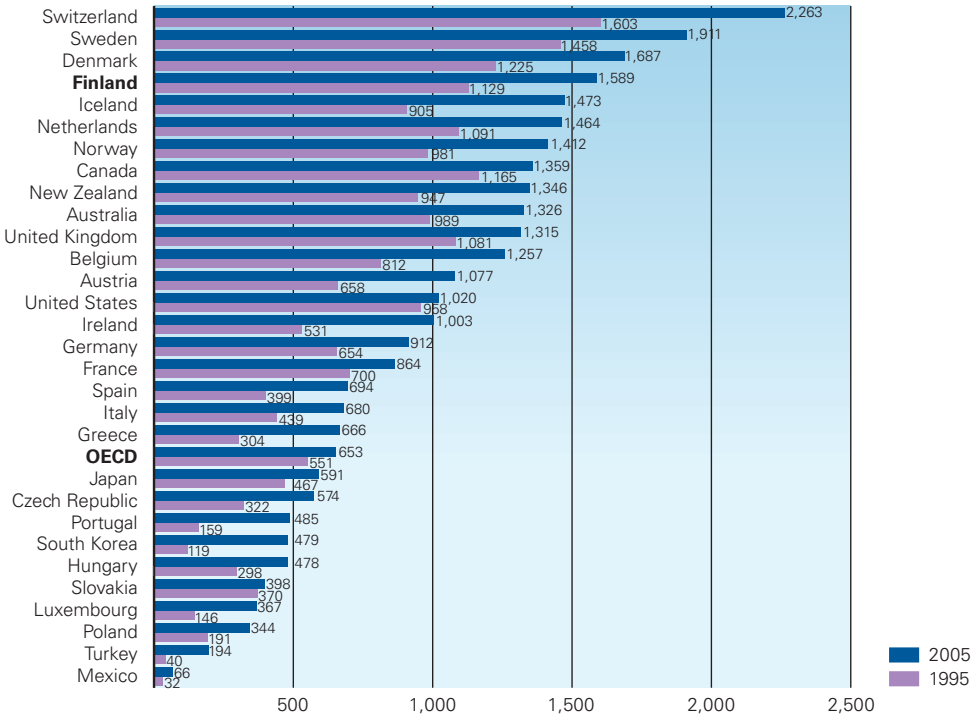

Figure 24. Number of scientific publications in OECD countries in 1995 and 2005 relative to one million population (in 1995 and 2004). Countries listed in order of the number of publications in 2005.

Sources: Main Science and Technology Indicators 2006/1; Thomson Scientific, NSI 1981–2005.

Finland ranked fifth. The top three countries remain unchanged over the past ten years, but Finland overtook Canada to climb to fourth place in the 2005 rankings.

Publication numbers in the OECD countries can also be compared to GDP (Table 3). Finland ranked fourth in this comparison in 2005 after Switzerland, Sweden and New Zealand.

King (2004) compared the nation's wealth (GDP / population) with the country's citation intensity (citations / GDP). In this comparison Finland ranked third among OECD countries after Switzerland and Sweden.

These indicators provide rough guidance for the interpretation of country differences. In principle they may help to shed light on differences in the efficiency of national research systems.

The development of publication numbers

The total number of publications in EU 25 countries more than doubled from 1985 to 2005 (Figure 25). During the same period the total number of publications in OECD countries increased 1.8-fold. The number of publications in Finland increased 2.5-fold over these 20 years.

Looking more closely at the changes in publication numbers from 1985 to 2005, the sharpest relative increase is recorded for South Korea (41-fold increase), Turkey (28-fold) and Portugal (14-fold). However, in 1985 the publication numbers for these countries were still comparatively low. Publication numbers in Turkey have

Table 3. Publication numbers in OECD countries[a] per GDP (1,000 million current PPP$[b] in 2004) in 2005. Countries listed in order of relative publication numbers.

[a] Except Iceland and Luxembourg due to small publication numbers.

[b] PPP$: Purchasing power parities per dollar.

Sources: Main Science and Technology Indicators 2006/1; Thomson Scientific, NSI 1981–2005.

	Publications per GDP
Switzerland	65
Sweden	61
New Zealand	55
Finland	53
Denmark	52
Netherlands	44
Canada	43
United Kingdom	43
Australia	41
Belgium	40
Norway	35

	Publications per GDP
Austria	33
Germany	32
Greece	31
Czech Republic	31
Hungary	30
France	30
Slovakia	29
Poland	28
Ireland	28
Spain	27
Portugal	27

	Publications per GDP
Turkey	26
United States	26
Italy	24
OECD	24
South Korea	23
Japan	20
Mexico	6

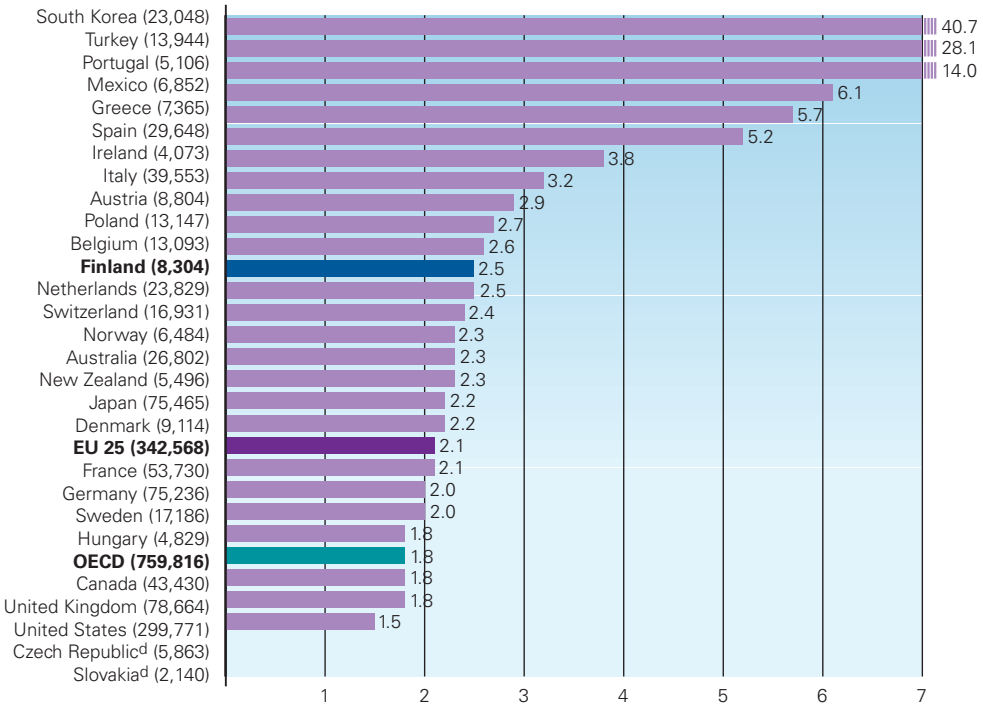

Figure 25. Change[a] in publication numbers in OECD countries[b] and the EU 25 group[c] from 1985 to 2005. Countries listed in order of the magnitude of change. Publication numbers for 2005 given in parentheses.

[a] Coefficient of change: E.g. 1 + [(publication number in 2005 – publication number in 1985) / publication number in 1985]. Coefficient of change is 1 if the number of publications is the same across the years compared.

[b] Data for Iceland and Luxembourg missing because of small overall number of publications.

[c] EU 25 refers to the current 25 EU countries during the period under review.

[d] Data for Czech Republic and Slovakia available from 1994, rate of change not available.

Source: Thomson Scientific, NSI 1981–2005.

