SCIENTIFIC RESEARCH in Finland

A Review of Its Quality and Impact in the Early 2000s

SUMMARY

ACADEMY OF FINLAND

Scientific Research in Finland: Summary of the General Section of the 2003 Review

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Cover illustration: Hanna Varis (1988): “The World”

Layout: PixPoint ky

ISBN 951-715-476-3 (print)
951-715-477-1 (pdf)

Review of the state and quality of scientific research in Finland

The main focus of the Academy of Finland's review of the state and quality of scientific research in Finland is upon developments in the early years of the twenty-first century. The review consists of a general section on questions of science policy; special themes that complement the general section; and reports compiled by the Academy's four Research Councils.

The main themes that cut across the general section and the whole review are the scientific and social impacts of science and research as well as the human resources of research. The review also assesses the impacts of research funding and science policy measures on the development of science and research, and on society more generally. The scientific outcomes and impacts of research in Finland are compared internationally using different indicators.

In the special theme reports, Rector Jorma Sipilä discusses the impacts of social research; Science Adviser Timo Kolu assesses the impacts of centres of excellence in research; and Science Adviser Hannele Kurki explores the role of gender in the Finnish research system.

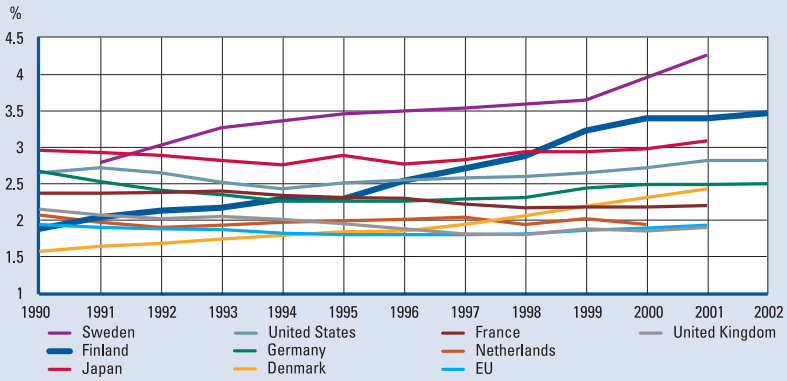
The Academy's Research Councils provide their assessments of progress made in the biosciences and environmental research, in cultural and social research, in the natural sciences and engineering and in health research, respectively. They also submit their recommendations for the future development of research in these fields.

Finland continues to invest in R&D

Since the mid-1990s, R&D expenditure in Finland has increased at an annual rate of 13.5 per cent. Average annual real growth in all the EU countries has been 3.4 per cent. In 2002, Finland's R&D intensity or R&D expenditure as a proportion of GDP is estimated at 3.5 per cent (Figure 1). Since 1999, no other OECD country except Sweden has spent more on R&D as a proportion of GDP.

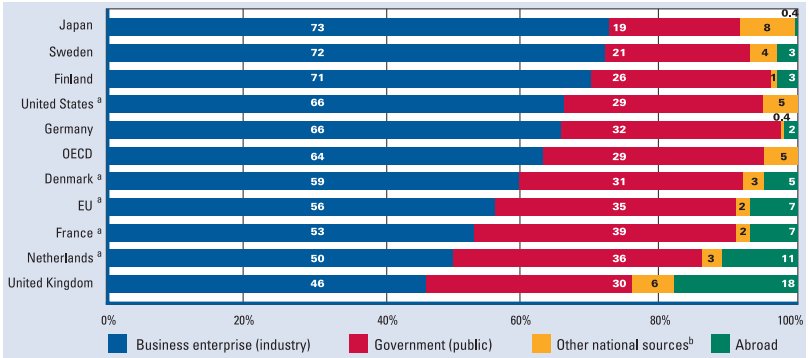
In 2001 business sector funding for R&D in Finland was the fourth highest among OECD countries, following Japan, Korea and Sweden (Figure 2). The figure in Finland was markedly higher than in the EU countries on average (56%).

■ Figure 1. R&D expenditure as a proportion of GDP (%) in selected OECD countries and the EU in 1990–2002.



Sources: Main Science and Technology Indicators 2002/2 & 2003/1, FoU-statistikk og indikatorer… 2003, Statistics Finland 2003b.

