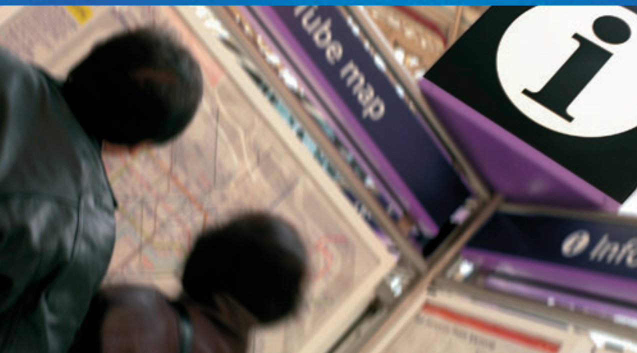
Publications of the Academy of Finland 7/09

Internationalisation of Finnish scientific research



Paavo-Petri Ahonen,
Mari Hjelt,
Erkki Kaukonen,
Pia Vuolanto (eds.)

Academy of Finland
Research funding and expertise

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Internationalisation of Finnish scientific research

Edited by
Paavo-Petri Ahonen
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Pia Vuolanto

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Description

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Title	Internationalisation of Finnish scientific research	
Abstract	The internationalisation of scientific research has been one of the key challenges for Finnish science policy for decades now. However, little empirical data has been available so far, and the development of the indicators needed for monitoring internationalisation has also been insufficient. The report studies the internationalisation of science and changes in it, as well as future prospects. It presents the development of internationalisation by field of science on the basis of the KOTA database. It includes a questionnaire survey on the practices of the internationalisation of research at universities and the problems involved. Analysis of the survey results covers trends in the forms of international activity, the partner countries of university units and motives for international cooperation as part of research work. The report includes a proposal for the development of indicators for the monitoring of internationalisation.	
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Julkaisussa tarkastellaan tieteen kansainvälistymisen ja sen muotojen muuttumista ja tulevaisuutta. Siinä esitetään KOTA-tietokantaan perustuen kansainvälistymisen kehitystä päätieteenaloittain. Kyselytutkimus yliopistotutkimuksen kansainvälisyyden käytännöistä ja ongelmista käsittelee mm. kansainvälisen toiminnan muotojen kehitystä, yliopistoyksiköiden yhteistyömaita ja kansainvälisen yhteistyön motivaatioita osana tutkimustyön käytäntöä.

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Foreword

Internationalisation has been one of the key objectives of Finnish science and technology policy for decades now. This is naturally the case in a small country that is dependent to some extent on the knowledge generated elsewhere in the world.

In recent years, conflicting views have been expressed on the internationalisation of Finnish science and research. It has been stated, on the one hand, that internationalisation progresses in line with the objectives set while, on the other hand, it has been claimed that the process of internationalisation has slowed down, particularly in the 2000s.

There has been very little empirical data available on the internationalisation of Finnish scientific research, and this has presented certain policy problems. This report represents an effort to provide such data. At the same time, it also starts off the work to develop reliable indicators for the monitoring of internationalisation.

This report is linked with preparations for a report on the state and quality of Finnish scientific research. Internationalisation is one of the priority themes in the latter report, which will be published in autumn 2009.

I wish to thank everyone who contributed to this report for their excellent work.

Paavo Löppönen

Director, Development and Evaluation

Scientific research in Finland: Recent trends of internationalisation

Paavo-Petri Ahonen
Johan Lunabba
Mari Hjelt
Mikko Syrjänen

Gaia Consulting Ltd

Executive summary

This research was commissioned by the Academy of Finland to support its ongoing review of the state of scientific research in Finland. One of the major focuses of that, the SIGHT2009 review, is internationalisation. The present research on recent trends of internationalisation in Finnish science and research and on the indicators of internationalisation was conducted by Gaia Consulting Ltd.

The aim was to address the following questions:

- How has the internationalisation of Finnish research advanced in 1990–2007 in the light of the statistics and research sources available?
- How have processes of internationalisation changed during this period?
- How well do the data and indicators available describe internationalisation?
- Could it be possible to develop more reliable indicators to assess and monitor internationalisation? What would these indicators be?

This final report summarises the main results of the research. Chapter 2 describes its implementation. Chapter 3 provides an overview of the phenomenon of internationalisation in scientific research and how this is measured. Chapter 4 describes the relevant statistical sources that are currently available and discusses recent trends of internationalisation. Chapters 5 and 6 consider the future outlook and discuss indicators of internationalisation more generally. Chapter 7 summarises the main conclusions.

There is an abundance of data on the internationalisation of science and research. The statistical and other written sources consulted for this work were specified by the Academy of Finland: the remit was to investigate reports and datasets compiled by Statistics Finland and the Ministry of Education, the MoE KOTA database, Academy of Finland materials and statistics, as well as OECD and Eurostat statistics. Interviews conducted with 29 experts provided another major source of information. For purposes of international comparison, the research explored the data collection efforts in Sweden, Norway and the Netherlands as well as the views taken by the leading research funding agencies in these countries on the phenomenon and on indicators of internationalisation: the Swedish Research Council (Vetenskapsrådet VR), the Research Council of Norway (RCN) and the Netherlands Organisation for Scientific Research (NWO). In addition, a round table discussion was held where experts exchanged views on the prospects of developing more reliable indicators for assessing and monitoring trends of internationalisation.

One of the main conclusions of this research is that assessments of internationalisation must continue to focus on scientific publishing, mobility (both shorter visits and more permanent moves) and the funding of science and research. Among the various sources consulted for this research, the most relevant and useful was the MoE KOTA database. The statistics gathered in that database make it clear that in the past few decades, international engagement has increased significantly in Finnish science and research. No bibliometric analyses were conducted for this research, but it is evident that international publishing databases offer useful sources of information.

The research supported the premise that, to some extent at least, it is necessary to give separate treatment to different fields of science. The overall picture is easily distorted by fields of science with high levels of international engagement if trends for co-authored international publications, for instance, are only represented in terms of cumulative numbers. Not all fields of science can share the same road to internationalisation; each of them has its own logic and its own context. There are marked differences even within individual fields of science. One thing that all of them have in common is that the volume of international publishing has increased significantly. International publishing volumes are highest of all in engineering and technology and in medicine and health sciences. The sharpest increase since 1994 is recorded for social sciences, engineering and the humanities. This evidence of increasing Finnish publication numbers is confirmed by international databases, although the absolute figures given in these sources are markedly lower than in the KOTA database.

KOTA statistics on international teacher and researcher visits from Finland indicate a declining trend for the past few years, both in terms of the number and duration of visits. However, the research conducted here suggests that the declining number and duration of visits does not in itself warrant the conclusion that international engagement is on the decline. Our interviews showed that other visits and informal exchange have in fact increased; they just do not show up in the statistics. It is also important to bear in mind that since the early 1990s, new advanced technologies have greatly facilitated information exchange and interfacing even without physical presence. KOTA sources also provide statistics on the number of foreign postgraduate students in Finland. These numbers have increased markedly across the board.

Research funding from international sources has increased considerably. KOTA provides statistics on the amount of foreign funding allocated to scientific research at Finnish universities. Based on these figures the amount of funding from EU sources, foreign business companies and other foreign sources has increased in all other disciplines except the humanities and agriculture and forestry sciences.

All in all, this research makes it clear that the level of international engagement in Finnish science and research has risen considerably over the past few decades; this is confirmed by virtually all indicators and all experts. The few exceptions seen in this pattern are merely a reflection of the fact that the statistical source in question cannot be used as a broad and reliable indicator of internationalisation.

The evidence is quite unequivocal then that scientific research in Finland has become more internationalised. However, Finland’s performance in international comparisons varies across different indicators. The per capita number of international publications in Finland is high. Figures for international mobility (in a more permanent sense) and the proportion of foreign-born nationals working in Finland, on the other hand, are well below the international average. The reasons are many and varied and have to do with the research system, geography, language policy and tradition.

Research policy and funding structures and the international environment in general have changed considerably over time. International engagement is encouraged to a much greater extent than before and peer models are much more readily available than before. Another significant underlying influence is the internationalisation of society more generally. Policy guidance has also played a part, but it is important to remember that scientists and researchers at the leading edge have always shown a strong commitment to international engagement.

International engagement must not be viewed as a separate aspect or function of scientific research, but on the contrary as an integral part of the everyday practice of doing science and research. One noteworthy trend is the gradual erosion of the distinction between the national and international. All fields of science and research are becoming more international, and international engagement is bound to gain increasing significance in the future. Based on a comparison of science policy discussions and debates in Finland and elsewhere, it seems that in many other countries internationalisation is not as prominent a concern as it is here. However, at least all the Nordic countries seem to share the same perceived need to adapt to globalisation.

Another recent momentous change impacting the realm of science and research was Finland's decision to join the European Union in 1995. The experts interviewed for this research stressed that while EU framework programmes for research are not usually at the cutting edge of science, they do have an important networking function, and for some research teams EU funding is absolutely crucial. Apart from global research cooperation and actions within the EU, Nordic cooperation is continuing to gather momentum. Collaboration within Europe's Nordic regions is recognised as an increasingly important strategic need. It is expected that science cooperation will continue to grow with Russia, China, India and other emerging science nations. The role of the United States is generally expected to decline or remain unchanged. The directions pursued and needs identified in different fields of science are also different.

Based on this research it seems that personal career planning and family considerations are emerging as ever greater obstacles to researcher mobility. A long-term research visit to a foreign country may prove not to have the desired career-boosting effect, but on the contrary present a risk to both the individual's career prospects and personal finances. In particular, the prospects of being able to return to a university post in Finland may be highly uncertain as competition for research posts is getting ever tougher. Internationalisation should be incorporated as an integral part of the development of research careers.

The Academy of Finland has devoted great effort to promote international engagement in science and research and it has various monitoring mechanisms in place. The Finnish Funding Agency for Technology and Innovation Tekes and its research funding policies have also contributed to strengthen internationalisation. According to the interviews in this research, a new emerging trend is the closer coupling of research funding with development cooperation. Research funding agencies will continue to work more closely with the Ministry for Foreign Affairs, and there is certainly scope here to develop new areas of cooperation and new funding arrangements. In this connection it is paramount to ensure strict adherence to the principles of ethical sustainability, for instance with regard to obtaining national research resources.

Science policy and strategic planning will continue to assume greater importance in internationalisation. Significant instruments in this regard include research programmes and infrastructures. As the research system continues to mature, so international engagement will become an increasingly natural part of doing science and research in all fields; it will no longer need to be separately stressed and emphasised. Nevertheless, it is safe to predict that internationalisation will remain a major theme in Finnish science and innovation policy for years to come.

Three areas of current focus in the measurement of international engagement will gain further emphasis. It is expected that the following indicators will retain their importance: 1) scientific publications in international series and produced in international collaboration; 2) international visits and mobility; and 3) research funding from international and foreign sources.

Various indicators and statistics are available to describe each of these areas, but data collection is less than comprehensive. For instance, data collection on research organisations other than universities remains inadequately harmonised. Most of the data consist of objectively verifiable quantitative indicators, but such aspects as the quality of publications or visits remain uncovered. Furthermore, the demand for such information is confined to a small circle of science policy decision-makers and experts. Although entirely relevant, the statistics and indicators are not exhaustive and therefore cannot provide adequate support for science policy decision-making. In particular, the measures currently used for monitoring mobility are open to criticism in that they give only a very crude and incomplete picture of what is a highly complex phenomenon.

The choice and development of indicators to support political decision-making is always ultimately a question of what those indicators are needed for, i.e. the requirements of the policy measures themselves. Data collection is a costly exercise and it is important to give careful thought to the appropriate level of resource allocation for the development of a tailored basket of indicators and for monitoring the internationalisation of science and research. Internationalisation is such a complex and multifaceted phenomenon that there is an endless range of items on which data could be collected. The challenge is to collect data that can more accurately describe the quality of internationalisation, but this is often a time-consuming and cumbersome process that involves subjective assessment – which leaves the data collected very much open to criticism. The decision to make a national investment in data collection must be based on national priorities of internationalisation.

This research prompted a wide range of ideas about different indicators that could be followed for general purposes. These ideas can be grouped into three categories: 1) indicators that already exist and that are currently used for data collection (e.g. number of publications); 2) indicators for which relevant data are available but for which data are not systematically collected (e.g. number of foreign professors at Finnish universities); and 3) indicators for which no data are currently collected or for which there exist no guidelines on required data (e.g. quality of international cooperation). Based on this research, a priority list was compiled on indicators that were considered particularly relevant for future needs. Some of the necessary data for these indicators already exist, but for some it will be necessary to collect completely new datasets and to allocate responsibilities for data collection. However, these questions as well as those concerning the costs of data collection are excluded from the remit of this research.

The proposed list of indicators for monitoring trends of internationalisation in scientific research is divided into four themes: 1) the internationalisation of scientific publishing; 2) international mobility and visits; 3) the acquisition of international research funding; and 4) international networking. There are 12 indicators on the list. The indicators that describe the internationalisation of scientific publishing are 1a) number of Finnish publications in international series; 1b) number of Finnish articles in international conference proceedings; 1c) number of co-authored international publications; and 1d) impact factor of Finnish publications divided by the impact factor of OECD publications. The indicators for international mobility and visits are 2a) number of visits by foreign senior researchers to Finland lasting more than one month; 2b) number of visits by Finnish senior researchers to foreign countries lasting more than one month; 2c) number of foreign professors in Finland; and 2d) number of foreign postgraduate students in Finland. The indicators for international science and research funding are 3a) amount of competitive basic research funding in Finnish organisations from foreign sources; 3b) science and research projects with joint international funding; and 3c) amount of research funding through EU framework programmes. In addition, it is suggested that international networking be measured by 4a) number of foreign examiners of doctoral dissertations. Many of these indicators allow for separate analysis of different fields of science. Furthermore, many indicators can be substituted by alternatives to describe percentage shares, networking or qualitative allocation.

1 Introduction

The Academy of Finland has begun work on its latest review of the state of the art of scientific research in Finland, which will be published under the title of SIGHT2009.[1] The review will include assessments of the strengths and weaknesses of Finnish science and research and on this basis proceed to offer suggestions on necessary structural changes and other development priorities. These assessments will be undertaken by the Academy's Research Councils in their respective fields of competence. As part of this review the Academy will commission outside experts to provide background research and material.

One of the major themes of the SIGHT2009 report is internationalisation. On this theme, the Academy has commissioned background research focusing on the internationalisation of scientific research in Finland and on its indicators. This research was conducted by Gaia Consulting Ltd. in February–September 2008. The remit was to address the following questions:

- How has the internationalisation of Finnish science and research advanced in 1990–2007 in the light of the statistics and research sources available?
- How have processes of internationalisation changed during this period?
- How well do the data and indicators available describe internationalisation?
- Could it be possible to develop more reliable indicators to assess and monitor internationalisation? What would these indicators be?

This final report summarises the main results of the research. Chapter 2 describes the implementation of the research. Chapter 3 provides an overview of the phenomenon of internationalisation in science and research and how it is measured. Chapter 4 describes the relevant statistical sources that are currently available and discusses recent trends of internationalisation. Chapters 5 and 6 consider the future outlook and discuss indicators of internationalisation more generally. Chapter 7 summarises the main conclusions.

1 The Academy of Finland has reviewed the state and quality of scientific research in Finland once every three years since 1997. The reports provide an overview of the Finnish research system, including such aspects as funding and labour resources, science policy and publication impact factors. See Academy of Finland (2000, 2003a, 2006).

2 Implementation of the research

2.1 Material and methods

This research is based on the following source materials:

- Reports and datasets compiled by Statistics Finland and the Ministry of Education, the KOTA database, Academy of Finland statistics and reports, and OECD and Eurostat statistics and reports
- Personal interviews with Finnish experts
- Interviews with research funding agencies in the Netherlands, Norway and Sweden and other written sources from these countries
- Round-table discussions with experts
- Other literature.

There is a relative abundance of material on the internationalisation of science and research. The statistical and other written sources consulted for this work were specified by the Academy of Finland. Reports and datasets compiled by Statistics Finland and the Ministry of Education were used primarily as background policy material and to support the drawing of conclusions. The Ministry of Education KOTA database was used to trace trends of internationalisation in different fields of science. Academy statistics and reports were studied to see whether and what kinds of structural changes have happened over time in international funding. Finally, OECD and Eurostat statistics were used to assess the performance of Finnish science and research in an international comparison.

Interviews were conducted with 29 experts (for a full list of the interviewees, see Appendix 1). Domestic experts were recruited from the following key target groups: Chairs of the Academy's four Research Councils, experts on the internationalisation of science and research, and senior management responsible for research at universities and research institutes. In addition, a number of foreign experts were interviewed. The list of interviewees was revised and approved by the Steering Group. The interviews were conducted in June-August 2008 either face-to-face or over the telephone.

For purposes of international comparison, interviews were conducted with experts on internationalisation at science funding agencies in three countries: the Swedish Research Council (Vetenskapsrådet VR), the Research Council of Norway (RCN) and the Netherlands Organisation for Scientific Research (NWO). Other national materials from these countries were also analysed. The aim was to find out how data describing internationalisation are collected in these countries.

A round-table discussion was held on 21 August 2008; the participants are listed in Appendix 2. The purpose was to exchange views with experts on the prospects of developing more reliable indicators for assessing and monitoring trends of internationalisation. Another aim was to verify the data collected for the research and to validate the conclusions drawn from this data.

2.2 Steering Group

The research was monitored and guided by a Steering Group at the Academy of Finland. The group members were Mr Paavo Löppönen, Director, Development and Evaluation; Ms Annamaija Lehvo, Senior Science Adviser; Ms Anu Nuutinen, Science Adviser; Ms Tiina Vihma-Purovaara, EU Affairs Manager; and Ms Kaisa Vaahtera, Project Secretary.

The Steering Group convened on five occasions during the research, and members of the group also took active part in the round-table discussion.

3 How to measure the internationalisation of science and research

3.1 Internationalisation: defining the phenomenon

Research is a broad and diverse activity of which international exchange and cooperation is an integral part. The focus of study here was limited to scientific research, most of which takes place at universities and research institutes. One of the challenges that cut across all our work, therefore, has been to draw international activities out of research, to identify it as a separate phenomenon; and on the other hand, to distinguish scientific research from all the other work done by universities and research institutes. Figure 3.1 illustrates the diversity and complexity of this field.

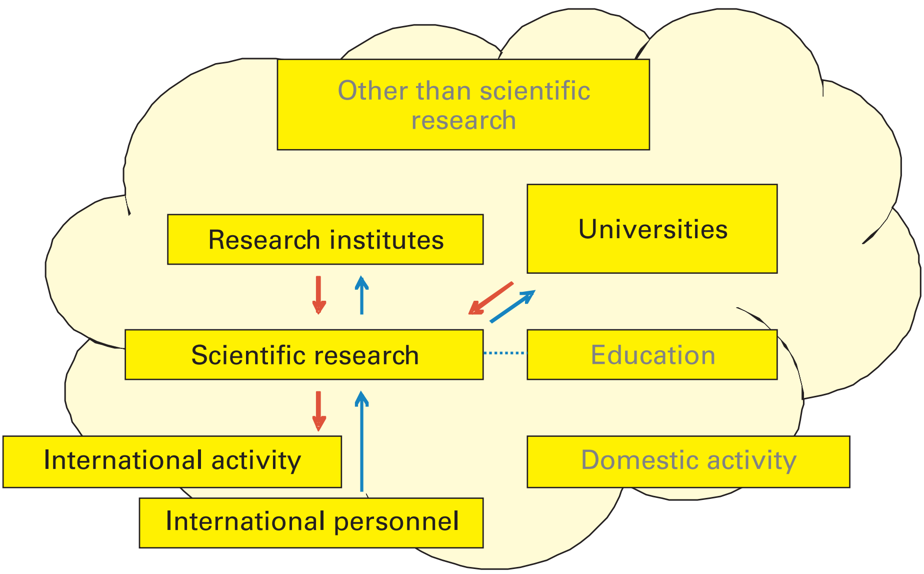


Figure 3.1. Scientific research and internationalisation: outlining the scope and context of study.

International engagement has always been a significant part of research and academia. For reasons of information access alone it has been important for researchers working in smaller countries to look beyond the borders of their own country. On the one hand, internationalisation has been a necessity driven by researchers' interests and needs, on the other hand, the course and direction of internationalisation has been steered by national needs. Research, and scientific research in particular, is primarily funded from national sources, and therefore decisions on international engagement are based on steering mechanisms for national funding.

The European Union has accorded a prominent position to science and research in the building of Europe's future and welfare. With the adoption of the Lisbon strategy in 2000, the European Commission and EU Member States committed themselves to create the European Research Area (ERA). The main objective of the Lisbon strategy was to make Europe "the world's most dynamic and competitive and knowledge-based economy by 2010". Since 2000, there has been a marked increase in cooperation especially among research funding agencies (in the form of peer reviews, joint research programmes, etc.). Although national funding volumes have not yet reached targeted levels, EU members are working closely to raise the quality standards of research, to increase the impacts of research and to bolster European competitiveness.

There is fairly broad consensus in the science community that international engagement is beneficial to scientific research. To some extent, international cooperation is considered a matter of course. More than 90% of the heads of university departments in Finland believe that research cooperation benefits the development of their own field of research.[2] A natural point of reference for assessments of the quality of research is provided by international comparisons. Leading-edge research does not necessarily have to be international, but it must by definition be at the international cutting edge. In practice, however, it is impossible to achieve excellence in research without international engagement and collaboration. Overall, by international comparison, Finland has performed reasonably well, as Lehvo and Nuutinen point out in their recent review[3]:

"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."

The demands of internationalisation are continuing to grow. Globally recognised drivers of science internationalisation include the self-organisation of scientific communities across national borders, the growth of international or bilateral research funding programmes, the globalisation of business and the continuing development of information technology, which is supporting all these trends.[4]

One of the motives for this research was to explore and understand the diversity of the science and research field in Finland. Highly internationalised disciplines may easily distort the bigger picture if the development of, say, the number of co-authored international publications is described by reference to cumulative rates. However, there is no escaping that different fields of science must to some extent by analysed separately. Not all disciplines can follow the same road to internationalisation, but

2 Hakala et al. (2003).
3 Lehvo and Nuutinen (2006).
4 Zitt and Bassecoulard (2004).

each field works within its own environmental limits and is governed by its own logic.[5]

Figure 3.2 provides a graphic illustration of the environment and component factors of international engagement in science and research, bearing in mind that the situation varies in different fields of science. Each field has achieved a certain level of international engagement (which is defined by the research teams working within that field, usually as the level achieved by the best teams) as well as certain general needs of internationalisation. These needs tie in with the bigger picture and with the social objectives specified among others in science and innovation policy. Each field has its own established resources and infrastructure, achieved scientific standard (which is partly determined in reference to the international standard) and networks of cooperation. Some of these networks are nationally organised, but in most fields there is also a strong international involvement. Broader environmental factors whose influence extends beyond individual fields include science and innovation policy, which among other things determines the amount of resources available for research. On the other hand, for any meaningful description of internationalisation, it is also necessary to take account of the changes taking place over time in the operating environment; this will also have a bearing on the choice of indicators used. Finally, we need to bear in mind the growing interaction between different fields and disciplines, i.e. the growing trends of multidisciplinarity, interdisciplinarity and transdisciplinarity, which are declared objectives of present-day science policy. This exchange and interaction may lead to new scientific breakthroughs and innovations on the interface of different disciplines, but at the same time the boundary lines between traditional disciplines are becoming increasingly blurred, sometimes paving the way to new fields of study such as bioinformatics or nanotechnology. The occasional convergence of different disciplines and fields of research is also an international phenomenon.

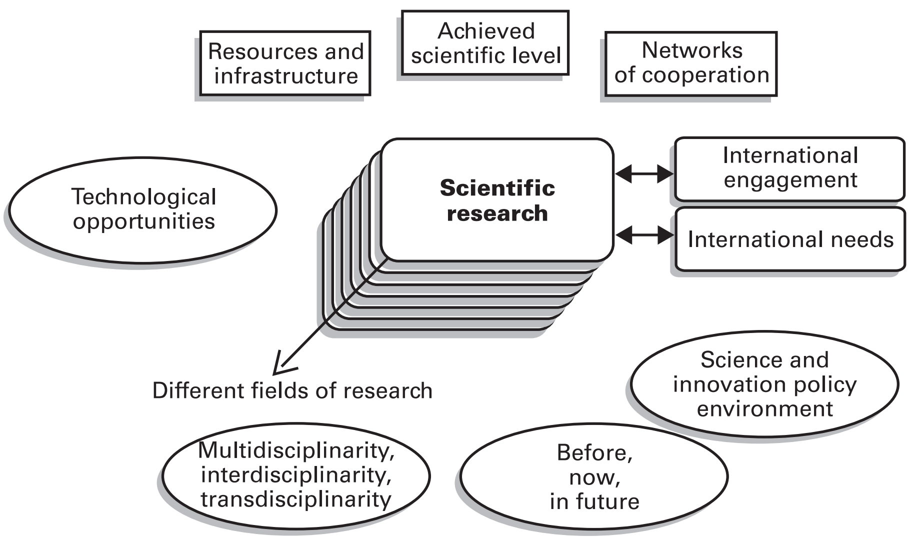


Figure 3.2. Factors of international engagement in scientific research

5 A corresponding conclusion regarding universities and government research institutes is put forward among others by Hakala et al. (2004).

The phenomenon of internationalisation is extremely complex and multifaceted and the first step in any analysis is to break it down into more manageable parts. For the purposes of this research, we have analysed internationalisation from four main perspectives:

1 Scientific publishing
2 Mobility
3 Research funding
4 Networks and cooperation

Although these four facets are analysed separately, they are obviously closely interwoven and to some extent even overlap. There are of course other, equally justifiable approaches to analysing the phenomenon of internationalisation, but our choice to focus on these four aspects was made on the basis of the datasets available and other materials collected in this research. Where necessary, each of these four facets can be studied separately for instance in relation to the motivation, benefits and outcomes of internationalisation.

3.1.1 Scientific publishing

The core foundation of scientific research has always been the publication of research results and critical peer reviews by the scientific community. Publishing on international forums is the most important visible output of internationalisation in scientific research. Scientists and researchers publish their work in international series either on their own or in collaboration with colleagues at home or abroad. Statistical data on international publishing are traditionally readily available.

Apart from shedding light on publishing volumes, an examination of scientific publishing provides valuable information on partners and fields of cooperation and on the quality of the publishing forums. Bibliometrics is a useful tool for weighing scientific outputs and impacts, and indeed it has been used more and more widely for purposes of evaluation and decision-making.

3.1.2 Mobility

In-depth cooperation and collaboration in science is not possible without physical movement. One key aspect of international engagement in science and research is that in order to gain access to the best information in the world, it is often necessary to travel to its sources. One indicator of scientific quality is the pull of attraction exerted towards other scientists and researchers. The physical mobility of researchers is a broad and complex phenomenon, both in terms of quantity, quality and duration, but in simplified terms it is about Finnish scientists and researchers going to work in other countries and about scientists and researchers from other countries coming to work in Finland. Virtual interaction and exchange is gaining ever greater importance with the continuing growth and proliferation of technological means of communication, and today's nomad researchers do not necessarily subscribe to the idea of having just one 'homeland'.

It is a common and fundamental element of science policy to promote the mobility of researchers, for this helps to disseminate knowledge and learning and to raise the quality of research. Indeed, policymakers and research organisations around the world share a widespread commitment to foster mobility. It is stressed, for example, that mobility is paramount to creating better research environments, to supporting research careers and to building networks.[6,7] It is important to bear in mind, though, that mobility can serve only as an indirect indicator of the quantity and quality of international cooperation.

3.1.3 Research funding

International collaboration in research funding is one of the key foundations for international engagement in scientific research. The trend has been for this collaboration to increase over time, and Finnish scientists and researchers have had excellent success in competing for international funding. On the other hand, it is important that the focus of examination centres on the internationalisation of domestic funding and on the incentive mechanisms built into research funding to encourage internationalisation.

3.1.4 Networks and cooperation

Science is universally international: researchers all over the world are working to resolve similar problems. There are no generic methodological obstacles to cooperation, and it seems that the international scientific community has adopted English as its lingua franca. The foundation for scientific research is provided by international networking and cooperation, which is not just about publications, mobility and funding applications. One of the basic notions informing this research is that global scientific cooperation involves much work that remains invisible in the statistics, even though that work is well-recognised by scientists and researchers in the field. The same applies to funding in that joint research projects funded from recognised sources and resources allocated to researcher mobility account for only a small proportion of all the funds used in international science and research. Figure 3.3

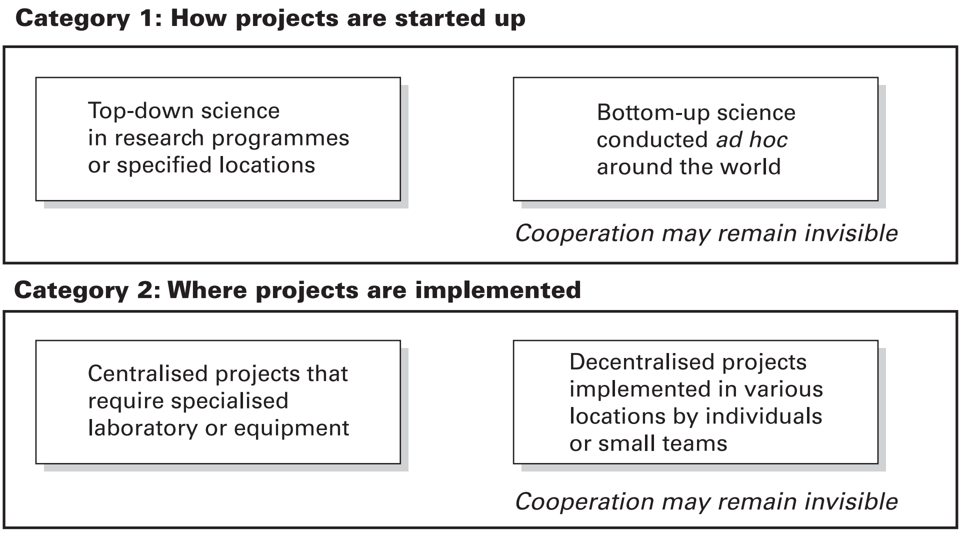


Figure 3.3. Different forms of research cooperation[8].

6 Academy of Finland (2007).
7 www.tekes.fi/kv_yhteistyo.
8 Wagner (2007).

provides an illustration of how all scientific research projects are divided into two categories in terms of both start-up and implementation, while a significant proportion of all cooperation may remain invisible. It is important for research funding agencies and policymakers to appreciate the logic of all these four categories in order to gain a clear understanding of the bigger picture. This is particularly true where the allocation of national resources needs to be improved and justified. Measures and indicators of internationalisation can accordingly be considered within the context and from the vantage-point of each of these categories.

3.2 Measures and indicators of internationalisation

One of the objectives defined for this research was to prepare recommendations for improved measures and indicators of the internationalisation of scientific research. The following outlines the challenges involved in measuring this complex phenomenon.

Our work starts out from a description of the current state of internationalisation based on existing indicators and statistical sources. It is assumed as a matter of course that the phenomenon of internationalisation in scientific research is in constant flux. This, in turn, dictates the need constantly to develop new tools for monitoring the phenomenon. The measurement of international engagement ties in with a number of broader policy-level issues, such as monitoring the development of the ERA.

Compared to the tools used in corresponding measurements of the science and technology system or the educational system and knowledge and skills resources, the measures used to describe the internationalisation of scientific research are still underdeveloped. For instance, the *Frascati manual*[9] developed for R&D surveys, the *Canberra manual*[10] for the measurement of human resources in science and technology, and other manuals designed for OECD science and innovation policy surveys do include some scattered concepts to describe the internationalisation of scientific research, but they offer no guidelines for monitoring procedures. It is possible therefore to make some important choices now to advance and improve monitoring regimes, but on the other hand the broader foundation for international data collection is still lacking. It must also be noted that the collection of monitoring data is often a costly exercise and therefore has to be selective.