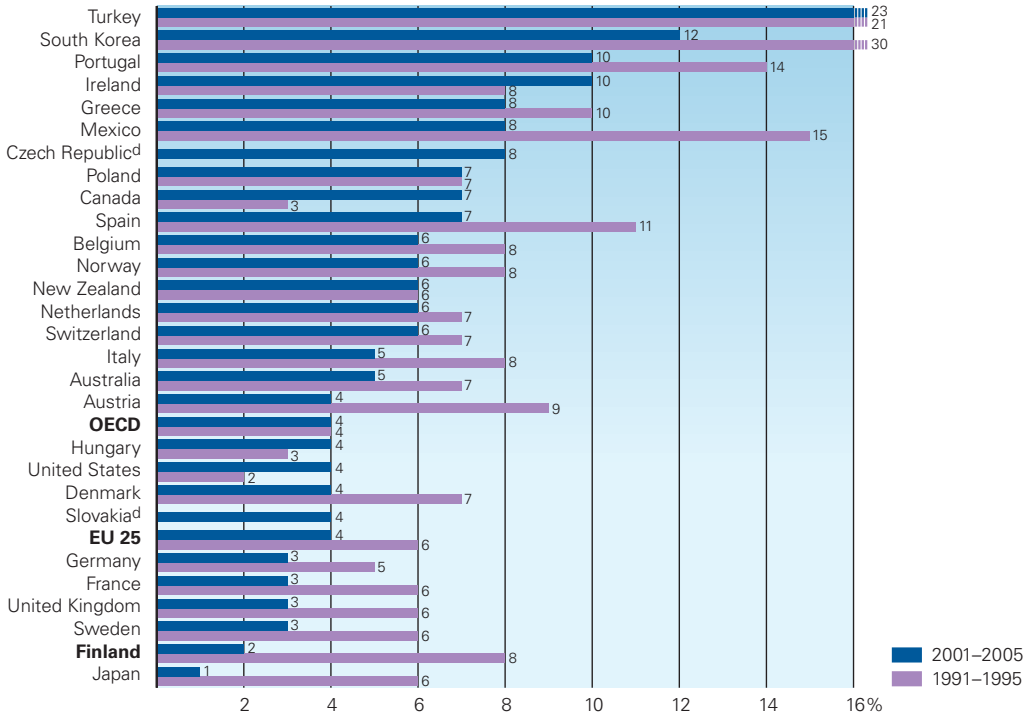

Figure 26. Average annual change[a] (%) in number of scientific publications in OECD countries[b] and the EU 25 group[c] in 1991–1995 and 2001–2005. Countries listed in order of the size of annual change in 2001–2005.

[a] Average annual change e.g. in 2001–2005: (Number of publications in 2005 / number of publications in 2001)$^{1/(t-1)}$, t = length of period under investigation. As the 2001–2005 period covers five years, the difference in the number of publications is raised to the power of 1/(5–1) = 0.25.

[b] Data for Iceland and Luxembourg missing because of small overall number of publications.

[c] EU 25 refers to the current 25 EU countries during the period under review.

[d] Data for Czech Republic and Slovakia available from 1994, average annual change in 1991–1995 not available.

Source: Thomson Scientific, NSI 1981–2005.

increased by more than 20 per cent per annum both in the early 1990s and again in the early 2000s (Figure 26). South Korea's annual increase rate of 30 per cent has slowed down to 12 per cent during the period under review. During 1991–1995, Portugal recorded a growth rate of 14 per cent and in 2001–2005 a growth rate of ten per cent.

Compared to the average rate of growth of publication numbers in the OECD countries (around four per cent annually in the early 1990s and early 2000s), the change in the number of publications in Finland was faster in the early 1990s but slower in the early 2000s. The Finnish figures showed the fastest growth in the 1990s: in the early 1990s the number of publications increased by eight per cent a year, by the end of the decade the figure was down to four per cent a year. The number of publications has continued to rise in the 2000s, but at a slower rate. In 2001–2005, the annual increase in the number of publications slowed to two per cent a year.

In the early 1990s, the total number of publications in the EU 25 group increased annually by six per cent. The rate of growth slowed to four per cent in the early 2000s. In Sweden, the UK, France, Germany and Denmark the trends have

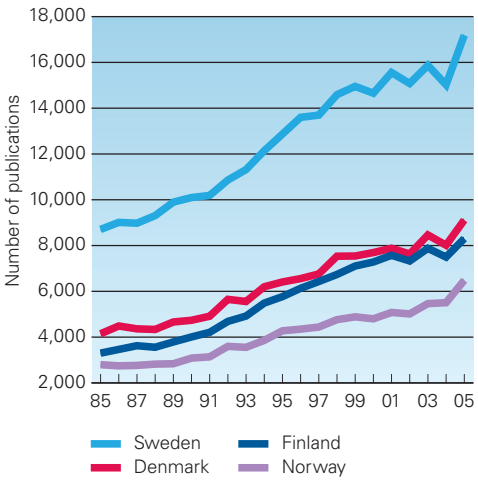

Figure 27. Development of publication numbers in the Nordic countries* in 1985–2005. Countries listed in order of the number of publications in 2005.

* Data for Iceland missing because of the small overall number of publications.

Source: Thomson Scientific, NSI 1981–2005.

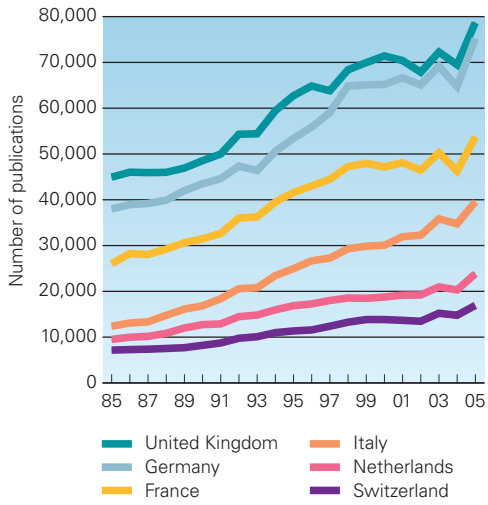

Figure 28. Development of publication numbers in selected OECD countries in 1985–2005. Countries listed in order of the number of publications in 2005.

Source: Thomson Scientific, NSI 1981–2005.

been very similar (Figures 27 and 28). By contrast, in the United States the increase in the number of publications has accelerated since the early 1990s, climbing to four per cent a year in the early 2000s.

Comparison of citation impacts

The visibility and scientific impact of research in OECD countries can be compared by means of the relative citation impact, which compares the number of citations received by publications from each country with the number of citations to publications from OECD countries on average. In this analysis OECD countries can be compared with one another by determining the point at which the publications in each country reach the average OECD number of citations (relative citation impact = 1).

In 1985–2005, the relative citation impact for Switzerland, Denmark, the United States, Netherlands, Sweden and the UK have been above the OECD average for this period (Figures 29a and 29b). In Finland and Belgium the relative citation impact climbed above the average level for the OECD countries in the early 1990s. Germany and Canada reached the average level for the OECD countries in the late 1990s, Austria, France and Italy only at the turn of the millennium, and Norway in the early 2000s. Publications in other OECD countries have so far received less citations than OECD publications on average. The two countries that come closest to the relative citation impact value of one are Australia and Ireland.

In 2001–2005, Swiss publications received 43 per cent more citations than OECD publications on average (Figure 30). Danish and US publications received 29 per cent more and Dutch publications 26 per cent more citations than the average. Iceland (22%, although the total number of publications is small), Sweden

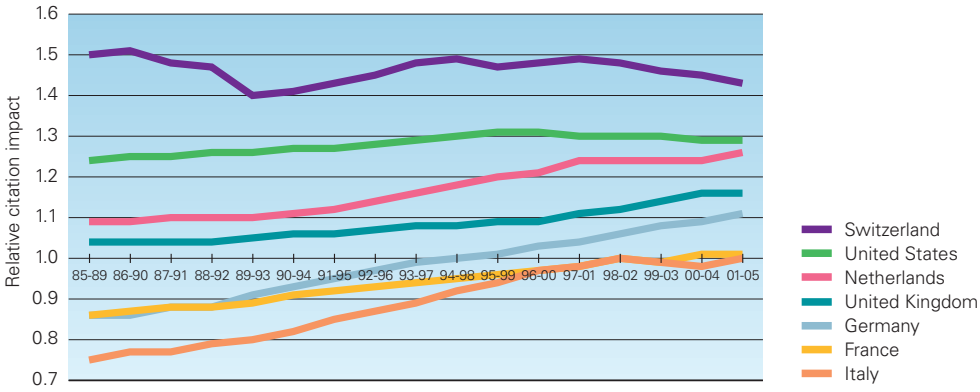

Figure 29a. Development of relative citation impacts* in selected OECD countries in 1985–2005. Countries listed in order of the citation impacts for the most recent period.

