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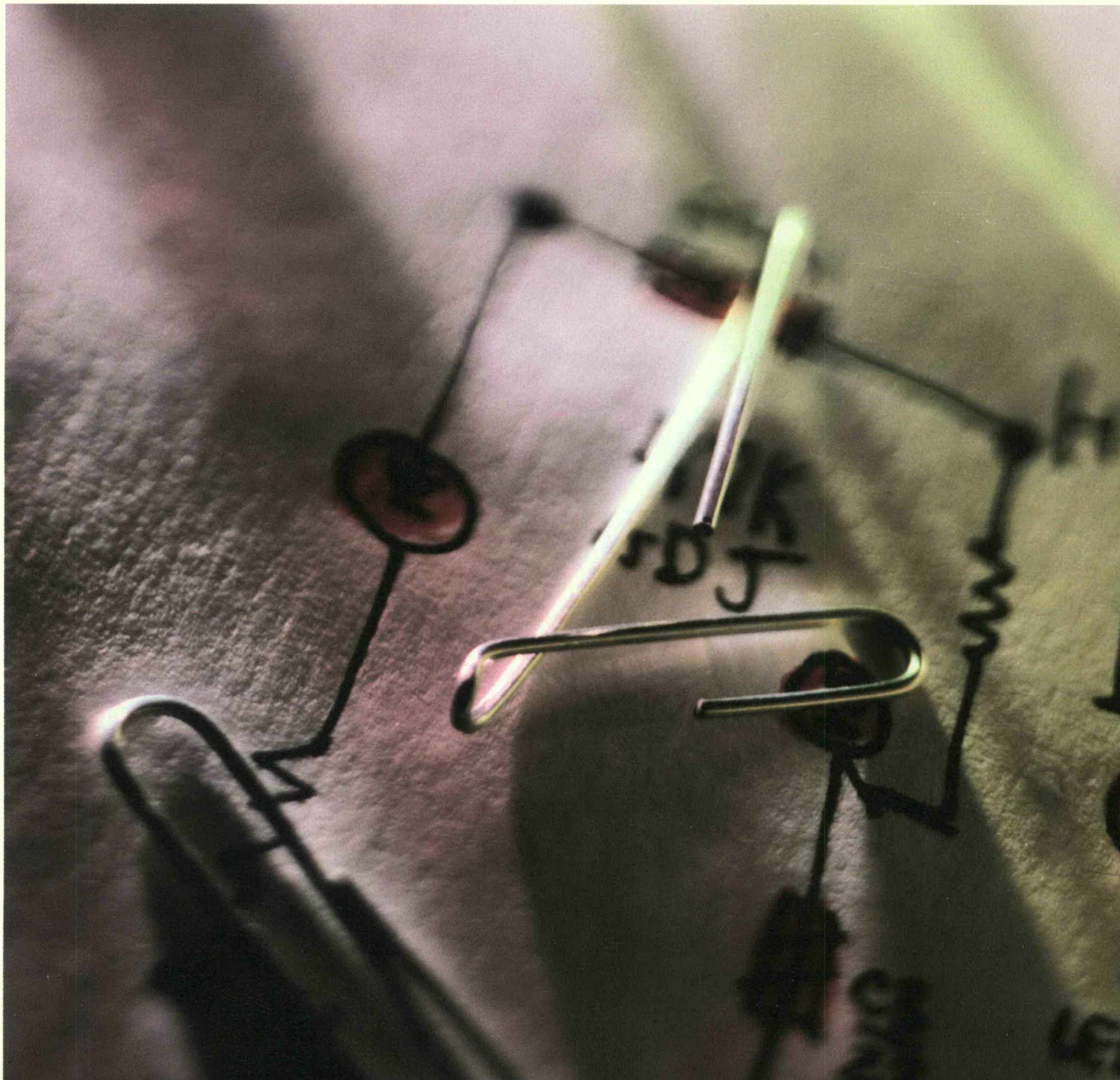
Tiede, teknologia ja tutkimus 2004:6
Vetenskap, teknologi och forskning
Science, Technology and Research

Science and Technology in Finland 2004



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Science and Technology in Finland 2004

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Foreword

Knowledge and know-how, scientific research and new technological applications are all crucial to the function of society and the economy. Science and Technology in Finland 2004 is the fifth statistical report compiled by Statistics Finland on these aspects. It provides data on the population's education, R&D funding and spending, patents, innovations, scientific publishing and international exchange in the field of science and technology. Additionally, information is given on new technologies, especially information and communication technologies.

As well as describing what has happened in Finland over the past few years, the report includes a wealth of international comparative data based primarily on OECD and Eurostat sources. The aim is to sketch the main lines of development and get an overall picture; more detailed data are available from the respective annual statistical reports.

The report was compiled and edited by Ari Leppälahti. Contributors from Statistics Finland are as follows: Ari Leppälahti (Chapters 1, 3.1,3.3– 3.6, 5, 7 and 8), Mika Tuononen (3.2), Tero Luhtala (4, 9 and 11.1–11.2), Markku Virtaharju (Chapter 6), Mervi Niemi (12.1–12.3) and Timo Sirkiä (12.4). The other contributors are Esko-Olavi Seppälä from the Science and Technology Policy Council of Finland (Chapter 2); Kai Husso, Science and Technology Policy Council of Finland (Chapter 3.7); Annamaija Lehvo and Anu Nuutinen, Academy of Finland (Chapter 10); Pirjo Kutinlahti and Marjo Uotila, VTT Finland, Technology Studies (11.3); Kimmo Pitkänen, EU Commission, DG Research (Chapter 13); and Markku Lämsä, National Technology Agency Tekes (Chapter 14).

Many thanks to all the contributors and others who have helped to produce this publication.

Helsinki, March 2005

Kaija Hovi
Director, Business Structures

Content

Explanation of symbols

Magnitude nil	–
Data not available or too uncertain for presentation	..
Preliminary data	*

1 Introduction

Science and Technology 2004 brings together the most up-to-date statistical information on science, technology and the information society. Statistics Finland's science and technology statistics, on the one hand, and information society statistics, on the other, have previously been published in separate indicator publications.[1] This report is an extended edition of the previous *Science and Technology 2000* report. It includes selected data from the series 'On the Road to the Finnish Information Society', i.e. on the information sector, technical infrastructure and the use of ICTs. Although science and technology and the information society are different and distinct concepts and although they are treated as separate statistical entities in both Finland and elsewhere, they are nevertheless closely interwoven and it certainly makes sense to deal with them together in this kind of volume. In thematic terms one might say that the indicators of science, technology and information society in this report describe knowledge and know-how – factors that are commonly regarded as major assets for Finland today and increasingly so in the future.

The structure, resources and development prospects of science and technology have often been approached from the vantage-point of the national innovation system. This system may be understood as comprising both the producers and end-users of knowledge as well as the interaction between the various parties involved. In recent years ever greater attention has been paid to the place and role of the national innovation system within the global operating environment.[2] This is also reflected in the growing importance to Finland of EU measures and the development of the European research system. On the other hand high technology sectors are also seeing increasing competition from outside the EU.

The need for a broad and comprehensive analysis has generated a large number of indicator publications describing science and technology. Examples include the reports published by the European Commission[3] and the US National Science Board.[4] In these reports as well as in the present volume that is based on a national Finnish perspective, the main emphasis is on a structural description of science and technology and on key trends in development in the recent past. To this end, this report draws together relevant statistical material from different sources and a few articles that give a more in-depth treatment of selected topics, including biotechnology and nanotechnology. The core of the report consists of traditional indicators such as human resources in science and technology, R&D funding and expenditure, patenting, innovations and foreign trade in high technology products. International comparisons focus on Finland's ranking on different indicators, but the EU's situation vis-à-vis other economic areas is also discussed.

1 Statistics Finland (2003a); Statistics Finland (2001a).
2 Science and Technology Policy Council of Finland (2002).
3 European Commission (2003a).
4 National Science Board (2004).

In addition to science and technology statistics, the report includes statistical data describing the development of the information society. Information and communication technology (ICT) and its use, which lies very much at the heart of the information society, has gained a significant role both in the national economy and in people's everyday life. Compared to science and technology indicators, where development efforts have been under way since the 1970s, work to compile statistics on the information society is a relatively novel exercise. The development of information society indicators started in earnest in the latter half of the 1990s. Among the aspects covered in the statistical analysis of the information society are goods, service and content production in the information sector, the technical infrastructure (communication networks and equipment), training and education in the ICT field as well as citizens' information society capabilities. The evolution of the information society is reflected among other things in new forms of business (Internet applications, electronic trade) as well as in citizens' and households' everyday life (mobile phones, computers and the Internet). Business networking, the 'new economy' or 'information economy' are some of the concepts that are associated with the impacts of the information society. On the individual level, there has also been talk about a digital divide, referring to the lesser or greater exclusion of certain population groups from the development of the information society.

Science, technology and the information society are complex, multidimensional concepts that remain in a constant state of flux: any statistical description of them is therefore bound to be selective and incomplete. However in this report we have sought to bring together the most important indicators, primarily those developed by the OECD and Eurostat. Many issues that tie in closely with the subject are excluded from the report: these include social innovations, administrative and other organisational reforms, and certain applications of knowledge and new communication technology (e.g. e-government). The success of science and technology also depends closely on public opinion towards science and technology and on the appeal of a career in research.[5] In the business sector, then, the main emphasis in this report is on the development of goods and services. One obvious target for development is the area of business know-how in the commercialisation of innovations, on which there has been much discussion in Finland. Although international comparisons are an integral part of the indicators used in this report, it would certainly be interesting to learn more about the global flows of know-how and technology and about Finland's place and role within these flows.

Structure of the report

This report covers three main themes. Chapters 3–5 deal with the human and economic resources of science and technology. These resources include the educated population, the funding allocated to research and the costs of research

5 Attitudes in Finland to science, see Science Barometer (2004)

and development activities. The second thematic cluster in Chapters 6–11 comprises the indicators that describe the outputs and impacts of science and technology. These include patents, the orientation of business to high technology production, scientific publications and international networking in the field of science and technology.

The thematic focus in Chapters 12–14 is on the key technologies of recent years, the impacts of which (whether realised or anticipated) extend across the whole economy and society. Biotechnology and nanotechnology are still evolving and developing, and their statistical description is accordingly in its infancy. Information and communication technology, on the other hand, is by now considered an integral part of the description of the information society mentioned earlier, and statistics on many aspects of ICTs are well established. Chapter 12 includes information on the enterprise activity in the information sector, the ICT infrastructure and the use of ICTs in businesses and households.

2 The science and technology policy environment

At the system level, the Finnish science and technology policy environment is stable and well established. For more than 20 years now, since the foundation of the National Technology Agency Tekes in 1983, our research system has had the same basic structure. The most visible change has been the launch in the 1990s of a new system of polytechnics, which following an experimental period was formally integrated into the national higher education system in 2000 and also charged with research responsibilities. Another, less visible change was the reorganisation in 1986 of Science Policy Council, which has since been known as the Science and Technology Policy Council of Finland. This reform meant that integrated attention was now paid to science and technology policy issues of national importance. It also led to the introduction of the concept of national innovation system and served to strengthen national unanimity about the role of knowledge and know-how in social, economic and cultural development.

The phenomenal growth of the information industry that got under way during the recession of the 1990s helped very much to bolster public confidence in the national strategy of knowledge and know-how. The way the economy pulled out of this recession was largely attributable to export-driven technological innovation in this field. Knowledge-intensive business rapidly emerged as the most dynamic element of the national economy. The growth and development of the information industry was of course primarily driven by the business sector and above all by Nokia, but the public sector certainly contributed with its investment programmes in education and research. Within the space of just a few years, the electrotechnical industry emerged as the national economy's third pillar alongside the forest and metal clusters.

Finland's strong economic performance was soon reflected in international comparisons of competitiveness. The Finnish school system also got its share of these successes, due to studies of children's and young people's learning achievements. In these and in certain other international comparisons of the performance of societies, Finland came out among the top achievers.

Strong growth in R&D spending helped to raise the quality and standards of Finnish research across the board. Research also received a major boost of internationalisation from Finland's decision to join the EU, which gave added international exposure and visibility to Finnish science and research. This is confirmed by various bibliometric indicators and related listings on which Finland's average rankings nowadays are high.

These national successes at the system level have attracted growing interest both abroad and at a regional and local level in what has become known as the 'Finnish model'. The way that our research and innovation activities are organised at the system level is seen as a benchmark of good practice; there is a real keenness to follow suit. At home, where regional development is seen to rely to an ever greater extent on high-level knowledge and know-how, there is an increasing tendency now towards the 'regionalisation' of national success factors. This is quite natural and certainly easy to understand: in the aftermath of the recession it was the country's major ICT centres – the biggest university towns and their environs – that recovered the fastest and got back onto a growth track where positive factors fed into each other.

Growing internationalisation

Finland today is an integral part of the global community. The globalisation of business and the reallocation of labour and production are familiar on these shores as well. Industrial and social structures are in a constant state of flux in all countries that are committed to maintaining their wealth and well-being under the conditions of the new international division of labour and the ongoing development towards an information society. For reasons of competition, there is growing pressure now for increased investment aimed at strengthening the dynamics of innovation. There no longer exist purely national operating environments.

Most OECD and EU countries today are investing increasingly in the development of science and technology. The EU's target, as set out in the Lisbon strategy, is to become the most competitive and dynamic knowledge-based economy in the world by 2010. An important part of this goal is to increase funding for R&D within the EU area to three per cent of GDP. Although it is not thought to be likely that these goals will be met within the time frame given, they do clearly reflect the commitment in these countries and regions to a strong and rapid development of science, technology and knowledge-intensive economies. The global competition for intellectual and material resources and for international business is intense indeed. Stagnation, it is thought, will inevitably lead to decline and falling behind in the competition.

In the 1990s Finland enjoyed excellent success in this competition. The prospects for the 2000s appear even more challenging, for several reasons. One of these reasons is that the international competition is getting tougher. Are we capable of providing the necessary platform for sustained economic growth, which in turn would pave the way to continued social and societal development?

The new challenges for science and technology policy

In its 2003 review under the title *'Knowledge, innovation and internationalisation'*, the Science and Technology Policy Council of Finland looks ahead at the challenges facing Finnish education, science, technology and innovation policy. These challenges may be described as follows:

The internationalisation of research and education at all levels. This challenge derives not only from the general needs of internationalisation in education, science and technology, but also from the small size of our country, which is reflected in all the challenges listed here. In its research and technology development Finland is labelled by specialisation in the ICT sector. The limits of the domestic recruitment base for higher education and for the demanding expert positions in this sector have more or less been reached. It is therefore necessary to consolidate and broaden the knowledge base, bearing in mind the needs of all other fields of research and technology. The home base can be strengthened in two parallel ways, i.e. by means of internationalisation both at home and abroad. This concerns not only students: statistics show that Finland has attracted an exceptionally small number of senior researchers and other high-level experts as well. The aim is not only to increase international cooperation, but to promote the internationalisation of our entire research strategy.

The integrated development of social and technological innovation. Technological innovation is one of Finland's recognized strengths. Now, at the dawn of the twenty-first century, there is a growing appreciation of the importance of the social dimension or the 'user perspective' of innovation. Social innovation goes much deeper, however, extending to the development of public service systems and various social structures, which needs to receive much more attention than has been the case so far. The Science and Technology Policy Council believes that this will help to achieve a more balanced social and economic development.

The Finnish foresight project. As Finland's rankings in international comparisons have continued to rise ever higher, it is clear that future science and technology policy measures have to do more than simply follow the example set by others. An independent effort is needed to search out future paths of development. This involves more than just technology foresight; it requires a broader examination and analysis of the future. Some work has already been done along these lines in the public sector, for instance by the Parliamentary Committee for the Future and the Ministry of Trade and Industry.

The development of new, creative innovation environments. Successful innovation is key to the success of both business companies and societies. This, in turn, requires an operating environment that supports creativity and innovations. One of the tasks of science and technology policy is to strengthen the material and intellectual resources out of which new innovations are created.

The development of research careers. Finland is one of the few countries where there remains strong interest in postgraduate studies and careers in research. However, it is widely felt that, in the absence of an established career path for researchers, the prospects for graduating PhDs interested in a research career are less than secure. This is bound to undermine the interest of young people and indeed adversely affect the prospects of recruitment from abroad. The graduate school system that was implemented in 1995 needs urgently to be expanded with a view to developing postdoc and further career stages.

Systematic system-level assessment. It is also necessary from time to time to conduct critical assessments of the basic structure and organisation of the whole Finnish research system – in spite of reassuring results from international comparisons – in order to make sure that science and technology policy measures can have their full intended impact. The Science and Technology Policy Council launched such an evaluation in 2003. It is expected that over the next few years, the results will help to enhance the efficiency of the public research system and the various organisations (technology centres, business incubators, etc.) interfacing with that system.

Increasing (public) research funding. Whenever questions of material or intellectual resources arise, the matter of size inevitably comes into play: Finland is a small country. In relative comparisons based on population numbers or the size of the national economy, Finland often ranks among the top performers, but the absolute volumes are nonetheless small. It is therefore imperative continuously to expand and strengthen the resource base and to intensify the allocation and shared use of the resources available. All this is geared to improving cooperation within the public sector and to increasing public/private partnerships.

Maintaining a good match between education and labour market requirements. Again, this challenge has to do with the recruitment base and with how the educational structure corresponds to local industry structures. Improved anticipation of educational needs is key to ensuring that there is as close a match as possible: this applies to both different branches of education and different levels of education.

Developing national competencies. The Finnish national economy has three main assets: the forest cluster, metal cluster and ICT cluster. A natural priority for science and technology policy is to promote the further development of these clusters by strengthening the relevant knowledge and know-how. In addition, steps are also needed that can pave the way to the creation of new national competencies. The best-known among these promising prospects is the biocluster – which has also remained such a prospect longer than any other field. For almost two decades now, considerable public funding has been channeled into biotechnology. The identification of potential new areas of growth requires strong expertise in anticipation and foresight. To provide adequate and consistent support for these areas, it is usually necessary to pool the resources of several different players and to have decision-making mechanisms whereby the allocation of selective support for the most promising fields can be developed into a flexible practice.

Strengthening the synergy of knowledge clusters, business and social capital in regional development. It is widely thought that regional development is increasingly dependent on the way that each region's own development factors evolve and on how well they are made to interact both amongst themselves and with the national and international levels. Public interventions have a particularly important role to play in strengthening knowledge and know-how (one example is provided by the so-called third task of universities and polytechnics) as well as in building up various service networks and generally in promoting business innovation. However, development efforts cannot be based on the same formula in all fields. According to the Science and Technology Policy Council of Finland, the greatest potential for the growth of productivity and other development exists where traditional industries can most speedily and efficiently exploit new technologies and know-how and apply them to business, products and production.

Where do we go from here?

Quality and relevance will remain the two main catchwords describing the future course of development of Finnish science and technology policy. Their improvement in an open international environment will probably require structural interventions as well. The fragmentation that continues to plague Finnish research, with a large number of small, separate units working in the same field of study, makes it much harder to take part in major international projects and programmes, let alone to lead and coordinate major EU projects or networks. The catchwords of quality and relevance, then, could well be complemented with those of *prioritisation, profiling and selective decision-making*. It is important to be able to identify and prioritise key areas of investment. In decision-making, it is necessary to be able to pool enough resources so that the priority areas of activity can be implemented in practice. This will also help to increase productivity of related activities. The level of investment must be further raised, but no doubt there are expectations of increased outputs as well: research results, scientific inventions, research-driven innovations. The profiling of all players in the research and innovation system is of great importance here: everyone wants to stand out from the 'background noise'. As regards the general preconditions for R&D, the aspect that will require much greater attention in the future is infrastructure development. Indeed, infrastructures may prove to have a decisive part to play in the effort to raise the quality standards and relevance of our own research on the existing foundation and to attract greater foreign interest in Finnish science and technology. At the same time it is obviously also important to be able to further develop our existing strengths, such as networking and horizontal cooperation.

3 Human resources in science and technology

A competent and well-educated population provides the necessary basis for strong scientific and technological know-how and for sustainable economic competitiveness. This, in turn, is crucial to attracting high value-added production, R&D and other key functions into the country. Public administration and the provision of high-quality welfare services also require a well educated and skilled workforce. And of course apart from all this, academic research and education are important values in their own right.

The structure and development of human resources in science and technology depend largely on the population structure and its projected development. The population's age structure is mirrored in the numbers entering and exiting the labour market at any point in time. In Finland much concern has been expressed in recent years about the ageing of the population, the dwindling size of age cohorts entering the labour market and the consequent decline in the dependency ratio, and the limited number of skilled and competent young people. On the other hand the new cohorts who are now entering the labour market are better educated, so the concerns voiced about our knowledge and know-how resources are perhaps somewhat premature. Apart from the population structure, other factors that have a bearing on the size and structure of S&T human resources include at least emigration and immigration as well as education policy measures. In this report, however, we will not be exploring the future prospects of our human resources potential on the basis of population or education projections, but the focus is confined to existing knowledge and know-how resources and to how they have developed since the early 1990s.

In a broad definition, human resources in science and technology (HRST) is understood as referring to all people who have a tertiary education or who are working in science and technology occupations. In the OECD's Canberra manual[1] on the measurement of human resources devoted to science and technology, the HRST framework is based on education and occupation criteria. Most expert assignments in science and technology require extensive education and training, and therefore the focus of attention in the assessment of human resources in science and technology is very much on the population with a tertiary education. The number of people with a tertiary education and the number of new tertiary degrees describe the supply of S&T human resources. Education is not, however, a necessary condition for being counted among S&T human resources, but the Canberra manual has the additional criterion of occupation: these are people whose jobs potentially involve tasks related to science or technological development. Occupation may be considered to mirror the demand for science and technology job tasks as reflected by the labour market. Given these definitions and classifications, human resources in science

1 OECD (1995a). HRST=Human resources in science and technology

and technology consist of those people who meet at least one of these two sets of qualification criteria, while the core group is made up of those who meet both the educational and occupational criteria. Persons with a tertiary education who are not currently working are also counted among S&T human resources. The main emphasis in this report is on educational data; occupational data are also included in EU country comparisons.

Personal knowledge and know-how resources in science and technology can be approached from several different angles. Apart from academic and vocational studies and degrees, increasing attention has been paid to the aspect of basic education, which lays the foundation for further studies. International comparisons of mathematics and science skills among schoolchildren offer particularly interesting insights from a science and technology point of view; these are briefly discussed under chapter 3.1 below. The following chapter deals with education expenditure, which describes the overall resources and the extent of the education system.

Defining human resources in science and technology

Persons with a tertiary education are defined as consisting of those who have completed a tertiary degree, i.e. a vocational post-secondary, polytechnic or university degree.[1]

On the occupation criterion, science and technology personnel are defined as including the main categories of professionals and technicians and associated professionals.[2] In a broad definition certain management occupations may also be included.

	Tertiary education	
Vocational qualifications	yes	no
yes	core group	vocational qualifications
no	qualifications based on education	
unemployed, outside active labour force	potential resource	

1 Levels 5 and 6 in the ISCED 1997 classification of educational qualification.
2 Main categories 2 and 3 in the ILO International Standard Classification of Occupations ISCO-88.

Chapter 3.3 moves on to the structure of the population with a tertiary education and traces relevant trends since the early 1990s. The number of new degrees completed annually provides a rough indication of changes in the volume and structure of higher educated human resources. The employment of people with a tertiary education and their movement across national borders are discussed under chapter 3.4. Eurostat has published comparative data for different countries where human resources in science and technology are defined on the basis of the above framework by reference to both education and occupation (chapter 3.5). In chapter 3.6 the focus is narrowed to personnel in R&D. In the last section results of the study on the mobility of PhDs are presented.

3.1 Mathematics and science in basic education

The national knowledge and know-how infrastructure is created in basic education. Scientific information and advanced technologies cannot be produced or indeed used without sufficient basic knowledge. In modern welfare societies such as Finland, universal and compulsory basic education is by now well established and taken for granted. The gulf that separates industrial and developing countries in science and technology resources is mainly attributable to differences in the extent and level of education. However, even advanced countries have been paying more attention of late to the way that the school system meets the needs of science and technology. In Finland, these questions have recently been addressed in a dedicated mathematics and science development programme (the LUMA project) run by the National Board of Education in 1996–2002. Finland has also taken part in the OECD's PISA[2] project, an international study comparing the achievement of 15-year-old students in certain knowledge and skills that are important for the future. This is not the place to go into the results of these projects in any detail, but both do raise important questions with respect to human resources in science and technology. For example, PISA has included comparisons of maths and science skills in different countries. Science and maths are both crucial skills for successful academic research, but the application of those skills is also of great importance in business R&D, which in Finland accounts for the bulk of R&D expenditure. Although the PISA project targets 15-year-old students, it is clear that the foundations built at this early stage will have a huge impact on later training and education as well as on the future resources of science and technology.

Girls increasingly active in science studies at upper secondary level

The LUMA development programme was aimed at identifying the focal areas and possible weaknesses in maths and science teaching and skills and at setting related targets. The final programme report[3] concludes that the number of new student places at universities and polytechnics in the natural resources sector and the technology and transport sector is well in line with existing plans. The number of students taking extended maths in the matriculation examination should be increased. In physics and chemistry, too, it was felt that more students should be encouraged to take longer courses and take the corresponding matriculation examination. The proportion of women among new engineering students is rising, but still comparatively low. On the other hand the gender differences in maths and science studies at upper secondary level are less pronounced than before. As for new entrants in vocational training, the LUMA final report draws attention to the weaknesses observed in maths skills.

2 PISA, Programme for International Student Assessment.
3 Ministry of Education (2002).

Finnish students' mathematics and science skills among the highest in the world

The OECD/PISA study assessed the school achievement of 15-year-old students by administering standardised tests to participants from different countries. In Finland a total of 156 schools took part: responses were obtained from almost 5,000 students, giving a response rate of almost 92%.[4] Mathematics skills were measured by assessing mastery and understanding of processes (general maths competencies), contents and applications, i.e. the emphasis was not merely on the knowledge and skills described in the school curriculum. The highest mean scores were recorded in Japan, Finland followed close on its heels in a group of other high performers that included Korea, New Zealand, Australia, Canada and Switzerland. Among the other Nordic countries, Norway's score was close to the OECD average; Denmark, Iceland and Sweden scored above the OECD average but nonetheless lagged behind Finland. Among the biggest participating countries the United States ranked midway through the OECD table, whereas Germany's score was below the OECD average. Finland, as indeed most other high performers in this comparison, recorded not only high average scores but also low variation in the scores. In fact the difference between the scores of the strongest and weakest 10 per cent of students was the smallest in Finland. There were no differences between girls and boys in their maths skills. In this regard, too, Finland ranked among the most egalitarian countries.

Science skills were also measured on three dimensions: mastery of scientific concepts; the ability to acquire, interpret and act upon evidence collected; and skills of practical application. In the Finnish report the PISA notion of science skills is expressed in terms of the capacity for scientific thinking in today's information society that is shaped and permeated by natural science and technology.

Finland's ranking among the 32 participating countries was exactly the same as in the maths component. In the science comparison the highest average score was recorded by Korea, followed by a group including Finland, England, Canada, New Zealand and Australia. The difference compared to the other Nordic countries was slightly larger than in the case of mathematics because Iceland's and Denmark's scores were below the OECD average. Likewise, the result for differences in performance levels was much the same as for mathematics, i.e. the difference between the strongest and weakest achievers was among the smallest in all the participating countries. As in the majority of participating countries, there were no major differences in Finland between boys' and girls' general science skills. Having said that, boys in Finland did achieve somewhat higher scores than girls in tests of technical application, whereas girls performed better than boys in tests related to social and ethical aspects of science.

4 The text is based on Finland's PISA report by Välijärvi & Linnakylä (2002). See also OECD (2003a).

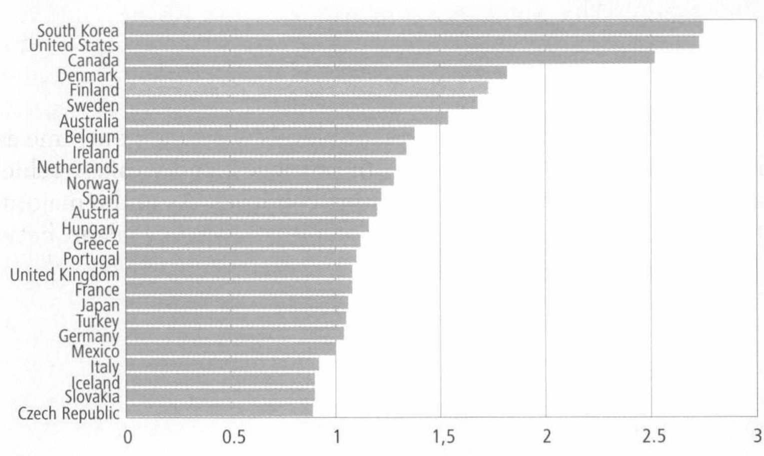
3.2 Education expenditure

Finland invests heavily in tertiary education

Total education expenditure[5] in Finland in 2001 amounted to 7.9 billion euros, up by 5.9 per cent on 2000. Tertiary education accounted for roughly 30 per cent of the total, showing very little change compared to the previous year. Tertiary education expenditure increased by 4.1 per cent on the previous year's figure. Following Withthe discontinuation of post-secondary vocational college level and vocational higher higher vocational level education, all tertiary education in Finland will be provided through now consists of polytechnics and universities(which comprises both polytechnics and universities). In 2001 the lowest level of tertiary education accounted for no more than one per cent of total expenditure on tertiary education; the rest was allocated to lower-degree and higher-degree level tertiary education and doctorate or equivalent level tertiary education. university and postgraduate education.

Finland spends somewhat more on education than the OECD countries on average.[6] In 2001 education expenditure as a proportion of GDP stood at 5.8 per cent, while the OECD average was 5.6 per cent. Expenditure on tertiary education as a proportion of GDP in 2001 was 1.7 per cent compared to 1.4 per cent in the OECD countries. Among European OECD members, Denmark, Finland and Sweden were the highest spenders on tertiary education spending relative to GDP (Figure 3.2.1).

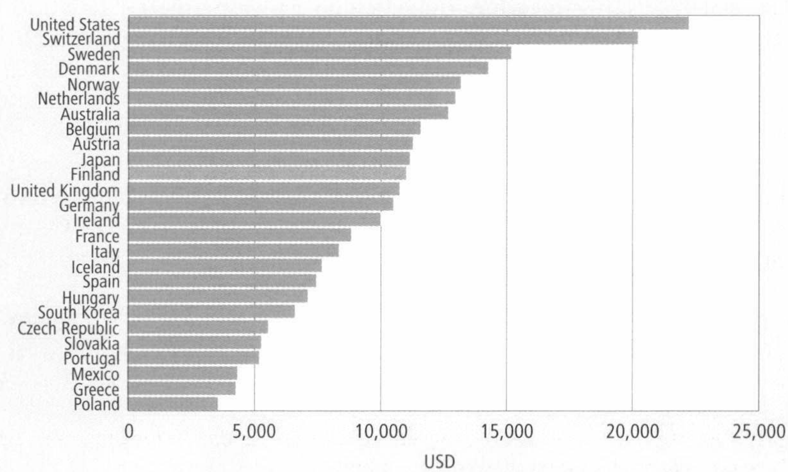
Figure 3.2.1
Expenditure on tertiary education as a proportion of GDP in OECD countries in 2001.
Source: OECD, Education at a Glance 2004.



5 UOE (UNESCO, OECD, Eurostat) questionnaires on education statistics.
6 OECD (2004a).

Finland's per-student education costs are around the average OECD figure at all levels of education. The per-student costs for tertiary education in Finland are slightly higher than the OECD average. Per-student costs at the tertiary level are the highest in the United States, where spending is about twice as high as in Finland or in the OECD countries on average. International comparisons of per-student costs at the tertiary level are complicated among other things by differences in the compilation of statistics on full-time and part-time studies (Figure 3.2.2).

Figure 3.2.2
Per-student education costs at tertiary level in the OECD countries in 2001, in USD purchasing power parity.
Source: OECD, Education at a Glance 2004.



Finland's education expenditure as a proportion of GDP has declined in recent years

In the OECD countries education expenditure relative to GDP remained more or less constant over the period from 1995 to 2001, but in Finland the figure dropped by one-half a percentage point. During this same period tertiary education expenditure as a proportion of GDP in Finland decreased by 0.2 percentage points. Part of the explanation lies in the extremely rapid growth of GDP in Finland in the late 1990s. In real terms Finland's education expenditure during the period under review increased by 18 per cent. At the same time the figure for tertiary education showed a real increase of 13 per cent. The growth of real expenditure in Finland was around the average for all OECD countries.

Education expenditure funded mainly from public sources

Private funding accounts for only a small proportion of total education spending in Finland. In 2001, 2.2 per cent of funding for all degree-oriented education came from private sources compared to the OECD average of 12.2 per cent. In tertiary education the corresponding figures were 3.5 per cent and 21.8 per cent, respectively.

Public education expenditure relative to GDP is much higher in Finland than in the OECD countries on average. In 2001, Finland's public education expenditure as a proportion of GDP was 6.2 per cent as opposed to 5.3 per cent in the OECD countries on average. Public tertiary education expenditure relative to GDP was 2.1 per cent in 2001, compared to 1.3 per cent in the OECD countries on average. In the OECD group the only country exceeding Finland's tertiary public education spending relative to GDP was Denmark, where the figure was 2.7 per cent. Public education spending as a proportion of total public expenditure in Finland stood at 12.7 per cent, which is exactly the same as the OECD average. OECD comparisons of public education spending also include government‘s financial aid to students.study grants.

3.3 Highly educated population and degrees

Education can be approached and examined from various different angles. Education is the foundation of culture and civilisation, and it may be seen as a basic right for all citizens. Finnish education policy is firmly grounded in the principle of

For our analysis of education within the school system we use the educational classification maintained by Statistics Finland.1 This classification is compatible with the 1997 International Standard Classification of Education (ISCED97).2 Tertiary education comprises the following categories:

- lowest level of tertiary education: 2–3 years of post-secondary education, e.g. polytechnic degree in agriculture, ttechnician engineer
- lower-degree level tertiary educationlower university education: 3–4 years of full-time post-secondary studies: e.g. polytechnic degrees, engineers and lower university degrees
- higher-degree level tertiary education:higher university education: e.g. Master's degrees
- doctorate or equivalent level tertiary education:postgraduate education: PhDs and licentiates

Level of education is determined on the basis of the person's highest latest degree. Where international comparative data are concerned it is important to bear in mind that national education systems differ, which inevitably complicates the application of standard classifications.

Six main categories of field of science are distinguished in line with OECD recommendations (the classification is attached as Appendix 3.1). Degrees are allocated to a given field of science primarily on the basis of the field of education. The field of science classification is only applied to higher-degree level tertiary educationhigher university and doctorate or equivalent level tertiarypostgraduate degrees.

1 Statistics Finland (2001b).

2 ISCED, International Standard Classification of Education.

equality: all population groups shall have equal access to education that corresponds to their needs and abilities.[7] On the other hand, education is also an investment that is expected to yield returns, which means that the targeting of education provision is influenced by labour policy considerations, for example. In an assessment of human resources in science and technology, our main attention is drawn to the group of people who have a tertiary education. Our examination here is confined to degrees completed within the formal school system; this means that vocational adult education and training, for instance, is excluded. Furthermore, our focus is exclusively on the economically active population, i.e. those aged 15–64.

Population with a tertiary education is continuing to grow

The population who have completed a tertiary education has continued steadily to grow since 1991. Overall the numbers have increased by some 240,000 persons: by 2002, a total of 930,000 persons aged 15–64 had completed tertiary qualifications. During the 1990s the figure increased on average by around three per cent a year, but in the early 2000s the rate has slowed down somewhat to just under two per cent a year (Table 3.3.1). In 1991 persons with a tertiary education accounted for around 20 per cent of the population aged 15–64: this proportion has risen steadily to 27 per cent in 2002 (Figure 3.3.1). The proportion of women in the population holding tertiary degrees has continually increased over the past ten years, standing at around 57 per cent in 2002. Among PhDs the proportion of women is still no more than one-third, but by 2002 more than one-half or 53 per cent of those with a higher tertiary degree were women (see Appendix Table 3.1).

In 2002 the social sciences accounted for the largest proportion of higher tertiary degrees or doctorate level education at 37 per cent (Figure 3.3.2). However, it is worth noting that in this connection the social sciences com-

Table 3.3.1
Trends in the number of persons with a tertiary education (excluding military education) in 1991–2002, population aged 15–64.
Source: Statistics Finland, Employment Statistics.

	Average annual growth, %			Number
	1991–1995	1995–1999	1999–2002	2002*
PhDs	6.5	7.5	6.6	14,813
Licentiates	5.8	3.2	1.4	8,135
Doctorate or equivalent level tertiary education total	**6.2**	**5.7**	**4.6**	**22,948**
Higher-degree level tertiary education	4.8	4.4	4.0	225,955
Other tertiary level	3.1	2.0	1.2	681,570
Tertiary education total	**3.5**	**2.6**	**1.9**	**930,473**

7 Ministry of Education (2004).

Figure 3.3.1
Persons with a tertiary degree (excluding military education), proportion of population aged 15–64 in 1991–2002.
Source: Statistics Finland, Employment Statistics.

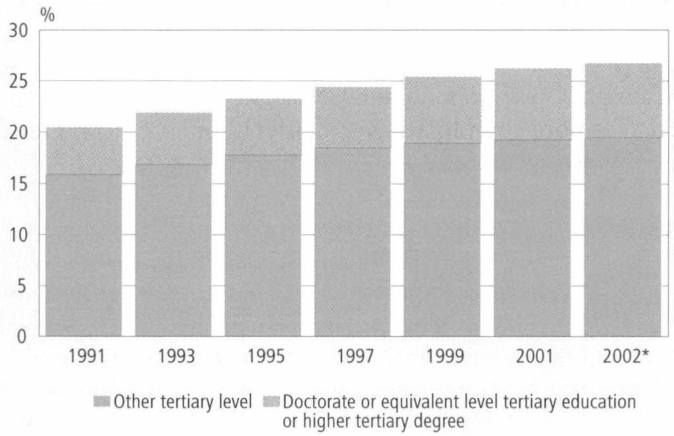
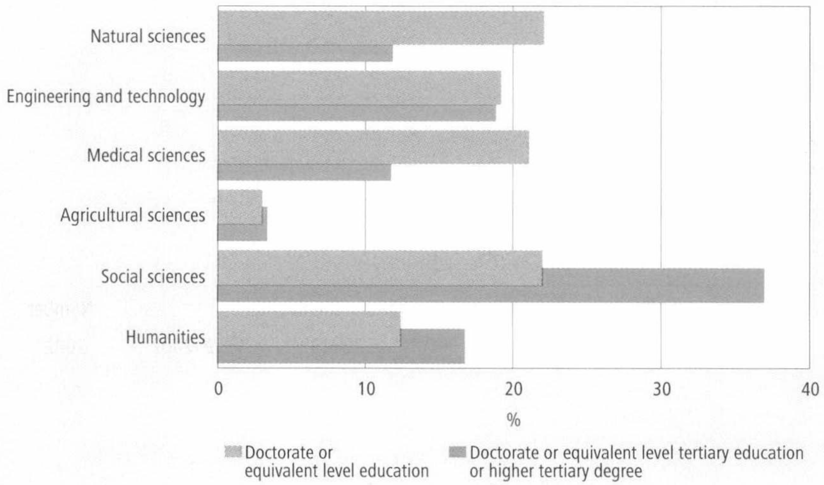


Figure 3.3.2
Persons with a higher tertiary degree or doctorate or equivalent level education (excluding military education) by field of science in 2002, population aged 15–64.*
Source: Statistics Finland, Employment Statistics.



prise not only disciplines that are taught at social science faculties, but also education, business administration, law, etc. The figures for the humanities and engineering and technology are at 17–19 per cent and for medicine and the natural sciences at 12 per cent. Agricultural sciences is a considerably smaller field of science. Social sciences are also the only field that has seen an increase in its share of all new degrees completed in 1991–2002: the figure has increased by almost four percentage points. The figures have decreased most for medical sciences, by about two percentage points. When we confine our analysis to persons with a doctorate level degree, the breakdown is different. The social sciences account for one-fifth of the total, but the natural sciences, engineering and technology, and medical sciences also record shares of around 20 per cent.

Women account for growing proportion of doctorate level degrees

Not only have the numbers completing tertiary degrees increased, but the level of education within this category has also risen: from 1991 to 2002, the proportion completing higher tertiary degrees or doctorate level degrees has grown from 22 per cent to 27 per cent. The number of new PhDs has increased very rapidly indeed. In spite of the continuing growth of PhD resources, the annual increase has been steadily at around seven per cent. The increase in the numbers completing higher tertiary degrees has also been fairly consistent at around four per cent a year. By contrast the increase in the numbers completing the licentiate's degree has virtually come to a standstill. In 2002 a total of some 23,000 persons had completed a doctorate or equivalent level tertiary degree, with women accounting for 36 per cent of this figure (Figure 3.3.3). Apart from the strong growth in the number of new PhDs, the most prominent trend in development has been the increase in the number of women with a doctorate level degree. The figure has been rising at a rate of around 10 per cent a year. Another clear indication of women's stronger role and presence in doctorate or equivalent level tertiary education is that they ac-

Figure 3.3.3
Holders of doctorate or equivalent level degrees total and proportion of women (excluding military education) in 1991–2002, population aged 15–64.
Source: Statistics Finland, Employment Statistics.

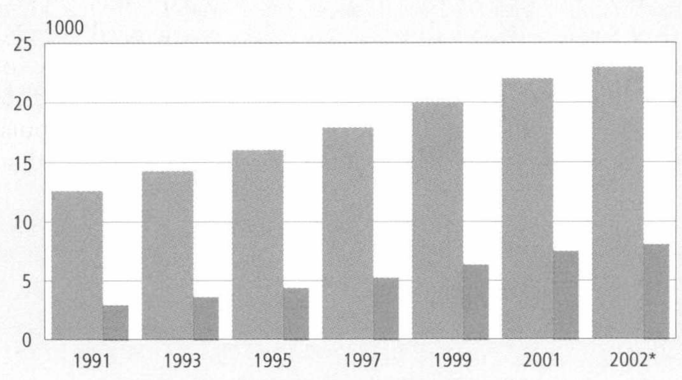


Table 3.3.2
Persons with a higher tertiary degree (excluding military education) by age group and field of science in 2002, population aged 15–64.*
Source: Statistics Finland, Employment Statistics.

	Total	Age cogort %				Average age
		15–34	35–44	45–54	55–64	
Natural sciences	29,670	30.1	27.3	26.1	16.5	42
Engineering and technology	46,957	31.8	30.5	25	12.7	41
Medical sciences	29,410	19.5	32.2	30.7	17.6	44
Agricultural sciences	8,553	21.5	34.3	27.1	17.1	43
Social sciences	92,170	31.1	34.4	21.4	13.1	41
Humanities	41,883	26	32	23.3	18.8	43
Unspecified	260	20	32.3	27.3	20.4	44
Total	**248,903**	**28.6**	**32.1**	**24.2**	**15.1**	**42**

counted for one-half of the increase of 10,000 persons in the numbers with a doctorate level degree in 1991-2002.

In 2002 the average age of persons with a higher tertiary degree or a doctorate level degree was 42 years. The age group under 35 accounted for about 29 per cent of all persons with a higher tertiary degree. Personnel in the category of medical sciences were somewhat older than in other fields: the mean age was 44 years and proportion of persons under 35 was 20 per cent. The mean age was also somewhat higher than the average in agricultural sciences. Personnel resources were the youngest in engineering and technology and social sciences.

One in three with a tertiary education live in the region of Uusimaa

In 2002 the only region which accounted for a much larger proportion of all persons with a tertiary degree (34 per cent) than of the total population in the country (27 per cent) was that of Uusimaa around the capital city of Helsinki. In Pirkanmaa, Itä-Uusimaa and Ostrobothnia the proportion of people with a tertiary education was the same as the proportion of the total population, in all other regions the numbers with a tertiary education was smaller than might be expected on the basis of population numbers. The region of Uusimaa also stands out clearly in an analysis of the numbers with a tertiary education as a proportion of the region's population. In Uusimaa this figure is 34 per cent compared to the national average of 27 per cent, which is only just reached by Pirkanmaa, Itä-Uusimaa, Varsinais-Suomi and nearly by Ostrobothnia. In all regions, however, the numbers with a tertiary degree is at least one-fifth of the region's total population aged 15–64. The differences between regions other than those mentioned above are also small (Table 3.3.3).

Table 3.3.3
Population with a tertiary education (excluding military education) by region in 2002, population aged 15-64.*
Source: Statistics Finland, Employment Statistics.

Region (NUTS3)[1]	Population total		Proportion with tertiary degree	Tertiary degree		Postgraduate education	
	no.	%	%	no.	%	no.	%
Uusimaa	914,721	26.9	34.2	312,742	33.6	10,835	47.2
Itä-Uusimaa	58,527	1.7	27.4	16,062	1.7	242	1.1
Varsinais-Suomi	294,111	8.6	27.0	79,320	8.5	2,494	10.9
Satakunta	150,280	4.4	23.3	34,967	3.8	305	1.3
Kanta-Häme	104,844	3.1	25.4	26,682	2.9	348	1.5
Pirkanmaa	298,454	8.8	27.7	82,580	8.9	2,117	9.2
Päijät-Häme	129,252	3.8	23.1	29,893	3.2	297	1.3
Kymenlaakso	118,647	3.5	23.0	27,263	2.9	161	0.7
South Karelia	87,367	2.6	23.1	20,218	2.2	307	1.3
Etelä-Savo	102,723	3.0	22.3	22,893	2.5	223	1.0
Pohjois-Savo	161,663	4.7	24.3	39,244	4.2	926	4.0
North Karelia	108,210	3.2	21.9	23,679	2.5	614	2.7
Central Finland	171,887	5.0	25.9	44,472	4.8	1,184	5.2
South Ostrobothnia	120,555	3.5	22.3	26,928	2.9	162	0.7
Ostrobothnia	108,350	3.2	26.9	29,186	3.1	409	1.8
Central Ostrobothnia	44,730	1.3	21.5	9,630	1.0	98	0.4
North Ostrobothnia	238,193	7.0	25.7	61,195	6.6	1,804	7.9
Kainuu	55,210	1.6	21.2	11,684	1.3	94	0.4
Lapland	120,722	3.5	23.1	27,840	3.0	300	1.3
Åland	16,749	0.5	23.9	3,995	0.4	28	0.1
Whole country	**3,405,195**	**100.0**	**27.3**	**930,473**	**100.0**	**22,948**	**100.0**

1 Regional classification system of the European Union (NUTS)

In 2002 the total number of persons with a doctorate level degree was almost 23,000, or some seven persons per 1,000 population aged 15–64. Almost half of them lived in the region of Uusimaa; Turku and Tampere and their environs accounted for some 10 per cent each, and North Ostrobothnia for eight per cent. All in all these regions accounted for three-quarters of all holders of doctorate level degrees. These same regions accounted for 58 per cent of all persons with a tertiary education, i.e. holders of doctorate level degrees were much more clearly concentrated in regional centres.

Level of education among young people higher than OECD average

Our comparison here of OECD countries looks at the numbers with a tertiary degree as a proportion of the population aged 25–34. As well as describing each country's investment in education, this also reflects a future projection of human resources in science and technology: after all this represents a new age cohort in the labour market who for the most part have completed their basic education and training. The two countries that come out on top in this comparison are Canada and Japan, where about half of the age group have a tertiary degreeeducation. The share in Finland is around 40 per cent, which puts us in the next group of countries with the United States, Norway, Sweden and others. In Mexico and Turkey only about one in ten in this age group have completed a tertiary degree (Table 3.3.4).

Table 3.3.4
Persons with a tertiary degree as a proportion of the population aged 25–34 in OECD countries in 2002.
Source: OECD Education at a Glance.

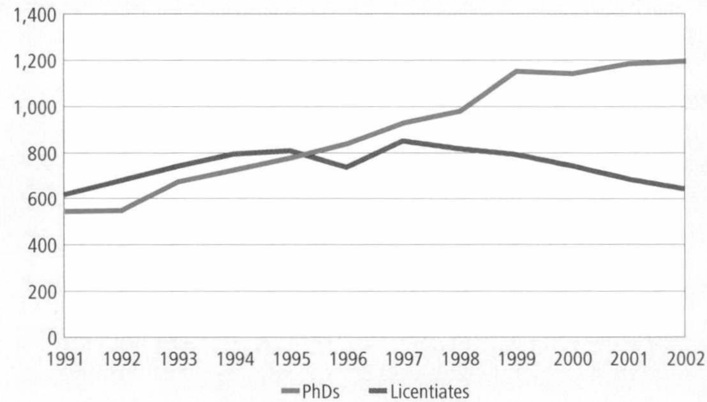
Country	%	Country	%
Canada	51	Iceland	29
Japan	50	Netherlands	28
South Korea	41	Switzerland	26
Norway	40	Greece	24
United States	39	Luxembourg	23
Finland	39	Germany	22
Sweden	39	Poland	16
Belgium	38	Portugal	15
Spain	37	Hungary	15
Ireland	36	Austria	15
France	36	Italy	12
Australia	36	Czech Republic	12
United Kingdom	31	Slovakia	12
New Zealand	29	Mexico	11
Denmark	29	Turkey	11
		OECD country mean	**28**

Strong growth in the number of PhDs and Master's degrees

The number of new degrees completed sheds useful light on the growth of the population with a tertiary education. In 1991–2002, the annual number of tertiary degrees completed has been in the range of 37,000–40,000. Women have accounted for some 60 per cent of all graduates. An increasing proportion of tertiary degrees consists of higher tertiary degrees or doctorate or equivalent level tertiary degrees: in 1991 their share was 29 per cent, by 2002 the figure had risen to 37 per cent (Appendix Table 3.2). In fact the combined number of lower tertiary degrees and lowest level tertiary degrees has remained more or less unchanged at the same time as the number of PhDs, Licentiate's and Master's degrees has increased by around 3,000.

Recent reforms of doctorate level education and training in Finland have included the launch of the graduate school system in 1995 and the dropping of the requirement that PhD candidates first take the Licentiate's degree. Indeed

Figure 3.3.4
PhDs and Licentiates in 1991–2002.
Source: Statistics Finland, Register of Degrees.



the number of new PhDs has been rising very sharply, more than doubling from 1991 to 2002 when the figure stood at almost 1,200 degrees completed (Figure 3.3.4). This growth peaked in 1999, which was also the first time that the annual number of PhD graduates exceeded 1,000. The new, demoted status of the Licentiate's degree is clearly reflected in the declining number of degrees completed since 1997. This has in fact led to a slight decrease in the overall number of doctorates. However, this does not mean that the numbers completing a doctorate level education have declined: the statistics are explained by the fact that previously, the same person used to have to take two degrees at this level whereas nowadays most will complete only one. What can be seen very clearly is the growing proportion of women. In 1991 women accounted for 35 per cent of all new doctorate level degrees; the 40 per cent mark was exceeded in 1996; and by 2002 the proportion was close to one-half (Figure 3.3.5).

Over one-third of all doctorate level and higher tertiary degrees completed each year are in the social sciences. The second biggest category is represented by engineering and technology, which has accounted for between 18–20 per cent of the total. Looking at how these shares have developed from 1991 to 2002, we find that the figure for the natural sciences has increased by a couple of percentage points, while the share of medical sciences has dropped by the same amount (Table 3.3.5). The breakdown of new tertiary degrees by field of science is very similar to the corresponding breakdown for existing tertiary degree holders, although the share of new degrees in medical sciences is somewhat higher than among current degree holders, while the share of agricultural sciences is lower among new graduates than among existing degree holders.

Figure 3.3.5
Doctorate or equivalent level degrees completed and the proportion of women in 1991–2002.
Source: Statistics Finland, Register of Degrees.

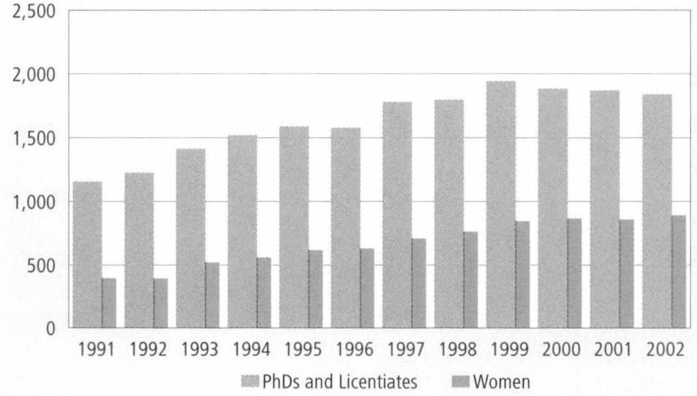


Table 3.3.5
Breakdown of new doctorate or equivalent level and higher tertiary degrees in 1991, 1995, 1999 and 2002 by field of science.
Source: Statistics Finland, Register of Degrees.

	1991 %	1995 %	1999 %	2002 %
Natural sciences	10.8	11.4	13.1	12.7
Engineering and technology	17.5	18.2	20.2	18.2
Medical sciences	16.1	14.3	13.4	13.4
Agricultural sciences	3.2	3.0	2.2	2.5
Social sciences	35.3	36.4	34.9	36.6
Humanities	17.2	16.6	16.1	16.6
Degrees total	**10,791**	**12,517**	**14,491**	**14,675**

3.4 Employment and international mobility of the population with a tertiary education

The match of education supply and demand in the labour market is not just an issue of S&T human resources. Major intervening factors include at least the economic situation and changes in the occupational structure. Therefore the discussion here is confined to some general information about the employment of the population with a tertiary education as described above. More detailed accounts of the employment, job changes and mobility can be found elsewhere.[8] Our discussion in this section is confined to the movement of the highly educated population into and out of Finland, summary of a more detailed study on the mobility of PhDs is in the chapter 3.7.

People with a tertiary education have good success in finding employment

Higher educated groups have much less difficulty in finding employment than others. The difference is clear under conditions of both high and low unemployment (Table 3.4.1). In 1995, in the wake of the recession, the unemployment rate was still at around 20 per cent, but the figure for people with a tertiary degree was twice as low.[9] In 2002 the corresponding difference was equally clear: the unemployment rate for people who did not have a tertiary education was 15 per cent compared to six per cent among those who did. There are also differences in jobless rates among those with a tertiary education. It would seem that PhDs are in practice fully employed, regardless of fluctuations in the general employment situation. Sensitivity to these fluctuations is the greatest among those with the lowest level tertiary education, but even here jobless rates have been well below the averages for the whole population.