■ Figure 2. Funding from different sources as a percentage share of R&D expenditure in selected OECD countries and in the EU in 2001 (or latest year for which figures available). The countries are rank-ordered according to the share of business funding.



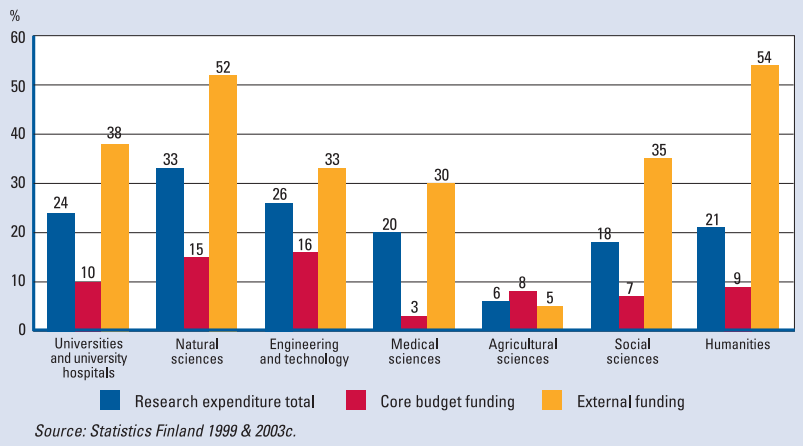
[a] Data on the US from 2002, Denmark from 1999 and the EU, France and the Netherlands from 2000.
[b] Other national sources refer to funding from the higher education sector and private non-profit institutions.

Source: Main Science and Technology Indicators 2003/1.

In Finland the business sector accounted for around 70 per cent and the public sector for less than 30 per cent of research funding. Crucially important for innovation, basic research is largely funded from the public purse. It is essential for reasons of maintaining a balanced funding structure that adequate public funding remains available within the research system.

In 2001 over half of the total expenditure of 790.6 million euros on university research (including universities and university hospitals) was funded from external sources, i.e. from other than core budget funds. By major fields of science, the share of external funding was greatest in the medical sciences at 66 per cent. In relative terms external funding grew most in the humanities and natural sciences from 1997 to 2001 (Figure 3).

■ Figure 3. Real change (%) in total research expenditure, core budget funding and external funding for research at universities and university hospitals from 1997 to 2001 by major field of science.



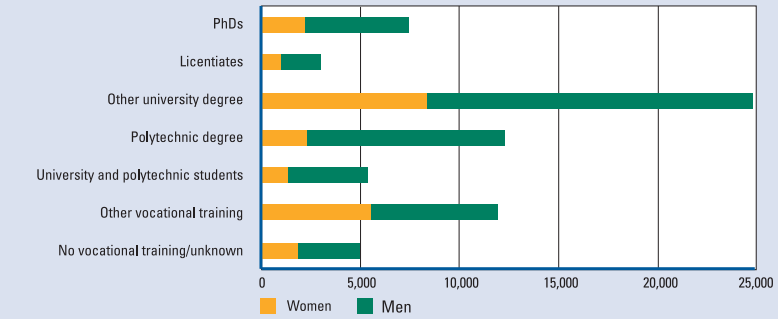
Source: Statistics Finland 1999 & 2003c.

R&D at polytechnics is funded chiefly from outside sources. At government research institutes, too, the role of external funding has increased from the late 1990s to the early 2000s. However, the structure of R&D funding varies widely from one research institute to the next.

Competent research personnel and high quality researcher training

Finland and Sweden rank among the most active EU Member States in terms of their investment in developing human resources and funding for research. In Finland, more than 70,000 people or some two per cent of the active workforce are engaged in R&D (Figure 4), which is a higher proportion than in any other OECD country. Personnel numbers have increased by one-quarter from 1997 to 2001. In 2000 the number of foreign nationals as a proportion of R&D personnel was the fourth lowest in the EU countries at 1.3 per cent. In 2001 PhDs accounted for 23 per cent of the workforce in the higher education sector, for 13 per cent in the public sector and for less than three per cent in the business enterprise sector.

Figure 4. R&D personnel by education and gender in 2001.