* Relative citation impact = impact factor e.g. for Switzerland (number of citations / number of publications) / impact factor for OECD.

Source: Thomson Scientific, NSI 1981–2005.

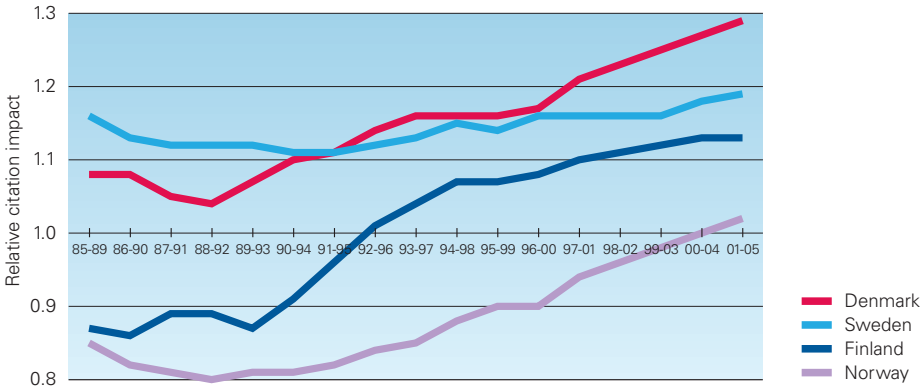

Figure 29b. Development of relative citation impacts[a] in the Nordic countries[b] in 1985–2005.

[a] Relative citation impact = impact factor e.g. for Finland (number of citations / number of publications) / impact factor for OECD.

[b] Data for Iceland missing because of the small overall number of publications.

Source: Thomson Scientific, NSI 1981–2005.

(19%) and the UK(16%) also ranked above Finland in a comparison of citation impacts in OECD countries. Finland ranked eighth, with its publications receiving 13 per cent more citations than OECD publications on average.

The differences between the number of citations received by publications in OECD countries have narrowed down. In 1991–1995, publications from no more than seven countries received more citations than publications from all OECD countries on average. In 2001–2005, publications from 15 countries, i.e. every other OECD country received more citations than OECD publications on average.

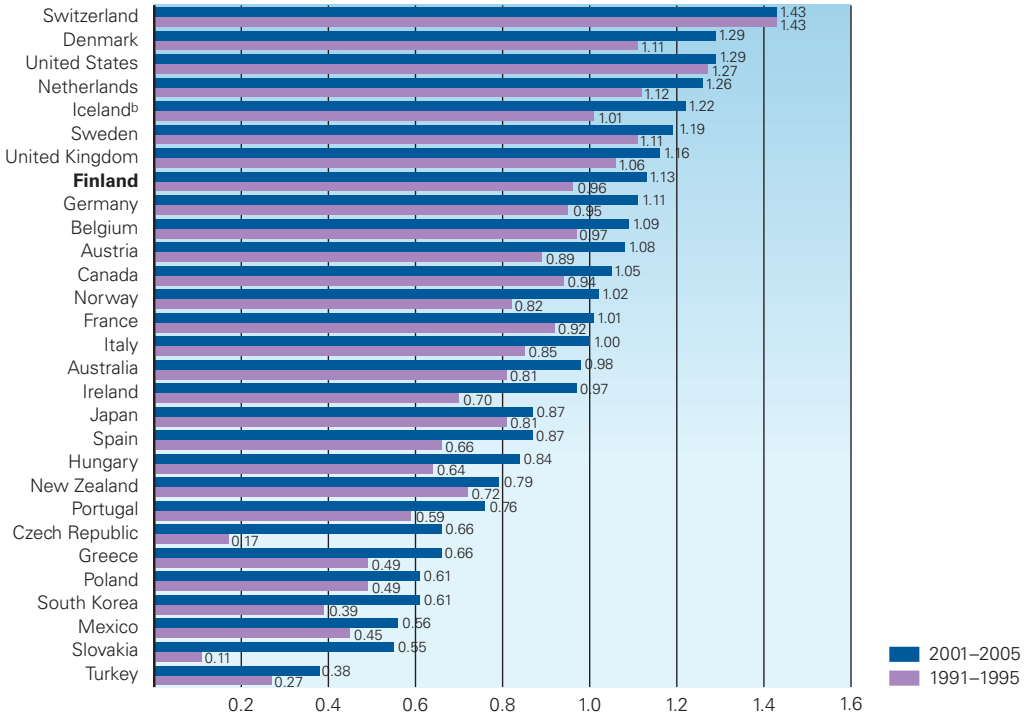

Figure 30. OECD countries' relative citation impacts[a] in 1991–1995 and 2001–2005. Countries listed in order of the citation impacts for the most recent period.

[a] Relative citation impact = impact factor e.g. for Finland (number of citations / number of publications) / impact factor for OECD.

[b] The number of publications for Iceland is small in comparison with other OECD countries. Values for Luxembourg are missing because of the small total number of publications.

Source: Thomson Scientific, NSI 1981–2005.

3.2 Comparison of the structure of publishing and citation impacts by major fields of science

The Finnish publishing profile is quite similar to the average OECD profile in which the natural sciences and medical sciences are very prominent (Figure 31). However, medical sciences account for a larger proportion of publishing in Finland than they do in OECD countries on average.

The natural sciences account for at least 45 per cent of all publications in two-thirds of OECD countries; this is the average figure for all OECD countries. The average figure for medical sciences in OECD countries is 33 per cent. In one-half of OECD countries the share of medical sciences is the same or higher than in the OECD on average. Medical sciences account for a larger proportion of the publishing profile than the natural sciences in only three countries. Engineering and technology account on average for eleven per cent of all OECD publications. In eleven countries the share of engineering and technology is the same or higher than the OECD average.

Table 4 shows the relative citation impacts for major fields of science in the OECD countries. This is obtained by comparing each country's citation impact in different fields (citations/publications) with the corresponding index for the OECD group.

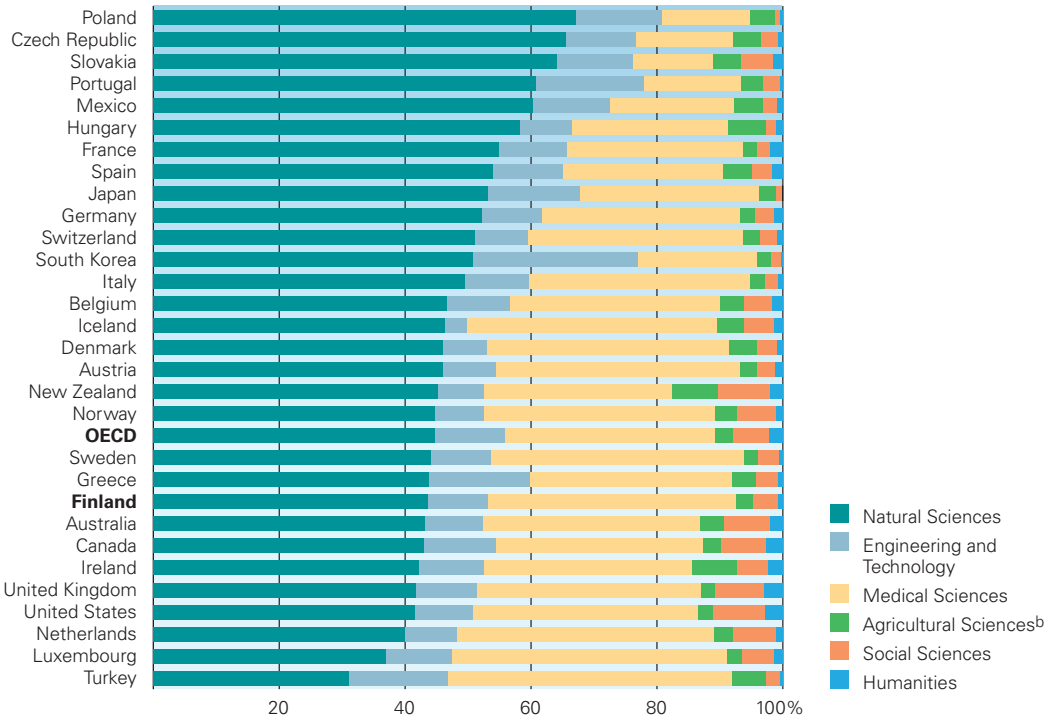

Figure 31. Publishing profile[a] of OECD countries by major field of science in 2001–2005.