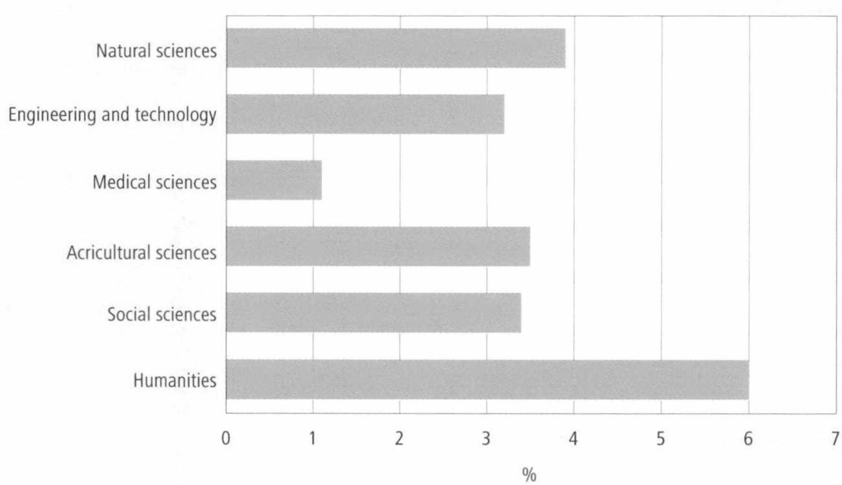
Table 3.4.1
Unemployment by education in 1995, 1999 and 2002.*
Source: Statistics Finland, Employment Statistics. Data on employment from the Ministry of Labour.

	1995	1999	2002
	%	%	%
PhD	1.8	1.7	1.9
Licentiate	4.4	3.7	3.5
Higher tertiary degree	5.6	4.0	3.7
Lower tertiary degree	8.9	7.1	6.6
Lowest level tertiary education	12.6	8.6	6.4
Higher educated total	10.2	7.0	5.7
Other	23.8	17.3	14.9
Total	**19.9**	**14.1**	**11.9**

8 E.g. Virtaharju (2002), Ekeland et al. (2003), OECD (2002a).
9 The unemployment figures presented here are based on Statistics Finland's Employment Statistics, where data on a person's employment situation are drawn from Ministry of Labour sources. In other words these are not official unemployment figures: our only purpose here is to shed light on the impacts of education upon differences in unemployment. Official unemployment statistics for Finland are published by Statistics Finland and the Ministry of Labour.

In 2002 the overall unemployment rate for persons with a doctorate level or higher tertiary degree was less than four per cent. An examination of unemployment rates by field of science reveals some interesting differences, most notably between the humanities and medical sciences. Whereas the unemployment rate for persons with a medical degree was close to zero, the figure for those with a degree in the humanities was six per cent (Figure 3.4.1). In other fields the unemployment rate was between three and four per cent.

Figure 3.4.1
Unemployment rate among persons with a doctorate or equivalent level or higher tertiary degree by field of science in 2002.*
Source: Statistics Finland, Employment Statistics. Data on employment from the Ministry of Labour.



Proportion of persons with a tertiary education increased in virtually all industries

In 2001 around 34 per cent of the employed population had a tertiary degree. This figure increased by 2.6 per cent from 1995 to 2001. The proportion of employees with a tertiary education has increased faster than average in public administration, in transport and in primary production. In business activities and trade there has been hardly any change at all in the proportion of employees with a tertiary education. Trends in manufacturing have been more or less in line with the average: in 2001 one in four employees in manufacturing had a tertiary degree. However by far the highest educational level is seen in public administration and other social and community service activities as well as in business activities and financial intermediation, where 46–49 per cent of the workforce have a tertiary degree. In terms of absolute numbers, on the other

Table 3.4.2
Employees with a tertiary degree by industry in 1995 and 2001.
Source: Statistics Finland, Employment Statistics.

	1995 Proportion of persons employed in industry	2001 Proportion of persons employed in industry	2001 Total
Agriculture and forestry, mining and quarrying	12.6	16.2	17,830
Manufacturing, energy, construction	22.5	24.6	143,345
Trade, hotels and restaurants	24.5	24.4	81,772
Transport, storage and communication	17.4	20.7	34,376
Business activities and financial intermediation	47.1	46.2	136,911
Public administration, social and community service activities	45.7	49.1	335,848
Industry unknown	33.4	22.8	9,648
Total	**31.7**	**34.3**	**759,730**

hand, manufacturing has somewhat more employees with a tertiary education than do business activities and financial intermediation.

Some 70 per cent of employees with a doctorate or equivalent level education work in public administration or other social or community service activities, which includes universities and other educational institutions. About one in five employees with a doctorate or equivalent level degree work in business activities and financial intermediation, the corresponding proportion for manufacturing is less than ten per cent (Table 3.4.3). In other industry branches the numbers with a doctorate are much smaller. The picture for employment

Table 3.4.3
Employees with a tertiary education by industry and degree in 2001.
Source: Statistics Finland, Employment Statistics.

	Doctorate or equivalent level education %	Higher tertiary degree %	Other tertiary education %	Total %
Agriculture and forestry, mining and quarrying	0.5	1.1	2.8	2.3
Manufacturing, energy, construction	8.7	14.4	20.8	18.9
Trade, hotels and restaurants	1.5	4.8	13.2	10.8
Transport, storage and communication	0.6	2.4	5.4	4.5
Business activities and financial intermediation	18.8	20.2	17.2	18.0
Public administration, social and community service activities	69.1	56.0	39.2	44.2
Industry unknown	0.8	1.2	1.3	1.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

among persons with a higher tertiary degree is rather similar, although the differences between industries are somewhat smaller. Among persons with a higher tertiary degree, 14 per cent are employed in manufacturing, while the figure for public administration and other social and community service activities is 56 per cent. Among all persons with a tertiary degree, 44 per cent are engaged in public administration or other social and community service activities, while the proportions for manufacturing and business activities are less than one-fifth in both.

Increased international mobility in the higher educated population

Brain drain and brain gain, the question of mobility in the higher educated population, is a traditional concern in studies of human resources. The growing trend of globalisation in recent years has also led to increasing international mobility in the workforce. It is anticipated that this increased freedom of movement will in turn lead to ever fiercer competition among different countries for the most skilled and competent people. For state actors it is important to monitor and analyse the flows of educated workforce, if for no other reason then simply because of the investments they have made in education. In Finland there has also been some discussion on the need to attract the most competent experts into the country.

Our examination here is confined to annual emigration and immigration data; we do not consider such issues as how much of the migration is attributable to people with a tertiary degree moving abroad to complete further studies or to work for a few years before returning to Finland. It is also worth noting that Finland has in place a comprehensive degree register, but information on the educational background of immigrants is not always as readily available. For this reason it is possible that the figures for the immigration of people with a higher education may be too low in comparison with those for emigration. Furthermore, in an assessment of the balance of migration, we must bear in mind the difficulties in comparing educational classifications across different countries.

From 1991 to 2002, emigration by people with a tertiary degree almost trebled from around one thousand persons to close to three thousand. The growth of immigration was slower, but on the other hand the baseline level was higher. In 2002 the number of immigrants with a tertiary education stood at 3,200, which is just over one thousand more than in 1991 (Tables 3.4.4 and 3.4.5). Although the international exchange of people with a tertiary education has been increasing, overall mobility in relation to the total national human resources with a tertiary education is not very high. In 1991, 1.6 persons per 1,000 population with a tertiary degree moved out of Finland, in 2002 the ratio was 3.2 to 1,000 population. In relative terms the sharpest increase since the early 1990s has been recorded for the emigration of people with a doctorate or equivalent level education. As such the numbers are not very high, but the 162 persons with a doctorate level degree who moved out of the country in 2002 was six times more than in 1991 (when the ratio was seven per 1,000 population). At the same time the number of people with a doctorate level de-

Table 3.4.4
Highly educated immigrants to Finland by degree in 1991–2002, population aged 15–64, most recent removal.
Source: Statistics Finland, Population Statistics.

Year	Lowest level tertiary education	Lower tertiary degree	Higher tertiary degree	Doctorate or equivalent level education	Total	Finnish citizens
1991	702	599	582	39	1,922	831
1992	602	477	622	51	1,752	700
1993	628	451	588	67	1,734	724
1994	562	416	466	43	1,487	750
1995	761	475	591	76	1,903	1,063
1996	907	509	697	96	2,209	1,388
1997	796	506	678	85	2,065	1,148
1998	800	527	702	72	2,101	1,299
1999	1,019	599	826	97	2,541	1,832
2000	1,005	681	897	103	2,686	2,059
2001	1,084	919	1,075	125	3,203	2,202
2002	1,044	920	1,119	117	3,200	2,307

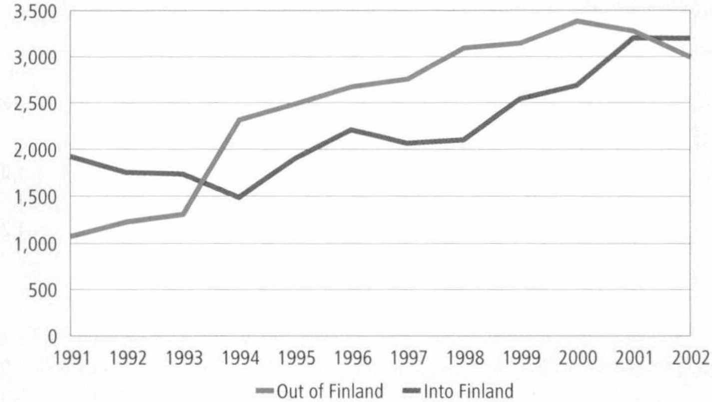
gree moving into Finland has trebled: in 2002 a total of 117 persons with a doctorate or equivalent level education moved in. Indeed this is the only category among higher educated persons where Finland recorded a net emigration loss. The balance for people with a higher tertiary degree was also clearly in the red in the mid-1990s, but the situation has evened out by 2002.

Table 3.4.5
Highly educated emigrants out of Finland by degree in 1991–2002, population aged 15–64, most recent removal.
Source: Statistics Finland, Population Statistics.

Year	Lowest level tertiary education	Lower tertiary degree	Higher tertiary degree	Doctorate or equivalent level education	Total	Finnish citizens
1991	468	204	376	27	1,075	1,025
1992	517	236	421	56	1,230	1,158
1993	545	263	456	43	1,307	1,258
1994	994	388	825	105	2,312	2,244
1995	1,064	379	941	103	2,487	2,410
1996	1,135	453	956	127	2,671	2,415
1997	1,187	440	1,025	104	2,756	2,619
1998	1,295	550	1,109	141	3,095	2,923
1999	1,358	602	1,067	119	3,146	2,970
2000	1,305	708	1,198	172	3,383	2,948
2001	1,207	733	1,189	149	3,278	3,100
2002	924	791	1,117	162	2,994	2,726

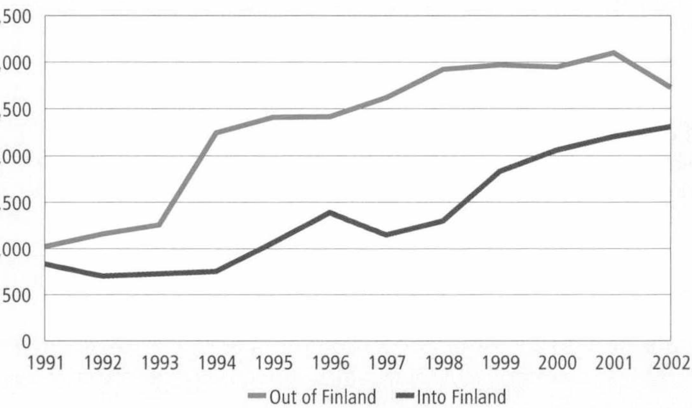
Apart from the overall growth trend, the emigration and immigration figures reveal that around the mid-1990s, Finland recorded a net emigration loss for higher educated persons. This period coincided with economic recession and a declining employment situation, as well as with Finland's new EEA/EU membership. In 1993–94 the emigration of higher educated people increased very sharply. At the same time immigration numbers began to decline, and the balance swung towards a net emigration loss. Emigration and immigration then increased at more or less the same rate until 2000, when emigration took a downturn and in 2001 the immigration/emigration balance swung in Finland's favour again (Figure 3.4.2). An examination of the movement of Finnish citizens who hold a tertiary degree shows that some of these people who move abroad apparently leave to stay for good (Figure 3.4.3). The difference between emigration and immigration can be taken as a rough indicator of the net outflow of people who have received a tertiary education in Finland.[10] The difference was at its greatest in 1998 when the number of highly educated Finnish citizens who moved abroad exceeded the figures for those moving into Finland by 1,600. In the early 2000s the difference has begun to narrow down and is now reverting to the situation in the early 1990s.

Figure 3.4.2
Emigration and immigration of people with a tertiary degree in 1991–2002, all persons aged 15–64.
Source: Statistics Finland, Population Statistics.



10 Since this analysis concerns the movement of Finnish citizens, the balance cannot in practice be significantly positive.

Figure 3.4.3
Emigration and immigration of people with a tertiary degree in 1991–2002, Finnish citizens aged 15–64.
Source: Statistics Finland, Population Statistics.



Sweden the most common country of origin and country of destination, net immigration from Russia

In 2002 Finland received the largest number of immigrants from Sweden: a total of 552 people holding a tertiary degree moved from Sweden to Finland, which represents 17 per cent of all immigrants with a tertiary education. Sweden was followed in this comparison by Russia (330) and Norway (301 people moving into Finland). The numbers moving in from the United States, United Kingdom and Germany were at roughly the same level, with almost 230 persons immigrating from each country. Not surprisingly the single most important area of origin for Finnish immigration is Europe: the EU alone accounts for 54 per cent of the total. The numbers immigrating from Asia are somewhat higher than those moving in from the Americas (including the US), accounting for 10 per cent of all immigrants with a tertiary education.

Sweden is also by far the most important country of destination: in 2002 a total of 578 higher educated people emigrated to Sweden (Table 3.4.7). Sweden accounted for 19 per cent of Finnish emigration, which is slightly higher than the figure for immigration from Sweden. The second most popular country of destination is the United States: the number of people moving out to the US was 330, or 11 per cent of all emigrants with a tertiary education. The US attracts a few more emigrants with a doctorate level degree than Sweden. The United Kingdom, too, is a more significant country of destination for Finnish emigrants than it is a country of origin for immigrants into Finland. The numbers with a tertiary education moving into Finland from Russia, on the other hand, are greater than the numbers emigrating to Russia. In 2002 a total of 330 persons moved to Finland, whereas no more than 38 higher educated persons moved out from Finland to Russia. The numbers moving in from Estonia (81) also exceeded the number of emigrants to Estonia (48). The exchange of higher educated people with China was at around the same level as with Estonia, but the balance for Finland shows a net loss.

Table 3.4.6
Higher educated immigrants to Finland by degree and country of origin in 2002, population aged 15–64, most recent removal.
Source: Statistics Finland, Population Statistics.

Country of origin	Total	Lowest level tertiary education	Lower tertiary degree	Higher tertiary degree	Doctorate or equivalent level education
Sweden	552	209	147	171	25
Russia	330	62	128	131	9
Norway	301	172	75	49	5
United States	228	52	57	100	19
United kingdom	228	71	59	87	11
Germany	222	70	59	87	6
Spain	110	49	24	34	3
Estonia	81	34	24	22	1
France	80	18	21	38	3
Denmark	77	23	14	35	5
Netherlands	73	24	21	26	2
Belgium	66	17	13	34	2
China	55	12	23	15	5
Switzerland	51	18	12	19	2
Ireland	44	15	17	12	–
Italy	42	16	9	15	2
Turkey	39	15	20	4	–
Austria	32	7	11	12	2
Singapore	30	9	11	10	–
Canada	27	8	9	10	–
EU 25	1,728	597	446	621	64
Nordic countries	938	407	238	258	35
Other Europe	463	104	164	184	11
Asia	330	75	130	111	14
America	278	71	73	114	20
Africa	53	11	21	19	2
Unknown	22	6	5	11	–
Oceania	17	5	4	7	1
Total	**3,200**	**1,044**	**920**	**1,119**	**117**

Table 3.4.7
Higher educated emigrants from Finland by degree and country of destination in 2002, population aged 15–64, most recent removal.
Source: Statistics Finland, Population Statistics.

Country of Destination	Total	Lowest level tertiary education	Lower tertiary degree	Higher tertiary degree	Doctorate or equivalent level education
Sweden	578	202	196	154	26
United States	330	76	82	143	29
United Kingdom	282	79	80	109	14
Norway	249	126	79	42	2
Germany	216	55	49	96	16
Spain	180	81	36	59	4
France	98	17	27	47	7
Belgium	93	19	13	58	3
Switzerland	92	26	17	47	2
Netherlands	89	29	20	36	4
Denmark	88	15	23	44	6
China	81	17	27	28	9
Canada	53	12	8	23	10
Estonia	48	15	11	19	3
Italy	42	12	11	18	1
Russia	38	10	13	12	3
Ireland	38	13	12	13	–
Luxembourg	35	11	5	19	–
Australia	33	14	6	11	2
Singapore	28	8	10	9	1
EU 25	1,886	582	504	711	89
Nordic countries	916	343	298	241	34
America	406	95	93	179	39
Asia	225	56	67	82	20
Other europe	146	42	35	64	5
Oceania	43	17	9	15	2
Africa	31	4	2	20	5
Unknown	7	2	2	3	–
Total	**2,994**	**924**	**791**	**1,117**	**162**

3.5 S&T human resources in the EU countries

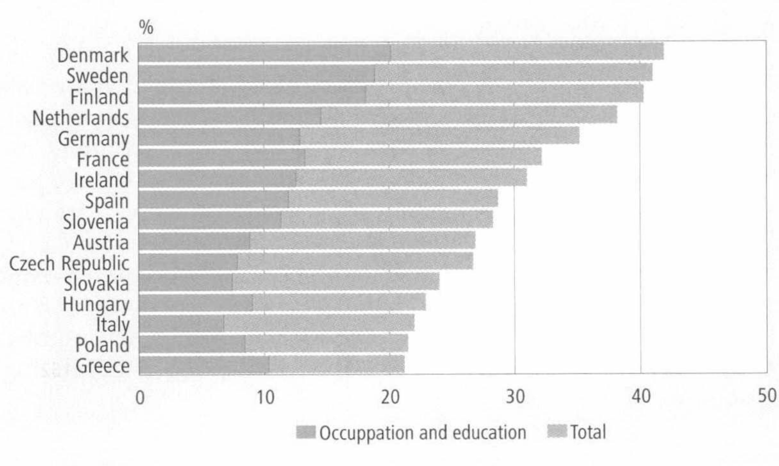
Finland ranks among the top EU countries in a comparison of human resources in science and technology. Eurostat's comparative data are based on a combination of education and occupational status from a harmonised labour force survey in the EU countries. In Finland, people with a tertiary education or expert assignments (professionals, technicians and associated professionals) in science and technology or closely related fields, account for some 40 per cent of the population aged

25–64, which is almost the same as in Sweden and Denmark (Figure 3.5.1 and Appendix Table 3.3). This figure is also over 30 per cent in the Netherlands, Germany and France, for instance, but no more than some 20 per cent in Italy, Greece and Poland. The average for the EU is around 30 per cent.

The core group of human resources consists of people who have a tertiary level education and who work in science and technology occupations. In this analysis, too, the profiles for Finland, Sweden and Denmark are very similar: the core group accounts for some 18 per cent of the population aged 25–64, which is among the highest figures in the EU. On the other hand, in Germany, for instance, about one-third of the human resources belong to the core group, which is 13 per cent of the age group 25–64. In Italy the corresponding proportion is no more than seven per cent.

Finland and Sweden differ in their S&T human resources in that Finland has a higher proportion of people with a tertiary education than Sweden (33% and 27%, respectively), whereas in Sweden 33 per cent of the population aged 25–64 are in science and technology occupations compared to 26 per cent in Finland.

Figure 3.5.1
People with a tertiary education or working in S&T occupations in selected countries in 2003, per cent of the population aged 25–64.
Source: Eurostat, New Cronos.



3.6 R&D personnel

Education and occupational status describe human resources based on S&T competencies. A more traditional approach is to focus on people working in actual R&D jobs.[11] R&D personnel consists of a smaller number of people than

11 See Chapter 5 for a definition of research and development.

Table 3.6.1
R&D personnel by sector, gender and education in 2002.
Source: Statistics Finland, Research and Development statistics.

	Total	of which women	Business enter-prises	of which women	Public sector	of which women	Univer-sities	of which women
PhDs	8,166	2,511	1,170	251	1,603	521	5,393	1,739
Licentiates	3,046	991	787	140	595	200	1,664	651
Other university degree	26,535	9,200	14,086	2,978	3,840	1,793	8,609	4,429
Polytechnics, higher vocational diploma	12,469	2,323	11,071	1,624	488	194	910	505
Other	22,905	9,335	12,126	3,575	4,230	2,507	6,550	3,253
Total	**73,121**	**24,360**	**39,239**	**8,568**	**10,756**	**5,215**	**23,126**	**10,577**

1 Incl. college engineers

S&T human resources, but on the other hand this category also includes people who do not have the education or occupational status defined above. This refers primarily to people in supportive jobs in R&D.

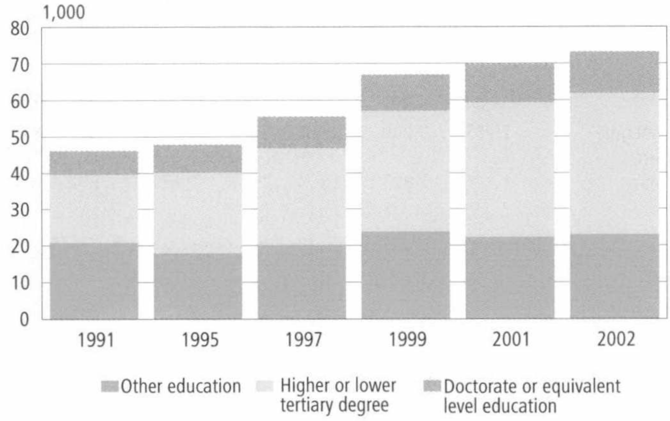
In 2002 the total numbers working in R&D stood at just over 73,000 persons, of whom about 54 per cent worked in business enterprises, 31 per cent at universities and the remaining 15 per cent in the public sector. One-third of the R&D personnel were women. Almost half of the R&D personnel in the university and public sector were women, compared to no more than about one-fifth in private business enterprises. The only groups where women are in the majority are university R&D personnel with a first degree or a polytechnic degree. The smallest proportion of women at 15 per cent was found in the group of private sector R&D personnel with a polytechnic level education.

More than two-thirds or 69 per cent of R&D personnel had at least a lower tertiary degree. Women accounted for 30 per cent of personnel with a tertiary degree, which is slightly less than their share of total R&D personnel. Among R&D personnel 11 per cent had a PhD, 15 per cent had a doctorate or equivalent level education. Two in three PhDs worked at universities. The number of postdoctoral researchers working at public research institutes is also higher than in business enterprises, which hired 14 per cent of all PhDs in 2002.

Number of women PhDs working in R&D showing strong growth

The total number of R&D personnel rose from 1991 to 2002 by 27,000. The fastest growth was recorded during 1997–1999, when the numbers engaged in R&D increased by more than 10,000 (Figure 3.6.1 and Appendix Table 3.4). The growth of R&D personnel is attributable almost entirely to the growing proportion of those with at least a tertiary degree, whose numbers doubled in 1991–2002; there has been hardly any change at all in the number of R&D personnel at other levels of education. The proportion of women has gone up from 31 to 33 per cent. There has been a particularly noticeable increase in the number of women PhDs in R&D: in 1991 women PhDs numbered less than 800, but by

Figure 3.6.1
R&D personnel in 1991–2002 by education.
Source: Statistics Finland, Research and Development statistics.



2002 the figure had trebled to over 2,500. It would seem that the share of women among R&D personnel is continuing to rise: in 1999–2002 women accounted for 40 per cent of the increase in R&D personnel and in 2001–2002 for 53 per cent.

The involvement of higher educated people in R&D can be assessed by linking the data for R&D personnel with register data describing higher educated human resources. In 2002 an estimated[12] 13 per cent of employees with a doctorate level

Table 3.6.2
People working in R&D as a proportion of the employed population by education in 2002, persons with a doctorate or equivalent level education or higher or lower tertiary degree.
Source: Statistics Finland, Research and Development statistics and Employment Statistics.

	Employed persons*	R&D personnel	Proportion of employed persons, %
PhDs	13,403	8,166	60.9
Licentiates	6,977	3,046	43.7
Doctorate or equivalent level education	**20,380**	**11,212**	**55.0**
Lower-degree and higher-degree level tertiary education	371,398	39,004	10.5
Total	**391,778**	**50,216**	**12.8**

12 The calculation is based on the numbers who have a doctorate or equivalent level education and a lower or higher tertiary education, i.e. those with a degree at the lowest level of tertiary education are omitted. This group is not separately identified in R&D personnel statistics. It is also worth noting that R&D statistics are based on questionnaire surveys, while the data for employment are drawn from register sources.

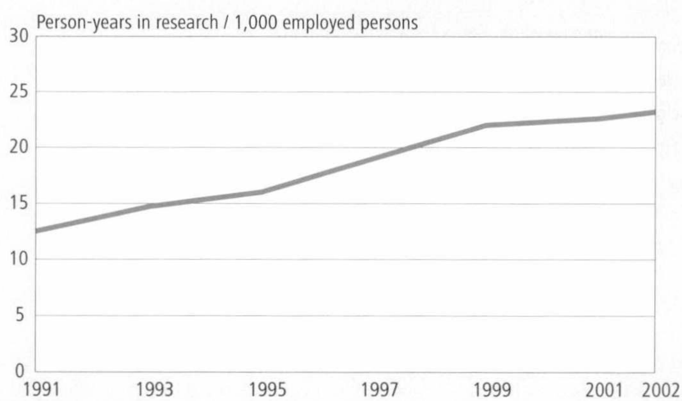
education or tertiary degree were engaged in R&D. Among PhDs some 60 per cent were involved in R&D, for licentiates the figure was about 44 per cent.

R&D personnel refers to all employees engaged in research and development jobs on a full-time or part-time basis. In order to gain a clearer picture of the labour input in R&D, data have also been collected on the number of full-time equivalent (FTE) or person-years in R&D, which is defined as the proportion of total annual working hours dedicated to R&D. In 2002 the total number of R&D personnel was 73,121, who together contributed a total of 55,044 FTE in research. As three-quarters of all R&D personnel work in research and development full-time, the breakdown of FTE by sector and by educational group closely follows the corresponding distribution for R&D personnel (Table 3.6.3). By contrast the breakdown by sector differs quite clearly from the breakdown of R&D expenditure (see Chapter 5.) Business enterprises account for 55 per cent of all person-years in research, but for almost 70 per

Table 3.6.3
Person-years (FTE) in R&D by sector and education in 2002.
Source: Statistics Finland, Research and Development statistics.

	Total	Business enterprises	Public sector	Universities
PhDs	6,342	920	1,250	4,172
Licentiates	2,248	612	474	1,162
Other university degree	20,414	11,167	2,880	6,367
Polytechnics, higher vocational diploma	9,628	8,584	354	690
Other university degree	16,412	9,038	2,881	4,493
Total	**55,044**	**30,321**	**7,839**	**16,884**

Figure 3.6.2
Person-years (FTE) in R&D per one thousand employed persons in 1991–2002.
Sources: Statistics Finland, Labour Force Survey and Research and Development Unit.



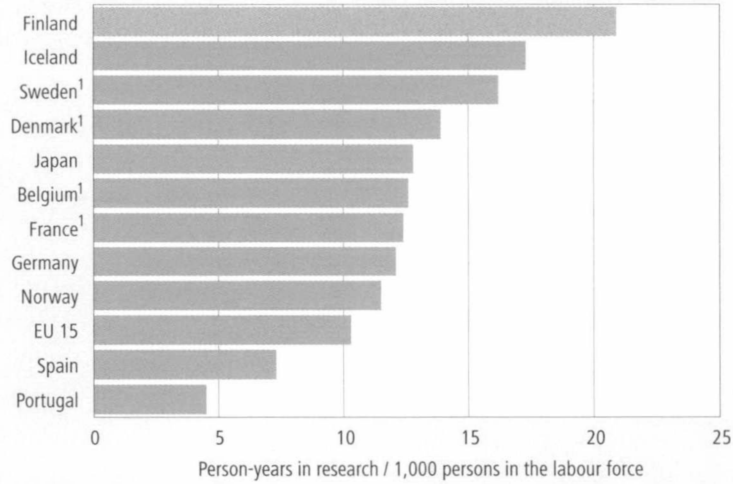
cent of all R&D expenditure. The university sector, then, accounted for 31 per cent of all FTE in research in 2002 and for 20 per cent of total expenditure. The difference is smallest in the public sector, where the figures are 14 per cent and 11 per cent, respectively.

Full-time equivalent is, however, a useful tool for purposes of assessing the relative significance of R&D labour input and indeed for purposes of international comparisons. The relative significance of R&D input has increased considerably since the early 1990s. Whereas in 1991 the number of person-years in research per one thousand employed persons was 13, the corresponding figure in 2002 was 23.2. Having said that it does seem that this increase has tapered off in the early 2000s.

Finnish R&D as a proportion of labour input among the highest in the OECD

For purposes of OECD country comparisons the research intensity of the labour input has been measured by comparing the number of person-years in R&D with the number of people in the active labour force. Finland's figure of 21 person-years in R&D per one thousand persons in the active labour force in 2002 is higher than in any other OECD country. The next highest figures are recorded for Iceland and Sweden at 16–17 person-years. In bigger countries such as Japan, Germany and France, the number of FTE in research per one thousand employed persons is around 12–13 (Figure 3.6.3).

Figure 3.6.3
Person-years (FTE) in R&D per one thousand persons in the labour force in selected OECD countries in 2002.
Source: OECD MSTI 2004-1.



1 Data from 2001

3.7 Mobility of PhDs in the Finnish labour market

3.7.1 Introduction

A highly educated workforce and R&D have a crucial role to play in a knowledge-based economy; they are central factors of successful innovation[13]. Indeed in recent years the number of persons with a tertiary education and their proportion of the active labour force have been increasing in the OECD countries. In many cases, the fastest growth rate has been recorded for PhDs[14]. At the same time, there have also been changes in labour market placement. The number of university graduates, including PhDs, has increased particularly in the business sector.

Apart from graduate placement and the demand for highly educated personnel, a third issue that has attracted increasing attention lately is mobility in the labour market. From the point of view of the innovation system, the mobility of highly educated persons is an important channel for the dissemination of knowledge and know-how[15]. The movement of an employee from one workplace to another is the most effective mean of transferring tacit knowledge and know-how that is tied to individuals. The impacts of mobility on the economy and innovation have been studied from various perspectives, including those of information management[16] and growth theories[17]. The importance of this issue is clearly reflected in the widespread adoption in OECD countries of various science and technology policy measures aimed at promoting mobility[18].

This final section of chapter 3 provides an overview of the mobility of PhDs in the Finnish labour market, i.e. the movement of people between and within different sectors and branches of the economy.[19] Some earlier work has been done on the mobility of personnel with higher education[20] and the placement of PhDs[21], but there is no earlier research on the mobility of PhDs.

13 E.g. OECD (2002b), European Commission (2003a).
14 OECD (2003b).
15 See OECD (1999a), OECD (1999b), European Commission (2002a), Smith, K. (2002).
16 Nonaka et al. (1998)
17 Romer (1990), Lundvall (1992).
18 OECD (2003b).
19 The material is drawn from Statistics Finland's Employment Statistics, with some complementary data from education and population statistics. To allow comparability between different sectors (there are significant organisational differences particularly between the private and public sector), central and local government offices and agencies, universities and research institutes are compared to business enterprises. The administrative units within these organisations are treated as workplaces (establishments): these include university departments, research institute laboratories and units and departments in central or local government.
20 E.g. Nås et al. (1998), Graversen et al. (2001), Virtaharju (2002).
21 E.g. Ministry of Education (2000), Aho &Jussi-Pekka (2002), Academy of Finland (2003a).

3.7.2 Volume and directions of mobility

The discussion below looks at the absolute volume and rates of PhD mobility and at the sectors that PhDs have exited and entered. Mobility refers to movement from one enterprise to another over the period of two consecutive years. Rate of mobility indicates the number of persons who have moved to another enterprise as a proportion of all employed PhDs[22].

Table 3.7.1 shows the number of PhDs who have changed jobs in different sectors in 1998–1999. During this period, more than 2,100 PhDs were moving in the labour market. The outflow mobility rate in 1998 was 17 per cent, the inflow rate in 1999 was 15.6 per cent (see Table 3.7.1, footnote 2). Intra-sectoral mobility as a proportion of total mobility stood at 32 per cent. The share of intra-sectoral mobility declined throughout the 1990s; in 1990 the figure was 40 per cent, in 1995 about 36 per cent. This reflects a favourable trend: PhDs are now moving across sectoral boundaries to a greater extent than before, thus disseminating their know-how more widely throughout the economy. It may also indicate that the distribution power of the Finnish innovation system has increased. In addition, the results suggest that a growing number of PhDs are working in other than research positions. As they move to new workplaces, they often also change occupations lines of profession.

Mobility rate was highest in sectors employing the largest number of PhDs, i.e. at universities, in local government, in the business enterprise sector and in central government. The single biggest mobility flow was found within the university sector. In 1998–1999, almost 220 PhDs moved to work at another university. On the other hand, although some 42 per cent of all employed PhDs worked in universities in 1999, the university sector accounted for around 35 per cent of total mobility. Intra-sectoral mobility within the university sector represented 12 per cent of total mobility. Mobility rates for universities were comparatively low, suggesting a tendency for PhDs to remain with the same employer for long periods and a relative lack of interest in moving to another sector. Mobility was the second highest within the local government sector and the third highest in the private business sector. In the local government sector, 38 per cent of PhDs who had changed jobs did so within the same sector. Up to 49 per cent of PhDs who left a business company remained within the business sector.

More than 100 PhDs moved from universities to the business sector (i.e. 17% of PhDs moving in the university sector and almost 29% of new recruits in enterprises). In absolut terms this was the largest intersectoral mobility flow. Almost 100 PhDs moved from universities to work in local and central government. The flows between universities and local governments are primarily explained by mobility between universities and central university hospitals; the latter belong to the local government sector. PhDs moving out from universities often went to other sectors, but the inflows into universities were also from various different directions. Sixty per cent of the PhDs recruited into uni-

22 For more about definitions, see Virtaharju (2002).

Table 3.7.1
Number of PhDs exiting and entering different sectors in 1998–1999 (mobility at enterprise level).
Source: Statistics Finland, Employment Statistics.

Delivering sector 1998	Receiving sector 1999 Central government	Local government	Universities	Polytechnics	Other schools (incl. Municipal schools)	Government research institutes
Central government	57	16	63	2	4	18
Local government	19	141	99	5	3	8
Universities	87	95	217	16	19	33
Polytechnics	1	4	8	–	1	–
Other schools (incl. municipal schools)	11	8	23	2	12	1
Government research institutes	10	13	25	1	1	4
Research institutes, non-profit	–	3	1	–	1	1
Other non-profit sector	10	8	19	5	6	3
Business enterprises	18	35	50	1	7	10
Unemployed	2	–	7	–	–	–
Student	1	15	28	–	2	2
Data missing[3]	11	64	123	2	12	15
PhDs moving total	227	402	663	34	68	95
Total number of PhDs 1999	656	1,997	4,668	91	358	1,087
Inflow rate (%)	34.6	20.1	14.2	37.4	19.0	8.7

Delivering sector 1998	Receiving sector 1999 Research institutes, non-profit	Other non-profit sector	Business enterprises	Data missing[3]	PhDs moving total	Total number of PhDs 1998	Outflow rate %
Central government	–	9	14	3	186	583	31.9
Local government	–	21	75	11	382	1,890	20.2
Universities	4	33	106	14	624	4,361	14.3
Polytechnics	–	–	1	2	17	51	33.3
Other schools (incl. municipal schools)	–	3	15	2	77	326	23.6
Government research institutes	–	–	12	3	69	998	6.9
Research institutes, non-profit	–	2	–	1	9	45	20.0
Other non-profit sector	–	18	15	5	89	396	22.5
Business enterprises	–	10	126	21	278	1,474	18.9
Unemployed	–	–	2	..	11	..	..
Student	–	2	4	..	54	..	..
Data missing[3]	–	14	64	13	318	134	..
PhDs moving total	4	112	434	75	2,114	10,258	17.0[2]
Total number of PhDs 1999	46	409	1,694	146	11,152		
Inflow rate (%)	8.7	27.4	25.6	..	15.6[2]		32.0 %[1]

1 Intra-sectoral mobility as a proportion of total mobility (excl. observations for which sectoral data are incomplete)
2 Mobility rate, % (excl. student and unemployed categories as well as observations for which sectoral data are incomplete in either 1998 or 1999 or both; n=445)
3 Observations for which data are incomplete have not been included in counting the mobility rates mentioned in the text

versities came from outside the university sector. Almost 10 per cent moved in from the business sector (50 PhDs).

A comparison of the numbers exiting each sector (in 1998) and entering from another sector (in 1999) shows that the increase in the number of PhDs attributable to mobility was greatest in the business sector (+ 156). Enterprises recorded the second highest inflow of PhDs after universities, but universities also had a high volume of outflow. Mobility rates were low at government research institutes, where the total number of PhDs in 1999 was 1,100. Changing jobs from government research institutes to universities and companies and vice versa was at a particularly low level.

3.7.3 Factors impacting mobility

In this section, a logistic regression model is exploited to study the impacts of economic conditions, i.e. economic cycles, on the inflow job-to-job mobility of PhDs (see Appendix Table 3.5). The explanatory factors in the model are unemployment rate and real annual rate of growth in GDP and R&D expenditure. Furthermore, mobility is studied against various background variables describing PhDs and workplace characteristics, including age, gender, major field of science, sector/industry of employment, and size of workplace. The data cover the period from 1989 to 1999. The criterion used in the study is inflow job-to-job mobility at the workplace (establishment) level, i.e. the number of PhDs who have moved to a new workplace since the previous year in relation to the number of employed PhDs in the economy or in the workplace concerned.

In Finland, PhDs show a very high level of labour market mobility. During the period under review, the average annual rate of inflow job-to-job mobility at the workplace level was 26 per cent. The outflow rate was about one percentage point lower. In theory, then, the PhD-level personnel in each workplace turns over in the space of about four years. In reality, however, some PhDs remain in the same job their whole career, while others may change jobs quite frequently.

GDP real growth: During periods of economic growth and expansion, new jobs are created and there are more vacancies available. With improved prospects of employment, people are more liable to change jobs, for instance for reasons of career advancement and better pay. During periods of economic slowdown, on the other hand, the number of jobs will decline and people tend to hold on to the jobs they have[23]. It may be assumed then that mobility follows economic cycles, i.e. that it increases during periods of economic growth and decreases during periods of recession. This is indicative of pro-cyclicity between mobility and economic development. However, the results show a negative, i.e. a countercyclical correlation between mobility rates and GDP. According to the estimate a 1.8 per cent increase in GDP reduces mobility rate by one per cent. In the last column of Appendix Table 3.5, the annual GDP growth rate has been delayed by one year. This is sufficient to produce a

23 See Boeri (1996)

procyclical correlation: a 0.9 per cent increase in GDP increases the mobility rate by one per cent. Part of the explanation for the delay between economic development and the mobility rate lies no doubt in the fact that the public sector reacts slower to economic fluctuations than the private sector, and in the event of recession, it is capable of buffering the effect of the cyclical turn on the permanence of jobs, the number of new jobs and mobility. It needs to be borne in mind that the public sector (including the non-profit sector) accounts for around 85 per cent of all employed PhDs. This is a much higher share than those recorded for other educational groups.

Unemployment rate: Unemployment among PhDs is at a relatively low level; in the 1990s, for instance, the unemployment rate never exceeded 2.1 per cent. In order to gain a clearer view of the development of the economy and labour markets, the variable included in the model was the unemployment rate for the whole labour force. We expected to see a procyclical relationship between unemployment and mobility, i.e. increasing mobility with a declining unemployment rate. According to the results a 1.2 per cent decrease in the unemployment rate increased the mobility rate by one per cent.

R&D expenditure real growth: The basic assumption was that increased R&D spending opens up new job opportunities for researchers and contributes to increased mobility. On the basis of the results, the relationship between expenditure growth and mobility was counter-cyclical. The estimates indicated that a 0.6 per cent increase in real expenditure reduced mobility by one per cent. When the R&D expenditure growth rate was delayed by one year, the relationship became positive: the mobility rate reacted very sensitively to increasing expenditure.

Sectors and industries: In this analysis, only those sectors/industries that had the largest number of PhDs were included. Among the major employers, universities showed the lowest mobility rates in 1989–1999. Mobility was lower in central government than in local government. By contrast, in the group of 'other education' (which includes public comprehensive schools, upper secondary schools and polytechnics), the mobility rates were high, suggesting a high prevalence of short periods of employment. In the business enterprise sector, the focus was narrowed to those sectors where there were at least 50 PhDs. There were marked differences between different industries. Mobility rate was highest in the sector of radio, TV and communication equipments. Mobility was also high in business services and R&D. By contrast, in the sector of precision and optical instruments as well as in chemicals, job changes were relatively infrequent. There were also marked sectoral differences in mobility rates between different fields of science.

In 1989–1999, the annual inflow job-to-job mobility rates for the whole PhD population at the workplace level were generally in the region of 20–30 per cent. In a more detailed analysis the mobility rates were highest in the following sectors: 'other education' (31–52% depending on the year); enterprises (25–43%); municipal employers (26–39%); and central government (23–37%). At universities, the mobility rate was 18–29 per cent. Mobility rates were lowest in government research institutes (10–15%) and in research institutes in the non-profit sector (5–15%).

Age: Age had a significant impact on the frequency of job changes. Mobility rates declined with advancing age. They were clearly higher among persons under 40 and lowest among persons aged 50 or over. The one exception here was represented by persons aged 55–59, who seemed to be inspired to one further period of activity on the labour market: their mobility rate was even higher than in the age group 40–44 years. When this group was combined with those aged 60 or over, the estimate became negative.

Gender: According to the estimate women had higher mobility rates than men. The difference was smallest during the recession, after which it began sharply to increase. In the late 1990s the mobility rate for women was 4–7 percentage points higher than for men. By field of science, men changed jobs more often than women in the natural sciences, engineering as well as in agricultural sciences.

Size of establishment: Size of establishment had a significant impact. Mobility rates declined with increasing personnel numbers in the workplace. However, in a small establishment the departure of one PhD may yield a very high mobility rate.

Field of science: The differences by field of science were considerable. The average annual rate of mobility was highest in the medical sciences (32%) and the social sciences (27%). The lowest rates were recorded for PhD graduates from engineering (19%) and the agricultural sciences (21%).

3.7.4 Summary and conclusions

Economic cycles had a major impact on the mobility of PhDs in the 1990s. The mobility rates were lowest during the economic recession and at times of high unemployment. When the economy began to pick up again, mobility rates soon returned to the levels recorded before the recession. The mobility of PhDs reacted to cyclical fluctuations at a one-year delay. In other educational level groups no corresponding delay has been found[24].

In 1989–1999, the mobility rate at the workplace level averaged 26 per cent and at the enterprise level about 19 per cent a year. The mobility rates for PhDs were higher than for other educational categories[25]. For example, the mobility rate at the workplace level was on average six percentage points higher than for the whole employed population and about 3.5 percentage points higher than for those with a higher tertiary degree. PhDs often changed jobs within the same company. Internal mobility as a proportion of total mobility at the workplace level was 27–42 per cent depending on the year. Internal mobility and its proportion of total mobility increased with economic revival in the latter half of the 1990s.

In order for the economy to function smoothly, it is important that mobility rates at the enterprise level do not remain too low or too high for extended periods, say at below 10 per cent or over 30 per cent. Slow mobility adversely

24 See Graversen et al. (2001).
25 See Husso (2002).

affects the transfer of know-how from one sector to another and the application of knowledge in different parts of the economy. A very high level of mobility, on the other hand, runs counter to the goals of introducing and establishing new knowledge and know-how and indeed to overall continuity in a given enterprise. It is, however, difficult to define any exact limits for the optimum mobility rate, which may furthermore vary depending on the perspective adopted, i.e. whether it is considered from the point of view of the innovation system as a whole or the employer's or the employee's perspective.

Age had a significant impact on mobility. In the early stages of their careers people are more liable to frequent job changes. The high mobility of young PhDs is probably also explained by the rapid increase in the number of new PhDs entering the labour market and by the difficulties in finding permanent jobs. Apart from age, size of the workplace and sector/industry also had a major influence on mobility rates. Women had a higher mobility rate than men. The differences by field of science in mobility were considerable.

Given the large number of new PhDs who graduate each year, it would be important more systematically to monitor their employment, placement and mobility. It might be useful to collect more detailed data than those presented here and to report the findings at 1–2 year intervals. This information would support educational and science policy planning and would open up useful new views on the development of labour markets and the dissemination of know-how in the innovation system.

Appendix Table 3.1
Population aged 16–64 with a tertiary degree (excluding military education) by level of education, field of science and gender in 1991–2002.*
Source: Statistics Finland, Employment Statistics.

Level of education Field of science	1991 Total	1991 of which women	1995 Total	1995 of which women	1999 Total	1999 of which women	2001 Total	2001 of which women	2002* Total	2002* of which women
PhD										
Natural sciences	1,744	345	2,218	528	2,907	809	3,250	973	3,445	1,077
Engineering and technology	839	51	1,194	109	1,700	205	1,972	255	2,131	300
Medical sciences	2,512	595	3,116	934	3,966	1,493	4,437	1,855	4,629	2,000
Agricultural sciences	284	88	342	112	450	168	504	203	535	222
Social sciences	989	208	1,329	337	1,953	614	2,342	816	2,531	908
Humanities	737	213	931	296	1,230	448	1,433	549	1,514	601
Unspecified	6	1	19	6	16	7	23	11	28	14
Total	**7,111**	**1,501**	**9,149**	**2,322**	**12,222**	**3,744**	**13,961**	**4,662**	**14,813**	**5,122**
Licentiate										
Natural sciences	1,450	441	1,636	547	1,659	571	1,653	584	1,629	584
Engineering and technology	1,457	144	1,864	226	2,176	338	2,231	364	2,283	386
Medical sciences	123	82	167	120	211	160	220	172	212	166
Agricultural sciences	142	55	155	60	159	60	145	55	146	57
Social sciences	1,454	431	1,938	683	2,322	935	2,492	1,090	2,528	1,148
Humanities	876	365	1,123	515	1,282	634	1,301	666	1,337	700
Total	**5,502**	**1,518**	**6,883**	**2,151**	**7,809**	**2,698**	**8,042**	**2,931**	**8,135**	**3,041**
Higher tertiary degree										
Natural sciences	15,571	6,911	18,342	8,394	21,907	10,432	23,725	11,475	24,596	11,938
Engineering and technology	26,836	3,485	31,704	4,737	37,756	6,180	40,863	6,946	42,543	7,370
Medical sciences	18,345	10,434	21,053	12,591	23,369	14,699	24,122	15,443	24,569	15,833
Agricultural sciences	6,303	2,443	6,845	2,908	7,489	3,451	7,751	3,704	7,872	3,809
Social sciences	48,445	23,927	61,679	32,876	75,474	42,717	83,100	48,235	87,111	51,197
Humanities	24,818	17,299	29,542	20,995	34,775	25,165	37,569	27,453	39,032	28,626
Unspecified	90	56	178	113	176	114	197	127	232	153
Total	**140,408**	**64,555**	**169,343**	**82,614**	**200,946**	**102,758**	**217,327**	**113,383**	**225,955**	**118,926**
Lower tertiary degree and lowest level tertiary education										
Total	**538,331**	**296,876**	**609,244**	**346,003**	**658,401**	**381,723**	**672,375**	**392,582**	**681,570**	**398,586**
All total	**691,352**	**364,450**	**794,619**	**433,090**	**879,378**	**490,923**	**911,705**	**513,558**	**930,473**	**525,675**

Appendix Table 3.2
Tertiary degrees (excluding military education) in 1991–2002.*
Source: Statistics Finland, Employment Statistics.

Level of education	1991		1995		1999		2002*	
Field of science	Total	of which women	Total	of which women	Total	of which women	Total	of which women
PhD								
Natural sciences	120	40	179	63	244	98	282	129
Engineering and technology	80	14	125	14	189	36	199	46
Medical sciences	175	65	208	110	313	186	297	184
Agricultural sciences	27	9	26	8	42	24	43	22
Social sciences	75	20	151	53	234	101	247	110
Humanities	63	31	83	34	127	56	127	63
Unknown	1	–	6	2	2	2	–	–
Total	**541**	**179**	**778**	**284**	**1 151**	**503**	**1 195**	**554**
Licentiate								
Natural sciences	138	48	151	64	167	73	165	76
Engineering and technology	168	25	179	43	178	42	151	45
Medical sciences	22	18	29	21	22	14	19	16
Agricultural sciences	16	9	19	10	12	5	9	5
Social sciences	156	67	267	119	261	120	189	121
Humanities	116	55	170	85	153	91	111	75
Total	**616**	**222**	**809**	**339**	**793**	**345**	**644**	**338**
Higher tertiary degree								
Natural sciences	900	427	1 101	522	1 492	762	1 419	722
Engineering and technology	1,639	356	1,980	415	2,560	517	2,323	493
Medical sciences	1,537	921	1,552	990	1,606	1,094	1,656	1,095
Agricultural sciences	297	153	326	187	269	162	314	182
Social sciences	3,567	2,156	4,141	2,659	4,561	3,010	4,930	3,375
Humanities	1,673	1,215	1,819	1,339	2,057	1,535	2,194	1,687
Unknown	21	13	11	5	2	1	–	–
Total	**9,634**	**5,241**	**10,930**	**6,117**	**12,547**	**7,081**	**12,836**	**7,554**
Lower tertiary degree and lowest level tertiary education								
Total	**26,415**	**16,961**	**28,768**	**18,034**	**24,329**	**15,336**	**25,024**	**16,064**
All Total	**37,206**	**22,603**	**41,285**	**24,774**	**38,820**	**23,265**	**39,699**	**24,510**

Appendix Table 3.3
S&T human resources in European countries by education and occupational status in 2003, proportion of population aged 25–64.
Source: Eurostat, New Cronos..

	Total	Education	Occupation	Both
Austria	38.2	24.7	28.1	14.6
Belgium	34.2	28.2	20.7	14.6
Cyprus	33.5	26.8	20.7	14.0
Czech Republic	28.8	25.0	15.8	12.0
Denmark	31.1	25.8	18.0	12.6
Estonia	22.0	10.8	18.1	6.8
Finland	26.9	16.5	19.2	8.9
France	21.2	18.1	13.5	10.4
Germany	34.8	29.5	21.3	16.0
Greece	27.0	18.2	16.9	8.1
Hungary	29.6	23.2	17.6	11.3
Ireland	28.3	14.9	23.9	10.5
Italy	17.3	9.2	14.0	5.9
Latvia	15.1	10.3	11.6	6.9
Lithuania	21.5	13.9	16.1	8.5
Luxembourg	32.2	23.1	22.3	13.3
Malta	41.0	27.0	32.8	18.9
Netherlands[1]	35.2	22.9	25.2	12.9
Poland	24.0	11.6	19.9	7.5
Portugal	28.3	17.7	22.0	11.4
Slovakia	40.3	32.8	25.6	18.2
Slovenia	41.9	31.8	30.3	20.2
Spain	26.7	11.9	22.7	7.9
Sweden	23.0	15.2	16.9	9.1
United Kingdom	36.6	30.4	18.5	12.3
EU 25[2]	29.8	20.7	20.7	11.6
EU 15[2]	31.0	21.9	21.3	12.2
2004 new EU-countries	23.7	14.7	17.8	8.7
Bulgaria	25.6	21.1	15.4	10.9
Iceland[1]	37.9	25.6	29.8	17.6
Norway	41.4	31.4	30.2	20.2
Romania	16.3	9.8	12.7	6.3
Switzerland	42.3	26.9	31.8	16.3

1 Data from 2002
2 Eurostat estimate

Appendix Table 3.4
R&D personnel by gender and education in 1991–2002.
Source: Statistics Finland, Research and Development Statistics.

Both genders	1991	1993	1995	1997	1999	2001	2002
PhDs	4,080	4,363	4,859	5,573	6,859	7,441	8,166
Licentiates	2,465	2,679	2,781	2,979	3,020	2,976	3,046
Other university degree	14,121	14,347	16,790	19,942	23,402	24,837	26,535
Polytechnics, higher vocational diploma	4,731	4,395	5,509	6,823	9,882	12,280	12,469
Other	20,782	16,326	17,928	20,172	23,803	22,255	22,905
Total	**46,181**	**42,111**	**47,866**	**55,490**	**66,965**	**69,788**	**73,121**
Women							
PhDs	785	929	1,134	1,418	2,113	2,219	2,511
Licentiates	680	736	799	914	948	916	991
Other university degree	4,441	4,625	5,400	6,410	7,967	8,377	9,200
Polytechnics, higher vocational diploma	260	367	525	563	1,326	2,301	2,323
Other	8,133	6,911	7,374	8,359	9,498	8,766	9,335
Total	**14,298**	**13,568**	**15,232**	**17,663**	**21,853**	**22,580**	**24,360**

Appendix Table 3.5

Logistic regression model of inflow job-to-job mobility of PhDs in 1989–1999. In the last column the annual rate of growth of the unemployment rate and GDP and R&D expenditure is delayed by one year (t+1). The criterion for mobility is change of workplace establishment since the previous year.[1]

Source: Statistics Finland, Employment Statistics.