The terminology surrounding monitoring and follow-up data, measures and indicators remains inconsistent. National surveys can often draw on comprehensive datasets and statistical sources and extract measures that are most relevant and interesting in view of the phenomenon under investigation. **For the purposes of this research we define a measure as referring to a numeric value that has general interest for describing the phenomenon in focus**. An indicator, then, is a statistical value that condenses complex information into a more manageable and readily understandable format. **In this research, indicator refers specifically to information that is used to support decision-making**. Indicators support and facilitate the setting of concrete objectives, the monitoring of their achievement and the planning of future actions. Indicators should describe the impact of actions taken and provide a clear picture of how the phenomenon in focus has developed. **An indicator is thus a subset of general statistical information and alternative measures, and it can also be**

9 Frascati manual (2002).
10 Canberra manual (1995).

based on qualitative information (e.g. various opinion polls). Statistical data collected for official purposes and indicators are closely interconnected, and generally indicators used to support national science policy decision-making should be based on statistically reliable sources.[11] Key principles of the production of official statistics include the publication of all relevant statistics, equal access for all, impartiality and openness.

Every indicator and every individual statistical item is necessarily a very narrow and limited description of a complex phenomenon. A typical example of an indicator of scientific research is the number of publications, which in itself sheds no light on the quality of science or on the differences between different fields of science. Informed decision-making always requires access to several different indicators so that the different facets of the phenomenon are fully covered. Indicators are also classified and grouped in various ways to form different kinds of 'indicator systems'[12]. Text Box 3.1 discusses one option for an indicator system to describe the internationalisation of scientific research.

Text Box 3.1.

Indicator system to describe the internationalisation of scientific research

One way of grouping indicators of scientific research is a fourfold classification into operating environment, input, system and output indicators.

Operating environment indicators describe the various factors affecting the phenomenon at a general level; they may describe the national situation or significant trends that indirectly impact the internationalisation of scientific research. These indicators describe the general changes that are taking place in the field of scientific research and that do not necessarily relate directly to internationalisation. In Finland, one example of a relevant operating environment indicator could be the proportion of foreign-born people in the country.

Indicators describing the actual phenomenon can be divided into **input, system** and **output indicators**. Examples of input indicators include policy measures aimed at supporting internationalisation, a typical output indicator would be the number of co-authored international publications. It is noteworthy that this distinction is by no means watertight. One difficulty is presented by the definition of a 'system', which describes the actual phenomenon under study, i.e. internationalisation in scientific research. The agents within the system may be defined as comprising scientists and researchers and the work they do, whereby decisions on policy measures and funding would rather be input factors impacting the system. One difficulty here is presented by the treatment of postgraduate students. In Finland, postgraduate students researching their PhD thesis may be regarded as an indicator of system internationalisation, whereas foreign-born postgraduate students might be seen as input factors. The true indicator of system internationalisation, then, would be the number of postgraduate students who upon completion of their PhD remain in Finland to continue their research. On the other hand, this could also be seen as an output indicator, describing the outcomes of policy measures taken.

11 See e.g. Statistics Finland (2006).

12 One area where much work has been done to develop indicators and indicator systems is in the field of sustainable development. One indicator classification system is the DPSIR model, in which indicators are divided into the categories of Driver, Pressure, System, Input and Response. See European Environment Agency (1999).

Overall, it is important not to pay too much attention to the indicator system or to how the indicators are classified; the key thing is to ensure that investments in development of indicators are matched to needs. The ultimate aim is to support policy planning and decision-making by clarifying assumed or known causal relations, i.e. to identify aspects that can be steered and influenced and those that are beyond direct influence. It is particularly important to clarify which factors are inputs and which describe the objective and the achievements so far. The tools included in the basket of indicators must be chosen with a view to simplicity and clarity. The choice of individual indicators and the design of the indicator system as a whole shall be informed by the following criteria:

- **Responsiveness to change.** No indicator can provide a meaningful description of impacts if its value remains unaffected by operational or environmental changes.
- **Relevance and interest value to users.** Indicator data must be relevant and meaningful to their users. Data on the internationalisation of scientific research are used by a wide range of organisations and individuals, and the selection of indicators must aim to strike a good balance between their different needs. For instance, the indicators used for purposes of external communication must have broad interest value for the general public.
- **Transparency and comprehensibility.** The indicators must be readily comprehensible and their association with the phenomenon measured must be clearly and transparently defined. Complex indicators that combine a number of different statistical elements only gain transparency after some time, once they are properly established (e.g. GDP).
- **Clarity of direction.** Good indicators should clearly demonstrate the direction of development, i.e. whether the situation is moving in a better or worse direction over time. If an indicator points in no clear direction, or if it is impossible to specify any clear target levels, then it is unlikely to have very much use value to decision-makers.
- **Future orientation.** The choice of indicators can also be informed by future projections, with a view to proactive development so that the indicators are more clearly oriented to future planning rather than reporting on the past. In this respect a major challenge comes from the delays in the collection of reliable statistical data.
- **Reliability.** All indicators must be based on scientifically or otherwise verified argumentation and reliable information. A major data foundation for the internationalisation of scientific research must consist of statistics compiled under national or international agreements.
- **Information accessibility.** The collection of indicator data requires ready access to information. The challenge here is that the statistical information needed to describe new phenomena requires changes in national and international practices of data collection. This is often a slow process that requires broad consultation and information sharing.
- **Unambiguity.** Good indicators are often combinations of several different indicators. The difficulty here is that this often detracts from their transparency as well as from the unambiguity of the indicator values. It is important that the underlying assumptions and calculations are simple and unambiguous enough.

- **Comparability.** Wherever possible, indicators should be comparable and compatible with other corresponding indicators collected by other organisations. Furthermore, indicators should be comparable over time so that indicator values can be reliably compared from one year to the next.
- **Cost efficiency of data collection.** The collection of indicator data is a costly exercise and it is important that the necessary data can be collected as cost efficiently as possible. There must be a reasonable balance between the costs of data collection and the uses of those data.
- **Minimum size, maximum coverage.** It is impossible to find any one single indicator that would satisfy all the requirements of data collection. On the other hand, for reasons of costs, communication and practicality, it does not make sense to have too large a basket of indicators.

As is evident from this last point, the requirements and criteria set for indicators are often contradictory. A common difficulty is that the basket of indicators tends to become too large. On the other hand, especially in the case of internationalisation, special challenges are presented by the complexity of the phenomenon, the accessibility of information and the costs of data collection.

4 Existing data sources on internationalisation

This Chapter reviews and discusses the data sources available on the internationalisation of scientific research in Finland. Section 4.1 introduces the main sources identified, and section 4.2 looks more closely at the MoE KOTA database, which is the main statistical source for the analyses in this research. Based on these data, section 4.3 describes the internationalisation of Finnish science and research from 1990 to 2007.

4.1 Description of the material

A review was conducted of the data sources available in order to identify datasets and measures describing the internationalisation of scientific research. Research and development (R&D) is often understood in very broad terms and taken to include product development in the private business sector, for instance. Most national and international statistics on research are accordingly broad and inclusive.[13] According to the Statistics Finland definition, research (and comparable development activity) is understood as referring to systematic work aimed at increasing the existing stock of knowledge and to discover new applications. The defining criterion for research is that it involves “an appreciable element of novelty”. R&D also comprises basic research, applied research and data collection conducted as part of research projects.[14] The main focus in this report is on scientific basic research, even though for most purposes it has been necessary to rely on datasets describing general R&D. Wherever possible, data on scientific basic research have been analysed separately. For example, in the case of student statistics the analysis has been focused on those pursuing a postgraduate degree (Licentiate’s or doctorate), and in the case of R&D funding separate treatment is given to funding allocated to universities.

One of the difficulties with the most commonly used datasets is that there is a relative scarcity of data describing basic research as compared to R&D more generally. The data describe the development of R&D in general, and in many cases the only way to identify the contributions of scientific basic research is through qualitative analysis. The one exception in this respect are bibliometric datasets, which are available in abundance and which allow for in-depth analyses of various aspects of the internationalisation of publishing. Within the confines of this research it was not possible to conduct a detailed bibliometric analysis, but Text Box 4.1. provides a brief description of the main sources used.

Data on the internationalisation of Finnish science and research were found in the Ministry of Education KOTA database, OECD statistics and reports, Statistics Finland materials and Academy of Finland sources. The most in-depth statistical source for our purposes was the KOTA database, which is described in closer detail under 4.2 below. Other sources are used primarily to validate the KOTA materials, and they are briefly described below. Table 4.2 lists all the data sources reviewed by theme.

13 Lemola et al. (2008) published in autumn 2008 a more detailed account of indicators for science, technology and innovation; this report is available in Finnish only.

14 http://www.tilastokeskus.fi/til/tkke/kas_en.html.

Academy of Finland

The Academy of Finland's reports of operations 1998–2007 proved a useful source of complementary information. Academy reports of operation describe the internationalisation of scientific research by using statistics on international research funding and on the number of international publications out by Finnish researchers.[15] The Academy's contribution to the development of international research is described among others by statistics on researcher exchange based on bilateral agreements, statistics on the proportion of foreign experts consulted for reviews of grants applications, and statistics on the amount of research funding allocated to international cooperation.[16]

The Academy has various unpublished sources on its own funding instruments. All research projects funded by the Academy may involve international elements, and the Academy is in the process of developing relevant monitoring tools.

OECD

The OECD publishes annually the *OECD Science, Technology and Industry Scoreboard*, which brings together statistics on the performance of OECD countries in science, technology and globalisation. The 2007 report[17] identifies seven different themes or indicators to describe the internationalisation of science and technology (G. Internationalisation of S&T). These indicators are:

- *G-1. Foreign ownership of domestic inventions*
- *G-2. Domestic ownership of inventions made abroad*
- *G-3. International co-operation in research (co-invention of patents)*
- *G-4. Sources of R&D funding from abroad*
- *G-5. International collaboration in science*
- *G-6. Internationalisation of R&D*
- *G-7. Foreign collaboration on innovation*

R&D internationalisation is described primarily from a business perspective, with special emphasis on the international transfer of R&D inputs and outputs from one country to another. The main observation is that R&D investment overall is on the increase in the OECD area and that investment in knowledge has accelerated at the same rate as GDP.

For our purposes the most interesting OECD indicators are International collaboration in science (G.5) and Internationalisation of R&D (G-6). Indicators of science collaboration are based on authorship statistics. The statistical table that is particularly relevant to internationalisation describes the number of scientific publications with authors from two or more countries. Trends for these figures are compared in the OECD report with other publications that have just one author, more than one author from the same research institute, or more than one author from the same country. The internationalisation of R&D is described through the number of business R&D units outside the host country. As a rule the OECD report does not look separately at the share of scientific research (Table 4.1).

In the OECD's 2005 STI Scoreboard, the term internationalisation only appeared in the context of patenting activities. The word 'international' was mentioned in

15 Academy of Finland reports of operation 1998–2007.

16 Ibid.

17 OECD (2007).

connection with mobility, trade and manufacturing technology, but the main emphasis was on business R&D.

Table 4.1. OECD indicators for international collaboration in science and R&D internationalisation. Source: OECD Science, Technology and Industry Scoreboard 2007.

Indicator	Measurement
International collaboration in science	Authorship indicators are a measure of collaboration in science. Four types of authorship of scientific articles are analysed: single author, single-institutional co-authored, domestic co-authored and international co-authored. Indicator graphs: 1) Change in authorship of scientific articles, 2) Trends in the authorship pattern in scientific articles, 3) Trends in the ratio of internationally co-authored scientific articles by country.
Internationalisation of R&D	As more multinationals set up offshore R&D laboratories, R&D activities in many OECD countries are becoming more internationalised and more closely linked to production abroad. Indicator graphs: 1) Share of R&D expenditure and turnover of affiliates under foreign control in total R&D and turnover, 2004, 2) R&D intensities of affiliates under foreign control and firms controlled by the compiling countries, 2004.

Statistics Finland

Statistics Finland sources include statistics on the financing of R&D and on resources allocated to research. As is international statistical practice, the main emphasis is on business R&D. There are very few statistics describing the internationalisation of scientific research; the only relevant datasets are those describing the share of foreign funding in universities[18] and the number of foreign postgraduate students in education statistics. The KOTA database has the same information.

Text Box 4.1. **ISI Web of Knowledge**[19]

No bibliometric analyses were conducted for this research. The most widely used scientific online database for purposes of bibliometric analysis is the ISI Web of Knowledge, a tool that is most typically used by universities and science policy professionals.

ISI Web of Knowledge provides direct links to several other databases and sources. In the present context the most significant among these is the Web of Science, which indexes almost 9,000 scientific publications in different disciplines. The service provides access to a number of citation indices, including the Science Citation Index SCI, the Social Sciences Citation Index SSCI and the Arts & Humanities Citation Index A&HCI.

One of the databases in the ISI Web of Knowledge product family is ISI Essential Science Indicators, which allows for qualitative analyses of research results and science trends based on over 11,000 publications in all subject areas.

18 http://www.stat.fi/til/tkke/tau.html

19 http://isiwebofknowledge.com/

Table 4.2. Themes and indicators of internationalisation compiled from the research material.

Theme	Source	Indicator
Teacher and researcher visits	KOTA database	Long visits abroad by university staff (number and duration)
		Visits by foreign teachers and researchers to Finland (number and duration)
	Academy of Finland reports of operations	Academy bilateral researcher exchange from Finland (number and duration)
		Academy bilateral researcher exchange to Finland (number and duration)
Foreign postgraduate students in Finland	KOTA database	Number of foreign postgraduate students
International publishing	KOTA database	Articles published abroad (refereed)
		Articles in edited volumes published abroad
		Monographs published abroad
	ISI Web of Knowledge*	Number of international publications and co-authored publications by Finnish researchers
International collaboration in science	OECD Science, Technology and Industry: Scoreboard 2007 (G-5)	Change in type of authorship of scientific articles, particularly co-authored international publications with authors from two or more countries (numbers)
		Trends in authorship pattern in scientific articles
		Trends in the ratio of internationally co-authored scientific articles by country.
Foreign funding	KOTA database	Research funding from the EU (€)
		Research funding from foreign companies (€)
		Other foreign research funding (€)
	Statistics Finland	Foreign funding sources
R&D internationalisation	OECD Science, Technology and Industry: Scoreboard 2007 (G-6)	Share of foreign R&D expenditure and turnover by country
		R&D intensities of foreign affiliates and businesses controlled by the compiling country

* Not directly consulted for this research, but was quoted in the source material for this research.

It became apparent in our research that science policy experts and other professionals also used other data sources on internationalisation, such as data on funding for FiDiPro professorships and ERC grants awarded to Finnish researchers. Some of these sources are compiled in-house and remain unpublished. The mechanisms used to monitor internationalisation are continuing to improve. For example, the Academy is constantly working to develop its data collection processes, and the Ministry of Education is upgrading the KOTA database.

4.2 Description of the KOTA database

Created and administered by the Ministry of Education, the KOTA database is an online service that contains a wide range of statistical data on universities and fields of study from 1981 onwards.[20] Statistics can be searched and retrieved by university, field of study and year. In this research we were not interested to explore differences between universities.

20 https://kotaplus.csc.fi/online/Etusivu.do

For simplicity and clarity we have here combined the 21 fields listed in the KOTA database into six fields of science to correspond with the OECD classification scheme.[21] The OECD fields of science are natural sciences, engineering and technology, medicine and health sciences, agricultural sciences, social sciences, and the humanities. The differences observed between different fields of science are described here using this classification. Appendix III.1 provides a summary of the OECD classification and the KOTA database fields of study.

The KOTA database contains statistics for 19 different subject areas.[22] In line with the definition of internationalisation outlined in Chapter 3, we have identified four key themes that are relevant to internationalisation and that the KOTA database can illuminate:

- Teacher and researcher visits
- Foreign postgraduate students
- International scientific publishing
- Foreign funding.

In 2006, the Ministry of Education appointed a working group to draft recommendations for the further development of the research portion of the KOTA database.[23] The working group suggested a range of improvements to data collection on scientific publishing, such as the adoption of a more detailed classification of publication type and the introduction of a field of science classification alongside its field of study classification. The recommendation most directly relevant to the monitoring of internationalisation was the suggestion that data on the mobility of teaching and research staff should be grouped by post or position held or career stage. The working group report was put out to consultation in spring 2008, and work to develop university publishing data continued throughout the autumn of 2008. In a recent report on sectoral research,[24] the recommendation is made that any data system created for sectoral research should be harmonised with the new Science-KOTA system.

The KOTA database is a key national data source on scientific research in Finland and it is important that future analyses of internationalisation continue to make good use of this valuable source.

Teacher and researcher visits

The KOTA database includes statistics since 1990 on visits by university teachers and researchers from and to Finland. Teaching and research staff are defined as including professors, senior assistants, assistants, lecturers, teachers, clinical lecturers, senior

21 Frascati Manual (2002).

22 KOTA database choices of topic: applicants and admitted, new students, students, foreign students, degrees, graduate placement, median graduation times, teachers, other staff, annual accounts, expenditure by performance areas, university premises, continuing education, open university instruction, teacher and researcher visits, scientific publishing, foreign-language first degree education, international student mobility (over 3 months) and teacher training schools. https://kotaplus.csc.fi/online/Haku.do.

23 Ministry of Education (2008).

24 Rantanen (2008).

teachers, researchers, doctoral students at graduate schools, senior lecturers in oral medicine, university lecturers, clinical instructors, full-time teachers and other part-time teachers.[25] The database does not specify the purpose of teacher and researcher visits, and they may be motivated by reasons other than scientific research.

The KOTA database contains statistics on the number and duration of visits. By duration, visits are grouped as either long (over one month) or short (2 weeks–1 month).[26] These data on teacher and researcher visits describe the mobility of university staff and as such help to fill in the picture of the internationalisation of Finnish scientific research. The current state and recent trends in teacher and researcher mobility are described in under 4.3.1 below.

Foreign postgraduate students

The KOTA database provides statistics since 1991 on the number of foreign postgraduate students in Finland. The figures indicate the number of foreign nationals enrolled at university during the autumn term.[27] The database does not specify the degree the students are pursuing. Statistics on the number of foreign postgraduate students in Finland gives added depth to the picture of the internationalisation of science by providing an indication of the attraction held by Finnish universities in other countries. KOTA does not provide breakdown data by students' country of origin or on the duration of their stay in Finland. Statistics on postgraduate students in Finland are discussed under 4.3.2 below.

International scientific publishing

The KOTA database contains statistics since 1994 on articles published in refereed journals abroad, articles published in edited volumes abroad and monographs published abroad. Statistics are not provided on doctoral dissertations, other theses or unrefereed periodicals.[28] International scientific publishing is an important theme of science internationalisation and describes the involvement of Finnish scientists and researchers in international activities. The current state and recent trends of international publishing are discussed under 4.3.3 below.

Foreign funding

The KOTA database includes statistics since 1999 on foreign funding made available for scientific research at Finnish universities. The funding sources identified in the database are the EU, foreign business companies and other foreign funding (e.g. foreign universities, central offices and agencies, governments and international organisations).[29] The statistics do not take into account changes in the value of money. The current state and recent trends in foreign funding are described in closer detail under 4.3.4. below.

25 KOTA manual (2007).
26 https://kotaplus.csc.fi/online/Haku.do
27 KOTA manual (2007).
28 https://kotaplus.csc.fi/online/Help.do?topic=scient.publication
29 https://kotaplus.csc.fi/online/Help.do?topic=annualaccounts

4.3 Current status and recent trends

The current status and recent trends in the internationalisation of Finnish science and research are described by reference to statistics compiled in the KOTA database. Changes and trends are presented primarily as descriptors.

For many themes it is difficult to compare the situation across different fields of science because of incompatible classifications (see Appendix III.1). For this reason different fields of science are also compared using indices that describe relative changes instead of absolute numbers. The current status and recent trends for individual fields of science are shown in Appendices III.2–25.

4.3.1 International teacher and researcher visits

The KOTA database contains statistics on visits by university teachers and researchers to and from Finland. Figures are provided both for the number of visits and for their duration in months. The database makes a distinction between long (over one month) and short (2 weeks–1 month) visits. To gain a broad overview we have here summed up the figures for all visits into one single indicator, i.e. Figures 4.1–4.4 do not provide breakdowns for short and long visits nor do they make a distinction between visits to and from Finland. Appendices III.2–7 provide details for the duration and number of visits in different fields of science and breakdowns for visits to and from Finland.

Figure 4.1 below describes the change in the overall number of visits by teachers and researchers in 1990–2007. As can be seen, the number of teacher and researcher visits is highest in the engineering field. In 2007, the overall number of visits stood at 852. In the natural sciences, the number of international visits in 2007 came to 774. In this field the peak in the number of international visits was reached in 1997 at

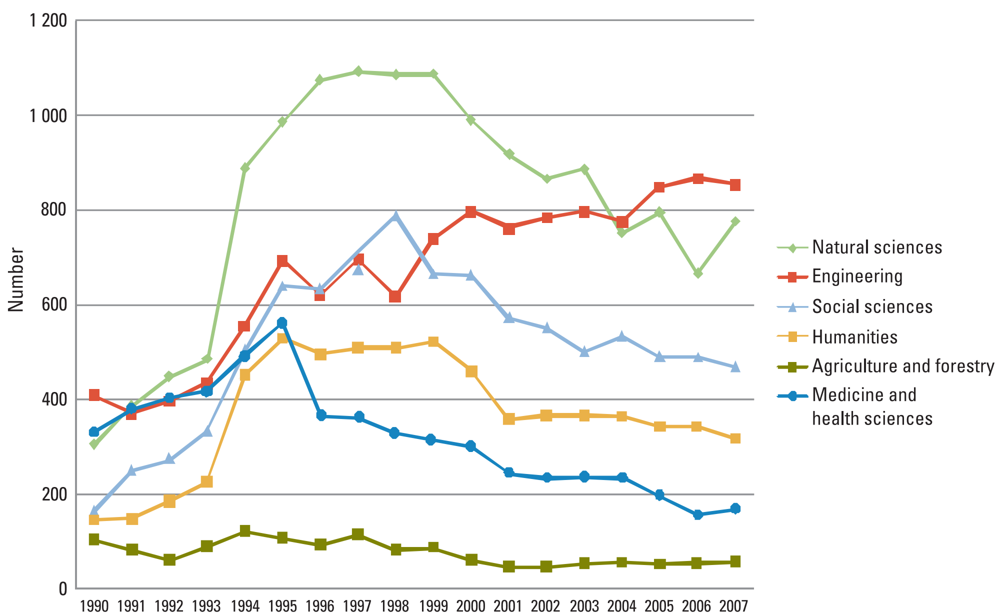
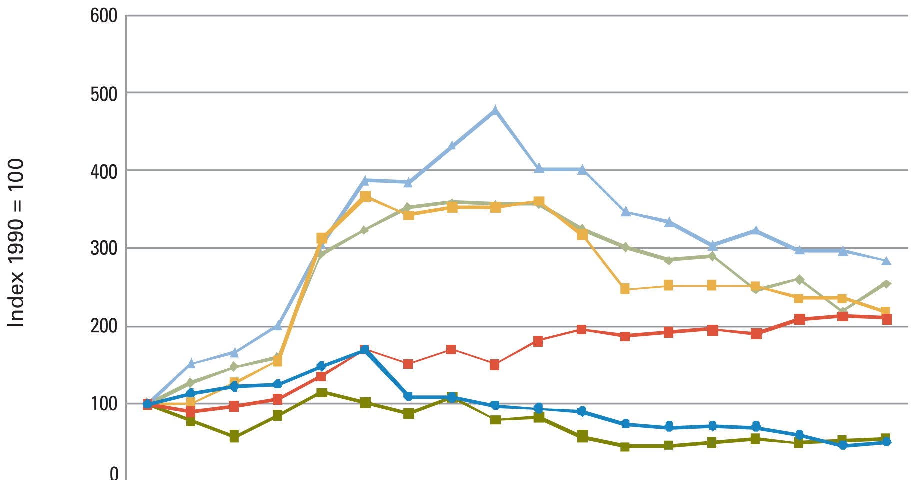


Figure 4.1. International teacher and researcher visits (number of visits). Source: KOTA database.

1,090. The lowest number of teacher and researcher visits is found for agriculture and forestry, which recorded just 58 visits in 2007.

Figure 4.2 uses an index to describe changes in the number of international teacher and researcher visits. The index is set at 100 for the total number of visits during the first year. The index for the next year (1991) is then determined as the ratio of the sum total of visits in 1991 to the number of visits in the first year (1990) etc.

As is apparent from Figure 4.2, the number of visits in the social sciences, natural sciences, humanities and engineering[30] has increased over the period from 1990 to 2007. The figures for medicine and health sciences, and the agriculture and forestry on the other hand, have declined. The relative increase in the number of visits has been sharpest of all in the social sciences, reaching 185% in 1990–2007. Since 1998, the growth trend for the social sciences has been negative. The number of teacher and researcher visits in medicine and health sciences and in agriculture and forestry has roughly been halved since 1990.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Natural sciences	100	127	147	159	292	324	353	359	357	357	325	302	284	291	247	261	219	255
Engineering	100	91	97	107	136	170	152	171	151	181	196	187	192	195	190	209	213	209
Social sciences	100	152	167	202	307	389	387	434	479	404	403	349	335	305	324	299	298	285
Humanities	100	102	128	156	313	367	343	353	353	362	319	249	253	253	252	237	237	219
Agriculture and forestry	100	79	59	86	115	103	88	110	80	84	59	45	46	51	55	50	52	56
Medicine and health sciences	100	115	122	126	148	170	110	108	99	95	91	74	70	71	70	60	47	51

Figure 4.2. Relative change in number of international teacher and researcher visits (index 1990= 100). Source: KOTA database.

Figure 4.3 describes the duration (in months) of international visits by teachers and researchers. As can be seen the duration of visits is longest in the field of engineering. In 2007, the combined total duration of these visits came to 3,925 months. The lowest figure in this comparison was recorded for agriculture and forestry at 164.

30 There are minor terminological differences in the OECD fields of science and the KOTA database fields of science. In this research when referring to the KOTA database the term engineering alludes both to engineering and technology (see Appendix 3, Table III.1).

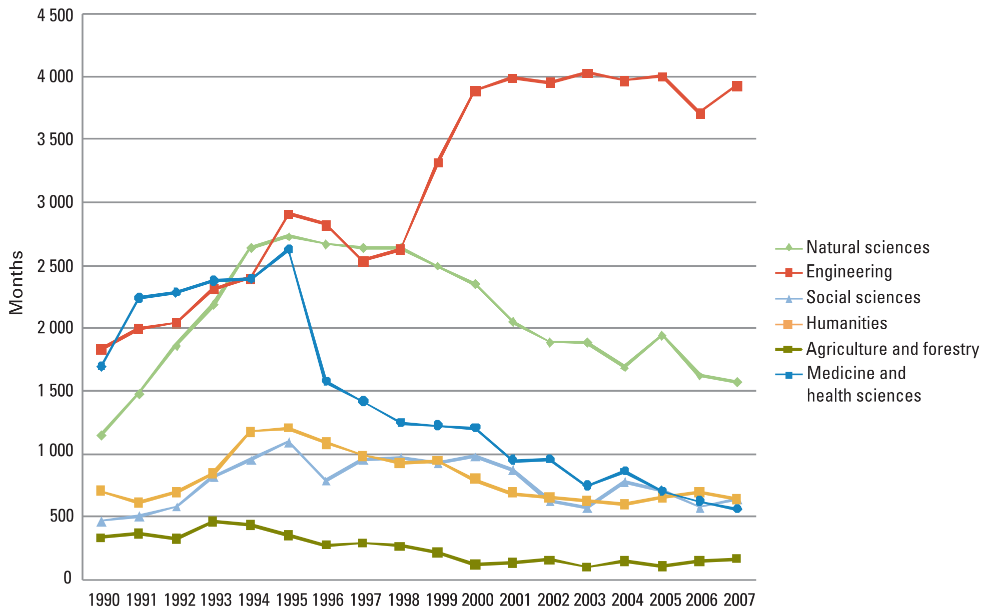
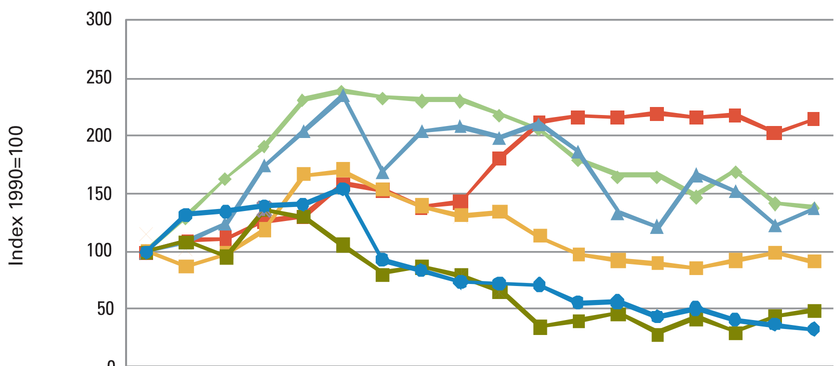


Figure 4.3. Changes in duration of international teacher and researcher visits (duration of visits, months). Source: KOTA database.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1998	2000	2001	2002	2003	2004	2005	2006	2007
Natural sciences	100	129	162	191	230	238	233	230	230	218	206	179	165	165	147	169	142	138
Engineering	100	109	111	126	131	159	154	138	143	181	212	217	216	220	216	218	202	214
Social sciences	100	108	124	175	205	235	169	204	209	199	211	187	134	122	166	152	123	137
Humanities	100	87	98	119	166	170	153	139	131	134	113	98	92	89	86	92	98	91
Agriculture and forestry	100	109	96	137	130	105	81	87	79	66	35	40	46	30	43	31	45	49
Medicine and health sciences	100	132	135	140	141	155	93	84	74	72	71	56	57	44	51	41	37	33

Figure 4.4. Relative change in the duration of international teacher and researcher visits (index 1990=100). Source: KOTA database.

Figure 4.4 describes recent trends for international teacher and researcher visits according to the duration of visits. As we can see, the duration of visits has increased most of all in the engineering and technology field, rising by 114% since 1990. During the period under review a positive trend is also recorded for the natural sciences and social sciences. The trend for the humanities, agriculture and forestry and medicine and health sciences, on the other hand, has been negative. In the field of medicine and health sciences the annual cumulative duration of international visits has dropped by 67% since 1990. With the single exception of engineering the overall trend for international visits has declined since 1995.

4.3.2 Foreign postgraduate students

Figure 4.5 provides a summary of the number of foreign postgraduate students in Finland in 1991–2007. In all fields of science the numbers have increased during the period under review. In absolute terms the highest number of foreign postgraduate students in 2007 was recorded in engineering, which had a total of 507 foreign students; the lowest number at 81 was recorded for agriculture and forestry. Appendices III.8–13 show the number of foreign postgraduate students in different fields of science.