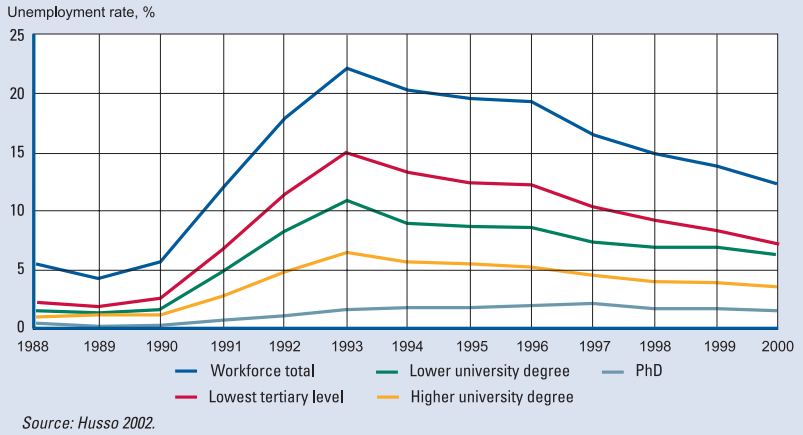


Source: Statistics Finland 2003.

Employment opportunities have been better for PhDs and people with a higher university degree than for other educational groups throughout the 1990s and early 2000s (Figure 5). In 2000, the unemployment rate for PhDs was 1.5 per cent and for people with a higher university degree 3.6 per cent, while the average figure for the whole workforce was around 10 per cent.

In an EU comparison Finland and Sweden have the highest number of new postdoctoral graduates per 1,000 population aged 25–34; the figure for Finland in 2000 was 1.0. According to OECD

Figure 5. Unemployment rate by level of education in 1988–2000.



Source: Husso 2002.

comparisons Finland's strengths include a high level of education, an efficient educational system and a high level of interest among its citizens in education. It is important that the Finnish education system as well as researcher training and graduate schools are continually assessed and developed. A new strategy for research careers is needed that takes into account both the needs of individual researchers and development needs in different fields of research. Key areas of development include the creation of a clear set of targets for the research career, the removal of remaining obstacles to a career in research, and maintaining and strengthening the competitiveness of the researcher's profession.

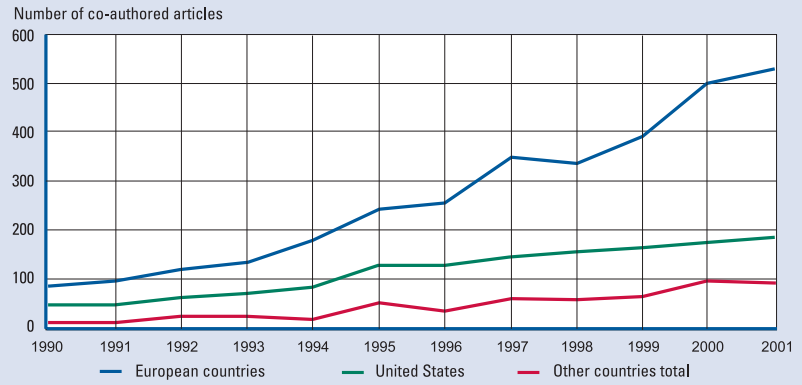
The quality standards of research should be further raised by intensifying researcher training and by recruiting competent and talented research personnel to work for universities, research institutes and business companies. In particular, the number of PhD researchers should be increased in the private business sector. Competition for gifted researchers and for projects and resources is tough as it is, but looks set to intensify even further. Highly qualified people are also needed in other than research jobs.

Research environment in constant flux

Internationalisation is continuing to present new challenges not only for organisations responsible for science policy, but also for R&D funding bodies, research organisations and individual researchers. Active and measured global cooperation and initiatives within the EU are particularly important in the effort to strengthen research resources and facilities, to raise the quality of research results and to increase the impacts of research. Nordic cooperation is geared to strengthening the competitiveness and to increasing the exposure and visibility of our region on the European periphery.

There has been a marked increase in the international cooperation of Finnish researchers in the 1990s and early 2000s. In the biosciences and medicine, for example, the number of scientific papers co-authored by Finnish and European researchers increased by 50 per cent, that of papers co-authored by Finnish and US researchers by 25 per cent in 1997–2001 (Figure 6).