[a] For the calculation of publishing profiles see Appendix 1.

[b] Forestry sciences not included in agricultural sciences as they are divided in the NSI database between different natural sciences.

Source: Thomson Scientific, NSI 1981–2005.

In the natural sciences, Finland ranked 12th among all OECD countries in 2001–2005. Finnish publications in the natural sciences received four per cent less citations than the corresponding publications in the OECD on average. In the field of engineering and technology, Finland ranked tenth, and the number of citations was one per cent higher than in the OECD countries on average. In the medical sciences, Finland ranked sixth in the OECD group, and publications in this field received 25 per cent more citations than OECD publications on average. In agricultural sciences Finland ranked first. Finnish publications received 56 per cent more citations than agricultural publications on average.

In the social sciences and humanities, Finland's rankings were 11th and 13th, respectively. In the social sciences Finnish publications received twelve per cent less citations than in the major field on average, in the humanities the number of citations was the same as in the OECD countries on average.

The relative citation impacts for Finnish disciplines by major field of science are shown in Table 5. The number of citations per publications in each discipline is compared to the average OECD figure in the corresponding field. This analysis reveals major differences in the relative citation impacts and draws attention to the great diversity within major fields of science.

Table 4. Relative citation impacts[a] for OECD countries by major field of science in 2001–2005 and for Finland also in 1991–1995. Countries listed in order of their relative citation impact.

[a] Relative citation impact = Impact factor e.g. for the major field of natural sciences in Finland (number of citations / number of publications) / impact factor for the same major field in OECD countries. The relative citation impact for the OECD in all major fields of science is one and is indicated in each table with a horizontal line.

[b] Forestry sciences not included in agricultural sciences as they are divided in the NSI database between different natural sciences.

[c] Less than 200 publications in this major field in 2001–2005.

Source: Thomson Scientific, NSI 1981–2005.

2001–2005	Natural Sciences		Engineering and Technology		Medical Sciences	
1	United States	1.30	Switzerland	1.50	Switzerland	1.36
2	Switzerland	1.30	Denmark	1.43	United States	1.30
3	Iceland	1.23	Netherlands	1.30	Iceland	1.29
4	United Kingdom	1.22	United States	1.21	Denmark	1.29
5	Netherlands	1.21	Austria	1.17	Belgium	1.26
6	Denmark	1.17	Germany	1.14	Finland (6)	1.25
7	Sweden	1.10	Belgium	1.12	Netherlands	1.24
8	Germany	1.08	Sweden	1.11	Canada	1.20
9	Austria	1.05	France	1.05	Sweden	1.17
10	Canada	1.00	Finland (10)	1.01	United Kingdom	1.17
11	Ireland	0.98	Norway	1.01	Norway	1.15
12	Finland (12)	0.96	Spain	0.99	Australia	1.06
13	France	0.94	United Kingdom	0.98	Italy	1.06
14	Belgium	0.94	Portugal	0.91	Germany	1.04
15	Australia	0.94	Italy	0.90	France	1.04
16	Norway	0.88	Ireland	0.90	Ireland	1.03
17	Italy	0.85	Japan	0.90	Luxembourg	1.01
18	Japan	0.83	Australia	0.89	Austria	1.01
19	Spain	0.80	Canada	0.89	Spain	0.95
20	Hungary	0.75	Czech Republic	0.88	New Zealand	0.94
21	New Zealand	0.74	New Zealand	0.88	Portugal	0.94
22	Portugal	0.70	Hungary	0.87	Hungary	0.93
23	Greece	0.65	Iceland[c]	0.84	Czech Republic	0.83
24	Luxembourg	0.65	South Korea	0.78	Japan	0.83
25	South Korea	0.64	Greece	0.76	Poland	0.78
26	Czech Republic	0.61	Slovakia	0.76	Slovakia	0.73
27	Poland	0.57	Mexico	0.71	Greece	0.66
28	Slovakia	0.53	Turkey	0.63	Mexico	0.64
29	Mexico	0.50	Poland	0.60	South Korea	0.59
30	Turkey	0.42	Luxembourg[c]	0.45	Turkey	0.33
1991–1995	Finland	0.86	Finland	1.02	Finland	1.01

	Agricultural Sciences[b]
Finland (1)	1.56
Iceland[c]	1.48
Denmark	1.42
United Kingdom	1.39
Norway	1.38
Sweden	1.37
Netherlands	1.31
Ireland	1.22
France	1.18
United States	1.17
Switzerland	1.15
Belgium	1.13
Canada	1.07
Portugal	1.07
Australia	1.06
New Zealand	1.04
Italy	1.03
Luxembourg[c]	1.01
Spain	1.00
Greece	1.00
Germany	0.89
South Korea	0.83
Japan	0.81
Austria	0.79
Czech Republic	0.61
Mexico	0.55
Slovakia	0.51
Poland	0.45
Hungary	0.43
Turkey	0.41
Finland	0.94

	Social Sciences
United States	1.16
Hungary	1.12
Netherlands	1.08
Canada	1.04
United Kingdom	1.00
Belgium	0.98
Germany	0.96
Italy	0.94
Sweden	0.91
France	0.90
Finland (11)	0.88
Norway	0.87
Denmark	0.86
Switzerland	0.85
Australia	0.85
Iceland[c]	0.81
New Zealand	0.77
Austria	0.75
Mexico	0.70
Spain	0.68
Ireland	0.68
Poland	0.65
South Korea	0.62
Japan	0.60
Luxembourg[c]	0.56
Portugal	0.53
Turkey	0.53
Greece	0.50
Czech Republic	0.28
Slovakia	0.20
Finland	0.78

	Humanities
Greece	1.94
Denmark	1.64
Netherlands	1.60
Iceland[c]	1.33
Portugal[c]	1.29
New Zealand	1.29
United Kingdom	1.27
Sweden	1.25
Japan	1.19
United States	1.17
Australia	1.06
Norway	1.01
Finland (13)	1.00
Italy	0.95
Mexico	0.93
Canada	0.93
Turkey	0.89
Austria	0.86
Germany	0.81
Belgium	0.79
Poland	0.77
Ireland	0.64
Switzerland	0.61
Hungary	0.58
South Korea	0.54
Czech Republic	0.52
Spain	0.51
France	0.49
Luxembourg[c]	0.49
Slovakia[c]	0.27
Finland	0.67

Table 5. Relative citation impacts[a] for Finnish disciplines[b] in 2001–2005. Disciplines with less than 100 publications[c] during the period concerned are excluded from the analysis. Disciplines are grouped according to the OECD major fields of science and listed in the order of their citation impacts. The relative citation impacts of major fields of science are given in parentheses.