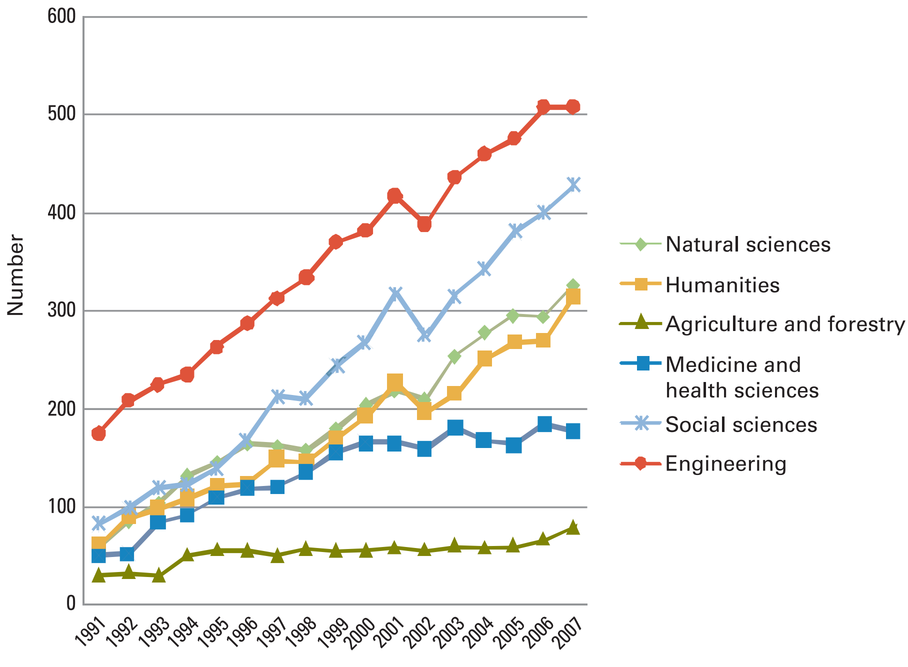
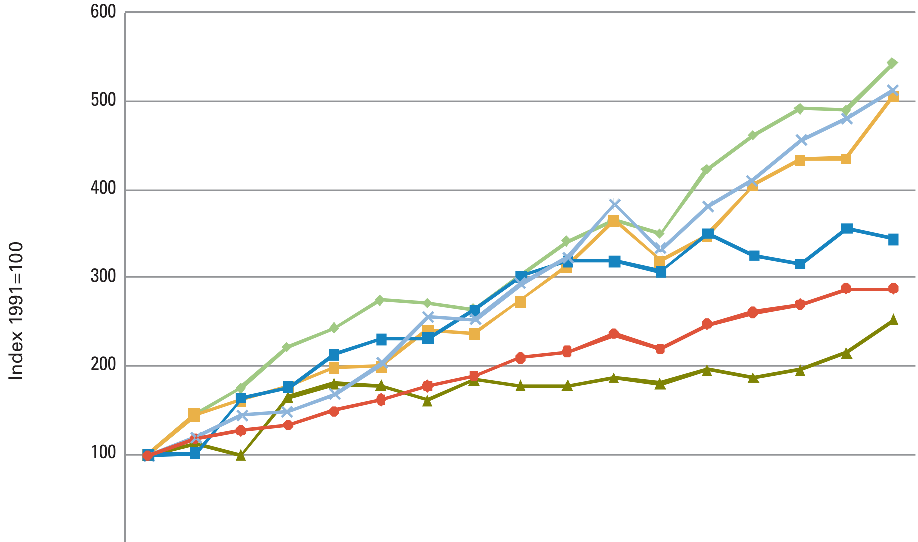


Figure 4.5. Foreign postgraduate students in Finland. Source: KOTA database.

Figure 4.6 shows how the proportion of foreign postgraduate students has changed since 1991. The index is pegged at 100 for the base year 1991. For the next year (1992), the index is determined as the ratio of the number of foreign students in 1992 to the number of students in the first year (1991) etc.

The number of foreign postgraduate students has increased sharply in all fields of science. The sharpest growth at 443% since 1991 is recorded for the natural sciences, followed by the social sciences at 414%; the humanities at 406%; medicine and health sciences at 244%; engineering at 188%; and agriculture and forestry at 153%.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Natural sciences	100	145	175	222	243	275	272	265	302	342	365	350	423	462	492	490	543
Humanities	100	145	161	177	198	200	240	237	274	313	366	319	348	405	434	435	506
Agriculture and forestry	100	113	100	166	181	178	163	184	178	178	188	181	197	188	197	216	253
Medicine health sciences	100	102	163	177	213	231	233	263	302	319	319	308	350	325	315	356	344
Social sciences	100	120	146	149	169	204	257	253	294	324	384	331	382	413	457	482	514
Engineering	100	119	128	134	150	163	178	190	210	217	237	220	248	261	270	288	288

Figure 4.6. Foreign postgraduate students by field of science (index 1991=100). Source: KOTA database.

Figure 4.7 shows the number of postgraduate students as a proportion of all postgraduate students by field of science in 1991–2007. This figure has been consistently highest in agriculture and forestry, standing at almost 13% in 2007. The lowest proportion is consistently recorded for the social sciences; in 2007 it was around 6.5%. On average, the proportion of foreign students has increased in all fields of science over the 17-year period under review, and was at its highest in 2007.

Finland has traditionally had a comparatively low number of foreign PhD students. According to 2004 OECD statistics,[31] the proportion of foreign PhD students in Finland is 7% and in Sweden, for instance, 25%.

31 OECD (2007).

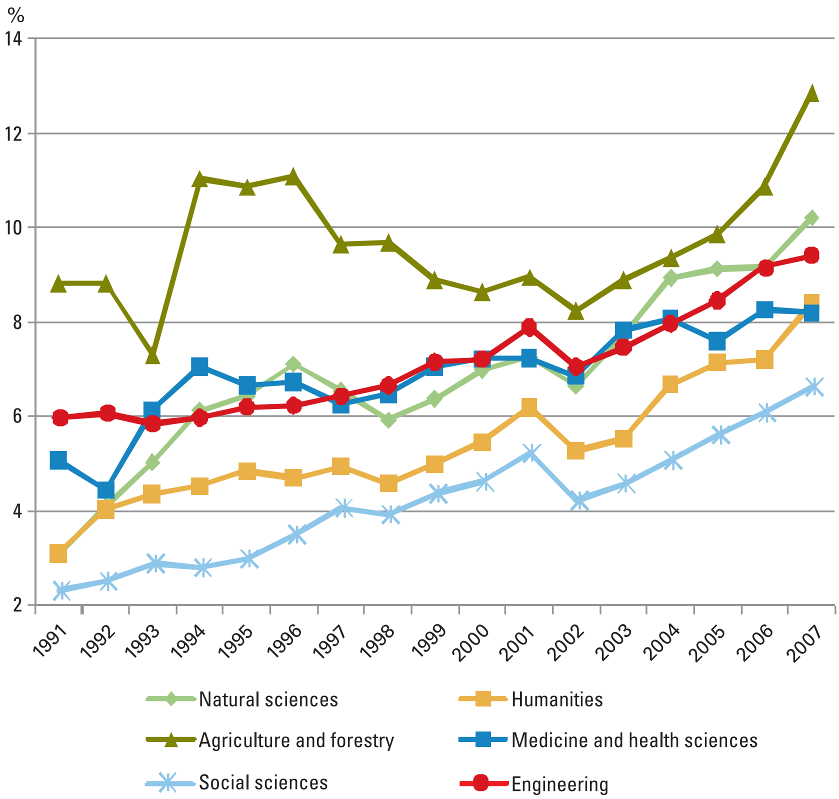


Figure 4.7. Foreign postgraduate students as a proportion of all postgraduate students by field of science 1991–2007. Source: KOTA database.

4.3.3 International scientific publishing

Figure 4.8 shows the development of the number of international publications in 1994–2007, combining all types of publication (articles, articles in edited volumes and monographs). Appendices III.14–19 describe the trends for individual types of publication by fields of science.

In 2007, the highest number of international publications was recorded for the engineering field (4,874 international publications) and the lowest in agriculture and forestry (499). A consistent trend observed for all fields of science is that international publishing has increased over the period from 1994 to 2007.

Figure 4.9 describes the development of international publishing using an index pegged at 100 in the base year 1994. The index describes the relative change in the volume of international publications. The index for the total number of international publications in 1995 is determined as the ratio of the total number of publications in 1995 to the number of publication in the base year (1994) etc.

As we can see, international publishing has increased across the board in 1994–2007. The biggest increase is recorded for the social sciences (167%), followed by the engineering (up 122%). In the humanities the number of international publications has increased by 59% and in the natural sciences by 54%. The lowest increase in the number of international publications is found for medicine and health sciences at 10%.

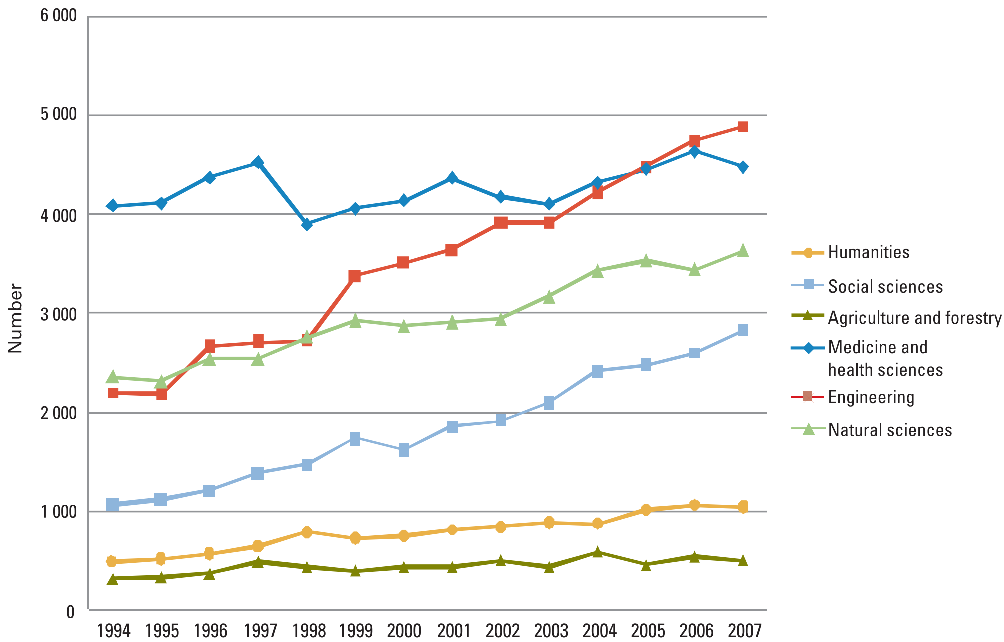
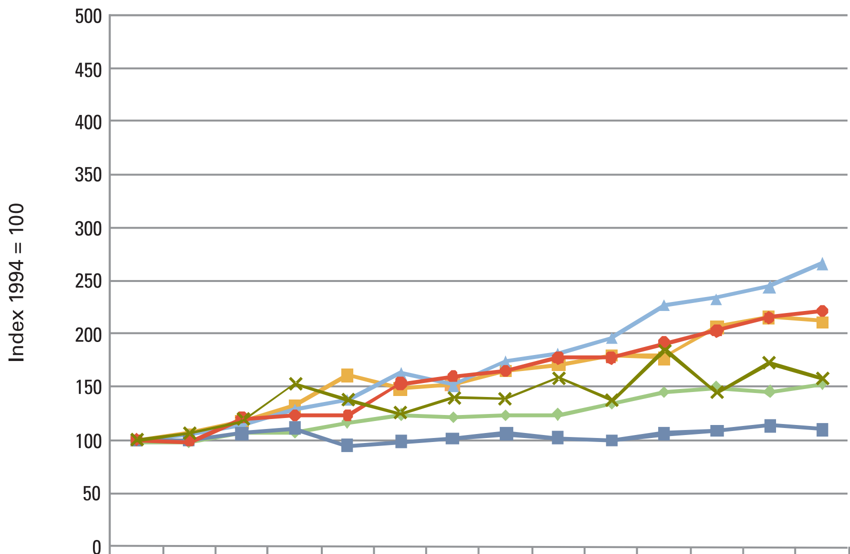


Figure 4.8. Summary of international scientific publishing. Source: KOTA database.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Natural sciences	100	98	108	108	117	124	122	124	125	134	146	150	146	154
Humanities	100	106	117	132	161	148	154	166	172	180	178	207	216	212
Social sciences	100	105	114	129	139	164	152	174	181	197	228	233	245	267
Agriculture and forestry	100	106	118	154	139	126	140	139	158	139	186	146	173	159
Medicine and health sciences	100	101	107	111	95	99	101	107	102	100	106	109	114	110
Engineering	100	99	121	123	124	154	160	166	178	178	192	204	216	222

Figure 4.9. International publications by field of science (index 1994=100). Source: KOTA database.

However, it is noteworthy that in these latter fields Finland has long performed at a very high level in comparison with the small size of the country, and therefore there has been less scope for further growth.

No bibliometric analyses were conducted for this research. However, various sources are available on international scientific publishing in Finland. Figure 4.10 shows the number of Finnish scientific publications as a proportion of total EU25 and OECD publications as well as the total number of Finnish publications in 1985–2005. It is noteworthy that both the number of Finnish publications and their share of EU25 and OECD publications have increased.

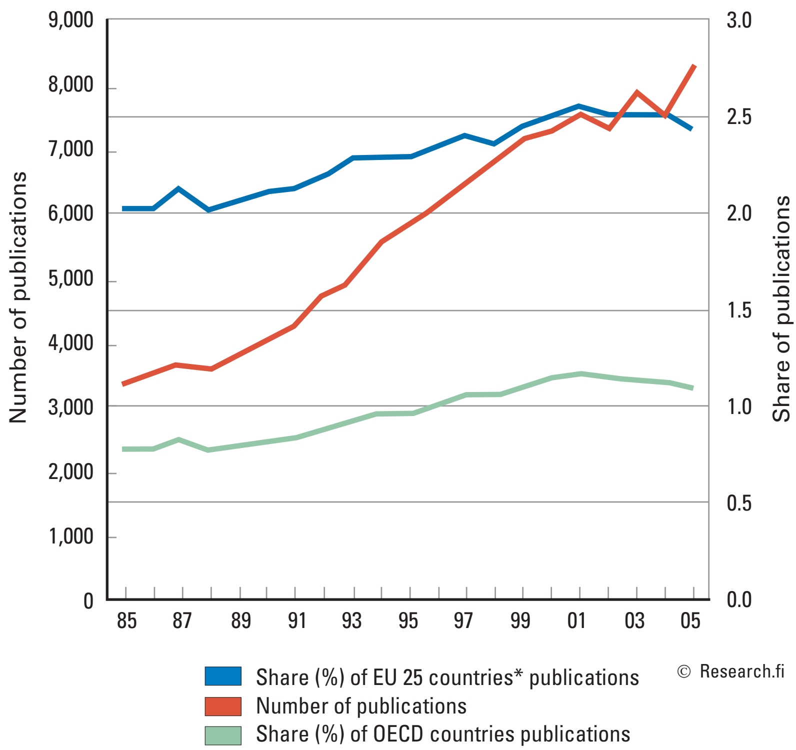


Figure 4.10. Finnish scientific publications as a proportion of EU25 and OECD publications and number of Finnish publications in 1985–2005. Figure: www.research.fi. Original source: Thomson Scientific, NSI 1981–2005.

4.3.4 Foreign funding

Figure 4.11 describes the development of foreign funding for scientific research in 1999–2007, combining the figures for monies secured by universities from EU sources, foreign companies and other foreign sources. The Figure does not take into account changes in the value of money. Appendices III.20–25 show the shares of different foreign funding sources by field of science.

The field of science that currently receives the most funding from foreign sources is engineering. In 2007 this field secured a total of close to 18.5 million euros in foreign funding. The figure is lowest in agriculture and forestry at just over one million euros.

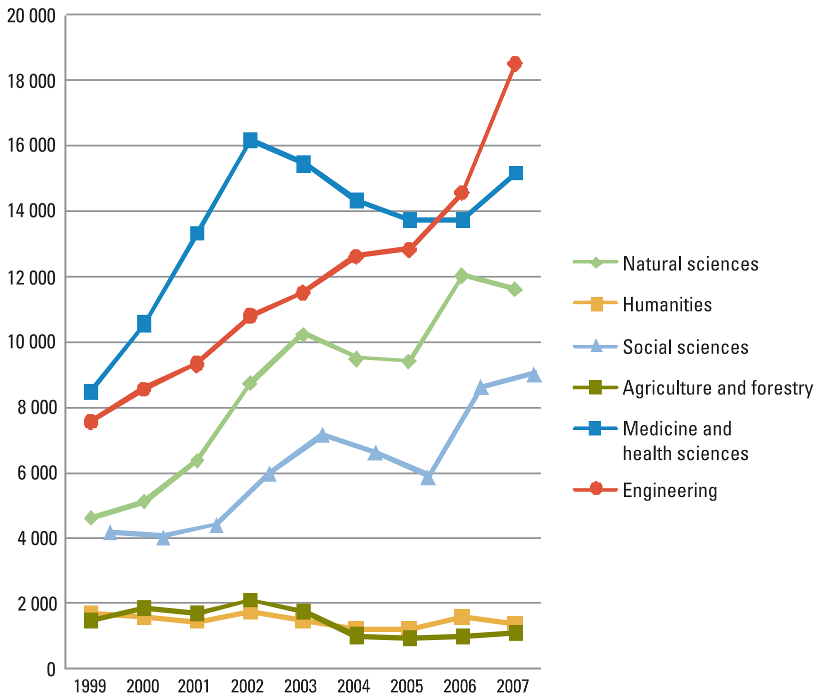
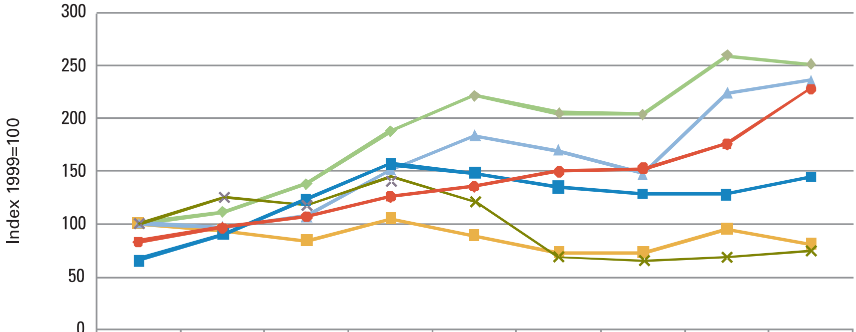


Figure 4.11. Foreign funding by field of science in 1999–2007 (thousand euros). Source: KOTA database.

Figure 4.12 illustrates the development of international research funding using an index pegged to 100 for the base year 1999. The index for the combined amount of foreign funding in 1999 is determined as the ratio of funding in 2000 to the corresponding amount of funding in the base year (1999) etc.

In relative terms foreign funding has increased most of all in the natural sciences. In 1999–2007 foreign funding for the natural sciences was up by 150%. Strong growth has also been recorded in engineering and technology (144%) and in the social sciences (135%). The figure for medicine and health sciences has increased by 79%. On the other hand, foreign funding for both agriculture and forestry and the humanities has declined during the period under review. International funding for the humanities has dropped by 1% since 1999 and for agriculture and forestry by as much as 25%.



	1999	2000	2001	2002	2003	2004	2005	2006	2007
Natural sciences	100	111	138	188	221	204	203	259	250
Humanities	100	94	84	104	89	73	73	95	81
Social sciences	100	96	107	151	183	169	147	224	235
Agriculture and forestry	100	126	117	144	120	70	65	68	75
Medicine and health sciences	100	124	157	191	182	169	162	162	179
Engineering	100	113	123	143	152	167	169	192	244

Figure 4.12. Development of international funding for different fields of science, index 1999=100. Source: KOTA database.

5 Processes of scientific research: How have they changed?

This Chapter looks at how the internationalisation of scientific research and its processes have changed in the light of the interviews conducted for this research. The discussion is organised around the three key themes of the research system, mobility and publishing, which are given separate treatment. However, it is important to bear in mind that these themes are closely interwoven.

For purposes of analysing processes of internationalisation in scientific research it is crucial first of all to exclude from the scope of that analysis the internationalisation of the university system in general or university education. There is a considerable abundance of earlier research on the general internationalisation of universities, and because of the intricate interweaving of various related phenomena it is sometimes difficult and indeed impossible to pull the different strands apart.[32] Scientific research is also conducted in research institutes, where the distinction between basic and applied research is hard to draw.

In Chapter 4 we showed that, generally speaking, international engagement has increased in volume terms. This is explained in part by the growing number of scientists and researchers. Our interviewees are unanimous in their view that international engagement as such, its modes and quality have become a well-established, routine aspect of research.

It was pointed out in the interviews that Finnish scientists and researchers are increasingly involved in international research at the leading edge. Although the processes of internationalisation in general have changed significantly during the present decade, there remains much variation between individual disciplines. The Tables in Chapter 4 confirm the view expressed by the interviewees that the humanities and social sciences have been slower to internationalise than the natural sciences – or in other words that the natural sciences have internationalised earlier. However, the interviewees also pointed out that the need for internationalisation is definitely recognised in the humanities and that things are changing very quickly.

One key factor that has greatly facilitated cooperation and collaboration over the past couple of decades is the phenomenal development of information technology and communication. The improved international skills and competencies of new generations of scientists and researchers must not be overlooked either.

"Scientists today are much better prepared and equipped for international collaboration. I suspect part of the credit goes to the inputs at lower levels of education, to student exchange years at upper secondary level and at universities. And CIMO has of course done its own share."

32 For a fresh angle on internationalisation from the university point of view, see Hoffman and Välimaa (2008).

5.1 Changes in the research system

The changes seen in the overall volume of international engagement can in part be explained by reference to pressures of structural change in the science and research system. In the 1980s there was much concern in Finland about the low number and high average age (around 40 years) of graduating PhDs in the country. These concerns prompted various science policy reforms and led to an increase in science funding. Crucially for the sustained development of the science and research system, public investment in research increased despite the recession of the early 1990s.

The internationalisation of research became a national science policy priority in the 1980s. The main argument and justification was to improve the nation's scientific and economic competitiveness. In all its reviews since 1973, the Research and Innovation Council (formerly the Science and Technology Policy Council) has consistently pointed out that international competition is continuing to intensify and that the only way to keep up with the competition is through investment in science and research.[33] Recently the emphasis has shifted increasingly to the requirements of adjusting to the challenges of globalisation. Since Finland produces only a small part of all the new information in the world, it is considered crucial that this information and new research results can be accessed through international cooperation.[34]

Our interviews for this research revealed that various political and funding structures have changed to such an extent that the overall environment for international engagement is different from the 1990s. There is much more encouragement for international engagement than before. Funding is also more readily available, given the growing recognition of the added value generated by international cooperation. Examples set by peers are also much more readily available than before.

New domestic funding sources have emerged and at the same time the amount of international funding available has increased. Scientists and researchers have improved personal skills and competencies, which is crucial to success in foreign competition. Funding has increased in terms of both overall volume and allocations to individual projects. Nowadays funding is provided even for very major research consortia, which contributes to increased networking.

The growth of joint European funding has also brought an increase in various common pot funding schemes.[35] In a true common pot funding scheme, funds allocated by one participating country may go to a research team based in another country. The risk for the funding agency, therefore, is that it may end up supporting research work carried out elsewhere, without gaining any immediate benefit. In more general terms, a major overarching benefit of this principle is that it supports the development of joint funding mechanisms and the ERA, for instance – although in a national context the focus may be inclined to turn to questions of R&D policy and to responsibilities to the country's own taxpayers.

33 The situation up to the year 2000 is addressed by Eela (2001). The same principle has continued during the 2000s.

34 Science and Technology Policy Council (1996); Science and Technology Policy Council (2003).

35 In a common pot scheme each participating country contributes to the common pot and funding is awarded from that pot to the most promising projects.

Apart from global research cooperation and collaborations within the EU, the interviewees also made repeated reference to Nordic cooperation. EU Framework Programmes have detracted much attention from Nordic cooperation, but there is growing awareness now of the strategic importance of cooperation in Nordic regions. Nordic funding and research cooperation is said to have increased in recent years, particularly in the fields of culture and social sciences.

Our interviewees are the most outspoken in their criticism against the slow renewal of the university system, which they say has failed to provide adequate resources and to motivate its researchers to apply for international funding. The situation is thought to be the worst in the humanities and social sciences. On the other hand, it is pointed out that international publications and contacts carry increasing weight in appointments to university posts.[36]

It is widely felt that graduate schools have great potential in promoting internationalisation. At the same time, though, there is prevailing opinion that they have not shown strong enough international commitment. At least they have nothing else to show for their efforts at internationalisation than their own statistics. It is possible, therefore, that the difficulty lies simply in inadequate national data collection.

The Academy of Finland has worked hard to promote the internationalisation of science and research, as has the Finnish Funding Agency for Technology and Innovation Tekes. Tekes has contributed significantly to the closer convergence of public sector research and private business sector R&D.

The Academy has invested heavily in promoting the internationalisation of science and research since the 1980s. Today the Academy has national responsibility for maintaining contact with various international science organisations. It has also worked consistently to develop its funding instruments. For purposes of assessment it has pioneered the international peer review, which is now firmly in place as standard practice and which has contributed significantly to raising the quality of scientific research. The method has been widely adopted by other agencies as well.

In the 1990s, the Academy's funding instruments for the promotion of mobility were highly significant and influential, but the volume and significance of dedicated mobility funding is now on the decline. Instead, mobility is promoted as an integral part of all Academy-funded research projects. The Academy also gives preference in its funding decisions to internationally merited scientists and researchers. The Academy's 2003 research programme strategy[37] has significantly bolstered the internationalisation of its research programmes. All in all, since the turn of the decade, the Academy has moved towards a more structural approach to supporting and promoting internationalisation, giving equal weight to all fields of science. In 2002, the Academy's new international strategy[38] provided strong direction for the development of the agency's operation, backed by the full commitment of its management team. One good example is provided by the greater emphasis given to international activities in the Academy's application process. The joint effort with Tekes to launch the FiDiPro funding programme is another important step that underscores the importance of high-quality international cooperation.

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36 Hakala et al. (2003).

37 Academy of Finland (2003b).

38 Academy of Finland (2002).

Finland's decision to join the European Union in 1995 also opened the door to EU framework programmes for research. In many fields of science this marked an opening of new international funding opportunities. Research projects administered under framework programmes always involve research organisations from several different countries. This has increased the need to network and to find new European partners in cooperation. Projects are selected with a view to high quality, and at the same time they are expected to generate added value – which in practice means better and closer cooperation. The enlargement of the European Union has further increased opportunities for cooperation. The European Research Area ERA is an important new tool in the drive to promote networking and cooperation.[39] From a Finnish perspective the ERA is also opening up exciting new opportunities in relation to the EU northern dimension, neighbouring areas and intensified Nordic cooperation.[40]

The EU's Fourth Framework Programme (FP4, 1994–1998) was the first programme to which Finnish scientists and researchers contributed as full EU members; earlier participations since 1987 were always through special agreement. The Finnish Secretariat for EU R&D was established in 1992. With the entry into force of the EEA Agreement in 1994, Finnish participants gained almost equal footing with those from full EU Member States.

The number of Finnish participations increased sharply in FP4, as soon as Finland had joined the EU. In the subsequent programmes FP5 and FP6, the number of participations has decreased (Figure 5.1), but the overall volume of funding has nonetheless increased. In other words the size of research projects has grown.[41]

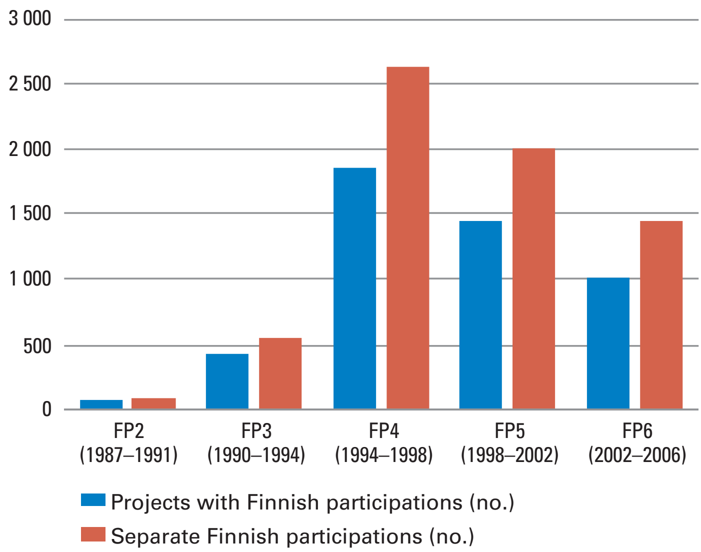

Figure 5.1. Finnish participations in EU framework programmes in 1987–2006 (FP2 = Second Framework Programme etc.).

39 EU Commission (2000).
40 Science and Technology Policy Council (2003).
41 Kuitunen et al. (2008).

Scientific research accounts for only part of the work that is done in EU framework programmes; in fact most of the funding through these programmes goes to applied research with close ties to business R&D, particularly to technical research. Scientists and researchers who have received the most funding support say that EU projects, despite expectations to the contrary, are not normally at the leading edge of science.[42] It is hard to generate genuinely new knowledge in these projects because they have to work within such closely defined parameters. However, they do have an important role to play in terms of international networking, and for some groups the funding secured from these sources is crucial. One of the benefits of EU funding is that it was supposed to pave the way to collaboration with southern European countries. A common complaint about framework programme funding is the amount of red tape involved.

One noteworthy aspect of EU research and science funding is the creation of the European Research Council (ERC). The goals of ERC research funding are defined in quite general terms, that is, to raise the quality of European research and to strengthen the global competitiveness of Europe. Projects funded are selected on the basis of scientific quality, and they involve researcher-driven scientific research that is carried out in high-quality research teams.

Our interviewees made the strong point that receipt of ERC funding is a mark of international recognition to the national research system. In this sense it serves as recognition of the quality of research and in itself enhances its impact. Indeed, every country that had success with its ERC funding applications is keen to advertise that success.[43] It emerged in our interviews that in many countries, shortlisted applications that remain without ERC funding are eventually supported from national sources.

In the longer term, science and research are also very much impacted by the national education system and its changes. Higher education in Finland has changed quite considerably since Finnish universities joined European collaboration structures. Finland has been among the first EU members to implement higher education reforms under the Bologna process, which is aimed at creating a European higher education area.

The science policy background outlined at the start of this section is complemented by the Government's resolution of 2005. This decision says that future efforts to develop the research system will be geared first and foremost to enhancing the quality and relevance of research and development. Another key objective is the internationalisation of education, research and innovation.[44] "Global development, the formation of the European Research Area and the intensification of Baltic cooperation require that special attention is given at all levels to international science and technology cooperation."

In the future it is important that Nordic cooperation be stepped up across the board. Indeed, this cooperation has been deepening both in research and in research funding. Nordforsk, the Nordic Research Board has taken on a more prominent role in developing this cooperation. All in all, international alliances among research

42 Ahonen et al. (2008).

43 See e.g. the German Research Foundation (DFG) brochure The Path to ERC Grants: Researchers in Germany Excel. http://www.dfg.de/internationales/europa/foerderung/erc/download/path_to_erc_grants_en.pdf.

44 Council of State (2005).

funding bodies are bound to increase. Another growing trend of international engagement is the integration of scientific research with development cooperation. Funding arrangements are already in place with the Ministry for Foreign Affairs in which scientific projects are more closely committed to developing countries. Science policy is set to gain increasing significance and within the field of science policy so too will international engagement.

5.2 Development of mobility

One of the simplest forms of international engagement is to participate in international meetings and seminars. This will usually require the ability to publish one's results and to exchange views on the international arena. Research cooperation proper, then, requires even greater commitment to collaboration, more resources and regular mutual visits. As described in Chapter 3, mobility can assume a wide range of different forms, both in terms of quantity, quality and duration. The definition and measurement of mobility is a particularly difficult challenge. For instance, there is no single and unambiguous definition for the shortest possible duration of a visit that should be counted as mobility. As a rule, visits lasting less than one month are generally considered short, while visits longer than one month are long.

Researcher mobility, as defined and understood in the context of science policy, typically refers to longer-term visits, and it may involve the provision of job opportunities and support for housing in the country of destination. This view is reflected for instance in various mobility portals, which in themselves are a modern form of communication.[45]

A number of funding mechanisms are available in Finland both for purposes of foreign visits and for bringing foreign researchers into Finland. Mobility funding and information is also available through the EU. The EU supports the mobility of researchers by striving to eliminate administrative and cultural obstacles. Information on research opportunities is provided through specific press releases and portals.