Explanatory variable	PhDs total			Natural sciences			Engineering			Medical sciences		
Unemployment rate	−0.012			−0.006			−0.016			−0.017		
GDP real growth		−0.018			−0.031			−0.016			0.011	
R&D expenditure real growth			−0.006			−0.012			−0.013			0.008
Constant	−0.433	−0.556	−0.549	−0.884	−0.891	−0.858	−0.944	−1.118	−1.045	−0.254	−0.535	−0.579
Gender:												
man	−0.102	−0.106	−0.103	0.061	0.049	0.052	0.024	0.024	0.018	−0.024	−0.009	−0.005
Age:												
under 30 yrs	0.794	0.805	0.798	0.401	0.438	0.425	1.081	1.077	1.086	1.180	1.182	1.184
30–34 yrs	0.282	0.287	0.284	0.331	0.354	0.346	0.333	0.331	0.335	0.374	0.385	0.385
35–39 yrs	0.177	0.179	0.178	0.179	0.191	0.187	0.268	0.267	0.269	0.213	0.217	0.217
45–49 yrs	−0.157	−0.160	−0.159	−0.187	−0.184	−0.185	−0.072	−0.081	−0.080	−0.253	−0.250	−0.250
50–54 yrs	−0.337	−0.337	−0.339	−0.266	−0.253	−0.257	−0.119	−0.124	−0.118	−0.480	−0.486	−0.487
55–59 yrs	0.096	0.098	0.094	0.278	0.284	0.276	−0.029	−0.024	−0.023	0.029	0.019	0.021
60–64 yrs	−0.521	−0.520	−0.519	−0.631	−0.612	−0.613	−0.455	−0.460	−0.455	−0.520	−0.522	−0.525
Sector of employment:												
central government	−0.217	−0.219	−0.219	0.212	0.213	0.209	−0.132	−0.143	−0.143	−0.168	−0.168	−0.168
university	−0.381	−0.386	−0.385	−0.230	−0.303	−0.302	−0.679	−0.687	−0.685	−0.206	−0.209	−0.209
other education	0.375	0.377	0.376	0.282	0.283	0.284	0.614	0.603	0.609	1.395	1.359	1.346
research institute	−1.050	−1.055	−1.057	−1.017	−1.011	−1.014	−0.618	−0.633	−0.631	−0.746	−0.763	−0.764
business sector:												
chemicals	−0.477	−0.494	−0.480	−0.384	−0.423	−0.402	−0.072	−0.084	−0.081	1.156	1.125	1.128
pharmaceuticals	−0.038	−0.038	−0.040	0.073	0.076	0.075	0.555	0.552	0.544	−0.101	−0.118	−0.119
radio, TV and communication equipment	0.574	0.587	0.579	1.088	1.143	1.130	0.844	0.848	0.865	–	–	–
medical, precision and optical instruments	−0.701	−0.703	−0.701	−0.631	−0.630	−0.629	−0.675	−0.680	−0.676	0.420	0.424	0.426
wholesale and retail trade	−0.174	−0.176	−0.174	−0.091	−0.082	−0.080	0.020	0.017	0.018	−0.307	−0.306	−0.308
R&D services	0.010	−0.009	0.002	0.209	0.202	0.211	0.003	−0.042	−0.044	0.884	0.868	0.857
business services	0.012	0.034	0.019	0.297	0.363	0.340	0.105	0.115	0.129	0.446	0.396	0.386
health care services	−0.102	−0.119	−0.109	0.022	0.023	0.022	–	–	–	−0.179	−0.165	−0.165
Size of workplace												
less than 10 persons	0.732	0.737	0.731	0.673	0.681	0.673	0.596	0.599	0.600	1.230	1.217	1.214
10–49 persons	0.341	0.338	0.342	0.470	0.466	0.466	0.457	0.468	0.470	0.324	0.327	0.337
50–99 persons	0.120	0.120	0.122	0.040	0.035	0.038	0.105	0.110	0.111	0.309	0.306	0.307
more than 250 persons	−0.305	−0.305	−0.305	−0.150	−0.151	−0.153	−0.505	−0.499	−0.500	−0.368	−0.368	−0.364
Cyclicality, p = pro-cyclical, c = counter-cyclical	p	c	c	p	c	c	p	c	c	p	p	p
Mobility rate 1989–1999		26.0 %			22.4 %			19.3 %			31.8 %	
Number of observations		86,749			20,522			11,479			30,203	

– no observations or insufficient observations to calculate estimate

1 Reference categories: woman; age 40–44 yrs; employment in local government sector; size of workplace 100–250 employees.

Appendix Table 3.5
Continued

Explanatory variable	Agriculture and forestry			Social sciences			Humanities			PhDs total (delayed variables)		
Unemployment rate	0.008			–0.018			–0.001			–0.025		
GDP real growth		0.006			–0.057			–0.051			0.009	
R&D expenditure real growth			0.007			–0.024			–0.018			0.001
Constant	–1.587	–1.479	–1.525	–0.679	–0.821	–0.737	–0.834	–0.719	–0.684	–0.212	–0.611	–0.599
Gender:												
man	0.005	0.006	0.008	–0.021	–0.041	–0.036	–0.120	–0.141	–0.133	–	–	–
Age:												
under 30 yrs	–0.940	–0.932	–0.925	0.752	0.862	0.812	0.356	0.350	0.362	–	–	–
30–34 yrs	0.186	0.188	0.182	0.226	0.290	0.271	0.318	0.336	0.336	–	–	–
35–39 yrs	0.094	0.099	0.101	0.071	0.105	0.097	0.264	0.270	0.273	–	–	–
45–49 yrs	–0.054	–0.054	–0.051	–0.088	–0.095	–0.099	–0.005	–0.034	–0.019	–	–	–
50–54 yrs	–0.155	–0.158	–0.158	–0.364	–0.336	–0.346	–0.178	–0.179	–0.176	–	–	–
55–59 yrs	0.016	0.003	0.007	0.096	0.122	0.120	0.257	0.271	0.264	–	–	–
60–64 yrs	–0.535	–0.547	–0.549	–0.607	–0.600	–0.605	–0.509	–0.516	–0.506	–	–	–
Sector of employment:												
central government	0.959	0.955	0.951	–0.006	0.005	–0.002	–0.360	–0.364	–0.368	–	–	–
university	0.495	0.494	0.490	0.117	0.121	0.115	–0.161	–0.157	–0.160	–	–	–
other education	1.156	1.152	1.136	0.928	0.980	0.964	0.239	0.254	0.249	–	–	–
research institute	–0.439	–0.438	–0.444	–0.688	–0.676	–0.684	–1.537	–1.555	–1.548	–	–	–
business sector:												–
manufacture of chemical products	0.104	0.096	0.097	–0.400	–0.521	–0.465	–	–	–	–	–	–
manufacture of pharmaceuticals	0.533	0.535	0.530	–0.910	–0.930	–0.929	–	–	–	–	–	–
manufacture of radio and television equipment	–	–	–	1.255	1.269	1.253	–	–	–	–	–	–
instruments and precision mechanics	–	–	–	1.585	1.554	1.548	–	–	–	–	–	–
wholesale and retail trade	0.884	0.892	0.886	0.823	0.852	0.843	0.455	0.537	0.436	–	–	–
research services	0.647	0.627	0.623	0.428	0.365	0.384	0.552	0.477	0.503	–	–	–
business services	1.959	1.950	1.932	0.530	0.643	0.606	0.847	0.988	0.911	–	–	–
health care services	–0.535	–0.542	–0.541	–0.149	–0.135	–0.140	–0.513	–0.536	–0.520	–	–	–
Size of workplace												
less than 10 persons	0.577	0.574	0.583	0.869	0.896	0.875	0.126	0.109	0.112	–	–	–
10–49 persons	0.531	0.532	0.557	0.555	0.559	0.551	0.211	0.193	0.194	–	–	–
50–99 persons	0.311	0.305	0.296	0.110	0.115	0.106	0.126	0.067	0.095	–	–	–
more than 250 persons	–0.201	–0.193	–0.150	0.090	0.104	0.091	–0.280	–0.314	–0.303	–	–	–
Cyclicity, p = procyclicity, c = countercyclicity	c	p	p	p	c	c	p	c	c	p	p	p
Mobility rate 1989–1999		21.0 %			26.5 %			23.9 %			26.0 %	
Number of observations		3,245			12,827			8,275			86,749	

– no observations or insufficient observations to calculate estimate

1 Reference categories: woman; age 40–44 yrs; employment in local government sector; size of workplace 100–250 employees.

Appendix 3.1: Classification of fields of science

1. **Natural sciences**
   Mathematics
   Computer science
   Physics
   Space sciences and astronomy
   Chemistry
   Biology, environmental sciences
   Geology
   Geosciences, meteorology

2. **Engineering and technology**
   Architecture
   Construction technology and municipal engineering
   Electrical engineering
   Energy technology
   Metallurgy and mining technology
   Mechanical engineering and manufacturing technology
   Process and materials technology
   Industrial chemistry, process engineering
   Pulp and paper technology
   Biotechnology, food technology
   Other technology

3. **Medical sciences**
   Biomedicine
   Clinical medicine
   Nutrition
   Public health science
   Dentistry
   Sport and health sciences
   Pharmacy
   Nursing science
   Veterinary medicine[1]

4. **Agricultural sciences**
   Agriculture and food sciences
   Forestry

5. **Social sciences**
   Economics
   Business administration, economic geography

1 Comes under agriculture and forestry in OECD classification.

Law
Social sciences
Psychology
Education
Political science, administrative science
Communication and information studies
Statistics[2]

6. **Humanities**
Philosophy
Linguistics
Art studies, literature
Theology
History and archaeology
Cultural studies

2 Comes under agriculture and forestry in OECD classification.

4 Government R&D funding

Statistics on government budget appropriations or outlays for R&D are compiled with a view to assessing the government's and ministries' objectives in supporting research and development: the aim of this so-called budget analysis is to obtain up-to-date information on R&D funding in various organisations and administrative branches and by the socio-economic objectives of research. The assessments of R&D funding are based upon government budget appropriations. Data received from the providers of funding, that is, ministries and organisations, are also used in R&D funding calculations. Some data are obtained directly from the State budget proposal. Funding provided for R&D is assessed separately from each of the relevant items in the budget. R&D expenditure in the universities is assessed by reference to Statistics Finland research statistics, which are used to determine the share of the funds allocated to research.

Public funding of R&D is defined as comprising government agencies' and institutions' research expenditure as well as government transfers and grants. The R&D activities of unincorporated state enterprises and local governments are excluded from the calculations. Since 1991, funding has been estimated on the net principle, i.e. the inclusion in the budget of the difference between directly linked revenue estimates and appropriations. In practice this means that expenditure entered into the budget of institutions providing fee-based services are dependent on external sources of revenue. With the exception of 2004, the calculations include both the budget proper and supplementary budgets.[1]

The first Statistics Finland survey on R&D funding included in the state budget was conducted in 1968, following the government's decision in 1966

Government research funding and R&D expenditure

Government R&D funding is measured not on the basis of actual expenditure, but on the basis of budgeted appropriations, i.e. the intention to spend money on R&D. For this reason the rapid data obtained from the budget analysis differ from the statistical figures on R&D expenditure that are published at a time lag of about one year. However as far as R&D funding is concerned budget proposals do not differ significantly from the budgets eventually adopted by Parliament. The final sums allocated to research are largely dependent on political decisions. Indeed at a general level these two sets of statistics measure different things: Statistics on government research funding are compiled from the point of view of the providers of funding, whereas R&D statistics measure expenditure from the point of view of the researcher and developer. Another factor that explains the differences in the final sums is that unlike the research statistics, the budget analysis includes membership fees and contributions to international organisations. Furthermore, part of the expenditure in the budget analysis consists of deferrable appropriations and budget authorities, which may be used across several years.

1 For more details on the method and principles of calculating research funding, see Statistics Finland (2004a).

regarding the compilation of R&D statistics. However it was not until 1975 that the Academy of Finland actually began to produce these statistics, which it continued to do until 2001. The present method of data collection has been used since 1997: as a rule the data are collected from agencies and institutions using a questionnaire designed on the basis of OECD and Eurostat recommendations. The definition of research and development is in compliance with OECD guidelines.[2]

R&D accounts for 4.5 per cent of government expenditure

The figure entered for R&D funding in the 2004 state budget stands at 1.54 billion euros. This is up by 93 million euros on the previous year's figure, marking a nominal increase of 6.4 per cent and a real increase of 3.6 per cent – and clearly reflecting the commitments of the new government that took office in 2003. The increase recorded in R&D funding is the greatest since 1997. If the figures were compared only to the 2003 budget proper, the increase would be greater still, i.e. almost 117 million euros. Government R&D funding

R&D funding as part of on-budget activities and science and technology policy

Government funding for R&D provides the necessary foundation for basic research as well as for the development of innovative scientific and technological know-how. By supporting R&D, the government can adapt the national economy to changing market conditions and strengthen its capacity for regeneration. The government has a major role to play in encouraging R&D and in supporting the creation of know-how in all sectors of the economy.

There is a broad consensus that the government's additional funding programme in the late 1990s had a positive and productive impact in society. The R&D resources of the National Technology Agency Tekes, the Academy of Finland as well as universities increased considerably. Overall the programme increased the volume of public research funding by one-quarter from 1996 to 1999. At the same time government R&D funding as a proportion of GDP peaked at 1.1 per cent in 1997, a very high level by international comparison.

However the real growth in funding ground to a halt in 1999 and the GDP share stagnated at around the one per cent mark, i.e. roughly the same level as in 1996 before the additional funding programme. Indeed throughout the period from 1996 to 2003, government funding for R&D increased at the same rate as GDP growth: the weight of R&D funding did not increase in spite of the extra injections of funding through the government programme.

In December 2002 the Science and Technology Policy Council of Finland came forward with the proposal that the successful development strategy of the late 1990s be continued by investing an additional 300 million euros in research from 2002 to 2007. This recommendation is largely being met, with a substantial front-end increase being made available in public R&D funding in accordance with the government policy line, starting from the 2003 supplementary budget. Public R&D funding as a proportion of GDP rose to 1.04 per cent in 2004.

2 OECD (2002c).

Table 4.1
R&D appropriations in the state budget in 1991–2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D.

Year	Government expenditure (excl. debt)	R&D funding	R&D funding as a proportion of government expenditure	Real change: Government expenditure	Real change: R&D funding
	EUR million	EUR million	%	%	%
1991	27,228	799.7	2.9	.	.
1992	29,766	839.8	2.8	7.3	2.9
1993	31,152	881.2	2.8	6.5	4.9
1994	29,572	887.1	3.0	–5.6	–1.3
1995	29,222	930.4	3.2	–2.0	3.9
1996	28,658	938.8	3.3	–2.5	–1.7
1997	27,831	1,183.9	4.3	–3.5	23.4
1998	27,676	1,249.7	4.5	–1.9	2.7
1999	27,309	1,275.2	4.7	–2.5	0.2
2000	28,141	1,295.9	4.6	0.1	–2.1
2001	29,672	1,352.4	4.6	2.9	0.9
2002	30,877	1,388.7	4.5	1.7	–0.4
2003	32,726	1,445.7	4.4	3.8	–0.3
2004	34,283	1,538.3	4.5	2.7	3.6

1991–2003: State budget + supplementary budgets, 2004: State budget

as a proportion of total state expenditure exclusive of government debt servicing is 4.5 per cent.

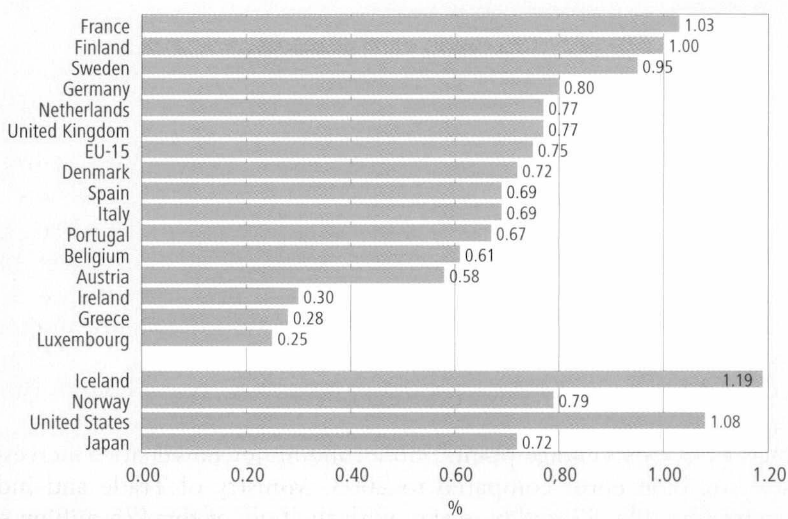
Government expenditure (excluding central government debt servicing) remained unchanged from 1991 to 1999. At the same time R&D funding showed a nominal increase of 60 per cent. This is primarily attributable to a government programme in 1997 to inject extra funds into science and technology, but in part also to changes in the calculation basis. As far as R&D funding is concerned 1997 marked a major turning-point, with real growth recorded at 23 per cent.

Since 1999 government expenditure has increased by just over one-quarter. At the same time R&D funding has gone up by 21 per cent, so in spite of a new programme to boost R&D funding its share of government expenditure has decreased from the level recorded in 1999. Since 1991 the real change in R&D funding has fluctuated from year to year. The average annual growth rate is 2.6 per cent.

Finland ranks among the leading investors in research and product development

In an international comparison public funding for R&D in Finland as a proportion of GDP has been very high for a number of years. The figures have been higher than the EU average since 1991. Finland further improved its ranking towards the end of the 1990s and in 1997 ranked as the leading EU country in terms of its public R&D investment. In 2002, the GDP share in Finland was the second highest after France. In the mid-1990s Sweden was still ahead of Finland, but since then the GDP share of R&D funding not only in Sweden but in most other EU countries has either declined or at best remained unchanged. With just a few exceptions it would seem that R&D funding has not grown in pace with the growth of GDP in those countries where the share has been the highest. With the exception of Iceland and the United States, the GDP share no longer exceeds the one per cent mark. The 2003 figure for the EU area at 0.75 per cent was roughly the same as in Japan, but markedly lower than in the United States. However within the EU there are considerable country differences. Luxembourg, Greece and Ireland stand apart with by far the lowest GDP shares (Figure 4.1): in 2003 these countries spent no more than around 0.3 per cent of their GDP on R&D.

Figure 4.1
Public R&D funding as a proportion of GDP in the EU and selected other countries in 2003. Sources: OECD, Main Science and Technology Indicators 2004/1, European Commission, Key Figures 2003–2004.

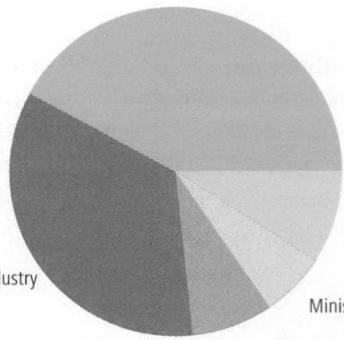


Partly preliminary data or estimates.
Data from 2002: United Kingdom, Spain, Ireland, Italy, France.

The bulk of R&D funding administered by the Ministry of Education and the Ministry of Trade and Industry

In the Finnish science and technology system the bulk of public R&D funding is channelled through the Ministry of Education and the Ministry of Trade and Industry (Figure 4.2). Each year these two administrative branches have accounted for around three-quarters of all R&D funding; in 2004 the figure rose to almost 77 per cent. The four biggest ministries, which in addition to the former two include

Figure 4.2
Breakdown of government R&D funding by administrative branch in 2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D.



the Ministry of Social Affairs and Health and the Ministry of Agriculture and Forestry, together administer more than 90 per cent of all R&D funding. The figures for other administrative braches are very modest by comparison. Since 1991 there have been only minor changes in the relative positions of different ministries. The only noteworthy development is the declining share of the Ministry of Agriculture and Forestry, which has dropped from ten to just over six per cent.

The major administrative branches in terms of R&D funding also received the bulk of the increase in funding in 2004. Funding increased most of all, by 45 million euros, in the administrative branch under the Ministry of Education. Over half of the increase went towards Academy of Finland operating costs and budget authorities. At the same time the Ministry's share of funding increased by 0.4 percentage points. Core funding for universities increased by almost 15 million euros compared to 2003. Ministry of Trade and Industry funding increased by 32 million euros, with the bulk of this (25 million euros) going towards increasing the budget authorities and technology grants of the National Technology Agency Tekes.

The biggest real increase was recorded for the Ministry of the Interior. Other administrative branches with relatively low levels of R&D funding also saw rapid growth, although there may be considerable year-on-year fluctuations. In 2004 R&D funding increased in all administrative branches except those under the Ministry of Transport and Communications and the Ministry of Defence.

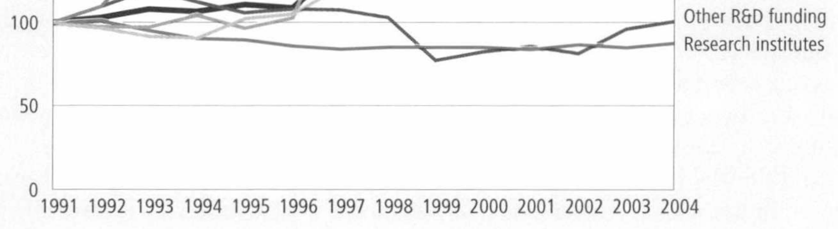
In 2004 the level of R&D intensity was by far the highest in the administrative branch under the Ministry of Trade and Industry, where 55 per cent of total expenditure was committed to R&D. The Ministry of Education spent less than 11 per cent of its budget on R&D. In all other administrative branches the figure is no more than a few per cent. The lowest R&D intensity was recorded for the Ministry of Finance at less than 0.2 per cent.

More than one-half of public R&D funding administered by Tekes and universities

Operating under the Ministry of Trade and Industry, the National Technology Agency Tekes is the single most significant source of public R&D funding in Finland. In 2004 it accounted for 28 per cent of all government appropriations or outlays on R&D, with the sum amounting to 432 million euros. Core university funding accounted for almost 27 per cent of total R&D funding, the Academy of Finland for 14 per cent, government research institutes for 16 per cent and central university hospitals for around three per cent. The figure for other R&D funding was 12 per cent, which included the research funds of ministries and their agencies (excluding the Academy of Finland and Tekes) as well as the membership fees and contributions to certain international organisations. In 2004 the Academy of Finland's share increased by one percentage point on the previous year, while that of universities decreased by roughly the same proportion. Budget funds for State research institutes was set to increase, in contrast to the previous year, but external funding decreased.

The National Technology Agency Tekes works to promote the competitiveness of Finnish business and industry by funding technological projects. Committed primarily to supporting industrial R&D, Tekes' financial resources have increased 2.8-fold from 1991 to 2004 (Figure 4.3), with average annual

Figure 4.3
Real development of government R&D funding by research organisation in 1991–2004 (1991=100).
Source: Statistics Finland, Government budget appropriations or outlays for R&D.



real growth reaching almost six per cent. Even faster growth has been recorded during this same period for the Academy of Finland, which promotes high-level scientific research. It should be noted, though, that part of the growth in Tekes and Academy funding during the 1990s is explained by the inclusion in the calculations of budget authorities. Universities' R&D funds have increased in real terms by two per cent a year. Government research institutes, on the other hand, have seen an annual real decrease of around one per cent in their budget funds, and other government research funding has remained unchanged. For other funding it needs to be noted that when the State Real Property Agency became a state-owned enterprise in 1999, the funds recorded to other research organisation categories went up by some 35 million euros.

How R&D funding is channelled

Tekes and Academy of Finland funding is based on open competition. Applicants are to submit their plans and proposals for review by experts, and the best projects are then selected for funding on the basis of these evaluations. There is also increased competition for funding among the sites where the research is conducted, i.e. universities and research institutes. Special government aid to central university hospitals is based on an annual publishing points system.

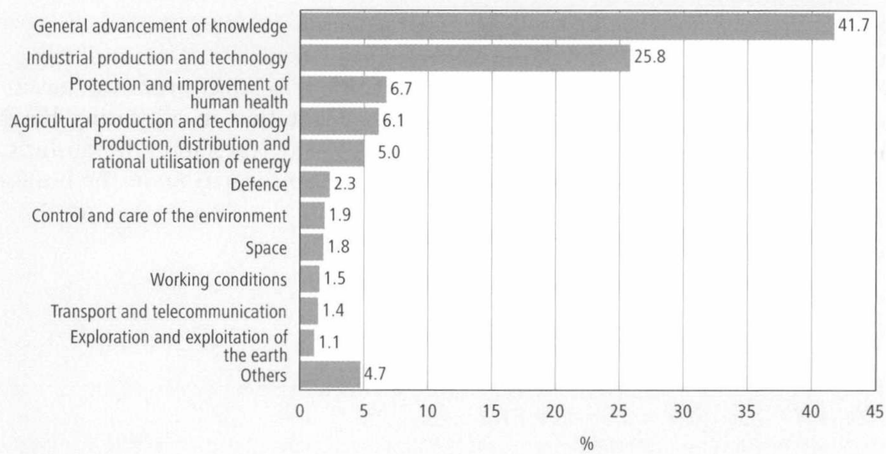
The drive towards competitive funding has gained increasing momentum since the mid-1990s. The two most important developments have been the growing share of Academy funding and the reduced share of research institutes' budget funds. During the government's supplementary funding programme, other ministry R&D funding, which includes non-earmarked ministry appropriations for R&D activities, showed a negative trend. In the past few years, however, there have been indications of a change in this respect.

The Science and Technology Policy Council of Finland takes the view that the concentrated allocation of R&D funding through the Academy of Finland and the National Technology Agency Tekes has helped to create a clear and efficient funding system.

Appropriations for the general advancement of knowledge have increased in the 2000s

When examined by the socio-economic objectives of research, the single most significant objective category is the general advancement of knowledge, which accounts for almost 42 per cent of all R&D funding (Figure 4.4). This includes Academy of Finland as well as university research funds in their entirety. Industrial production and technology accounts for 26 per cent. The figure for social structures and relationships is 16 per cent; the most significant subcategory here is the protection and improvement of human health, accounting for almost 7 per cent.

Figure 4.4
Breakdown of government R&D funding by objective in 2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D.



The single biggest objective category in the EU area in 2002 was general university funds. In Finland this category accounted for 27 per cent of all funding, whereas in the EU the corresponding share was 32 per cent. In the EU industrial production and technology accounted for no more than 10 per cent, whereas the share of defence was over 15 per cent. Countries investing heavily in defence research included the United Kingdom, Spain, France and Sweden. In Finland the corresponding proportion was around a couple of per cent.

In 2004 the sharpest increase was recorded for the general advancement of knowledge. Within this category the bulk of the total increase of 49 million euros was channelled via the Academy of Finland to the funding of science and research, although basic research carried out at universities also received a substantial increase. Part of the explanation for these changes lies in the fact that R&D funding for polytechnics was included in the figures for the first time in 2004. Funding for social structures and relationships increased by 16 million euros, which was mainly allocated to research on working conditions and the protection and improvement of human health.

Investment aimed at the development of industrial production and technology increased throughout the 1990s, but in recent years this trend has come to a halt. The same applies to research in the fields of energy, the exploration and exploitation of the earth as well as infrastructure and the general planning of land use. The protection and improvement of human health today accounts for twice as large a share as it did in 1991. This is explained by the R&D appropriations for central university hospitals almost tripling with the introduction of a separate item.

Apart from the general advancement of knowledge, other areas of growth in the early 2000s have included R&D in agriculture, forestry and fishing; defence research and to some extent research on cultural activities and international relations. However the volumes in the latter two categories are relatively modest. Investment in research on working conditions from 1991 to the present date has been something of a rollercoaster ride. However given the nature of these data there are some problems of interpretation in allocating R&D funding to the different subcategories under social structures and relationships.

Appendix Tables 4.1–4.3 provide more detailed information on the breakdown of government R&D appropriations by research organisation, administrative branch and socio-economic objectives in 1991–2004.

R&D funding of State research institutes

The research intensity of administrative branches can also be assessed by reference to the role of State research institutes in each branch's operation. At the Ministry of Agriculture and Forestry and the Ministry of Social Affairs and Health, almost 90 per cent of R&D funding goes to their research institutes. At the Ministry of Trade and Industry, which has by far the highest general research intensity, no more than 14 per cent of all R&D funding is allocated directly to research institutes. However this statistic is distorted by the fact that a

The aims and relevance of State research institutes

State research institutes in different administrative branches constitute an integral part of public administration. They have a key role to play in the development of society, and ever since Finnish membership of the European Union the range of their tasks has continued to expand. The research evidence produced by these institutes must have applicability to both national and European problems. Assessments by outside experts have rated the work of sectoral research institutes very highly, although some criticisms have been raised regarding their social relevance and impacts.

Research institutes in the public sector finance their operation in two ways. Most of the research and development work in government institutions is funded from budget appropriations. In addition, funding is obtained from outside sources, which may include both fees collected for services provided as well as funding from budget items other than those dedicated to the institute. The purpose and aim of increased external funding is to strengthen the quality and relevance of research and also to gain practical benefits from research. However the Science and Technology Policy Council of Finland takes the view that the core funding of research institutes as well as universities must be large enough and sufficiently strong in relation to other funding so that their scientific knowledge base can be reinforced independently of outside influence. Many institutes have no domestic competition and therefore they must work constantly on their own structural improvement and development. Among the key areas of development identified by the Science and Technology Policy Council are the strengthening of international cooperation as well as national horizontal cooperation between different administrative branches.

significant proportion of the external funding for VTT Technical Research Centre of Finland within this branch is channelled through the National Technology Agency Tekes. If this were taken into account, the share of funding to Ministry of Trade and Industry research institutes would rise to 20 per cent.

Funding for sectoral research highly concentrated

The government's programme for supplementary R&D funding in the latter half of the 1990s had only limited impact on the direct funding of State research institutes, and there were no major changes in terms of their public R&D funding in the early 2000s. In 2004, however, research institutes were granted an additional 14 million euros from the budgets of their respective administrative branches, and their spending amounted to almost 254 million euros. This marked a real growth of three per cent on the figure for 2003.

The three biggest institutes: VTT Technical Research Centre of Finland, Agrifood Research Finland and the Finnish Forest Research Institute, together account for more than one-half of budget R&D funds. When the share of these units in the field of technology and agriculture and forestry research is added to the funds going to the three major institutes under the Ministry of Social Affairs and Health – the National Public Health Institute, the National Research and Development Centre for Welfare and Health and the Finnish Institute of Occupational Health – their combined share of the total R&D funding for research institutes amounts to almost three-quarters.

In 2004 the biggest increase in funding will be recorded for the National Public Health Institute at almost six million euros, with real growth reaching 30 per cent, way ahead of the rest of the field. Funding for VTT Finland will increase by four million euros. The Finnish Forest Research Institute, the Geological Survey of Finland and Agrifood Research Finland will also have around one million euros more to spend on research. Four institutes will see some decrease in their R&D funding: the Radiation and Nuclear Safety Authority, the Finnish Institute of Occupational Health, the Finnish Game and Fisheries Research Institute and the Government Institute for Economic Research.

Research institutes must secure almost one-half of their funding from outside sources

The total research expenditure of sectoral research institutes in 2004 amounted to 470 million euros. Almost half or 46 per cent of this, a total of 217 million euros, came from outside sources. In contrast to budget funds, external funding decreased in 2004: the figure dropped by almost eight million euros on 2003. At the same time the share of external funding declined by three percentage points. Behind this decrease in external R&D funding was VTT Finland.

VTT Finland's total funding amounted to 213 million euros, 70 per cent of which came from outside sources. VTT Finland accounted for 68 per cent of total outside funding for research institutes. The only other organisation that received more than one-half of its research funding from external sources was the Finnish Environment Institute. Other institutes that rely to a significant

Table 4.2
R&D funding for government research institutes in 2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D in 2004.

Research institute	Budgetary funding	External funding		Total	Percentage share of external funding
		Total	of which EU funding		
	EUR million				%
National Research Institute of Legal Policy	1.2	0.2	–	1.4	14.8
Government Institute for Economic Research	3.7	1.0	0.4	4.7	21.4
Research Institute for the Languages of Finland	4.7	0.4	–	5.1	7.9
National Board of Antiquities	2.2	0.4	–	2.6	16.2
Finnish Geodetic Institute	3.1	0.6	0.2	3.7	15.5
Finnish Game and Fisheries Research Institute	9.1	2.5	0.5	11.6	21.5
Agrifood Research Finland	31.4	16.4	1.0	47.8	34.3
Finnish Forest Research Institute	38.0	4.2	0.9	42.2	10.0
National Veterinary and Food Research Institute	4.0	0.6	0.1	4.6	13.6
Finnish Institute of Marine Research	4.2	0.8	0.5	5.0	15.8
Finnish Meteorological Institute	6.8	3.2	0.5	10.0	31.7
National Consumer Research Centre	1.8	1.0	0.0	2.8	34.1
VTT Technical Research Centre of Finland	64.5	148.1	17.0	212.6	69.7
Geological Survey of Finland	8.7	1.2	0.8	9.9	12.6
National Research and Development Centre for Welfare and Health	14.4	4.5	0.8	18.8	23.6
Finnish Institute of Occupational Health	13.7	7.6	2.0	21.3	35.7
National Public Health Institute	23.0	10.0	2.7	33.0	30.3
Radiation and Nuclear Safety Authority	6.1	0.7	0.3	6.8	10.8
Finnish Environment Institute	9.4	10.3	1.1	19.7	52.2
Regional Environment Centres	3.6	3.0	0.8	6.6	45.4
Total	**253.6**	**216.7**	**29.6**	**470.3**	**46.1**

extent on external funding include the Finnish Institute of Occupational Health, Agrifood Research Finland and the National Public Health Institute.

R&D funding from the EU in 2004 was estimated at almost 30 million euros, up by almost five million euros on the figure for the previous year. VTT Finland's share of the total was almost 17 million euros, i.e. 57 per cent.

Business venture capital

New and developing innovative companies need a business environment which provides access to new technology, know-how and advice and effective capital investment markets. Sufficient self-financing is a basic precondition for all business and innovation, but start-up companies also require funding from outside sources.

Venture capital investment refers to medium-range or long-term funding made available to a fast-growing unlisted company in exchange for a share of equity in the business. In Finland venture capital investments are made by venture capital businesses as well as 'business angels', i.e. private individuals who invest relatively small sums in new start-up companies. Company establishment, growth and internationalisation is supported not only by private venture capital businesses, but also by actors in the public sector. Access to venture capital is crucial to business innovation and the growth of productivity.

Private venture capital investments grew very rapidly in Finland in the 1990s with the development of the financing system more generally. VC investment played a decisive role in the growth of the Finnish ICT sector. The financing system in Finland seems satisfactory: both public venture capital and private capital investments reach start-up companies reasonably well.

Venture capital investments provide funding for the seed, start-up and expansion stages of the company life-cycle. Funding for these early phases can be divided into the following categories:

Seed financing refers to the often relatively small amount of capital that is used to establish a new company. The funds are used for purposes of research, product development and the initial organisation of the company before the actual start-up of business operations.

Seed consortia are part of the funding services provided by the Finnish National Fund for Research and Development Sitra to start-up companies. They can grant equity loans that will help these companies advance from product development to commercialisation, which in turn will make it easier for them to take advantage of other funding instruments. Seed consortia are funded by Sitra, local banks, banking groups' venture capital units and regional venture capital funds.

The PreSeed service, which is jointly funded by Sitra and the National Technology Agency Tekes, accelerates the establishment of new technological businesses, secures their capital supply and supports the presentation of the business to other prospective investors. Its aim is to advance the commercialisation of technology projects and to smooth their path to the business capital markets proper. Markets are surveyed, the future competitive situation analysed and commercial success factors identified in order to bolster the credibility of the target companies' business plans. Along with the investments, business know-how and expertise is also injected into the start-up companies. For technology-oriented businesses in search of initial funding, a secure marketplace is created that is not governed by fluctuations in the capital markets proper. The number of business angels has increased with the PreSeed funding programme: at year-end 2003 the number of these private investors in start-up companies was 220 compared to around one hundred one year previously. It is expected that during 2004, the figure will rise further to 300. This group has rapidly grown into a significant force indeed: it currently represents an investment capacity of over 20 million euros.

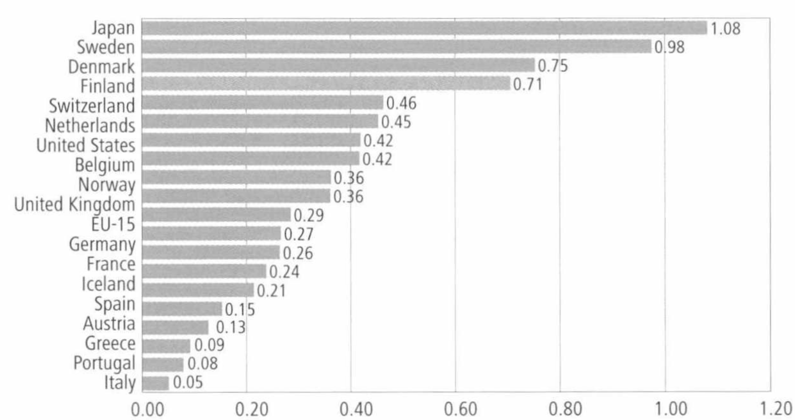
Businesses in the start-up stage require funding for product development and test marketing. ***Start-up financing*** is usually offered to companies that have recently been organised or that have been in business for a short while, but that have not yet commercialised their products. These companies will already have a business plan and will have researched the markets.

First-stage financing during the early of stages of growth provides support for companies that have expended their initial capital and that have succeeded in their product development. It is designed to help them proceed to commercial production and sales.

Venture capital investments in Finland have tended to concentrate on the early stages of business development. In 2004 seed and start-up financing accounted for over 34 per cent of all capital investments, while the figure in the EU was less than 29 per cent and in the United States 25 per cent1. In Finland the seed stage alone accounted for almost seven per cent, while in most other countries the corresponding proportion was no more than a few per cent. Funding at the expansion phase was high, at around 90 per cent, in Italy and Spain, for instance. In 2002 capital investments at the seed and start-up stages as a proportion of GDP was the highest in Japan at 1.08 per mille. The corresponding statistics for the United States and the EU were much lower, i.e. 0.42 and 0.29. In Finland (as well as in Sweden and Denmark) the share (0.71 ‰) was clearly higher than in Europe on average (Figure 4.5).

Know-how intensive business that is dependent on external funding and start-up companies are susceptible to fluctuations in the capital markets. Public technology funding can play an important role in ironing out the effects of such short-term fluctuations. In Finland public capital investment schemes are mainly focused on funding the critical early stages of commercialising know-how acquired in research. Public funding has an important role to play in patching up the shortcomings of the financial markets at the seed, start-up and growth phases. Private investment in seed-stage companies has decreased appreciably in recent years, and therefore this critical stage of funding has been left to public funding bodies. So far, however, the volume of public venture capital funding for Finnish businesses has been low in comparison with the investments made by the companies themselves.

Figure 4.5
Venture capital investments at the seed and start-up stages as a proportion of GDP (‰) in selected countries in 2002.
Source: European Commission, Key Figures 2003–2004.



1 European Commission (2003b)

Major state-owned enterprises committed to business development and funding and other organisations sharing the same goals include the Finnish National Fund for Research and Development Sitra, the National Technology Agency Tekes, Finnish Industry Investment Ltd, Finnvera plc, Finpro and Employment and Economic Development Centres, all of which work closely with each other. The former three in particular are major providers of venture capital.

The Finnish National Fund for Research and Development **Sitra** provides funding for start-up technology companies and growth businesses as well as for purposes of commercialising innovations. The National Technology Agency **Tekes** supports new technology companies by granting capital loans for establishing the business. Tekes and Sitra also have joint funding schemes for the development of business ideas. Because of the current market situation the emphasis in Tekes' capital investments has shifted increasingly in the direction of follow-up investments. The state-owned **Finnish Industry Investment plc** makes investments in capital funds and directly in target companies with a view to promoting the productisation and commercialisation of new innovations. It also committed to developing regional capital investment activities and steering the allocation of venture capital funds from EU sources to funds and target companies.

Finnvera plc, another state-owned company, offers special financing services on a regional basis and also channels EU funding to the SME sector in Finland. In its capacity as provider of venture capital, Finnvera complements the markets. **Employment and Economic Development Centres** may also provide funding for development and investment projects in the business sector. They offer guidance in questions related to funding through EU programmes and make decisions on EU funding. **Finpro** is an expert and service organisation owned by Finnish companies: its mission is to promote the internationalisation of Finnish business and to reduce the risks that this involves.

Sources: Finnish Venture Capital Association www.fvca.fi
Finnish National Fund for Research and Development Sitra www.sitra.fi
National Technology Agency Tekes www.tekes.fi

Appendix Table 4.1
Government R&D funding by research organisation in 1991–2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D.

Research organisation	EUR million					%				
	1991	1995	1999	2003	2004	1991	1995	1999	2003	2004
Universities	226.2	245.0	323.3	393.3	407.9	28.3	26.3	25.3	27.2	26.5
University central hospitals	–	–	60.5	48.7	48.7	–	–	4.7	3.4	3.2
Academy of Finland	75.5	77.2	155.5	188.6	214.6	9.4	8.3	12.2	13.0	13.9
National Technology Agency Tekes	156.6	263.0	410.8	407.2	432.4	19.6	28.3	32.2	28.2	28.1
Statet research institutes	209.9	199.0	208.0	239.5	253.6	26.2	21.4	16.3	16.6	16.5
Other R&D funding	131.5	146.2	117.0	168.3	181.1	16.4	15.7	9.2	11.6	11.8
Total	**799.7**	**930.4**	**1,275.2**	**1,445.7**	**1,538.3**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Funding of the National Technology Agency includes budget authorities and appropriations from 1993 onwards and funding for the Academy of Finland from 1997 onwards.
1991–2003: State budget + supplementary budgets, 2004: State budget

Appendix Table 4.2
Government R&D appropriations by administrative branch in 1991–2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D.

Administrative branch	EUR million					%				
	1991	1995	1999	2003	2004[1]	1991	1995	1999	2003	2004
Ministry for Foreign Affairs	14.6	11.6	7.5	10.1	12.3	1.8	1.2	0.6	0.7	0.8
Ministry of Justice	0.7	1.0	1.0	1.2	1.6	0.1	0.1	0.1	0.1	0.1
Ministry of the Interior	1.7	1.5	5.4	9.4	12.9	0.2	0.2	0.4	0.7	0.8
Ministry of Defence	11.4	19.4	18.2	41.5	35.0	1.4	2.1	1.4	2.9	2.3
Ministry of Finance	5.0	12.0	6.6	7.7	9.6	0.6	1.3	0.5	0.5	0.6
Ministry of Education	318.9	346.3	494.4	602.8	648.1	39.9	37.2	38.8	41.7	42.1
Ministry of Agriculture and Forestry	80.5	76.1	75.3	92.4	99.1	10.1	8.2	5.9	6.4	6.4
Ministry of Transport and Communications	28.7	30.7	30.4	29.4	28.6	3.6	3.3	2.4	2.0	1.9
Ministry of Trade and Industry	257.9	352.0	490.1	497.7	529.4	32.3	37.8	38.4	34.4	34.4
Ministry of Social Affairs and Health	54.3	57.8	114.4	117.9	122.6	6.8	6.2	9.0	8.2	8.0
Ministry of Labour	1.5	1.9	6.0	11.2	14.0	0.2	0.2	0.5	0.8	0.9
Ministry of the Environment	24.2	20.0	25.7	24.1	25.1	3.0	2.1	2.0	1.7	1.6
Prime Minister's Office	0.3	0.3	0.3	0.3	–	0.0	0.0	0.0	0.0	–
Total	**799.7**	**930.4**	**1,275.2**	**1,445.7**	**1,538.3**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

1 Project funding for research and development at polytechnics (worth 6.9 million euros) included for the first time in the administrative branch under the Ministry of Education
1991–2003: State budget + supplementary budgets, 2004: State budget

Appendix Table 4.3
Government R&D appropriations by socio-economic objective in 1991–2004.
Source: Statistics Finland, Government budget appropriations or outlays for R&D.

Objective	EUR million					%				
	1991	1995	1999	2003	2004	1991	1995	1999	2003	2004
Agricultural production and technology	71.1	66.4	72.8	88.5	94.1	8.9	7.1	5.7	6.1	6.1
Industrial production and technology	194.7	294.9	356.6	384.7	397.3	24.3	31.7	28.0	26.6	25.8
Production, distribution and rational utilisation of energy	29.1	32.8	79.3	63.5	77.2	3.6	3.5	6.2	4.4	5.0
Defence	11.4	19.4	17.5	41.6	35.1	1.4	2.1	1.4	2.9	2.3
Exploration and exploitation of the Earth	14.8	11.3	21.4	14.9	16.3	1.8	1.2	1.7	1.0	1.1
Social structures and relationships	144.0	147.8	213.0	233.4	249.7	18.0	15.9	16.7	16.1	16.2
Transport and telecommunication	24.2	27.5	17.4	24.5	21.9	3.0	3.0	1.4	1.7	1.4
Infrastructure and general planning of land-use	4.2	4.8	13.1	4.4	6.3	0.5	0.5	1.0	0.3	0.4
Control and care of the environment	25.7	23.7	28.0	28.4	29.8	3.2	2.5	2.2	2.0	1.9
Working conditions	13.9	14.2	17.1	14.9	22.4	1.7	1.5	1.3	1.0	1.5
Protection and improvement of human health	30.4	32.8	89.1	96.5	102.3	3.8	3.5	7.0	6.7	6.7
Social security systems	12.7	14.0	12.8	11.0	6.5	1.6	1.5	1.0	0.8	0.4
Education	1.3	1.9	1.6	1.9	1.7	0.2	0.2	0.1	0.1	0.1
Cultural activities	7.4	7.6	10.1	16.1	14.7	0.9	0.8	0.8	1.1	1.0
International relationships	10.7	7.2	8.7	9.3	11.5	1.3	0.8	0.7	0.6	0.7
Other social objectives	13.4	14.1	15.0	26.5	32.6	1.7	1.5	1.2	1.8	2.1
General advancement of knowledge	310.2	337.5	482.0	591.6	641.1	38.8	36.3	37.8	40.9	41.7
General university funds (GUF)	226.3	245.0	323.3	393.3	407.9	28.3	26.3	25.3	27.2	26.5
Non-oriented research	84.0	92.6	158.7	198.3	233.2	10.5	9.9	12.4	13.7	15.2
Exploration and exploitation of space	24.4	20.5	32.6	27.5	27.5	3.1	2.2	2.6	1.9	1.8
Total	**799.7**	**930.4**	**1,275.2**	**1,445.7**	**1,538.3**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

1991–2003: State budget + supplementary budgets, 2004: State budget

5 R&D expenditure

Science and technology rest upon the foundation of research and the systematic development of new methods, products and applications, or research and development (R&D). R&D comprises both the basic academic research that is done at universities and the product development work that is done at business enterprises. In other words, it may involve either the search for new scientific information, a development effort driven by social and political objectives, or a market-driven for quest for profits. Given the inherent complexity and diversity of the phenomenon, it is impossible unambiguously to measure the value or output of R&D, either in economic or other terms. Therefore the basic indicator traditionally used in statistics is the extent of R&D activities, i.e. the resources invested in R&D.

Statistics based on harmonised methods have been compiled in the OECD countries since the 1960s. In Finland the first comprehensive statistical dataset was published for 1971. An adequate level of investment in R&D is considered crucial to the nation's level of civilisation, its welfare and economic competitiveness. University research and education provide a foundation for know-how that is based on the latest scientific knowledge, while product development in the business sector yields competitive, high value added products. International comparisons have indeed shown that most advanced economies have strong research sectors. However it is important to note that R&D expenditure is an indicator of the extent of these activities and that no direct association can be shown between expenditure and (economic or other) output.

Whereas in Chapter 3 the focus was on human resources in R&D, the discussion here is on expenditures of R&D. Expenditure and R&D personnel numbers are obviously closely connected to each other because traditionally, wage and salary expenses have accounted for over one-half of total expenditure. An assessment of the extent of R&D activities in money terms provides the necessary foundation for determining the relative economic weight and significance of these activities. The level of expenditure depends, on the one hand, on the measures taken by the public authorities, for instance on the volume of core funding allocated in the budget to universities or the amount of R&D subsidies granted to enterprises (see the section on government R&D funding in Chapter 4). As far as business enterprises are concerned R&D expenditure represents an investment in the maintenance and development of their real competitiveness based on know-how. Seen as an investment on which a return is expected, the level of business R&D expenditure depends on expectations of the how the know-how produced will generate value added in the products and services brought to the marketplace.

We begin with a review of the development of R&D expenditure in Finland at the level of the national economy and in an international comparison. The subsequent chapters look more closely at R&D activities in universities, in the government sector [1] and in business enterprises. Since there have been signifi-

1 The government sector includes private non-profit institutions.

R&D in statistics

Research and development (research and product development) comprises the production of knowledge in academic basic research through to concrete, market-driven product development. Based on guidelines issued by the OECD[1] research and development (R&D) is here understood as referring to creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications. The key criterion is that this activity is aimed at something essentially new. Research and development is defined as comprising basic research, applied research as well as experimental development:

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

Experimental development is systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

Expenditure is defined as comprising all costs arising from R&D activities, wages and salaries, other operating costs and investments. It includes R&D carried out in Finland, i.e. work done in the foreign units of Finnish enterprises, for instance, is excluded. On the other hand EU funded research carried out in Finland is included.

1 OECD (2002c)

cant changes on the Finnish R&D scene since the early 1990s, most of the time series describe the period from 1991 to 2002. More detailed analyses are presented for recent trends mainly from 1995 onwards. International comparisons are mainly among the EU-15 and OECD countries.

5.1 International comparisons

R&D expenditure as a proportion of GDP describes the relative weight of research and product development in national economies. International comparisons of this kind require some caution, however. Firstly, national R&D intensity is affected by the structure of business and industry in each country. Industries with a high R&D intensity include pharmaceuticals and electronics. Furthermore, the very definition of R&D emphasises industrial manufacturing, which lowers the intensity of service-oriented economies. Secondly, as was pointed out above, a high level of R&D intensity does not correlate directly with national economic success or competitiveness. Thirdly, it is necessary to bear in mind that major international corporations can have a very dominant role particularly in smaller national economies. And fourthly, modern military industry is typically an R&D intensive business and therefore investment in this industry will drive up the R&D intensity of this country.

Finland among the leading R&D investors, the EU is lagging behind the competitors

In 2002 total R&D expenditure as a proportion of GDP in the EU-15 area was just short of 2 per cent. When the new members that joined in 2004 are included, the figure is 1.8 per cent. By far the highest proportion is observed for Sweden at 4.3 per cent. Finland, too, is well above the EU average at 3.5 per cent. Among the big EU members Germany's share is 2.5 per cent, whereas Italy and Spain are pulling down the EU average: in both these countries R&D expenditure as a proportion of GDP is no more than around one per cent (Figure 5.1.1).

In the new EU members that joined in 2004, R&D expenditure as a proportion of GDP is generally lower than in the old member states (EU-15). Slovenia ranks 11th in a comparison where both new and old members are included, but Poland and Slovakia, for instance, recorded a figure of just 0.6 per cent in 2002.

The EU has much to improve compared to the United States and Japan

In 2002 Japan spent 3.1 per cent and the United States 2.6 per cent of GDP on R&D – both well above the combined EU-15 R&D intensity of 1.9 per cent of GDP.

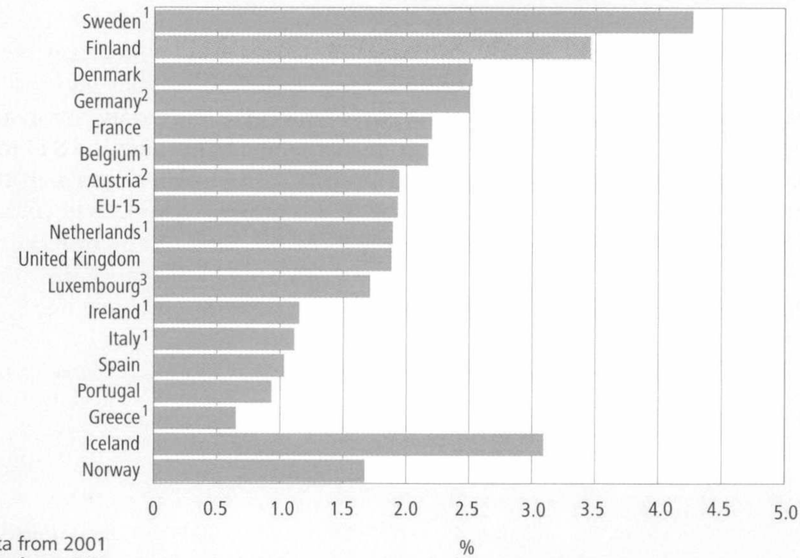
Not only the structural indicator of intensity but also the volume of R&D underlines the technological supremacy of these leading economic powers. In 2002 total R&D spending in the EU-15 area amounted to 191.5 billion US dollars. However, this is no more than 69 per cent of the R&D expenditure in the United States.[1] The new member states help to narrow down the gap to some extent: the R&D expenditure for the EU-25 area was 70 per cent of the corresponding US figure in 2002. Although Japan's R&D intensity is the highest of the three, the volume of its R&D expenditure is no more than 39 per cent of the figure in the United States

There is a recognised need in the European Union to step up the community's research efforts and to strengthen its technological competitiveness. In 2002 the Barcelona European Council set the target of increasing R&D expenditure in the EU area to three per cent of GDP by 2010, with the added proviso that two-thirds of this should come from the private sector. In Finland these targets were in fact met by the turn of the millennium.

Determined to strengthen the public research base in Europe and to narrow the lead held by its rivals, the European Commission has drawn up an action plan[2] which comprises four main sets of actions. The first of these highlights the need for consistent policy measures that support general coordination and the attainment of the objectives set out. The second set of actions aims at improving the R&D infrastructure and other structural factors: examples include the availability of competent researchers, legislative measures and the coordination of different funding schemes. The third set of actions addresses the need to secure a sufficient level of public funding for research, while the fourth aims at improving the environment for private R&D investment in Europe. Examples here include the creation of a community patent system and the development of an intellectual property rights and product standardisation system.

1 Calculated on the basis of purchasing power parity. Source: OECD (2004b).
2 COM 2003 226 final/2.

Figure 5.1.1
R&D expenditure as a proportion of GDP in 2002: EU-15, Iceland and Norway. Source: OECD, Main Science and Technology Indicators 2004/1.



1 Data from 2001
2 Data from 2003
3 Data from 2000

The above-mentioned structural factors impacting the GDP share indicator are clearly evident in a comparison of the Nordic countries. In Finland and Sweden major global corporations operating in R&D intensive industries occupy a prominent position, and GDP shares of R&D expenditure are accordingly among the highest in the world. In Norway R&D expenditure as a proportion of GDP is lower than in Finland and Sweden, but its national economic wealth is greater than either Finland's or Sweden's.[2] The importance of the oil industry in the Norwegian economy is well known. Oil refining, as indeed other forms of energy production, is in turn characteristically a low R&D intensity industry.

By far the highest level of R&D intensity is recorded for Israel, where R&D expenditure accounted for no less than 4.7 per cent of GDP in 2002. According to data compiled by the OECD, China spent 1.2 per cent of its GDP on research and product development in 2002, which is almost exactly the same figure as in Russia (see Appendix Table 5.1 for further comparative data on the OECD countries).