	Relative citation impact
NATURAL SCIENCES (0.96)	
Instrumentation / Measurement	1.49
Physics	1.33
Animal Sciences	1.30
Molecular Biology & Genetics	1.30
Environment / Ecology	1.26
Earth Sciences	1.25
Experimental Biology	1.17
Applied Physics / Condensed Matter / Materials Science	1.15
Biology	1.12
Spectroscopy / Instrumentation / Analytical Science	1.12
Animal & Plant Sciences	1.02
Mathematics	0.99
Biochemistry & Biophysics	0.97
Physical Chemistry / Chemical Physics	0.94
Microbiology	0.93
Optics & Acoustics	0.91
Aquatic Sciences	0.88
Chemistry & Analysis	0.86
Inorganic & Nuclear Chemistry	0.86
Plant Sciences	0.86
Cell & Developmental Biology	0.83
Organic Chemistry / Polymer Science	0.83
Computer Science & Engineering	0.82
Chemistry	0.79
Space Science	0.65
Entomology / Pest Control	0.63
Multidisciplinary[d]	0.30
ENGINEERING AND TECHNOLOGY (1.01)	
AI, Robotics & Automatic Control	1.31
Engineering Management/General	1.29
Engineering Mathematics	1.23
Information Technology & Communications Systems	1.19
Chemical Engineering	1.15
Electrical & Electronics Engineering	0.96
Mechanical Engineering	0.95
Environmental Engineering / Energy	0.93
Metallurgy	0.93
Materials Science & Engineering	0.92
Biotechnology & Applied Microbiology	0.77
Nuclear Engineering	0.75

	Relative citation impact
MEDICAL SCIENCES (1.25)	
General & Internal Medicine	3.13
Research/Lab Medicine & Medical Technology	1.83
Oncology	1.53
Neurology	1.51
Medical Research, General Topics	1.44
Pharmacology/Toxicology	1.42
Dermatology	1.38
Cardiovascular & Respiratory Systems	1.36
Reproductive Medicine	1.35
Clinical Immunology & Infectious Disease	1.34
Endocrinology, Nutrition & Metabolism	1.34
Oncogenesis & Cancer Research	1.28
Orthopedics & Sports Medicine	1.28
Medical Research, Diagnosis & Treatment	1.23
Endocrinology, Metabolism & Nutrition	1.20
Cardiovascular & Hematology Research	1.19
Urology & Nephrology	1.19
Gastroenterology & Hepatology	1.17
Surgery	1.17
Pediatrics	1.13
Environmental Medicine & Public Health	1.12
Rheumatology	1.10
Hematology	1.07
Dentistry / Oral Surgery & Medicine	1.06
Medical Research, Organs & Systems	1.04
Pharmacology & Toxicology	1.02
Public Health & Health Care Science	1.01
Radiology, Nuclear Medicine & Imaging	1.00
Anesthesia & Intensive Care	0.99
Immunology	0.99
Otolaryngology	0.99
Health Care Sciences & Services	0.95
Ophthalmology	0.94
Clinical Psychology & Psychiatry	0.93
Neurosciences & Behavior	0.93
Psychiatry	0.85
Physiology	0.84
AGRICULTURAL SCIENCES[e] (1.56)	
Food Science / Nutrition	1.59
Agricultural Chemistry	1.48
Agriculture / Agronomy	1.47
Veterinary Medicine / Animal Health	1.38
SOCIAL SCIENCES (0.88)	
Library & Information Science	1.66
Education	1.29
Environmental Studies, Geography & Development	0.96
Management	0.94
Psychology	0.85
Economics	0.76
Sociology and Social Sciences	0.61

[a] Relative citation impact = Impact factor for Finland in certain field of science (number of citations / number of publications) / impact factor for OECD in the same field. Relative citation impact for OECD is one.

[b] Disciplines correspond to those listed in the deluxe version of the NSI database.

[c] For example, publication numbers for individual disciplines in the humanities are too low for an examination of relative citation impacts.

[d] Multidisciplinary field excludes articles from Science, Nature and PNAS. Articles from these journals have been reassigned to specific categories.

[e] Forestry sciences not included in agricultural sciences as they are divided in the NSI database between different natural sciences.

Source: Thomson Scientific, NSI 1981–2005.

4 Summary and conclusions

In 2005, Finnish researchers produced 8,300 publications, which is the highest figure on records. Over the past 20 years, the total number of Finnish publications has increased 2.5 times over. The growth was fastest in the early 1990s, when the number of publications increased at around eight per cent per annum. In the 2000s, the annual growth rate has slowed to a few per cent.

In 1995–2004, Finnish researchers had the most international collaboration with colleagues from other EU countries. During this period the number of joint publications with EU colleagues increased by 85 per cent. The number of joint publications with the Nordic countries went up by 78 per cent and with North American countries by 42 per cent. The major partner countries in this order are the United States, Sweden, the UK, Germany, France, the Netherlands and Russia.

Universities are involved in 69 per cent of all Finnish publications, the corresponding figure for government research institutes is 17 per cent. Business companies account for six per cent of all publications. In 1995–2004, there were no major shifts in the relative shares of different sectors. During the period under review, the number of publications by universities increased by one-third and the corresponding figure for government research institutes by one-quarter.

The Finnish publishing profile leans towards the natural sciences and the medical sciences, as is the case in the OECD countries on average. In Finland the share of medical sciences is higher than the corresponding OECD average. The medical sciences have a very prominent role in the publishing profile of Finnish universities that are responsible for basic research. The share of natural sciences and agricultural sciences is the highest in government research institutes. In business companies the main emphasis in publishing is in the field of applied engineering and technology. Publishing in the humanities is concentrated in universities.

Finnish publications account for just over two per cent of all EU 25 publications and for just over one per cent of all OECD publications. Finland's shares have increased since the late 1980s, but declined from the peak levels recorded in 2001.

Relative to population numbers, the number of publications produced in Finland in 2005 was 1,600 per one million population. In a comparison of 30 OECD countries Finland ranked fourth after Switzerland, Sweden and Denmark. In 1995 Finland ranked fifth. The top three countries have remained unchanged over the past ten years, but Finland overtook Canada to climb to fourth place in the 2005 rankings.

The total number of publications in the EU 25 countries more than doubled in the past 20 years. During the same period, the total number of publications in OECD countries increased 1.8-fold. The increase for Finland was 2.5-fold. Compared to the average growth rate for publications in the OECD countries, the change in the number of Finnish publications was faster in the early 1990s but slower in the early 2000s. In Sweden, the UK, France, Germany and Denmark the trends have been very similar.

In the early 2000s Finnish publications received on average six citations per publication, 13 per cent more than OECD publications on average. Finland ranked eighth in a comparison of the citation impacts in all OECD countries.

Over the past 20 years the relative citation impacts for Switzerland, Denmark, the United States, the Netherlands, Sweden and the UK have been above the OECD average for this period. Finland's relative citation impact climbed above the OECD average in the early 1990s and showed rapid growth through the whole decade.

By major field of science, Finnish publications in the natural sciences received four per cent less citations than natural science publications in the OECD countries on average in the early 2000s. In engineering and technology, the number of citations was one per cent higher than in the OECD countries on average. Publications in the medical sciences received 25 per cent more citations than medical publications in the OECD on average. In agricultural sciences Finland ranked first. Finnish publications received 56 per cent more citations than OECD agricultural publications on average. In the social sciences, Finnish publications received twelve per cent less citations than in this field on average, while in the humanities the number of citations was the same as in the OECD countries on average.

Our analysis of bibliometric science indicators allows us to draw a few conclusions about the development of Finnish scientific research and its position internationally. Relative to population and GDP, Finland is one of the world's biggest publishers, ahead of such traditionally strong countries in scientific research as the UK and Germany. The quality of scientific research in Finland is higher than in the OECD countries on average. The quality level in agricultural sciences and medical sciences is significantly higher than the OECD average.

The internationalisation of Finnish scientific research has progressed favourably since the 1990s. In particular, international collaboration among university researchers has expanded considerably with foreign universities and research institutes.