The diversity of possible definitions for mobility was clearly highlighted both in the expert interviews and in the workshop organised for this research. Even very short, one-day visits were considered a form of mobility. It emerged that researcher visits are getting ever shorter, or at least that the number of short visits is continuing to grow. Earlier, the thinking used to be that the international scientific career kicked off with a postdoc appointment lasting 1–2 years. Nowadays, however, increasing numbers of shorter visits are made even during the PhD thesis process. Indeed a major change in patterns of mobility is that this is now started at a younger age, at an earlier stage of the research career. It is very difficult and expensive to keep track of this kind of often informal activity.

The interview material collected for this research confirmed our assumption (which was discussed briefly in Chapter 3) about the growth of informal and invisible cooperation. For example, it is common practice at international conferences to try and seek out new partners for cooperation. This is true most particularly for more

45 A Google search with the term "researcher's mobility portal" produced almost 25,000 hits. Examples include http://ec.europa.eu/euraxess (European Commission – EURAXESS Jobs Portal) and www.aka.fi/eracareers (The Researchers Mobility Portal Finland).

experienced scholars, but ever younger researchers are now seizing this same opportunity. While travelling to conferences, scientists may visit their foreign partners to agree on the dispatch of materials or samples. Professors cannot stay abroad for long periods, but new ideas on research cooperation can be rolled out during visits lasting no more than a few hours. In other words, even very short visits can be highly productive, yet it is impossible to produce meaningful national statistics.

The picture emerging from the interviews about the research career and long-term visits during the early stages of the research career is somewhat divided. Some interviewees say that in previous decades, funding for foreign visits came from abroad and that exchange years spent abroad were essential for a successful career (*"Two years at MIT guaranteed a good career on return to Finland."*), but nowadays mobility is no longer necessary or may not even benefit one's career at home. Others, however, said that mobility, as we know it today, did not even exist before, but nowadays it is impossible to have a research career without international engagement.

"It's impossible to get young people to go anywhere any more. Earlier if you wanted to be a professor there was no two ways about it, you had to go abroad. Publications grow out of these contacts. But in a sense we're now more international today."

Planning for personal research careers and family considerations, for instance, have emerged as important obstacles to mobility.[46] A long-term research visit to a foreign country may not necessarily have the desired career-promoting effect, but on the contrary it may present a risk to both career prospects and personal finances. This is the feeling especially at universities. At research institutes it is apparently easier to encourage postdoc visits abroad by guaranteeing employment on return.

The diversity of our respondents' personal experiences and perspectives added depth and diversity to the range of responses received. Our interviews gave further strength to the assumption that there are differences not only between but also within different fields of science, but it is extremely difficult to nail down those differences.

As regards the motives for mobility, it emerged from the interviews that exchange through international engagement takes place on more equal grounds than before. Earlier, movement from Finland to other countries was motivated by the search for new information and expertise. For teams at the cutting edge of science, research collaboration has always been of paramount importance. Even greater weight is attached to quality. Funding bodies, for instance, seem to have little interest in anything other than research at the very sharpest edge. The same is evident among scientists and researchers: "You have to keep an eye on where people are going." Scientific tourism is not tolerated.

Finland seems to have greater difficulty than many other countries attracting students and higher educated groups.[47] This was not an issue specifically addressed in the interviews. Nonetheless it is clear that the quality standards of scientific research can only be raised through successful recruitment of top-level foreign researchers and through long-term visits. One priority challenge is indeed to make Finland a more attractive option and to remove the obstacles to getting these people in.

46 The family issue, for Finnish scientists and researchers, is also raised in a recent OECD report, see OECD (2008).

47 E.g. OECD (2008).

Text Box 5.1. **EU 7FP: Marie Curie Action of the People Programme**

Budget: 4.7 billion euros (2007–2013)

Marie Curie Actions to support researcher training and mobility are funded through the EU 7FP People Programme. Marie Curie funding is provided for the training of early stage researchers, career development, researcher mobility between industry and academia, international researcher mobility and a few specific support measures designed to promote research careers in Europe.

5.3 Publishing

It is difficult to overstate the importance of international publishing to research teams or indeed to individual research careers. As the old adage goes, it is a matter of "publish or perish". Within the field of science and research itself, the quality of research is largely assessed by reference to the volume of publications, and to an increasing extent by reference to the quality of publications. The evidence from this research indicates that publications remain a vital aspect of the development of internationalisation. This is an area for which monitoring tools and mechanisms are well established and on which information is consequently readily available.

On the other hand, the number of publications is continuing to rise sharply throughout the world. Part of the reason for this lies in the growing trend of publishing in article format. Indeed, the number of publications produced by individual researchers does not in itself provide a reliable indicator of the quality of their work. It would be important to be able to make quality comparisons between different publications, but there is no consensus on the methods with which this could be done. In particular, comparisons between different fields of science are highly problematic. One measure for the standard of publications is the impact factor, which remains in common use despite widely reported problems.[48] The number of citations to individual scientific articles is a common and well-accepted measure of the scientific impact of publications.

Other key forms of international engagement, i.e. international researcher mobility and international research funding, are also expected to generate scientific impacts in the form of publications. In this connection scientific publishing serves as a measure of quality at least in the sense that publications. There is no justification to invest scarce resources in international scientific activity without documented scientific results.

The global number of scientific publications is continuing steadily to increase. Chapter 4 gave some publication statistics to illustrate growth rates in individual fields of science in the context of the internationalisation of Finnish science and research. As we saw, the volume of publications by Finnish scientists and researchers on international arenas is growing, but it is useful to compare these figures with the proportions recorded for other countries. Figure 4.10 showed the number of Finnish scientific publications as a proportion of EU25 and OECD publications as well as the total number of Finnish publications in 1985–2005. Over the past 20 years, Finland's share of total world publications has increased.

48 Stenius (2003).

A question of growing interest in the future concerns the partners with which Finland will have cooperation. There is even an interest to get the organisational level involved. At the same time, there is a perceived need to assess the quality of publications by means of citation analysis.

5.4 Motives for networking and cooperation

Our interviewees were very clear in stressing that internationalisation must not be seen as a value in itself. It is crucial to bear in mind that it is just a tool to achieve higher standards of scientific quality. The primary objective must always be high-quality research.

"As I said, international activity today describes the quality of science, and that's what we want to do, high-quality science, so you have to be as international as possible."

The ongoing revolution in the methods of communication and contact has brought about an important change in the shape of the globalisation of science. The cycles of science have accelerated, too, with publications both appearing and losing their currency more rapidly than before.

Previously, international engagement was largely a channel for the exchange of scientific information. Nowadays, cooperation is widely seen as a basic tool of scientific research. Many of our interviewees drew attention to the trend that the vast majority of research teams today are ever more closely involved in international activities.

Specific needs and interests are often different in different fields of science. In some of these fields the progress of internationalisation has been extremely rapid. In medicine, engineering and the natural sciences it is crucial to reach and remain at the international cutting edge. In other fields the needs for internationalisation are less pressing, and consequently the social sciences and humanities, for instance, have joined up later.

The language of natural sciences (mathematics, physics, chemistry, etc.) is always universal. In these fields there are much fewer obstacles to international engagement. Yet it is essential even for scholars in the humanities to keep abreast of international trends. It is important to bear in mind that regardless of the field of science, all leading researchers have always been international, even though some of their work is grounded in national interests.

In some fields of science the motive for collaboration lies in the high costs of research. These fields have internationalised to a greater extent than others. A good example is provided by physics and the establishment in this field of CERN, the European Organization for Nuclear Research. Through CERN, not only physics but by all accounts the natural sciences more generally have been exposed to heavy influences of internationalisation. The sheer size of these infrastructures has changed ways of doing things, but at the same time it has resulted in international funding being exclusively targeted to specific segments.

The drivers of change vary widely between different fields of science and direct comparisons are extremely difficult. Even within individual fields there are often marked differences, and some fields of science are very firmly grounded in national interests. Generally, however, there is a degree of interdependence and in all fields of study it is crucial to keep up to date with methodological developments. Joint research programmes are one way of increasing international exchange and cooperation in any field of science. ERA-NET actions and the calls opened under the ERA-NET umbrella are a good example of how grassroots activity always grows out of the desire for cooperation and out of the presence of network funding.

Other drivers of change mentioned by our interviewees were the growth of competition in international activities and the growth of personal rewards. However, the material collected here does not in itself warrant the conclusion that these drivers have any significant impact on internationalisation.

Previously, scientific research used to be more researcher-driven; the initiatives came from individual researchers and their networks. Many of our interviewees expressed the view that this situation has changed and that activities are increasingly steered by various strategies. Examples mentioned included the strategies of internationalisation adopted by universities and research funding agencies.

As far as research structures are concerned, policy direction is considered particularly significant for the promotion of national interests. However, the motives behind this policy direction are often considered unclear. Earlier we referred to the motive of ensuring the quality of research results, and the same applies at the system level. Public decision-making supports international engagement with a view to assuring the highest possible quality standards.

Apart from policy direction, another driver of change mentioned by our interviewees is the internationalisation of capitals, which in Finnish business companies has led to operational expansion beyond national boundaries.

The internationalisation of research became a major science policy priority in the 1980s. Finnish scientists and researchers gained access to a large number of new research networks as decisions were announced to join various international organisations, including the European Science Foundation (ESF) in 1980[49], the European Molecular Biology Laboratory (EMBL) in 1984[50], EUREKA in 1985[51], the European Space Agency (ESA) in 1987[52] and the European Organization for Nuclear Research CERN[53] in 1991.

There is broad consensus among Finnish experts that funding issues are a major driver of change. Joint programmes are one key means of strategic direction. In particular, the Academy of Finland has heavily emphasised the requirement of international cooperation in its research programmes, which according to the interviewees has had a very strong steering influence.

49 www.esf.org

50 http://www.embl.org

51 EUREKA was established in 1985 as a European network of market-oriented, industry-driven research and product development: its aim is to develop products, processes and services for the global marketplace. http://www.tekes.fi/kv_yhteistyo/eureka/eureka.html

52 http://www.esa.int/esaCP/Finland.html

53 http://public.web.cern.ch/Public/Welcome.html

Another motive for international cooperation is to secure commercial competitive edge. Sometimes the resources available nationally are simply inadequate to resolve the problems faced. A technical or economic competitive advantage may be gained simply through involvement in leading-edge research networks and through access to new results at as early a stage as possible. For a technology company the only viable option may be to join a top-class network. In principle, the only motive for business companies to follow and conduct research is to improve their competitiveness.

For research institutes, the most natural partners in cooperation are corresponding national institutes from other countries. There are various mechanisms of cooperation among these institutes, sometimes even dedicated secretariats. Research institutes are driven to internationalisation, in part, by the European harmonisation of public authorities for instance in data collection. At the same time, research institutes are continuing to pursue the objective of creating a European Research Area.

5.5 Other future changes

It is the inevitable fate of small countries that they must constantly keep a close eye on what is happening elsewhere in the world. Indeed, international engagement is set to continue to grow and become more commonplace. This must not be seen as a discrete endeavour, but on the contrary as an integral part of everyday science and research. In business and industry the same changes and the same evolution towards internationalisation started some 15 years ago, but science and research are only just starting out on this road.

The globalisation of science further underscores the importance of quality. It is possible that input-output thinking will evolve and expand. International exchange has served as a measure of the quality of science, but the problem is that there are so many mediocre universities and research institutes in the world. Sometimes the investments and inputs may be dedicated to the development of strategic partnerships rather than science, but that may be perfectly justified. However, in this case it is paramount that decision-making is pronouncedly deliberate and conscious.

It is expected that science cooperation will continue to expand with Russia, China and India, all emerging countries with huge and diverse potential. Australia and the UK are also mentioned frequently, particularly as likely partners in the field of medicine. South America and Africa will probably gain increasing significance. It is thought that the role of the United States will decline or remain unchanged.

It is believed that in the wake of globalisation, the Nordic countries will work more closely in a united front particularly in relation to China, India and other Asian countries. In general, various kinds of mega-networks are set to increase, both within individual fields of science and in different clusters. On the other hand, it is pointed out that the involvement of the EU, for instance, is not necessarily needed, but countries or regions can just as well represent themselves vis-à-vis more remote partners in cooperation. Bilateral cooperation is set to increase as well.

In individual research projects, international exchange will increase and become more diversified. Greater emphasis will be placed on pragmatic interests, i.e. cooperation must yield genuine added value. Various ranking lists will gain increasing importance as quality criteria. The number of units at the very cutting edge will continue to decrease, and it will become more and more difficult to maintain one's position at the top because of tougher competition. The cycles of science and research will continue to get shorter.

Experts and management team members will become increasingly international in their practices. The background of doctoral thesis reviewers provides a good indication of how international a certain field of science has become. In the humanities opponents are still mainly Finnish, but this is expected slowly to change. In the future it will still be necessary to conduct separate evaluations for separate fields. In all fields of science an important way of promoting internationalisation is through doctoral training.

Physical detachment and independence of the geographical location of infrastructures will increase. The same databases will be used the world over by growing numbers of teleworkers. As scientific problems continue to become more complex, so project groups will become bigger and clusters will be formed. At the same time, transdisciplinary projects will increase. Wikipedia-type solutions will gain in popularity. Information technology and infrastructure in general will continue to develop.

Text Box 5.2.
Interviewees' comments and proposals to science and technology funding bodies on how to support the internationalisation of research

Funding agencies must listen with a keen ear the researchers. They have to respond proactively to the needs out in the field and to changes happening in their environment. Internationalisation strategies have to state clearly their priorities, what they want to achieve.

Flexible incentives are needed to promote international exchange, some sort of intermediate forms to existing ones. Funding today is rather short-term and often haphazard.

Funding instruments for returning scholars and the mobility of Finnish scientists and researchers need to be considered broadly. It's essential that researchers returning to Finland can get their life sorted out. All in all, structural issues present quite a barrier and anyone who's thinking of leaving is faced with financial question marks. Host universities and research organisations are in a crucial position.

As far as funding applications are concerned, CVs should be brought under national data collection. If CVs were in standard format, that would facilitate comparisons enormously. This should be done electronically. One option might be to insist that CVs are submitted in EU format.

With regard to foreign researchers arriving in Finland there are major issues where obstacles need to be removed and integration must be promoted (taxation, social conditions, xenophobia, requirements of Nordic family life).

Funding agencies need to make sure that international activity does not remain hidden simply because publishable end-trails of research remain hidden in the absence of adequate funding.

International alliances will continue to proliferate and we need to have our say in them. It's also necessary to consider what we can afford to get involved in, given the resources available. It's important to take proactive international initiatives.

Monitoring of the resources made available to funding agencies and related statistics must be comprehensive for the part of international activities. Monitoring of networks must be targeted on specific focus areas. At the European level national monitoring is appropriate, but in the case of China, for instance, more background information is needed. The monitoring must cover the strengths and focal areas in different countries. Bibliometric comparisons alone are not enough.

International engagement must be incorporated as an everyday part of the work of funding experts and units. Funding organisations must be actively involved in the effort to make them an integral part of the official picture of Finland.

6 Indicators of inter-nationalisation

6.1 Existing data sources and indicators

The experts we interviewed for this research were unanimous in their emphasis on three basic aspects in the measurement of internationalisation. It was also expected that these three aspects will continue to remain the main focus of measurement: 1) scientific publications co-authored with international partners and published in international series; 2) international visits and mobility; and 3) research funding from foreign and international sources. Almost all interviewees also agreed that measurements of internationalisation called for a stronger qualitative element. At least from a validation point of view it would be interesting to know whether qualitative and quantitative indicators differ in terms of the end result.

"It's often forgotten what exactly lies behind the figures. It would be important to develop qualitative indicators, too."

"What we're measuring now are certainly the right things, but we'd need more. We'd need more substance. It would be good to measure input-output ratios and aspects of impact."

"Indicators always lag somewhat behind, but it would be important to develop qualitative indicators. We'd need to have more qualitative criteria for follow-up purposes."

International publications are widely considered an important, perhaps the most important indicator of internationalisation. However, the number of international publications is increasing all the time. The measurement of numbers alone is simply not enough. Increasing effort is now being made to monitor networking through publications, using bibliometric methods to identify typical partners in cooperation. Likewise, publication numbers are increasingly monitored now by field of science, which can also be linked with analyses of networking with researchers in specific countries. Based on our interviews it seems that Finland's areas of strength are of specific interest to various audiences.

It is possible to extract a whole range of indicators from the existing statistical sources on publication numbers. An example is provided by Figure 4.10, which showed the number of Finnish publications as a proportion of total world publications. Similarly, statistics can be compiled on publication numbers per capita or per number of researchers, etc. There is a growing trend now for assessments to be conducted of the quality of publications and to integrate these assessments with statistical data. One way of assessing the quality of outputs and media is by using impact factors, although this has also received some criticism.[54] Various derived characteristics are presented in numerous reviews of publication numbers, research systems and human resources in science and technology. The challenge, however, is

54 See also Stenius (2003).

that the indicators currently in use hardly ever incorporate determinants specifically related to internationalisation. Typically, comparisons are made between national datasets that do not contain any specific references to international activities.[55]

Indicators of various types of research visits, including more permanent migration, are widely considered outdated (if indeed they exist at all), even though they are key aspects of internationalisation. The nature of mobility has very much changed over time and it would be important to have mechanisms in place to monitor even short-term visits and to consider mobility in the broader context of the researcher's career. The impact of this indicator should be given close thought.

"There has been a systematic effort to recruit competent people from a foreign background. The number of these people and their country of origin are real indicators."

"The data we collect in Finland for (mobility) indicators is surprisingly weak."

Apart from research visits, another important indicator is the number of professorial visits to and from Finland. In this and in other mobility contexts, the general sense among our interviewees was that it is necessary to monitor short and even ultra-short visits. The KOTA database was mentioned as an important source on mobility. High expectations were placed on the new Science KOTA database that is currently under development. However, the data burden placed by the current system of data collection for the KOTA database on individual researchers is considered problematic. The database does not cover the contribution of scientists and researchers moving out of academia or those moving to other countries, which especially in the field of medicine is high. The classifications used for the duration of visits in the KOTA database are considered outdated: for a professor, for instance, three months is very long time to spend abroad.

The third indicator of internationalisation highlighted in the interviews is international funding. This consists of research funding from foreign and international sources as well as Finnish funding instruments for international mobility and cooperation. Funding bodies have not systematically collected funding data related to internationalisation. Bilateral agreements are an indication of active international involvement, but it would be more important to know what exactly has been achieved through these agreements.

Research funding secured from certain prestigious foreign and international sources is considered in itself an indication of high-quality research. In this instance the receipt of funding can itself be considered indicative of impact. An example of such a prestigious, high-quality source of funding is the European Research Council (ERC), which was discussed earlier in Chapter 5.

The task of developing commensurate indicators is highly challenging, and any such indicators must be viewed critically. The experts interviewed for this research were not aware of any basket of indicators used for the measurement of changes in internationalisation. Measures focusing on international publications, funding and mobility are considered suitable for inclusion in this case. Funding is one aspect that is easy to follow, but this is not necessarily the case with publications and mobility.

55 One might even describe them as employing "OECD type classifications".

Table 6.1 provides an overview of the measures discussed by the experts interviewed for this research, both those that are in current use and those that they would want to see introduced. In some cases separate comment was made about the possibility to carry out measurements separately for individual fields of science.

Table 6.1. Indicators of the internationalisation of scientific research by theme mentioned by the experts interviewed.

ThEME	INDICATOR
International scientific publications	Co-authored international publications*
	Finnish publications in international scientific series*
	Articles published in highly acclaimed international series (*Science, Nature*, etc.) and in other high impact factor series
	Finnish contributions to international conference publications
	Finnish publications as a proportion of all OECD publications
International mobility and visits	Visits by scientists and researchers from Finland
	Visits by scientists and researchers to Finland
	Number of foreign professors in Finland*
	Number of Finnish professors abroad
	Number of foreign postgraduate students in Finland*
	Proportion of foreign researchers in Finland*
	Very short visits abroad
Funding	EU framework programme funding for Finnish participants
	International competitive research funding, e.g. NSF, NIH and ERC funding
	Statistics on peer review activities in connection with the awarding of grants
	Funding for joint international projects
	Participation in international calls
	International collaboration in industrial R&D
Other networking	Number of research partners
	Number of invited lectures
	Bilateral funding agreements
	Working hours invested in international activities

* In total and by field of science.

6.2 International comparison

Sweden

In Sweden, data on the internationalisation of science and research are compiled by Statistics Sweden (SCB)[56]. SCB is Sweden's official statistical agency whose original databases are accessible to fee paying subscribers. In the area of internationalisation, the main data items collected are co-authored publications and mobility. In general, however, trends of internationalisation do not seem to be a major priority in Sweden. Nevertheless, some structures have been so designed that international cooperation in

56 www.scb.se

science and research is promoted. No distinctive national characteristics were seen in the Swedish statistics. Bibliometric analyses of publications by Swedish researchers are published on a regular basis.

The mobility of PhD graduates across borders (in both directions) seems to be a matter of particular interest from a national resources point of view, but apart from its basic data sources SCB does not compile any specific national statistics on mobility. Recently, however, the agency has published a dedicated report on international mobility.[57] EU funding received through EU framework programmes is monitored by a separate office under the Swedish Governmental Agency for Innovation Systems VINNOVA.

The Swedish Research Council (Vetenskapsrådet, VR) uses the international Web of Science to monitor publication data. In addition, VR has recently conducted a questionnaire on the subject of researcher mobility. VINNOVA and SSF (Swedish Foundation for Strategic Research) have similar interests. The VR questionnaire showed a response rate of 60%. The findings show that international activity is very high and that 80–90% of the respondents are engaged in international cooperation.[58]

VR also monitors various international funding statistics. Funding obtained from foreign sources is in itself regarded as an indication of quality. Funding received for an EU project, for instance, is obviously an important merit for any researcher. However, funding received from the VR is considered an even greater merit. The one exception to this rule is ERC funding, which is rated very highly indeed. International cooperation in the context of research programmes is not generally rated as a high priority by VR.

Norway

In Norway, national R&D data are compiled by NIFU-STEP[59] in collaboration with Statistics Norway[60], the country's central statistical office. Norway's R&D statistics are quite comprehensive and cover all sectors and fields of science. They are compiled on a contractual basis, with the work funded by the Research Council of Norway (RCN)[61]. NIFU-STEP reports are based on various standard data collections from universities and research institutes and on specific targeted questionnaires. The national report is published annually and it is the most important data source on all R&D in Norway.[62] This annual NIFU-STEP report also includes data broken down by individual fields of science. Individual fields of science are reviewed separately about once every ten years.

There are no distinctive national characteristics in the Norwegian data collected on internationalisation. The most important indicator of international exchange and collaboration is that of joint international publications. Special interest is given to partners in cooperation, such as the United States and Germany. For example, Norwegian researchers co-authored 1,100 publications with Finnish colleagues in 2007.

57 SCB (2007).
58 Unpublished VR report.
59 www.nifustep.no
60 www.ssb.no
61 www.forskningsradet.no
62 Report on Science & Technology Indicators for Norway 2007. RCN.

RCN compiles its own data on international activities in a separate funding database. In addition, data on funding obtained for purposes of scientific research through EU framework programmes are presented separately. At the European level RCN has been significantly involved in ERA-NET programmes under FP6.

RCN has a good and comprehensive picture of its research funding for international cooperation and for what in Norway is called 'internationalisation'. Apart from international cooperation, internationalisation comprises research that is based on global responsibility and in which Norway is involved as a 'global partner'. Here the main research concern is to try and understand global problems, and the focus is outside Norway's boundaries. Alternatively, the research aim may be to resolve problems in developing countries that do not themselves have the resources to conduct this kind of research.

Policy design and decision-making is supported by RCN's own databases and nationally collected data, in this order.

Netherlands

The national centre for science and technology research in Holland is called the Netherlands Observatory of Science and Technology (NOWT).[63] NOWT also compiles the annual national R&D report.[64] No new indicators of international activity arise from this report, but it is worth noting that figures for co-authored international publications are also grouped by partner countries. During the period from 2003 to 2006, the report mentions a total of 1,355 joint publications with Finnish partners. A major focus in the report is on international R&D comparisons. There are no distinctive national characteristics in the statistical processes or datasets compiled by NOWT, but researcher mobility is mentioned as one specific area of focus.

The Dutch Ministry of Economic Affairs monitors science, technology and innovation policy indicators. In connection with an international comparison of publication numbers, a recent Ministry report offers an interesting comparison of impact factors for selected countries.[65]

The national funding agency for scientific research in Holland is the Netherlands Organisation for Scientific Research (NWO).[66] NWO has a strong international orientation both as an organisation in general and specifically in its funding. There is a clear trend to incorporate international elements in research. However, international exchange and cooperation is not normally given separate consideration in funding reviews, which are exclusively focused on scientific quality and merit. Publication data are followed using international databases such as the ISU.

The NWO keeps close track of the international spending of its funds. Special attention is given to participation in EU framework programmes and to success in international calls. For instance, NWO annual reports highlight the organisation's share of successful applicants in EUROCORES and EURYI calls.[67] National contact

63 www.nowt.nl

64 Science and Technology Indicators 2008. Netherlands Observatory of Science and Technology NOWT.

65 Science, Technology and Innovation in the Netherlands – Policies, facts and figures 2006. Ministry of Economic Affairs.

66 www.nwo.nl

67 NWO Annual Report 2006.

persons (NCP) conduct some analysis of different themes under EU framework programmes. Dutch ministries are also interested in monitoring research funding. International data are collected on some programmes, but not for instance on centre of excellence operations.

Conclusions

The three countries included in our brief international comparison do not seem to give any special consideration to indicators of internationalisation. Nonetheless, the importance of international engagement is clearly appreciated and there is a commitment to promote internationalisation. National science and technology indicator series use the same measures that are widely employed in international comparisons. Our examinations revealed no nationally unique indicators.

The three science funding organisations in these countries – VR, RCN and NWO – all made the point that international exchange and cooperation is not given special emphasis in competition for funding, but the key criterion is scientific quality. It is, however, recognized as a normal, integral part of scientific research. One area that is specially monitored in the funding agencies' own databases is the share of international activity. For science policy purposes, the agencies also monitor international publications (using general international publishing databases), mobility (most specifically the proportion of PhD graduates) and other funding statistics (especially EU framework programmes).

In Sweden, mobility has received special consideration in recent years. Norway has placed special focus on aspects of global responsibility. The Netherlands seemed to be the least interested to give special consideration to questions of internationalisation. International comparisons have figured prominently in national R&D indicator reports (Netherlands and Norway).

6.3 Potential new indicators

At the start of this Chapter we suggested that three basic indicators will continue to retain their position in the measurement of international engagement. However, in the future it will be necessary to give closer thought to assessing the quality of international exchange and cooperation, too. Our list, therefore, is modified as follows:

1. Scientific publications appearing in international series and co-authored with international partners: numbers and analysis of publications of exceptionally high quality.
2. International visits and mobility: numbers and assessment of the quality of the targets of these visits and the people making these visits.
3. Research funding secured from foreign and international sources: quantity and quality.

The workshop convened for this research addressed the question as to which indicators should be retained. The three measures above are to remain on this list, alongside any new ones introduced. A clear need was expressed for more accurate and more diverse indicators of researcher exchange (long vs short visits; visits in both directions). International funding was in itself considered an indicator of high quality, but even here it is possible to single out certain funding agencies. In the case of networking the demonstration of quality will become ever more important. However, the definition and measurement of the quality of cooperation is extremely difficult. One way to go about this challenge is to consult various international ranking lists of universities and research institutes and to look at Finnish collaborations with units that rank among the best performers on these lists. The difficulty is that general ranking lists do not detail the best partners in different fields of science, and there is good reason to question the accuracy of these ranking lists.

The assessment of quality or impact can never be a purely objective excercise, but it always involves an element of subjective choice. In other words, the criteria applied in the assessment of quality must always be created from a certain perspective.

The specific concern of the workshop and the whole research was to look into the possibility of creating new measures and indicators. During the course of this work several suggestions were put forward regarding such indicators, but many of them were extremely cumbersome and difficult to implement in practice. The costs of data collection would be all too high if the collaborations of each individual scientist and research were subjected to qualitative assessment.

New indicators suggested in the interviews for the measurement of international engagement were as follows:

- The proportion of foreign experts among PhD thesis examiners. This serves as an indication of internationalisation in the field of science concerned.
- Finnish members in the administration and management of international organisations.
- Finnish keynote speakers at international scientific conferences.
- The proportion of foreign experts in various management and steering groups.
- Persons mentioned in prefaces to monographs.
- Working hours dedicated to international tasks and operations.

As is evident from this list, there were, in the end, comparatively few suggestions. One of the easiest items to measure among those listed would be the number of foreign examiners of PhD theses, which might also provide interesting time series for individual fields of science. Measurement of the three last items in the list, in turn, would be extremely time-consuming.

Among the indicators of internationalisation raised in the workshop were the following:

- Cooperation with multinational corporations
- Participation in international research concerning global challenges (e.g. environmental and climate changes issues)
- Very short visits (1 day–2 weeks)
- Masters-level training programmes conducted in the English language
- International visibility (funding received by Finnish scientists and researchers; visibility in organisations and on editorial boards).

The workshop, too, generated only comparatively few suggestions. The measures outlined above do undoubtedly measure international engagement or are related to international visibility. The critical question that needs to be asked, however, is whether they are appropriate as indicators of the internationalisation of scientific research. All the workshop participants agreed on the importance of measuring high-quality international activity. The same observation was made in the interviews conducted for this research.

The point was made in the workshop that relative indicators are widely used and provide valuable guidance and support for decision-making. On the reverse side of the coin, however, the facts and phenomena behind these figures may become blurred. The workshop submitted for consideration new relative indicators in which the quality of operations can be described using a relative or proportional figure:

- Percentage of high-quality publications = high-quality publications/all publications
- Percentage of high-quality international funding = high-quality funding (from international sources or internationally reviewed)/all funding
- Percentage of high-quality partners in cooperation = high-quality network/ total number of contacts

These indicators are specifically intended to measure the aspects of quality and impact. The challenge here would be to define the categories of publications, funding agencies and research organisations that are considered to represent the highest quality. One possibility would be to use bibliometric tools and research ranking lists, but there is no single objective way to tackle this. Another intervening factor is change over time. All in all, the proposal for using relative indicators for measuring quality is worthy of support.

Table 6.2 provides an overview of the new proposed indicators. The possibility of conducting analyses by field of science is indicated separately.

In Chapter 3.3. it was pointed out that in this report, indicator refers specifically to information that serves to support decision-making. Indicators support the identification of concrete objectives, the monitoring of their attainment and the planning of future measures. Indicators should describe the impact of measures taken and clearly illustrate the development of the phenomenon that is the focus of analysis.

Table 6.3 summarises the findings of this research in the form of a list of indicators that together would provide as accurate a description as possible of the internationalisation of scientific research at the present time. The list is compiled both with a view to brevity and practical applicability given the current methods of data collection. A large number of interesting indicators are excluded because they are difficult, expensive or even impossible to monitor. One area that is particularly challenging is that of international cooperation, where work is needed to develop better indicators of quality. One possibility might be to identify the potential partners in cooperation and to use these indicators of quality, but in practice this is extremely difficult to do.

Table 6.2. Proposed new indicators of the internationalisation of scientific research.

NEW INDICATORS	COMMENT
Proportion of high-quality scientific publications*	Requires definition of quality e.g. by citation indices
Proportion of high-quality partners in cooperation*	Requires definition of quality e.g. by using ranking lists
Proportion of high-quality international funding*	Requires definition of high-quality funding agencies
Proportion of foreign examiners of PhD dissertations*	Measures development within fields of science
Number of Finnish members in administration and management of international organisations	Requires identification of organisations to be monitored
Finnish researchers as keynote lecturers at international conferences*	Data collection laborious
Proportion of foreign experts on various management and steering groups	Data collection laborious
Persons mentioned in prefaces to monographs*	Data collection laborious
Working hours spent in international tasks and operations	Data collection laborious
Cooperation with multinational corporations	Requires analysis of concrete forms of cooperation
Participation in international research addressing global challenges	Difficult to concretise. Almost all research can be associated with some global challenge.
Very short visits*	Data collection laborious
Number of Masters-level training programmes conducted in the English language*	Indicates international engagement in future scientific activities
Visibility in international organisations and on editorial boards	Requires concretisation

* Separate analysis for different fields of science possible.