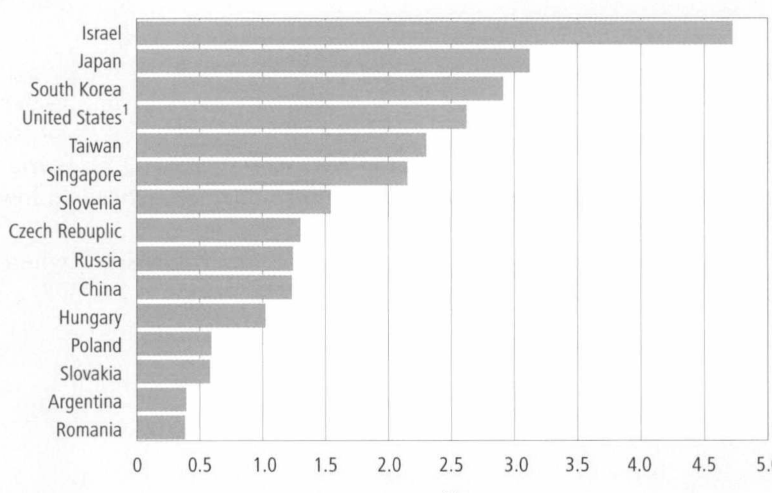
2 In 2001, for instance, purchasing power adjusted GDP per capita was at practically the same level in Finland and Sweden. If this level is indexed at 100, the figure for Norway is 122. Source: Statistics Finland (2003b).

Emerging Asian economies are investing in R&D

Many of Asia's emerging economies are beginning to overtake traditional industrial countries in terms of their R&D investment. A good example is South Korea, where R&D spending as a proportion of GDP climbed to almost three per cent in 2002. In an EU comparison this would be enough to earn the country third place after Sweden and Finland. Its GDP share has grown very rapidly indeed: in 1991 the figure still stood at 1.9 per cent. In volume terms South Korea's R&D investment exceeds the figures for Canada and Italy, for instance; on the other hand the figure is just over 40 per cent of Germany's R&D investment. As in Finland, the electronics and electrotechnical industries in Korea account for a rather large proportion of business sector R&D: the figure in 2002 was 46 per cent. In general industrial manufacturing is clearly the main engine of R&D, the share of service industries was around nine per cent. The R&D intensity in Taiwan and Singapore is also above the EU average (Figure 5.1.2).

Finland emerged as the EU's second most research intensive economy in the 1990s, primarily towards the end of the decade. In 1991 Finland's R&D expenditure as a proportion of GDP was still around the EU average at two per cent, but ten years later the figure was 3.4 per cent, or 1.8 times higher than the EU average. On the other hand it is clear that Finland cannot account for a very large share of EU research activities as a whole; in 2001 the figure was 2.6 per cent[3] of the total volume of EU R&D activities. Like Finland, Swe-

Figure 5. 1.2
R&D expenditure as a proportion of GDP in selected countries in 2002.
Source: OECD, Main Science and Technology Indicators 2004/1.



1 Data from 2003

3 Calculated in euros (nominal prices). Source: Eurostat (2004a).

Figure 5.1.3
R&D expenditure as a proportion of GDP in 1991-2002: EU-15, United States, Japan and China.
Source: OECD, Main Science and Technology Indicators 2004/1.

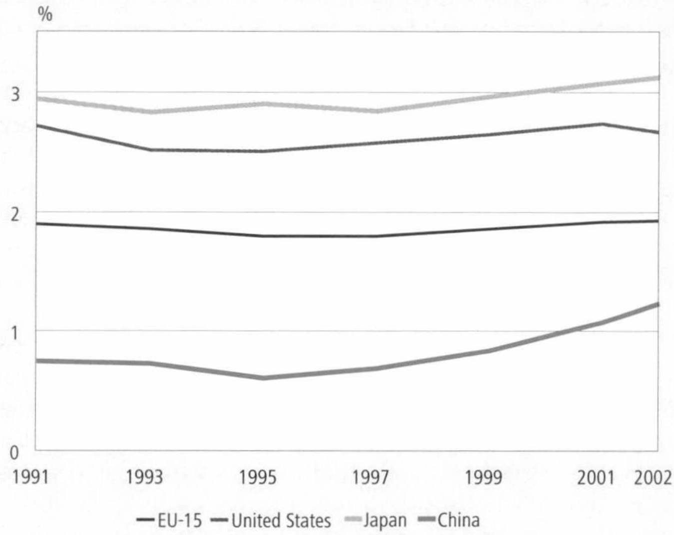
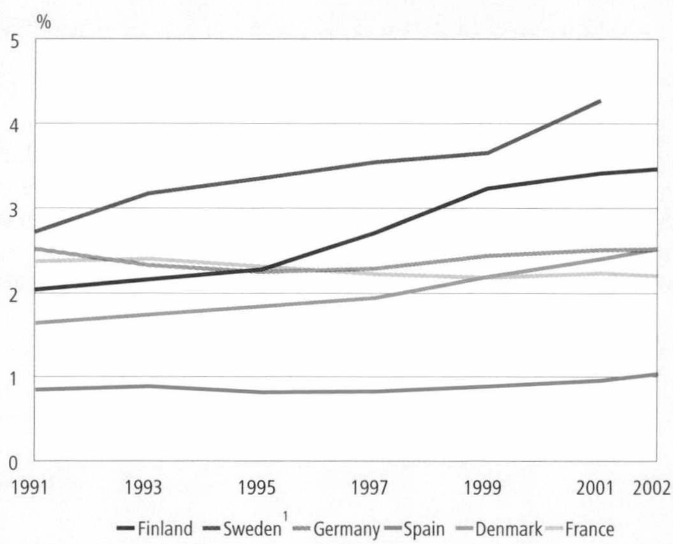


Figure 5.1.4
R&D expenditure as a proportion of GDP in 1991–2002 in selected EU countries.
Source: OECD, Main Science and Technology Indicators 2004/1.



1 Data from 2001

den has seen relatively rapid growth in its R&D expenditure. In the late 1990s Finland almost reached Sweden's level of R&D intensity, but since then it seems that the gap has begun to widen again in favour of Sweden. In volume terms Finland's R&D investment in 2001 was 44 per cent of the corresponding volume in Sweden. Overall the R&D intensity in the EU-15 area has remained virtually unchanged, and there has been little progress in closing the gap to the United States and Japan (Figure 5.1.3). There has been hardly any improvement in the R&D intensity of the biggest EU economies, and in Germany, for instance, the current figure of 2.5 per cent is lower than before reunification when it peaked at 2.8 per cent. R&D intensity has also decreased rather than increased in France and the United Kingdom. In Italy and Spain, the two major EU countries with a low R&D intensity to start with, investment in R&D has not increased to any significant extent either (the trend for Spain is shown in Figure 5.1.4). In spite of its declared goal of closing to the gap to Japan and the United States, the EU looks set to fall even further behind following the membership in 2004 of the post-transitional economies that have a low level of R&D intensity. The rapid changes in the Chinese economy have also spilled over into R&D activities, which seem to have increased as a proportion of GDP since the early 2000s (Figure 5.1.3). In volume terms China's R&D expenditure was just over one-third of the level for the EU-25 countries.

5.2 R&D expenditure in Finland: general trends

Major shift in sectoral breakdown

R&D expenditure increased much faster in Finland than the rest of the economy in 1991–2003, i.e. 2.3-fold in real value.[4] At the same time there has been a major shift in the breakdown of R&D activities by sector: as a result of strong growth in the private business sector, the public/private ratio in R&D has widened from 40/60 per cent to 30/70 per cent. The most prominent trend has been the halving of the share of the government sector (i.e. mainly sectoral government research institutes) from 20 per cent to close to 10 per cent of total expenditure (Table 5.2.1). The share of the higher education sector has decreased by three percentage points. It is important to note, though, that during the period under review this sector has expanded to comprise research spending at central university hospitals and polytechnics. Without these additions the figure for the sector (i.e. universities alone) in 2002 would be 16.3 per cent, or around five percentage points lower than in 1991.

4 R&D expenditure deflated by GDP market price index.

Table 5.2.1
R&D expenditure by sector and as a proportion of GDP in 1991–2003.
Source: Statistics Finland, Research and Development.

Year	Business enterprises		Public sector		Higher education sector[2]		Total	Real growth of expenditure[3]	R&D expenditure as % of GDP[4]
	EUR million	%	EUR million	%	EUR million	%	EUR million	1991=100	%
1991	975.1	57.0	357.5	20.9	378.0	22.1	1,710.6	100	2.0
1993	1,048.5	58.4	379.7	21.1	367.5	20.5	1,795.8	101	2.2
1995	1,373.4	63.2	374.4	17.2	424.6	19.6	2,172.4	114	2.3
1997	1,916.7	66.0	408.6	14.1	579.5	20.0	2,904.9	150	2.7
1998	2,252.8	67.2	443.9	13.2	657.8	19.6	3,354.5	168	2.9
1999	2,643.9	68.2	470.1	12.1	764.8	19.7	3,878.8	194	3.2
2000	3,135.9	70.9	497.4	11.2	789.3	17.8	4,422.6	215	3.4
2001	3,284.0	71.1	500.9	10.8	834.1	18.1	4,619.0	218	3.4
2002	3,375.1	69.9	529.7	11.0	925.6	19.2	4,830.3	226	3.5
2003[1]	3,527.9	70.5	515.4	10.3	963.8	19.2	5,007.1	234	3.5

1 Figure for university sector is an estimate
2 Central university hospitals from 1997 onwards, polytechnics from 1999 onwards
3 Deflated by GDP price index
4 GDP for 2002 and 2003 based on Statistics Finland's preliminary data

Growth tapered off in the 2000s

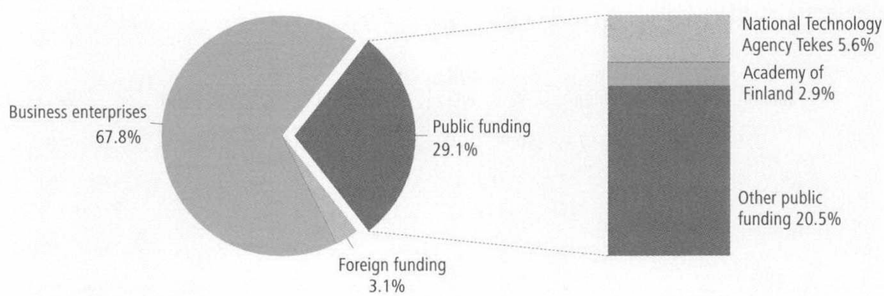
The latest data available indicate that the strong growth of R&D expenditure that was sustained throughout the 1990s has now come to a virtual standstill. During the period from 1995 to 2000, average annual real growth was as high as 13 per cent. The change at the turn of the 2000s has been quite dramatic: in 2000–2002 the growth rate has dropped to around 2.5 per cent a year. As a consequence R&D expenditure as a proportion of GDP has remained at the level of around minkä lisäksi arvio vuodelle 2003 ennakoi t&k-menoille käytännössä nollakasvua. 3.4–3.5 per cent. In 2003 it seems that the figure will be 3.5 per cent and R&D expenditure about 5 billion euros.[5] It also seems that the structural shift has stopped at the 30/70 per cent ratio in favour of the private business sector.

Public R&D funding in Finland at a comparatively low level

In 2002 a total of just over 4.8 billion euros was spent on R&D in Finland. The business sector accounted for 68 per cent, the public sector for 29 per cent and foreign sources for 3 per cent (Figure 5.2.1). The National Technology Agency Tekes accounted for 5.6 per cent of research financing and the Academy of Finland for almost three per cent; their combined contribution was almost 30 per cent of all public funding for R&D. The single biggest category of public

5 The figure for the higher education sector in 2003 is an estimate; therefore the same applies to the overall situation in 2003.

Figure 5.2.1
Funding of R&D expenditure in 2002.
Source: Statistics Finland, Research and Development..



research funding is represented by core budget funding for universities (general university funds, GUF).[6]

Table 5.2.2 provides a more detailed analysis of actual flows of funding for R&D. As we have seen, business enterprises spend 70 per cent of total R&D expenditure and account for 68 per cent of R&D funding. The university sector does not finance research by other organisations, its own funding (413 million euros) consists of dedicated appropriations from the state budget and universities' own funds. When these are added to other public sector R&D funding, the total figure for public research funding in 2002 amounts to 1.4 billion euros, or some 29 per cent of R&D expenditure. R&D projects undertaken by government research institutes and universities on commission from business enterprises carry a total value of 130 million euros. The remaining three per cent of R&D expenditure is funded from foreign sources, such as the EU and foreign companies. From a national point of view this may be interpreted as R&D exports, but no figures are available on corresponding imports (i.e. R&D funded by Finnish sources abroad) because the statistics only cover R&D activities in Finland.[7]

One of the consequences of the sharp increase in the share of the private business sector is that in an international comparison, public funding accounts for a comparatively small proportion of R&D expenditure in Finland. According to OECD data for 2002,[8] the figure for Finland was 26 per cent, which is somewhat lower than the OECD average of 30 per cent, but considerably lower than the EU

6 The data presented here for research funding refer to actual spending on R&D as distinct from appropriations allocated to R&D (see Chapter 4).

7 R&D carried out and funded by multinational corporations operating in Finland is counted as work funded by the Finnish unit even if the funding comes from foreign units.

8 In OECD statistics public R&D funding does not include R&D loans granted by public organisations. In national statistics, by contrast, these loans are counted as public funding.

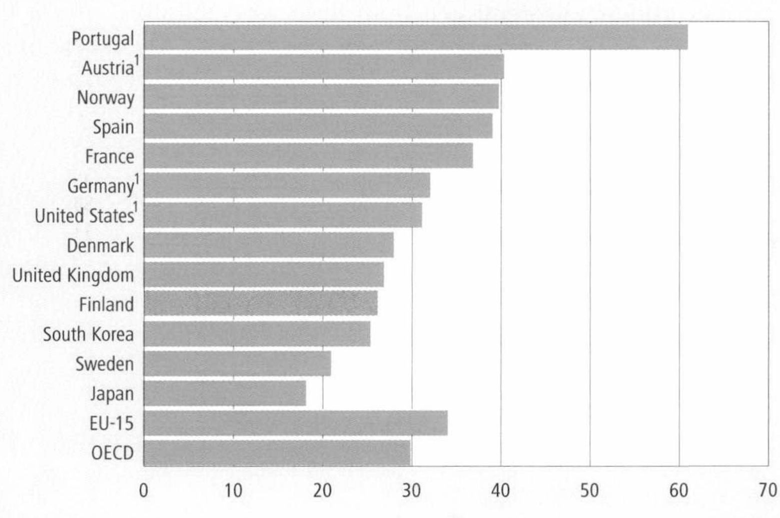
Table 5.2.2
R&D expenditure by sector of performance and source of funding in 2002. Source: Statistics Finland, Research and Development.

Sector of performance	Source of funding: Business sector, EUR million	%	Public sector, EUR million	%	University sector, EUR million	%	Foreign funding[1], EUR million	%	Total, EUR million	%
Business sector	3,147.2	93.2	193.8	5.7	–	–	34.1	1.0	3,375.1	100.0
Public sector	72.4	13.7	414.3	78.2	–	–	42.9	8.1	529.7	100.0
University sector	57.0	6.2	380.4	41.1	413.2	44.6	74.9	8.1	925.6	100.0
Total	**3,276.7**	**67.8**	**988.5**	**20.5**	**413.2**	**8.6**	**151.9**	**3.1**	**4,830.3**	**100.0**

1 Funding reported as received from foreign group units is classified as own funding, which reduces the share of foreign funding.

average of 34 per cent. Among the Nordic countries the figures in Denmark come quite close to those recorded in Finland, in Sweden they are lower, but in Norway noticeably higher or 40 per cent. All in all the volume of public funding as a proportion of total R&D expenditure varies quite widely: in Portugal and Poland the share is around 60 per cent, in the United States and Germany just over 30 per cent and in Japan 18 per cent (Figure 5.2.2 and Appendix Table 5.1).

Figure 5.2.2
Public funding as a proportion of R&D expenditure in selected countries in 2002. Source: OECD, Main Science and Technology Indicators 2004/1.



1 Data from 2003

Three sub-regional units account for more than two-thirds of R&D expenditure

The sub-regional unit of Helsinki accounts for 44 per cent of R&D expenditure in Finland; the next highest figures are recorded for Tampere (13 per cent) and Oulu (11 per cent). All these three sub-regional units have major universities, and they are also characterised by a high level of business investment in R&D: enterprises here account for 67–76 per cent of regional R&D expenditure. In the sub-regional units of Kuopio and Joensuu, by contrast, research relies more heavily on the contributions of the public sector, primarily the local universities.

The region of Uusimaa accounts for practically the same share of R&D expenditure as the sub-regional unit of Helsinki, around 44 per cent (Table 5.2.4). The regions of Pirkanmaa, North Ostrobothnia and Varsinais-Suomi form the next cluster, each accounting for 11–13 per cent of R&D expenditure. The figure for North Ostrobothnia is almost the same as for the sub-regional unit of Oulu, and the figure for Pirkanmaa refers to the Tampere sub-regional unit. Varsinais-Suomi, on the other hand, is divided between Turku and Salo. In all other regions the figure is less than four per cent. Research is most heavily concentrated in the government sector, where research institutes based in Uusimaa account for almost two-thirds of total R&D expenditure. In the

Table 5.2.3
R&D activities by R&D expenditure in the biggest sub-regional units in 2002.
Source: Statistics Finland, Research and Development.

	R&D expenditure total	Share of R&D expenditure	Enterprises' share
	EUR million	%	%
Whole country	4,830.3	100.0	70
Helsinki	2,112.3	43.7	67
Tampere	619.9	12.8	73
Oulu	528.9	11.0	76
Turku	354.5	7.3	61
Salo	234.9	4.9	100
Jyväskylä	158.8	3.3	54
Kuopio	98.1	2.0	33
Vaasa	72.1	1.5	86
Joensuu	48.9	1.0	31
Pori	44.9	0.9	89
Porvoo	44.8	0.9	99
Lappeenranta	41.0	0.8	42
Lahti	38.4	0.8	92
Kotka-Hamina	31.8	0.7	96
Forssa	26.4	0.5	18
Hämeenlinna	23.0	0.5	83
Rovaniemi	21.7	0.4	20
Others	329.9	7.0	–

Table 5.2.4
R&D expenditure by sector and region in 2002.
Source: Statistics Finland, Research and Development.

Region (NUTS3)[1]	Total		Business sector		Public sector		University sector	
	EUR million	%	EUR million	%	EUR million	%	EUR million	%
Whole country	**4,830.3**	**100.0**	**3,375.1**	**100.0**	**529.7**	**100.0**	**925.6**	**100.0**
Uusimaa	2,133.3	44.2	1,437.3	42.6	340.7	64.3	355.3	38.4
Itä-Uusimaa	45.9	0.9	45.5	1.3	0.3	0.1	0.1	0.0
Varsinais-Suomi	606.9	12.6	466.3	13.8	15.2	2.9	125.4	13.5
Satakunta	67.3	1.4	59.5	1.8	1.0	0.2	6.8	0.7
Kanta-Häme	61.2	1.3	29.7	0.9	28.3	5.3	3.3	0.4
Pirkanmaa	648.0	13.4	480.1	14.2	50.0	9.4	117.9	12.7
Päijät-Häme	46.3	1.0	42.1	1.2	1.3	0.2	3.0	0.3
Kymenlaakso	43.6	0.9	41.5	1.2	0.4	0.1	1.7	0.2
South Karelia	60.0	1.2	35.8	1.1	1.6	0.3	22.7	2.4
Etelä-Savo	22.6	0.5	10.7	0.3	3.5	0.7	8.4	0.9
Pohjois-Savo	119.7	2.5	50.0	1.5	13.7	2.6	56.0	6.0
North Karelia	58.1	1.2	20.9	0.6	9.7	1.8	27.5	3.0
Central Finland	181.5	3.8	106.6	3.2	16.9	3.2	58.0	6.3
South Ostrobothnia	23.9	0.5	19.2	0.6	0.6	0.1	4.1	0.4
Ostrobothnia	84.8	1.8	74.2	2.2	1.0	0.2	9.7	1.0
Central Ostrobothnia	11.4	0.2	7.0	0.2	2.2	0.4	2.3	0.2
North Ostrobothnia	552.9	11.4	420.4	12.5	30.7	5.8	101.8	11.0
Kainuu	18.3	0.4	10.1	0.3	1.5	0.3	6.6	0.7
Lapland	43.2	0.9	17.7	0.5	10.3	1.9	15.2	1.6
Åland	1.4	0.0	0.6	0.0	0.8	0.1	0.0	0.0

1 Regional classification system of the European Union (NUTS)

university sector the share of Uusimaa is almost 40 per cent. The regional breakdown in the business sector follows more or less the same pattern as the overall regional breakdown of R&D expenditure.

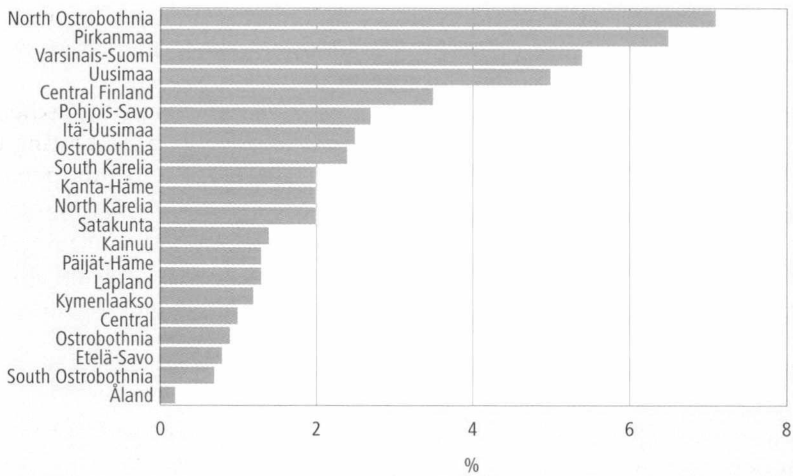
There have been some changes in the regional breakdown of R&D expenditure during the period from 1995 to 2002 (Appendix Table 5.2). During this time Uusimaa's share of total R&D expenditure has decreased by four percentage points. In relative terms the region whose share has declined most is Itä-Uusimaa, where the figure has dropped from 2.5 per cent to one per cent. There has also been a clear declining trend in the regions of Ostrobothnia and Kanta-Häme. The figures have increased for the three regional centres of R&D activity mentioned above, i.e. North Ostrobothnia, Varsinais-Suomi and Pirkanmaa.

R&D intensity by far the highest in Oulu, Salo and Tampere

The economic weight of R&D in different regions is measured by comparing R&D expenditure against the value added generated in the region and by calculating R&D personnel numbers per 1,000 employed persons. Three sub-regional units stand out in this comparison, namely Oulu, Salo and Tampere. In these areas R&D expenditure as a proportion of value added is 8-10 per cent (see Appendix Table 5.3). The next cluster comprises the sub-regional units of Jyväskylä, Helsinki and Turku, but here the corresponding proportion in 2002 was five per cent, i.e. just above the national average of four per cent. In Oulu, 87 employed persons out of one thousand are involved in R&D, in Tampere and Salo the ratio is around 64 per 1,000 employed persons. In this comparison the results for Helsinki, Jyväskylä and Turku are at around the level of 40-45 researchers. The regional differences in R&D are also evident in a relative comparison because in several sparsely populated sub-regional units R&D expenditure as a proportion of value added is around 1-2 per cent or even less, and for the most part the numbers involved in R&D are less than 15 per one thousand employed persons

Not surprisingly, the picture is very much the same when the situation is examined by region (Figure 5.2.3). In North Ostrobothnia there is very little R&D outside Oulu and environs, and indeed the value added share of R&D expenditure here is 7.1 per cent as compared to 10.4 per cent for the Oulu sub-regional unit. Pirkanmaa comes a strong second in this comparison: the gap over Varsinais-Suomi is explained by the fact that the nine per cent value added share for Salo is not enough to lift the whole region to the same level as Pirkanmaa. As was the case with sub-regional units, the differences between regions are quite considerable. In South and Central Ostrobothnia and Etelä-Savo, for instance, R&D expenditure as a proportion of regional value

Figure 5.2.3
R&D expenditure as a proportion of value added by region in 2002.
Source: Statistics Finland, Research and Development.



added is less than one per cent, and the number of people working in R&D is 7–8 per one thousand employed persons.

R&D intensity in Uusimaa and Oulu and environs among the highest in Europe

In other EU countries, too, regions differ in terms of the intensity or extent of R&D activities. However regional comparisons are complicated by the fact that data are only available at a rather crude level, i.e. level 2 of the NUTS regional classification, which in the Finnish case means Åland and the five (four from 2003 onwards) major regions on the mainland.[9] In other respects, too, the regional data are somewhat incomplete; the data for the UK, for instance, are for NUTS level 1. In 2001, R&D accounted for two per cent of GDP in the EEA.[10] With R&D intensities in excess of four per cent, the list was headed by Braunschweig, Stuttgart, Oberbayern and Tübingen in Germany, Stockholm and Western Sweden as well as the major region of Uusimaa and Northern Finland (which includes the sub-regional unit of Oulu).[11]

In an analysis of regional R&D volumes, the major region of Uusimaa (which comprises the regions of Uusimaa and Itä-Uusimaa) accounted for 1.2 per cent of GDP in the EEA. The figure for the major region of Northern Finland is just 0.3 per cent. The biggest concentrations in the 2001 data were the Greater Paris region (8.1 per cent), the Munich region or Oberbayern (4.1 per cent) and Stuttgart (3.5 per cent). The R&D volume of these leading European research areas is in fact greater than the figure for the whole Finnish economy.

5.3 Universities and government research institutes

5.3.1 Higher education sector

One of the main functions of universities is to conduct research. Universities have a major role to play most particularly in basic research that has no immediate practical applications in view, as well as in fields where there are no significant financial rewards to be expected. In addition to science and arts universities, higher education research statistics cover polytechnics as well as central university hospitals.

With total research expenditure in the university sector standing at 926 million euros in 2002, science and arts universities accounted for 786 million (85%), central university hospitals for 84 million and polytechnics for 56 million euros (Table 5.3.1). Research expenditure by polytechnics has increased

9 See Kunnat ja kuntapohjaiset aluejaot 2003 (Municipalities and regional divisions based on municipalities). Tilastokeskus, käsikirjoja 28. The classification of major regions has changed from 2003; for instance the major region of Uusimaa has been replaced by the larger region of Southern Finland. However the analysis here is based on the 2001 classification of major regions.

10 EU-15, Iceland and Norway (ETA).

11 Eurostat (2004b).

Table 5.3.1
R&D expenditure in the higher education sector in 2002 by university. Source: Statistics Finland, Research and Development.

	EUR million	%
University sector total	**925.6**	**100.0**
Universities total	**786.3**	**85.0**
Science universities total	775.4	83.8
University of Helsinki	203.2	25.8
University of Turku	74.8	9.5
Åbo Akademi University	28.6	3.6
University of Oulu	83.0	10.6
University of Tampere	51.2	6.5
University of Jyväskylä	54.7	7.0
Helsinki University of Technology	93.8	11.9
Helsinki School of Economics and Business Administration	11.5	1.5
Swedish School of Economics and Business Administration	6.5	0.8
Turku School of Economics and Business Administration	7.8	1.0
University of Vaasa	7.4	0.9
Lappeenranta University of Technology	21.7	2.8
Tampere University of Technology	57.2	7.3
University of Kuopio	41.9	5.3
University of Joensuu	23.6	3.0
University of Lapland	8.5	1.1
Arts universities total	10.9	1.2
Sibelius Academy	4.0	0.5
University of Art and Design Helsinki	4.4	0.6
Theatre Academy	2.0	0.3
Academy of Fine Arts	0.6	0.1
Central university hospitals	83.6	9.0
Polytechnics	55.6	6.0

very sharply from the level of 27 million euros first recorded in 1999. Another noteworthy feature for polytechnics is that three-quarters of their research is funded from outside sources. The share of external funding is even higher (93%) at central university hospitals. A significant proportion of research at central university hospitals is funded from special grants (so-called EVO) from the Ministry of Social Affairs and Health. In 2002 the Ministry accounted for 69 per cent of hospital research funding (Table 5.3.2).

Table 5.3.2
R&D expenditure in the higher education sector by source of funding, sector and major field of science.
Source: Statistics Finland, Research and Development.

	Research expenditure total	Own funding (budged funding)	External funding							
			Total	Academy of Finland	National Technology Agency Tekes	Other government	Domestic enterprises	Other domestic funding	EU funding	Other foreign funding
	EUR 1,000									
Total	**925,556**	**402,165**	**523,389**	**128,993**	**81,830**	**122,009**	**57,026**	**58,623**	**50,009**	**24,900**
Sector										
Universities	786,281	384,282	401,998	126,896	77,324	47,568	47,343	47,067	35,975	19,825
Central university hospitals	83,647	5,841	77,806	2,034	634	59,389	5,243	4,598	1,132	4,777
Polytechnics	55,628	12,042	43,585	63	3,872	15,053	4,440	6,958	12,902	298
Field of science										
Natural sciences	237,209	109,953	127,255	51,752	26,824	13,013	11,078	10,454	11,842	2,292
Engineering and technology	183,449	64,701	118,748	16,065	34,463	16,313	25,200	9,496	14,951	2,261
Medical sciences	232,392	76,463	155,929	21,411	11,250	65,269	11,894	17,957	10,184	17,965
Agricultural sciences	22,069	7,559	14,510	3,433	1,250	3,914	778	2,013	2,976	147
Social sciences	175,498	95,850	79,649	21,137	6,966	18,593	7,445	15,326	8,783	1,399
Humanities	74,940	47,642	27,299	15,196	1,077	4,906	632	3,377	1,273	838

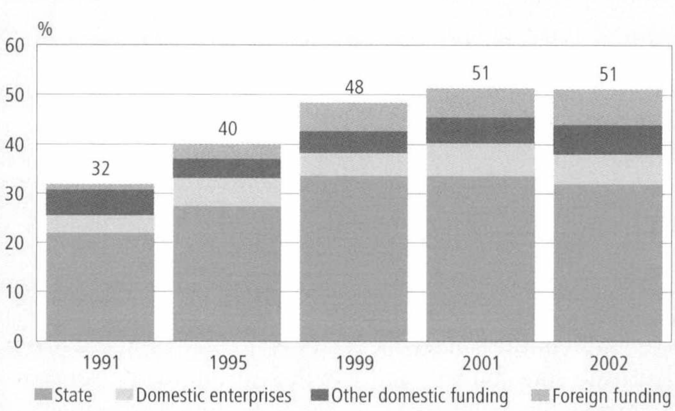
External funding for universities increased sharply in the 1990s

Funding for research in the university sector is divided between general university funds from the state budget and funding from outside sources. In recent years much interest has been directed towards the development of external funding. On the one hand it is pointed out that external funding is crucial for research projects that would never get off the ground in situations where core budget resources are scarce. Furthermore, much of this funding is allocated on a competitive basis or provided by customers, which in itself can be taken as an indication of quality and relevance. On the other hand external research funding is not considered entirely unproblematic: some consider it to represent a threat to traditional free research, and concerns have also been voiced over the lack of long-term commitments and problems surrounding the publication of research results.

Universities (excluding polytechnics and central university hospitals) saw a sharp increase in external funding during the 1990s. In 1991 its share was 32 per cent, in 2001–2002 around 51 per cent. External funding is also defined as including government support other than core budget funding for universities. This category of funding (which mainly consists of Academy of Finland and Tekes funding) increased by ten percentage points in 1991–2002. In 2002 Academy of Finland funding accounted for 16 per cent of universities' research expenditure, i.e. almost one-third of total external research funding. Tekes provided 10 per cent of universities' research funding, or almost 20 per cent of their external funding.

The share of university research funding provided by domestic business enterprises has increased from 3.6 per cent in 1991 to 6 per cent in 2002. However in relative terms the biggest change has occurred in the proportion of funding from foreign sources. Whereas in 1991 only one per cent of university research funding came from outside Finland, the corresponding proportion in 2002 was seven per cent. The biggest single factor has been the research funding obtained from EU sources: in 2002 almost five per cent of university research was funded from EU coffers.

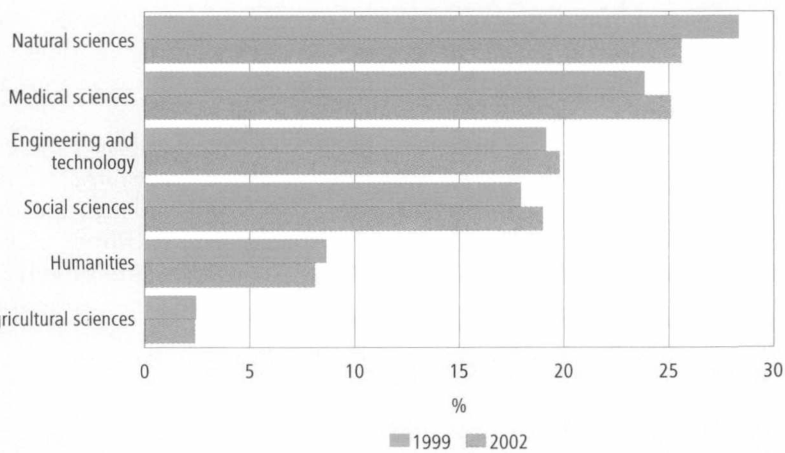
Figure 5.3.1
Development of external research funding for universities in 1991–2002.
Source: Statistics Finland, Research and Development.



The share of natural sciences has slightly decreased

The two major fields of science in terms of research expenditure are the natural sciences and medical sciences, both of which accounted for just over one-quarter of total research expenditure in the university sector in 2002. Compared to 1999, however, the share of natural sciences has declined by al-

Figure 5.3.2
Breakdown of research expenditure in the higher education sector by major field of science in 1999 and 2002.
Source: Statistics Finland, Research and Development.

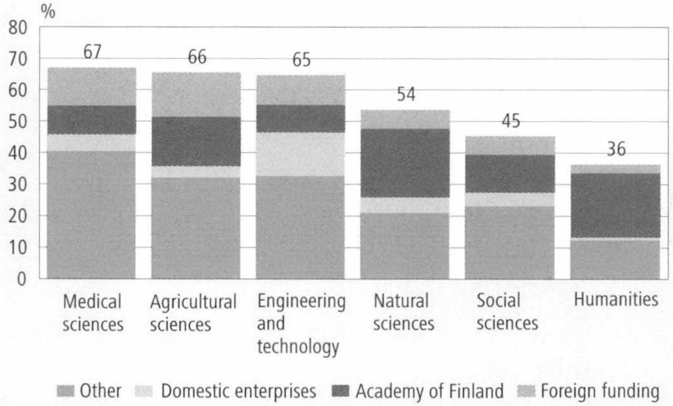


most three percentage points. The figures for medical sciences, engineering and social sciences have all increased. In a more detailed analysis, by far the biggest field of science is that of clinical medicine, which in 2002 accounted for 13.7 per cent of total expenditure. The figure for biology and environmental sciences was 7.7 per cent. Other fields of science recording figures in excess of five per cent were computer science, electrical engineering, business administration and biomedicine (see Appendix Table 5.4).

Up to two-thirds of research in individual fields of science funded from outside sources

Two-thirds of the research done in medicine, engineering and technology as well as agriculture and forestry is funded from non-core budget sources. In 2002 the lowest figure was recorded in the humanities at 36 per cent. In medicine 12 per cent and in agriculture and forestry 14 per cent of the funding comes from abroad, while in engineering and technology domestic business enterprises account for the same 14 per cent of research at universities (Figure 5.3.3 and Table 5.3.2). Tekes accounts for a larger share of funding for technology and engineering research than the business sector, i.e. for some 19 per cent of university research expenditure in this field. In the natural sciences and humanities the Academy of Finland accounts for one-fifth of total research funding.

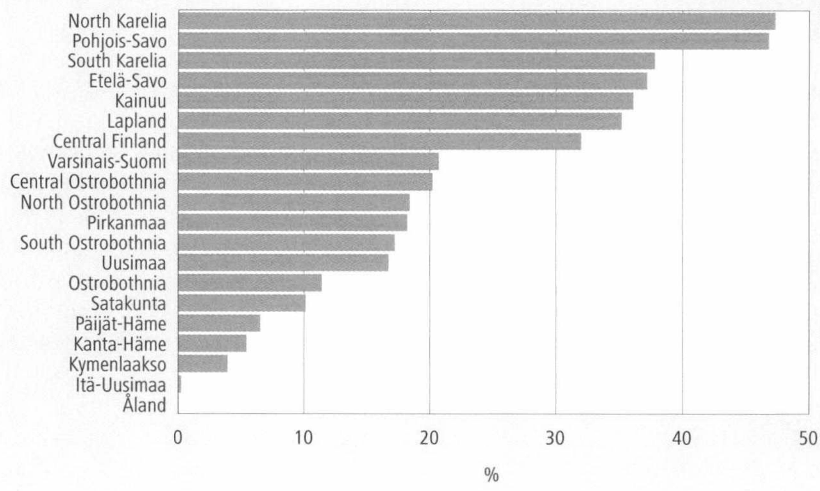
Figure 5.3.3
R&D activities in the higher education sector in 2002: proportion of external funding by field of science.
Source: Statistics Finland, Research and Development.



University research carries regional significance

University cities have great significance to the level of research activities in regions which do not have strong business R&D. Research done at the universities of Joensuu and Kuopio means that universities account for almost one-half of total research expenditure in the regions of North Karelia and Pohjois-Savo.

Figure 5.3.4
Universities' share of R&D expenditure by region in 2002.
Source: Statistics Finland, Research and Development.



By contrast in the regions of Uusimaa, Pirkanmaa and North Ostrobothnia, all of which have major universities, the university sector accounts for less than 20 per cent of research expenditure in these regions. On the other hand when we narrow our focus to individual universities, the level of research expenditure at the University of Helsinki is in a class of its own: Helsinki accounts for one-quarter of total university research expenditure. The figures for Helsinki University of Technology and the universities of Oulu and Turku are around 10 per cent each (see Table 5.3.1 above).

5.3.2 Government research institutes and public administration

Government sector research statistics cover public administration and government research institutes, social security funds and institutions as well as private non-profit research institutions. Local government is not included in the statistics.

Public sector accounts for a smaller proportion of total R&D expenditure than before

In 2003 public sector R&D expenditure totalled 515 million euros, 55 per cent of which was financed through unit core (budget) funding. Most of the research in the public sector is done at research institutes in the technology and

Table 5.3.3
R&D expenditure in the public sector by source of funding, administrative branch and sector in 2003.
Source: Statistics Finland, Research and Development.

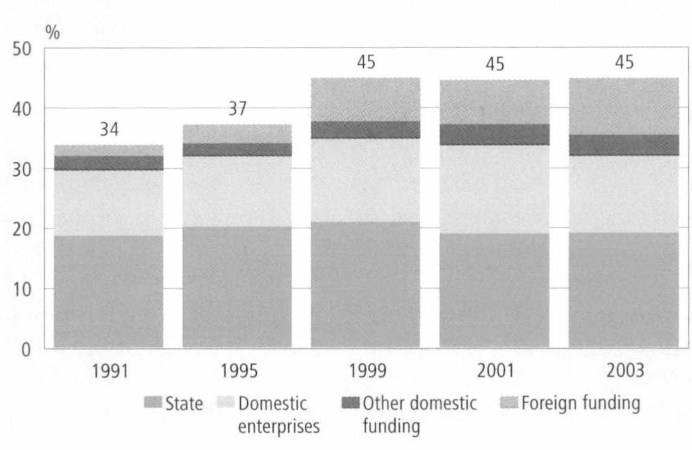
	R&D expenditure Own funding EUR million	External funding	Total
Public sector total	**283.7**	**231.7**	**515.4**
Administrative branches	250.5	214.5	465.0
Prime Minister's Office	0.1	–	0.1
Ministry for Foreign Affairs	–	–	–
Ministry of Justice	1.0	0.4	1.4
Ministry of the Interior	0.3	0.1	0.4
Ministry of Defence	31.3	–	31.3
Ministry of Finance	5.6	3.0	8.6
Ministry of Education	5.0	0.8	5.7
Ministry of Agriculture and Forestry	78.2	23.0	101.2
Ministry of Transport and Communications	14.8	4.6	19.4
Ministry of Trade and Industry	59.2	141.8	201.1
Ministry of Social Affairs and Healt	51.3	29.1	80.4
Ministry of Labour	0.1	–	0.1
Ministry of the Environment	3.6	11.8	15.4
Other pubic institutions	19.4	0.8	20.2
Private non-profit institutions	13.8	16.4	30.2

engineering, agriculture and medicine sectors. Accordingly the biggest administrative branches are the Ministry of Trade and Industry (which accounts for 39 per cent of public sector R&D expenditure), the Ministry of Agriculture and Forestry (20 per cent) and the Ministry of Social Affairs and Health (16 per cent). R&D expenditure at the Ministry of Defence amounted to 31 million euros, six per cent of all research in the public sector (Table 5.3.3).

As was discussed earlier (see Table 5.2.1), public sector spending as a proportion of total R&D expenditure declined sharply from 21 per cent in the early 1990s to 11 per cent in 2002. This, however, is explained by the faster growth recorded by universities and the business sector in particular; in fact in real terms research expenditure increased even in the public sector: in 2002 the figure was 18 per cent higher than in 1991.

The public sector has seen the same kind of change in the structure of its research funding as universities, i.e. a growing proportion of R&D expenditure is financed from sources other than core budget funding, with funding from abroad showing a particularly noticeable increase (Figure 5.3.5). All in all the share of external research funding has increased by 10 percentage points from around 34 per cent in 1991 to some 45 per cent at the turn of the millennium; since then there has been only little movement. Seven percentage points of the increase in external funding is explained by the growth of foreign funding.

Figure 5.3.5
Proportion of external funding in the public sector R&D in 1991–2003.
Source: Statistics Finland, Research and Development.



Technology and engineering the biggest field of science

Breakdowns by field of science have been studied by reference to the number of person-years in research (full-time equivalent, FTE). Technology and engineering has been consistently the biggest field of science, although its share of all FTE in research has declined from 40 per cent in 1995 to 34 per cent in 2003. Another

Table 5.3.4
Breakdown of person-years in public sector research by major field of science in 1995–2003.
Source: Statistics Finland, Research and Development.

Year	Natural sciences %	Engineering and technology	Medical sciences	Agricultural sciences	Social sciences and humanities
1995	17.3	40.5	10.2	22.8	9.2
1997	16.0	37.0	13.0	23.0	11.0
1999	16.0	37.1	13.7	22.6	10.6
2001	15.2	37.0	14.1	22.4	11.2
2003	16.3	34.2	15.9	22.2	11.4

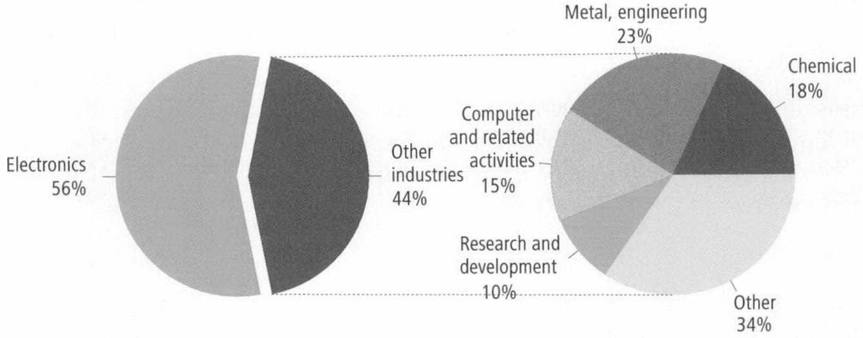
significant field of science in the public sector is agriculture and forestry, which has accounted for around 22–23 per cent of total FTE in research. The figure has risen quite sharply in medical sciences from around 10 per cent of all person-years in public sector research in 1995 to about 16 per cent in 2003. The social sciences (9 per cent of FTE) and the humanities (2 per cent) have a less prominent role than other major fields of science in public sector research.

Research in the public sector showed a higher degree of regional concentration than in the two other main sectors, with the region of Uusimaa accounting for almost two-thirds of all public sector research expenditure (see Table 5.2.4). The only other region that stands out to some extent is Pirkanmaa, where the share was less than ten per cent or some 50 million euros in 2002.

5.4 Business R&D

Business R&D statistics cover both manufacturing industries and most service industries; the most notable exceptions are the financial intermediation and insurance sector, retail trade and education. Although the service sector in general has gained added significance, manufacturing industries still account for the bulk of R&D activities. In 2003 R&D expenditure in the business sector amounted to a total of 3,528 million euros: manufacturing industries accounted for almost 80 per cent of this and service industries for the remaining 20 per cent. In primary production and mining and quarrying, activities that qualify as R&D are at a very low level indeed. The electronics industry accounts for around 56 per cent of total expenditure; the next biggest industries are the manufacture of metal products, machinery and transport equipment (10 per cent) and the chemical industry (about 8 per cent), which represents 18 per cent of R&D outside the electronics industry (Figure 5.4.1). By contrast the figure for the wood processing industry, which is important to the Finnish national economy, is less than three per cent. The biggest service industry is computer and related activities, which accounts for seven per cent of all business R&D expenditure.

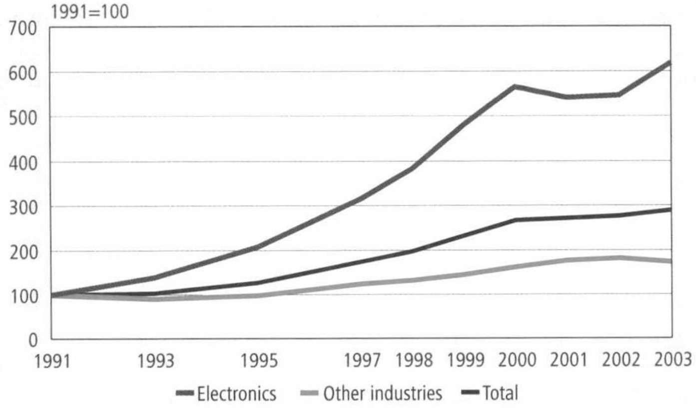
Figure 5.4.1
Business R&D in 2003: spending in the electronics industry and other industries as a proportion of total R&D expenditure.
Source: Statistics Finland, Research and Development.



Growth in R&D powered by electrotechnical industry, growth in other manufacturing industries rather modest

Finland's emergence as one of the world's most R&D intensive economies is explained in practice by the sharp increase in business R&D investment. At the same time there have been major structural shifts within the business sector. In the early 1990s the electronics and electrical industries accounted for about one-quarter of business sector R&D expenditure, but in the 2000s the share has increased to well over one-half. The growth of the electronics industry was partic-

Figure 5.4.2
Development of R&D expenditure in the electronics industry and other business in 1991–2003, 1991=100, in real values.
Source: Statistics Finland, Research and Development.



ularly rapid in the last years of the 1990s. The weight of the electronics industry is also reflected in the total R&D volume of the business sector, which has shown strong growth (Figure 5.4.2). Outside the electronics industry the real value of R&D expenditure increased 1.7-fold during the period from 1991 to 2003, while the corresponding increase in the electrotechnical industry was 6.2-fold.

The growth of R&D expenditure came to a virtual standstill at the turn of the millennium both in the electronics industry and in other branches. In 2000–2001 R&D spending in the electronics industry declined even in nominal terms, and in 2002 the figures still remained below the real value of expenditure in 2000 (Table 5.4.1). In 2003 R&D expenditure in the electronics industry began sharply to increase again. In other industries the figures showed a slight downward trend in 2003.

Table 5.4.1
Business enterprises' R&D expenditure by industry in 1997–2003.
Source: Statistics Finland, Research and Development.

	1997	1999	2000	2001	2002	2003	Real change 1997–2003	Share of turnover 2002[1]
	EUR million						1997=100	%
Enterprises total	**1,916.7**	**2,643.9**	**3,135.9**	**3,284.0**	**3,375.1**	**3,527.9**	**166**	**1.6**
Manufacturing total	1,540.4	2,161.9	2,538.9	2,601.6	2,617.1	2,800.2	164	2.4
Food industry	50.0	53.8	62.7	60.4	49.5	46.3	84	0.6
Textiles and wearing apparel industry	10.3	12.6	13.3	14.7	11.1	10.8	95	0.7
Wood processing industry	73.3	76.3	87.2	92.9	97.2	94.8	117	0.5
Chemical industry	196.8	222.5	256.8	288.0	321.6	285.9	131	2.2
Metal and engineering industry	281.4	338.7	350.1	400.3	367.0	355.4	114	1.4
Electronics industry	902.7	1,421.1	1,725.0	1,700.6	1,732.1	1,963.5	197	5.9
Other manufacturing	26.1	36.8	43.7	44.7	38.7	43.5	151	0.5
Electricity, gas and water supply	29.6	28.0	19.8	28.9	14.4	7.9	24	0.2
Construction	16.5	24.7	31.7	24.5	39.9	41.2	226	0.3
Wholesale trade and commission trade	25.9	42.1	57.5	53.4	75.9	61.7	215	0.2
Transport, storage and communication	70.0	110.6	107.0	132.6	114.1	85.2	110	0.6
Computer and related activities	41.7	94.0	123.2	189.2	229.0	235.0	509	4.6
Research and development	91.2	111.1	135.8	125.0	175.7	150.7	149	–[2]
Other business activities	65.3	51.0	104.8	112.0	89.7	128.1	177	1.9
Other industries	36.2	20.5	17.3	16.8	19.2	17.9	45	0.3

1 Share of turnover calculated for enterprises with more than 10 employees.
2 Share of turnover not comparable to other industries.

Strong growth in R&D in computer and related activities

The more detailed industry analysis from 1997 onwards is based on the 1995 industrial classification. All in all business R&D expenditure increased by 1.6 billion euros in 1997–2003, in real terms spending increased 1.7-fold. In the food industry and textiles manufacturing the volume of R&D has somewhat declined. The forest industry as well as metal and mechanical engineering industries have stepped up their investment in R&D to some extent, in the chemical industry the growth has been slightly faster. In 2003, though, R&D expenditure in the chemical industry took a downward turn.

In 1997–2003 even faster growth in R&D investment than that recorded by the electronics industry was seen for computer and related companies. R&D spending in this industry increased five times over from 1997 to 2003, at the same time as the industry's share of total business R&D increased from around two to almost seven per cent. The growth of R&D activities in computer related business gathered pace most particularly after 1999. There has also been marked growth in the category of research and development services, and in other business services R&D spending has also increased. Furthermore, wholesale and construction have shown strong relative growth, although the overall volumes in these cases are rather small and therefore even minor changes take on greater weight.[12] In the energy supply industry R&D investment has clearly decreased.

Measured in terms of R&D expenditure as a proportion of turnover, the electronics industry and computer and related activities are the two most research intensive industries: R&D expenditure as a proportion of turnover is six per cent in the electronics industry and almost five per cent in computer and related activities. The figure is also comparatively high in the chemical industry (which includes the highly R&D intensive manufacture of pharmaceuticals) at 2.2 per cent. In most industries, however, R&D expenditure as a proportion of turnover is less than one per cent.

Business enterprises' own research funding has increased

Business enterprises' own funding of R&D has increased from around 87 per cent in the early 1990s to around 93 per cent in 2003 (Table 5.4.2).[13] In real terms the figure increased three times over during the ten-year period from 1993 to 2003. Although the share of public funding has decreased from ten per cent to less than six per cent, its volume has nonetheless increased in real terms. The remaining two percentages points of external funding for business R&D is divided more or less in half between R&D funded by other domestic enterprises (i.e. commissioned from other business enterprises) and funding from abroad. If the share of

12 As far as wholesale is concerned it is noteworthy that the focus of most of these businesses' R&D activities is on other areas. An example is provided by multinational pharmaceuticals companies that have R&D activities in Finland: the focus of their R&D is on pharmaceuticals even though they are classified as pharmaceuticals wholesalers.

13 Own funding includes funding by the enterprise itself as well as by other group units. Public funding includes public administration, the National Technology Agency Tekes, the National Research and Development Fund Sitra, Finnvera, local governments and other public sources, subsidised loans and government grants.

Table 5.4.2
Public and other external funding as a proportion of business R&D expenditure in 1991–2003.
Source: Statistics Finland, Research and Development.

	1991	1993	1995	1997	1999	2001	2003
	%						
External funding total	12.4	13.4	12.3	10.8	9.9	7.4	7.3
Public funding	9.8	9.7	8.4	6.5	6.2	5.5	5.4
Electronics industry	13.4	8.6	5.2	3.8	3.2	1.9	1.8
Other industries	8.5	10.3	10.1	9.2	9.9	9.4	9.9

public R&D funding is examined in branches other than the electronics industry, no decrease is seen. In business outside the electronics industry, public funding as a proportion of R&D expenditure has been consistently at around 9-10 per cent. In fact in 1991 public funding accounted for around 13 per cent of total R&D expenditure in the electrotechnical industry, i.e. well above the average for other industries. In the early 2000s, the figure has dropped to two per cent.

Public funding has great importance for small companies. Most of the companies in the category of less than 10 employees are Tekes customers, and consequently about one-third of their R&D expenditure is covered from public sources. The corresponding proportion for companies with 10–99 employees is 19 per cent. In enterprises with more than 100 employees the share of public R&D funding drops to around six per cent, and in enterprises with more than 500 employees it is around two per cent. Measured in terms of the volume of public R&D funding, on the other hand, the difference is much less pronounced: in enterprises with less than 50 employees R&D funding amounted

Table 5.4.3
Business R&D expenditure and funding by enterprise size category in 2003.
Source: Statistics Finland, Research and Development.

Number of	R&D total	of which			
		own funding	public funding	other source of funding	share of public funding
	EUR million				%
Total	**3,527.9**	**3,270.8**	**190.3**	**66.8**	**5.4**
0 – 9	68.4	39.1	26.1	3.2	38.2
10 – 49	240.5	165.6	55	19.8	22.9
50 – 99	158.1	124.2	20.7	13.2	13.1
100 – 249	274.6	252.8	16.3	5.5	5.9
250 – 499	301.7	273.6	18.3	9.8	6.1
500 +	2,484.7	2,415.4	54	15.3	2.2

to around 80 million euros and in businesses with more than 250 employees around 70 million euros in 2003 (Table 5.4.3).

Major enterprises account for three-quarters of R&D expenditure

R&D expenditure is very much concentrated in the biggest enterprises. In 2003 enterprises with more than 250 employees accounted for almost 80 per cent of total R&D expenditure. The figure for enterprises with 50–249 employees was 12 per cent and for those with less than 50 employees nine per cent (Table 5.4.4). A pattern of concentration is evident even among major enterprises in that the ten biggest units (companies or groups) accounted for more than one-half or 58 per cent of R&D expenditure in the business sector in 2003.[14] The highest degree of concentration is seen in the electronics and woodprocessing industries, where enterprises with more than 250 employees account for more than 90 per cent of R&D expenditure in the respective industry. In manufacturing industries in general the highest volumes of R&D are recorded in major enterprises, although the metal and engineering industry does constitute something of an exception: major enterprises here account for 56 per cent of R&D expenditure. In service industries R&D expenditure is more evenly divided between companies of different sizes than in manufactur-

Table 5.4.4
Business R&D expenditure by industry and size of enterprise in 2003.
Source: Statistics Finland, Research and Development.