In many research-intensive countries such as the United States, Germany, France and the UK, the growth of scientific research was at its fastest in the 1980s. In Finland the fastest growth of scientific research was recorded in the early 1990s. In the early 2000s, strong growth has been seen in the smaller science countries of southern Europe such as Portugal and Turkey, as well as in the Asian countries of China and South Korea. The geography of scientific research is changing and by all accounts it will continue to change significantly over the next decades.

Acknowledgements

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Appendix Table 1.

Publication numbers and citation impacts[a] for organisations with more than 100 publications in 2000–2004. Figures presented for natural sciences, engineering and technology, and medical sciences. Breakdowns also provided for the natural sciences by the classification of disciplines used by Statistics Finland[b]. Publications numbers of less than 20 and corresponding citation impacts have been removed from the table.

Period 2000–2004	ALL		**Natural sciences**		BIO1		BIO2	
	publ	CI	publ	CI	publ	CI	publ	CI
UNIVERSITIES								
Åbo Akad Uni	1,795	3.4	959	4.3	188	6.94	146	3.84
Uni of Helsinki	16,517	5.88	6,294	6.87	1,959	9.05	1,567	4.16
Helsinki Uni Technol	4,763	2.53	2,112	3.92	78	3.97	78	3.35
Helsinki Sch Econ	183	1.46	27	1.67				
Uni of Joensuu	1,320	2.91	996	3.46	56	8.88	486	3.47
Uni of Jyväskylä	2,680	3.33	1,634	4.12	158	6.17	439	3.55
Uni of Kuopio	4,124	5.39	884	5.13	314	7.72	318	3.58
Lappeenranta Uni Technol	507	0.81	116	1.76			22	1.36
Uni of Oulu	5,276	4.2	1,863	4.55	515	8.22	426	3.25
Uni of Tampere	3,245	5.14	360	7.87	244	10.12	40	5.98
Tampere Uni Technol	2,018	1.42	608	3.23	32	7.53	47	2.94
Uni of Turku	6,342	4.84	2,287	5.04	653	7.58	541	4.88
RESEARCH INST								
Agrifood Res Finland	579	3.43	286	4.69	40	10.08	231	3.49
Finnish Environm Inst	338	3.02	277	3.5			234	3.09
Finnish Inst Marine Res	146	2.66	129	2.95			94	2.64
Finnish Meteorol Inst	546	3.75	442	4.27			113	5.05
Forest Res Inst	756	2.83	679	2.97	39	3.33	599	2.99
Game and Fish Res Inst	316	2.5	287	2.63			272	2.64
Geol Survey Finland	206	2.6	174	2.99			39	2.95
Inst Occupat Health	1,071	3.77	162	4.46	39	7.9	69	2.04
Natl Publ Health Inst	2,765	7.6	656	9.16	469	10.89	169	5.13
Rad and Nucl Safety Author	167	3.19	113	2.91			71	2.89
STAKES	387	3.05						
Vet and Food Res Inst	174	3.07	65	3.43	34	4.76	21	2
VTT	2,009	2.31	805	4.29	200	6.87	97	3.29
ENTERPRISES								
Nokia Grp	566	0.85	70	1.97				
Orion Corp	272	5.04	43	4.05				
KCL Ltd	124	1.69	41	2.49			21	2.52
Metso Corp	111	0.41						
Fortum Corp	138	1.52	59	2.85				
OTHERS								
Canc Registry Finland	220	9.97						
Family Fed Finland	137	7.23	43	6.44	43	6.44		
Finnish Red Cross	205	5.57	32	9.72	32	9.72		
Hosp Dist Keski-Suomi	298	6.35	24	6.63				
Orton Hosp Invalid Fdn	186	3.16						
Rheumatism Fdn Hosp	215	3.16						
Social Insurance Inst	176	9.46						
UKK Inst	171	6.68						

[a] In comparing the impact factors of different organisations we need to bear in mind the differences in the relative weight of various disciplines in their publishing profiles (see also Figures 1 and 2 in Appendix 1).

[b] See descriptions of major fields of science, classification of disciplines used by Statistics Finland and BIO1/BIO2 classification in Table 1 in Appendix 1. See also Figures 1 and 2 in Appendix 1.

Source: Thomson Scientific, NCR 1995–2004.

Chemistry		Geosciences, Meteorology		Mathematics		Physics		**Engineering and technology**		**Medical sciences**	
publ	CI	publ	CI	publ	CI	publ	CI	publ	CI	publ	CI
398	3.34			21	1.38	186	4.19	333	2.02	299	4.89
1,116	5.21	305	6.11	195	1.64	1,243	9.04	398	3.23	8,315	6.34
522	3.82	35	1.51	107	1.55	1,311	4.18	1,179	2.3	342	4.9
								30	1.27		
262	3.51	28	3.46	26	0.92	159	2.08	87	1.8	64	2.61
382	4.13			140	1.99	583	4.28	110	1.95	464	3.69
144	3.17	52	6			43	3.79	83	2.75	3,019	5.8
49	2.67					46	1.09	198	1.31		
281	3.18	158	2.23	81	0.72	437	3.78	314	1.76	2,495	5.42
				31	0.65			44	0.66	2,500	5.52
146	3.53			36	0.89	292	2.87	528	1.28	142	3.03
412	3.29	43	3.37	98	1.4	489	4.25	179	2.36	3,375	5.53
										26	5.88
		38	7.55					27	1.85		
		32	3.22								
		263	4.33			98	4.55	28	3.71		
		38	2.34					20	1.65		
		128	2.97								
								58	2.14	738	4.33
		21	6.1					27	7.93	2,216	7.3
								42	1.29	41	6.44
										326	3.31
										53	3.87
195	4.32	23	4.65			278	3.01	508	1.93	94	2.39
				21	0.43	38	1.82	146	1.84		
										209	5.45
								63	1.75		
								66	0.44		
41	3.32							69	1.67		
										213	10.15
										109	7.28
										175	5.04
										281	6.48
										172	3.22
										209	3.11
										174	9.57
										162	6.93

Appendix 1. Material and methods

Description of the databases

The material used for this report was drawn from two bibliometric databases compiled and maintained by the private US company Thomson Scientific: the National Science Indicators (NSI) database for 1981–2005 and the National Citation Report (NCR) database for 1995–2004. All the journals indexed in these databases are peer-reviewed.

OECD major fields of science	NSI Standard fields	NSI Deluxe fields
OECD 1: NATURAL SCIENCES (Natural Sci)	Chemistry (excluding Chemical Engineering) Ecology / Environment Mathematics Microbiology Molecular Biology & Genetics Multidisciplinary[a] Physics Plant & Animal Sciences (excluding Veterinary Medicine / Animal Health)	Biochemistry & Biophysics Biology Computer Science & Engineering Earth Sciences Experimental Biology Instrumentation / Measurement Space Science
OECD 2: ENGINEERING AND TECHNOLOGY (Eng & Tech)	Engineering (excluding Instrumentation / Measurement) Materials Science	Biotechnology & Applied Microbiology Chemical Engineering Geological, Petroleum & Mining Engineering Information technology & Communication Systems

The journals indexed in the databases and the publications contained in these journals are assigned to fields-of-science categories that correspond to the classification in *Thomson Scientific Current Contents®*. Table 1 below illustrates how these categories are matched in this report with the OECD classification of six major fields of science.

Table 1. Correspondence between the OECD major fields of science and the science classifications used in the NSI and NCR databases. The content of the six OECD major fields of science, based on these databases, is the same; the combination of NSI standard and deluxe fields corresponds to NCR fields.

[a] Multidisciplinary (natural sciences) journals excluding articles from Science, Nature and Proceedings of the National Academy of Sciences of the USA (PNAS). Articles from these journals have been reassigned to specific categories.

[b] BIO1/BIO2 classification is used in Appendix Table 1 in this report.

[c] Publications in the forestry sciences are spread out across different natural science categories; forestry sciences are not assigned to their own category in the NSI and NCR databases.