Figure 6. Articles co-authored by Finnish and foreign researchers in 83 biosciences and medical journals in 1990–2001.



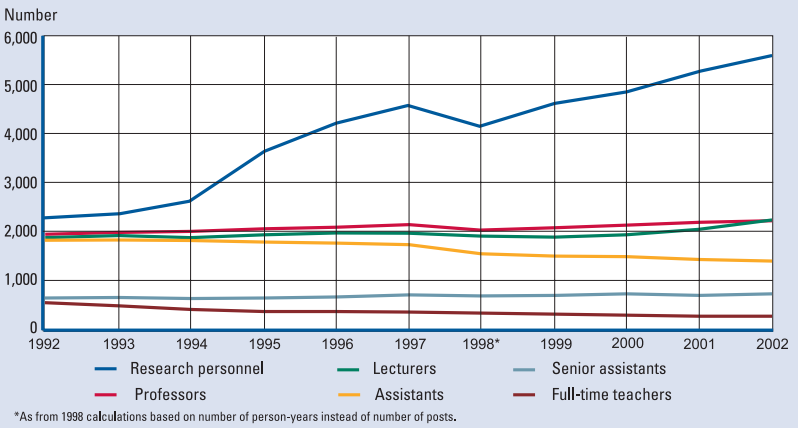
Source: Institute for Scientific Information, Web of Science.

Since the mid-1990s programme funding has become an important tool of science policy that is used for steering research in a certain direction and to a certain end. In 1998–2002, the Academy of

Finland allocated some 150 million euros to support research programmes, with a further 74 million euros going to centres of excellence in research. The National Technology Agency Tekes granted 880 million euros to support technology programmes. Research and technology programmes, cluster programmes and centre of excellence programmes are effective ways of networking research by pooling the resources of different funding bodies both nationally and internationally. Significant results and synergy benefits have been achieved by means of networking and programme coordination.

Universities in Finland have a major task on their hands to strike the right balance between their responsibilities in research and education on the one hand, and the new requirements of societal service functions, on the other. In contrast to the number of teaching staff, there has been a sharp increase in the number of research personnel hired on a fixed term basis with project funding (Figure 7). Some of the most significant changes of late have included national and internal reorganisation and reprofiling as well as the intensification of regional, national and international

■ Figure 7. University teaching staff (professors, senior assistants, assistants, lecturers and full-time teachers) and research personnel in 1992–2002.



*As from 1998 calculations based on number of person-years instead of number of posts.

Source: KOTA database, Ministry of Education.

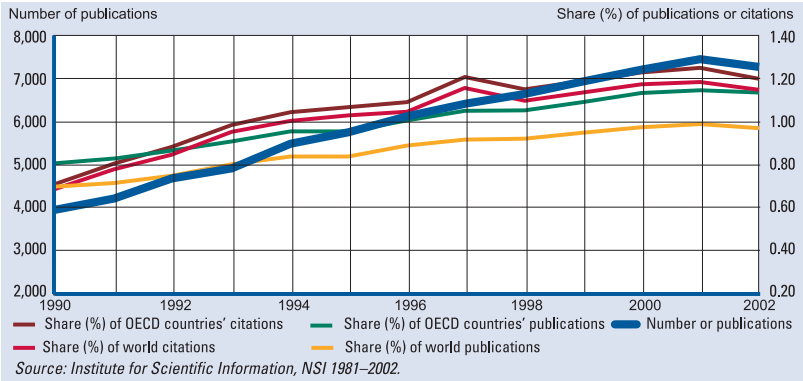
cooperation. Universities and government research institutes have taken steps to develop their services and set up units with the purpose of promoting the commercialisation of research ideas and securing researchers' legal and economic interests.

In developing universities' funding structure, attention must be paid to the ratio between core budget funding and external funding, as well as to the continuity of funding from outside sources. In so far as these factors are in proper balance, competitive funding will ensure a sustained or improved quality of work.

Research results in an international comparison

Among the key objectives of Finnish science policy are to improve the quality and international exposure of research and to strengthen its scientific impact. These objectives have been attained reasonably well. During the 1990s and early 2000s, international publishing by Finnish researchers has rapidly increased (Figure 8). Finnish-authored publications are cited more and more often. For example, in the late 1980s and early 1990s Finland's relative citation impact was below the OECD average, but from 1998 through to 2002, Finnish publications received seven per cent more citations than OECD publications on average (Table 1).