Table 6.3. Proposed key indicators of the internationalisation of scientific research.

THEME	INDICATOR	DESCRIPTION	ALTERNATIVE DERIVED INDICATORS**
Internationalisation of scientific publishing	Number of Finnish publications in international series*	Standard method of describing the results and extent of scientific activity	Relative to number of researchers or population. Proportion of publications in comparison group (OECD, EU, etc.)
	Number of Finnish articles in international conference publications*	Important channel of publication in many fields of science and comparable to publications	
	Number of co-authored international publications*	Indicator describing the extent of international cooperation	Divided by selected countries or even organisations
	Impact factor of Finnish publications/ impact factor of OECD publications*	Relative quality indicator compared to relevant comparative group	Comparisons with e.g. all countries, EU countries or individual countries
International mobility and visits	Visits to Finland by foreign senior researchers lasting more than one month*	Describes Finland's scientific appeal	Divided by country of origin
	Visits from Finland by senior researchers lasting more than one month*	Describes the research system; possible to retain quality indicator	Divided by target country
	Number of foreign professors in Finland*	Describes the standard and appeal of Finnish science	Relative to all professors
	Number of foreign postgraduate students in Finland*	Describes Finland's appeal	Relative to all postgraduate students
Securing international research funding	Amount of competitive foreign funding for basic research in Finnish organisations*	Describes the quality of Finnish research	Relative to number of R&D personnel, researchers or population
	Scientific research projects with joint international funding*	Describes the volume and network of global activity	
	Amount of EU framework programme funding*	Describes the networking of research in Europe	Relative to population number or share of funding from Finland
Other international networking	Foreign examiners of PhD theses*	Indicator describing the development of different fields of science	

* Separate measurement for different fields of science possible.

** In international comparisons absolute figures produced by various indicators are usually compared e.g. with population number or GDP.

7 Summary and conclusions

Key areas of focus in the investigation of internationalisation include scientific publishing, mobility (both shorter visits and more permanent moves) and research funding. Among the various sources consulted for this research the most useful was provided by the MoE KOTA database. The statistics gathered in that database make it clear that Finnish science and research has become increasingly internationalised over the past few decades.

The volume of international publishing has increased significantly in all fields of science. The number of international publications is highest of all in engineering and technology and in medicine and health sciences. The sharpest increase since 1994 is recorded for social sciences, engineering and the humanities. This evidence of increasing publication numbers is confirmed by international databases, although the absolute figures given in these sources are markedly lower than in the KOTA database.

KOTA statistics on international teacher and researcher visits from Finland indicate a declining trend for the past few years, both in terms of the number and duration of visits. However, the research conducted here suggests that the declining number and duration of visits does not in itself warrant the conclusion that international engagement is on the decline. Our interviews showed that other visits and informal exchange have in fact increased; they just do not show up in the statistics. It is also important to bear in mind that since the early 1990s, new advanced technologies have greatly facilitated information exchange and interfacing even without physical presence. KOTA sources also provide statistics on the number of foreign postgraduate students in Finland. These numbers have increased markedly across the board.

Research funding from international sources has increased considerably. KOTA provides statistics on the amount of foreign funding allocated to scientific research at Finnish universities. Based on these figures the amount of funding from EU sources, foreign business companies and other foreign sources has increased in all other disciplines except the humanities and agricultural sciences.

All in all, this research makes it clear that the level of international engagement in Finnish science and research has risen considerably over the past few decades; this is confirmed by virtually all indicators and all experts. The few exceptions seen in this pattern are merely a reflection of the fact that the statistical source in question cannot be used as a broad and reliable indicator of internationalisation.

The evidence is quite unequivocal then that scientific research in Finland has become more internationalised. However, Finland's performance in international comparisons varies across different indicators. The per capita number of international publications in Finland is high. Figures for international mobility (in a more permanent sense) and the proportion of foreign-born nationals working in Finland, on the other hand, are well below the international average. The reasons are many and varied and have to do with the research system, geography, language policy and tradition.

Research policy and funding structures and the international environment in general have changed considerably over time. International engagement is encouraged to a much greater extent than before and peer models are much more readily available than before. Another significant underlying influence is the internationalisation of society more generally. Policy guidance has also played a part, but it is important to remember that scientists and researchers at the leading edge have always shown a strong commitment to international engagement.

International engagement must not be viewed as a separate aspect or function of scientific research, but on the contrary as an integral part of the everyday practice of doing science and research. One noteworthy trend is the gradual erosion of the distinction between the national and international. All fields of science and research are becoming more international, and international engagement is bound to gain increasing significance in the future. Based on a comparison of science policy discussions and debates in Finland and elsewhere, it seems that in many other countries internationalisation is not as prominent a concern as it is here. However, at least all the Nordic countries seem to share the same perceived need to adapt to globalisation.

Another recent momentous change impacting the realm of science and research was Finland's decision to join the European Union in 1995. The experts interviewed for this research stressed that while EU framework programmes for research are not usually at the cutting edge of science, they do have an important networking function, and for some research teams EU funding is absolutely crucial. Apart from global research cooperation and actions within the EU, Nordic cooperation is continuing to gather momentum. Collaboration within Europe's Nordic regions is recognised as an increasingly important strategic need. It is expected that science cooperation will continue to grow with Russia, China, India and other emerging science nations. The role of the United States is generally expected to decline or remain unchanged. The directions pursued and needs identified in different fields of science are also different.

Based on this research it seems that personal career planning and family considerations are emerging as ever greater obstacles to researcher mobility. A long-term research visit to a foreign country may prove not to have the desired career-boosting effect, but on the contrary present a risk to both the individual's career prospects and personal finances. In particular, the prospects of being able to return to a university post in Finland may be highly uncertain as competition for research posts is getting ever tougher. Internationalisation should be incorporated as an integral part of the development of research careers.

The Academy of Finland has devoted great effort to promote international engagement in science and research and it has various monitoring mechanisms in place. Tekes and its research funding policies have also contributed to strengthen internationalisation. According to the interviews in this research, a new emerging trend is the closer coupling of research funding with development cooperation. Research funding agencies will continue to work more closely with the Ministry for Foreign Affairs, and there is certainly scope here to develop new areas of cooperation and new funding arrangements. In this connection it is paramount to ensure strict adherence to the principles of ethical sustainability, for instance with regard to obtaining national research resources.

Science policy and strategic planning will continue to assume greater importance in internationalisation. Significant instruments in this regard include research programmes and infrastructures. As the research system continues to mature, so international engagement will become an increasingly natural part of doing science and research in all fields; it will no longer need to be separately stressed and emphasised. Nevertheless, it is safe to predict that internationalisation will remain a major theme in Finnish science and innovation policy for years to come.

Three areas of current focus in the measurement of international engagement will gain further emphasis. It is expected that the following indicators will retain their importance: 1) scientific publications in international series and produced in international collaboration; 2) international visits and mobility; and 3) research funding from international and foreign sources.

Various indicators and statistics are available to describe each of these areas, but data collection is less than comprehensive. For instance, data collection on research organisations other than universities remains inadequately harmonised. Most of the data consist of objectively verifiable quantitative indicators, but such aspects as the quality of publications or visits remain uncovered. Furthermore, the demand for such information is confined to a small circle of science policy decision-makers and experts. Although entirely relevant, the statistics and indicators are not exhaustive and therefore cannot provide adequate support for science policy decision-making. In particular, the measures currently used for monitoring mobility are open to criticism in that they give only a very crude and incomplete picture of what is a highly complex phenomenon.

The choice and development of indicators to support political decision-making is always ultimately a question of what those indicators are needed for, i.e. the requirements of the policy measures themselves. Data collection is a costly exercise and it is important to give careful thought to the appropriate level of resource allocation for the development of a tailored basket of indicators and for monitoring the internationalisation of science and research. Internationalisation is such a complex and multifaceted phenomenon that there is an endless range of items on which data could be collected. The challenge is to collect data that can more accurately describe the quality of internationalisation, but this is often a time-consuming and cumbersome process that involves subjective assessment – which leaves the data collected very much open to criticism. The decision to make a national investment in data collection must be based on national priorities of internationalisation.

This research prompted a wide range of ideas about different indicators that could be followed for general purposes. These ideas can be grouped into three categories: 1) indicators that already exist and that are currently used for data collection (e.g. number of publications); 2) indicators for which relevant data are available but for which data are not systematically collected (e.g. number of foreign professors at Finnish universities); and 3) indicators for which no data are currently collected or for which there exist no guidelines on required data (e.g. quality of international cooperation). Without addressing the costs of data collection or whether the relevant data even are available, Table 7.1 provides a summary list of indicators that on the basis of this research are considered particularly relevant for future needs. Some of the data needed for these indicators do exist, but for some it will be necessary to collect completely new datasets and to allocate responsibilities for data collection. However, these questions are excluded from the remit of this research.

Table 7.1. Proposed key indicators of the internationalisation of scientific research: priorities for the future.

THEME	INDICATOR	DESCRIPTION	ALTERNATIVE DERIVED INDICATORS**
Internationalisation of scientific publishing	Number of Finnish publications in international series *	Standard method of describing the results and extent of scientific activity	Relative to number of researchers or population. Proportion of publications in comparison group (OECD, EU, etc.)
	Number of Finnish articles in international conference publications*	Important channel of publication in many fields of science and comparable to publications	
	Number of co-authored international publications*	Indicator describing the extent of international cooperation	Divided by selected countries or even organisations
	Impact factor of Finnish publications/ impact factor of OECD publications*	Relative quality indicator compared to relevant comparative group	Comparisons with e.g. all countries, EU countries or individual countries
International mobility and visits	Visits to Finland by foreign senior researchers lasting more than one month*	Describes Finland's scientific appeal	Divided by country of origin
	Visits from Finland by senior researchers lasting more than one month*	Describes the research system; possible to retain quality indicator	Divided by target country
	Number of foreign professors in Finland*	Describes the standard and appeal of Finnish science	Relative to all professors
	Number of foreign postgraduate students in Finland*	Describes Finland's appeal	Relative to all postgraduate students
Securing international research funding	Amount of competitive foreign funding for basic research in Finnish organisations*	Describes the quality of Finnish research	Relative to number of R&D personnel, researchers or population
	Scientific research projects with joint international funding*	Describes the volume and network of global activity	
	Amount of EU framework programme funding*	Describes the networking of research in Europe	Relative to population number or share of funding from Finland
Other international networking	Foreign examiners of PhD theses*	Indicator describing the development of different fields of science	

* Separate measurement for different fields of science possible.

** In international comparisons absolute figures produced by various indicators are usually compared e.g. with population number or GDP.

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Appendix 1. interviewees

Antti Ainamo, Finnish Society for Science and Technology Studies
Antti Arjava, Finnish Cultural Foundation
Johanna Björkroth, University of Helsinki
Johanna Hakala, University of Tampere
Riikka Heikinheimo, Finnish Funding Agency for Technology and Innovation (Tekes)
Erja Heikkinen, Ministry of Education
Eila Helander, University of Helsinki, Research Council for Culture and Society
Kari Hjelt, Nokia Research Center
Kai Husso, Science and Technology Policy Council of Finland
Markku Karlsson, UPM Kymmene
Markku Kivinen, University of Helsinki, Aleksanteri Institute
Anne Kovalainen, Turku School of Economics, Research Council for Culture and Society
Helena Kääriäinen, National Public Health Institute
Riitta Mustonen, Academy of Finland
Jussi Mykkänen, Vaisala Oyj
Jussi Nuorteva, National Archives of Finland
Erkki Oja, Helsinki University of Technology, Research Council for Natural Sciences and Engineering
Leena Paavilainen, Finnish Forest Research Institute (Metla)
Anneli Pauli, European Commission
Paavo Pelkonen, University of Joensuu, Research Council for Biosciences and Environment
Heikki Ruskoaho, University of Oulu
Liisa Savunen, Finnish Council of University Rectors
Heikki Toivonen, Finnish Environmental Administration
Kalervo Väänänen, University of Turku, Research Council for Health
Perttu Vartiainen, University of Joensuu
Yrjö Viisanen, Finnish Meteorological Institute
Daphne den Hollander, NWO, Netherlands
Thomas Hansteen, RCN, Norway
Carl Jacobsson, Vetenskapsrådet, Sweden

Appendix 2. Workshop participants

Johanna Björkroth, University of Helsinki
Eila Helander, University of Helsinki, Research Council for Culture and Society
Erkki Kaukonen, University of Tampere
Markku Kivinen, University of Helsinki
Jorma Lammasniemi, VTT Technical Research Centre of Finland
Annamaija Lehvo, Academy of Finland
Susan Linko, Academy of Finland
Paavo Löppönen, Academy of Finland
Riitta Mustonen, Academy of Finland
Anu Nuutinen, Academy of Finland
Erkki Oja, Helsinki University of Technology, Research Council for Natural Sciences and Engineering
Minna Palmroth, Finnish Meteorological Institute
Tuomas Parkkari, Science and Technology Policy Council of Finland
Olli Poropudas, Ministry of Education
Jaana Roos, Academy of Finland
Marja-Leena Tolonen, Finnish Funding Agency for Technology and Innovation (Tekes)
Kaisa Vaahtera, Academy of Finland
Leena Vestala, Ministry of Education

Appendix 3. Description of the material

This Appendix summarises the main sources used in this research in table format. The main conclusions drawn from this material are outlined in Chapter 4.

Table III.1. OECD fields of science and technology classification and KOTA database fields of study.

OECD Fields of Science and Technology Classification	KOTA database fields of study
Natural Sciences	**Natural Sciences**
Biological sciences	Natural Sciences
Chemical sciences	
Earth and related environmental sciences	
Mathematics and computer sciences	
Physical sciences	
Engineering and technology	**Engineering**
Civil engineering	Engineering
Electrical engineering, electronics	
Other engineering sciences	
Medical and Health Sciences	**Medicine and Health Sciences**
Basic medicine	Pharmacy
Clinical medicine	Dentistry
Health sciences	Sport Sciences
	Medicine
	Health Sciences
Agricultural sciences	**Agriculture and Forestry**
Agriculture, forestry, fisheries and allied sciences	Veterinary medicine
Veterinary medicine	Agriculture and Forestry
Social Sciences	**Social Sciences**
Economics	Education
Educational sciences	Economics
Other social sciences	Law
Psychology	Psychology
	Social Sciences
Humanities	**The Humanities**
History	The Humanities
Languages and literature	Fine Arts
Other humanities	Music
	Art and Design
	Theatre and Dance
	Theology

Appendix 4. Figures

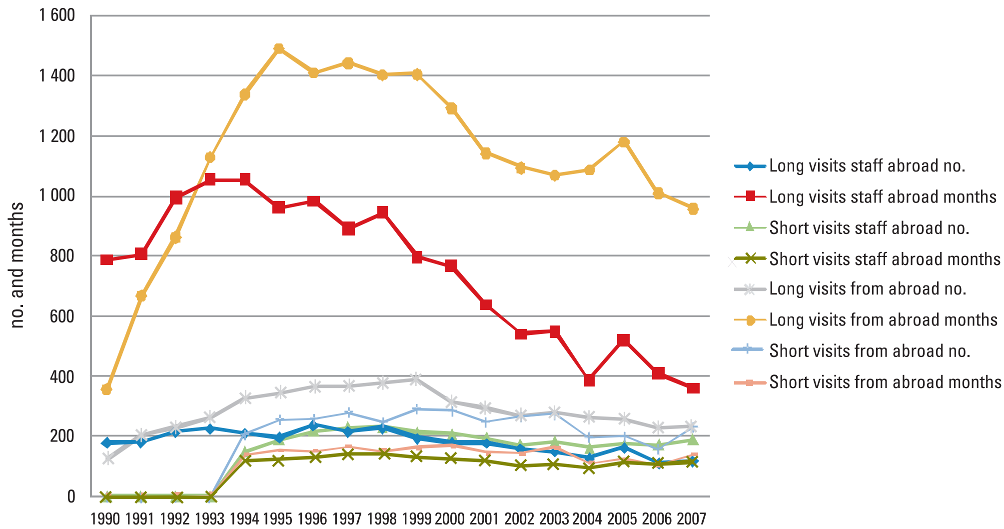

Figure III.1. International teacher and researcher visits in the natural sciences (KOTA database).

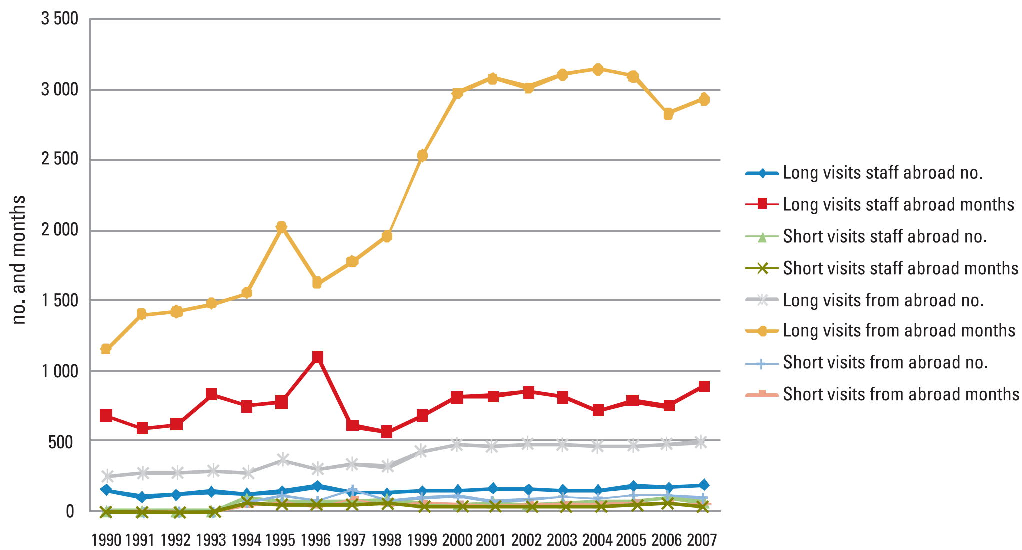

Figure III.2. International teacher and researcher visits in engineering (KOTA database).

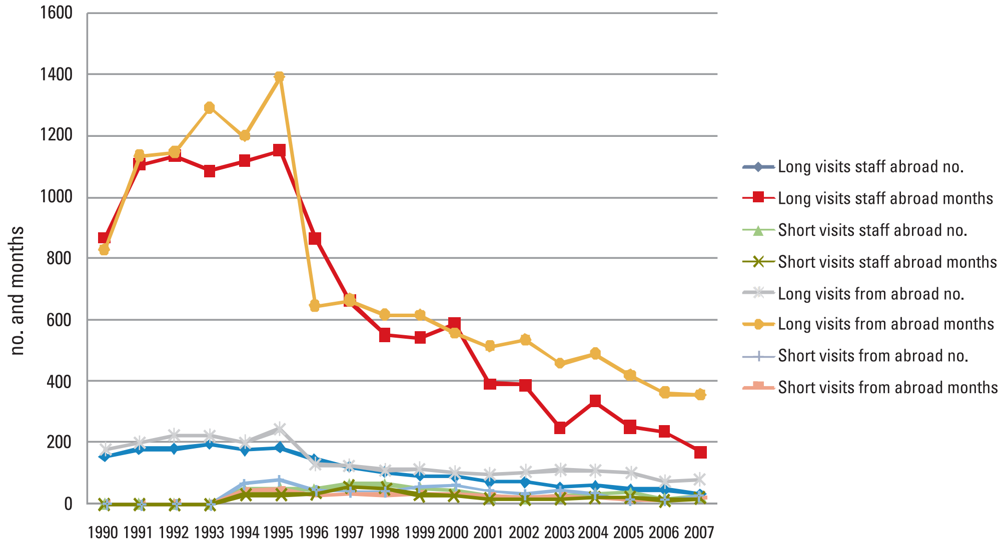

Figure III.3. International teacher and researcher visits in medicine and health sciences (KOTA database).

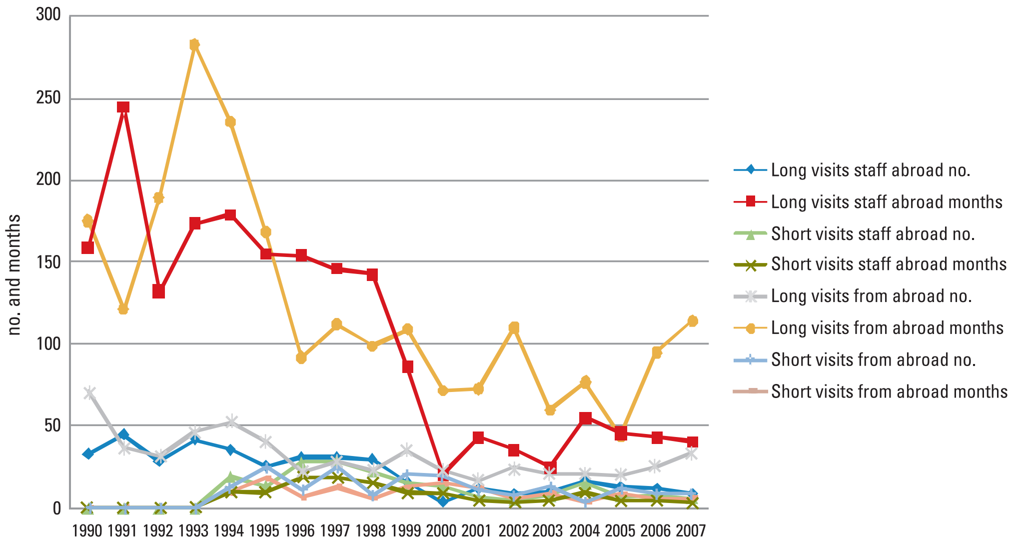

Figure III.4. International teacher and researcher visits in agriculture and forestry (KOTA database).

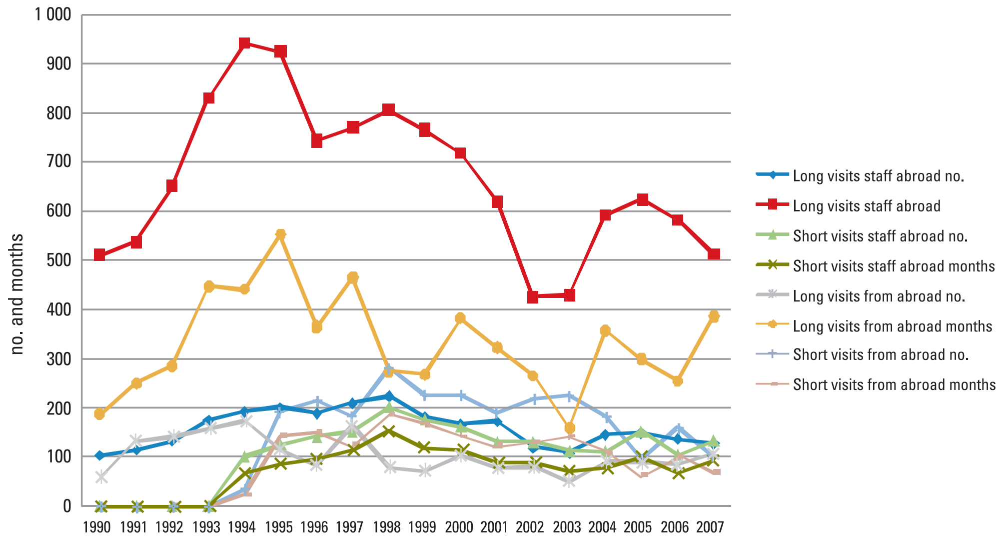

Figure III.5. International teacher and researcher visits in social sciences (KOTA database).

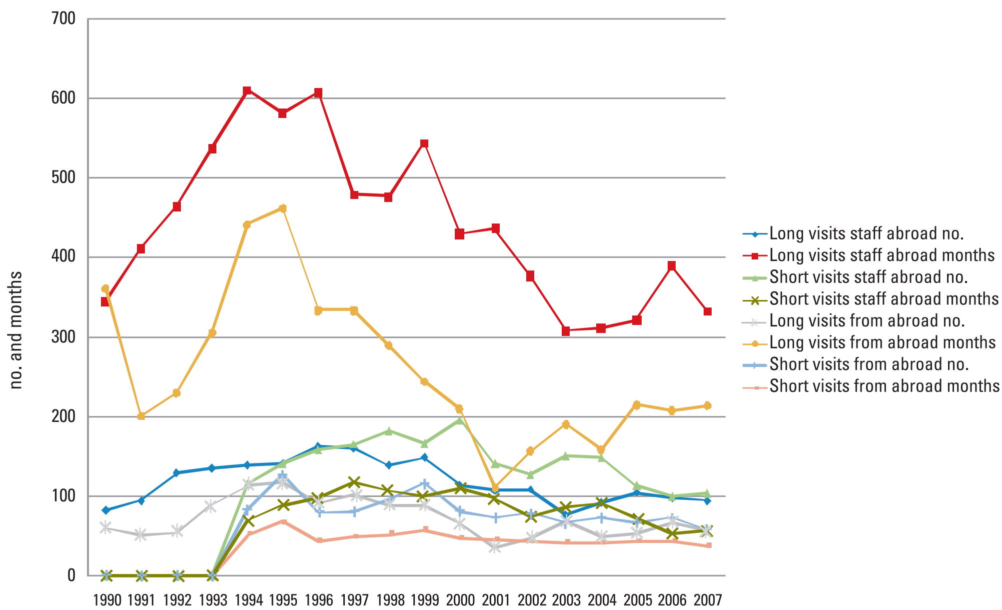

Figure III.6. International teacher and researcher visits in the humanities (KOTA database).

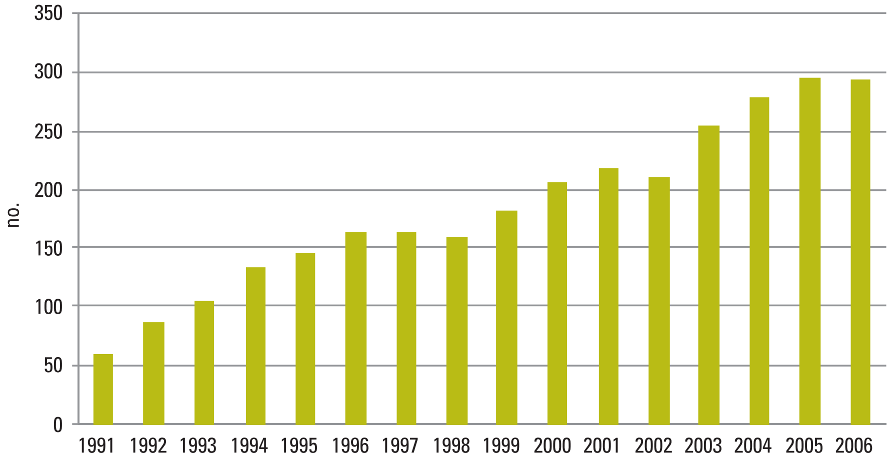

Figure III.7. Foreign postgraduate students in the natural sciences (KOTA database).

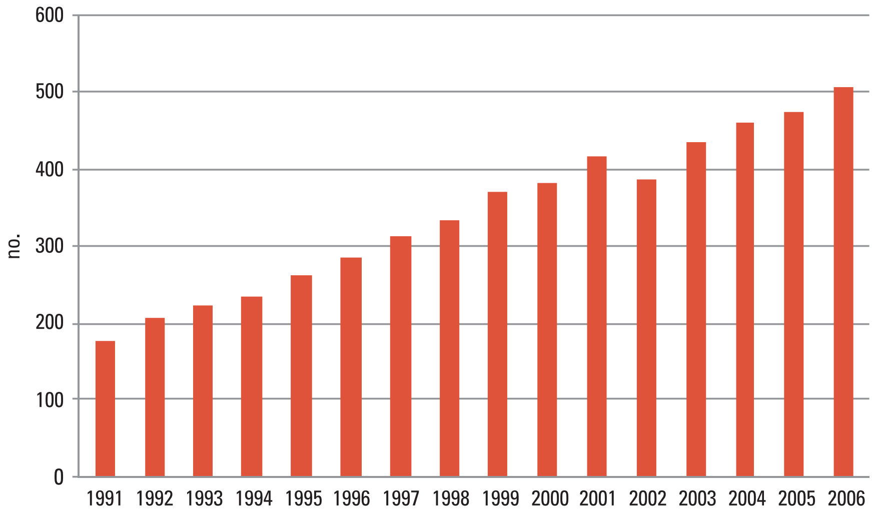

Figure III.8. Foreign postgraduate students in engineering (KOTA database).

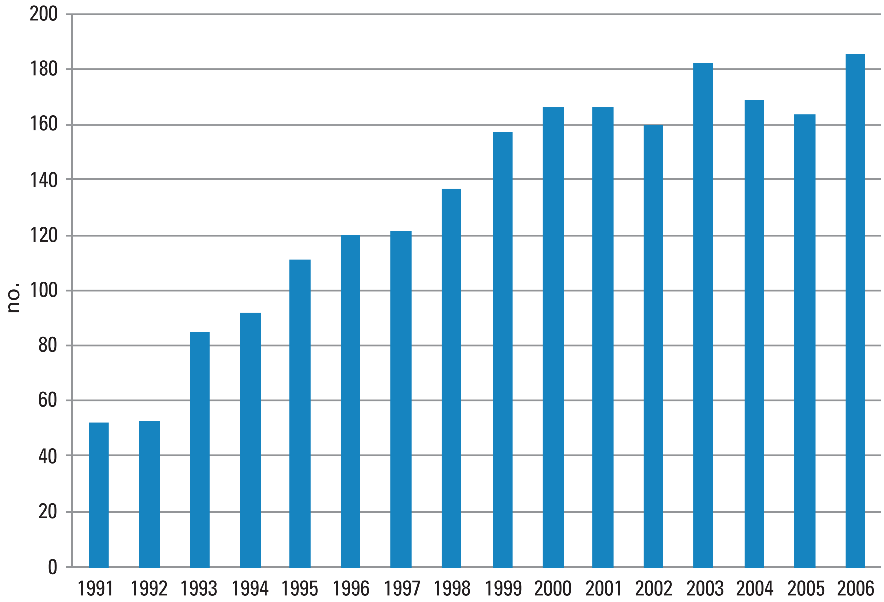

Figure III.9. Foreign postgraduate students in medicine and health sciences (KOTA database).

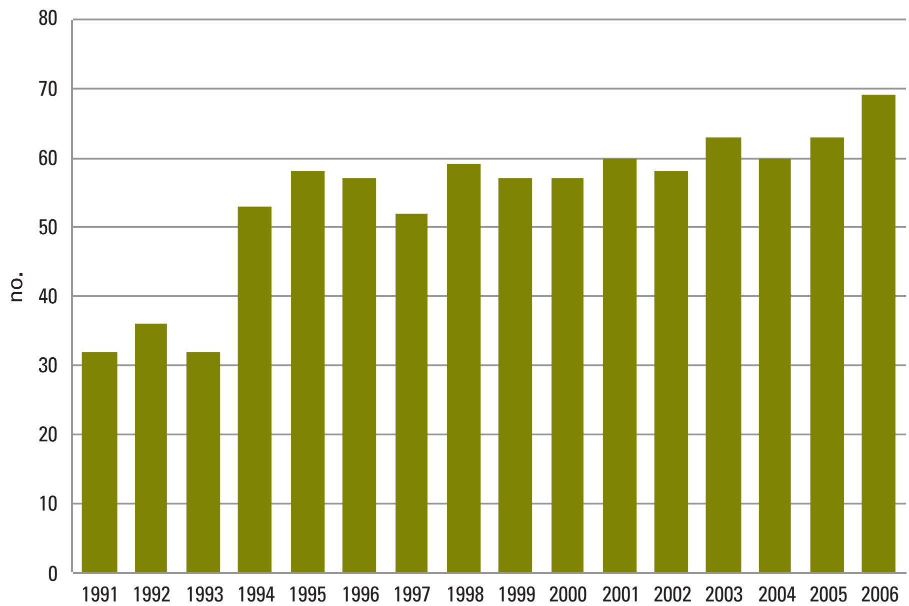

Figure III.10. Foreign postgraduate students in agriculture and forestry (KOTA database).