Sources: Frascati Manual (2002); Thomson Scientific, NSI 1981–2005 and NCR 1995–2004; Statistics Finland (2005).

NCR fields	Statistics Finland disciplines
	Biology, Environmental Sciences
Animal & Plant Sciences	BIO2[b]
Animal Sciences	BIO2
Aquatic Sciences	BIO2
Biochemistry & Biophysics	BIO1
Biology	BIO1
Cell & Developmental Biology	BIO1
Environment / Ecology	BIO2
Entomology / Pest Control	BIO2
Experimental Biology	BIO2
Microbiology	BIO1
Molecular Biology & Genetics	BIO1
Plant Sciences	BIO2
Analytical, Inorganic & Nuclear Chemistry	Chemistry
Chemistry	
Chemistry & Analysis	
Inorganic & Nuclear Chemistry	
Organic Chemistry / Polymer Science	
Physical Chemistry / Chemical Physics	
Spectroscopy / Instrumentation / Analytical Sciences	
Computer Science & Engineering	Computer Science
Mathematics	Mathematics
Earth Sciences	Geosciences, Meteorology
Applied Physics / Condensed Matter / Materials Science	Physics
Instrumentation & Measurement	
Optics & Acoustics	
Physics	
Space Science	Space Sciences and Astronomy
Multidisciplinary[a]	
Aerospace Engineering	
AI, Robotics & Automatic Control	
Biotechnology & Applied Microbiology	
Chemical Engineering	
Civil Engineering	
Computer Engineering, Technology & Applications	
Electrical and Electronics Engineering	
Engineering Management / General	
Engineering Mathematics	
Environmental Engineering & Energy	
Geological, Petroleum & Mining Engineering	
Information Technology & Communications Systems	
Materials Science & Engineering	
Mechanical Engineering	
Metallurgy	
Nuclear Engineering	

OECD major fields of science	NSI Standard fields	NSI Deluxe fields
OECD 3: MEDICAL SCIENCES (Medical Sci)	Clinical Medicine Immunology Neurosciences & Behavior Pharmacology	Endocrinology, Nutrition & Metabolism Physiology Psychiatry Public Health & Health Care Science Rehabilitation
OECD 4: AGRICULTURAL SCIENCES[c] (Agricultural Sci)	Agricultural Sciences	Veterinary Medicine / Animal Health
OECD 5: SOCIAL SCIENCES (Social Sci)	Economics & Business Education Law Social Sciences, general (excluding Public Health & Health Care Science; Rehabilitation)	Psychology
OECD 6: HUMANITIES (Humanities)	Humanities are included only in the deluxe version.	Archaeology Art & Architecture Classical Studies General History Language & Linguistics Literature Performing Arts Philosophy Religion & Theology

NCR fields	Statistics Finland disciplines
Anesthesia & Intensive Care Cardiovascular & Hematology Research Cardiovascular & Respiratory Systems Clinical Immunology & Infectious Disease Clinical Medicine Clinical Psychology & Psychiatry Dentistry / Oral Surgery & Medicine Dermatology Endocrinology, Metabolism & Nutrition Endocrinology, Nutrition & Metabolism Environmental Medicine & Public Health Gastroenterology & Hepatology General & Internal Medicine Health Care Sciences & Services Hematology Immunology Medical Research, Diagnosis & Treatment Medical Research, General Topics Medical Research, Organs & Systems Neurology Neurosciences & Behavior Oncogenesis & Cancer Research Oncology Ophthalmology Orthopedics, Rehabilitation & Sports Medicine Otolaryngology Pediatrics Pharmacology & Toxicology Pharmacology/Toxicology Physiology Psychiatry Public Health & Health Care Science Radiology, Nuclear Medicine & Imaging Rehabilitation Reproductive Medicine Research / Laboratory Medicine & Medical Technology Rheumatology Surgery Urology & Nephrology	
Agricultural Chemistry Agriculture / Agronomy Food Science / Nutrition Veterinary Medicine / Animal Health	
Anthropology Communication Economics Education Environmental Studies, Geography & Development Law Library & Information Sciences Management Political Science & Public Administration Psychology Social Work & Social Policy Sociology & Anthropology Sociology & Social Sciences	
Archaeology Art & Architecture Classical Studies General History Language & Linguistics Literature Performing Arts Philosophy Religion & Theology	

Description of the National Science Indicators 1981–2005 (NSI) database

The National Science Indicators database provides publication and citation data for individual fields of science as well as aggregated data for OECD countries and EU 25 countries in 1981–2005. According to the database the OECD countries accounted for 86 per cent of all world publications in 1985–2005.

OECD countries in this report refers to the current 30 member states. All of them are included in the country comparisons even for the period prior to their membership. Accordingly, the aggregated data for EU 25 countries include the data for the ten new EU members even for the period prior to their membership.

The NSI database comprises some 10,000 scientific journals from different fields of science. There are four main categories of publication: articles, notes, reviews and proceedings papers. The *standard version* of the database includes 24 discipline subcategories as well as the category multidisciplinary. The *deluxe version*, which also includes publication data for the humanities, has 106 discipline subcategories.

A publication is ascribed to a particular country when the affiliation of at least one of its authors is within that country. It follows that when publication and citation data from different countries are combined, there is some inevitable overlap. A joint publication by authors from different countries is entered in the database as one publication under each of the countries concerned. Some of this overlap has been eliminated from the total number of publications recorded for OECD countries and EU 25 countries, so the total publication numbers are lower than the figures calculated by summing up the publication numbers individually for these countries. For purposes of comparing publication and citation data for individual countries to the corresponding OECD figures in this report, we have relied on the database OECD figures unless otherwise specified in connection with the Figure or Table concerned.

Analyses by major fields of science also involve a degree of overlap where publication data are concerned. Since some of the journals indexed in the database are classified under more than one discipline, the combination of publication and citation data from individual fields means that some publications are counted more than once. In the calculation of publishing profiles the number of publications in major fields of science are compared to the sum total number of publications calculated from different major fields of science rather than to the total number of a country obtained from the database, which is smaller than the summed number compiled from different major fields of science. The sum of the publication shares in the former case is 100 per cent.

Description of the National Citation Report 1995–2004 (NCR) database

The National Citation Report (NCR) database comprises publication and citation data for Finnish publications in different fields of science in 1995–2004. Some 6,300 scientific journals are indexed in the database.

The Finnish NCR database for 1995–2004 includes a total of 92,000 international scientific publications in which at least one author has a Finnish affiliation (i.e. address in Finland). Some 85 per cent of these publications are

articles published in international scientific series, the rest are mainly international reviews and meeting abstracts.

By OECD major fields of science, more than 80 per cent of the publications fall under the headings of the medical sciences and the natural sciences. The database comprises only a small part of Finnish publications in the social sciences and humanities. The database has some 10,000 publications under the heading of *No category*: these are excluded from the analysis using the OECD classification of major fields of science.

Publications by Finnish researchers and citations to those publications in different years can be retrieved from the database by individual researcher, organisation, country and discipline. In addition, data on collaboration are available by researcher, organisation and country.

The material was standardised for increased reliability. This means that the names and address information (city, country) for the authors' Finnish organisations were corrected. Correcting the numerous typing errors was a laborious and time-consuming task. The name of an organisation may have appeared in various different forms, and even the authors of the publications themselves record their organisations in different ways. Furthermore, some authors indicate the name of their graduate school, research programme etc. rather than the actual physical place of work. Changes in the names of organisations during 1995–2004 were also standardised. Tracing business mergers and changes in company names was also a major undertaking.

Analysis of citations

By comparing the number of citations to publications over a certain period of time to the total number of publications we get an indicator that is known as the impact factor, which must be used and interpreted with caution. Figures 1 and 2 (p. 50) illustrate the breakdown of the total NCR database material within the major fields of natural sciences and engineering and technology according to the science classification used by Statistics Finland. Disciplines within the natural sciences or engineering and technology have different impact factor profiles, because publication and citation practices vary between difference fields of science.