■ Figure 8. Number of Finnish publications and number of Finnish publications and citations as a proportion of OECD and world publications and citations in 1990–2002.



Source: Institute for Scientific Information, NSI 1981–2002.

■ Table 1. Development of OECD countries' impact factor and relative citation impact in 1988–1992, 1993–1997 and 1998–2002. The countries are rank-ordered according to the values for the most recent period.

Impact factor[a] / OECD countries	1988–1992	1993–1997	1998–2002	Relative citation impact[b] / OECD countries	1988–1992	1993–1997	1998–2002
Switzerland	5.05	5.91	6.67	Switzerland	1.46	1.47	1.46
United States	4.34	5.19	5.93	United States	1.26	1.29	1.30
Netherlands	3.79	4.61	5.64	Netherlands	1.10	1.14	1.23
Denmark	3.58	4.62	5.54	Denmark	1.04	1.15	1.21
Sweden	3.89	4.53	5.14	Sweden	1.13	1.12	1.12
United Kingdom	3.58	4.31	5.09	United Kingdom	1.04	1.07	1.11
Iceland	3.03	4.64	4.92	Iceland	0.88	1.15	1.08
Finland	3.04	4.15	4.89	Finland	0.88	1.03	1.07
Germany	3.06	3.98	4.88	Germany	0.89	0.99	1.07
Belgium	3.20	4.14	4.85	Belgium	0.93	1.03	1.06
Canada	3.03	3.99	4.84	Canada	0.88	0.99	1.06
OECD	3.45	4.03	4.57	OECD	1.00	1.00	1.00
Italy	2.75	3.61	4.56	Italy	0.80	0.90	1.00
France	3.11	3.84	4.55	France	0.90	0.95	1.00
Austria	2.74	3.60	4.50	Austria	0.79	0.89	0.98
European Union	3.07	3.77	4.45	European Union	0.89	0.94	0.97
Norway	2.78	3.39	4.38	Norway	0.81	0.84	0.96
Australia	2.92	3.37	4.24	Australia	0.85	0.84	0.93
Ireland	2.19	2.82	4.06	Ireland	0.63	0.70	0.89
Japan	2.90	3.21	3.84	Japan	0.84	0.80	0.84
Spain	1.94	2.88	3.76	Spain	0.56	0.71	0.82
New Zealand	2.49	3.00	3.57	New Zealand	0.72	0.74	0.78
Luxembourg	0.79	2.24	3.44	Luxembourg	0.23	0.56	0.75
Hungary	1.73	2.60	3.18	Hungary	0.50	0.65	0.70
Portugal	1.81	2.42	3.17	Portugal	0.52	0.60	0.69
Greece	1.67	2.12	2.76	Greece	0.48	0.53	0.60
Czech Republic	–	1.52	2.63	Czech Republic	–	0.38	0.58
Poland	1.56	2.05	2.53	Poland	0.45	0.51	0.55
Mexico	1.62	1.95	2.46	Mexico	0.47	0.48	0.54
South Korea	1.26	1.63	2.35	South Korea	0.37	0.40	0.51
Slovakia	–	1.13	2.21	Slovakia	–	0.28	0.48
Turkey	0.98	1.21	1.56	Turkey	0.28	0.30	0.34

[a] Impact factor = number of citations by Finnish publications, for example, divided by the number of Finnish publications.
[b] Relative citation impact = each country's impact factor divided by impact factor for OECD countries. For example, the relative citation impact for Finland in the period 1998–2002 is calculated as follows: 4.89 / 4.57 = 1.07.

Source: Institute for Scientific Information, NSI 1981–2002.

Finland compares favourably in an assessment of the citation impacts of 30 OECD countries in different fields of science (Table 2). In the agricultural sciences, Finland ranked third in 1998–2002; in the humanities, we ranked fourth. In the medical sciences as well

Table 2. OECD countries' relative citation impact* by major field of science in 1998–2002.