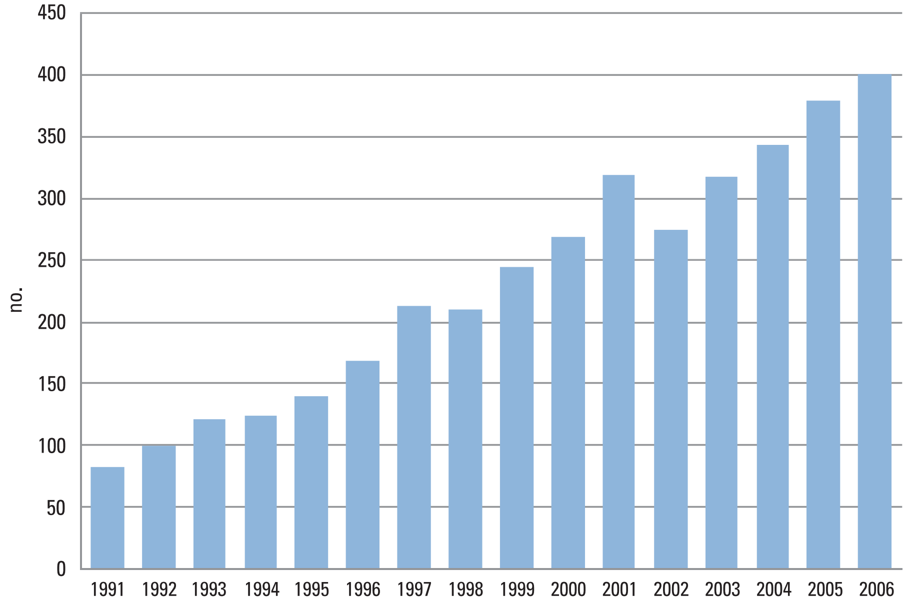

Figure III.11. Foreign postgraduate students in the social sciences (KOTA database).

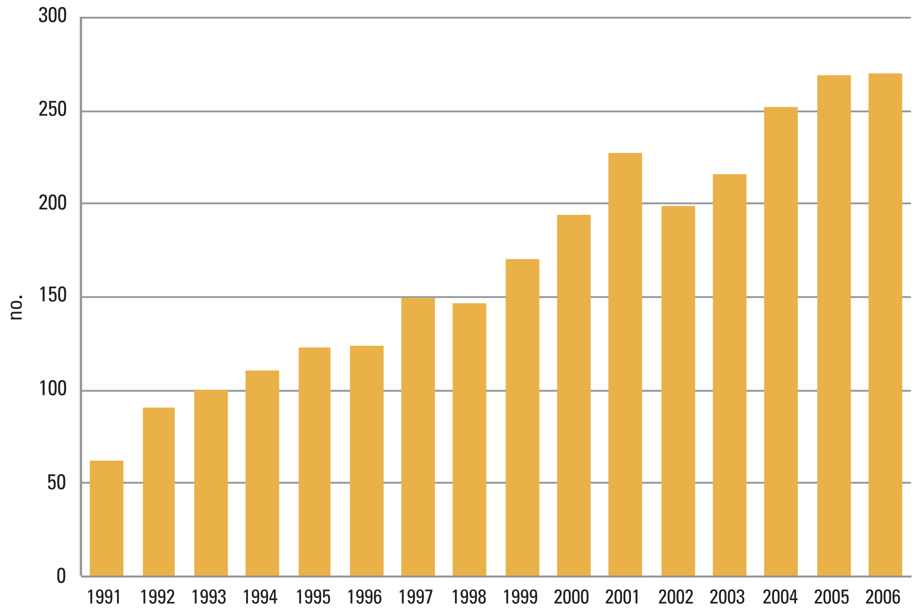

Figure III.12. Foreign postgraduate students in the humanities (KOTA database).

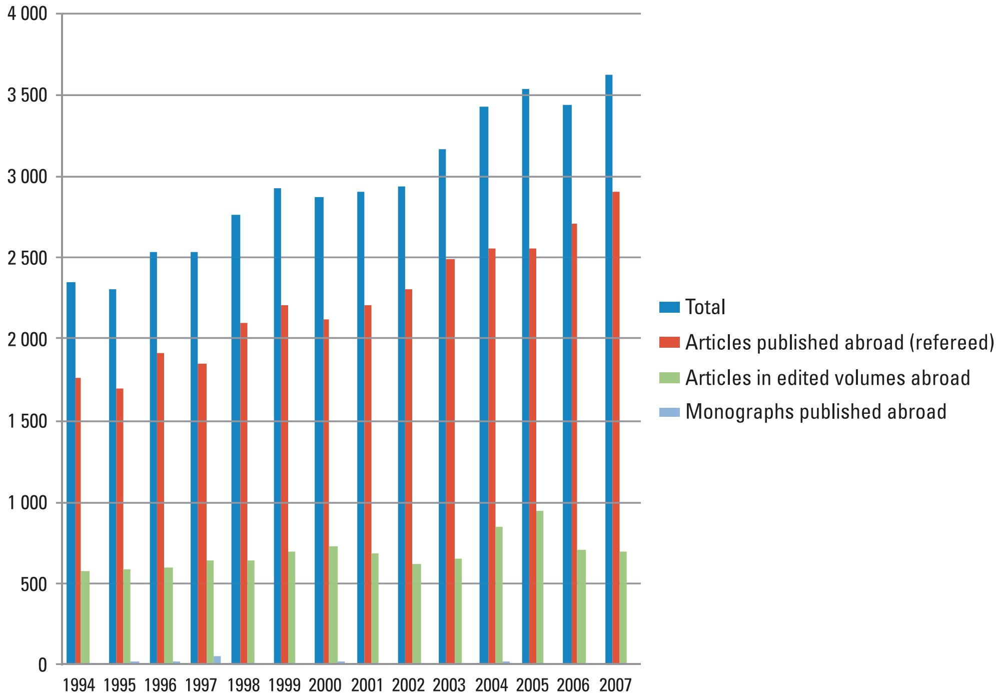

Figure III.13. International publications in the natural sciences (KOTA database).

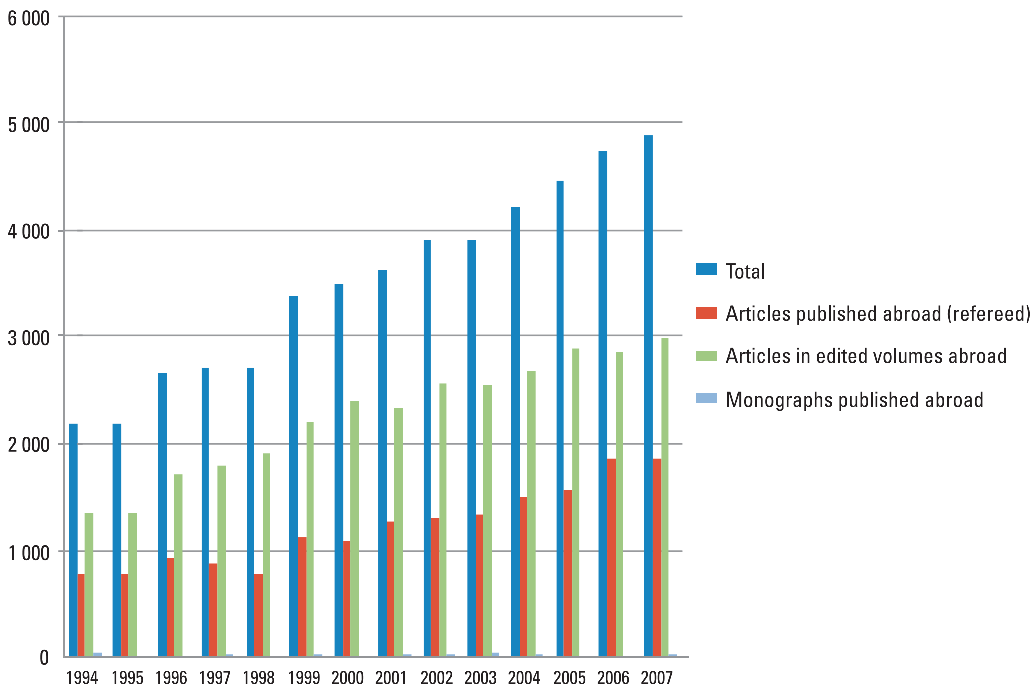

Figure III.14. International publications in engineering (KOTA database).

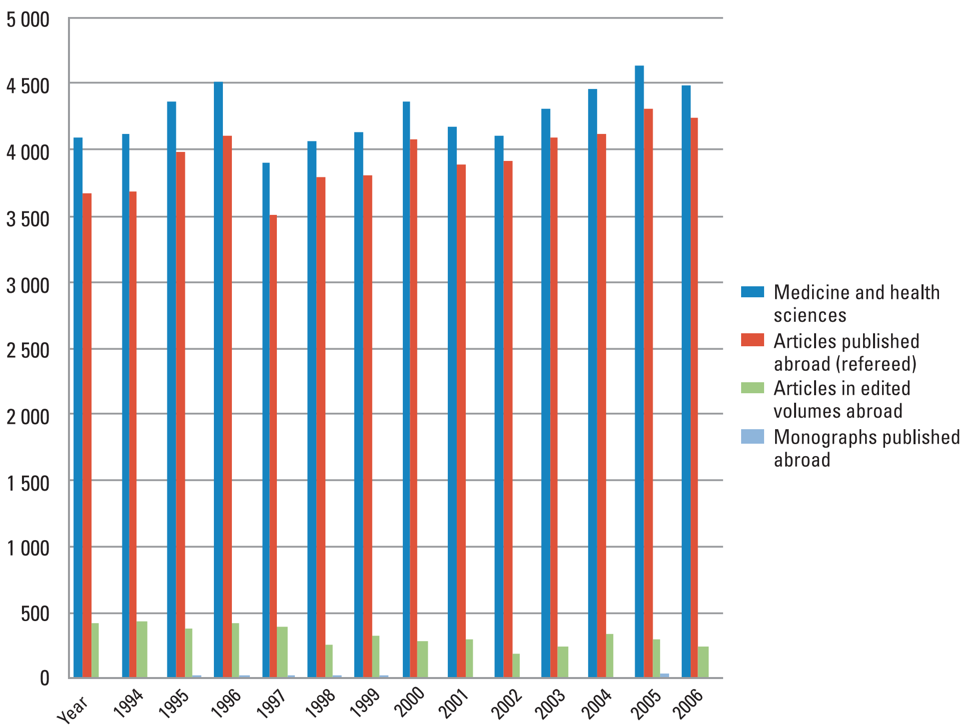

Figure III.15. International publications in medicine and health sciences (KOTA database).

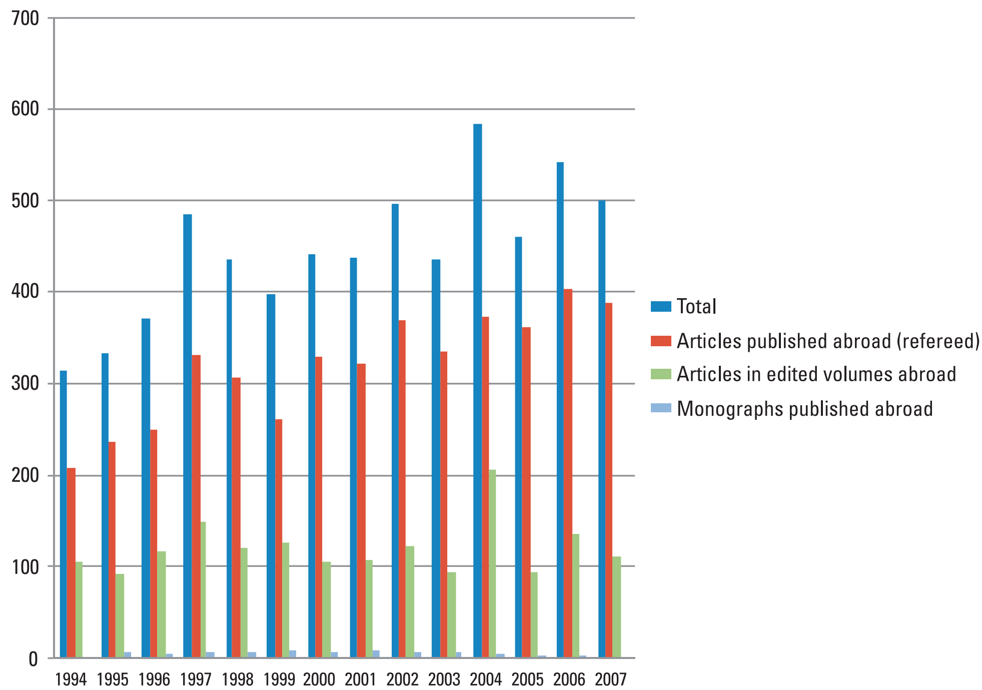

Figure III.16. International publications in agriculture and forestry (KOTA database).

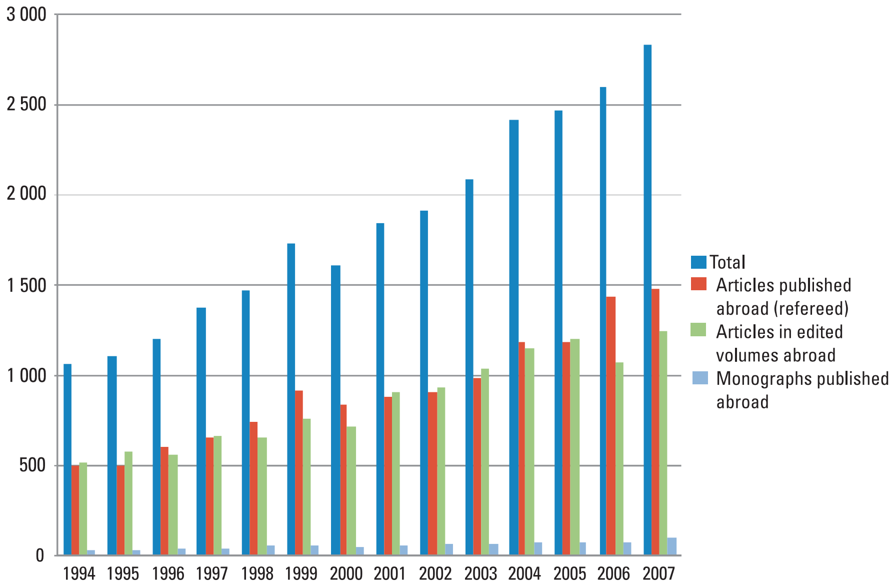

Figure III.17. International publications in social the sciences (KOTA database).

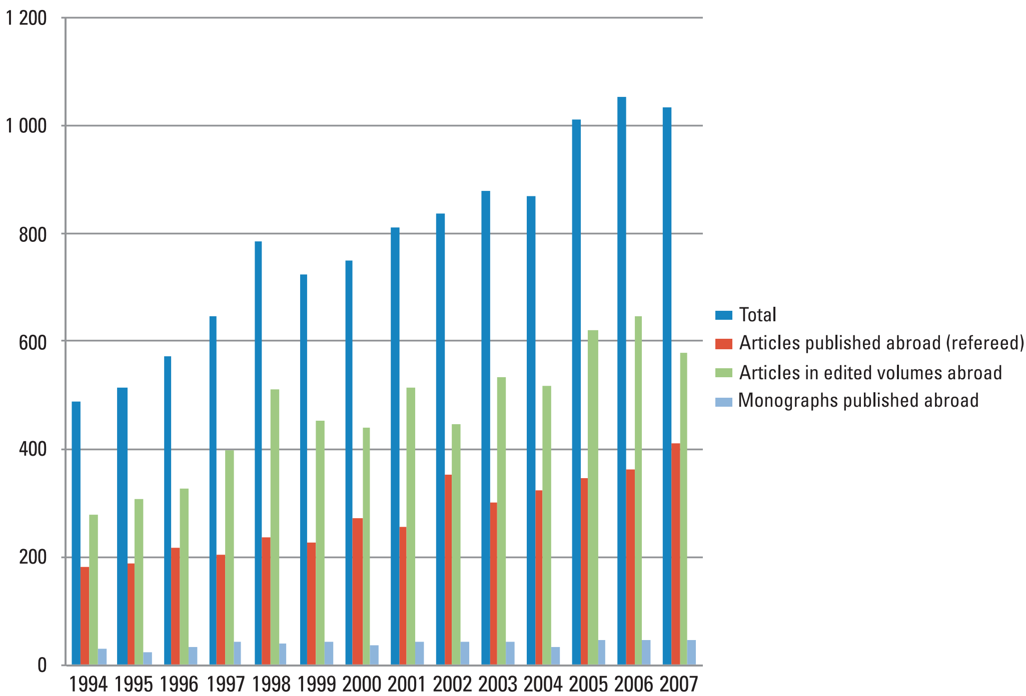

Figure III.18. International publications in the humanities (KOTA database).

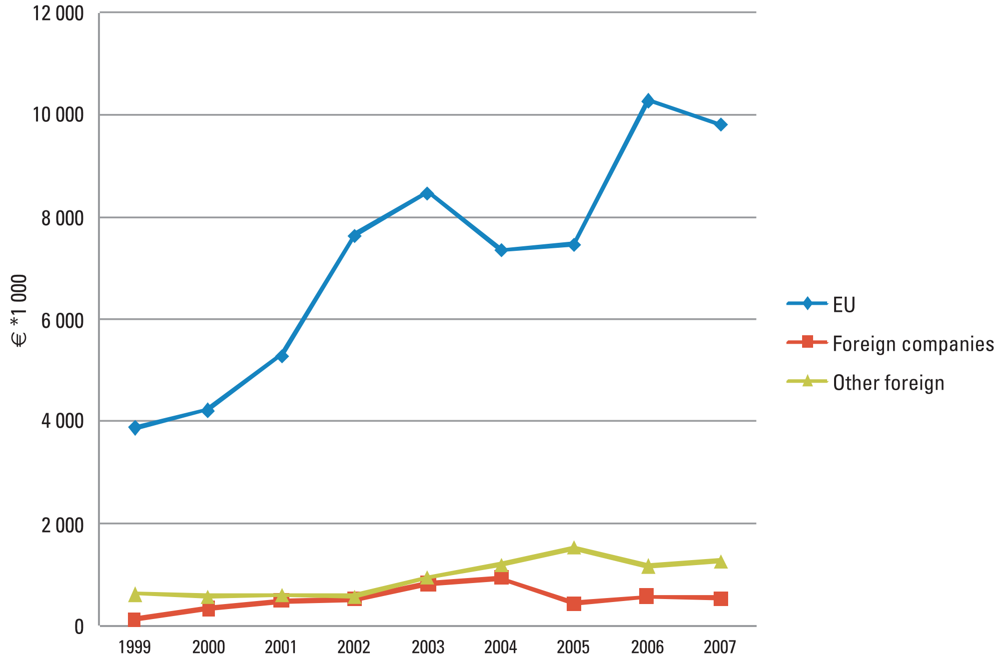

Figure III.19. Foreign funding in the natural sciences (KOTA database).

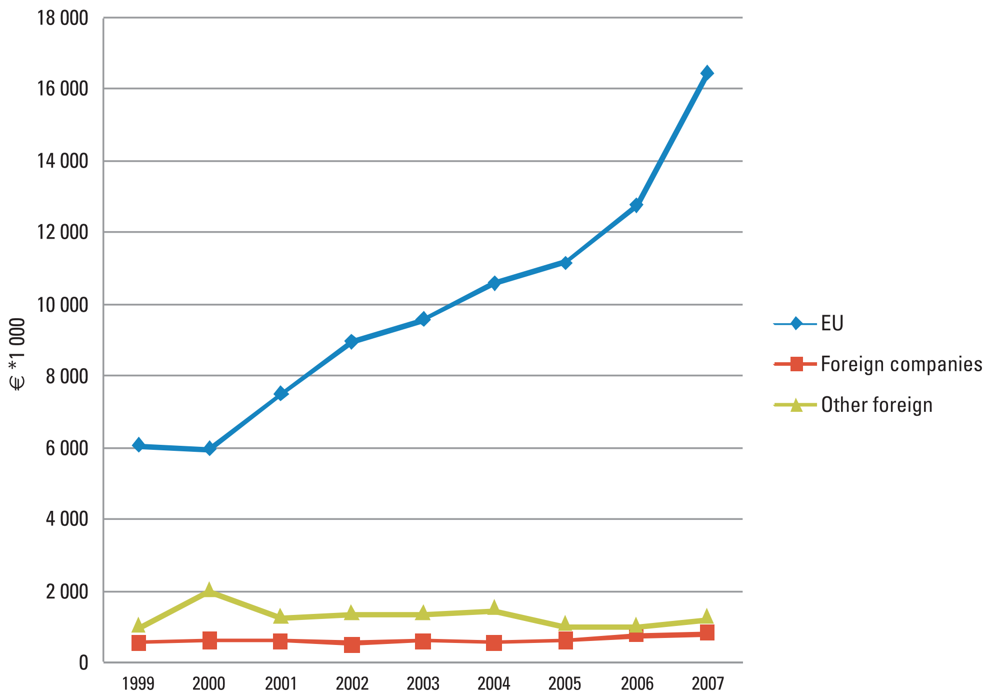

Figure III.20. Foreign funding in engineering (KOTA database).

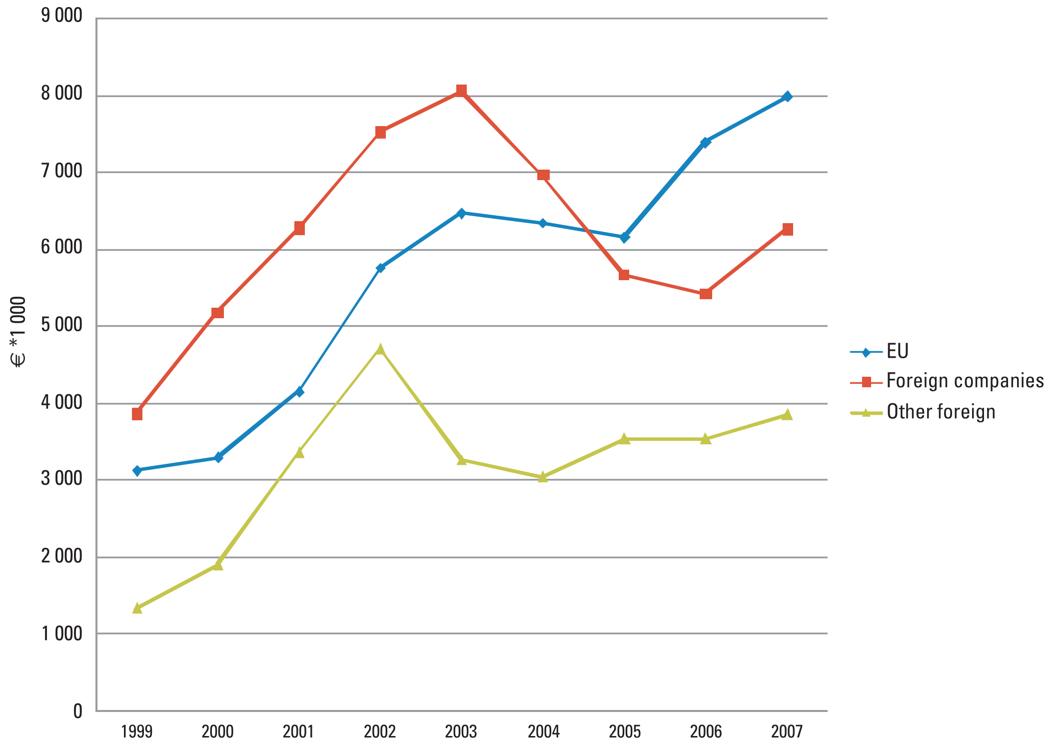

Figure III.21. Foreign funding in medicine and health sciences (KOTA database).

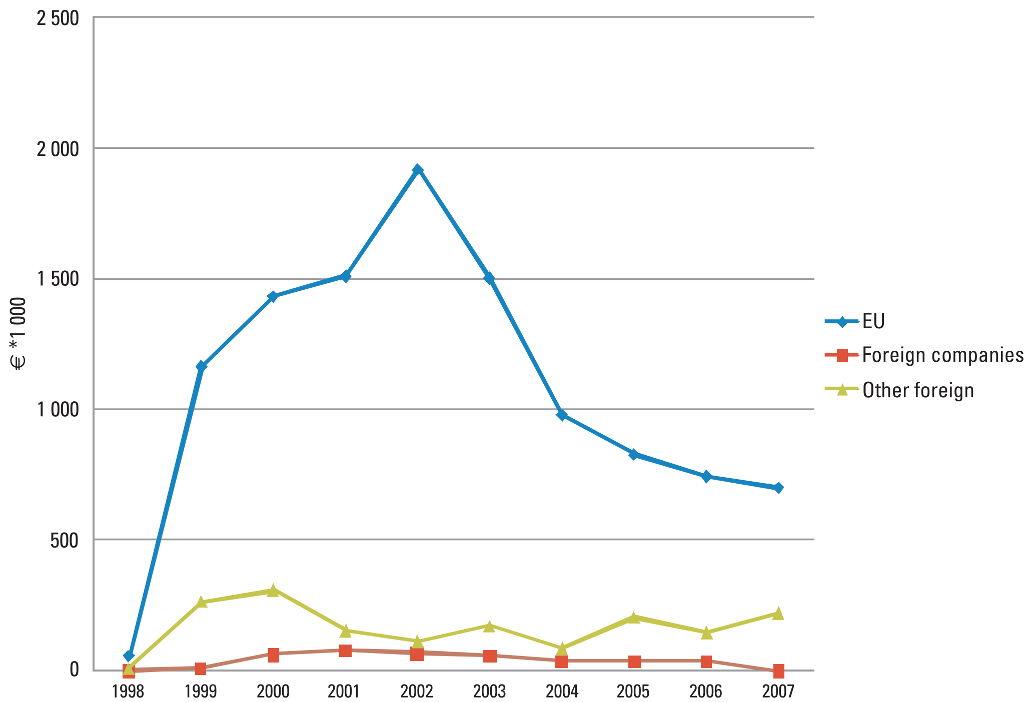

Figure III.22. Foreign funding in agriculture and forestry (KOTA database).

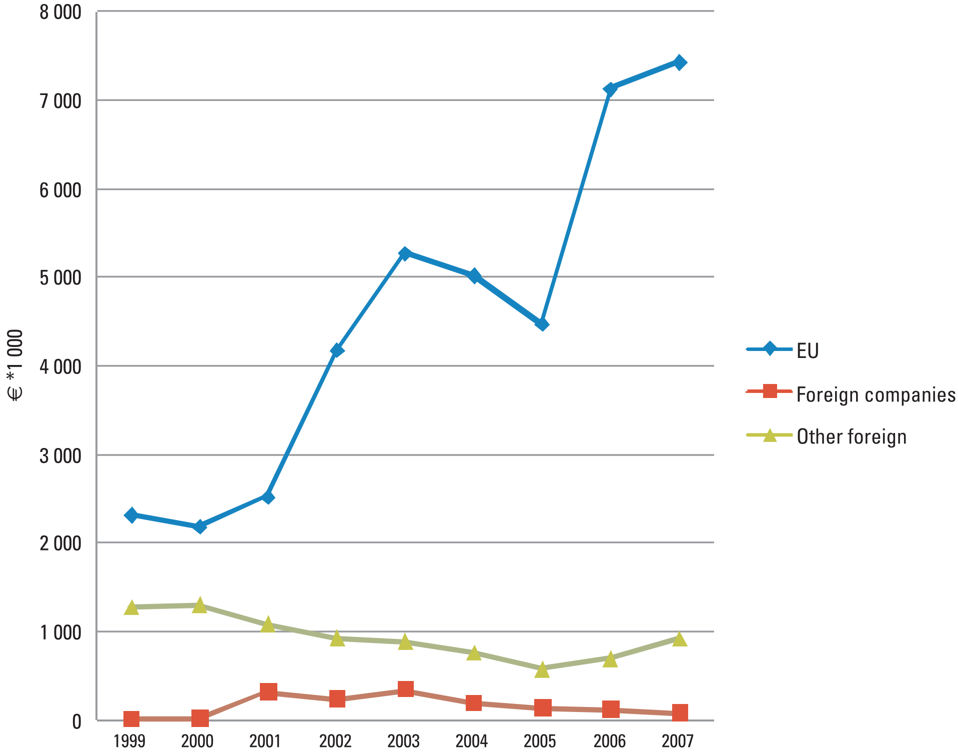

Figure III.23. Foreign funding in social sciences (KOTA database).

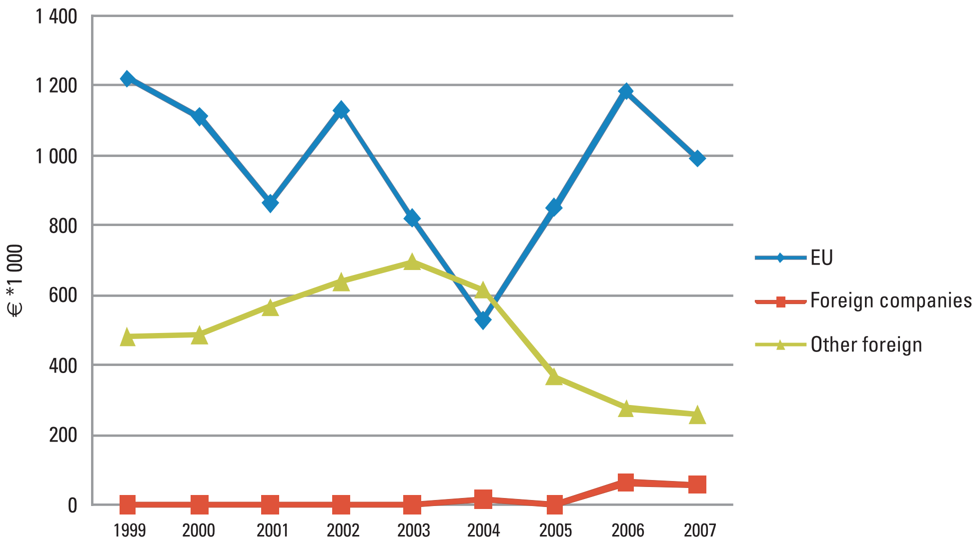

Figure III.24. Foreign funding in the humanities (Source: KOTA database).

Internationalisation of university research: practices and problems

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1 Finnish science policy and internationalisation

For Finnish science and research, internationalisation is at once a challenge and a necessity. Finland's remote location on the northern edges of Europe and its small population have always driven scientists and scholars from this country to search for information and intellectual inspiration from foreign shores. There are very few people in the world who speak Finnish, so for purposes of international interactions there has been no option but to learn foreign languages. Finnish business and industry, too, is heavily dependent on foreign trade and capital flows, which has very much influenced the country's industrial structure and the course of technological development (Kaukonen 1998, 37).

It is a striking indication of the speed of change that as late as the 1950s, the focus in Finnish science was still firmly on the promotion of national culture, on the 'cultivation of the mind at the highest level'. The national scientific endeavour also bolstered the development of the natural sciences and other disciplines with immediate potential applications. Earlier, Finland's most important science partners had come from Germany, but from the 1950s the United States emerged as an increasing influence. Internationalisation still remained rather cautious in the 1960s, even though OECD science policy began to have a modernising influence on the Finnish science field. The US influence continued to increase as scholarships and exchange programmes gave Finnish scientists and scholar's greater access to American universities.