Different fields of research can differ quite widely in terms of the amount of time required by data collection, the speed at which they respond to new literature, the life-span of publications and publishing and citation practices. In medicine and molecular biology, for instance, research results may become outdated within a matter of months, whereas in the social sciences many studies may still be cited decades after their publication. These differences will also be reflected in the impact factors in different disciplines. It follows that different fields of science cannot be rank-ordered on the basis of their impact factors.

A study of publication and citation numbers is poorly suited to comparing the outcomes or impacts of different *organisations*. The results are often distorted because publication and citation numbers are too low. In an examination of impact factors it is necessary to take account of the publishing profiles of individual disciplines.

Appendix Table 1 (pp. 42–43) in this report shows the impact factors for the

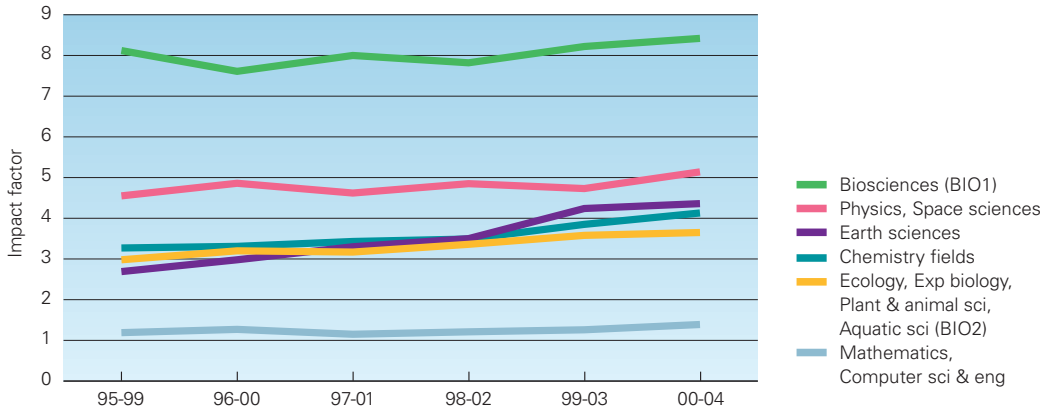

Figure 1. Development of citation impact for natural sciences publications in NCR database in 1995–2004 according to the science classification used by Statistics Finland.

Source: Thomson Scientific, NCR 1995–2004.

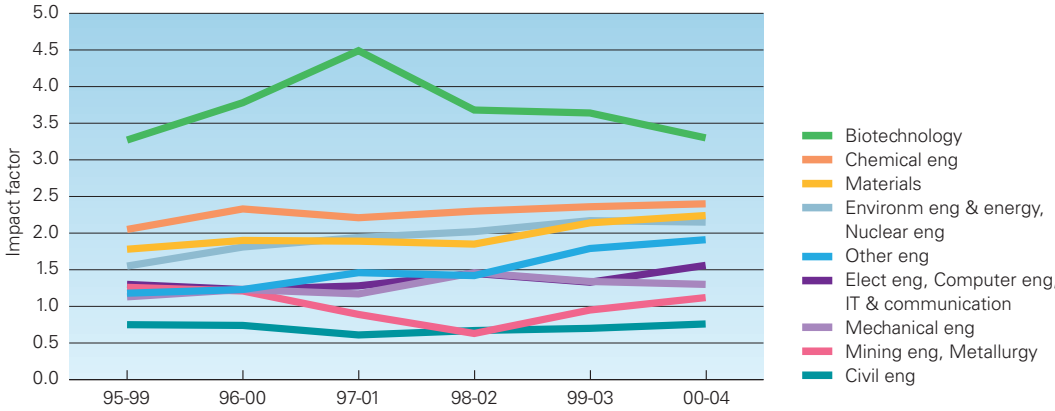

Figure 2. Development of citation impact for engineering and technology publications in NCR database in 1995–2004 according to the science classification used by Statistics Finland.

Source: Thomson Scientific, NCR 1995–2004.

Finnish organisations with the largest number of publications in 2000–2004. The figures differ from one another mainly because of differences in these organisations' publishing profiles in different disciplines. The figures are presented for natural sciences, engineering and technology, and medical sciences. Breakdowns are also provided for the natural sciences by the classification of disciplines used by Statistics Finland. At this level some of the publication numbers are too small for a meaningful analysis.

Appendix 2. Development of publishing in China, India and Russia

After the major OECD publishers, the next highest publication numbers in the world are recorded for China, India and Russia. In 1985–2005, the three countries together accounted for eight per cent of all world publications. In 2005, China alone published almost 60,000 publications and Russia and India some 24,000 publications.

Publishing in China has increased significantly (Figure 1). From 1995 to 2005, the number of publications in China increased 4.4-fold and in India 1.6-fold. The number of publications in Russia in 2005 was slightly lower than in 1995.

China, India and Russia still have some way to go to reach the average number of citations to publications from the OECD countries (relative citation impact, Figure 2). In 2001–2005, Chinese publications received 47 per cent less citations than OECD publications on average, Indian publications 55 per cent less and Russian publications 57 per cent less. The Chinese and Indian relative citation impacts in particular have shown rapid growth since the mid-1990s.

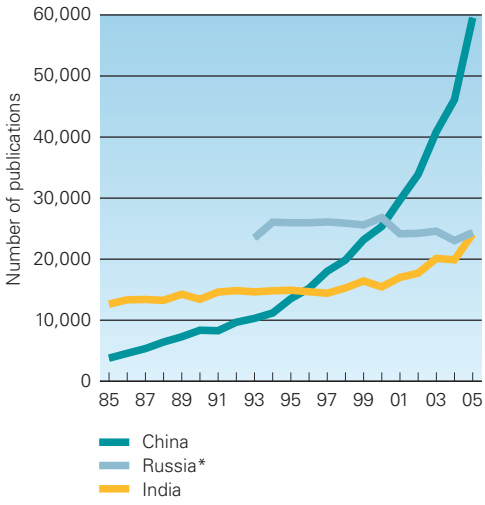

Figure 1. Development of publication numbers in China, Russia* and India from 1985 to 2005. Countries listed in order of the number of publications in 2005.

* Data for Russia begin in 1993.

Source: Thomson Scientific, NSI 1981–2005.

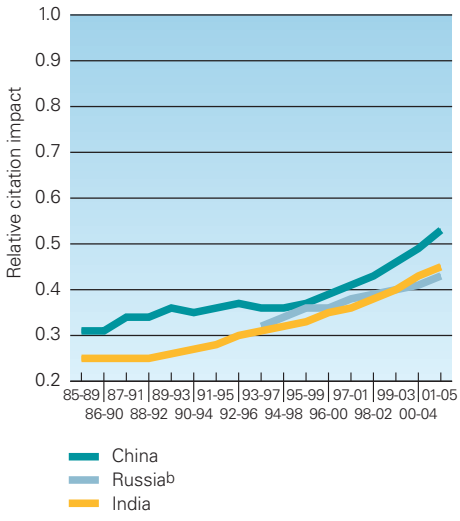

Figure 2. Development of relative citation impacts[a] in China, India and Russia in 1985–2005. Countries listed in order of the citation impacts for the most recent period.

[a] Relative citation impact = impact factor (number of citations / number of publications) e.g. for China / impact factor for OECD.

[b] Data for Russia begin in 1993.

Source: Thomson Scientific, NSI 1981–2005.

This report provides an international comparison of research outputs and the scientific impacts, visibility and quality of research in Finland with other EU and OECD countries from 1985 to 2005. The structure and level of publishing in Finland are examined in closer detail by sector, organisation and major field of science from the mid-1990s onwards.

Bibliometric methods have become well established over the past ten years as tools for assessing the scientific impact of research. They are based on the use of publication and citation data. The Academy of Finland has used these methods since the late 1990s in its assessments of the state and quality of Finnish scientific research.

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