	R&D expenditure	Number of employees		
		0 – 49	50 – 249	250 +
	EUR million	%		
Enterprises total	**3,527.9**	**9**	**12**	**79**
Manufacturing	2,800.2	4	9	87
Food industry	46.3	10	27	63
Textile and wearing apparel industry	10.8	17	20	63
Wood processing industry	94.8	1	5	94
Chemical industry	285.9	4	12	84
Metal and engineering industry	355.4	9	35	56
Electronics industry	1,963.5	2	3	94
Other manufacturing	43.5	26	30	44
Electricity, gas and water supply	7.9	5	33	62
Construction	41.2	12	6	83
Wholesale trade and commission trade	61.7	33	62	6
Transport, storage and communication	85.2	5	5	90
Computer and related activities	235.0	36	27	37
Research and development	150.7	29	26	45
Other business activities	128.1	31	15	54
Other industries	17.9	31	28	41

14 Based on Statistics Finland calculations.

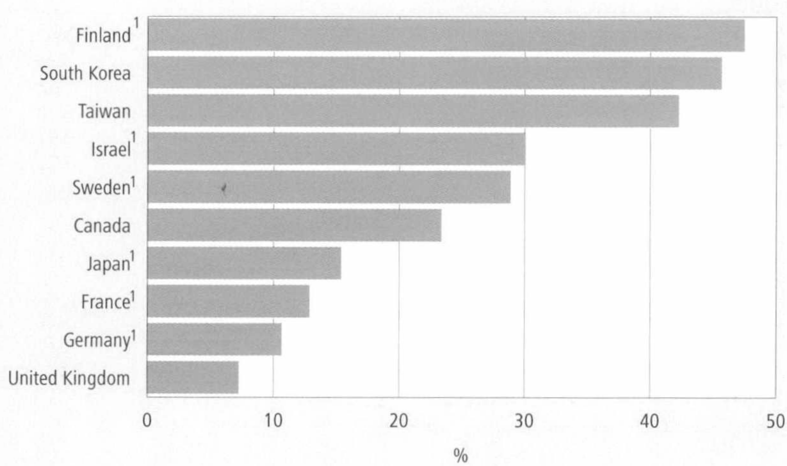
ing industries. The breakdown for wholesale is completely different, virtually all R&D is done in SMEs. In computer and related activities, too, major enterprises account for no more than 37 per cent of R&D expenditure.

Electronics industry R&D exceptionally important in Finland

The strong growth of R&D in the electronics industry in the 1990s and the consequent increase in the total volume of R&D in the business sector compared to other sectors is also clearly in evidence in an international comparison. The 70 per cent share recorded for the business sector in Finland is admittedly just two per cent lower than the OECD average, but the margin compared to the EU average is rather wider at about five percentage points (Appendix Table 5.1). The OECD average is pushed up by the United States, where business spending as a proportion of total R&D expenditure is 87 per cent, and by Japan, where the figure is 74 per cent.

Finland's ranks first in a comparison of the electronics industry's share of total R&D expenditure. The figure in Finland is 48 per cent, the two other countries with figures over and above 40 per cent are the Asian industrial economies of Korea and Taiwan. In France and Germany the share of the electronics industry is just over 10 per cent. One indication of Sweden's broader base of industrial R&D in comparison with Finland is that even though its business sector accounts for a larger proportion of R&D expenditure than in Finland, the share of the electronics industry is clearly lower, around 30 per cent.

Figure 5.4.3
The electronics industry's share of total R&D expenditure in selected countries 2002. Source: OECD, Main Science and Technology Indicators 2004/1.



1 Data from 2001

Appendix Table 5.1
R&D indicators in the OECD countries in 2002.
Source: OECD, Main Science and Technology Indicators 2004/1.

	R&D expenditure[1]	R&D expenditure as proportion of GDP	Business funding as a proportion of R&D expenditure	Public funding as a proportion of R&D expenditure
	USD million	%	%	%
Australia[2]	7,809.7	1.54	47.5	45.7
Austria[4]	4,616.0	1.94	..	40.4
Belgium[3]	6,052.9	2.17	73.7	21.4
Canada[4]	18,447.4	1.87	53.7	34.0
Czech Republic	2,001.4	1.30	61.1	42.1
Denmark	3,962.3	2.52	69.3	28.0
Finland	4,761.1	3.46	69.9	26.1
France	36,618.0	2.20	62.2	36.9
Germany[4]	54,283.6	2.50	69.1	32.1
Greece[3]	1,209.8	0.65	32.7	46.9
Hungary	1,445.5	1.02	35.5	58.6
Iceland	252.6	3.09	57.2	34.0
Ireland[3]	1,316.8	1.15	69.7	22.6
Italy[3]	16,351.3	1.11	49.1	..
Japan	106,838.2	3.12	74.4	18.2
Luxembourg[2]	363.5	1.71	92.6	7.7
Mexico[3]	3,565.1	0.39	30.3	59.1
Netherlands[3]	8,683.5	1.89	58.2	36.2
New Zealand[3]	977.6	1.18	36.5	46.4
Norway	2,694.2	1.67	57.4	39.8
Poland	2,433.7	0.59	21.4	61.1
Portugal	1,775.4	0.93	34.4	61.0
Slovakia	380.8	0.58	64.3	44.1
South-Korea	23,549.5	2.91	74.9	25.4
Spain	9,386.6	1.03	54.6	39.1
Sweden[3]	10,221.2	4.27	77.6	21.0
Switzerland[2]	5,507.1	2.57	73.9	23.2
Turkey[2]	2,909.6	0.64	33.4	50.6
United Kingdom	31,037.4	1.88	67.0	26.9
United States[4]	284,584.3	2.62	68.9	31.2
OECD total	648,988.0	2.26	68.0	29.9
EU-25	198,596.5	1.83	63.6	34.7
EU-15	191,451.5	1.93	64.4	34.1
Argentina	1,604.7	0.39	26.1	70.2
China	72,014.4	1.23	61.2	33.42
Israel	6,293.5	4.72	72.9	24.72
Romania	542.3	0.38	60.3	48.4
Russia	14,733.9	1.24	69.9	58.4
Singapore	2,188.9	2.15	61.4	41.8
Slovenia	590.8	1.54	59.7	35.6
Taiwan	12,194.1	2.30	62.2	35.2

1 USD million, calculated on the basis of purchasing power parity.
2 Data from 2000
3 Data from 2001
4 Data from 2003

Appendix Table 5.2
R&D expenditure by region in 1995–2002.
Source: Statistics Finland, Research and Development.

Region (NUTS3)[1]	Breakdown of R&D				
	1995	1997	1999	2001	2002
Uusimaa	48.3	46.2	45.1	44.5	44.2
Itä-Uusimaa	2.4	2.1	1.4	1.4	0.9
Varsinais-Suomi	10.1	9.4	9.7	10.1	12.6
Satakunta	1.9	1.6	1.5	1.6	1.4
Kanta-Häme	2.1	1.6	1.2	1.3	1.3
Pirkanmaa	9.7	13.1	14.1	15.0	13.4
Päijät-Häme	1.1	0.8	1.0	1.1	1.0
Kymenlaakso	1.3	1.2	1.0	0.8	0.9
South Karelia	1.7	1.4	1.3	1.2	1.2
Etelä-Savo	0.5	0.5	0.6	0.4	0.5
Pohjois-Savo	2.3	2.5	2.2	2.2	2.5
North Karelia	1.5	1.3	1.4	1.2	1.2
Central Finland	3.5	3.8	4.0	3.8	3.8
South Ostrobothnia	0.4	0.4	0.6	0.5	0.5
Ostrobothnia	2.7	2.5	2.1	2.0	1.8
Central Ostrobothnia	0.2	0.3	0.2	0.2	0.2
North Ostrobothnia	8.4	9.8	11.3	11.4	11.4
Kainuu	0.5	0.4	0.4	0.4	0.4
Lapland	1.4	1.0	1.0	0.8	0.9
Åland	0.0	0.0	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

1 Regional classification system of the European Union (NUTS)

Appendix Table 5.3
R&D activities by region in 2002.
Source: Statistics Finland. Research and Development.

Region (NUTS3)[1]	R&D expen- diture	R&D personnel	Person- years in research	R&D expendi- ture as a pro- portion of value added	R&D personnel per 1000 employed persons
	EUR million			%	
Total	**4,830.3**	**73,121**	**55,044**	**4.0**	**31.0**
Uusimaa	2,133.3	31,169	23,848	5.0	42.1
Helsinki	2,112.3	30,718	23,587	5.2	44.3
Lohja	14.1	306	181	1.1	10.9
Tammisaari	7.0	145	80	0.9	7.5
Itä-Uusimaa	45.9	581	469	2.5	17.1
Loviisa	1.1	21	12	0.3	3.0
Porvoo	44.8	559	456	3.2	20.7
Varsinais-Suomi	606.9	7,485	6,222	5.4	36.7
Loimaa	2.0	39	25	0.3	2.6
Salo	234.9	1,821	1,827	9.0	62.7
Turku	354.5	5,390	4,196	5.1	39.9
Vakka-Suomi	5.4	90	81	0.7	5.4
Åboland-Turunmaa	10.1	146	94	2.5	17.5
Satakunta	67.3	1,245	804	1.4	12.4
Kaakkois-Satakunta	4.6	95	69	0.9	6.6
Pohjois-Satakunta	1.7	42	16	0.4	3.3
Pori	44.9	770	533	1.9	15.9
Rauma	16.1	339	186	1.1	13.3
Kanta-Häme	61.2	1,201	902	2.0	17.0
Forssa	26.4	576	529	3.9	36.1
Hämeenlinna	23.0	465	275	1.4	12.0
Riihimäki	11.8	160	99	1.8	10.0
Pirkanmaa	648.0	9,396	7,617	6.5	48.5
Etelä-Pirkanmaa	19.3	285	192	2.2	17.3
Kaakkois-Pirkanmaa	1.5	36	33	0.9	9.2
Lounais-Pirkanmaa	3.0	52	28	0.8	5.4
Luoteis-Pirkanmaa	2.9	86	58	0.6	7.4
Tampere	619.9	8,887	7,288	8.4	64.7
Ylä-Pirkanmaa	1.4	50	19	0.2	3.4
Päijät-Häme	46.3	966	495	1.3	11.6
Heinola	8.0	152	67	1.6	13.1
Lahti	38.4	814	428	1.2	11.3
Kymenlaakso	43.6	707	416	1.0	9.0
Kotka-Hamina	31.8	432	273	1.8	12.2
Kouvola	11.8	275	144	0.5	6.3
South Karelia	60.0	1,105	819	2.0	20.7
Imatra	18.9	263	206	1.8	16.8
Kärkikunnat	–	–	–	–	–
Lappeenranta	41.0	840	612	2.5	28.2
Länsi-Saimaa	..	..	..	..	..

Appendix Table 5.3 *continued*

Region (NUTS3)[1]	R&D expenditure	R&D personnel	Person-years in research	R&D expenditure as a proportion of value added	R&D personnel per 1000 employed persons
	EUR million			%	
Etelä-Savo	22.6	526	323	0.8	8.1
Juva	1.7	35	20	0.5	4.2
Mikkeli	12.8	254	184	1.0	8.3
Pieksämäki	2.1	36	24	0.6	4.0
Savonlinna	6.0	201	95	0.8	12.0
Pohjois-Savo	119.7	2,306	1,855	2.7	23.4
Koillis-Savo	1.5	23	20	0.5	3.0
Kuopio	98.1	1,835	1,565	4.3	38.9
Sisä-Savo	2.8	93	49	1.4	17.6
Varkaus	10.0	155	122	1.4	10.8
Ylä-Savo	7.3	200	98	0.8	8.3
North Karelia	58.1	1,336	829	2.0	20.5
Ilomantsi	0.5	29	9	0.4	9.9
Joensuu	48.9	1,176	724	2.8	30.5
Central Karelia	2.1	37	30	0.7	4.7
Outokumpu	4.1	60	47	2.4	13.8
Pielisen Karelia	2.5	34	19	0.5	3.0
Central Finland	181.5	3,161	2,325	3.5	30.0
Jyväskylä	158.8	2,702	2,056	5.3	45.2
Jämsä	10.6	306	177	1.4	25.7
Southeastern Central Finland	..	..	..	..	..
Keuruu	0.4	10	4	0.0	0.8
Saarijärvi	2.0	42	23	0.7	5.6
Viitasaari	0.7	13	4	0.4	2.5
Äänekoski	8.5	75	61	1.6	7.8
South Ostrobothnia	23.9	578	318	0.7	7.1
Eteläiset seinänaapurit	2.3	81	26	0.7	8.8
Härmänmaa	7.9	169	109	1.7	12.4
Järviseutu	1.0	24	9	0.3	2.9
Kuusiokunnat	0.9	33	11	0.2	2.8
Pohjoiset seinänaapurit	10.2	232	144	0.8	8.7
Suupohja	1.6	39	19	0.4	3.4
Ostrobothnia	84.8	1,325	1,022	2.4	17.2
Jakobstadsregionen	10.0	215	145	1.0	9.8
Kyrönmaa	2.0	29	23	1.0	5.6
Sydösterbottens kustregion	0.8	22	6	0.2	2.4
Vaasa	72.1	1,058	848	3.6	26.0
Central Ostrobothnia	11.4	228	180	0.9	7.7
Kaustinen	0.2	5	2	0.1	0.7
Kokkola	11.3	223	178	1.2	10.1

Appendix Table 5.3 *continued*

Region (NUTS3)[1]	R&D expen-diture	R&D personnel	Person-years in research	R&D expendi-ture as a pro-portion of value added	R&D personnel per 1000 employed persons
	EUR million			%	
North Ostrobothnia	552.9	8,264	5,680	7.1	53.5
Ii (Oulunkaari 1.1.2003 alkaen)	2.1	26	10	0.6	3.3
Koillismaa	1.1	14	13	0.3	1.8
Nivala-Haapajärvi	0.6	13	12	0.1	1.1
Oulu	528.9	7,710	5,343	10.4	87.1
Raahe	17.3	383	248	2.4	25.7
Siikalatva	0.3	25	6	0.1	3.6
Ylivieska	2.6	93	48	0.4	5.7
Kainuu	18.3	333	247	1.3	9.9
Kajaani	17.0	287	217	1.7	11.4
Kehys-Kainuu	1.3	46	30	0.3	5.4
Lapland	43.2	1,168	645	1.2	16.3
Itä-Lappi	1.3	28	12	0.4	3.9
Kemi-Tornio	13.4	262	175	0.9	10.7
Pohjois-Lappi	4.6	85	73	1.7	11.4
Rovaniemi	21.7	670	347	1.9	27.7
Torniolaakso	0.4	13	4	0.3	4.0
Tunturi-Lappi	1.7	110	34	0.8	20.2
Åland	1.4	41	29	0.2	2.5
Mariehamns stad	0.4	13	8	0.1	1.1
Ålands landsbygd	1.0	29	21	0.5	7.1
Ålands skärgård	–	–	–	–	–

1 Regional classification system of the European Union (NUTS)

Appendix Table 5.4
Research expenditure in the university sector by field of science in 2002.
Source: Statistics Finland, Research and Development.

Field of science	EUR million	%
Clinical medicine	126.7	13.7
Biology, environmental sciences	71.4	7.7
Computer science	61.7	6.7
Electrical engineering	56.9	6.1
Business administration, economic geography	50.6	5.5
Biomedicine	48.0	5.2
Physics	40.6	4.4
Education	39.7	4.3
Chemistry	29.0	3.1
Mechanical engineering and manufacturing technology	28.6	3.1
Linguistics	27.8	3.0
Social sciences	26.0	2.8
Process and materials technology	22.7	2.5
Art studies, literature	19.8	2.1
Other technology	18.5	2.0
Mathematics	16.6	1.8
Nursing science	15.8	1.7
Biotechnology, food technology	14.6	1.6
Political science, administrative science	14.0	1.5
Law	13.7	1.5
Construction technology, municipal engineering	13.4	1.4
Agricultural and food sciences	12.7	1.4
Pharmacy	11.4	1.2
History and archeology	10.4	1.1
Psychology	10.4	1.1
Communication and information studies	10.2	1.1
Public health science	9.7	1.1
Forest products technology	9.5	1.0
Forestry	9.4	1.0
Veterinary medicine	8.4	0.9
Economics	8.1	0.9
Energy technology	7.9	0.9
Dentistry	7.1	0.8
Space sciences and astronomy	7.0	0.8
Cultural studies	6.9	0.7
Geosciences, meteorology	6.8	0.7
Theology	6.3	0.7
Architecture	4.3	0.5
Geography	4.0	0.4
Philosophy	3.9	0.4
Metallurgy and mining technology	3.5	0.4
Industrial chemistry, chemical process engineering	3.5	0.4
Statistics	2.9	0.3
Sport science	2.8	0.3
Nutrition	2.5	0.3
Total	**925.6**	**100.0**

6 Patenting

Patents statistics as technology indicators

In this chapter technology outputs are described by reference to patents statistics. The data on domestic patents are from the National Board of Patents and Registration, international patenting is described on the basis of figures from the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO).

A patent is an exclusive right to exploit an invention commercially, granted for a limited term to the inventor or the holder of the inventor's rights. At the same time, with its release into the public domain, the existing technical information becomes universally accessible, against a fee. The significance of patenting is demonstrated by the sharp rise in the number of patent applications. In 2003 the EPO received a total of some 117,000 patent applications, with the average annual increase in 1995-2003 standing at around seven per cent. In the United States the number of patent applications in 2003 was close to 170,000. One of the advantages of using patent databases as a source of technology indicators and technological research is that there is an abundance of data available that allow for easy international comparison over extended periods of time. The EPO database, for example, comprises 25 million patent specifications from 1979 onwards.

Patent indicators are the most important and frequently used measure of innovation output; after all the patent is associated by definition with the innovation. At the same time these indicators describe the transfer of knowledge between business firms, countries and different fields of technology. The growth of internationalism is in turn clearly reflected in the increasing divergence of the patent applicants' and inventors' countries of residence.

However, patent statistics tend to give only a partial or incomplete picture of new technology because not all new innovations are or can be patented. One of the factors that may deter applicants is that the process itself is slow and may take many years. There is also the cost factor to consider: the costs of applying for and maintaining a patent may run up to thousands of euros.

One factor that complicates comparisons is that the grounds on which patents are awarded vary between different countries, and there may also be considerable differences in the rules and regulations governing patents.

The economic significance of patents varies. Sometimes companies may consciously decide not to protect a commercially viable innovation at all: it may make more sense to keep a new innovation secret rather than publicise it through the patenting process. Another option that is open to companies is to protect a new innovation by trademarking.

Patented products or methods may be major innovations of substantial economic value, or minor improvements to existing products or processes. As far as statistics are concerned, however, all patents are equal. The significance of patenting to the national economy or to an individual business company may be considerable: the monies poured into the development of patents may be paid back several times over.

Material and concepts

The data on patents applied and granted in Finland are based on figures from the National Board of Patents and Registration database. The data on international patenting are drawn from the OECD patent database and EPO annual reports. Regional and country data are based on information for the patent inventor unless otherwise stated. Annual data for international patenting are based on the patent application's priority date.

A patent is an exclusive right commercially to exploit an invention granted by the relevant authority for a limited period (usually 20 years) to the inventor or the holder of the inventor's rights. A patent is issued on condition that the invention is new and innovative, i.e. based on non-obvious information and has industrial application. At the same time as a patent guarantees exclusive rights to the commercial exploitation of the invention, it also means that it is brought into the public domain: the patent applicant is required to disclose all material information concerning the invention. Indeed the requirement of publicity is one of the most important features of the patenting system.

Date of priority is the first date on which a patent application has been filed for the invention concerned in any country.

Country of priority is the country where a patent application is first filed. This is usually the applicant's country of residence.

Date of publication is the date when the information relating to the patent application becomes public, which is usually 18 months after the date of priority.

Date of issuance is the date on which the patent authority issues the patent. Patent protection obtained for an invention is effective retroactively from the date of application. In Finland the processing of a patent application takes about 2 –2.5 years, at the European Patent Office around five years and at the United States Patent and Trademark Office three years.

Triadic patent families is a patent indicator developed by the OECD which combines the patents granted by the three biggest patent authorities (in Europe, the US and Japan) to the same invention. This is done on the basis of the patent's priority or priorities. The aim is to avoid overlapping calculations and to reduce the impact of the number of domestic applications. A patent granted by all three patent offices also serves as an indicator of an internationally valuable and important invention.

European Patent Convention, EPC

The European Patent Convention was signed in 1973 and it came into force in 1977. The convention led to the foundation of the **European Patent Office** (EPO), which grants European patents. Currently 30 countries have acceded to the Convention. In addition, there are six extension states to which a European patent can be extended on separate application.

A single application filed with the European Patent Office (EPO) suffices to obtain a patent in all designated contracting states. A European patent affords the same rights in these contracting states as a patent granted by a national patent office. The EPO is not an EU institution.

PCT applications are based on the Patent Cooperation Treaty (PCT), which took effect in 1978 and which currently covers 123 countries. At the first stage of filing a PCT application, applicants shall designate the countries in which they wish to file or retain the option to file a patent application with one patent office in a contracting country. The actual processing of the application takes place at the next, regional/national stage. The patent is always granted by a regional (e.g. European Patent Office) or national patent authority (in Finland the National Board of Patents and Registration). Administration of PCT applications is the hands the World Intellectual Property Organisation (WIPO).

6.1 Patenting in Finland

Number of patent applications received from foreign countries continues to fall

In 2003 the total number of patent applications filed in Finland was 2,187 (Table 6.1.1), down by some 200 on the figure one year previously. This was entirely attributable to the decreasing number of domestic applications. The number of applications filed with the National Board of Patents and Registration directly from foreign countries was down to just 214. Most of these applications came from the United States (60), followed by Sweden (19) and Germany (18). Foreign patenting today takes place almost entirely through the EPO. In 2003 Finland appeared as a designated country in around 104,000 applications, which is approximately 90 per cent of all EPO applications. The option of filing a patent with the EPO is also reflected in the number of domestic applications. Among the 1,480 EPO applications filed by Finnish applicants, Finland appeared as a designated country in 1,402 applications.

Table 6.1.1
Patent applications filed in Finland in 1995–2003.
Source: National Board of Patents and Registration.

Year	Domestic applicants			Foreign applicants	Total
	Private individual	Enterprise /association	Domestic total		
1995	731	1,393	2,124	4,240	6,364
1996	802	1,424	2,226	3,087	5,313
1997	784	1,626	2,410	2,258	4,668
1998	680	1,791	2,471	387	2,858
1999	678	1,833	2,511	359	2,870
2000	695	1,883	2,575	338	2,913
2001	627	1,764	2,391	277	2,668
2002	550	1,606	2,156	216	2,372
2003	467	1,506	1,973	214	2,187

Most domestic applications filed by enterprises

More than three quarters or 76 per cent of all domestic patent applications were filed by enterprises and associations, the remaining one-quarter by private individuals. In both categories the numbers dropped by around one hundred compared to the previous year.

In 2003 a total of 527 enterprises or associations applied for a domestic patent. This was 83 less than in 2002. Thirty-one enterprises applied for a patent together with another company, 18 enterprises filed 10 applications or more. Most enterprises only filed one patent application: in 2003 these enterprises numbered 363.

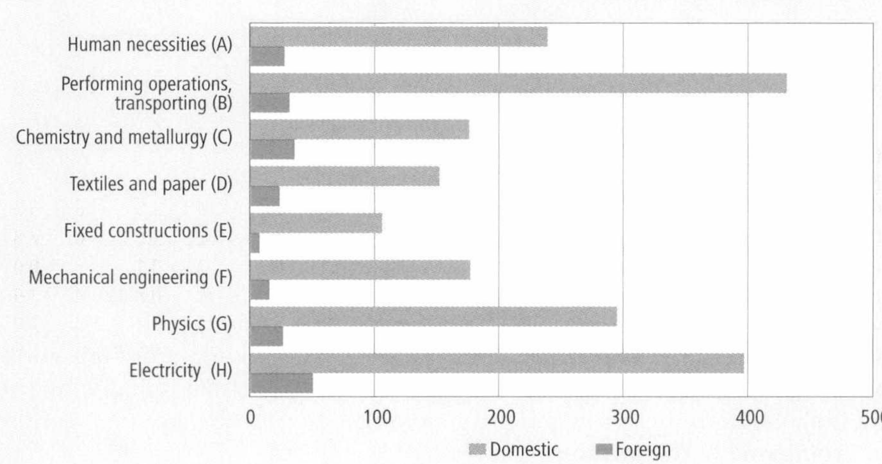
The proportion of private individuals among patent applicants is comparatively high in Finland; this is explained in part by the number of applications filed by university researchers. However, no national or internationally comparable data are available on patenting by universities. It is estimated that university researchers in Finland file some 80–140 patent applications each year.[1]

Largest number of patent applications in the performing operations and transporting section

In an examination based on the International Patent Classification (IPC), the largest number of domestic patent applications (accounting for almost 22%) was recorded in the performing operations and transporting section (Figure 6.1.1). The electricity section, which in previous years has accounted for the largest proportion, now accounted for two percentage points less. Among foreign applications electricity remains the single biggest category, accounting for 23 per cent of all applications. The next highest figure for foreign applications was recorded in the chemical and metallurgical section at 16 per cent.

Table 6.1.2 shows the breakdown of patent applications filed in Finland using a more detailed technology classification.[2] In this analysis the biggest categories in 2003 were telecommunications technology (13.6%), building and civil engineering (9.7%) and paper manufacture and printing (8.0%). Both domestic and foreign patent applications were concentrated in the field of telecommunications (13.4% and 15.9%). Among applications received from for-

Figure 6.1.1
Patent applications filed in Finland by IPC section in 2003.
Source: National Board of Patents and Registration.



1 Academy of Finland (2000)
2 Engelsman, E.C. & A.F.J. van Raan (1991)

Table 6.1.2
Patent applications filed in Finland by technology field in 1999, 2001 and 2003. Source: National Board of Patents and Registration.

Technology sector	1999		2001		2003					
	Total	%	Total	%	Total	%	Dom-estic	%	For-eign	%
Mining and quarrying, civil engineering, building materials, air conditioning, waste treatment	334	11.6	285	10.7	213	9.7	198	10.0	15	7.0
Paper manufacture, printing	237	8.3	199	7.5	176	8.0	153	7.8	23	10.7
Textiles, clothing, leisure, textile machinery	58	2.0	64	2.4	55	2.5	53	2.7	2	0.9
Biomedicine	74	2.6	74	2.8	61	2.8	59	3.0	2	0.9
Agriculture, foodstuffs, tobacco	118	4.1	114	4.3	87	4.0	80	4.1	7	3.3
Biotechnology and gene technology, pharmaceuticals	94	3.3	87	3.3	89	4.1	68	3.4	21	9.8
Organic chemistry, petroleum chemistry	72	2.5	71	2.7	46	2.1	29	1.5	17	7.9
Polymer materials (polymer chemistry)	36	1.3	13	0.5	8	0.4	4	0.2	4	1.9
Manufacture and application of polymers	36	1.3	35	1.3	27	1.2	25	1.3	2	0.9
Inorganic chemistry	26	0.9	32	1.2	30	1.4	30	1.5	–	–
Surfacing, crystal growing	23	0.8	13	0.5	15	0.7	15	0.8	–	–
Process technology, separating and combining materials	116	4.0	116	4.3	121	5.5	113	5.7	8	3.7
Mechanical technology, mechanical engineering, weapons	115	4.0	93	3.5	88	4.0	80	4.1	8	3.7
Materials handling, machine tools	140	4.9	131	4.9	108	4.9	98	5.0	10	4.7
Goods handling, transfer equipment, robots	139	4.8	128	4.8	148	6.8	137	6.9	11	5.1
Transporting, traffic	130	4.5	119	4.5	82	3.7	80	4.1	2	0.9
Engines, turbines, pumps	70	2.4	87	3.3	50	2.3	45	2.3	5	2.3
Electric power, nuclear technology	52	1.8	36	1.3	44	2.0	36	1.8	8	3.7
Electric machines	59	2.1	61	2.3	58	2.7	52	2.6	6	2.8
Lasers	–	–	1	0.0	2	0.1	2	0.1		0.0
Optical equipment	24	0.8	33	1.2	20	0.9	16	0.8	4	1.9
Instruments, control equipment	77	2.7	69	2.6	57	2.6	53	2.7	4	1.9
Metrology, sensors	148	5.2	166	6.2	105	4.8	101	5.1	4	1.9
Data processing	72	2.5	148	5.5	136	6.2	124	6.3	12	5.6
Information storage	1	0.0	4	0.1	1	0.0	–	–	1	0.5
Telecommunications	567	19.8	418	15.7	298	13.6	264	13.4	34	15.9
Image transfer	11	0.4	39	1.5	21	1.0	20	1.0	1	0.5
Electronics, electronic components	41	1.4	32	1.2	41	1.9	38	1.9	3	1.4
Total	**2,870**	**100,0**	**2,668**	**100,0**	**2,187**	**100,0**	**1,973**	**100,0**	**214**	**100,0**

eign countries, the next biggest category was patents in the field of paper manufacture and printing (10.7%).

Most patent applications from the region of Uusimaa

The regional origin of a patent application is usually determined on the basis of the inventor specified in the application; if there are several inventors, the various regions will be recorded accordingly. In 2003 Uusimaa accounted for 39.2 per cent of all applications filed by enterprises and associations (Table 6.1.3), showing very little change from the figure in 1999. The share of Pirkanmaa has also remained steadily at around 15 per cent. The figure for Varsinais-Suomi increased by 1.5 percentage points from 1999 to 2003. The figures for both North Ostrobothnia and Central Finland were around seven per cent.

In 2003 one-third or 467 of all patent applications filed by private inventors came from the region of Uusimaa. The second and third highest proportions were recorded for Central Finland (10.5%) and Pirkanmaa (10.1%), respectively.

Table 6.1.3
Patent applications filed by enterprises and associations in Finland by region[1] in 1999, 2001 and 2003.
Source: National Board of Patents and Registration.

Region (NUTS3)[2]	1999	%-osuus	2001	%-osuus	2003	%-osuus
Uusimaa	696	38.0	638	36.2	591	39.2
Itä-Uusimaa	11	0.6	21	1.2	14	0.9
Varsinais-Suomi	128	7.0	141	8.0	128	8.5
Satakunta	39	2.1	55	3.1	46	3.1
Kanta-Häme	31	1.7	29	1.6	21	1.4
Pirkanmaa	283	15.4	281	15.9	222	14.7
Päijät-Häme	51	2.8	48	2.7	38	2.5
Kymenlaakso	46	2.5	38	2.2	16	1.1
South Karelia	15	0.8	15	0.9	24	1.6
Etelä-Savo	41	2.2	16	0.9	13	0.9
Pohjois-Savo	32	1.7	45	2.6	28	1.9
North Karelia	21	1.1	23	1.3	33	2.2
Central Finland	126	6.9	132	7.5	82	5.4
South Ostrobothnia	23	1.3	19	1.1	16	1.1
Ostrobothnia	37	2.0	22	1.2	37	2.5
Central Ostrobothnia	8	0.4	14	0.8	11	0.7
North Ostrobothnia	126	6.9	130	7.4	113	7.5
Kainuu	5	0.3	6	0.3	7	0.5
Lpaland	18	1.0	15	0.9	7	0.5
Åland	1	0.1	2	0.1	–	–
Domestic total	**1,738**	**94.8**	**1,690**	**95.8**	**1,447**	**96.1**
Foreign countries	58	3.2	56	3.2	51	3.4
Unknown	37	2.0	18	1.0	8	0.5
Total	**1,833**	**100.0**	**1,764**	**100.0**	**1,506**	**100.0**

1 Based on inventor's address as specified in the application
2 Regional classification system of the European Union (NUTS)

Patent applications by enterprises

Uusimaa accounted for the largest proportion of domestic patent applications filed by enterprises in all main sections of the IPC classification (Appendix Table 6.1). In the sections of electricity (46.8%), textiles and paper (46.2%) and physics (46.1%) its share was almost one-half. Pirkanmaa recorded a high proportion of applications in the physics (22%) and electricity sections (15.5%). The second highest number of electricity patent applications (18%) came from North Ostrobothnia. Central Finland accounted for a large proportion of patent applications in the textiles and paper section (21%) and in mechanical engineering (13%).

In 2003 more than one-fifth of all domestic patent applications filed by enterprises were in the electricity sector (Appendix Table 6.1). The performing operations section accounted for almost the same proportion, while applications in the physics section accounted for the third largest proportion (16%). The proportion of electricity applications has decreased considerably: in 2000 this section accounted for about 30 per cent of all applications. Among the applications filed by enterprises in North Ostrobothnia, electricity accounted for more than one-half or 55 per cent. More than half of the applications filed by inventors from Kainuu and South Karelia fell under the category of performing operations. Central Finland, for its part, specialises in patent applications in textiles and paper: this section accounted for 38 per cent of all the applications in this region. The number of patent applications by enterprises in other regions remained comparatively low.

Appendix Table 6.2 shows the breakdown of enterprises filing patent applications and domestic patent applications by industry (including joint applications). More than one-half of the enterprises and 68 per cent of their applications in 2003 represented manufacturing industries. The share of manufacturing both among enterprises and their applications decreased by around two percentage points. The largest number of patenting enterprises and applications was recorded in the metal and mechanical engineering industry, which accounted for 22 per cent of all patenting enterprises and 31 per cent of applications. The figures for the electronics industry dropped from the level in 2000, the share of enterprises by around one percentage point and the share of applications by around seven percentage points. Among non-manufacturing industries, the highest figures were found in the category of business activities (which includes patent offices and technical service companies), which accounted for 16 per cent of patenting enterprises and nine per cent of all applications.

Number of patents granted rising again

In 2003 the total number of patents granted was 2,402 (Table 6.1.4). Most of the domestic patents or 1,121 patents were granted to enterprises. Foreign applicants accounted for 48 per cent of all patents granted. The overall number of patents was up by more than 500 compared to the figures in 1999 and 2000. The number of patents granted to foreign applicants also increased on the previous year. The transfer of foreign patenting from the National Board of

Patents and Registration to the European Patent Office is reflected in the sharp increase in the number of European patents taking effect in Finland. In 2003 more than 6,200 European patents took effect in Finland. All told, the number of patents granted by the National Board of Patent and Registration that were in force in 2003 stood at 18,601, while the number of EPO patents in force was 13,362.

In 2003, 29 per cent of all patents granted to domestic applicants were in the electricity section. Among the patents granted to foreign applicants, the biggest single category was represented by the chemical and metallurgical section (35%) (Table 6.1.5). The proportion of domestic applicants was highest in

Table 6.1.4
Patents granted in Finland in 1995–2003.
Source: National Board of Patents and Registration.

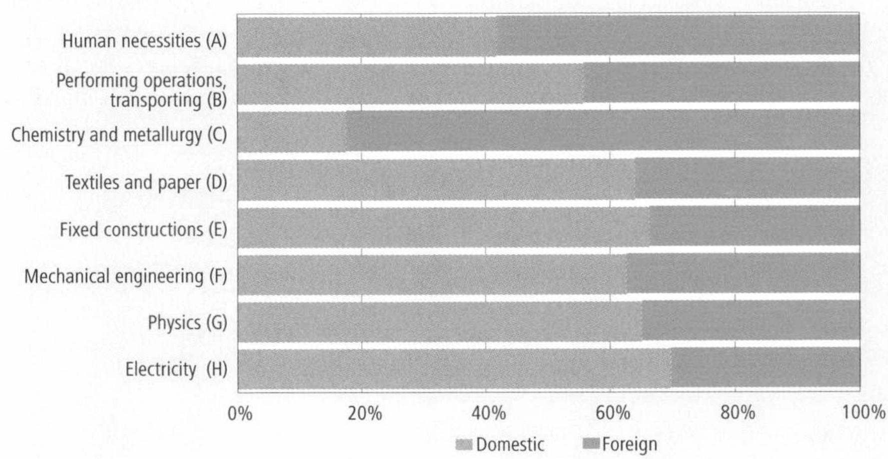
Year	Patents granted by NBPR total	of which to foreigners	EPO patents enforced in Finland[1]
1995	2,347	1,484	–
1996	2,302	1,348	–
1997	2,298	1,203	6
1998	2,064	1,106	130
1999	1,786	860	710
2000	1,939	948	1,405
2001	2,047	955	1,833
2002	2,056	986	4,259
2003	2,402	1,161	6,266

1 Finland acceded to the European Patent Convention on 1 March 1996

Table 6.1.5
Patents granted in 1999, 2001 and 2003.
Source: National Board of Patents and Registration.

Section	1999			2001			2003		
	Total	of whicf dom-estic	foreign	Total	of whicf dom-estic	foreign	Total	of whicf dom-estic	foreign
Human necessities	250	105	145	246	107	139	251	105	146
Performing methods, transporting	294	179	115	349	184	165	494	275	219
Chemistry and metallurgy	429	75	354	387	91	296	492	86	406
Textiles and paper	146	118	28	169	108	61	238	152	86
Fixed constructions	73	45	28	72	41	31	68	45	23
Mechanical engineering, lighting, heating, weapons, blasting	159	90	69	198	81	117	152	95	57
Physics	126	79	47	128	83	45	194	126	68
Electricity	309	235	74	498	397	101	513	357	156
Total	**1,786**	**926**	**860**	**2,047**	**1,092**	**955**	**2,402**	**1,241**	**1,161**

Figure 6.1.2
Patents granted to domestic and foreign applicants in Finland by section in 2003, per cent.
Source: National Board of Patents and Registration.



the electricity sector at 70 per cent. This figure was also rather higher in the categories of fixed constructions (66%) and physics (65%). In the chemical and metallurgical section, by contrast, the majority or 83 per cent of all patents were granted to foreign applicants. Foreign applicants also accounted for more than one-half of all patents granted in the human necessities section.

6.2 International patenting

European patenting shows strong growth

Following the slowdown in the early 1990s the number of European patent applications has been increasing rapidly (Figure 6.2.1). Since 1993 the total number of applications has grown at an annual rate of 7.8 per cent. Finland acceded to the European Patent Convention in 1996; since then the number of Finnish applications has climbed rapidly to around 1,500. All in all a total of 109,000 European patent applications were filed in 2001.

The EU's current 25 Member States accounted for 46 per cent of all applications filed in 2000. This share has remained at more or less the same level throughout the 1990s. The highest figure was recorded for the United States at about 27 per cent. Within the EU, Germany accounted for the largest proportion at 20 per cent, while the figures for the other major EU members France and the UK were much lower at 5.4 and 4.2 per cent, respectively. Finland accounted for 1.3 per cent of all applications, the 11th highest figure in 2003.

Figure 6.2.1
European patent applications in 1985–2001.
Source: OECD, Patent database, September 2004.

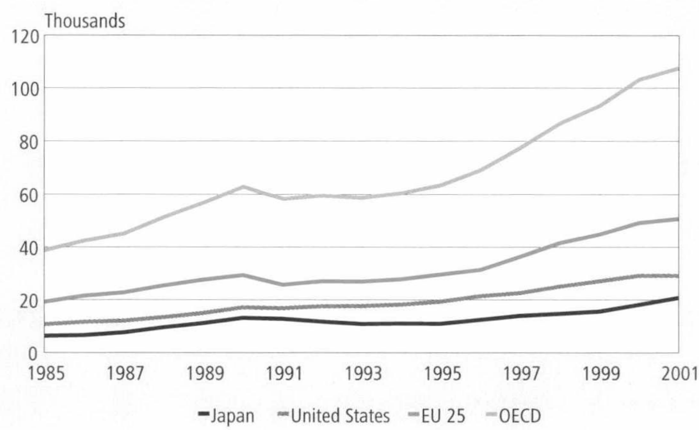
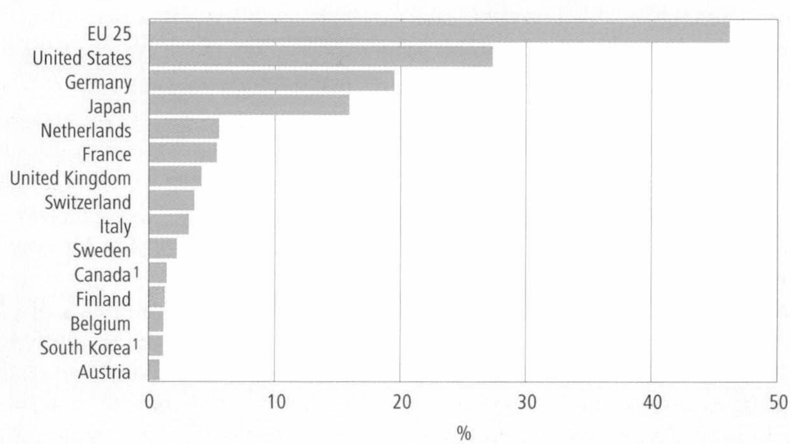


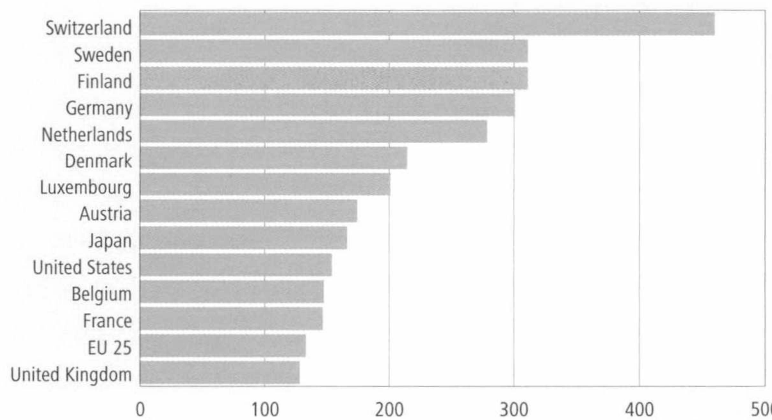
Figure 6.2.2
Selected countries' share of European patent applications in 2003.
Source: EPO Annual Report 2003.



1 Data from 2000

Relative to population, Finland recorded the third highest number of European patent applications (Figure 6.2.3). The highest figure was recorded for Switzerland at about 460 applications per one million population. In the EU countries the corresponding figure was 134 applications.

Figure 6.2.3
European patent applications per one million population in selected OECD countries in 2002.
Source: OECD, Patent database, September 2004.



In 2003 Finnish inventors filed a total of 1,480 European patent applications (including regional-stage PCT applications; Appendix Table 6.3). European patenting in Finland is very much concentrated on PCT applications; less than 30 per cent of all European applications were filed directly with the European Patent Office. Just under half of all applications filed in 2003 were addressed directly to the EPO.

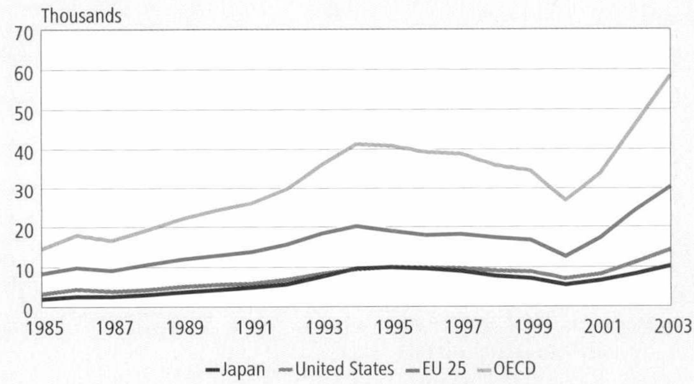
Finnish applications specified a total of 29,480 designated countries where the patent will be enforced once granted. The average number of designated countries per application was 20, the same as the average for all applications. The countries designated most often in Finnish applications were Germany, France and the UK, which accounted for five per cent of all designated countries. Finland, for its part, appeared as a designated country in 104,220 applications, or 89 per cent of all applications.

In 2003 Finnish patent applications were concentrated in the fields of paper manufacture and telecommunications. Finland had the largest share of applicants (14%) in paper technology, in telecommunications the proportion was five per cent. In relative terms Finland was the most specialised country in telecommunications technology, accounting for 41 per cent of all EPO applications. Sweden specialised in nanotechnology, Germany in engines and pumps.

60,000 European patents in 2003

Since 1985, the number of European patents granted has increased on average by eight per cent a year (Figure 6.2.4). Growth has been particularly vigorous since 2000 at almost 30 per cent a year. During the period from 1985 to 2003, the share of applications from EU countries (51%) dropped at the same time

Figure 6.2.4
European patents granted in 1985–2003.
Source: OECD, Patent database, September 2004



as the share of applications from the US and Japan increased by about six percentage points.

In 2003 Finnish inventors were granted 653 European patents. Since 2000 Finland's share of European patents has been at around the one per cent level

Table 6.2.1
European patents granted in 1999 and 2003.
Source: OECD, Patent database, September 2004.

	1999			2003		
	Patents total	ICT	Bio-technology	Patents total	ICT	Bio-technology
Netherlands	876	269	31	1,562	436	49
Sweden	S646	106	13	1,500	295	32
France	2,969	627	47	4,959	1,052	103
United Kingdom	2,020	583	76	3,239	913	159
Italy	1,268	211	19	2,469	346	26
Finland	360	104	8	653	244	10
Austria	375	50	10	759	103	17
Germany	7,554	1,253	88	13,657	2,412	208
Denmark	235	24	16	521	73	30
EU countries total	**17,028**	**3,348**	**335**	**30,806**	**6,047**	**682**
Switzerland	1,041	167	18	1,794	294	31
Japan	7,145	3,170	117	10,267	3,868	212
United States	8,849	2,788	399	14,301	4,297	722
All countries total	**35,367**	**9,803**	**935**	**59,992**	**15,153**	**1,754**

1 By inventor's country of residence

(Table 6.2.1, by inventor's country of residence). The share of Finnish patents was higher than the average for all patents in the ICT sector (1.6%), and lower than the average in biotechnology (0.6%). The US accounted for the largest proportion of all patents (24%) as well as for patents in the ICT sector (28%) and in biotechnology (41%).

The average number of designated countries in granted EPO patents was 11. In patents granted to Finland, the average number of designated countries was 12. The countries designated most often in Finnish patents were Germany (686), France (673), the UK (655), Italy (597) and Spain (440).

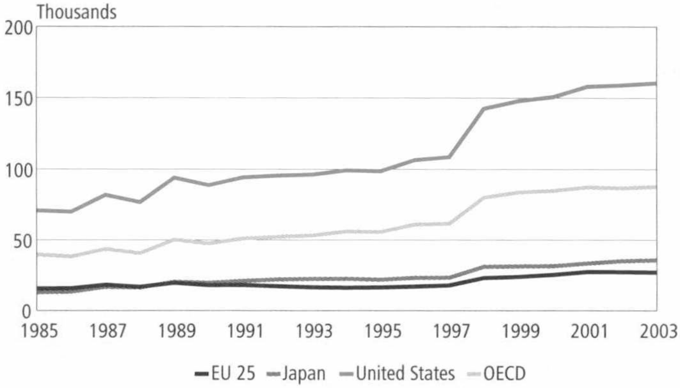
81,500 patents to foreign inventors in the United States

In 2003 a total of some 170,000 patents were granted in the United States (Figure 6.2.5). Foreign applicants accounted for 48 per cent of this figure. The combined share of EU Member States was 16 per cent, considerably less than the figures for the United States (52%) and Japan (21 %). The proportion of patents granted to foreign applicants increased by two percentage points compared to 2000.

Japan's share of all patents granted to foreign applicants in the United States has long been by far the highest (Table 6.2.2). In 2003 Japan accounted for around 44 per cent of all patents granted to foreign applicants. The second biggest country by a wide margin was Germany, accounting for 14 per cent.

Finland has accounted for around one per cent of all foreign patents granted in the United States throughout the early 2000s. In 2003 the number of patents grants stood at 870, which marks an average annual increase of 7.5 per cent since 1999. More than one-half or 450 of the patents granted to Finnish applicants were in the ICT sector. The number of patents in the biotechnology sector was 14. The highest proportions of foreign patents in the ICT sector and biotechnology were recorded for Japan (54% and 20%) and Germany (89% and 14%).

Figure 6.2.5
Patents granted in the United States1 in 1985–2003.
Source: OECD, Patent database, September 2004.



1 By inventor's country of residence

Table 6.2.2
Patents granted to selected countries[1] in the United States in 1999 and 2003.
Source: OECD, Patent database, September 2004.

	1999			2003		
	Patents total	ICT	Bio-technology	Patents total	ICT	Bio-technology
Finland	653	261	37	869	450	14
Sweden	1,405	399	52	1,511	498	59
Denmark	487	68	89	537	110	84
Austria	488	67	27	595	142	20
Germany	9,370	1,566	249	11,465	2,849	276
France	3,827	885	185	3,879	1,092	188
United Kingdom	3,602	983	234	3,646	1,249	172
Netherlands	1,265	397	84	1,331	498	64
EU 25 total	**23,768**	**5,117**	**1,110**	**26,936**	**7,660**	**985**
Switzerland	584	86	28	1,335	275	44
Japan	31,161	14,540	471	35,587	17,890	367
Other countries	14,445	5,097	491	17,643	7,380	456
Foreign countries total	**69,959**	**24,839**	**2,101**	**81,500**	**33,205**	**1,852**
United States	83,633	26,419	4,189	87,621	34,357	3,438
All countries total	153,592	51,258	**6,290**	**169,121**	**67,562**	**5,290**

1 By inventor's country of residence

6.3 Triadic patent families

Triadic patent families are defined as a set of patents granted by the European, US and Japanese authorities that share one of more priorities. In other words, these are patents issued to one and the same invention at all three patent offices.[3]

The concept of triadic patent families and the calculation method developed by the OECD are both designed to improve the international comparability of patent indicators: above all, the aim is to eliminate as far as possible the overlap that is caused in traditional indicators by the inclusion of patents granted in several countries and the impacts of domestic patenting. Furthermore, triadic patent families are a more useful indicator for purposes of assessing the significance of patented inventions. It is reasonable to assume that an invention is more significant if patent applications are filed with all three major patent offices.

A total of 43,000 triadic patent families in 2000

The number of triadic patent families has increased at an average annual rate of 4 per cent a year from 1985 to 2000. The sharpest increase was recorded between 1991 and 1999. Since then the growth rate has clearly slowed down. The same trends are seen in countries with the highest number of patent families, i.e. the United States, Japan, Germany and France (Figure 6.3.1). The to-

3 OECD (2004c)

tal number of Finnish patent families in 2000 was around 500. Finland has shown one of the fastest growth rates for triadic patent families: on average the figures have increased by 16 per cent a year.

The United States accounted for the largest proportion of all triadic patent families at 34 per cent. The combined share of EU-25 was the next highest 31 per cent, while Japan recorded the second highest figure for individual countries (29%). The number of Finnish triadic patent families more than doubled from 1991 to 2000. Nevertheless their share remained at no more than 1.1 per cent.

Figure 6.3.1
Triadic patent families in 1985–2000.
Source: OECD, Main Science and Technology Indicators.

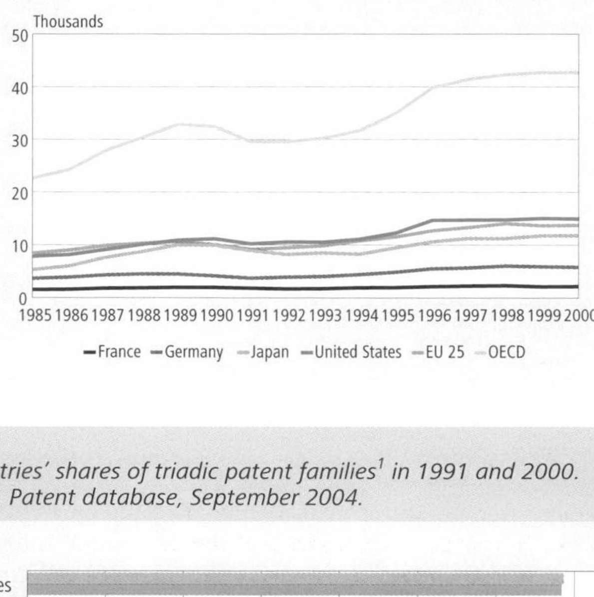
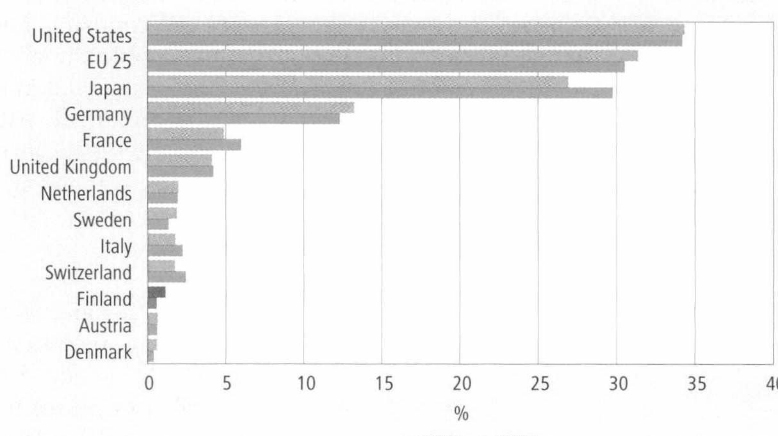


Figure 6.3.2
Selected countries' shares of triadic patent families[1] in 1991 and 2000.
Source: OECD, Patent database, September 2004.



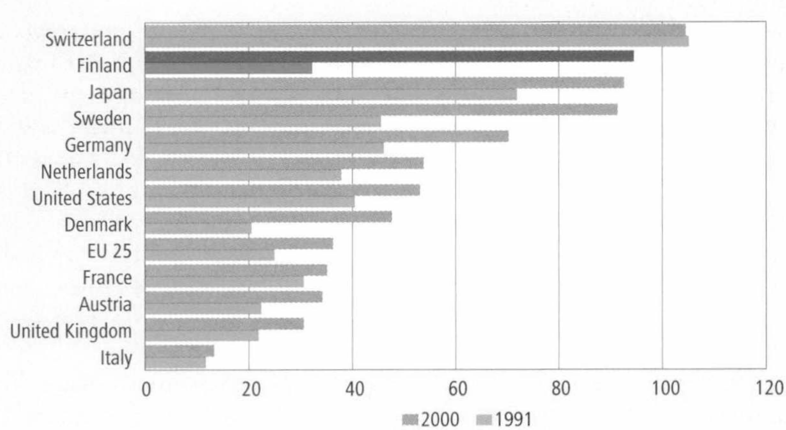
1 By inventor's country of residence.