	Natural sciences		Engineering and technology		Medical sciences		Agricultural sciences		Social sciences		Humanities	
1	Switzerland	1.40	Switzerland	1.49	United States	1.29	Luxembourg	3.73	United States	1.15	Greece	2.16
2	United States	1.37	Denmark	1.28	Switzerland	1.26	Netherlands	1.56	Netherlands	1.04	Netherlands	1.56
3	Netherlands	1.19	United States	1.23	Iceland	1.23	Finland (3.)	1.52	Belgium	1.00	New Zealand	1.35
4	United Kingdom	1.18	Netherlands	1.12	Canada	1.21	Denmark	1.47	Canada	0.99	Finland (4.)	1.33
5	Denmark	1.14	Belgium	1.08	Netherlands	1.21	Switzerland	1.34	Italy	0.99	Portugal	1.26
6	Germany	1.06	Germany	1.08	Finland (6.)	1.17	Belgium	1.31	Finland (6.)	0.97	United Kingdom	1.23
7	Sweden	1.04	Sweden	1.07	Denmark	1.14	United Kingdom	1.31	United Kingdom	0.96	United States	1.19
8	Canada	1.02	France	1.07	Belgium	1.13	Sweden	1.23	Switzerland	0.93	Australia	1.17
9	Austria	0.95	United Kingdom	0.98	United Kingdom	1.12	Ireland	1.15	Sweden	0.92	Japan	1.16
10	Belgium	0.95	Austria	0.98	Sweden	1.11	United States	1.13	France	0.85	Turkey	1.14
11	France	0.95	Ireland	0.96	Norway	1.06	France	1.10	New Zealand	0.82	Denmark	1.00
12	Finland (12.)	0.93	Italy	0.95	Italy	1.02	Norway	1.05	Norway	0.81	Hungary	0.94
13	Australia	0.93	Canada	0.94	Australia	0.99	Canada	1.04	Australia	0.80	Canada	0.92
14	Ireland	0.92	Norway	0.94	New Zealand	0.98	Australia	1.00	Hungary	0.80	Belgium	0.82
15	Iceland	0.90	Australia	0.93	France	0.97	Spain	0.97	Germany	0.80	Germany	0.77
16	Italy	0.89	Finland (16.)	0.93	Germany	0.96	Italy	0.96	Denmark	0.77	Sweden	0.75
17	Norway	0.85	Spain	0.91	Ireland	0.94	New Zealand	0.96	Austria	0.73	Norway	0.74
18	Japan	0.80	Hungary	0.91	Austria	0.91	Germany	0.92	Iceland	0.73	Iceland	0.60
19	Spain	0.79	Japan	0.87	Portugal	0.88	Portugal	0.87	Luxembourg	0.67	Ireland	0.59
20	New Zealand	0.74	Czech Republic	0.87	Spain	0.82	Austria	0.83	South Korea	0.65	Italy	0.57
21	Luxembourg	0.69	Portugal	0.82	Luxembourg	0.82	Japan	0.81	Ireland	0.63	Poland	0.57
22	Portugal	0.63	New Zealand	0.73	Hungary	0.78	South Korea	0.78	Portugal	0.63	Switzerland	0.55
23	Greece	0.62	Mexico	0.71	Japan	0.75	Slovakia	0.76	Spain	0.61	Mexico	0.49
24	Hungary	0.61	South Korea	0.71	Czech Republic	0.72	Greece	0.76	Japan	0.58	South Korea	0.47
25	Czech Republic	0.54	Slovakia	0.70	Slovakia	0.67	Iceland	0.75	Poland	0.55	Slovakia	0.44
26	Mexico	0.51	Greece	0.68	Poland	0.65	Poland	0.69	Mexico	0.51	Spain	0.41
27	South Korea	0.50	Iceland	0.64	Mexico	0.58	Mexico	0.67	Turkey	0.48	Austria	0.38
28	Poland	0.50	Poland	0.62	Greece	0.58	Turkey	0.52	Greece	0.45	France	0.36
29	Slovakia	0.46	Luxembourg	0.59	South Korea	0.52	Hungary	0.50	Czech Republic	0.28	Czech Republic	0.31
30	Turkey	0.37	Turkey	0.58	Turkey	0.28	Czech Republic	0.39	Slovakia	0.19	Luxembourg	0.00
	European Union	0.96	European Union	0.99	European Union	0.94	European Union	1.07	European Union	0.88	European Union	0.85

* The relative citation impact has been calculated by dividing each country's impact factor for the major field of science by the corresponding impact factor for the OECD, while the relative citation impact for the OECD is one. In agricultural sciences, for example, the relative citation impact for Finland is 1.52, which means that agricultural publications produced in Finland have accrued 52 per cent more citations during the period 1998–2002 than agricultural publications in all OECD countries on average.