In the 1970s, Finnish science focused principally on developing and expanding the higher education system, on addressing national issues and on building up the welfare state. European influences, and Western European influences in particular, became progressively stronger. Cooperation was also stepped up with socialist and developing countries. This scientific exchange and interaction was to a significant extent coordinated through agreements negotiated by the Academy of Finland, which was established in its present form in 1970.

In the 1970s and early 1980s, the internationalisation of science was still seen as an integral part of foreign policy, and international cooperation was considered a tool for reducing international inequality and tension. Since the late 1980s, the drive towards greater internationalisation has been justified by the goal of improving the country's scientific and economic competitiveness and developing the national innovation system: it was claimed that without active international contact and collaboration Finland would not be able to keep up with development. Indeed, Finland decided to join various West European cooperation structures, such as EUREKA (a network supporting product development and marketing; Finland joined in 1985), CERN (European Organization for Nuclear Research, Finland joined in 1991) and ESA (European Space Agency, associate membership in 1987, full membership in 1995). The Academy of Finland commissioned its first international evaluation of scientific disciplines in the mid-1980s. A major emphasis here was on international merits and relations of cooperation. In general, the Academy began increasingly to favour research teams of international repute, both in its funding decisions and policies more generally (Hakala et al. 2003, 147–149).

Science and technology development in Finland gathered significant momentum in the years following the early 1990s recession. With the rise of Nokia, information technology became the country's most important industry. At the same time, the increased availability of external funding gave a major boost to academic research at universities. The role of the country's major funding agencies (Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation) was strengthened and their mutual coordination improved. The system of core funding for universities was re-established on the basis of performance agreements: the principal funding criterion now was the number of Master's degrees and PhDs produced. Postgraduate training received a major impetus from the introduction of the graduate school system. Internationalisation in science and research gained increasing prominence with the appointment in 1994 of the first ten Centres of Excellence in Research.

During the 1990s, the view gained ground in science policy that internationalisation can help to promote Finnish science and research to the international leading edge, and that for this reason it is important for Finnish researchers to work closely with the best international talents and to get involved in international networks (Hakala et al. 2002, 357). Finland's decision to join the European Union in 1995 paved the way for Finnish researchers to participate fully in EU research programmes (Hakala et al. 2003, 148). These programmes have helped to build up the critical mass needed in different fields of research and also brought increasing diversity to international cooperation. Research collaboration has been undertaken not only with strong science nations, but also with countries with which Finland has had no other contact (Hakala et al. 2002, 377–378). Indirectly, too, EU research programmes have helped lower the threshold of internationalisation. Furthermore, Finland has its share of funding through EU Structural Funds, which is mainly intended to support R&D in regions where development is lagging behind. Pressures of internationalisation were also created by the vision of a European Research Area (ERA), the purpose of which is to establish within the European Union "an internal market of knowledge where there is free and active movement of knowledge, technology and researchers." (Hakala et al. 2004, 73).

This diversification has continued into the new millennium. The emphasis on internationalisation has steadily grown, and the Science and Technology Policy Council (renamed as the Research and Innovation Council from the beginning of 2009) has identified internationalisation as a major science policy priority (Hakala et al. 2004, 73–74). The Academy of Finland launched its first Centre of Excellence programme in 2000–2005, granting CoE status to 26 leading research units. Increasing attention has been paid to internationalisation at home, particularly to attracting top researchers to work in Finland. One of the tools developed to support this objective is the Finland Distinguished Professor programme (FiDiPro), a funding programme jointly administered by the Academy and Tekes. Since 2007, the two agencies have also worked closely in building a network of Strategic Centres for Science, Technology and Innovation (SHOK). The aim with this project has been to pool the resources of business companies, research institutes and universities in better networked, leading-edge research centres with a view to supporting key industries and service branches.

2 The international dimension of the Finnish science and technology system: the project

The Unit for Science, Technology and Innovation Studies at the University of Tampere conducted a major postal questionnaire on public research organisations' internationalisation in late 2004 and early 2005. Working under the title 'The International Dimension of the Finnish Science and Technology System', the project was funded through the Tekes ProAct programme. The questionnaire surveyed 17 universities (science universities and the University of Art and Design Helsinki) and 19 government research institutes. The units targeted were all actively engaged in research and had an established research organisation: an appointed director of operations and more than one research team or research project. The questionnaire was sent out in November 2004 to a total of 771 unit directors. The response rate was 42%.

Responses were obtained from 320 university research units. The questionnaires were completed by the unit directors, who were asked to express their views on the internationalisation of their research unit. Disciplines were grouped into six categories: natural sciences, engineering and technology, medicine and health sciences, agricultural and forest sciences, social sciences and the humanities. For data analysis, agricultural and forest sciences were combined with the natural sciences. In addition, multidisciplinary research units (with two or more disciplines having a strong representation) were grouped separately. Table 1 provides data on the participating university units by discipline: the response rate was highest for multidisciplinary units, closely followed by engineering and technology units and by social sciences and natural sciences units. Response rates were below average for the humanities, medicine and health sciences and agricultural and forest sciences.

Table 1. Responding university units by field of science.

Field of science	University	
	Response rate	N
Natural sciences	43	45
Engineering and technology	49	81
Medicine and health sciences	31	43
Agricultural sciences*	25	2
Social sciences	44	81
Humanities	40	36
Multidisciplinary	50	32
Total	**42**	**320**

*) combined with the natural sciences

The questionnaire was designed to explore the following aspects of internationalisation: forms of internationalisation and quantitative trends, reasons for internationalisation, researcher exchange and foreign recruitment and the impacts of public research funding and other support mechanisms available for unit internationalisation. Apart from these core issues, various background data were collected on the research organisations: type of unit (traditional university department/research centre), staff number, field of science category and field of science, distinctive characteristics of research conducted at the unit, unit funding structure and collaborating partners at home and abroad. The questionnaire offers a cross-section of internationalisation at Finnish universities' research units in the mid-2000s.

This report discusses the findings of the TaSTI project that are most directly relevant to the Academy of Finland project on universities' research facilities. The discussion of the questionnaire results is organised around the following themes: proportion of foreign staff, forms of internationalisation, partner countries, reasons for international cooperation and problems of internationalisation.

3 Foreign staff and working abroad

3.1 Proportion of foreign staff at university units

The respondents were asked how many of the staff who had worked for at least six months at the unit in 2003 had a foreign background. The number of foreign staff was compared against the total staff number at the unit[1] (Table 2). On average, foreign staff accounted for around six per cent of the units' total staff (median 6.2, mean 9.9). One-quarter of the units had no foreign staff at all, but in around one-fifth they accounted for 10–20 per cent of total staff numbers. By field of science category, the proportion of staff from foreign countries was highest in the humanities and engineering units. These two disciplines differed statistically significantly from medicine and health sciences and the social sciences ($p<0.05$), which had the lowest proportion of foreign staff. Natural sciences and multidisciplinary units fell in-between these two categories, but did not differ statistically significantly from any of them.

Table 2. Proportion of foreign staff by field of science.

		Percentage of foreign staff				Total
		Zero	6% or less	6.1–14%	over 14%	
Natural sciences	Number of units	5	14	14	13	46
	% of units	11	30	30	28	100
Engineering and technology	Number of units	10	18	23	30	81
	% of units	12	22	28	37	100
Medicine and health sciences	Number of units	12	14	9	6	41
	% of units	29	34	22	15	100
Social sciences	Number of units	30	19	15	11	75
	% of units	40	25	20	15	100
Humanities	Number of units	12	3	10	11	36
	% of units	33	8	28	31	100
Multidisciplinary	Number of units	7	10	6	8	31
	% of units	23	32	19	26	100
Total	Number of units	76	78	77	79	310
	% of units	25	25	25	26	100

Figure 1 compares the situation in traditional university departments and research units by field of science. Traditional university departments are those that offer basic tuition and degrees, while research units are predominantly or exclusively focused on doing research work. In the social sciences and in multidisciplinary units and to some extent in engineering fields, the proportion of foreign nationals was somewhat higher in research units than in traditional university departments. In the humanities,

1 Total staff number indicated by respondent (i.e. heads of units), with no distinction made between researchers and other staff.

the number of foreign staff was high in traditional departments, which is probably explained by the large number of foreign teachers especially in linguistics. At medical departments, too, the number of foreign staff was higher than at research units.

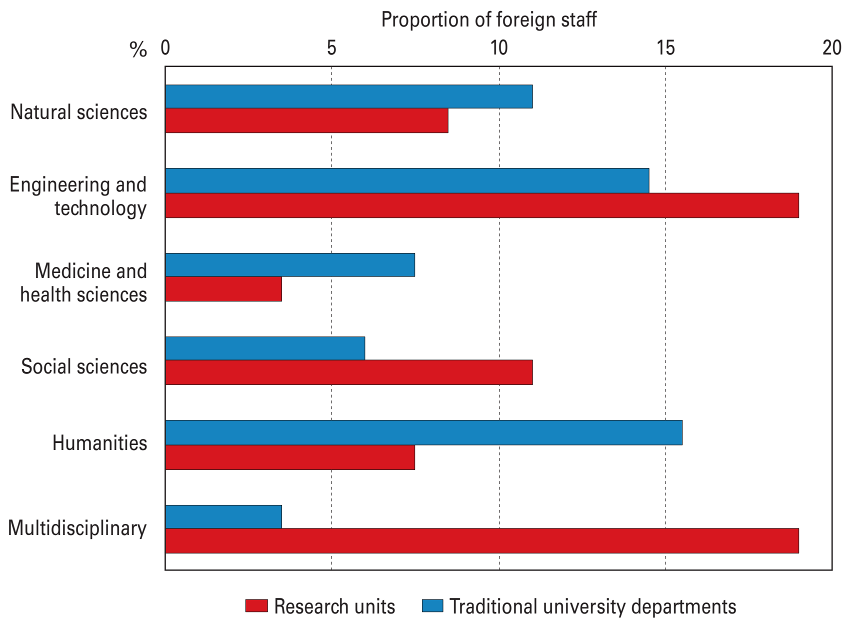

Figure 1. Proportion of foreign staff employed for at least six months at responding units in 2003 by type of unit in different fields of science.

3.2 University unit staff with experience of working abroad

The questionnaire included one item to measure the number of unit staff who had worked abroad for at least one month in 2003. These numbers were compared against the total number of unit staff (as in the case of foreign staff above). As is shown in Table 3, the number of staff who had worked abroad as a proportion of unit staff was highest in multidisciplinary units, and this figure differed statistically significantly from all other disciplines ($p<0.05$). In natural science units, too, the number of staff who had worked abroad was higher than in other disciplines, but the difference was statistically significant only in relation to medicine and health sciences, which had the lowest number of staff who had worked abroad.

Table 3. Proportion of staff working abroad for at least one month at responding units by field of science.

		Proportion of staff who had worked abroad				Total
		Zero	6% or less	6.1–14%	over 14%	
Natural sciences	Number of units	7	14	15	9	45
	% of units	16	31	33	20	100
Engineering and technology	Number of units	17	24	27	10	78
	% of units	22	31	35	13	100
Medicine and health sciences	Number of units	15	9	7	10	41
	% of units	37	22	17	24	100
Social sciences	Number of units	17	22	18	16	73
	% of units	23	30	25	22	100
Humanities	Number of units	7	8	8	10	33
	% of units	21	24	24	30	100
Multidisciplinary	Number of units	6	12	5	7	30
	% of units	20	40	17	23	100
Total	Number of units	69	89	80	62	300
	% of units	23	30	27	21	100

4 University units' forms of internationalisation

4.1 Current forms of internationalisation

In 2003, the most common form of internationalisation for the university units responding to our survey was participation in international conferences and seminars (Figure 2). Two-thirds of the units said that participation in conferences was high or very high. Other common forms of internationalisation included informal contact among researchers and international publishing. Well over half of the units reported high or very high frequencies for these forms of internationalisation. Joint publications with researchers from other countries were also relatively common.

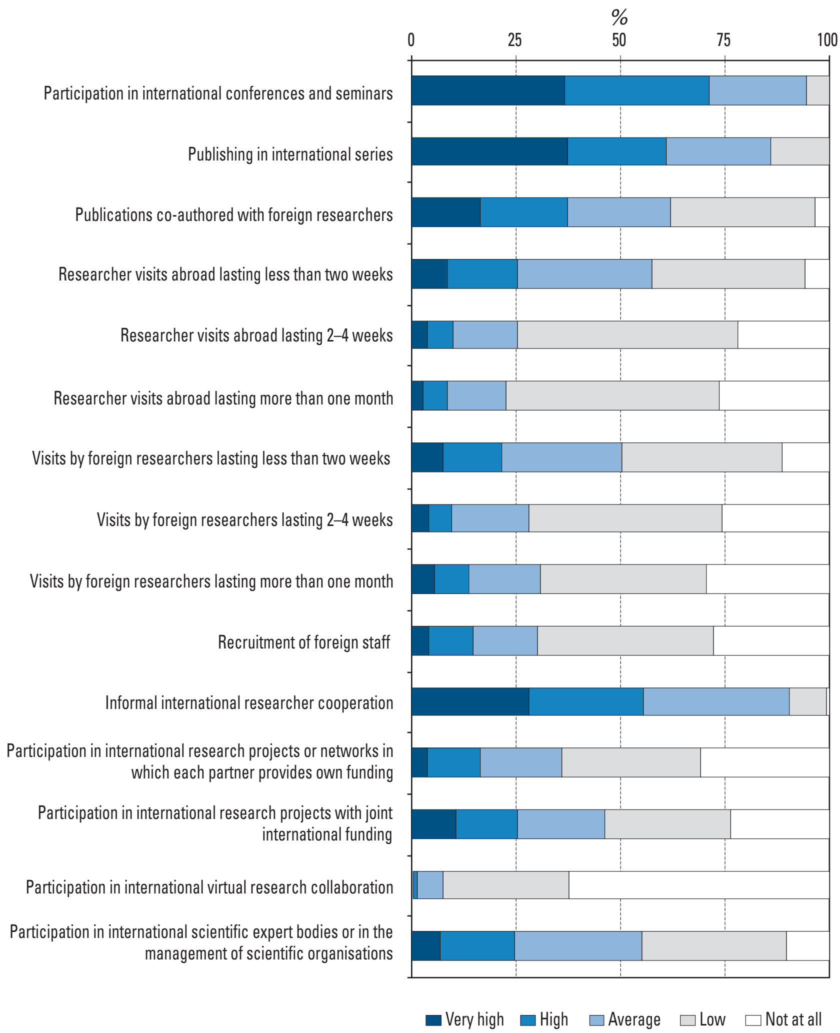

Figure 2. Forms of internationalisation at responding units.

Somewhat less common forms of internationalisation were short visits (less than two weeks) to or from Finland; participation in international expert bodies or in the management of scientific organisations; and participation in international research projects with joint international funding. Nonetheless, around one-quarter (21–25%) of the units reported high or very high participation in these forms of international activity. Relatively infrequent forms of internationalisation included research projects or networks in which the partners provide their own funding (17%); recruitment of foreign staff (15%); and researcher visits to or from Finland lasting two weeks or more. Around one-tenth of the units reported a large or very large number of such visits.

Some forms of internationalisation differed statistically significantly between different fields of science (Table 4). International publishing was particularly common in medicine and health sciences, whereas in the humanities it was less common.

Table 4. Forms of internationalisation at responding units by field of science: percentage of respondents indicating high or very high participation in each item.

	Natural sciences (n=47)	Engineering and tech-nology (n=81)	Medicine and health sciences (n=42)	Social sciences (n=81)	Human-ities (n=36)	Multi-discipli-nary (n=32)	Total (n=320)
Participation in international conferences and seminars	**85**	74	74	62	69	68	71
Publishing in international series *	87	59	**95**	42	39	55	61
Publications co-authored with foreign researchers *	**66**	29	43	28	20	52	37
Researcher visits abroad lasting less than two weeks	**40**	20	21	20	25	35	25
Researcher visits abroad lasting 2–4 weeks *	19	10	5	3	8	**23**	10
Researcher visits abroad lasting more than one month *	17	9	2	3	8	**19**	9
Visits by foreign researchers lasting less than two weeks *	35	17	14	15	22	**39**	21
Visits by foreign researchers lasting 2–4 weeks *	**22**	6	2	6	8	19	10
Visits by foreign researchers lasting more than one month	**23**	13	17	9	8	16	14
Recruitment of foreign staff *	**26**	22	5	6	6	**26**	15
Informal international researcher cooperation *	**74**	44	40	59	67	55	55
Participation in international research projects or networks in which each partner provides own funding	**26**	11	12	17	21	16	17
Participation in international research projects with joint international funding *	37	24	23	18	17	**45**	25
Partcipation in international virtual research cooperation	0	0	0	1	3	**6**	1
Participation in international scientific expert bodies or in the management of scientific organisations *	**45**	19	24	17	23	32	25

*) differences between fields of science statistically significant (p<0.05)

Publications co-authored with foreign researchers were most common in the natural sciences. Recruitment of foreign staff was more common in the natural sciences and in multidisciplinary units. Informal international cooperation between researchers and involvement in the international scientific community were most common in the natural sciences. Participation in international research projects that have joint funding was most common in multidisciplinary units.

4.2 Comparison of internationalisation by field of science

The items describing internationalisation were reduced into four factor variables: 1) international academic output, 2) long visits, 3) short visits and 4) international projects (see Appendix 1). Figure 3 provides a summary of these factor variables in different fields of science. Frequencies for 'international publications and conference participations', 'short visits" and 'international projects' differ between different fields of study, whereas no significant correlation is seen with 'long visits'.

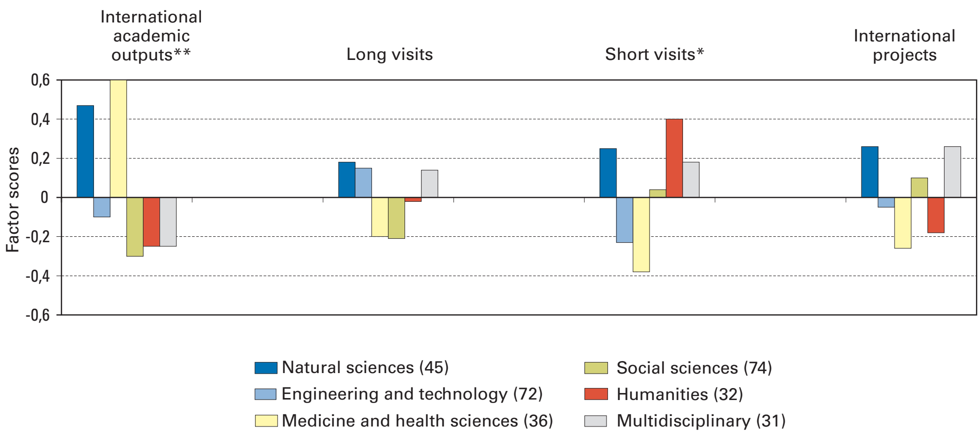

Figure 3. Field of science and mean factor scores for dimensions of internationalisation in research. Impact of unit size controlled for.

'International academic outputs' were more common in medicine and health science and in natural science units than in other fields of study. 'Long visits' were most typical in the natural sciences, engineering and technology fields and in multidisciplinary units and least typical in medical and health sciences and in social sciences units. However, the differences in internationalisation on this dimension were quite minor.

'Short visits' were particularly common in the humanities, but also in the natural sciences and in multidisciplinary units. On this dimension, internationalisation was less common than average in engineering and technology and in medicine and health sciences units. 'International projects' were most typical in the natural sciences and multidisciplinary units and least common in medical and health sciences units.

Natural science units showed the greatest diversity in their internationalisation, recording higher than average scores on all four dimensions. In engineering and technology units the only dimension of internationalisation where scores were slightly higher above average was that of 'long visits'. In the field of medical and health sciences, the main focus of internationalisation was clearly on 'international academic outputs'. The opposite was true for the international profile of multidisciplinary units: scores for the dimension of 'international academic outputs' were lower than average, whereas other dimensions of internationalisation were higher than average. In the humanities, internationalisation consisted primarily of 'short visits'; on other dimensions there was relatively little internationalisation when compared to other fields of study. Social sciences units seemed the least internationalised: 'international academic outputs' and 'long visits' in particular were less typical than in other fields, while 'short visits' and 'international projects' were about as common as in all units on average.

4.3 Development of forms of internationalisation over the past five years and future prospects

Development of forms of internationalisation. Apart from the current prevalence of different forms of internationalisation, the respondents were asked to assess the quantitative development of these activities over the past five years (1999–2004). None of these forms had decreased, but for most units they had remained unchanged. There were also some indications of growth during this short period of time, most typically in those forms of engagement that were rated as the most common.

Informal exchange and interaction among researchers across national borders had increased at most university units (Figure 4). Over half or approximately half of the units estimated that international publishing, participation in conferences and co-authored publications with foreign researchers had increased during the five-year period. Around one-third of the units also reported an increase in participation in international scientific expert bodies or in the management of scientific organisations, in participation in international research projects with joint funding, recruitment from abroad, and in short (less than two weeks) researcher visits to or from Finland. Other forms of research visits had increased to a somewhat lesser extent; in fact the figures showed very little change at all. Just over one-tenth of the responding university units reported that their participation in internationally organised virtual cooperation had increased.

The increase recorded for some forms of internationalisation differed statistically significantly between different fields of study (Table 5). These included the shorter duration of researcher visits from Finland, researcher visits longer than one month to Finland and the recruitment of foreign staff. Differences were also seen in the level of participation in international research projects and involvement in science management in different fields of science. These were reported to have increased most of all in multidisciplinary units. The one exception was the recruitment of foreign staff, which had increased most of all in social sciences units.

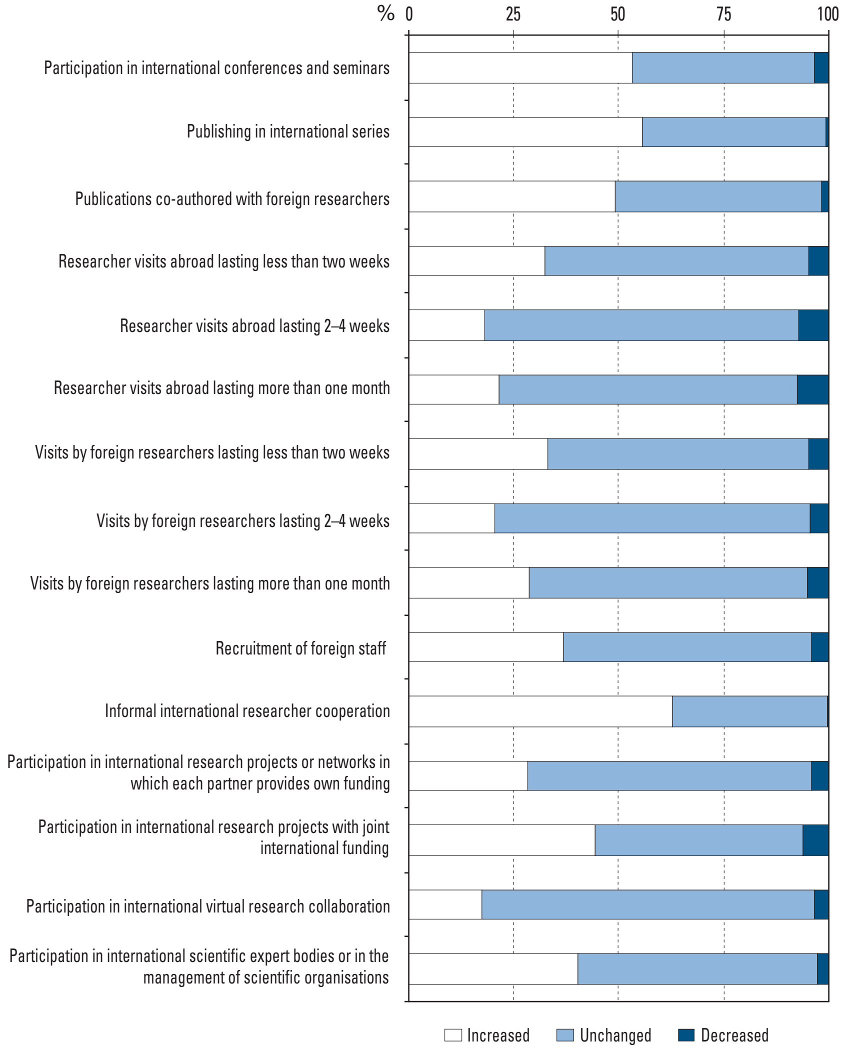

Figure 4. Change in forms of internationalisation at responding units over past five years.

Future areas of emphasis for internationalisation. The respondents were asked which aspects of internationalisation would be given priority in the unit's future plans. According to the participating units the main focus of their future internationalisation would be on international publishing (Figure 5). Other areas of future focus will include participation in international conferences and seminars and participation in internationally funded research projects. There were no major differences between different fields of science in the priority areas identified for future internationalisation. However, the humanities did differ from the rest of the field in that the main emphasis was placed on participation in international conferences, whereas for other fields of study the main area of emphasis was international publishing.

Table 5. Change in forms of internationalisation at responding units by field of science: percentage of units where respondents indicate an increase in form of internationalisation.

	Natural sciences (n=47)	Engineering and technology (n=81)	Medicine and health sciences (n=42)	Social sciences (n=81)	Humanities (n=36)	Multidisciplinary (n=32)	Total (n=320)
Participation in international conferences and seminars	51	47	41	56	59	**76**	53
Publishing in international series	53	52	52	59	48	**72**	56
Publications co-authored with foreign researchers	50	51	34	51	41	**62**	49
Researcher visits abroad lasting less than two weeks *	22	33	19	31	44	**55**	33
Researcher visits abroad lasting 2–4 weeks *	16	20	0	19	12	**41**	18
Researcher visits abroad lasting more than one month	18	24	15	22	8	**39**	21
Visits by foreign researchers lasting less than two weeks	27	28	21	41	42	**43**	33
Visits by foreign researchers lasting 2–4 weeks	25	19	10	25	12	**28**	20
Visits by foreign researchers lasting more than one month *	36	34	23	26	0	**40**	29
Recruitment of foreign staff *	47	33	21	**50**	14	41	37
Informal international researcher cooperation	65	58	47	68	64	**75**	63
Participation in international research projects or networks in which each partner provides own funding	30	29	14	35	10	**39**	28
Participation in international research projects with joint international funding *	58	44	28	41	20	**69**	45
Participation in international scientific expert bodies or in the management of scientific organisations *	54	35	36	42	19	**56**	40

*) differences between fields of science statistically significant ($p<0.05$).

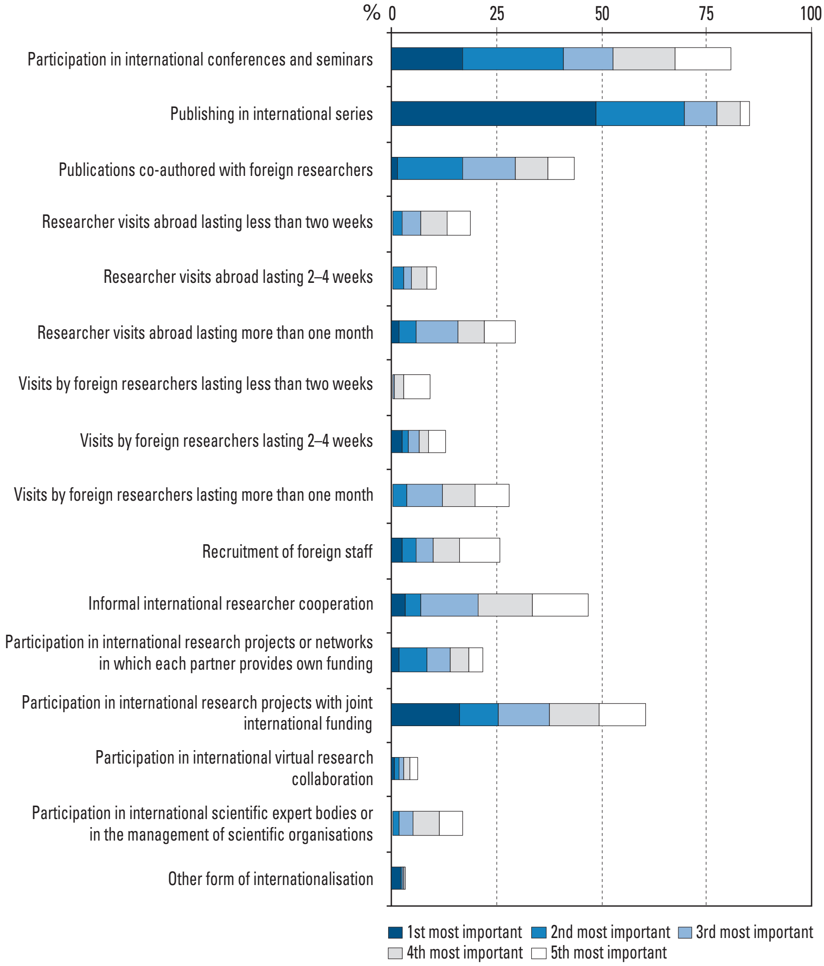

Figure 5. Future areas of emphasis for internationalisation at responding units.

5 University units' partner countries in cooperation

The respondents were asked to identify, in order of importance, the five countries with which their units had the most research collaboration. Among the 320 university units that responded to the questionnaire, 303 replied to this item. In all fields of science the four countries mentioned most often in the top five lists were Sweden, Germany, the United States and the UK (Table 6). Russia came next on this list in all other fields of science except engineering and technology, where France was mentioned more often; in medicine and health sciences, where Italy was mentioned more often; and in the social sciences, where Norway was mentioned more often.

Table 6. Five most important partner countries for responding units (n = 303).

Most important partner country			Among three most important			Among five most important		
	N	%		n	%		n	%
USA	57	19	Sweden	135	45	Sweden	182	60
Sweden	51	17	Germany	128	42	Germany	172	57
Germany	43	14	USA	113	37	USA	166	55
UK	37	12	UK	96	32	UK	149	49
Russia	22	7	France	41	14	Russia	74	25

The United States was mentioned most often among the top five partners in natural science as well as in medicine and health science units (Table 7). Germany was the most frequently mentioned partner in engineering and technology and in multidisciplinary units. In the social sciences the country mentioned most often among the top five partners was the UK, in the humanities it was Sweden. The UK ranked among the two most common partners in multidisciplinary units as well. In the engineering and technology field, international research collaboration was more heavily concentrated in the sense that the three top partners stood out more clearly from the fourth most common partner than elsewhere. In other words, the difference between the third and the fourth most typical partner in engineering units was bigger than the difference in other fields of science.

These results were compared with findings from an earlier survey also by the Unit for Science, Technology and Innovation Studies in 1998 and 1999,[2] where unit heads were asked to identify their three most important research partners (Table 8). In both questionnaires the top six countries were the same, although the order was not: it would seem that since the previous survey, Sweden and Germany have gained in significance, particularly at the expense of the United States. In the more recent survey, the top nine countries included altogether three Nordic countries, i.e. not only Sweden but also Norway and Denmark. Japan no longer appeared on this list.

2 Hakala, Kaukonen, Nieminen & Ylijoki 2003. Yliopisto – tieteen kehdosta projektimyllyksi? Gaudeamus.

Table 7. Most typical partner countries for responding units by field of science.

	Most	2nd most	3rd most	4th most	5th most	
	References among five most important partner countries					n
Natural sciences	USA	Germany	Sweden	UK	Russia	
	63%	57%	57%	52%	41%	46
Engineering and technology	Germany	Sweden	USA	UK	France	
	69%	64%	51%	31%	31%	77
Medicine and health sciences	USA	Sweden	Germany	UK	Italy	
	65%	63%	55%	48%	25%	40
Social sciences	UK	Sweden	USA	Germany	Norway	
	67%	62%	51%	45%	26%	76
Humanities	Sweden	USA	Germany	UK	Russia	
	62%	56%	53%	47%	38%	34
Multidisciplinary	Germany	UK	Sweden	USA	Russia	
	66%	52%	48%	45%	38%	29
Total	**60%**	**57%**	**55%**	**49%**	**25%**	302

Table 8. Most important/typical partner countries by field of science in the 1998–1999 university survey and in the 2004 questionnaire.