Table 6.3.1
Triadic patent families[1] in selected countries 1996–2000.
Source: OECD, Patent database, September 2004.

	1996			1998			2000		
	Patents total	ICT	Bio-technology	Patents total	ICT	Bio-technology	Patents total	ICT	Bio-technology
Finland	342	175	9	316	141	7	74	40	2
Sweden	790	337	27	656	325	29	114	33	6
Denmark	216	31	37	190	35	27	55	8	3
Germany	5,396	1,226	164	5,416	1,159	120	2,021	337	20
France	2,103	623	88	1,931	615	88	667	193	13
United Kingdom	1,581	659	124	1,384	506	109	329	113	9
Netherlands	778	349	39	729	331	26	376	178	3
Italy	682	144	15	593	143	14	215	25	1
Austria	211	32	7	244	74	8	94	27	3
EU 25 total	**12,650**	**3,700**	**542**	**11,967**	**3,448**	**463**	**4,119**	**1,003**	**66**
Switzerland	791	147	29	704	134	11	335	66	4
Japan	10,361	4,569	274	10,084	4,348	180	7,064	2,383	54
United States	12,795	4,920	1,070	12,618	5,060	963	6,930	2,365	224
All countries total	**38,206**	**13,888**	**2,043**	**37,224**	**13,632**	**1,744**	**19,304**	**6,087**	**373**

1 Numbers of applications submitted for the same invention to EPO, JPO and USPTO in 2000 are estimates. By inventor's country of residence.

Figure 6.3.3
Triadic patent families[1] per one million population in 1991 and 2000.
Source: OECD, Patent database, September 2004



1 Numbers of applications submitted for the same invention to EPO, JPO and USPTO in 2000 are estimates. By inventor's country of residence.

Relative to population, Finland has the second highest number of triadic patent families among all OECD countries (Figure 6.3.3). The highest proportion in 2000 was recorded for Switzerland at some 105 patent families per one million population. With the exception of Switzerland, all countries recorded an increase in these numbers compared to the early 1990s Finland showed by far the biggest increase in the number of triadic patent families relative to population, which rose by 62 compared to 1991. The next highest increase was recorded for Sweden at around 45 triadic patent families.

6.4 International cooperation in patenting

This section moves on to discuss aspects of international cooperation between patent holders and patent inventors. A distinction is made between three types of cooperation:

- domestic ownership of foreign inventions, e.g. patents owned by Finnish enterprises or private individuals that have one or more foreign inventors;
- foreign ownership of domestic inventions, e.g. inventions (patents) made in Finland that have one or more foreign owners;
- patents that involve one or more foreign inventors.

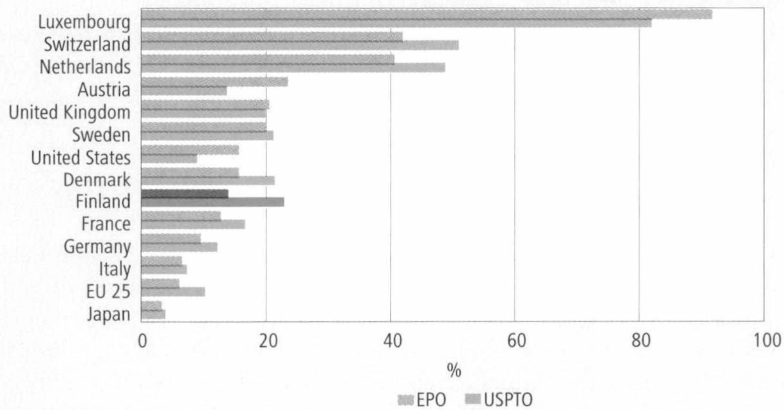
This cooperation is described by reference to patents granted by the European Patent Office (EPO) and the US Patent and Trademark Office (USPTO). The statistics presented here are gross figures and therefore neither the total nor the country numbers are exactly the same as those presented above.

Ownership of foreign patents is at the highest level in small countries. This is explained in part by the location of major corporations in these countries. Much of their product development is done elsewhere. The largest number of foreign inventions was owned by US and German patent holders. However, given the high overall number of patents in these countries, internationalisation was at a relatively low level.

Ownership of foreign inventions was by far the highest in Luxembourg, where over 80 per cent of EPO patents and over 90 per cent of USPTO patents had a foreign inventor (Figure 6.4.1.). However the overall number of patents granted was low, no more than some 60 a year. Among the countries with significant patenting activities, the highest proportion was recorded for Switzerland, where some 40 per cent of EPO patents and around half of USPTO patents had a foreign inventor. The figures recorded in the Netherlands were at almost the same level as in Switzerland. About one-quarter or 23 per cent of all USPTO patents granted to Finnish applicants had a foreign inventor, among EPO patents the share was noticeably lower at 14 per cent. Internationalisation in European patents was lowest in Japan (4%) and Italy (6%).

In the 1990s the number of domestic applications for inventions made abroad increased most in Finland, Sweden and Switzerland. In 2000, 23 per cent of EPO patents applications filed by Finnish applicants had a foreign inventor, showing an increasing of 13 percentage points from 1992. In Swedish applications the share

Figure 6.4.1
Domestic ownership of foreign inventions,[1] per cent.
Source: OECD, Patent database, September 2004.



1 Foreign inventions owned by domestic applicants as a proportion of all patents granted by the EPO and USPTO, average for 1999, 2001 and 2003

was 27 per cent, showing an increase of 14 percentage points, and in Swiss applications 47 per cent, up by 11 percentage points[4] (OECD 2004).

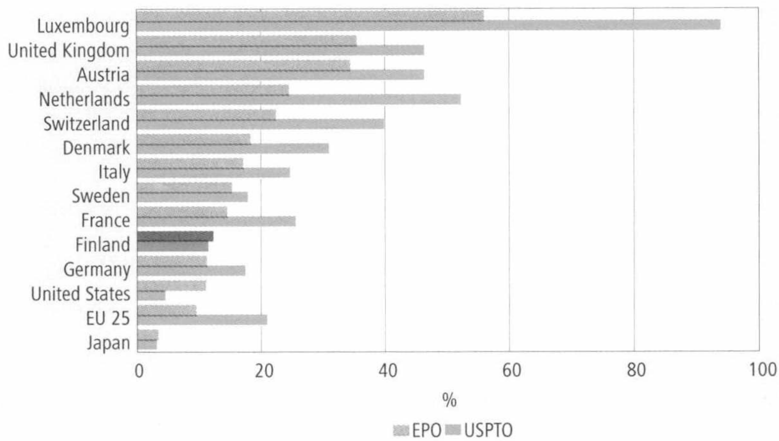
As the process of internationalisation gathers momentum and companies continue to relocate their operations in new countries, the number of domestic inventions owned by foreign patent holders will continue to rise. In 2000 the two countries with the highest proportion of foreign applicants for EPO patents on domestic inventions were Luxembourg and Russia: in both cases 60 per cent of these applications were filed by a foreign applicant[5].

Studied by reference to the number of patents granted (Figure 6.4.2), Luxembourg again had the largest proportion of foreign owners of domestic inventions: the proportion for EPO patents was 56 per cent and for USPTO patents 95 per cent. The next highest figures were recorded for the UK and Austria, where 34 per cent of EPO patents and 46 per cent of USPTO patents had a foreign applicant (or a joint foreign applicant). The proportion of foreign applicants for inventions made in Finland was around 13 per cent, both in the case of European and US patents. At the EU level the figure for EPO patents was around ten per cent and for USPTO patents around 20 per cent.

The involvement of foreign inventors in domestic innovation provides a measure of the internationalisation of scientific activities and product development. Joint patenting has generally shown a tendency to increase. Foreign inventors were involved in 12 per cent of all Finnish inventions for which an EPO application was filed in 2000. This was up by almost four percentage points on the figure in the early 1990s[6].

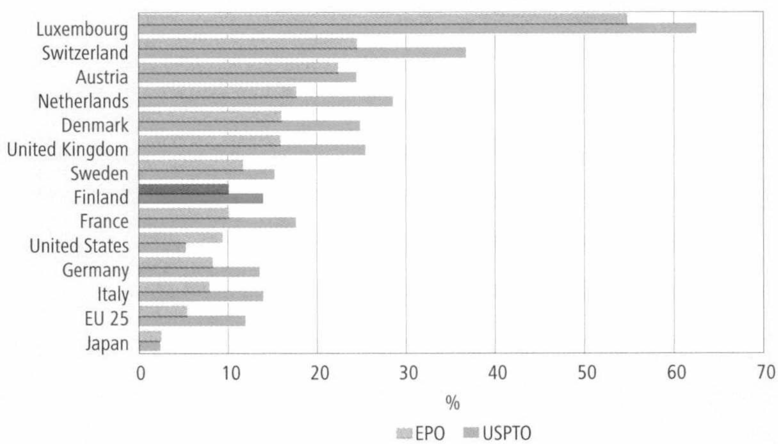
4 OECD (2004d)
5 OECD (2004d)
6 OECD (2004d)

Figure 6.4.2
Foreign ownership of domestic inventions,[1] per cent.
Source: OECD, Patent database, September 2004.



1 Domestic inventions owned by foreign applicants as a proportion of all patents granted by the EPO and USPTO, average for 1999, 2001 and 2003

Figure 6.4.3
Joint inventions[1] as a percentage of domestic inventions.
Source: OECD, Patent database, September 2004.



1 Patents with at least one foreign inventor as a proportion of all patents granted by the EPO and USPTO, average for 1999, 2001 and 2003

The proportion of joint innovations was highest for patents granted to applicants from Luxembourg, 55 per cent in the case of EPO patents and 63 per cent in USPTO patents. In major countries with high levels of patenting such as Germany and the United States, the proportion of joint inventions was relatively low: for EPO patents the figure was less than 10 per cent. In Finnish patents the proportion of joint inventions was around 12 per cent, both for EPO patents and USPTO patents.

In 2003 European patents owned by Finnish holders had the highest number of inventors from Germany, the United States and Sweden (Table 6.4.1). In patents granted in the United States, the largest number of inventors came from the United States, Germany and the United Kingdom.

Among patents granted by the EPO for inventions made in Finland, the largest number of patent owners came from Sweden and the United States. As for patents granted in the United States, the largest number of patent owners were from the United States, followed by Sweden at almost the same level and by Switzerland.

In both EPO and USPTO patents, the largest number of joint inventions was recorded with Swedish, US and British inventors.

Table 6.4.1
Partner countries in patents granted to Finnish inventors in 2003.
Source: OECD, Patent database, September 2004.

Partner's country of residence	Finnish holder, foreign inventor		Foreign holder, Finnish inventor		Domestic invention, foreign inventor involved	
	European patents	US patents	European patents	US patents	European patents	US patents
Austria	4	5		1	4	5
Switzerland	2	5	8	13	2	8
Germany	29	35	4	5	5	8
Denmark	8	21	1	3	2	3
France	1	3	1	2	1	5
United Kingdom	18	33	3	6	11	12
Italy	3	4	1		3	3
Japan		7		2		1
Netherlands	2	5	1	7	2	5
Sweden	16	21	30	25	20	14
United States	25	87	16	31	17	43
Foreign cooperation total	**116**	**239**	**69**	**100**	**67**	**115**
Patents total	**697**	**996**	**686**	**926**	**686**	**926**

Appendix Table 6.1
Patent applications by enterprises and associations by patent category and region[1] in 2003, per cent.
Source: National Board of Patents and Registration.

Patent category	Total	IPC section[2]							
		A	B	C	D	E	F	G	H
Uusimaa	39.2	27.7	37.6	35.2	46.2	20.0	24.5	46.1	46.8
Itä-Uusimaa	0.9	0.8	1.5	1.4	0.0	0.0	1.0	0.8	0.9
Varsinais-Suomi	8.5	15.4	10.7	13.8	2.8	18.5	7.1	6.5	4.1
Satakunta	3.1	0.0	5.6	9.7	0.7	7.7	2.0	0.8	0.6
Kanta-Häme	1.4	1.5	2.4	1.4	1.4	3.1	1.0	0.4	0.9
Pirkanmaa	14.7	9.2	13.0	15.2	11.9	13.8	11.2	22.0	15.5
Päijät-Häme	2.5	5.4	3.3	3.4	0.0	3.1	6.1	0.4	1.8
Kymenlaakso	1.1	1.5	1.2	0.0	3.5	1.5	1.0	0.8	0.0
South Karelia	1.6	3.1	3.6	0.0	1.4	0.0	2.0	0.4	0.9
Etelä-Savo	0.9	3.8	0.3	0.0	2.1	1.5	0.0	1.2	0.6
Pohjois-Savo	1.9	6.2	2.1	2.8	1.4	6.2	0.0	0.4	0.3
North Karelia	2.2	5.4	2.7	0.7	1.4	12.3	5.1	0.8	0.0
Central Finland	5.4	3.1	3.8	1.4	21.7	3.1	13.3	4.5	1.5
South Ostrobothnia	1.1	0.8	2.7	0.0	0.0	3.1	4.1	0.0	0.0
Ostrobothnia	2.5	1.5	2.7	0.7	2.1	0.0	11.2	1.2	2.3
Central Ostrobothnia	0.7	1.5	0.9	2.1	0.0	0.0	2.0	0.0	0.6
North Ostrobothnia	7.5	8.5	1.2	4.8	0.7	0.0	3.1	9.8	18.1
Kainuu	0.5		1.2	0.0	0.0	3.1	0.0	0.8	0.0
Lapland	0.5	2.3	0.3	0.0	0.0	1.5	1.0	0.4	0.0
Åland	–	–	–	–	–	–	–	–	–
Domestic total	**96.1**	**97.7**	**96.4**	**92.4**	**97.2**	**98.5**	**95.9**	**97.6**	**94.7**
Unknown / foreign country	3.9	2.3	3.6	7.6	2.8	3.1	4.1	2.9	5.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Uusimaa	100.0	6.1	21.5	8.6	11.2	2.2	4.1	19.1	27.1
Itä-Uusimaa	100.0	7.1	35.7	14.3	0.0	0.0	7.1	14.3	21.4
Varsinais-Suomi	100.0	15.6	28.1	15.6	3.1	9.4	5.5	12.5	10.9
Satakunta	100.0	0.0	41.3	30.4	2.2	10.9	4.3	4.3	4.3
Kanta-Häme	100.0	9.5	38.1	9.5	9.5	9.5	4.8	4.8	14.3
Pirkanmaa	100.0	5.4	19.8	9.9	7.7	4.1	5.0	24.3	23.9
Päijät-Häme	100.0	18.4	28.9	13.2	0.0	5.3	15.8	2.6	15.8
Kymenlaakso	100.0	12.5	25.0	0.0	31.3	6.3	6.3	12.5	0.0
South Karelia	100.0	16.7	50.0	0.0	8.3	0.0	8.3	4.2	12.5
Etelä-Savo	100.0	38.5	7.7	0.0	23.1	7.7	0.0	23.1	15.4
Pohjois-Savo	100.0	28.6	25.0	14.3	7.1	14.3	0.0	3.6	3.6
North Karelia	100.0	21.2	27.3	3.0	6.1	24.2	15.2	6.1	0.0
Central Finland	100.0	4.9	15.9	2.4	37.8	2.4	15.9	13.4	6.1
South Ostrobothnia	100.0	6.3	56.3	0.0	0.0	12.5	25.0	0.0	0.0
Ostrobothnia	100.0	5.3	23.7	2.6	7.9	0.0	28.9	7.9	21.1
Central Ostrobothnia	100.0	18.2	27.3	27.3	0.0	0.0	18.2	0.0	18.2
North Ostrobothnia	100.0	9.7	3.5	6.2	0.9	0.0	2.7	21.2	54.9
Kainuu	100.0	0.0	57.1	0.0	0.0	28.6	0.0	28.6	0.0
Lapland	100.0	42.9	14.3	0.0	0.0	14.3	14.3	14.3	0.0
Åland	–	–	–	–	–	–	–	–	–
Domestic total	**100.0**	**8.8**	**22.5**	**9.3**	**9.6**	**4.4**	**6.5**	**16.5**	**22.4**
Unknown / foreign country	100.0	5.1	20.3	18.6	6.8	3.4	6.8	11.9	30.5
Total	**100.0**	**8.6**	**22.4**	**9.6**	**9.5**	**4.3**	**6.5**	**16.3**	**22.7**

1 Inventors identified, gross (same person may be identified in more than one application)
2 A: Human necessities, B: Performing operations, transporting, C: Chemistry and metallurgy, D: Textiles and paper, E: Fixed constructions, F: Mechanical engineering, G: Physics, H: Electricity

Appendix Table 6.2
Enterprises filing patent applications and applications by industry in 2000–2003.
Source: National Board of Patents and Registration.

Industry	2000		2001		2002		2003	
	Enter-prises	Appli-cations	Enter-prises	Appli-cations	Enter-prises	Appli-cations	Enter-prises	Appli-cations
	no.	no.	no.	no.	no.	no.	no.	no.
Manufacturing total	308	1 343	296	1137	323	1,093	272	1 032
Food industry	17	28	10	23	15	30	8	14
Textiles, clothing and leather industry	4	5	6	12	5	11	2	2
Wood processing industry	18	46	20	52	25	65	21	57
Chemical industry	36	126	34	102	45	99	36	92
Metal and engineering industry	131	526	125	467	142	509	117	475
Electronics industry	73	561	69	419	64	336	61	355
Other manufacturing	29	51	32	62	27	43	27	37
Electricity, gas and water supply	1	1	3	3	2	2		
Construction	17	19	19	23	21	26	7	10
Wholesale trade and commission trade	49	81	54	75	50	79	47	65
Transport, storage and communication	10	100	14	94	15	64	18	65
Computer and related activities	41	64	61	94	53	87	39	60
Research and development	25	99	30	118	30	90	23	115
Other business activities	88	146	104	176	83	147	84	132
Other business activities	33	45	35	55	33	46	37	47
Enterprises total	**572**	**1,898**	**616**	**1,775**	**610**	**1,634**	**527**	**1,526**

	2000		2001		2002		2003	
	Enter-prises	Appli-cations	Enter-prises	Appli-cations	Enter-prises	Appli-cations	Enter-prises	Appli-cations
	%	%	%	%	%	%	%	%
Manufacturing total	53.8	70.8	48.1	64.1	53.0	66.9	51.6	67.6
Food industry	3.0	1.5	1.6	1.3	2.5	1.8	1.5	0.9
Textiles, clothing and leather industry	0.7	0.3	1.0	0.7	0.8	0.7	0.4	0.1
Wood processing industry	3.1	2.4	3.2	2.9	4.1	4.0	4.0	3.7
Chemical industry	6.3	6.6	5.5	5.7	7.4	6.1	6.8	6.0
Metal and engineering industry	22.9	27.7	20.3	26.3	23.3	31.2	22.2	31.1
Electronics industry	12.8	29.6	11.2	23.6	10.5	20.6	11.6	23.3
Other manufacturing	5.1	2.7	5.2	3.5	4.4	2.6	5.1	2.4
Electricity, gas and water supply	0.2	0.1	0.5	0.2	0.3	0.1	0.0	0.0
Construction	3.0	1.0	3.1	1.3	3.4	1.6	1.3	0.7
Wholesale trade and commission trade	8.6	4.3	8.8	4.2	8.2	4.8	8.9	4.3
Transport, storage and communication	1.7	5.3	2.3	5.3	2.5	3.9	3.4	4.3
Computer and related activities	7.2	3.4	9.9	5.3	8.7	5.3	7.4	3.9
Research and development	4.4	5.2	4.9	6.6	4.9	5.5	4.4	7.5
Other business activities	15.4	7.7	16.9	9.9	13.6	9.0	15.9	8.7
Other business activities	5.8	2.4	5.7	3.1	5.4	2.8	7.0	3.1
Enterprises total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Appendix Table 6.3
European applications by patent category in selected countries in 2003.
Source: European Patent Office Annual Report 2003.

Patent category	Applying Finland	Sweden	Germany	France	United Kingdom	Netherlands	Switzerland	Japan	United States	Other	Total
Agriculture	12	35	175	68	47	72	53	73	199	228	962
Foodstuffs, tobacco	11	9	188	51	80	178	132	90	240	280	1,259
Personal effects and domestic articles	11	34	375	240	137	107	112	147	371	684	2,218
Health	47	226	846	287	344	182	336	585	2,988	1,200	7,041
Prep. for med. dent. or toilet purposes	28	101	1,170	588	337	168	246	464	1,973	929	6,004
Preparing and mixing	41	43	696	207	158	146	140	364	997	428	3,220
Shaping	49	139	1,296	258	141	104	221	714	1,249	913	5,084
Printing	8	12	303	27	48	49	70	552	529	250	1,848
Transporting	63	184	2,588	783	349	213	424	1,297	1,591	1,433	8,925
Micro-structural technology, nanotechnology	1	6	20	4	2	4	4	9	37	26	113
Inorganic chemistry	9	19	333	155	53	54	36	343	414	317	1,733
Organic chemistry	26	188	1,267	354	405	206	419	769	2,056	890	6,580
Macromolecular compounds	43	9	666	176	73	132	138	635	980	346	3,198
Dyes, petroleum, animal and veg. oils	6	6	421	82	188	225	139	358	825	182	2,432
Fermentation, sugar, skins	22	48	698	207	188	233	132	449	1,643	609	4,229
Metallurgy	19	39	264	72	32	33	46	396	369	237	1,507
Textiles and flexible materials	4	5	318	75	38	40	110	183	265	314	1,352
Paper	79	29	189	18	11	20	11	41	120	56	574
Building	37	70	845	254	178	106	114	125	214	759	2,702
Mining	2	9	27	27	39	56	6	6	211	67	450
Engines, pumps	17	63	1,279	178	120	28	71	771	787	404	3,718
Engineering in general	16	85	1,045	214	117	38	73	493	605	462	3,148
Lighting, heating	37	49	525	146	70	87	72	259	347	467	2,059
Weapons, blasting	5	42	100	52	17	0	13	15	64	81	389
Instruments	199	367	3,556	1,207	945	2,123	674	4,623	6,991	2,330	23,015
Nucleonics	1	7	41	18	5	8	0	23	45	36	184
Electric techniques	74	181	2,002	598	260	635	215	2,489	2,407	1,129	9,990
El. and electric comm. techn.	611	554	1,425	1,073	458	1,157	168	2,254	3,323	1,463	12,486
Unclassified	2	3	43	12	3	55	5	7	23	40	193
Total	**1,480**	**2,562**	**22,701**	**7,431**	**4,843**	**6,459**	**4,180**	**18,534**	**31,863**	**16,560**	**116,613**

7 Innovation in enterprises

One of the motives behind the development of innovation indicators has been the need to gain a more complete picture of technological development than that provided by R&D and patenting data alone. Whereas R&D expenditure measures the investment made in development and patents statistics describe applications of new technologies and methods, innovation surveys are concerned with the outcomes of development, with the new products brought to the marketplace or with the new processes introduced. Innovations may be based upon research and product development or patents, but also upon know-how obtained in other ways. In this sense innovation statistics are more comprehensive in their coverage than R&D and patents statistics. As well as measuring the outputs themselves, innovation surveys are interested in various aspects related to how those outputs have come about, such as sources of in-

On definitions of innovation

The concept of innovation is used in various contexts. In a broad sense one may refer to the innovation system or innovation policy; in a narrower sense, innovation may be taken to refer to an incremental improvement to a product, for instance. The most advanced statistics available are those that measure commercial innovations by business enterprises – which is also the focus of the present chapter. A new area that has attracted increasing attention of late is the notion of social innovations. Although some sketches have been offered in theoretical and empirical research to unravel their essence, there is no established statistical description of social innovations and they are therefore excluded from the discussion here.

International guidelines for compiling innovation statistics are provided in the OECD's Oslo Manual,[1] which defines an innovation as a new product, service or production method. Organisational and managerial reforms are excluded from this definition. The technological emphasis attached to innovation means that changes confined to the physical appearance or design of a product do not qualify as innovations.

The definitions applied in the EU's third innovation survey in 2000 (CIS3, Community Innovation Survey) and in Statistics Finland's innovation survey in 2002 for product and process innovations were as follows:

A product innovation is a product or service that is either new or significantly improved with respect to its fundamental characteristics (e.g. intended use, technical specifications, incorporated software or other immaterial components, user friendliness). Changes of a solely aesthetic nature are not included.

A process innovation includes new or significantly improved production technology, methods of supplying services or of delivering products. A process innovation has a significant impact for instance on the level of output, quality of products or services, or costs of production and distribution.

An enterprise has engaged in innovation activity if it has had innovations or projects aimed at innovations.

1 OECD (1997a)

formation, costs, structures of cooperation, and obstacles to innovation. One of the difficulties in innovation surveys is that much of the relevant data cannot be readily extracted from business accounting, but they have to be separately collected on the basis of respondents' own assessments.

Chapter 7.1 below describes the structure of innovation activity in Finland on the basis of Statistics Finland's survey in 2002. International comparative data are available from the EU's third innovation survey; the results of that survey are discussed under chapter 7.2.

7.1 Extent of innovation activity

The most recent information available on innovation in business enterprises dates from 2002. The definitions applied were the same as those used two years previously in the EU innovation survey, with which these data are compared. However, it needs to be pointed out that whereas the EU data in 2000 were collected separately in a dedicated innovation survey, the data in 2002 were collected by means of extra innovation items added to an annual R&D inquiry. Comparability may be affected by differences in response rates, for instance, which in the statutory R&D survey was around 80 per cent but in the voluntary EU innovation survey no more than 50 per cent.

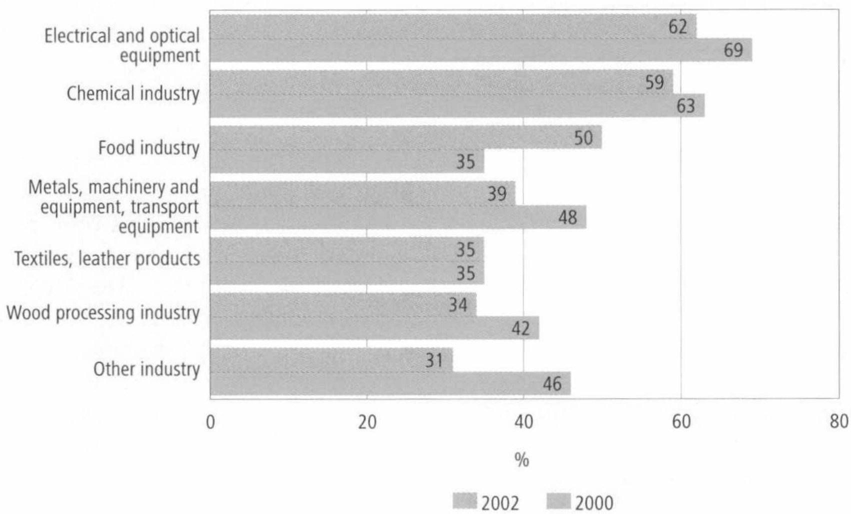
Innovation activity reported by 41 per cent of manufacturing enterprises in 2002

The number of manufacturing enterprises with innovation activities dropped by eight percentage points compared to 2000, when 49 per cent reported having innovation activity. In 2000–2002, around 30 per cent of manufacturing firms with at least 10 employees said they had brought new products to the marketplace. Process innovations were reported by 20 per cent of manufacturing firms. These figures were also down on those for 1998–2000, when product innovations were reported by 37 per cent and process innovations by 24 per cent of manufacturing enterprises.

The level of innovation activity was highest in the electronics industry, where 57 per cent of enterprises reported new products or processes and just over 60 per cent reported innovation activity in 2000–2002. The next highest figures were recorded for the manufacture of machinery and equipment and for the chemical industry, where innovations were reported by 45–55 per cent of enterprises and innovation activity by 55–60 per cent. Innovation was also at a comparatively high level in the food industry, where 45 per cent of firms reported innovations. In basic metals, metal products, the manufacture of machinery and wood processing, on the other hand, the figure was somewhat lower at 30 per cent (Appendix Table 7.1).

Compared to the results for 2000, the proportion of enterprises with innovation activities declined in all other industries except foodstuffs, where the figure actually increased, as well as the textile industry, where the proportion remained unchanged. The biggest decline was recorded in the category of

Figure 7.1.1
Proportion of innovating manufacturing enterprises with at least 10 employees in 1998–2000 and 2000–2002.
Source: Statistics Finland, Innovation Statistics.



other industry, which here included publishing and printing, glass and stone products, furniture and sports goods. However, there was also a clear decrease in innovation activity in industries that carry greater weight, i.e. in the metal, engineering and electronics industries, where the proportion of enterprises reporting innovation activity declined by 7–9 percentage points.

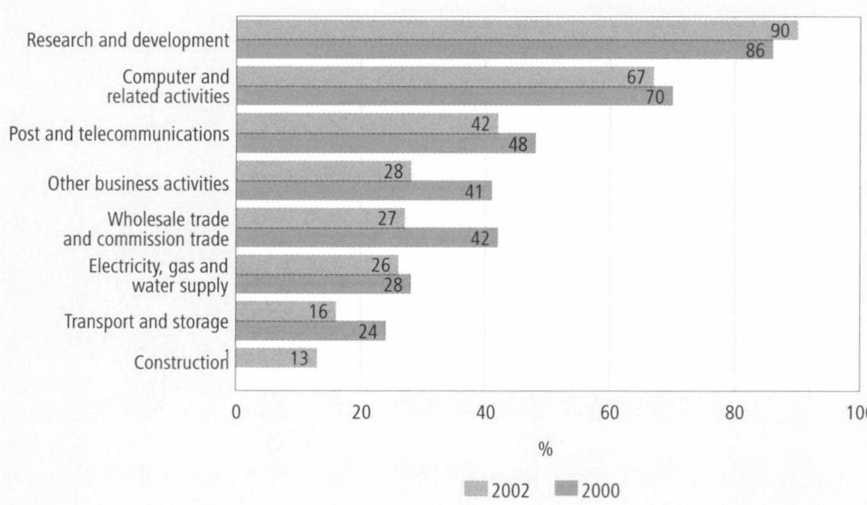
Within the structure of innovation activity, process innovations had the greatest relative significance in the wood processing industry, where 23 per cent of enterprises reported both product and process innovations. In the food industry, too, process innovations had greater than average significance. The electronics industry was clearly concentrated on product innovations: one-half of the enterprises in this sector reported product innovations, while the proportion of process innovations was around 30 per cent. In the metal and engineering industry, too, product innovations account for the bulk of innovation activity.

High level of innovation activity in computer and related activities

Outside industrial manufacturing, the largest number of innovations was recorded in computer and related activities and research and development, where 55–60 per cent of enterprises reported new products, services or processes (Figure 7.1.2). In terms of innovation activity these sectors stand apart from the others even more. It is self-explanatory from the industry definition itself that virtually all enterprises in the R&D sector engage in innovation activity. One indication is provided by the fact that almost 80 per cent of R&D enterprises reported 'not yet completed innovation projects', which in practice means ongoing R&D activities. However, even in computer and related activities the proportion of enterprises with innovation activities is 67 per cent, which is more than in the electronics industry, for instance. Among post and telecommunications firms some 40 per cent had innovation activities in 2000-2002. In the energy supply sector and wholesale, the proportion was less than 30 per cent.

In service industries, too, the number of enterprises engaging in innovation was lower than in 2000, with the single exception of the research sector. The sharpest decrease of about 15 percentage points was seen in wholesale and other business activities. In computer and related activities, on the other hand, there was no marked change in the number of enterprises with innovation activities.

Figure 7.1.2
Proportion of innovating service sector enterprises with at least 10 employees in 1998–2000 and 2000–2002.
Source: Statistics Finland, Innovation Statistics.



1 No data in 2000

Few innovations in transport and construction

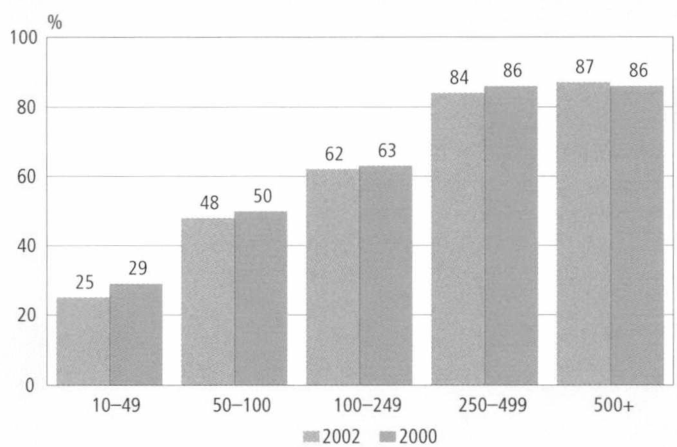
In the construction industry as well as in transport and storage, 13–16 per cent of enterprises reported innovation activities. In 2000–2002, no more than one in ten enterprises in these industries had launched new products or services. In transport services the number of enterprises with innovation activities dropped by eight percentage points compared to 2000.

Innovation activities declined mainly in small enterprises

Enterprise size provides a stronger explanation for the prevalence of innovation activity than industry sector (Figure 7.1.3). This has its background in the greater financial resources of major enterprises, but also in the fact that one single innovative product, service or process suffices to qualify an enterprise as an innovating one. One-quarter of enterprises with 10–49 employees engaged in innovation in 2000–2002, among enterprises with more than 250 staff the figure was close to 90 per cent. Compared to 2000, the proportion of innovating enterprises with 10–49 employees decreased by four percentage points. In companies with more than 100 employees, only minor changes were seen.

Cooperation ties in closely with innovation. In 2000–2002, 64 per cent of innovating enterprises were actively involved in R&D or other innovation projects together with other enterprises, research institutes or universities.

Figure 7.1.3
Proportion of innovating enterprises in 2000–2002 by number of employees, manufacturing and services (excluding construction).
Source: Statistics Finland, Innovation Statistics.



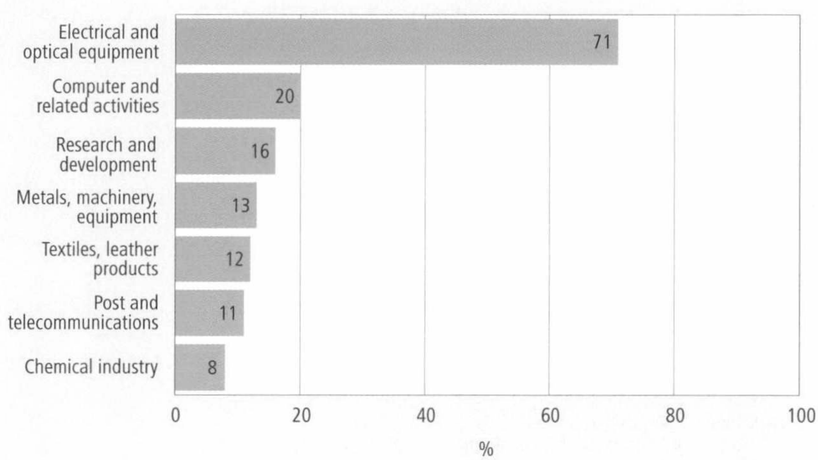
More than two-thirds of electronics industry turnover attributable to innovations

The economic significance of innovation activity has been measured primarily in two different ways, i.e. in terms of the costs incurred from innovation and in terms of the impacts of innovation on turnover. Innovation costs consist in large part of traditional R&D expenditure, and therefore the real novelty offered by innovation surveys is provided by output indicators based on turnover.

Some 70 per cent of the turnover from the manufacture of electrical and optical equipment was attributable to product innovations, i.e. new products introduced in the market during the past three years. In other manufacturing industries innovations accounted for 5–13 per cent of turnover. In computer and related activities, one-fifth of the turnover consisted of innovative products or services. By contrast in the energy supply sector and transport services, innovations account for no more than around one per cent of turnover.

Like innovation activity, the proportion of turnover attributable to innovations increases with enterprise size. In enterprises with less than 100 employees, new products or services account for five per cent of turnover; in enterprises with 100–500 employees the figure is less than ten per cent; and in enterprises with more than 500 staff almost 30 per cent.

Figure 7.1.4
Product or service innovations as a proportion of turnover in selected industries in 2002. Source: Statistics Finland, Innovation Statistics.



7.2 Community innovation survey

One indication of the importance attached in EU policy to promoting innovation is provided by the fact that Eurostat has now coordinated and partly funded three innovation surveys covering all member states at those times. One of the difficulties with the Eurostat survey lies in the length of time required by production: the latest data currently available are from the period 1998–2000. Although the data have been collected using harmonised methods, differences in interpreting the questions in different countries, differences in response rates and other similar factors may have affected the comparability of the results. The comparisons here include the EU-15 member states for which data have been available and the EEA countries Norway and Iceland.

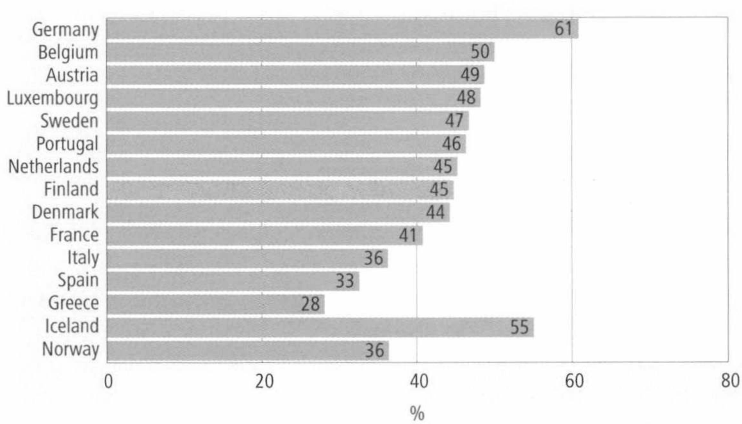
German enterprises show the highest level of innovation activity

By far the highest level of innovation activity was seen in Germany, where some 60 per cent of enterprises in 1998–2000 had product or process innovations or activities aimed at such innovations. In most EU-15 countries the proportion of innovating enterprises was 44–50 per cent. Finland also ranked among these countries in this intermediate group. The figure was lowest in Greece at 28 per cent, but in the other Mediterranean countries of Spain and Italy, too, only about one-third of enterprises engaged in innovation.

As a general rule, manufacturing enterprises reported more innovation activity that service sector enterprises. The biggest difference in favour of manufacturing was seen in Belgium, the Netherlands and Denmark at about 16 percentage points (Appendix Table 7.2). In Finland 49 per cent of manufacturing enterprises reported innovation activities, in the service sector the figure was 40 per cent. Among the EU countries only Greece and Portugal had more innovating service enterprises than innovating manufacturing enterprises.

The EU survey has used a number of different variables to study factors related to innovation activity. The following looks at some aspects of cooperation, information sources and obstacles to innovation.

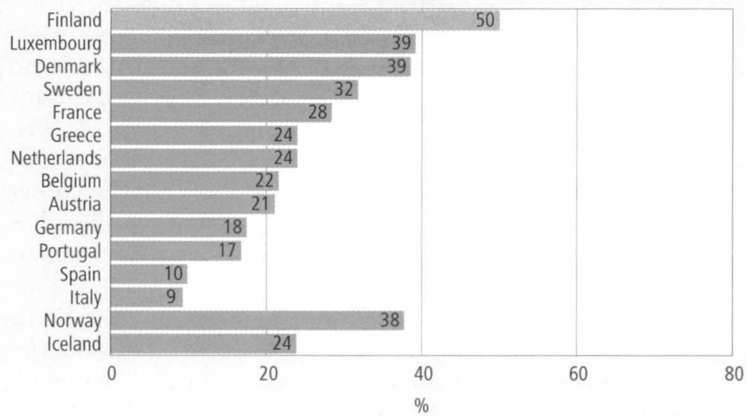
Figure 7.2.1
Innovating enterprises in 1998–2000 by country.
Source: Eurostat, Community Innovation Survey (CIS3).



Finland strong in innovation cooperation

In a European comparison Finnish innovating enterprises showed by far the highest level of active involvement in joint R&D and other innovation projects with other organisations (Figure 7.2.2). The country differences in terms of

Figure 7.2.2
Enterprises involved in innovation cooperation in 1998–2000 by country, proportion of enterprises reporting innovation activity.
Source: Eurostat, Community Innovation Survey (CIS3).



participation in cooperation were much more pronounced than for innovation activities as such. Whereas in Finland every other innovating enterprise reported cooperation, the next highest proportion was recorded in Luxembourg and Denmark at 39 per cent. It is noteworthy that in Germany, which had by far the highest proportion of innovating enterprises, no more than 18 per cent of these reported involvement in cooperation. Italy and Spain stood out as countries where both innovation activity and related cooperation were well below the EU average.

Customers an important source of information for innovation in Sweden

Asked about the importance of different sources of information for innovation,[1] almost half of the innovating enterprises in Sweden regarded the information they received from customers as highly significant. This was much higher than in the next group of countries: Germany, France, Luxembourg, Denmark and Norway, where the corresponding figures were around 35 per cent. In Finland the proportion was 25 per cent. Customers were considered an important source of information for innovations least often in the Netherlands, Italy and Iceland. However, it is important to observe that among Finnish enterprises two-thirds regarded the information they received from customers as at least significant, which together with Germany was the second

1 The weight of each factor was measured on a four-tiered scale: high significance, significant, low significance; not relevant.

highest figure in the EU. In Sweden the combined share of significant and highly significant responses was 80 per cent (Appendix Table 7.3).

The development of innovations is also supported by contacts with universities and the new information they produce. Generally speaking universities were considered a less significant source of information for innovations than customers. Seven per cent of German, Swedish and Greek enterprises rated universities as a highly significant source of information; the figures for the other EU countries were in the region of 2–5 per cent. The differences are greater when we look at the proportion of enterprises that regard universities as at least a significant source of information for innovation. In this analysis Finland, Sweden and Germany stand apart from all other countries with a figure of around 20 per cent. In Belgium, Austria and Greece the corresponding proportion is about 15 per cent, but for instance in Italy no more than six per cent.

French and Dutch enterprises report less often obstacles to innovation

There are various potential obstacles that may hamper innovation. In Finland and Sweden, 12–14 per cent of innovating enterprises regarded the costs involved in innovation activity as a major problem. It seems that the cost factor is a much bigger problem for German and Austrian enterprises, but also for Spanish and Greek enterprises, where 30–33 per cent of innovating enterprises indicated that costs represented a major obstacle to innovation (Appendix Table 7.4).

One issue that has received much attention in the innovation policy debate is the availability of a well-educated and competent workforce. This would seem to be a problem most particularly in Germany, where one-quarter of innovating enterprises in 1998–2000 rated this as a significant obstacle to innovation. The difference compared to France, for instance, is considerable: here no more than three per cent considered the availability of competent staff a serious problem. Likewise, it seems that at least for the time being the lack of competent staff is not a major problem in Finland, as just seven per cent of innovating enterprises considered this a significant factor.

Overall enterprises in France, the Netherlands and Iceland rated the above factors as major obstacles to innovation far less often than others.

Appendix Table 7.1
Innovation activities in enterprises by industry and size class in 2000–2002.
Source: Statistics Finland, Innovation Statistics.

Industry	Innovations			Innovation projects			Innovations	Product or innovations proportion of turnover
	Total	Products or services	Processes	Total	Not yet completed	Suspended		
	%							
All enterprises	**27**	**24**	**15**	**20**	**19**	**4**	**32**	**18**
Manufacturing total	**35**	**31**	**21**	**28**	**27**	**6**	**41**	**27**
Food industry	45	40	33	34	33	6	50	8
Textiles, leather products	27	26	18	20	20	1	35	12
Wood processing industry	30	23	23	21	21	3	34	7
Chemical industry	48	44	32	44	42	12	59	8
Metals, machinery and equipment, transport equipment	31	28	17	26	24	5	39	13
Electrical and optical equipment	57	52	31	51	49	13	62	71
Other industry	27	23	15	20	19	3	31	5
Electricity, gas and water supply	21	15	9	20	19	5	26	1
Construction	10	9	3	7	6	1	13	6
Wholesale trade and commission trade	23	20	10	14	13	2	27	4
Transport and storage	12	9	7	7	6	2	16	1
Post and telecommunications	37	29	24	32	29	15	42	11
Computer and related activities	60	55	32	44	42	12	67	20
Research and development	54	46	29	77	74	15	90	16
Other business activities	26	24	18	14	14	3	28	4
Employees								
10– 49	21	19	12	14	13	2	25	5
50– 99	39	33	22	30	29	6	48	5
100–249	52	47	31	48	46	10	62	9
250–499	72	66	44	68	68	18	84	8
500+	79	72	63	81	78	35	87	28

Appendix Table 7.2
Enterprises with innovation activities with at least 10 employees in 1998–2000.
Source: Eurostat, Community Innovation Survey (CIS3).

	Total	Manufacturing	Services
	%		
Austria	49	53	45
Belgium	50	59	42
Denmark	44	52	37
Finland	45	49	40
France	41	46	34
Germany	61	66	57
Greece	28	27	33
Italy	36	40	25
Luxembourg	48	49	48
Netherlands	45	55	38
Portugal	46	45	50
Spain	33	37	25
Sweden	47	47	46
Iceland	55	54	56
Norway	36	39	34

Appendix Table 7.3
Importance of sources of information for innovation activities in 1998–2000.
Source: Eurostat, Community Innovation Survey (CIS3).

Importance of source of information	Source of information					
	Customers			Universities		
	highly important	important	total	highly important	important	total
	%	%	%	%	%	%
Austria	21	33	54	5	10	15
Belgium	28	31	59	5	11	16
Denmark	35	19	54	4	8	12
Finland	26	39	64	3	18	21
France	34	25	59	2	9	11
Germany	35	29	64	7	14	21
Greece	26	20	46	7	8	14
Italy	15	19	34	2	3	6
Luxembourg	33	18	52	2	6	9
Netherlands	17	35	52	2	6	8
Portugal	21	28	50	4	6	9
Spain	20	26	46	3	7	10
Sweden	48	32	80	7	16	23
Iceland	16	11	27	1	5	6
Norway	35	33	69	3	11	13

Appendix Table 7.4
Importance of obstacles to innovation activities in 1998–2000.
Source: Eurostat, Community Innovation Survey (CIS3).

	Costs of innovation activity			Lack of competent personnel		
	highly important	important	total	highly important	important	total
	%	%	%	%	%	%
Austria	29	38	68	16	30	46
Belgium	10	17	27	11	17	28
Denmark	–	–	–	–	–	–
Finland	12	27	39	7	29	36
France	9	9	18	3	9	12
Germany	32	34	66	24	30	55
Greece	30	27	57	18	22	40
Italy	17	22	39	11	17	28
Luxembourg	11	20	30	8	19	27
Netherlands	6	10	16	9	10	19
Portugal	26	29	55	17	24	41
Spain	33	29	62	14	26	40
Sweden	14	24	38	13	25	38
Iceland	8	13	21	3	7	9
Norway	16	26	43	4	17	22

8 Employment and production by technology level

The role and meaning of technology development and the application of new methods varies in different types of business activity. However the industry classification does not classify business activities according to their technology intensity, but the allocation of industries to different technology levels is based on data on R&D expenditure. OECD calculations are based on R&D expenditure as a proportion of gross production and value added.[1] In the service sector the measurement of technology level is more difficult than in manufacturing because R&D statistics for services are less comprehensive than in manufacturing and have not been compiled for as long. Nevertheless it is possible in the service sector to identify a separate category of knowledge-intensive high technology services.[2]

High technology manufacturing *(Nace code)*[1]

Pharmaceuticals (244), computers and office machinery (30), electronics and telecommunications equipment (32), instruments and precision products (33), aerospace (353)

Medium-high technology manufacturing

Chemical products (24 excluding 244), machinery and equipment (29), electrical machinery and apparatus (31), transport equipment (34, 352, 354, 355)

Medium-Low technology manufacturing

Manufacture of refined petroleum products (23), manufacture of rubber and plastic products (25), manufacture of non-metallic mineral products (26), manufacture of basic metals (27), manufacture of fabricated metal products (28), building of ships and boats (351)

Low technology manufacturing

Manufacture of food products and beverages (15, 16), manufacture of textiles and wearing apparel (17, 18, 19), manufacture of wood and wood products (20), manufacture of pulp and paper (21), publishing and printing (22), manufacturing n.e.c. (36), recycling (37)

Knowledge-intensive high technology services

Post and telecommunications (64), computer and related activities (72), research and development (73)

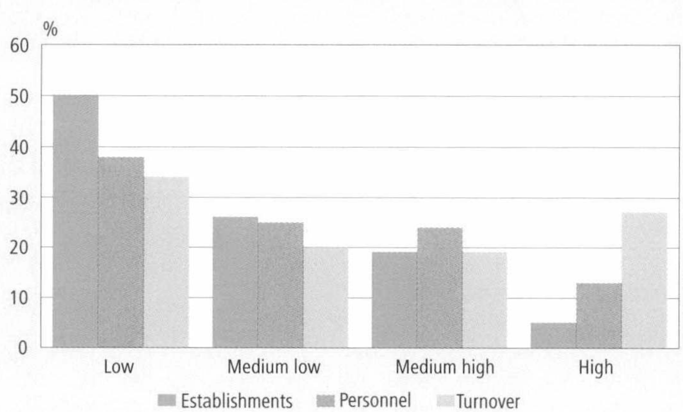
1 Statistical classification of economic activities in the European Community, Nace Rev.1.1.

1 OECD (2003c).
2 Eurostat (2004c).

Two in three high technology jobs in the manufacture of communication equipment

In 2002 some 54,000 persons were employed in high technology establishments, representing 13 per cent of the total manufacturing workforce. The manufacture of communication equipment accounted for 64 per cent of all personnel working in high technology establishments. Some 12,000 people worked in the manufacture of instruments and just over 4,000 in the manufacture of pharmaceuticals. Measured in terms of turnover, the high technology industry cluster has much greater significance, accounting for more than one-quarter of the turnover of all manufacturing establishments. The same is true for the manufacture of communication equipment, which accounts for almost 90 per cent of the turnover of all high technology establishments (Appendix Table 8.3). High technology industries is the only category where the industry's share of total manufacturing turnover exceeds its corresponding share of personnel (Figure 8.1). Furthermore, the average personnel number in high technology establishments is greater than in other categories; the only exception is the manufacture of instruments, which is concentrated in much smaller units (the same applies to the manufacture of computers, although the volumes here are comparatively low).

Figure 8.1
Breakdown of the number, personnel and turnover of manufacturing establishments by technology level in 2002.
Source: Statistics Finland, Business Register.



Increased turnover for high technology establishments

The turnover of high technology establishments as a proportion of total manufacturing turnover has increased sharply from 10 per cent in 1995 to almost 27 per cent in 2002. Their share of total manufacturing personnel has also increased by a few percentage points: in 2002 high technology establishments employed 15,000 persons more than they did in 1995. On the other hand there has been no major change in the overall number of establishments. Among individual high technology industries the most noteworthy change has been seen in the manufacture of computers and office machinery, which has virtually disappeared from Finland. In 1995 it still employed 3,000 persons, but in 2002 the figure was down to less than 500.

Knowledge-intensive high technology services (KISHT)[3] account for around nine per cent of total employment in the service sector and for just over six per cent of service sector turnover. Since 1995 there has been hardly

Figure 8.2
High technology establishments' share of the number, personnel and turnover of manufacturing establishments in 1995–2002.
Source: Statistics Finland, Business Register.

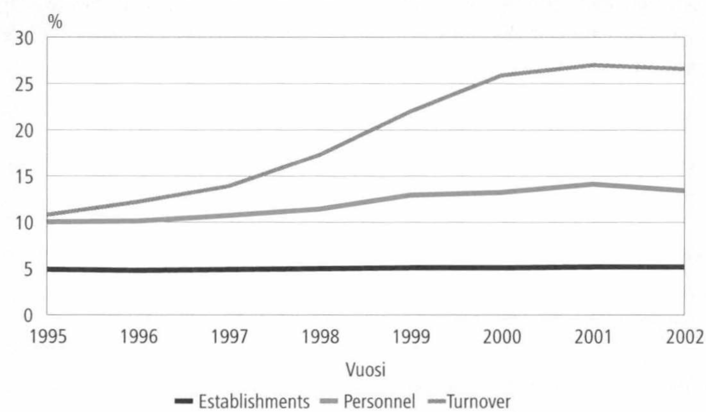
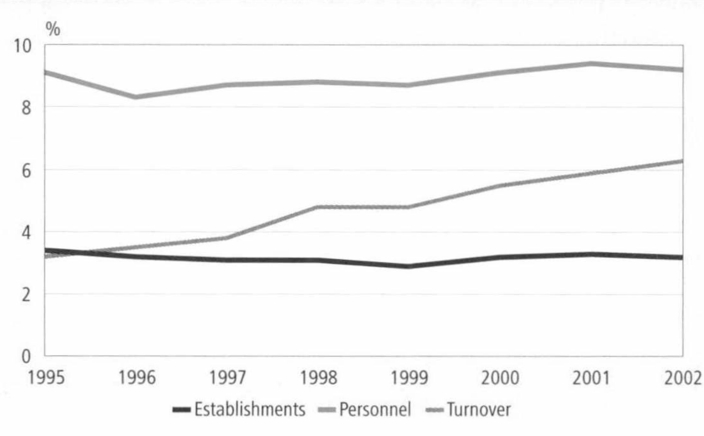


Figure 8.3
Knowledge-intensive high technology services' share of the number, personnel and turnover of service sector establishments in 1995–2002.
Source: Statistics Finland, Business Register.



3 KISHT = Knowledge-intensive high technology services, see Eurostat (2004b).

any change in their share of personnel or the total number of establishments, but their share of turnover has increased (Figure 8.3). In spite of this knowledge-intensive high technology services account for a larger proportion of service sector personnel than they do of turnover in this sector, which contrasts the situation in manufacturing. In the KISHT category computer and related activities have shown strong growth, employing 16,000 persons in 1995 and 36,000 persons in 2002.

High technology industry has a strong role in North Ostrobothnia, Uusimaa, Varsinais-Suomi and Kainuu

In 2002 some 13 per cent of manufacturing employees worked in high technology industries. The proportion is highest in North Ostrobothnia at 31 per cent. The next highest figure is recorded for Uusimaa at 28 per cent, followed by Varsinais-Suomi and Kainuu where 22 per cent of manufacturing jobs are in high technology industries. The regional differences are considerable: in Pirkanmaa the figure is still 14 per cent, but in all other regions it is less than 10 per cent, and in many cases no more than a few per cent (Appendix Table 8.4). On the other hand when we look at the share of knowledge-intensive high technology services as a proportion of all service sector jobs, the regional differences are much less pronounced. The share of telecommunications, computer and research services is highest in Uusimaa at 12 per cent. In Pirkanmaa and Central Finland the figure is around 10 per cent, in most other regions around 6–8 per cent.