Source: Institute for Scientific Information, NSI 1981–2002.

as in the social sciences, Finland came sixth. Our ranking in the natural sciences was twelfth and in engineering and technology sixteenth.

Research has diverse social impacts that vary across different fields

Changes in the relationship between science and society have brought growing demands for the assessment of the impacts of research funded from the public purse. Globalisation, increasing competition and new technological challenges are among the factors that are calling for greater attention to be paid to the social impacts of scientific research. Ever greater attention has been paid to the impacts and effectiveness of public funding, and the principles of management by results have been put into place.

Basic research has diverse and interactive social impacts that are often of an indirect and long-term nature. The diffusion of the social impacts of research is mediated through various kinds of application and impact mechanisms. The cooperation, mutual dependence and joint learning of the different actors involved is paramount. Social impacts, impact mechanisms and outcomes cannot be uniformly assessed in different fields of research. All fields of research usually have both economic and other social impacts. Social impacts are extremely difficult to assess and measure.

An example of the economic and technological impacts of research is provided by the various applications in medicine and biotechnology as well as the impacts of electronics and IT research on the development of the Finnish economy. The cultural and social impacts of research are seen, for example, in changes in values, ways of thinking, and social practices and structures. It is legitimate to talk about a social innovation when new ways of thinking or new approaches, once established, promote welfare and well-being in society.

The Finnish research and innovation environment is in many ways of a high quality and competitive. The balanced development of

different components of the research and innovation system requires a closer understanding of the various impacts of research. Positive, intended social impacts can be achieved when all the necessary facilities and resources are in place. With the operating environment of research in a constant state of flux, making sure they are in place is a challenging task indeed. Most importantly, it is necessary to maintain a high quality of research, which among other things requires a system of research funding based on open competition and efficient mechanisms of researcher training. It is also important for research to take risks; otherwise it will lose its capacity for regeneration.

Background of the review

The Academy of Finland carries out a review of the state and quality of scientific research in Finland once during the three-year term of its Research Councils. The assignment is based on Government decisions concerning the development of education and research as well as agreements on target outcomes signed between the Ministry of Education and the Academy of Finland. The previous reviews were published in 1997 and 2000.

The primary aim of the review is to serve the needs of national and international bodies and organisations responsible for science and technology policy as well as research funding. It also provides useful information for researchers and research organisations.

Work to compile the review has been carried out under the supervision of a steering group appointed by the Board of the Academy of Finland. The group was chaired by Anneli Pauli, Vice President, Research (Academy of Finland). Its other members were the chairs of the Academy Research Councils: Professor Riitta Keiski (Research Council for Natural Sciences and Engineering), Professor Arto Mustajoki (Research Council for Culture and Society), Professor Terttu Vartiainen (Research Council for Biosciences and Environment) and Professor Eero Vuorio (Research Council for Health); and Markku Karlsson, Senior Vice President, Technology (Board of the Academy of Finland) and Director Sakari Karjalainen (Ministry of Education). Programme Manager Tarmo

Lemola and Professor Reijo Miettinen have served as permanent expert members to the steering group.

Science Adviser Timo Oksanen, Science Adviser Annamaija Lehvo and Project Officer Anu Nuutinen from the Academy of Finland have compiled and written the general section of the report and edited the review.

Source

Oksanen, Timo, Annamaija Lehvo & Anu Nuutinen (2003; eds.). Scientific Research in Finland. A Review of Its Quality and Impact in the Early 2000s. *Publications of the Academy of Finland* 10/03.

Further information

The Academy of Finland is an expert organisation in research funding and science policy. The Academy's object is to promote high-level scientific research through
– long-term quality-based research funding,
– science and science policy expertise and
– efforts to strengthen the position of science and scientific research.

The Review is available in PDF format on the Academy's website. For a hard copy, please contact Academy of Finland Communications at viestinta@aka.fi.

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