		Most	2nd most	3rd most	4th most	5th most	
		References among three most important partner countries					n
Natural sciences	1999	USA	UK	France	Germany	Sweden	57
	2004	Germany	Sweden	USA	UK	France	46
Engineering and technology	1999	Germany	USA	Sweden	UK	Japan	74
	2004	Germany	Sweden	USA	France	UK	77
Medicine and health sciences	1999	USA	Sweden	Germany	UK	Hungary	47
	2004	USA	Sweden	UK	Germany	France	40
Social sciences	1999	USA	UK	Sweden	Germany	Russia	92
	2004	UK	Sweden	USA	Germany	Denmark	76
Humanities	1999	Sweden	USA	UK	Germany	Estonia	60
	2004	Sweden	Germany	USA	Russia	Estonia	34
Multidisciplinary	1999	USA	UK	Germany	Russia	Sweden	18
	2004	Germany	USA	Sweden	UK	Russia	29
Total	**1999***	**USA**	**Sweden**	**Germany**	**UK**	**Russia**	**348**
	2004	**Sweden**	**Germany**	**USA**	**UK**	**France**	**302**

*) responses weighted so that the field of science breakdown corresponds to breakdown in 2004 questionnaire.

The geographical extent of international research collaboration was studied using a set of ten country categories identified by the participating university units as their most typical partners. For analytical accuracy we clustered some countries into smaller groups, even though they officially are part of some larger category. For this reason the Nordic countries, for instance, are not included in the West European category, and the Baltic countries and Russia are not in the East Europe category. These country groups are mutually exclusive, i.e. one country can only belong to more than one group. In all fields of science, university units had the most cooperation with West European countries (Table 9). In relative terms the units with the most active cooperation with West European countries were those in the fields of natural sciences, engineering and social sciences as well as multidisciplinary units: over 90% of these units identified some West European country among their top five most important partners. Among medicine and health science units 83% and among humanities units 85% had cooperation with West European countries. Part of the reason for the strong prominence of Western Europe (as compared to the Nordic and North American categories, for instance) lies obviously in the fact that there are many more countries within the former than in the latter categories.

The second most common category of partners was the Nordic countries, followed by North America (USA or Canada). Cooperation with the Nordic countries was reported most often by units in the fields of medicine and health sciences and social sciences. Relatively most cooperation with the North American countries was reported in the fields of natural sciences and medicine and health sciences. In the natural sciences, cooperation with North American countries was even more typical than cooperation with the Nordic countries. In other fields of science there was a larger number of units where at least one Nordic country featured more often among the five most important partners than the United States or Canada.

Table 9. Percentage of responding units in different fields of science with partners from different country categories among the five most common partner countries.

	Western Europe	Nordic countries	USA or Canada	Baltic countries or Russia **	Asia	Eastern Europe	Oceania	Middle East	South America	Africa	n
Natural sciences	91	63	70	61	24	20	9	4	4	0	46
Engineering and technology	92	68	53	26	24	19	8	0	1	3	78
Medicine and health sciences	83	75	68	23	8	15	10	3	0	3	40
Social sciences	91	72	55	32	12	11	8	0	0	1	76
Humanities	85	68	56	53	15	21	3	3	3	0	34
Multidisciplinary	90	62	48	55	28	14	10	0	0	0	29
Total	**89**	**69**	**58**	**38**	**18**	**16**	**8**	**1**	**1**	**1**	**303**

**) Statistically significant group differences (p<0.01 in logistic regression analysis)

6 Reasons for international cooperation

University research units were asked to detail the reasons for their international cooperation (Figure 6). The most important motives were to learn about the latest scientific knowledge or methods, to obtain scientific knowledge complementing the unit's own knowledge, to create networks, to promote research careers and to contribute to scientific development within one's own field: 96% of the respondents described these as somewhat important, important or very important reasons for cooperation. Other important reasons included the international publishing, increasing awareness of the unit abroad, securing domestic funding, improving the quality of research at the unit, improving prospects of success in the competition with other units in the same field, obtaining international funding, gaining first-hand

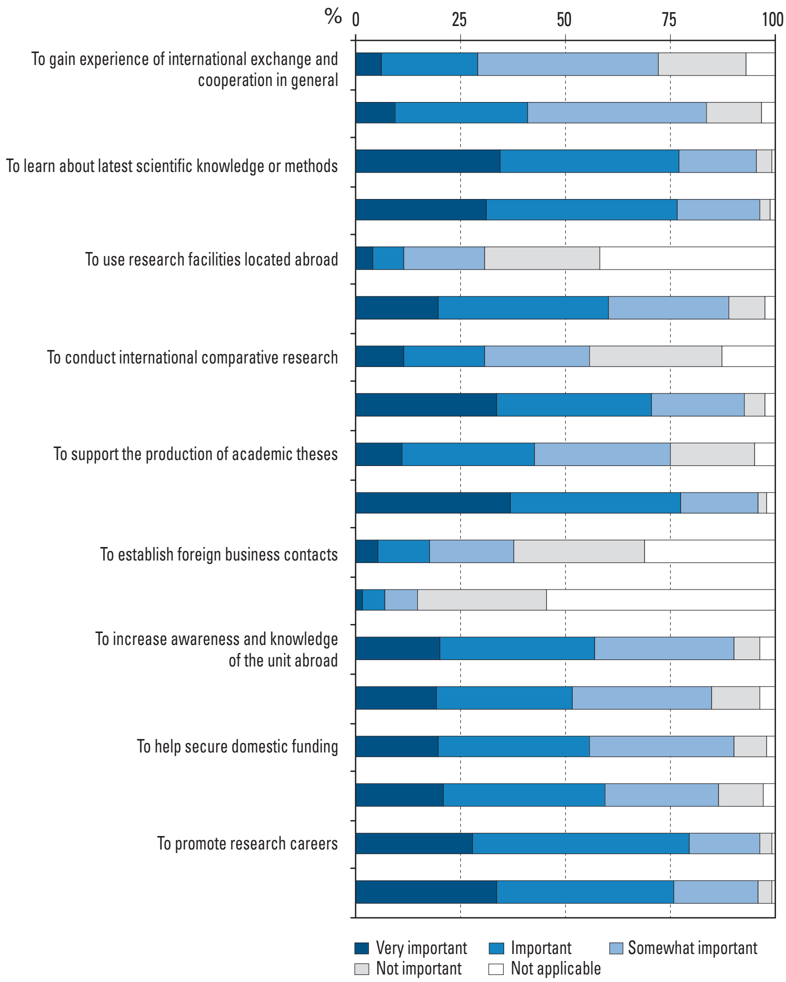

Figure 6. Reasons for international cooperation at responding units.

experience of new practices in order to gain new ideas and inspiration. Between 84 and 93% of the respondents rated these factors as important.

Statistically significant differences between fields of science were seen in six reasons for international cooperation (Table 10). Gaining access to research facilities abroad was mentioned by far more often in natural science units than in other field of science categories. Among natural sciences units, 30% considered this an important motive for international cooperation, while the figure for other units ranged between 1 and 15%. This result is at least partly explained by the fact that in some natural science disciplines (e.g. physics), research equipment is extremely expensive and beyond the resources of a small country such as Finland.

Table 10. Percentage of responding units where reason for international cooperation was somewhat important, important or very important by field of science. Only those reasons are shown where statistically significant differences were seen between fields of science ($p<0.05$).

Reason for international cooperation	Natural sciences (n=47)	Engineering and technology (n=81)	Medicine and health sciences (n=42)	Social sciences (n=81)	Humanities (n=36)	Multi-disciplinary (n=32)
To use equipment located abroad	**30**	14	15	1	3	10
To conduct international comparative research	22	20	25	**50**	24	35
To establish foreign business contacts	13	**30**	24	6	6	23
To develop and sell commercial products	2	13	**17**	3	0	6
To obtain international funding	65	56	54	35	41	**71**
To compete successfully with other units in same field	67	56	69	51	50	77

The motive of international comparative research was mentioned most often in social sciences units, where 50% rated this as at least somewhat important. In other fields of science, the percentage ranged between 20 and 35%. Establishing international business contacts was mentioned most often in engineering and technology units: here 30% considered this as at least a somewhat important motive. The figures for medicine and health sciences and for multidisciplinary units reached almost the same level. In other fields of science, establishing foreign business contacts was a much less common motive for international cooperation.

The development and selling of commercial products was a more common reason for international cooperation in medicine and health science units than in other units. This motive was mentioned next most often in engineering units. Obtaining international funding, on the other hand, was a more typical motive in multidisciplinary units than in other units, although it was mentioned quite often by natural science units as well. Improving the unit's prospects of success in competition with other units in the same field was a somewhat more common motive for international cooperation in multidisciplinary units than in others.

7 Problems with internationalisation at university units

Attracting foreign researchers to Finland. The respondents were asked to what extent certain factors had deterred foreign researchers and/or postgraduate students from seeking positions at their units (Figure 7). The factor that emerged as the single most important obstacle to seeking a position at a unit was a lack of funding. Finland's northern climate and remote location, family reasons and the absence of a centre of expertise in the field concerned were also mentioned as deterring factors. Language problems and lack of awareness of the unit in other countries also contributed to deterring foreign researchers from moving to work in Finland. Negative attitudes to foreigners in Finland, bureaucratic procedures, the scarcity of Finnish language training opportunities and inadequate hardware facilities at the unit, on the other hand, were thought to have only minor bearing on attracting foreign researchers to Finland.

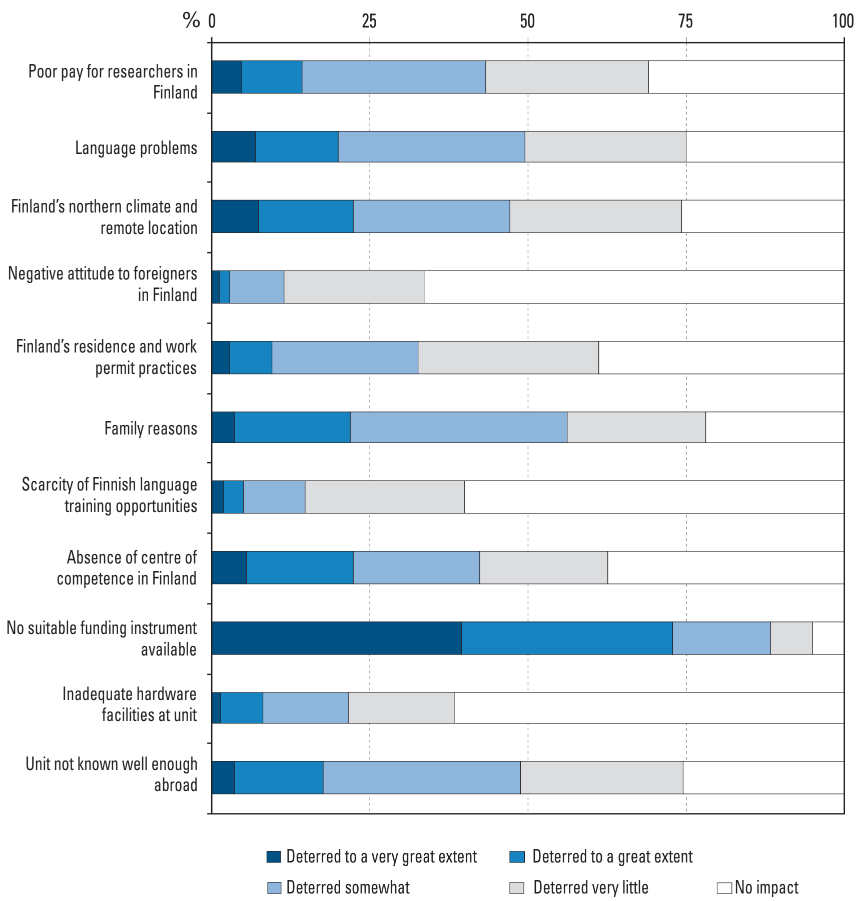

Figure 7. Factors deterring foreign researchers from seeking positions at responding units.

Table 11. Factors deterring foreign researchers from seeking positions in the unit by field of science: percentage of units where the respondents felt that the factor in question had deterred them from seeking positions to a great or very great extent.

	Natural sciences (n=47)	Engineering and technology (n=81)	Medicine and health sciences (n=42)	Social sciences (n=81)	Humani-ties (n=36)	Multidisci-plinary (n=32)
Poor pay for researchers in Finland compared to Western Europe and the USA	11	9	14	13	6	**27**
Language problems	13	21	**22**	18	21	17
Finland's northern climate and remote location	**28**	22	21	16	9	27
Negative attitude to foreigners in Finland	4	**5**	2	1		
Finland's residence and work permit practices	13	**11**	10	5	3	7
Family reasons	17	17	**33**	18	6	17
Scarcity of Finnish language training opportunities *		5	**13**	1	9	
Absence of a large enough centre of expertise comprising university units, research institutes and business companies in Finland	15	14	25	25	9	**28**
Unit does not have access to funding instruments to flexibly recruit foreign staff	63	70	68	**79**	67	77
Inadequate hardware facilities at unit *	11	9	**18**	1	3	3
Unit not known well enough abroad *	13	20	15	12	6	**33**

*) differences between fields of science statistically significant (p<0.05).

Among the factors that were thought to reduce foreign researchers' interest in coming to Finland, three showed significant differences between different fields of science (Table 11). The scarcity of Finnish language training opportunities and inadequate hardware facilities were most often perceived as deterring factors in medicine and health science units. Lack of awareness of the unit in other countries was identified as a more common obstacle in multidisciplinary than in other units.

Movement of Finnish researchers to other countries. An item was included in the questionnaire to determine the reasons deterring researchers from leaving the unit and moving to work in other countries (Figure 8). Family reasons and the scarcity of staff resources at the unit emerged as the most important reasons: over half of the respondents said these were the main factors deterring them from leaving. Financial obstacles and lack of time were mentioned by almost half of the respondents. Lack of interest or uncertainty about getting one's job back on return was not identified as

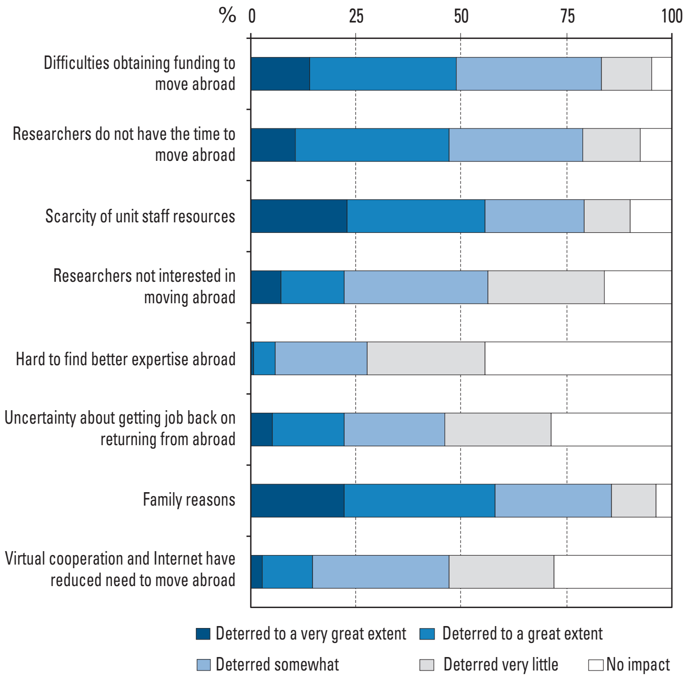

Figure 8. Factors deterring researchers at responding units from going to work abroad.

Table 12. Factors deterring researchers at responding units from going to work abroad by field of science: percentage of units where the respondents felt that the factor in question had deterred movement to a great or very great extent.

	Natural sciences (n=47)	**Engineering and technology** (n=81)	**Medicine and health sciences** (n=42)	**Social sciences** (n=81)	**Humani-ties** (n=36)	**Multi-discipli-nary** (n=32)
Difficulties obtaining funding to move abroad	35	44	55	47	**56**	54
Researchers do not have the time to move abroad	46	33	43	**54**	44	54
Scarcity of unit staff resources mean that senior researchers cannot move abroad	41	51	50	60	**68**	54
Researchers not interested in moving abroad *	22	28	26	16	3	**29**
Hard to find better expertise abroad	2	**10**		5	6	4
Uncertainty about getting job back on returning from abroad	22	20	21	17	12	**39**
Family reasons	52	58	60	58	35	**71**
Virtual cooperation and Internet have reduced need to move abroad	15	11	10	**16**	15	14

*) differences between fields of science statistically significant (p<0.05).

major obstacles to leaving. The factors with the least impact were the growth of virtual cooperation and the difficulty of finding greater expertise abroad than at home.

With just one exception the factors deterring researchers from moving abroad did not show statistically significant differences between different fields of science (Table 12). In multidisciplinary units, researchers' lack of interest to move abroad was considered a restrictive factor more often than in other units.

Main problems in internationalisation. The questionnaire included an open-ended item in which the respondents were asked to identify the three main factors hampering the unit's internationalisation. Among the respondents, 86% mentioned at least one problem and 39% three problems or more. As is shown in Figure 9, by far the most common perceived hindrances to internationalisation were funding problems: 65% of the university units said that this was one of the main barriers to internationalisation.

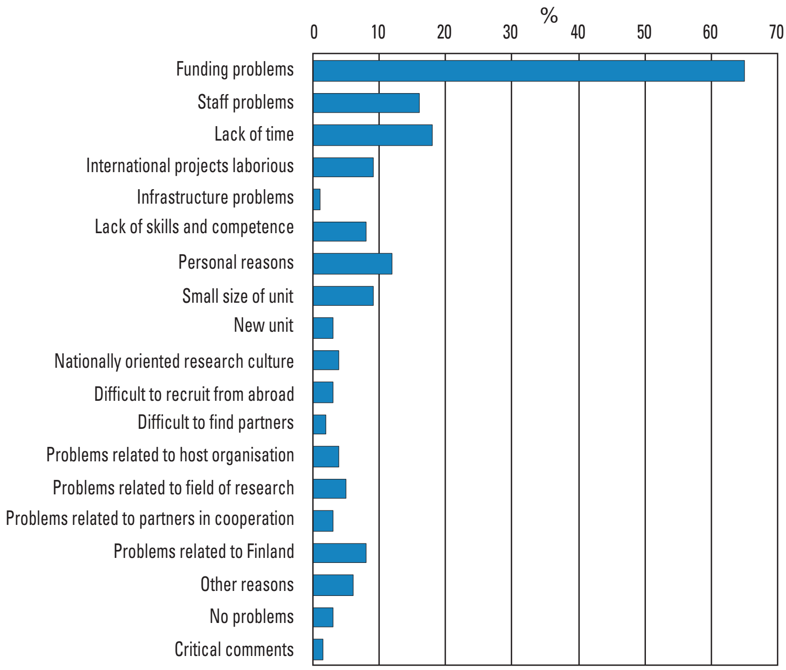

Figure 9. Main perceived problems of internationalisation at responding units: percentage of units indicating that the item concerned was among the three major problems.

Financial problems were mentioned most often in natural science and humanities units: 72% of these units identified funding as one of their three main problems (Table 13). This problem was least typical in medicine and health science units, amongst which it was mentioned by 56%.

The only problem of internationalisation where statistically significant differences were seen between different fields of science was the complaint that international projects are laborious and time-consuming. This seemed to be a particularly common

Table 13. Problems of internationalisation at responding units by field of science: percentage of units indicating that the item concerned was among the three major problems.

	Natural sciences	Engineering and technology	Medicine and health sciences	Social sciences	Humanities	Multidisciplinary
Funding problems	72	67	56	64	72	59
Staff problems	19	11	14	19	14	16
Lack of time	15	17	14	20	31	6
International projects laborious*	19	11	2	6	0	3
Infrastructure problems	0	2	2	0	6	0
Lack of skills and competence	2	7	5	7	8	13
Personal reasons	15	21	14	6	8	13
Small size of unit	2	9	9	12	8	13
New unit	0	5	0	6	0	6
Nationally oriented research culture	2	6	2	7	6	3
Difficult to recruit from abroad	6	2	7	2	0	0
Difficult to find partners	0	0	5	2	3	9
Problems related to host organisation	9	4	0	4	6	6
Problems related to field of research	0	5	2	7	11	6
Problems related to partners	0	5	5	1	0	3
Problems related to Finland	13	9	2	6	6	16
Other reasons	6	5	2	6	8	6
n	42	73	31	75	32	27

*) differences between fields of science statistically significant ($p<0.05$)

problem in natural science units. It was mentioned next most often in engineering and technology units. None of the humanities units in this survey felt that international projects were overly laborious. Some minor differences were seen in other perceived problems, too. Lack of time was the most common problem in humanities units and the least common in multidisciplinary units. Lack of knowledge and skills (i.e. lacking competencies with regard to internationalisation and lacking research skills) was the most common problem in multidisciplinary units. This was least typical in natural science units, among which only a few referred to this as a problem of internationalisation. Personal reasons (e.g. family reasons) were mentioned as a problem most often in engineering and technology units and least often in social science units.

8 Summary: Internationalisation as a changing research practice

At a science policy level as well as in everyday research practice, internationalisation appears as an integral part of the normal conduct of scientific research. Scientific interaction is local, national and at once international by nature. This exchange and interaction is essentially about generating new scientific knowledge, communicating and transferring new research methods and perspectives, assimilating new knowledge and publishing new research results. Internationalisation is a form and tool of scientific exchange, not an objective or value in itself. Since internationalisation is an integral part of scientific interaction, it does not differ from other forms of scientific communication, interaction or cooperation.

Good relations of scientific interaction require complete reciprocity and at least some continuity. International activity requires special competencies so that the benefits of mutual interaction can be fully reaped on both sides. International interaction is aimed selectively at creating added value, mutual benefits. This is reflected in the result reported here for the social sciences, according to which the collection of international comparative material is a major motive for international cooperation. Both parties benefit from comparisons, and at the same time all partners gain access to data that would be hard to obtain without cooperation.

In Finland, the small size of our research system and our limited research staff resources create specific challenges for internationalisation. International exchange is particularly important to researchers who do not have many colleagues at home. Researchers need international contacts in order to maintain their skills and competencies. For a small country with a small research system, it is important to develop both weak and strong links of interaction. Weak links are characterised by diversity, they explore virgin territory and facilitate extensive networking. Strong links or partnerships are based on long-standing and confidential relationships and foster diverse collaboration. Furthermore, researchers in Finland have to be particularly active in order to retain their partnership position in international research infrastructures. According to our data, access to research facilities is among the most important motives for international cooperation in the natural sciences.

An effective research system requires both broadly based research and maintenance of competencies, and on the other hand, specialised research and competencies focusing on national strengths and needs. In the future, national and regional issues will continue to remain important in many fields, even though economic, environmental, cultural and other globalisation is changing the nature of research problems, making them ever more complex. Specialisation in selected areas of strength and divisions of labour between universities and within disciplines may become increasingly important to effective international cooperation.

The forms and methods of internationalisation vary widely from one field of science to the next. This is largely a function of the differences between the nature, core contents, objectives and audiences of different fields of science. In some fields, research knowledge is universal and global, in others it is nationally more specific or local, depending on the nature, substance and objectives of the field of science. These differences are reflected in the fact that in engineering and technology, for example, business contacts were identified as a major motive for international cooperation, and in medicine and health sciences, the emphasis was placed on international publications and on the development and sales of commercial products. These reasons were hardly mentioned at all in the natural sciences, social sciences and humanities.

Depending on the traditions in the field of science concerned, research produces many different kinds of results. The most visible and most easily measurable among these results are publications. Our questionnaire shows that the publication of international articles is the most typical form of internationalisation in medicine and health sciences, whereas in the natural sciences articles co-authored with foreign researchers emerged as the most significant form of cooperation. This result is consistent with findings from studies of publishing cultures (Puuska and Miettinen 2008, 28–37): in the natural sciences and medicine, an international article is a method of communication, in engineering and technology the forum of publication is largely determined by the audience and end-users of research, whereas in the social sciences and humanities there is both a monograph culture (e.g. history, philosophy) and a culture dominated by international articles (e.g. psychology).

Different fields of science also differ in terms of international mobility. It seems that the proportion of foreign-born staff is highest in the humanities and engineering disciplines, while the proportion of staff who have worked abroad is highest in multidisciplinary units and in the natural sciences. The recruitment of foreign staff also seems to be common in the natural sciences and in multidisciplinary units.

It seems that multidisciplinary units are the most active in terms of international cooperation. At the same time, they are also the most dependent on that cooperation. For instance, project cooperation with foreign researchers is very common in multidisciplinary units, where the main motive for international cooperation is to secure international funding. This is probably indicative of a scarcity of national funding in new multidisciplinary fields, and on the other hand, of the fact that the best researchers in these fields are working in other countries. In other words, the value added generated by internationalisation might be greater in new than in established fields of science.

The rich diversity of internationalisation and the differences observed between different fields of science present a huge challenge for the assessment of the rate and degree of internationalisation. The purpose of these assessments is to rank research in order of importance and to identify the very best work at the international cutting edge, even though the task of defining the best is highly problematic and open to interpretation. Indeed, internationalisation should not be measured using just one indicator. If all efforts are focused on developing such an indicator that may adversely affect international activity itself and its long-term development. The same goes for other scientific activities and their assessment. The indicator may take the upper hand and lead to a situation where formal and actual activities are designed on disparate sets of principles.

Despite the inherent problems with measures and indicators, it is nonetheless necessary to assess and measure the quality and intensity of internationalisation in different contexts. Based on our materials, it is important every now and then to pause and consider the validity of existing indicators of internationalisation. It is also necessary to keep track of these indicators; are they keeping up with the changing forms of internationalisation and internationalisation? With the continuing growth of electronic forms of communication, for instance, it is possible that in the future the focus of internationalisation may shift from mobility to publications and research funding.

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Appendix Factor analysis model for university units

The questionnaire respondents were asked to assess to what extent different forms of internationalisation were present in their units (Figure 2). All these forms of engagement were specifically related to research.

For each item, scores were ascribed to the units on the basis of the frequency of that particular form of internationalisation. The minimum score for one item was one point (indicating that the form of internationalisation was not present at all) and the maximum score five points (indicating a high level of internationalisation).

Table I. Scale for items measuring presence of different forms of internationalisation.

Forms of internationalisation	not at all	low	average	high	very high
Participation in international conferences and seminars	1	2	3	4	5
...	1	2	3	4	5

A factor analysis model was created to summarise the information yielded by the questionnaire items and to facilitate analysis of this information. This is a statistical method that allows for the items measuring internationalisation to be clustered into larger groups. These clusters are then used to develop new variables of internationalisation that combine several different items (so-called factors). In practice, what this means is that we can reduce the original 15 internationalisation variables to a much smaller number. We included in the model 14 items measuring the presence of different forms of internationalisation; the one item excluded from this analysis was the one measuring "Participation in internationally organised virtual cooperation" (e.g. virtual research units and laboratories), because it overlapped too much with other items measuring international research cooperation.

Factor analysis allows us to identify dimensions of internationalisation that lie behind the questionnaire items and that are shared in common by the units concerned. It is based on item-to-item correlations. In other words, items (i.e. forms of internationalisation) that correlate with each other, i.e. that are usually typical of the same units, tend to load on the same factor. Factor analysis produces the item factor loadings for each dimension or factor of internationalisation. The factor loadings describe the intensity of the correlation with each factor.

Factor analysis was used to extract summary variables describing each dimension of internationalisation or each factor by calculating factor scores. The items loading most highly on each factor were weighted in the factor score variables. The mean value for the factor score variables is 0, i.e. the factor scores for each unit describe how far they deviate from the mean on the dimension concerned. This means that units with positive values on a given dimension are more international on that particular dimension, while those with negative values are on average less international than others. In the analyses below, the factor score variables are standardised: the standard deviation for all is 1, which means that they are directly comparable with each other.

By testing various options we found that a four-factor solution was most appropriate for the university units here. With the exception of just three questionnaire items (recruitment of foreign staff, informal international cooperation and participation in international scientific expert bodies or in the management of scientific organisations), the four-factor model explains over half of the variation in each item (communality > 0.5). The model explains around 60% of the overall variation of all items. The factors are labelled according to the variables with the highest factor loadings.

I factor: 'International academic outputs'

The items with the highest loadings on the first factor were international publications (0.804), participation in international conferences (0.710), publications co-authored with foreign researchers (0.611) and participation in international scientific expert bodies or in the management of scientific organisations (0.450) (Table II). These forms of international activity (particularly international publications and participation in international conferences) have a wide range of promotive effects (e.g. on access to research funding, on one's own personal career, on monitoring progress in one's own field). One common denominator that is shared in common by all these four activities is that they are typical tools of achieving academic merit.

II factor: 'Researcher exchange focused on long researcher visits'

The items with the highest loadings on the second factor were visits to and from other countries, particularly visits lasting 2–4 weeks and those lasting more than one month. However, the loading obtained by the latter form of internationalisation on this factor is lower than on the first factor. In practice, long researcher visits are significantly related to the conducting of research abroad by Finnish researchers and to the work done by foreign researchers in Finland. These forms of activity can be described as being largely related to the transfer of know-how or tacit knowledge to and from other countries and to improving researchers' research skills.

III factor: 'Researcher exchange focused on short researcher visits'

On the third factor, the highest loadings are recorded for short, less than two-week visits to and from Finland and to "average" visits lasting 2–4 weeks to Finland. The significance and function of short visits lies largely in the support they provide to international research and its various forms (e.g. the start-up, maintenance and development of international operations and the preparation of international publications and research projects).

IV factor: 'International projects'

The highest loadings on the fourth factor are found for participation in international projects or networks in which each party provides their own funding (0.627), participation in international projects with joint funding (0.618) and informal international cooperation (0.438). The loadings for informal cooperation are almost as high as on the first factor (0.399). The variables with the highest loadings are largely related to concrete international research collaboration.

Table II. University units: rotated factor matrix for items describing different forms of internationalisation (four-factor solution).

	I	II	III	IV	Communality
Participation in international conferences and seminars	0.710	.	.	.	0.592
Publishing in international series	0.804	.	.	.	0.732
Publications co-authored with foreign researchers	0.611	.	.	0.324	0.602
Researcher visits abroad lasting less than two weeks	.	0.414	0.528	.	0.618
Researcher visits abroad lasting 2–4 weeks	.	0.751	.	0.311	0.798
Researcher visits abroad lasting more than one month	.	0.745	.	.	0.689
Visits by foreign researchers lasting less than two weeks	.	0.348	0.811	.	0.891
Visits by foreign researchers lasting 2–4 weeks	.	0.574	0.459	.	0.677
Visits by foreign researchers lasting more than one month	0.331	0.479	0.314	.	0.523
Recruitment of foreign staff	0.375	.	0.309	.	0.352
Informal international researcher collaboration	0.399	.	0.318	0.438	0.475
Participation in international research projects or networks in which each partner provides own funding	.	0.301	.	0.627	0.504
Participation in international research projects with joint international funding	.	.	.	0.618	0.527
Involvement in the management of scientific organisations	0.450	.	.	0.346	0.410

The model was estimated using the maximum likelihood method.

The solution was varimax rotated to maximise or minimise the loadings on each factor and in this way to facilitate interpretation.

Loadings lower than 0.3 are not shown in the Table.

The internationalisation of scientific research has been one of the key challenges for Finnish science policy for decades now. However, little empirical data has been available so far, and the development of the indicators needed for monitoring internationalisation has also been insufficient.

This report studies the internationalisation of science and changes in it, as well as future prospects. It includes a questionnaire survey on the practices of the internationalisation of research at universities and the problems involved. Analysis of the survey results covers trends in the forms of international activity, the partner countries of university units, and motives for international cooperation as part of research work.

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