In absolute terms high technology jobs are concentrated in Uusimaa: in manufacturing the region accounts for 42 per cent of high technology jobs and in the service sector for 54 per cent. Other regions with a large share of high technology manufacturing jobs include North Ostrobothnia and Varsinais-Suomi (16–17 per cent) and Pirkanmaa (13 per cent), which in the service sector ranks second after Uusimaa with its 9 per cent share.

R&D quite heavily concentrated in high technology industries

High technology industries account for around 70 per cent of R&D expenditure in manufacturing and for 54 per cent of total R&D expenditure in the business enterprise sector.[4] The corresponding figures for research personnel are 54 per cent in manufacturing and 44 per cent in the business sector. In other words high technology industries have a rather dominant position in business sector R&D, even accounting for the fact that the definition of technology level itself is based on R&D activities. This industry category accounts for a much greater share of R&D than it does of economic activity as described above. In the service sector knowledge-intensive high technology services account for 68 per cent of R&D expenditure. However, it is important to note that the R&D statistics do not cover all service industries.

4 R&D and innovation data apply to the enterprise level in contrast to the establishment data above.

Table 8.1
R&D expenditure by technology level in 2002.
Source: Statistics Finland, Research and Development

	R&D personnel	Person-years in research	R&D expenditure EUR million
Total	**39,239**	**30,321**	**3,375.1**
Manufacturing total	28,181	23,070	2,617.1
High technology industries	17,092	15,048	1,806.1
Medium high technology industries	5,965	4,550	490.0
Medium low technology industries	2,504	1,588	145.8
Low technology industries	2,620	1,884	175.2
Services	10,943	7,194	751.5
Knowledge-intensive high technology services	7,136	5,162	513.5
Other services	3,807	2,031	238.1
Other industries	115	58	6.4

High technology industries are also the most active in terms of introducing new products in the marketplace and in developing and applying new production methods, although the difference compared to medium-high technology firms is not as pronounced as in R&D activities. In 2000–2002, 56 per cent of high technology enterprises had launched product innovations, in medium-high industries the figure was 44 per cent. Both of these figures were well above the business sector average of 24 per cent. Product innovations' share of turnover in high technology industries, on the other hand, was in a class of its own: in 2002 three-quarters of their turnover came from new products. With the exception of turnover share mentioned above, innovation activity in general in knowledge-intensive high tech-

Table 8.2
Innovation activity in enterprises by technology level in 2002.
Source: Statistics Finland, Innovation Statistics.

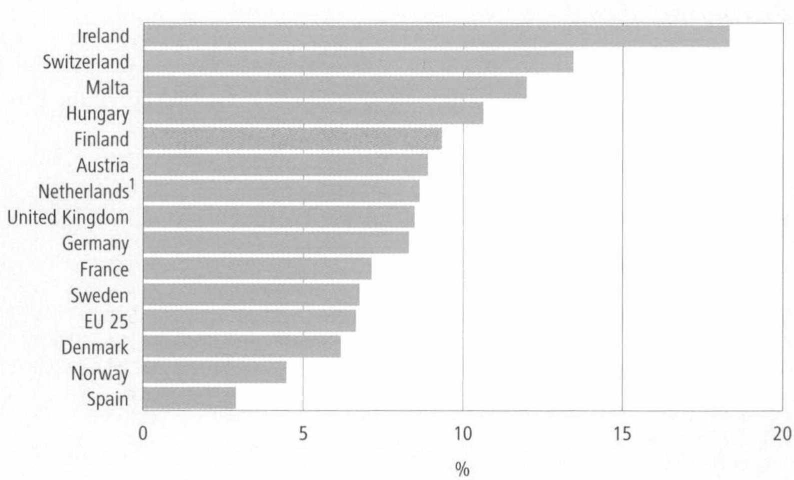
	Product or process innovations	Product or innovations	Process innovations	Product or innovations as proportion of turnover
	%	%	%	%
Total	**26.8**	**23.6**	**15.2**	**18.1**
Manufacturing total	35.1	31.1	21.2	27.5
High technology industries	62.7	56.3	33.5	75.1
Medium high technology industries	47.0	44.3	23.0	15.3
Medium low technology industries	24.6	20.9	17.8	8.2
Low technology industries	31.6	26.8	20.8	7.3
Services	20.9	18.4	10.9	5.0
Knowledge-intensive high technology services	55.1	49.3	30.4	13.4
Other services	16.4	14.3	8.4	3.3

nology services was almost at the same level as in high technology manufacturing industries. The KISHT group differed noticeably from other service industries: for instance every other KISHT enterprise had product or service innovations, while the figure in other service industries was 14 per cent.

High technology employment in Finland above European average

Compared with a sample of other European countries, Finland has relatively high numbers of people working in high technology manufacturing as a proportion of the total manufacturing workforce (Figure 8.4 and Appendix Table 8.5).[5] In Finland high technology industries account for just over nine per cent of employment, compared to the EU average of 6.6 per cent. The figure in Finland is higher than in any other Nordic country. The country with by far the highest rate of employment in high technology is Ireland, where the figure is 18 per cent. The proportions are also high in Switzerland and in the new EU member Hungary. The major EU member states cluster around the EU average, but in Spain, Greece and Portugal, for instance, no more than 1–3 per cent of the manufacturing workforce are employed in high technology industries.

Figure 8.4
Employment in high technology industries as a proportion of total employment in selected European countries in 2003.
Source: Eurostat, New Cronos.



1 Data from 2002

5 The figures for employment in high technology differ from those based on the establishment data drawn from Statistics Finland's Business Register (Figure 8.1 and Appendix Table 8.2). There are two reasons for this: First, the source here is the EU Labour Force Survey which is conducted at enterprise level; and second, for reasons of data limitations, the following are counted among high technology industries: computer and office machinery (30), communication equipment (32) and instruments (33).

Appendix Table 8.1
Number of establishments by technology level in 1995–2002.
Source: Statistics Finland, Business Register.

	1995	1998	2000	2002
Total	**205,990**	**233,128**	**238,747**	**243,647**
Manufacturing	26,009	28,214	27,618	27,484
High technology industries	1,277	1,409	1,404	1,438
Pharmaceuticals	37	39	35	43
Computers and office machinery	63	63	58	61
Communication equipment	326	374	372	374
Instruments	833	915	924	947
Aerospace	18	18	15	13
Medium high technology industries	4,739	5,044	4,982	5,118
Chemical products	343	372	367	378
Machinery and equipment	3,553	3,797	3,758	3,858
Electrical machinery and apparatus	514	519	521	549
Transport equipment	329	356	336	333
Medium low technology industries	6,386	7,162	7,101	7,226
Low technology industries	13,607	14,599	14,131	13,702
Services	179,981	204,914	211,129	216,163
Knowledge-intensive high technology services	6,107	6,290	6,794	6,841
Post and telecommunications	3,020	2,325	2,213	1,881
Computer and related activities	2,914	3,725	4,316	4,638
Research and development	173	240	265	322
Other services	173 874	198 624	204 335	209 322

Appendix Table 8.2
Number of personnel in establishments by technology level in 1995–2002.
Source: Statistics Finland, Business Register.

	1995	1998	2000	2002
Total	**1,067,254**	**1,169,571**	**1,237,308**	**1,261,148**
Manufacturing	381,007	392,853	402,609	400,554
High technology industries	38,026	44,745	53,307	53,785
Pharmaceuticals	3,996	4,138	4,131	4,266
Computers and office machinery	3,069	2,780	945	455
Communication equipment	19,522	24,819	34,498	34,482
Instruments	8,394	9,683	10,776	11,812
Aerospace	3,045	3,326	2,957	2,771
Medium high technology industries	91,749	93,140	93,533	94,855
Chemical products	14,326	13,274	12,850	13,099
Machinery and equipment	53,282	54,018	54,982	56,745
Electrical machinery and apparatus	14,974	15,633	16,046	16,095
Transport equipment	9,167	10,216	9,655	8,916
Medium low technology industries	83,339	92,100	97,498	99,952
Low technology industries	167,893	162,869	158,272	151,962
Services	686,248	776,719	834,698	860,594
Knowledge-intensive high technology services	62,590	68,207	76,125	79,278
Post and telecommunications	43,641	42,816	40,840	40,535
Computer and related activities	15,785	22,221	31,983	36,354
Research and development	3,163	3,170	3,301	2,389
Other services	623,658	708,512	758,574	781,316

Appendix Table 8.3
Turnover of establishments by technology level in 1995–2002.
Source: Statistics Finland, Business Register.

	1995	1998	2000	2002
	EUR million			
Total	**162,335**	**207,216**	**256,068**	**268,377**
Manufacturing	57,855	74,237	97,560	99,006
High technology industries	6,231	12,820	25,307	26,324
Pharmaceuticals	387	479	589	751
Computers and office machinery	928	1,191	452	70
Communication equipment	3,933	9,839	22,581	23,482
Instruments	879	1,193	1,578	1,915
Aerospace	104	118	107	107
Medium high technology industries	12,151	15,896	18,199	18,824
Chemical products	3,103	3,801	4,253	4,506
Machinery and equipment	6,166	8,282	9,836	10,181
Electrical machinery and apparatus	1,848	2,723	3,015	2,916
Transport equipment	1,034	1,091	1,095	1,220
Medium low technology industries	12,008	14,737	19,391	19,875
Low technology industries	27,465	30,785	34,663	33,982
Services	104,480	132,979	158,509	169,371
Knowledge-intensive high technology services	3,345	6,378	8,729	10,676
Post and telecommunications	1,854	3,581	4,922	6,498
Computer and related activities	1,388	2,597	3,486	4,006
Research and development	103	200	320	172
Other services	101,135	126,602	149,780	158,695

Appendix Table 8.4
Employment in high technology industries by region in 2002.
Source: Statistics Finland. Business Register.

Region (NUTS3)[1]	High techno-logy industries	Manu-facturing total	High technology share of manu-facturing personnel %	Region's share of high technology personnel %	Knowledge-intensive high technology services	Services total	Knowledge-intensive services' share of service personnel %	Region's share of knowledge-intensive service personnel %
Total	**53,785**	**400,554**	**13.4**	**100.0**	**79,278**	**860,594**	**9.2**	**100.0**
Uusimaa	22,395	81,412	27.5	41.6	42,446	354,194	12.0	53.5
Itä-Uusimaa	151	7,703	2.0	0.3	222	10,934	2.0	0.3
Varsinais-Suomi	9,340	42,932	21.8	17.4	5,048	71,610	7.0	6.4
Satakunta	184	22,985	0.8	0.3	1,867	29,680	6.3	2.4
Kanta-Häme	204	14,034	1.5	0.4	1,215	22,082	5.5	1.5
Pirkanmaa	6,700	47,177	14.2	12.5	6,731	65,690	10.2	8.5
Päijät-Häme	391	20,501	1.9	0.7	1,819	27,066	6.7	2.3
Kymenlaakso	210	15,695	1.3	0.4	1,137	27,555	4.1	1.4
south Karelia	82	11,462	0.7	0.2	1,378	17,438	7.9	1.7
Etelä-Savo	347	9,608	3.6	0.6	916	17,429	5.3	1.2
Pohjois-Savo	1,139	14,912	7.6	2.1	2,637	29,491	8.9	3.3
North Karelia	251	10,923	2.3	0.5	1,143	16,640	6.9	1.4
Central Finland	1,827	21,114	8.7	3.4	3,058	31,999	9.6	3.9
South Ostrobothnia	205	14,775	1.4	0.4	1,235	22,095	5.6	1.6
Ostrobothnia	474	17,464	2.7	0.9	1,819	21,347	8.5	2.3
Central Ostrobothnia	50	4,873	1.0	0.1	549	8,078	6.8	0.7
North Ostrobothnia	8,797	28,673	30.7	16.4	4,125	48,232	8.6	5.2
Kainuu	873	3,990	21.9	1.6	485	8,524	5.7	0.6
Lapland	154	9,252	1.7	0.3	1,252	22,980	5.4	1.6
Åland	9	1,069	0.8	0.0	198	7,532	2.6	0.2

1 Regional classification system of the European Union (NUTS)

Appendix Table 8.5
Manufacturing personnel in selected countries by technology level in 2003.
Source: Eurostat, New Cronos.

	Total	High	Medium high	Medium low	Low	High	Medium high	Medium low	Low
	1 000 persons					%			
EU 25	34,068.8	2,258.6	10,455.6	8,274.3	13,080.2	6.6	30.7	24.3	38.4
EU 15	30,380.6	2,045.1	9,585.8	7,370.8	11,378.9	6.7	31.6	24.3	37.5
Belgium	720.1	29.3	231.0	177.5	282.4	4.1	32.1	24.7	39.2
Czech Republic	1,305.7	57.3	352.3	406.1	490.0	4.4	27.0	31.1	37.5
Denmark	425.2	26.2	139.2	98.8	161.0	6.2	32.7	23.2	37.9
Germany	8,257.0	684.1	3,281.6	1,954.7	2,336.6	8.3	39.7	23.7	28.3
Estonia	129.9	8.1	11.6	21.3	88.9	6.3	8.9	16.4	68.4
Greece	514.1	11.7	68.2	118.0	316.1	2.3	13.3	23.0	61.5
Spain	2,969.0	85.7	772.0	768.8	1,342.5	2.9	26.0	25.9	45.2
France	4,075.4	290.0	1,272.1	1,068.2	1,445.0	7.1	31.2	26.2	35.5
Ireland	283.2	51.9	59.9	55.5	115.9	18.3	21.1	19.6	40.9
Italy	4,948.8	249.3	1,387.9	1,279.1	2,032.5	5.0	28.0	25.8	41.1
Lithuania	265.7	10.4	34.2	29.7	191.5	3.9	12.9	11.2	72.1
Luxembourg	18.2	0.9	1.7	11.4	4.2	4.9	9.1	62.7	23.2
Hungary	925.8	98.2	226.1	186.8	414.7	10.6	24.4	20.2	44.8
Malta	28.8	3.4	5.7	5.2	14.5	12.0	19.8	18.0	50.3
Netherlands1	1,030.8	88.8	243.5	197.6	500.9	8.6	23.6	19.2	48.6
austria	713.0	63.3	166.2	216.2	267.2	8.9	23.3	30.3	37.5
Portugal	1,016.0	14.4	145.0	197.1	659.6	1.4	14.3	19.4	64.9
Slovenia	264.2	8.1	72.1	68.9	115.1	3.1	27.3	26.1	43.6
Slovakia	567.9	25.3	148.0	153.1	241.5	4.5	26.1	27.0	42.5
Finland	453.9	42.3	122.2	101.6	187.8	9.3	26.9	22.4	41.4
Sweden	702.3	47.4	258.6	164.3	232.0	6.7	36.8	23.4	33.0
United Kingdom	4,253.7	359.9	1,436.8	961.9	1,495.2	8.5	33.8	22.6	35.1
Norway	282.5	12.6	89.9	48.1	131.9	4.5	31.8	17.0	46.7
Switzerland	603.2	81.0	199.1	121.1	202.0	13.4	33.0	20.1	33.5

1 Data from 2002

9 Foreign trade in high technology products

This Chapter looks at technology application and technology transfer from the vantage-point of foreign trade in high technology. Research and development generates new knowledge and new technology, the industrial application of which leads to new production processes and products and to foreign trade in technology-intensive products. Indicators are available to describe the development of the structure and volume of foreign trade in different countries as well as their competitiveness and success in the international science and technology-intensive markets.

Overall demand for high technology products has continued to strengthen and at the same time their share of total trade has increased. The positive impacts of the broad and extensive use of these products on economic productivity and growth are well known. High technology products are more clearly oriented to the international marketplace than less technology-intensive products.[1] Indeed, they provide a useful measure of the country's ability to take advantage of and commercialise the results of research and technological innovations. A high level of trade in high technology products as a proportion of total foreign trade is associated with a high level of R&D investment, productivity growth and well-paid and high qualification jobs.

The domestic data on foreign trade presented here are from the ULTIKA database maintained by the National Board of Customs, the foreign data are from the OECD's international trade statistics.

Defining the concept of high technology

The concept of high technology can be approached from an industry, enterprise or product point of view, or in terms of the technical features of the technology concerned[2]. For statistical purposes the most useful approach is to focus on industry and products. The OECD has divided industries into four different categories according to their R&D intensity. Today's high technology industries are Aerospace; Pharmaceuticals; Computers and office machinery; Electronics-communications and Scientific instruments (the latter since 2001). A similar principle is used to define high technology product groups.

1 OECD (2003c)
2 OECD (1995b) and OECD (1997b)

High technology product groups

One difficulty with an industry approach is that not all enterprises within the high technology sector have a very high level of R&D intensity, nor do all their products necessarily meet the criteria of high technology products. High technology products are also produced by other than high technology industries. Indeed a product perspective gives us a more accurate picture of high technology production that does an industry perspective. The product list is based on calculations of R&D intensity for different product groups.

There are nine high technology product groups as based on the current OECD definition. High technology products are defined as those where R&D costs amount to at least 4 per cent of industry turnover. The main product groups are as follows:

- Aerospace
- Computers and office machinery
- Electronics and telecommunications
- Pharmaceuticals
- Scientific instruments
- Electrical machinery
- Chemicals
- Non-electrical machinery
- Armaments

A detailed list of high technology product groups and products complete with SITC Rev. 3 item descriptions is attached in Appendix 9.1.

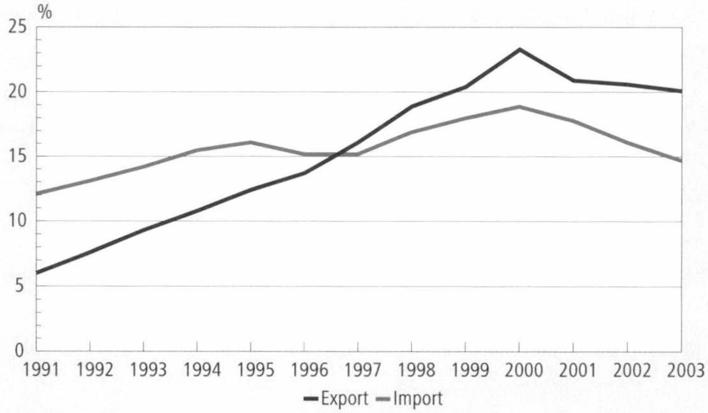
9.1 *Finnish foreign trade in high technology products*

High technology products account for one-fifth of Finland's exports

Finnish high technology exports as a proportion of total exports increased throughout the 1990s, climbing from just six per cent in 1991 to its highest level ever at over 23 per cent in 2000. In the new millennium the figure has dropped back somewhat, standing at 20 per cent in 2003. This is no major collapse, however, because with the exception of the peak year 2000 the share has been at virtually the same level since 1999. The share of high technology exports exceeded the figure for imports for the first time in 1997, and in 2003 the share of exports was more than five percentage points higher than the share of imports.

The trends for high technology imports from 1991 to 2003 have been quite closely in line with those for exports. In imports, too, the peak of 19 per cent was reached in 2000, and since then the figure has dropped back to less than 15 per cent, around the same level as in the mid-1990s. Indeed the share of imports has decreased clearly more than the share of exports. The margin between the two figures was last at this level in 1992, although at that time the difference was in favour of imports.

Figure 9.1.1
Finnish high technology exports and imports as a proportion of total exports and imports in 1991–2003.
Source: National Board of Customs, ULTIKA.



Value of high technology exports in excess of 9 billion euros

In 2003 the value of high technology exports from Finland totalled around 9.3 billion euros, down by over 400 million euros or around four per cent on the previous year. Compared to 2000, however, the figure has dropped by 2.2 billion euros or almost 20 per cent. In spite of these trends over the past couple of years, the value of exports remains much higher than in 1999. The depression in high technology exports since 2000 is more prominent than in other products, where a fallback of one billion euros translates into a drop of just less than three per cent. The rapid longer term growth of high technology exports is clearly illustrated by the fact that in 2003, the value of exports was ten-fold compared to 1991, when the current growth trend started (Appendix Table 9.1). At the same time exports of other products increased 2.5-fold. During the period from 1991 to 2003, the value of high technology exports increased on average by 21 per cent a year, for other products the figure was eight per cent.

In 2003 the value of high technology imports was more than 5.3 billion euros. Imports also fell back by almost 400 million euros or six per cent compared to the previous year. After four consecutive years of decline, the value of imports now stands at the same level as in 1999. In this analysis, too, the trends for imports over the past few years have been more dramatic than for exports. Imports of other products, by contrast, rose to record levels in 2003. However the value of high technology imports tripled and during the period from 1991 to 2003 increased on average by close to 10 per cent a year, or one-half of the figure recorded for export growth.

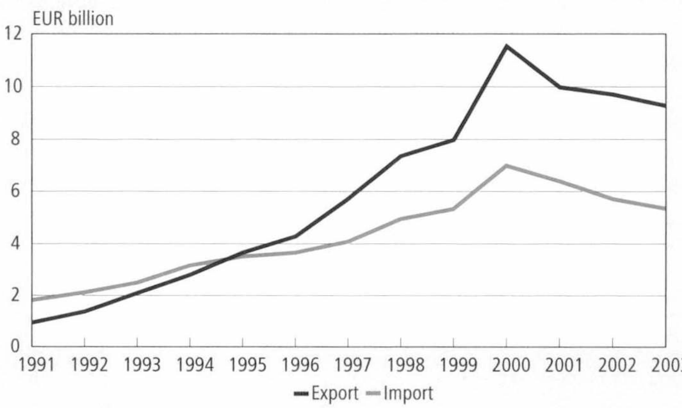
In 2003 Finland's foreign trade surplus for high technology products was almost four billion euros, and the export-import ratio was at a record high level of 1.74 (Table 9.1.1). In 1991 the corresponding figure was no more than 0.52. The positive balance of foreign trade has shown particularly rapid growth since 1995, when the value of exports exceeded imports for the first time (Figure 9.1.2). For other than high technology products the export-import ratio in 2003 was 1.19.

Table 9.1.1
High technology product groups as a proportion of total Finnish high technology exports and imports and the export-import ratio for product groups in 1991, 1995, 2000 and 2003.
Source: National Board of Customs, ULTIKA.

Product group	1991			1995		
	Exports %	Imports %	Exports/ Imports	Exports %	Imports %	Exports/ Imports
Aerospace	0.6	7.3	0.04	1.2	4.5	0.28
Computers and office machinery	23.9	28.4	0.44	20.9	30.7	0.72
Electronics and telecommunications equipment	39.4	25.8	0.80	60.3	39.2	1.61
Pharmaceuticals	1.7	4.4	0.20	0.4	3.1	0.14
Scientific instruments	26.7	14.0	1.00	11.6	9.3	1.31
Electrical machinery	2.4	2.2	0.58	1.2	4.7	0.26
Chemicals	1.7	4.5	0.20	1.2	3.8	0.33
Non-electrical machinery	2.5	6.4	0.21	2.4	3.3	0.76
Armaments	1.1	7.0	0.09	0.8	1.3	0.68
Product groups total	**100.0**	**100.0**	**0.52**	**100.0**	**100.0**	**1.05**
Value total, EUR billion	**0.9**	**1.8**	–	**3.7**	**3.5**	–

Product group	2000			2003		
	Exports %	Imports %	Exports/ Imports	Exports %	Imports %	Exports/ Imports
Aerospace	0.8	5.1	0.27	1.1	1.9	1.04
Computers and office machinery	3.7	19.8	0.31	2.7	20.6	0.23
Electronics and telecommunications equipment	83.7	50.7	2.73	82.5	48.4	2.97
Pharmaceuticals	0.3	1.8	0.24	0.8	3.7	0.39
Scientific instruments	7.3	7.7	1.57	9.3	9.3	1.74
Electrical machinery	1.9	9.5	0.33	1.1	8.4	0.23
Chemicals	0.5	2.1	0.40	0.5	2.8	0.34
Non-electrical machinery	1.3	2.4	0.91	1.3	2.6	0.90
Armaments	0.4	0.7	0.79	0.5	2.3	0.42
Product groups total	**100.0**	**100.0**	**1.66**	**100.0**	**100.0**	**1.74**
Value total, EUR billion	**11.5**	**7.0**	–	**9.3**	**5.3**	–

Figure 9.1.2
Value of Finnish foreign trade in high technology products in 1991–2003.
Source: National Board of Customs, ULTIKA.



Balance of foreign trade in electronics and telecommunications equipment shows a surplus of more than five billion euros

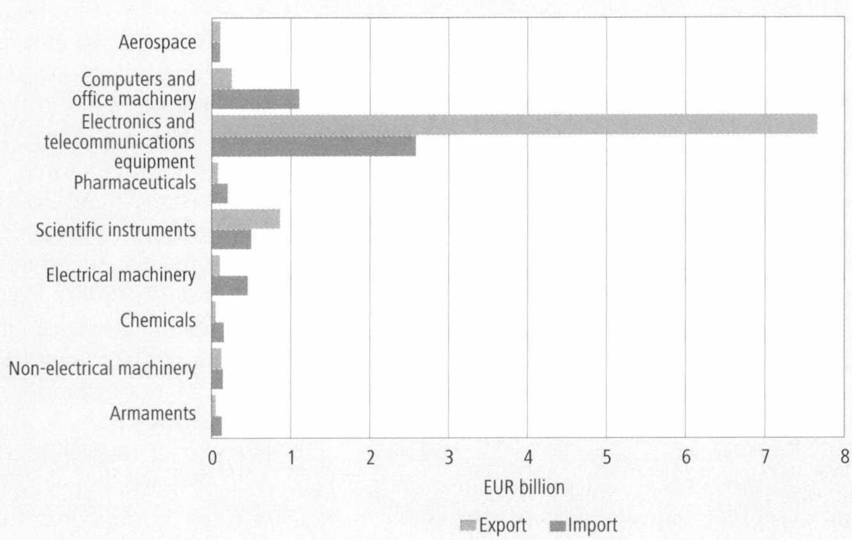
In 2003 electronics and telecommunications equipment accounted for more than 80 per cent of high technology exports, with its value standing at 7.7 billion euros (see Appendix Table 9.1). In spite of declining volumes, the share of this category has remained at the same level for a number of years. The decline in exports of electronics and telecommunications equipment accounts for almost the entire decrease in high technology exports in 2003. However, the value of electronics and telecommunications equipment exports increased more than 20-fold in 1991–2003, with the average annual increase standing at 29 per cent. The surplus in the balance of foreign trade in this product group has also grown noticeably. In 1991 the balance still showed a deficit, but since 2000 a surplus of five billion euros or more has been recorded every year. Electronics and telecommunications equipment now account for 52 per cent of the total surplus of 9.8 billion euros in Finnish foreign trade. The figure pushed past the 50 per cent mark in 2003.

Scientific instruments has reclaimed its position as the second biggest export category ahead of computers and office machinery. In 1991 the product groups' rank ordering was very similar to that of the past few years, but at that time electronics and telecommunications equipment still held a rather marginal lead. Following a period of intense growth, exports of scientific instruments have remained at around 850 million euros since 2000. Exports of computers and office machinery, on the other hand, have continued rapidly to shrink, and in 2003 exports in this category were down to just over one-quarter of the peak figures recorded in 1997. The only group showing growth in

2003 was aerospace, in all other product groups exports either declined or remained more or less unchanged. Aerospace exports amounted to more than one hundred million euros, which is more than twice the figure for 2002. The biggest decrease at 25 per cent was recorded for arms exports.

Electronics and telecommunications equipment was the single biggest product group in imports as well (2.6 billion euros). Computers and office machinery imports amounted to 1.1 billion euros (Figure 9.1.3). Imports of scientific instruments and electrical machinery were also high: the figure in both groups was close to half a billion euros. In spite of the dominant position of electronics and telecommunications equipment, imports were more evenly spread out across the different product groups. With the exception of armaments and pharmaceuticals, imports in all product groups decreased from the previous year. Arms imports almost doubled.

Figure 9.1.3
Value of Finnish foreign trade in high technology products by product group in 2003. Source: National Board of Customs, ULTIKA.



Foreign trade shows a deficit in most product groups

In 2003 Finland's trade balance showed a surplus in just three of the nine high technology product groups. The export-import ratio in the category of electronics and telecommunications equipment was the highest at 2.97, the figure for scientific instruments was 1.74 and for aerospace marginally positive at 1.04. The export-import ratio was weakest for computers and office machinery and electrical machinery: in both groups the figure was 0.23. In small product groups there is quite considerable annual variation in the export-import ratio.

Without the contribution of electronics and telecommunications equipment, Finland's foreign trade balance in high technology would show a deficit of more than 1.1 billion euros. The deficit for computers and office machinery increased in 2000 to almost one billion euros, and has remained at around the same level ever since. The deficit for electrical machinery has also been counted in hundreds of millions of euros in recent years. The surplus for scientific instruments, on the other hand, has been growing steadily for the past decade, and is now approaching 400 million euros.

Asia gaining a stronger role in high technology trade

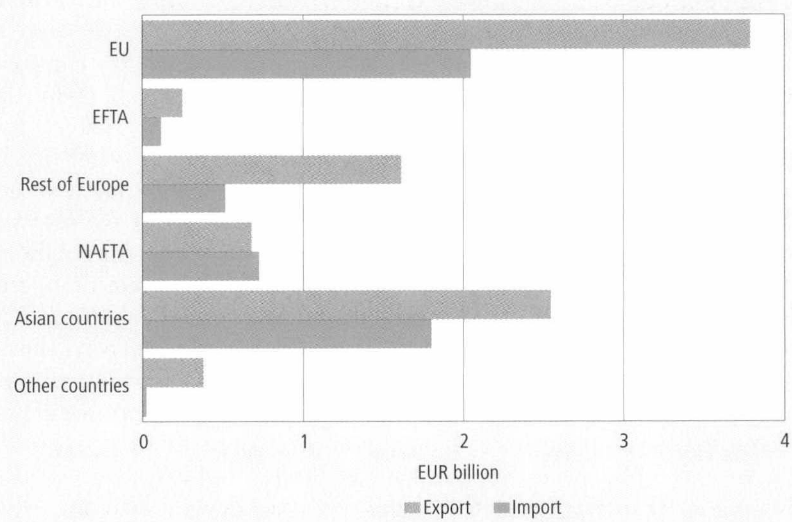
In 2003 Finland's biggest foreign trade partner in high technology was the EU area (Table 9.1.2 and Figure 9.1.4). Finnish high technology exports to EU countries amounted to 3.8 billion euros, high technology imports totalled two billion euros. Exports to EU countries were down by one billion euros compared to 2002 and by a further one billion compared to the peak level in 2000. The pattern has been very similar albeit less pronounced in imports: here the figure decreased by almost 200 million euros compared to 2002 and by 800 million euros compared to 2000. Around the turn of the millennium EU countries accounted for around 50 per cent of Finnish high technology exports, but more recently the figure has dropped back to the level of just over 40 per cent that was recorded in the early 1990s. Imports have developed more steadily, and since the short-term hike that was seen following Finnish, Swedish and Austrian membership of the EU there have been no major changes. In 2003 the export-import ratio with the EU countries was 1.85.

Foreign trade with the EFTA group is relatively low, partly because of the small size of the free trade area today. Exports and imports with EFTA account for just over two per cent of Finland's foreign trade in high technology. Foreign trade with Eastern European countries, on the other hand, has picked up quite vigorously after a slow period in the early 1990s. Exports of high technology products to non-EU and non-EFTA Europe (mainly Eastern Eu-

Table 9.1.2
Breakdown of Finnish foreign trade in high technology products in 1991–2003 and the export-import ratio in 2003 by country group.
Source: National Board of Customs, ULTIKA.

Country group	1991		1995		2000		2003		
	Exports %	Imports %	Exports %	Imports %	Exports %	Imports %	Exports %	Imports %	Exports/ Imports
EU	40.6	39.9	51.3	44.1	50.0	40.8	41.0	39.3	1.85
EFTA	25.3	15.4	4.4	2.6	5.6	1.8	2.7	2.2	2.18
Rest of Europe	10.3	2.1	12.1	3.0	15.8	7.6	17.4	9.8	3.16
NAFTA	7.8	23.2	7.3	20.7	5.4	19.1	7.3	13.8	0.94
Asian countries	11.6	19.1	20.8	29.3	18.3	29.7	27.5	34.5	1.42
Other countries	4.4	0.2	3.9	0.3	4.9	1.0	4.1	0.4	17.88

Figure 9.1.4
Value of Finnish foreign trade in high technology products by country group in 2003. Source: National Board of Customs, ULTIKA.



rope) amounted to 1.6 billion euros. The volume of imports is substantially lower so that Finland's trade balance with these countries shows a surplus of more than one billion euros.

Asia has gained a much stronger role in high technology trade over the past years. At the current rate of growth, Asia is projected to overtake the EU as the main source of Finnish imports within the next few years. The margin has narrowed every year: in 2003 the difference has been reduced to just 250 million euros in favour of the EU. All in all high technology imports from Asia amounted to 1.8 billion euros, while the value of exports totalled 2.5 billion. Exports have also remained strong, and the export-import ratio with these countries has no longer fluctuated but remained positive in the early part of the 2000s.

Trade with the NAFTA group (United States, Canada and Mexico) has traditionally shown a deficit. The situation remained unchanged in 2003, although the deficit was down to just over 40 million euros after imports fell back by half a billion euros. The export-import ratio with NAFTA was 0.94; this figure has gradually been improving as far as Finland is concerned. In relative terms NAFTA has much greater significance in high technology imports than exports.

United Arab Emirates has emerged as the major market for high technology exports

Finland's high technology exports are quite heavily concentrated, although less so than in the mid-1990s. In 2003 the 20 biggest export countries accounted for 80 per cent of all Finnish high technology exports (Table 9.1.3). In 1995 just 15 countries accounted for the same proportion.

In 2003 the single biggest market for Finnish high technology exports was the United Arab Emirates: the value of exports to the UAE totalled almost one billion euros, more than twice as much as in 2002. This is explained by the strong demand for mobile phones. Exports to the UK, on the other hand, fell back by more than half a billion euros in one year, but even so the UK was the third biggest export market after Germany. Exports to Russia have shown particularly strong growth in recent years. In 2003 high technology exports to these three countries amounted to more than 800 million euros. Brisk growth was also recorded for exports to Estonia in the late 1990s so that by 2000, the value of exports was five times higher than in 1995. More recently, however, exports have ebbed back to the previous level of 100 million euros. On the other hand there has been sharp fluctuation in the value of exports to major

Table 9.1.3
High technology exports and imports: Finland's main trade partners in 2003
Source: National Board of Customs, ULTIKA.

Export	EUR million	%	Import	EUR million	%
United Arab Emirates	1,006.4	10.9	United States	696.9	13.4
Germany	883.4	9.6	China	609.7	11.7
United Kingdom	879.4	9.5	Germany	574.2	11.0
Russia	828.1	9.0	Japan	474.3	9.1
United States	596.3	6.4	United Kingdom	303.1	5.8
Italy	335.2	3.6	France	253.3	4.9
China	327.7	3.5	Sweden	251.9	4.8
Sweden	321.1	3.5	Estonia	233.7	4.5
France	299.5	3.2	Hungary	206.3	4.0
Saudi Arabia	254.9	2.8	South Korea	193.2	3.7
Spain	254.2	2.7	Netherlands	162.6	3.1
Netherlands	247.2	2.7	Ireland	151.6	2.9
Poland	207.8	2.2	Malaysia	145.1	2.8
Japan	153.7	1.7	Denmark	135.3	2.6
Greece	150.3	1.6	Taiwan	128.7	2.5
Hongkong	147.8	1.6	Switzerland	94.4	1.8
Taiwan	145.9	1.6	Singapore	89.5	1.7
Norway	127.8	1.4	Belgium	66.6	1.3
South Africa	121.5	1.3	Italy	64.2	1.2
Hungary	116.5	1.3	Philippines	56.3	1.1
Total	**7,404.7**	**80.1**	**Total**	**4,890.8**	**93.9**
Other countries	1,843.2	19.9	Other countries	317.3	6.1
Exports total	**9,284.1**	**100.0**	**Imports total**	**5,330.8**	**100.0**

Country breakdowns not available for some product groups trade partners, such as China, France and Switzerland. Years of strong growth have been followed by periods of plateauing-out or even minor collapses. Exports to France plummeted from 620 million euros to less than one-half this figure in 2003. Similar fluctuations have also been seen with more distant trade partners such as the Philippines, Taiwan and Thailand. Exports to Taiwan quadrupled in one year to 150 million euros, but this is still 100 million less than the figure in 2000. Indeed, it seems apparent that single orders have a very major role in high technology trade between individual countries. All in all there are quite sharp annual fluctuations in the value and shares of exports to different countries.

China overtakes Germany, Japan and the UK to become the second biggest source of imports

High technology imports are even more heavily concentrated than exports. In 2003 the 20 biggest countries accounted for 94 per cent of all Finnish imports, in 2000 just 15 countries made up the corresponding proportion. The four biggest countries – the United States, China, Germany and Japan – alone accounted for nearly half of all Finnish imports. Imports from the US decreased in 2003 by almost half a billion euros or 42 per cent. At the same time imports from China increased by almost the same proportion and 160 million euros, effectively narrowing down the gap between these two countries. High technology imports from the United States amounted to around 700 million euros and from China to over 600 million euros. In relative terms the sharpest increase was recorded for imports from Hungary at 177 per cent. Imports from France doubled in one year. Imports from the UK, another major trade partner for Finland, also declined sharply, i.e. by 160 million euros or more than one-third from the figure in 2002.

High technology trade with most European countries shows a surplus

In 2003 Finland's high technology foreign trade showed the largest surplus with the United Arab Emirates (1 billion euros), Russia (810 million euros) and the United Kingdom (580 million euros). The export-import ratio with the UAE was phenomenal (205871.69) because imports of high technology were virtually non-existent. With Russia the corresponding ratio was 48.03 and with the UK 2.90. Trade with Germany, Italy, Saudi Arabia, Spain and Poland showed a surplus of a couple of hundred million euros. Among other major European trade partners, high technology trade with Greece and Poland was heavily skewed in favour of Finland.

In 2003 the deficit in Finland's high technology foreign trade was largest with Japan at 320 million euros. Trade with China showed a deficit of over 280 million euros. A clear deficit was also recorded in high technology trade with South Korea, Malaysia, Estonia and the United States: the figures for each of these countries were at least 100 million euros in deficit. Finland's export-import ratio was weakest with Malaysia at just 0.08. In recent years the ratio has developed favourably for Finland in trade with Japan and above all with the United States.

9.2 International comparisons

Foreign trade in high technology booming in the Far East

High technology exports as a proportion of total exports showed strong growth towards the end of the 1990s not only in the EU area but in other OECD countries as well. Since 2000, however, this growth has plateaued in most of these countries, including Finland. In spite of the slowdown the share of high technology has increased compared to 1991 in all countries except Japan and Spain. Since 1995 the development of high technology exports as a proportion of total exports has been exceptionally rapid in Hungary and the Czech Republic: Hungary has seen an almost fivefold increase, the Czech Republic an almost fourfold increase. In this comparison the increase of almost 17 percentage points recorded for Hungary from 1995 to 2002 is in a class of its own.

Since the mid-1990s high technology exports as a proportion of total imports in OECD countries has been clearly highest in Ireland: in 2002 the figure was 36 per cent. High technology exports have increased very rapidly but then fallen back quite suddenly as well: one year previously 46 per cent of Irish exports consisted of high technology products. Indeed in 2003 the non-OECD member Taiwan emerged as the top exporter of high technology: the proportion here was 41 per cent (Table 9.2.1). Other Far Eastern countries have also been climbing up the table: South Korea, Hong Kong and China now rank among the states where high technology exports as a proportion of total exports is at least one-fifth. Apart from Ireland, other countries in the OECD group reaching this level are the UK, Finland, Switzerland, Hungary, the United States and Japan. In 1995 Finnish high technology exports as a proportion of total exports was around the EU average at just over 12 per cent. Since then the proportion in Finland has constantly been five percentage points above the EU average. In 2002 high technology exports as a proportion of total exports remained at less than five per cent only in Iceland, Poland, New Zealand, Slovakia, Australia and Norway.

High technology imports as a proportion of total imports have generally increased during the period from 1991 to 2002, in spite of the slight fallback after 2000. The proportion has decreased in just a few countries, such as Spain and Canada. Since 1995 the proportion of high technology imports has increased most rapidly in Taiwan, China, Hungary and Hong Kong: all these countries have recorded an increase of ten percentage points or more. Comparative data since 1991 are available mainly from the OECD countries, amongst which Ireland stands apart with a 20 percentage point increase. In 2002 the proportion of high technology imports in Europe was highest in Ireland (38%) and Hungary (20%). In the Far East, the figure for Taiwan (36%) was around the same as for Ireland. The proportion of high technology imports remained at less than ten per cent only in Greece, Belgium, Slovakia and Spain.

EU members with the lowest level of foreign trade in high technology also have a higher level of imports than exports. This, according to the European Commission, reflects the low level of high technology manufacturing in these countries in general. The proportions probably reflect the industrial structure of these countries. In some cases multinational corporations have a very major impact on the national economy.[3]

Table 9.2.1
High technology exports and imports as a proportion of total exports and imports in selected OECD and other countries in 1991–2002.
Source: OECD.

Country	1991		1995		2000		2002	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
	%	%	%	%	%	%	%	%
Finland	**6.0**	**12.1**	**12.4**	**16.1**	**23.3**	**18.9**	**20.6**	**16.1**
Sweden	11.1	13.4	12.9	16.5	18.7	18.5	13.5	14.1
Denmark	9.6	12.0	10.1	12.3	14.3	14.8	14.9	17.1
Germany	11.6	12.7	11.6	12.8	16.2	18.7	15.1	17.1
Austria	7.9	10.0	7.7	10.3	12.8	15.0	14.1	13.7
Netherlands	10.6	12.2	15.2	16.4	24.9	26.3	19.4	19.4
Belgium	–	–	5.8	6.6	8.0	9.7	7.0	8.3
Luxembourg	–	–	–	–	13.7	17.8	12.6	16.4
France	14.6	12.8	15.2	13.3	20.0	17.3	17.5	15.0
United Kingdom	17.9	15.5	19.9	17.6	25.9	23.9	25.1	19.5
Ireland	27.0	18.1	32.9	28.7	41.3	37.2	35.9	37.9
Spain	5.8	11.7	5.5	9.0	6.3	11.9	5.7	9.3
Portugal	3.2	7.8	4.5	9.2	5.5	10.7	6.2	10.1
Italy	7.4	10.7	7.4	10.8	8.5	13.0	8.2	11.8
Greece	1.4	6.4	3.1	6.9	6.9	10.3	6.6	8.0
EU countries	**11.9**	**12.6**	**12.4**	**13.1**	**17.4**	**18.0**	**15.6**	**15.5**
Iceland	0.1	9.5	1.9	9.8	1.7	13.2	1.7	12.6
Norway	3.6	11.0	3.7	12.4	3.2	15.8	4.8	13.7
Switzerland	14.6	12.3	16.0	14.7	20.0	18.9	21.6	17.7
Poland	–	–	2.1	9.3	2.8	12.7	2.4	10.8
Czech Republic	–	–	3.4	11.8	7.8	14.2	12.4	15.7
Slovakia	–	–	–	–	3.6	8.6	2.9	9.2
Hungary	–	–	4.7	9.1	23.0	20.1	21.7	20.2
Canada	8.9	15.2	9.0	16.6	11.9	17.8	9.0	14.3
United States	25.2	15.9	24.0	20.0	29.8	20.9	27.9	17.6
South Korea	–	–	22.9	16.8	31.6	25.3	28.5	22.6
Japan	23.3	9.9	25.3	14.8	27.0	20.0	21.2	18.4
China	–	–	8.8	12.5	16.8	21.3	21.0	27.0
Taiwan	–	–	27.8	20.4	41.9	35.5	41.4	35.6
Hongkong	–	–	15.4	18.3	22.6	26.6	25.5	28.6
Australia	3.3	19.2	4.9	18.6	4.2	19.9	4.5	18.1
New Zealand	–	–	2.1	16.3	2.9	16.4	2.8	13.1

3 European Commission (2002a)

The US remains the world leader in high technology trade

In 2002 the value of US high technology foreign trade stood at over 420 billion euros. Germany recorded the second highest figure at 188 billion euros (Table 9.2.2). The combined value of EU trade in high technology amounted to almost 770 million euros (Figure 9.2.1). US exports decreased by almost 50 billion euros from 2000, EU exports by only half this amount. Japanese exports declined by almost the same amount as in the US, but in percentage terms the drop was much greater. Similar patterns have been observed in imports. China has seen its trade patterns develop in a completely opposite direction, and at the same time the volume of its high technology trade has risen to the same level as Japan's. From 1995 to 2002, only Hungary (50%) and the Czech Republic (42%) recorded a faster average annual increase in the value of exports than China (33%). The growth rate in Finland is just above the international average at 14 per cent a year. The same countries figure most prominently in an analysis of imports since 1995: growth has been fastest in Hungary (33% a year), China (31%) and the Czech Republic (20%). In Finland the growth of imports (7%) is slightly below the EU average.

The comparability of aggregate EU figures is reduced by the fact that the statistics on EU exports include trade among EU members. If internal trade were excluded, the figures would be significantly different because trade between EU members is quite lively. Eurostat figures indicate that 55 per cent of EU countries' foreign trade in high technology in 2001 consisted of trade with other community members.

Figure 9.2.1
Foreign trade in high technology products in EU countries, the United States, Japan and China in 2002.
Source: OECD.

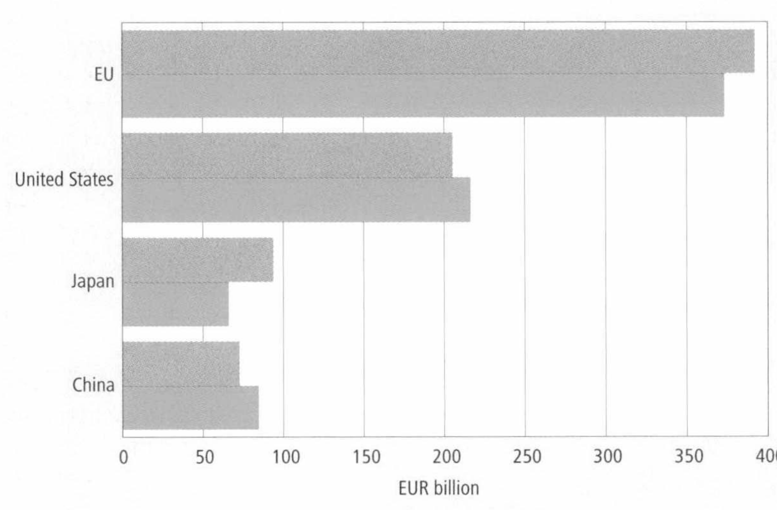


Table 9.2.2
Value of exports and imports in high technology products and export-import ratio in selected OECD and other countries in 1991–2002.
Source: OECD.

Country	1991			1995			2000			2002		
	Exports	Imports	Exports/ Imports	Exports	Imports	Exports/ Imports	Exports	Imports	Exports/ Imports	Exports	Imports	Exports/ Imports
	EUR billion			EUR billion			EUR billion			EUR billion		
Finland	**1.1**	**2.1**	**0.52**	**3.8**	**3.6**	**1.05**	**11.5**	**7.0**	**1.66**	**9.7**	**5.7**	**1.71**
Sweden	5.0	5.4	0.92	7.7	7.8	0.99	17.6	14.6	1.21	11.6	9.9	1.16
Denmark	2.9	3.3	0.88	3.9	4.3	0.91	7.7	7.2	1.07	8.8	8.9	0.99
Germany	37.9	40.0	0.95	46.6	45.6	1.02	96.5	100.7	0.96	98.9	89.1	1.11
Austria	2.6	4.1	0.64	3.4	5.2	0.66	8.6	11.0	0.79	10.7	10.4	1.03
Netherlands	11.5	12.4	0.93	20.6	19.8	1.04	48.7	49.9	0.98	36.0	33.7	1.07
Belgium	–	–	–	7.5	7.7	0.97	16.1	18.1	0.89	16.0	17.4	0.92
Luxembourg	–	–	–	–	–	–	1.2	2.0	0.57	1.1	2.0	0.57
France	25.3	23.9	1.06	33.0	27.7	1.19	64.1	56.9	1.13	56.7	48.3	1.17
United Kingdom	26.5	26.3	1.00	36.8	36.2	1.02	80.0	88.4	0.90	76.9	72.6	1.06
Ireland	5.3	3.1	1.73	11.0	7.1	1.55	34.2	20.4	1.67	33.6	21.0	1.60
Spain	2.7	8.8	0.31	3.8	7.8	0.49	7.7	19.7	0.39	7.6	16.5	0.46
Portugal	0.4	1.7	0.26	0.8	2.4	0.34	1.5	4.7	0.31	1.7	4.3	0.40
Italy	10.2	15.8	0.65	13.1	16.8	0.78	22.0	33.4	0.66	21.9	30.5	0.72
Greece	0.1	1.1	0.09	0.3	1.4	0.19	0.8	3.3	0.25	0.8	2.8	0.27
EU countries	**131.5**	**148.0**	**0.89**	**192.3**	**193.3**	**1.00**	**418.3**	**437.4**	**0.96**	**392.1**	**373.2**	**1.05**
Iceland	0.0	0.1	0.01	0.0	0.1	0.20	0.0	0.4	0.10	0.0	0.3	0.13
Norway	1.0	2.3	0.43	1.2	3.1	0.38	2.1	5.9	0.35	3.1	5.1	0.60
Switzerland	7.3	6.6	1.10	10.0	9.0	1.11	17.4	16.9	1.03	20.2	15.7	1.28
Poland	–	–	–	0.4	2.0	0.18	1.0	6.7	0.14	1.1	6.3	0.17
Czech Republic	–	–	–	0.4	1.9	0.23	2.5	5.0	0.50	5.1	6.8	0.74
Slovakia	–	–	–	–	–	–	0.5	1.2	0.39	0.4	1.6	0.27
Hungary	–	–	–	0.5	1.1	0.43	7.0	7.0	1.00	7.9	8.1	0.98
Canada	8.7	14.5	0.60	12.4	20.8	0.60	35.9	46.3	0.78	24.2	33.7	0.72
United States	81.7	65.4	1.25	100.3	118.1	0.85	253.1	275.9	0.92	205.3	216.5	0.95
South Korea	–	–	–	22.4	17.7	1.26	59.0	44.1	1.34	49.2	36.4	1.35
Japan	59.3	19.0	3.13	85.8	38.0	2.26	140.2	82.5	1.70	93.8	66.0	1.42
China	–	–	–	10.0	12.6	0.79	45.4	52.0	0.87	72.5	84.5	0.86
Taiwan	–	–	–	24.0	16.3	1.48	66.8	53.2	1.26	56.5	41.9	1.35
Hongkong	–	–	–	20.4	27.4	0.74	49.7	61.9	0.80	54.7	63.1	0.87
Australia	1.1	6.0	0.18	2.0	8.2	0.24	2.9	14.6	0.20	3.1	13.4	0.23
New Zealand	–	–	–	0.2	1.7	0.12	0.4	2.5	0.16	0.4	2.1	0.20

Finland's trade in high technology shows the largest surplus

Throughout the 1990s the surplus of foreign trade in high technology was the highest in Japan. In 1991 Japan's export-import ratio was 3.13, almost twice as high as in Ireland which ranked second. Since then Japan's trade in high technology has gradually become more balanced, and by 2001 both Ireland and Finland recorded higher export-import ratios than Japan. In 2002 Finland overtook Ireland with the world's highest ratio of 1.71. In most countries the slower growth of high technology imports than exports is reflected in a growing foreign trade surplus as well as in a slight improvement of the export-import ratio. The favourable trends in Finland since 1995 are really only matched by Hungary and the Czech Republic. Although Japan's ratio has declined very sharply, the country continues to show a large surplus in its high technology trade. The export-import ratios in both the EU and the United States have remained steadily at around 1.00.

Specialisation in high technology trade differs widely between EU countries

The indices shown in Table 9.2.3 describe the specialisation of EU countries in high technology exports. The analysis is based on the relative specialisation index (RSI)[4], in which the figures vary within the range of ±1 depending on the country's foreign trade specialisation. As in previous years, the EU countries that specialised most clearly in high technology exports in 2002 were Ireland (specialisation index 0.39) and the United Kingdom (0.23). Finland, the Netherlands and France also recorded positive indices. For all other EU countries at that time, the figure was negative. The weakest specialisation in high technology exports was recorded by Spain, Portugal and Greece. Finland's specialisation index was still marginally negative in 1995.

At the level of product groups high technology exports were most specialised in countries where the index for a certain product group was highest both within a country and in comparison with other countries (these figures are in boldface and underlined in the Table). At the product group level Finnish high technology exports were oriented more strongly than in other countries to electronics and telecommunications equipment; in Sweden to non-electrical machinery; in the United Kingdom to armaments; in Denmark to pharmaceuticals; in France to aerospace; in Ireland to computers and office machinery; and in Germany to scientific instruments.

Apart from Finland, electronics and telecommunications equipment occupy an important place among others in Ireland, while computers and office machinery are important to high technology exports from the Netherlands. Another distinctive feature is the prominent role of arms exports in Austria and Italy. The armaments index is also the highest in Spain, for instance, although this hardly is a reflection of the great significant of arms exports from this country. The highest individual index value is recorded at 0.66 for the exports of computers and office machinery from Ireland. However, the index values vary quite widely from year to year, especially in the smaller product groups.

4 The index values for country exports have been calculated using the following formula: (country's share of EU countries' high technology exports / country's share of EU countries' total exports – 1) / (country's share of EU countries' high technology exports / country's share of EU countries' total exports + 1). When a country's share of the EU countries' combined high technology exports exceeds its share of the EU's total exports, its specialisation is positive. The higher the value of the index, the more strongly the country is oriented to high technology exports when compared to other countries. Index values for individual products groups have been calculated using the same principle.

Table 9.2.3
High technology exports by product groups in EU countries in 2002: index of relative specialisation
Source: OECD.

Country	Aerospace	Computers and office machinery	Electronics and telecommunications equipment	Pharma-ceuticals	Scientific instruments
Ireland	–0.83	**0.66**	0.45	0.35	0.14
United Kingdom	0.25	0.20	0.31	0.03	0.14
Finland	–0.92	–0.69	**0.53**	–0.78	0.04
Netherlands	–0.66	**0.54**	–0.26	–0.17	0.10
France	**0.44**	–0.27	–0.06	0.03	–0.03
Germany	0.10	–0.18	–0.04	–0.30	**0.18**
Denmark	–0.73	–0.32	0.03	**0.55**	0.08
Austria	–0.36	–0.29	0.07	0.33	–0.20
Sweden	–0.27	–0.58	0.13	–0.14	0.07
Luxembourg	–0.95	–0.19	**0.27**	–0.97	–0.28
Italy	–0.23	–0.62	–0.42	0.12	–0.40
Belgium	–0.88	–0.33	–0.51	**0.14**	–0.50
Greece	–0.06	–0.74	–0.40	–0.26	–0.73
Portugal	–0.57	–0.49	–0.30	–0.56	–0.68
Spain	–0.53	–0.63	–0.48	–0.28	–0.50

Country	Electrical machinery	Chemicals	Non-electrical machinery	Armaments	Hi-tech exports total
Ireland	–0.18	–0.86	–0.66	–1.00	0.39
United Kingdom	0.34	0.15	0.17	**0.47**	0.23
Finland	–0.25	–0.65	–0.35	0.32	0.14
Netherlands	0.05	0.10	–0.37	–0.92	0.11
France	–0.28	0.26	0.01	0.05	0.06
Germany	0.11	0.07	0.10	–0.35	–0.02
Denmark	–0.18	–0.05	–0.78	–0.56	–0.02
Austria	0.23	–0.47	–0.08	**0.36**	–0.05
Sweden	0.02	–0.73	**0.20**	–0.51	–0.07
Luxembourg	–0.79	–0.62	–0.91	–0.95	–0.11
Italy	–0.29	–0.28	0.14	**0.22**	–0.31
Belgium	–0.35	–0.17	–0.09	–0.50	–0.38
Greece	–0.67	**0.06**	–0.94	–0.70	–0.40
Portugal	0.18	–0.52	–0.94	**0.19**	–0.44
Spain	–0.55	–0.08	–0.30	**0.04**	–0.47

Relative specialisation index: (country's share of EU countries' high technology exports / country's share of EU countries' total exports – 1) / (country's share of EU countries' high technology exports / country's share EU countries' total exports + 1). The figures in boldface indicate the highest country values. Underlined figures are the highest value for each product group. At the level of product groups high technology exports were most specialised in countries where the index for a certain product group was highest both within a country and in comparison with other countries (these figures are in boldface and underlined in the Table).

Appendix 9.1

High technology product groups and SITC (Standard International Trade Classification, Rev. 3) codes. The classification in the Table is based on the 1995 OECD definition of high technology products. Product groups marked with an asterisk belong to the most technology-intensive category ('leading-edge products'). The R&D intensity of these products is in excess of 8.5%.

1. Aerospace

792* = Aircraft and associated equipment; excl. 7928, 79295, 79297
714* = Aeroplane motors; excl. 71489, 71499
87411* = Other navigational instruments

2. Computers and office machinery

75113 = Word processing machines
7513 = Photocopying apparatus; excl. 75133, 75135
752* = Computers; excl. 7529
75997 = Parts and accessories of group 752

3. Electronics and telecommunications

76381 = Video apparatus
76383 = Other sound reproducing equipment
764* = Telecommunications equipment; excl. 76493, 76499
7722 = Printed circuits
77261 = Electrical boards and consoles 1,000V
77318 = Optical fibre cables
77625* = Microwave tubes
77627* = Other valves and tubes
7763* = Semi-conductor devices
7764* = Electronic integrated circuits and microassemblies
7768* = Piezo-electric crystals
89879 = Numeric recording stays

4. Pharmaceuticals

5413* = Antibiotics
5415* = Hormones and their derivatives
5416* = Glycosides, glands, antisera, vaccines
5421 = Medicaments containing antibiotics or derivatives thereof
5422 = Medicaments containing hormones or other products of heading 5415–

5. Scientific instruments

774* = Electro-diagnostic apparatuses for medicine or surgery and radiological apparatuses
871* = Optical instruments and apparatuses
87211 = Dental drill engines
874* = Measuring instruments and apparatuses; excl. 87411, 8742
88111 = Photographic cameras
88121 = Cinematographic cameras
88411 = Contact lenses
88419 = Optical fibres other than those of heading 7731–
8996 = Orthopaedic appliances; excl. 89965, 89969

6. Electrical machinery

7786* = Electrical capacitors, fixed, variable or adjustable; excl. 77861, 77866–77869
7787* = Electrical machines, having individual functions
77884* = Electric sound or visual signalling apparatuses

7. Non-electrical machinery

71489* = Other gas turbines
71499* = Parts of gas turbines
7187* = Nuclear reactors, and parts thereof; fuel elements, etc.

72847	=	Machinery and apparatus for isotopic separation
7311	=	Machine-tools working by laser or other light or photon beam, ultrasonic, electro-discharge or electro-chemical processes
7313	=	Lathes for removing metal; excl. 73137, 73139
73142	=	Other drilling machines, numerically controlled
73144	=	Other boring-milling machines, numerically controlled
73151	=	Milling machines, knee-type, numerically controlled
73153	=	Other milling machines, numerically controlled
7316	=	Machine-tools for deburring, sharpening, grinding, lapping etc; excl. 73162, 73166, 73167, 73169
73312	=	Bending, folding, straightening or flattening machines, numerically controlled
73314	=	Shearing machines, numerically controlled
73316	=	Punching machines, numerically controlled
7359	=	Parts and accessories of 731– and 733–
73733	=	Machines and apparatuses for resistance welding of metal, fully or partly automatic
73735	=	Machines and apparatuses for arc, including plasma arc welding of metal, fully or partly automatic

8. Chemicals

52222	=	Selenium, tellurium, phosphorus, arsenic and boron
52223	=	Silicon
52229	=	Calcium, strontium and barium
52269	=	Other inorganic bases
525*	=	Radioactive materials
531	=	Synthetic organic colouring matter and colour lakes
57433	=	Polyethylene terephthalate
591*	=	Insecticides, disinfectants

9. Armaments

891* = Arms and ammunition

General characteristics of high technology products and processes include:

- significant dependence on research and development;
- increased significance of businesses' capacity for innovation and their ability to adopt and apply new information;
- growing significance of personnel with a high level of education, particularly in engineering and natural sciences;
- high risk capital investments and their rapid depletion;
- the short life-span of products and processes and the relatively rapid diffusion of technological innovations;
- strong cooperation in R&D between domestic and international companies, research institutes and universities;
- close links of domestically created technologies with international trade and the intensification of competition.

High technology products change over time, which means that definitions must be updated accordingly. New technologies and products based on these technologies are continuously developed, whereas older technologies reach maturity and become less technology intensive, medium-level or even low-level technologies. For this reason it is necessary to modify industry and product based definitions of high technology as well.

Appendix Table 9.1
Foreign trade in Finnish high technology products by product group in 1991, 1995 and 1999–2003.
Source: National Board of Customs, ULTIKA.

Product group	1991	1995	1999	2000	2001	2002	2003
	EUR million						
Aerospace							
Exports	5.2	43.4	20.9	94.9	162.9	48.4	106.3
Imports	130.5	156.9	275.6	354.3	320.5	131.1	101.8
Trade balance	–125.3	–113.5	–254.7	–259.4	–157.5	–82.7	4.5
Computers and office machinery							
Exports	223.9	764.1	787.5	431.7	354.8	292.3	250.4
Imports	507.9	1,068.2	1,475.9	1,378.5	1,353.8	1,220.3	1,099.9
Trade balance	–284.1	–304.1	–688.4	–946.9	–999.1	–928.0	–849.5
Electronics and telecommunications equipment							
Exports	369.2	2,204.1	5,996.5	9,648.3	8,145.0	8,060.3	7,659.4
Imports	462.9	1,367.2	2,139.7	3,531.6	3,135.2	2,813.3	2,578.1
Trade balance	–93.7	836.9	3,856.7	6,116.8	5,009.8	5,247.0	5,081.4
Pharmaceuticals							
Exports	16.0	15.6	25.8	30.8	33.6	75.1	76.1
Imports	79.4	108.0	136.6	128.0	147.9	187.1	196.5
Trade balance	–63.4	–92.3	–110.8	–97.2	–114.3	–112.1	–120.5
Scientific instruments							
Exports	250.3	424.8	712.3	846.3	898.9	859.5	862.7
Imports	251.1	324.4	472.1	539.2	567.8	530.5	496.4
Trade balance	–0.8	100.4	240.2	307.1	331.1	329.1	366.3
Electrical machinery							
Exports	22.4	42.6	200.9	221.2	114.1	106.2	103.7
Imports	38.5	165.0	493.3	662.7	506.9	452.6	448.7
Trade balance	–16.1	–122.6	–292.4	–441.5	–392.7	–346.5	–345.1
Chemicals							
Exports	15.8	43.6	46.2	59.0	173.9	62.2	50.9
Imports	80.2	133.7	131.8	149.4	163.0	156.5	149.2
Trade balance	–64.4	–90.0	–85.6	–90.4	10.9	–94.3	–98.3

Appendix Table 9.1
Continued

Product group	1991	1995	1999	2000	2001	2002	2003
	EUR million						
Non-electrical machinery							
Exports	23.7	87.6	122.5	151.0	59.3	140.9	123.6
Imports	115.2	115.5	157.2	166.2	139.7	142.6	137.5
Trade balance	–91.7	–27.9	–34.7	–15.2	–80.3	–1.7	–13.9
Armaments							
Exports	10.8	30.8	60.6	40.4	38.9	68.3	51.0
Imports	125.1	45.2	26.6	50.9	36.0	62.0	122.6
Trade balance	–114.5	–14.5	34.0	–10.5	2.8	6.3	–71.6
High technology products total							
Exports	937.0	3,656.6	7,973.2	11,523.7	9,981.5	9,713.2	9,284.1
Imports	1,791.0	3,484.2	5,308.9	6,960.8	6,370.8	5,696.0	5,330.8
Trade balance	–854.1	172.4	2,664.3	4,562.8	3,610.7	4,017.2	3,953.3
Other products							
Exports	14,677.8	25,948.0	31,147.6	37,960.7	37,818.9	37,380.9	36,922.4
Imports	12,966.4	18,137.2	24,265.8	29,876.6	29,519.9	29,713.7	31,034.9
Trade balance	1,711.3	7,810.8	6,881.8	8,084.1	8,299.0	7,667.2	5,887.5
Foreign trade total							
Exports	15,614.9	29,604.6	39,120.7	49,484.3	47,800.4	47,094.1	46,206.4
Imports	14,757.5	21,621.4	29,574.6	36,837.4	35,890.7	35,409.8	36,365.6
Trade balance	857.4	7,983.2	9,546.1	12,646.9	11,909.7	11,684.4	9,840.8

10 Scientific publishing

10.1 Bibliometric science indicators

Scientific publishing is an important way of disseminating research results in the scientific community. Any piece of research that is published in a scientific journal must first of all pass the scientific peer review process. Publications in scientific journals are often cited in later research.

Publications and the number of citations they receive may, with certain limitations, be regarded as indicators of the outcomes of scientific activity. The number of publications reflects the productivity of research. The appreciation, visibility and scientific impacts of research activities are measured in terms of the number of citations received by articles during a certain period of time.

The quantitative analysis of publishing is known as bibliometrics. Its sources include various publication and citation databases, such as those maintained by the US-based Institute for Scientific Information (ISI). A major factor restricting the applicability of international databases is the over representation of American and English-language journals, which causes problems of interpretation especially in the social sciences and humanities.

Numeric indices describing scientific publishing are called bibliometric science indicators. They can be used for instance in science administration and universities for purposes of assessing the outcomes of research activities from the point of view of science promotion. The rapid growth of evaluation has led to an increased use of various different indicators describing the volume, level and impacts of research. This chapter uses the following bibliometric science indicators:

Bibliometric science indicators

Number of publications	• Publication numbers are studied by country, by major field of science and by discipline. • Describes the outcomes of research.
Share of publications	• Number of Finnish publications as a proportion of all publications in the OECD countries.
Number of publications relative to population	• Publication number per 10,000 population. • Gives a rough indication of the output of research relative to the size of the nation.
Number of citations	• Number of citations received by certain publications during a certain period.
Share of citations	• Number of citations received by Finnish publications as a proportion of citations received by all OECD publications.
Impact factor	• Number of citations / number of publications. • For example, the average number of citations received by the publications of a certain country during a certain period. • Gives a rough indication of the visibility and scientific impact of research.
Relative citation impact	• Impact factor for a certain country / impact factor for OECD, while the relative citation impact for the OECD is one. • How many per cent more or less citations Finnish publications, for instance, have received in comparison with the average for the OECD countries during a certain period. • How many per cent more or less citations Finnish publications in the natural sciences, for instance, have received in comparison with the OECD average for the natural sciences during a certain period. • Gives a rough indication of the visibility and scientific impact of research.

Bibliometric science indicators have limited applicability and their interpretation is rarely simple and straightforward. Taken at face-value, without due critical consideration, their use in evaluations may easily lead to false conclusions. They are best suited for purposes of assessing scientific publishing within an individual country or internationally, or within a certain discipline.

Publishing and citation practices vary from one discipline to another, and therefore direct comparisons across different disciplines are not possible. In medicine and molecular biology, for example, research results may become outdated within a matter of years, in the social sciences many studies are still cited decades after their publication.

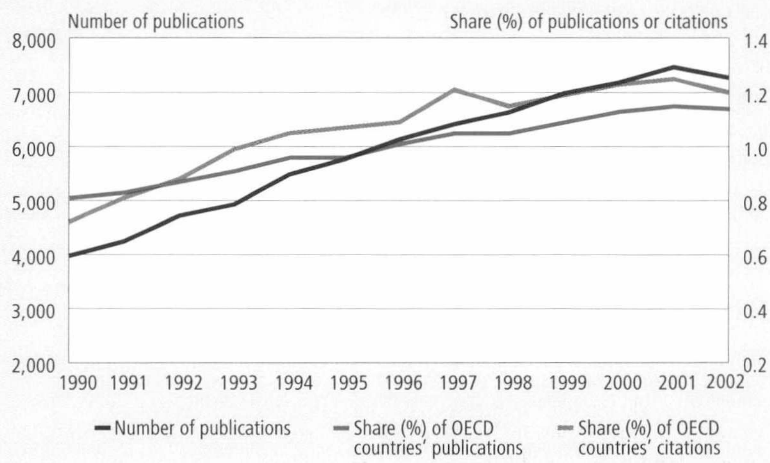
10.2 Finnish publishing in international comparison

This chapter draws on relevant sections from Academy of Finland reviews of the quality and impact of scientific research in Finland in 2003 and 2000. The analyses make use of the National Science Indicators (NSI) database maintained by the Institute for Scientific Information (ISI)[1] (for a description of the database, see Appendix 10.1; and for the classification of major fields of science, see Appendix Table 10.1).

Finland's share of OECD publications has increased

The total number of Finnish scientific publications increased throughout the 1990s (Figure 10.2.1). In 1990, the number of Finnish research papers appearing

Figure 10.2.1
Number of Finnish publications and number of Finnish publications and citations as a proportion of OECD publications and citations in 1990–2002.
Source: Institute for Scientific Information, NSI 1981–2002.



1 National Science Indicators on Diskette (1981–2002). Institute for Scientific Information, Philadelphia, PA.

in international publications stood at around 4,000; by 2002, the figure had almost doubled to 7,300. The increase in the number of Finnish publications was particularly rapid in the early part of the 1990s, but slowed down around the turn of the millennium. The same pattern is seen for the growth of OECD publications. In the 1990s the Finnish growth rate in the number of publications was exceeded primarily in emerging economies and/or countries with less advanced research infrastructures.

Finland's share of OECD publications has shown strong growth from the early 1990s to the early 2000s. In 1990 the figure was 0.81 per cent, from 1996 onwards it has been in excess of one per cent. In 2002 the share was 1.14 per cent. The number of citations received by Finnish publications as a proportion of the citations received by OECD publications has also increased, rising from 0.72 per cent in 1990 to 1.20 per cent in 2002. Finland's share of all citations received by OECD publications pushed past the one per cent mark in 1994.

In 2002 Finland ranked fourth (after Switzerland, Sweden and Denmark) in an OECD comparison of number of publications relative to population size (Table 10.2.1).[2] In 1990 Finland was still ninth in this comparison. From 1990 to 2002, the number of Finnish publications relative to population size has increased by 75 per cent. With the exception of the United States, all countries listed in Table 10.2.1 have recorded an increase in their relative publication volumes.

Table 10.2.1
Number of publications per 10,000 population in selected OECD countries in 1990–2002. Source: Institute for Scientific Information, NSI 1981–2002; OECD, Main Science and Technology Indicators 2003/2.

	Number of publications / 10,000 population												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Switzerland	12	13	15	15	16	17	17	18	18	19	19	19	18
Sweden	12	12	13	13	14	15	15	16	16	17	16	17	17
Denmark	9	10	11	11	12	12	13	13	14	14	14	15	14
Finland	8	8	9	10	11	11	12	12	13	14	14	14	14
Netherlands	8	9	10	10	10	11	11	12	12	12	12	12	12
United States	9	9	9	9	9	10	9	9	9	9	9	9	9
Germany	7	6	6	6	6	7	7	7	8	8	8	8	8
Japan	4	4	4	4	4	5	5	5	5	5	5	6	5
OECD	6	5	6	6	6	6	6	6	6	6	6	6	6

For more details of all OECD countries, see Academy of Finland (2003b)

2 The international comparison of scientific publishing is based on an analysis of publishing in all OECD countries (for more details, see Academy of Finland (2003b)). The eight countries included in the comparisons here have been selected from amongst those with a high level of R&D expenditure as a proportion of GDP. In addition, a sample of smaller research countries have been included that in the light of bibliometric science indicators have shown high levels of research outcomes and impacts.

Finnish publications receive more citations than OECD publications on average

When we compare the impact factors for different countries to the OECD impact factor, we can see how many per cent more or less citations the publications in each country have received in comparison with OECD publications on average (index=1) during a certain period. In the early 1990s Finland's relative citation impact was below the OECD average (Table 10.2.2). However since 1992–1996, Finnish publications have received as many or more citations than publications in the OECD countries on average. During the 1998–2002 period, Finnish publications received seven per cent more citations than publications in the OECD countries on average (relative citation impact = 1.07).

Compared to the citations received by publications in the OECD countries on average, the publications in all eight countries listed in Table 10.2.2 received more citations at the turn of the millennium than they did in the early 1990s. There have been only minor changes in the rank ordering of these countries during the period under review: Finland has overtaken Germany and Denmark has overtaken Sweden. In a comparison of the relative citation impacts of 30 OECD countries, Finland ranked eighth in the 1998–2002 period. Among the countries listed in Table 10.2.2, Switzerland (1st), United States (2nd), Netherlands (3rd), Denmark (4th) and Sweden (5th) were ahead of Finland. Among other OECD countries the United Kingdom (6th) and Iceland (7th) were also ahead of Finland.

Although Finland's shares of all OECD publications and citations are comparatively low, an international comparison of impact factors suggests that Finnish research has in fact quite a strong scientific impact globally. Finland compares very favourably indeed with other OECD countries when publication numbers are examined against population size. Finland has also increased its share of the total number of publications in OECD countries throughout

Table 10.2.2
Relative citation impact in selected OECD countries in 1990–2002.
Source: Institute for Scientific Information, NSI 1981–2002.

	Relative citation impact[1], OECD = 1								
	1990–1994	1991–1995	1992–1996	1993–1997	1994–1998	1995–1999	1996–2000	1997–2001	1998–2002
Switzerland	1.40	1.43	1.44	1.47	1.48	1.45	1.47	1.48	1.46
United States	1.27	1.27	1.28	1.29	1.30	1.30	1.30	1.30	1.30
Netherlands	1.11	1.11	1.13	1.14	1.16	1.19	1.20	1.23	1.23
Denmark	1.09	1.10	1.11	1.15	1.14	1.14	1.15	1.19	1.21
Sweden	1.11	1.11	1.12	1.12	1.13	1.13	1.14	1.13	1.12
Finland	0.90	0.95	1.00	1.03	1.05	1.05	1.06	1.07	1.07
Germany	0.93	0.95	0.97	0.99	1.00	1.01	1.04	1.05	1.07
Japan	0.82	0.82	0.81	0.80	0.80	0.80	0.81	0.83	0.84

1 Relative citation impact = Country impact factor / OECD impact factor.

the 1990s. Finland's share of the citations received by OECD publications has also increased. The strong growth of Finland's relative citation impact from the early 1990s to the early 2000s is particularly noteworthy.

Finnish research has strong international impact in several major fields of science

The Finnish profile of scientific publishing is concentrated in the natural sciences and medical sciences, which together accounted for 84 per cent of Finnish publishing in 1998–2002 (Table 10.2.3). The figures for all other major fields of science were markedly lower. Among the OECD countries we find that Finland and Sweden have rather similar publishing profiles: the share of medical sciences is higher than in the OECD countries on average.

The visibility and scientific impact of research in Finland can be described by reference to the relative citation impact, which indicates how many per cent more or less citations the publications in each country have received when compared to the average for OECD countries (index=1). Finland's ranking among the OECD countries is examined by major field of science in Appendix Table 10.2.

Finnish research has high international visibility in many fields of science. In four of these fields Finland's impact factor ranks between 3rd and 6th among OECD countries, but in two fields only 12th and 16th. The major field of science that performed best in this comparison was agricultural science, which ranked third and received 52 per cent (index=1.52) more citations than publications in OECD countries on average. Finnish humanities ranked fourth, receiving 33 per cent more citations than publications in OECD countries on average.

Table 10.2.3
Publishing profiles of selected OECD countries by major field of science in 1998–2002, per cent. The countries are rank ordered according to the share of natural sciences. Source: Institute for Scientific Information, NSI 1981–2002.

Country	Percentage share of maior field of science					
	Natural sciences	Medical sciences	Engineering and technology	Agricultural sciences	Social sciences	Humanities
Japan	56.2	28.1	12.2	2.3	1.0	0.1
Germany	55.1	29.6	8.8	1.7	3.2	1.7
Switzerland	54.2	33.2	7.5	1.3	2.8	1.0
Denmark	53.8	33.2	5.4	3.1	3.6	0.9
Sweden	46.7	38.0	8.3	1.5	4.9	0.6
Finland	45.9	38.5	7.4	2.3	5.1	0.8
Netherlands	45.5	36.7	6.8	2.1	7.7	1.3
United States	43.6	32.4	8.1	1.5	11.4	3.0
OECD	47.7	31.2	9.2	2.0	7.5	2.4

Finnish medical sciences and social sciences also had rather good success, both ranking sixth in this comparison. However the number of citations received by Finnish social sciences was three per cent lower than for publications in OECD countries on average. Natural sciences ranked 12th and engineering 16th. Publications in these fields received seven per cent less citations than natural science and engineering OECD publications on average.

10.3 Publishing in universities by major field of science and discipline

This chapter examines publication volumes at Finnish universities on the basis of Statistics Finland's questionnaire materials[3]. No international comparative data are available.

Publishing in foreign journals has increased in all major fields of science

Finnish universities' number of publications increased by nine per cent in 1999–2002 (the figure for 2002 was 22,614; see Appendix Table 10.3). The biggest increase at 26 per cent was recorded in the major field of agricultural sciences. Examined by discipline, publishing increased most rapidly in industrial chemistry and chemical process engineering, statistics, space sciences and astronomy as well as in biomedicine, which all recorded growth rates of almost 200 per cent or more. Publishing decreased most, by more than one-third, in nursing science, sport science, architecture and veterinary medicine.

In 2002 the number of articles published in foreign journals as a proportion of all university publications averaged 68 per cent. The major fields of science with the strongest international orientation were the natural sciences (85%), engineering and technology (80%) and medical sciences (75%). Space science and astronomy, physics, industrial chemistry and process engineering, chemistry and electrical engineering accounted for more than 90 per cent of all foreign publications.

The number of articles published in foreign journals went up by 15 per cent in 1999–2002. The figures increased most in agricultural sciences (44%), social sciences (32%) and the humanities (30%), where domestic publishing continues to have a prominent role as well.

Differences in the nature and traditions of different lines of research mean that there are also differences in publishing practices both between and within major fields of science. Research in medicine and the natural sciences often involves a joint collaborative effort and touches upon issues that are of broad international interest. The publications themselves are often short articles that report on empirical research results.

Articles appearing in refereed journals are the predominant category of foreign publishing, especially in the medical sciences (92%) but also in agricul-

3 Statistics Finland. Universities' number of publications (2004). Helsinki. (unpublished statistics).

tural sciences (75%) and natural sciences (67%). In the field of engineering the corresponding proportion was no more than 34 per cent. By discipline, the largest number of refereed articles as a proportion of foreign publishing was recorded in biotechnology and food technology, forest products technology and industrial chemistry as well as chemical process engineering.

Distinctive characteristics of publishing in the social sciences and humanities

In many disciplines within the social sciences and humanities not only international journals but also domestic scientific publications are an important channel for the dissemination of research results. Examples of scientific publishing with significant societal impact include research in the fields of theology, social scientific environmental research and women's studies. Research may also be concerned with nationally distinctive features; one example is provide by law.

Publishing in Finnish social sciences and humanities has a relatively strong international orientation. In 2002, 47 per cent of social scientific publications and 38 per cent of publications in the humanities appeared abroad (Appendix Table 10.3). The most international disciplines were psychology (70%), statistics (67%), and business administration and economic geography (65%).

In the social sciences, international publications accounted for less than 40 per cent in the social sciences proper (i.e. sociology, social psychology, social policy and social work), education, political science and administrative science. In the humanities the figure was less than 40 per cent in art studies, literature, theology and cultural studies. The lowest proportion of foreign publications was recorded in law (18%) and in history and archaeology (20%).

Publishing increased in all disciplines within the social sciences and humanities in 1999–2002. Publishing abroad increased by around 30 per cent in both major fields of science. The fastest growth was recorded in psychology and philosophy at more than 90 per cent. The only disciplines where foreign publishing did not increase were law, education and economics. In all disciplines where Finnish publishing increased, such as business administration and economic geography, psychology, philosophy and history and archaeology, the number of foreign publications increased as well.

In the social sciences and humanities, articles appearing in refereed journals are not as predominant as in the medical sciences, for instance. In 2002 their share of total publishing in the social sciences averaged 35 per cent and in the humanities 36 per cent (Table 10.3.1). In 1999–2002 the number of refereed articles increased by 20 per cent in the social sciences and by 36 per cent in the humanities. A refereed article appearing in a journal was the most significant type of publication in psychology (72%) and in statistics (62%).

Articles in edited volumes play a major role in disseminating research results in the humanities, but also in the social sciences. In all humanities disciplines and most social sciences disciplines, the proportion of articles appearing in edited volumes in 2002 was 50–66 per cent. In the social sciences their number increased by eight per cent, in the humanities it decreased by 15 per cent.

Table 10.3.1
Different types of university publications in the social sciences and humanities as a proportion of all publications in 2002 and change in volumes in 1999–2002. Source: Statistics Finland, Universities' number of publications.

	Refereed articles in journals	Change in number of publications 1999–2002	Articles in edited volumes	Change in number of publications 1999–2002	Monographs	Change in number of publications 1999–2002	Publications in university series	Change in number of publications 1999–2002[1]
	%	%	%	%	%	%	%	%
Economics	37	−6	28	−36	25	−26	12	..
Business administration, economic geography	23	16	63	58	7	58	7	..
Law	27	−16	63	−34	9	−20	2	..
Social sciences	36	48	50	3	11	−14	3	..
Psychology	72	111	24	125	4	67	1	..
Education	33	−19	52	8	8	−40	7	..
Political science, administrative science	40	24	43	−17	14	−9	2	..
Communication and information studies	37	92	51	12	4	−74	7	..
Statistics	62	375	28	325	5	0	7	..
Social sciences total	**35**	**20**	**51**	**8**	**9**	**−18**	**5**	**27**
Philosophy	32	77	54	113	7	78	6	..
Linguistics	34	41	53	−38	8	−19	5	..
Art studies, literature	30	25	55	−15	10	14	5	..
Theology	24	−20	50	−10	22	76	5	..
History and archaeology	33	88	52	20	12	−24	3	..
Cultural studies	25	0	66	−11	8	−23	1	..
Humanities total	**31**	**36**	**54**	**−15**	**11**	**0**	**4**	**56**

1 Publication numbers in university series are too small for the calculation of changes in individual disciplines.

The monograph is a highly respected means of publishing research results in the social sciences and humanities. In 2002 monographs accounted for about 10 per cent of all publishing in the social sciences and humanities. The largest number of monographs was published in economics (25%) and theology (22%). In 1999–2002 the number of monographs decreased in the social sciences and remained unchanged in the humanities.

Appendix 10.1.
Description of the National Science Indicators (NSI) database

The National Science Indicators (NSI) database contains publication and citation data for more than 170 countries in 1981–2002, broken down by field of research. In around 106,800 scientific articles, at least one of the authors is Finnish. The database indexes some 5,500 scientific journals in the natural sciences and engineering and technology as well as 1,800 social science journals and 1,200 journals in the arts and humanities. All the journals indexed are peer-reviewed. The NSI database has two classification systems: the standard version comprises 24 disciplines and the deluxe version 105 disciplines. The humanities are only included in the deluxe version.

Appendix Table 10.1
Correspondence between OECD major fields of science[1] and the NSI classification.

OECD major fields of science	NSI database disciplines
Natural sciences	Biology & Biochemistry Chemistry Computer Science Ecology/Environment Geosciences Mathematics Microbiology Molecular Biology & Genetics Physics Plant & Animal Science Space Science
Engineering and technology	Engineering Materials Science
Medical sciences	Clinical Medicine Immunology Neurosciences & Behavior Pharmacology Psychiatry (Deluxe)
Agricultural sciences	Agricultural Sciences2
Social sciences	Economics & Business Education Law Psychology (Deluxe) Social Sciences, general
Humanities	Archaeology (Deluxe) Art & Architecture (Deluxe) Classical Studies (Deluxe) General (Deluxe) History (Deluxe) Language & Linguistics (Deluxe) Literature (Deluxe) Performing Arts (Deluxe) Philosophy (Deluxe) Religion & Theology (Deluxe)

1 Classification based primarily on standard version.
2 Agricultural Sciences have no classification in NSI database

Appendix Table 10.2
OECD countries' relative citation impact[1] by major field of science in 1998–2002.
Source: Institute for Scientific Information, NSI 1981–2002.

Natural sciences		Engineering and technology		Medical sciences	
Switzerland	1.40	Switzerland	1.49	United States	1.29
United States	1.37	Denmark	1.28	Switzerland	1.26
Netherlands	1.19	United States	1.23	Iceland	1.23
United Kingdom	1.18	Netherlands	1.12	Canada	1.21
Denmark	1.14	Belgium	1.08	Netherlands	1.21
Germany	1.06	Germany	1.08	**Finland (6.)**	**1.17**
Sweden	1.04	Sweden	1.07	Denmark	1.14
Canada	1.02	France	1.07	Belgium	1.13
Austria	0.95	United Kingdom	0.98	United Kingdom	1.12
Belgium	0.95	Austria	0.98	Sweden	1.11
France	0.95	Ireland	0.96	Norway	1.06
Finland (12th)	**0.93**	Italy	0.95	Italy	1.02
Australia	0.93	Canada	0.94	Australia	0.99
Ireland	0.92	Norway	0.94	New Zealand	0.98
Iceland	0.90	Australia	0.93	France	0.97
Italy	0.89	**Finland (16.)**	**0.93**	Germany	0.96
Norway	0.85	Spain	0.91	Ireland	0.94
Japan	0.80	Hungary	0.91	Austria	0.91
Spain	0.79	Japan	0.87	Portugal	0.88
New Zealand	0.74	Czech Republic	0.87	Spain	0.82
Luxembourg	0.69	Portugal	0.82	Luxembourg	0.82
Portugal	0.63	New Zealand	0.73	Hungary	0.78
Greece	0.62	Mexico	0.71	Japan	0.75
Hungary	0.61	South Korea	0.71	Czech Republic	0.72
Czech Republic	0.54	Slovakia	0.70	Slovakia	0.67
Mexico	0.51	Greece	0.68	Poland	0.65
South Korea	0.50	Iceland	0.64	Mexico	0.58
Poland	0.50	Poland	0.62	Greece	0.58
Slovakia	0.46	Luxembourg	0.59	South Korea	0.52
Turkey	0.37	Turkey	0.58	Turkey	0.28

1 Relative citation impact = Country impact factor / OECD impact factor.
The OECD relative citation impact in each major field of science is one;
this is marked by a line.

Appendix Table 10.2
continued

Agricultural sciences		Social sciences		Humanities	
Luxembourg	3.73	United States	1.15	Greece	2.16
Netherlands	1.56	Netherlands	1.04	Netherlands	1.56
Finland (3.)	**1.52**	Belgium	1.00	New Zealand	1.35
Denmark	1.47	Canada	0.99	**Finland (4.)**	**1.33**
Switzerland	1.34	Italy	0.99	Portugal	1.26
Belgium	1.31	**Finland (6.)**	**0.97**	United Kingdom	1.23
United Kingdom	1.31	United Kingdom	0.96	United States	1.19
Sweden	1.23	Switzerland	0.93	Australia	1.17
Ireland	1.15	Sweden	0.92	Japan	1.16
United States	1.13	France	0.85	Turkey	1.14
France	1.10	New Zealand	0.82	Denmark	1.00
Norway	1.05	Norway	0.81	Hungary	0.94
Canada	1.04	Australia	0.80	Canada	0.92
Australia	1.00	Hungary	0.80	Belgium	0.82
Spain	0.97	Germany	0.80	Germany	0.77
Italy	0.96	Denmark	0.77	Sweden	0.75
New Zealand	0.96	Austria	0.73	Norway	0.74
Germany	0.92	Iceland	0.73	Iceland	0.60
Portugal	0.87	Luxembourg	0.67	Ireland	0.59
Austria	0.83	South Korea	0.65	Italy	0.57
Japan	0.81	Ireland	0.63	Poland	0.57
South Korea	0.78	Portugal	0.63	Switzerland	0.55
Slovakia	0.76	Spain	0.61	Mexico	0.49
Greece	0.76	Japan	0.58	South Korea	0.47
Iceland	0.75	Poland	0.55	Slovakia	0.44
Poland	0.69	Mexico	0.51	Spain	0.41
Mexico	0.67	Turkey	0.48	Austria	0.38
Turkey	0.52	Greece	0.45	France	0.36
Hungary	0.50	Czech Republic	0.28	Czech Republic	0.31
Czech Republic	0.39	Slovakia	0.19	Luxembourg	0.00

1 Relative citation impact = Country impact factor / OECD impact factor.
The OECD relative citation impact in each major field of science is one;
this is marked by a line.

Appendix Table 10.3
University publishing by major field of science and discipline in 1999–2002.
Source: Statistics Finland, Universities' number of publications.

	All publications total	Change % for publications	Per cent of foreign publications	Change % for foreign publications	Refereed foreign publications as % of all foreign	Change % for domestic publications
	2002	1999–2002	2002	1999–2002	2002	1999–2002
All total	**22,614**	**9**	68	15	65	–3
Natural sciences total	**5,594**	**11**	**85**	**17**	**67**	**–11**
Mathematics	419	–11	83	–7	76	–28
Computer science	1,238	75	86	82	27	44
Physics and astronomy	1,108	–11	93	–4	76	–54
Space sciences and astronomy	209	199	99	304	73	–84
Chemistry	774	–11	92	–6	81	–43
Biology, environmental sciences	1,443	8	80	10	86	4
Geography	138	0	40	41	62	–16
Geosciences, meteorology	265	35	67	33	59	38
Engineering and technology total	**3,182**	**13**	**80**	**19**	**34**	**–5**
Architecture	105	–38	27	–33	36	–39
Construction technology, municipal engineering	214	–2	64	–6	18	7
Electrical engineering	1,163	7	91	10	28	–17
Energy technology	95	–21	88	–19	38	–35
Metallurgy and mining technology	70	23	73	34	37	0
Mechanical engineering and manufacturing technology	451	18	80	40	22	–27
Process and materials technology	429	0	82	9	36	–28
Industrial chemistry, chemical process engineering	118	413	95	433	56	200
Forest products technology	124	2	59	–19	66	59
Biotechnology, food technology	222	118	80	87	76	529
Other technology	190	74	55	60	38	95
Medical sciences total	**6,277**	**6**	**75**	**3**	**92**	**15**
Biomedicine	1,019	191	87	207	92	118
Clinical medicine	3,902	–1	72	–11	93	37
Nutrition	64	83	81	73	90	140
Public health science	492	15	75	40	93	–25
Dentistry	191	–21	80	–14	90	–42
Sport science	101	–43	53	–52	80	–29
Pharmacy	166	–3	83	–6	96	17
Nursing science	202	–45	58	–41	85	–50
Veterinary medicine	140	–35	82	–40	84	14
Agricultural sciences total	**585**	**26**	**51**	**44**	**75**	**10**
Agricultural and food sciences	249	56	58	127	74	8
Forestry	336	10	46	8	76	12

Appendix Table 10.3
Continued

	All publications total	Change % for publications	Per cent of foreign publications	Change % for foreign publications	Refereed foreign publications as % of all foreign	Change % for domestic publications
	2002	1999–2002	2002	1999–2002	2002	1999–2002
Social sciences total	**4,530**	**9**	**47**	**32**	**45**	**–5**
Economics	218	–18	50	–2	56	–30
Business administration, economic geography	1,260	44	65	49	30	36
Law	547	–28	18	–20	25	–29
Social sciences	540	12	36	60	47	–5
Psychology	415	114	70	95	77	176
Education	876	–9	39	–10	50	–9
Political science, administrative science	363	–1	32	24	49	–9
Communication and information studies	249	16	42	67	50	–5
Statistics	61	259	67	242	76	300
Humanities total	**2,446**	**0**	**38**	**30**	**42**	**–12**
Philosophy	216	110	42	94	49	123
Linguistics	804	–18	52	12	43	–37
Art studies, literature	429	0	34	53	34	–15
Theology	276	0	30	24	33	–8
History and archaeology	510	27	20	46	49	23
Cultural studies	213	–12	35	44	35	–27

11 International cooperation in science and technology

For a small country like Finland, active involvement in international science and technology cooperation is absolutely essential. Indeed one of the major goals in the recent development of the Finnish science system has been to diversify its research cooperation. This has been achieved by new agreements of cooperation, broader participation in research programmes and support for the international mobility of researchers. Business R&D is also more international than before.

Chapter 11.1 below describes the international mobility of Finnish researchers in the light of exchange data from universities, the Academy of Finland and the Centre for International Mobility (CIMO). Chapter 11.2 proceeds to introduce the main forms of European research cooperation in which Finland is involved. Finland is also a member of numerous international scientific organisations and networks of research cooperation. Apart from European frameworks, major partners of global cooperation include the OECD and UNESCO. Nordic cooperation in science and technology nowadays has a strong regional motivation, its aim being to increase the competitiveness and visibility of what in a European perspective is a rather peripheral region. Bilateral cooperation with several countries, including the United States, Russia, Japan and China, remains important as well.

11.1 International mobility of researchers

One of the most effective forms of scientific cooperation and exchange of information is for researchers to spend periods working in foreign countries. This greatly facilitates the transfer of expertise in our increasingly globalised world: it allows researchers to familiarise themselves with work that is done in other countries, to exchange views with experts in their own fields, to collect materials and to set up joint projects. Teacher exchange programmes are an important way of improving the quality of teaching, promoting the development of teaching and providing variation to teaching methods and contents.

The discussion below provides information on visits by Finnish teachers and researchers to foreign countries as well as on visits by foreign teachers and researchers to Finland. The data for universities and polytechnics are drawn from Ministry of Education databases (KOTA and AMKOTA) and from Statistics Finland's science and technology statistics. The data on Academy of Finland funding decisions have been compiled by the science organisation's International Relations Unit. The data on CIMO grant programmes have been supplied by the organisation's scholarships unit.

11.1.1 Personnel exchange at universities and polytechnics

Average duration of university visits 4–5 months

In 2003 Finnish teachers and researchers made a total of almost 600 one-month or longer visits to foreign universities. The average duration of these visits was 4.3 months, but the figures varied widely for different universities. At the University of Kuopio, personnel visits to foreign countries lasted on average almost eight months, whereas the visits of the two staff travelling from the Theatre Academy lasted no more than one month. The data cover all staff members from professors to laboratory technicians. They also include Academy of Finland researchers, other researchers hired on a full-time basis for at least six months as well as researchers in receipt of senior scientist grants.

In 2003 Finnish universities and polytechnics received visits by almost 1,100 foreign teachers and researchers. This figure does not include foreign staff recruited on a contract basis or students on postgraduate degree

Table 11.1.1
Teacher and researcher visits by university in 2003.
Source: Ministry of Education, KOTA database.

University	From Finland[1]		To Finland[2]		Total		Total	
	no.	months	no.	months	no.	%	months	%
University of Helsinki	138	508	177	600	315	18.9	1,108	14.3
Helsinki University of Technology	91	514	172	960	263	15.8	1,474	19.0
University of Turku	78	282	140	441	218	13.1	723	9.3
University of Oulu	69	279	108	403	177	10.6	682	8.8
University of Jyväskylä	33	104	74	380	107	6.4	484	6.2
Tampere University of Technology	33	143	228	1,708	261	15.7	1,851	23.9
University of Tampere	31	90	30	92	61	3.7	182	2.3
Åbo Akademi University	29	135	58	260	87	5.2	395	5.1
University of Kuopio	22	173	35	234	57	3.4	407	5.3
University of Joensuu	11	38	4	9	15	0.9	47	0.6
Lappeenranta University of Technology	14	95	18	103	32	1.9	198	2.6
Helsinki School of Economics and Business Administration	7	22	6	10	13	0.8	32	0.4
University of Vaasa	4	24	16	30	20	1.2	54	0.7
Swedish School of Economics and Business Administration	7	26	2	3	9	0.5	29	0.4
University of Art and Design Helsinki	–	–	6	8	6	0.4	8	0.1
Theatre Academy	2	2	3	10	5	0.3	12	0.2
University of Lapland	5	10	8	23	13	0.8	33	0.4
Turku School of Economics and Business Administration	5	25	1	1	6	0.4	26	0.3
Sibelius Academy	–	–	1	1	1	0.1	1	0.0
Academy of Fine Arts	–	–	1	1	1	0.1	1	0.0
Total	**579**	**2,470**	**1,088**	**5,277**	**1,667**	**100.0**	**7,747**	**100.0**

1 Periods of one month or longer spent by university staff working or studying at foreign universities or research institutes.
2 Foreign researchers working for at least one month at university departments during the year.

programmes. The total number of visits was thus almost twice as high as the corresponding number for visits by Finnish teachers and researchers. The average duration of these visits was 4.9 months. At the Tampere University of Technology, foreign teachers and researchers spent on average 7.5 months and at the University of Kuopio over six months.

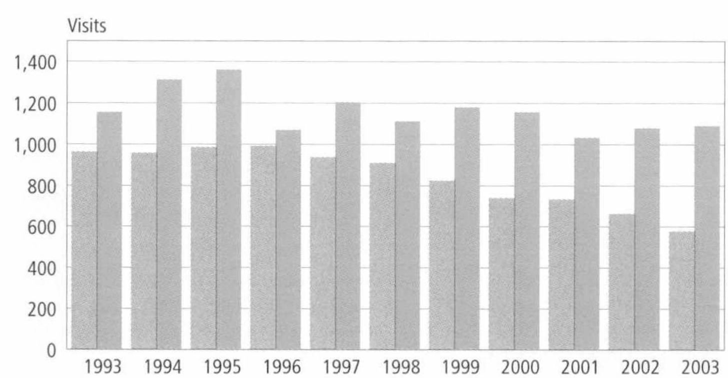
Measured in numerical terms, the highest level of staff exchange was recorded for the University of Helsinki, which accounted for almost one-fifth of all teacher and researcher visits (Table 11.1.1). The figures for both Helsinki University of Technology and Tampere University of Technology were around 16 per cent. The latter had the highest staff exchange level when measured in terms of the total number of months: Tampere University of Technology accounted for almost one-quarter of all visit-months. Visits by foreign personnel to Finland accounted for over 90 per cent of these months.

No more than 3.6 per cent of university teaching and research personnel[1] took part in exchange programmes in 2003. The figures were highest for the Swedish School of Economics and Business Administration (5.5%), Helsinki University of Technology (5.2%) and the University of Turku (5.1%).

Visits from Finland to abroad on the decline

The popularity of teacher and researcher exchange, particularly visits from abroad to Finland, increased sharply in the early 1990s, peaking in 1995 (Figure 11.1.1). Since then the number of visits to Finnish universities has remained more or less steadily around 1,100, but the number of visits from Finland to abroad has decreased every year so that by 2003, the number of visits was down to just 60 per cent of the figure recorded in 1995. Indeed it seems that in recent years, Finnish researchers have shown much less interest in

Figure 11.1.1
Teacher and researcher visits (one month and longer) at universities in 1993–2003. Source: Ministry of Education, KOTA database.



1 Including postgraduate students at graduate schools

spending time abroad than before. The decline started at the same time as cutbacks in university funding began to affect the whole operation of Finnish universities, including their international exchange programmes. Faced with a growing scarcity of funds, university departments have also had to apply stricter criteria in their choice of people wanting to travel. Engineering sciences have been less affected than other disciplines since here the share of external funding is greater and the cutbacks in core funding have therefore had less dramatic effects.

In the early 1990s the University of Helsinki still accounted for about 30 per cent of total staff exchange, but since then the figure has dropped to around 20 per cent. By contrast the figure for Tampere University of Technology has risen from just over four per cent to the current level of 16 per cent. Helsinki University of Technology has also seen its share increase considerably. There have been no marked changes in the average duration of visits over the past decade: the figure has been consistently at between four and five months. Since 1997 the average duration of visits to Finland has been longer than the duration of visits from Finland to abroad.

Most visits in engineering and natural sciences

Measured in terms of number of visits, by far the biggest field of study is engineering: in 2003 it accounted for 38 per cent of the total. The corresponding proportion for the natural sciences was 26 per cent. In the case of visits from abroad to Finland, the proportion of engineering sciences was even higher at 45 per cent. The figures for both these fields are thus much higher today than they were in the early 1990s. Medicine accounted for 17 per cent of total staff exchange in 1993, the figure now has dropped to seven per cent.

The most recent statistics available for visits by major fields of science are from 2002. These data have been collected in connection with R&D surveys in the university sector. In this analysis the share of natural sciences increases to over 43 per cent and that of engineering drops to 24 per cent. Together these two disciplines account for an even greater share of all visits to Finland, i.e. 77

Table 11.1.2
Teacher and researcher visits (one month or longer) at universities in 2002.
Source: Statistics Finland.

	Researcher visits from Finland 1 month or longer		Researcher visits toFinland 1 month or longe	
	Visits	Months of work	Visits	Months of work
Natural sciences	215	823	455	2,174
Engineering and technology	93	513	272	1,814
Medical sciences	72	362	121	634
Agricultural sciences	6	13	12	61
Social sciences	105	375	55	187
Humanities	102	373	34	100
Fields of science total	**593**	**2,460**	**949**	**4,971**

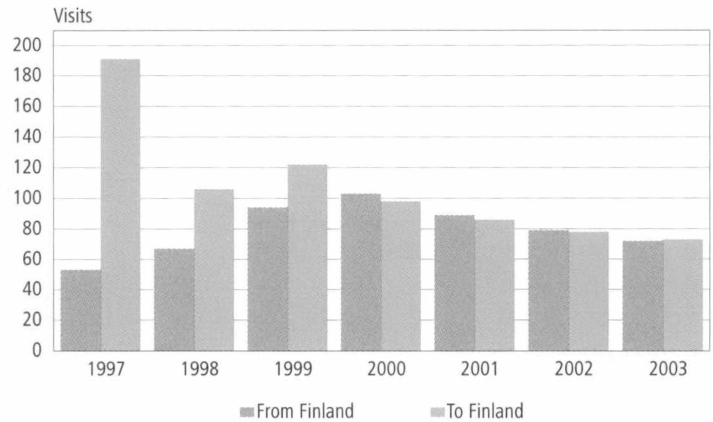
per cent. The social sciences and humanities account for over 17 per cent of all visits from Finland to abroad, but only less than one in ten visits from abroad to Finland are in these fields.

Closer balance in staff exchange at polytechnics

In 2003 Finnish polytechnics recorded 72 teacher or expert visits to foreign countries lasting a minimum of one month. The number of visits to Finland was 73. The average duration of visits to other countries was no more than 1.7 months, whereas in the opposite direction the visits lasted on average 2.6 months. Staff exchange was at its highest in the late 1990s, but since then the figures have consistently fallen. At the same time, though, the mutual balance between visits to and from Finland has improved (Figure 11.1.2).

By field of study, the largest number of visits was recorded in the fields of engineering and transport as well as in the social welfare, health and sport sector. In 2003 both these categories accounted for about 24 per cent of all visits.[2]

Figure 11.1.2
Teacher and expert visits (one month or longer) at polytechnics in 1997–2003. Source: Ministry of Education, AMKOTA database.



2 Aalto, Pirjo & Irma Garam (2004)

11.1.2 Promoting international mobility among researchers: the role of the Academy of Finland[3]

A strong international orientation cuts across all Academy of Finland operations. The Academy is committed to supporting and facilitating the international research cooperation of Finnish scholars by making available its science policy expertise, by providing funding for research projects and by participating in the work of Nordic, European and other international science and research organisations. Most of the funding provided for purposes of supporting international research and researcher mobility is channelled through research projects, research programmes and centres of excellence in research.

One of the key motivations behind the ongoing efforts to strengthen the European Research Area is to promote researcher mobility. Nordic cooperation shares the same goal, as well as seeking to promote participation in researcher training and to offer improved access to research infrastructures. The main forums of Nordic cooperation are the Joint Committees of Nordic Research Councils (NOS), the Nordic Academy for Advanced Study (NorFA) and the Nordic Optical Telescope.

Finnish researchers studying and working abroad are supported both through Academy project funding and dedicated grants ('researcher training and research abroad'). The Academy also supports international mobility by issuing grants for purposes of bilateral researcher exchange, which in different regions and countries is based on agreements signed between the respective funding bodies. Furthermore, researcher exchange is supported jointly with the US National Institutes of Health and the Netherlands Organisation for Scientific Research (NWO).

All decisions on the funding of research projects and on supporting international researcher mobility are made by the Academy's Research Councils.

Researchers visiting the US and the UK receive one-half of all grants

In 2003, the Academy's four research councils,[4] awarded grants to a total of 355 Finnish researchers for purposes of working abroad (Table 11.1.3). The biggest single target country was the United States (accounting for 30% of all grants), followed by the United Kingdom (approx. 19%). The average duration of visits was 4.3 months. Research in the field of the Research Council for Culture and Society accounted for almost one-half of all visits and for 40 per cent of all months spent abroad. Visits in disciplines hosted by the Research Council for Natural Sciences and Engineering were the longest, averaging 5.2 months.

3 This chapter is by Eeva Ikonen from the Academy of Finland

4 The Research Council for Culture and Society, the Research Council for Natural Sciences and Engineering, the Research Council for Health and the Research Council for Biosciences and Environment

Table 11.1.3
Grants awarded by the Academy of Finland for research abroad, research funding decisions by Research Council in 2003.
Source: Academy of Finland.

Country visited	Research Council								Total		Share (no.)
	BE		CS		NE		HR				
	no.	months	no.	months	no.	months	no.	months	no.	months	%
United States	15	74	35	123	18	85	38	161	106	443	29.9
United Kingdom	10	52	42	148	8	56	7	36	67	292	18.9
Italy	–	–	50	199	–	–	–	–	50	199	14.1
Sweden	3	25	–	–	16	71	10	35	29	131	8.2
France	5	26	10	38	–	–	5	26	20	90	5.6
Germany	8	29	2	7	4	25	1	12	15	73	4.2
Canada	9	30	–	–	3	13	–	–	12	43	3.4
New Zealand	–	–	4	14	–	–	5	26	9	40	2.5
Netherlands	–	–	4	14	1	12	2	13	7	39	2.0
Australia	–	–	1	6	–	–	4	26	5	32	1.4
Switzerland	–	–	3	10	2	18	–	–	5	28	1.4
Denmark	–	–	2	13	–	–	3	13	5	26	1.4
Austria	–	–	–	–	5	20	–	–	5	20	1.4
Belgium	–	–	2	10	2	8	–	–	4	18	1.1
Spain	–	–	4	14	–	–	–	–	4	14	1.1
India	–	–	4	10	–	–	–	–	4	10	1.1
Japan	–	–	–	–	3	18	–	–	3	18	0.8
China	–	–	3	7	–	–	–	–	3	7	0.8
Czech Republic	–	–	–	–	2	7	–	–	2	7	0.6
Total	**50**	**236**	**166**	**613**	**64**	**333**	**75**	**348**	**355**	**1,530**	**100.0**
%	14.1	15.4	46.8	40.1	18.0	21.8	21.1	22.7	100.0	100.0	

BE Research Council for Biosciences and Environment
CS Research Council for Culture and Society
NE Research Council for Natural Sciences and Engineering

Russia accounts for one-half of all visits to Finland

Based on bilateral agreements of cooperation with different countries and science organisations, the number of months that visiting researchers spent in Finland in 2003 was more than twice the duration of visits by Finnish researchers abroad (Table 11.1.4). Finnish researchers with funding granted by Academy Research Councils spent the largest number of months in Germany, Russia and Japan. Researchers from Russia accounted for by far the largest proportion of visits to Finland. More than three-quarters (77%) of the months spent by Russian researchers in Finland were covered by invitation grants, and Russia accounted for 40 per cent of all researcher mobility. The number of months spent by Finnish researchers abroad and foreign researchers in Finland on the basis of bilateral agreements was highest in the disciplines hosted by the Research Council for Natural Sciences and Engineering, accounting for 45 per cent of total staff exchange. The lowest overall

Table 11.1.4
Researcher mobility based on bilateral agreements, decisions by Research Council in 2003.
Source: Academy of Finland.

Country	Research Council, months								Total	
	BE		CS		NE		HR			
	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland
Argentina	0.5	6.5	–	–	–	–	–	3.0	0.5	9.5
Bulgaria	0.3	2.8	–	1.9	3.2	1.3	0.2	0.7	3.7	6.6
Iran	–	–	0.8	–	–	–	–	–	0.8	–
Japan	7.7	4.8	0.5	–	35.6	24.3	0.5	24.3	44.2	53.5
China	1.5	12.5	2.4	2.0	2.3	–	–	–	6.2	14.5
South Korea	–	–	–	–	–	0.7	–	–	–	0.7
Latvia	0.5	–	0.8	0.4	–	–	–	–	1.3	0.4
Lithuania	–	–	0.9	0.5	–	–	–	–	0.9	0.5
Poland	0.7	8.2	1.7	0.9	5.9	3.4	0.9	8.4	9.3	20.9
=invitation grant	–	–	–	–	–	1.5	–	–	–	1.5
Romania	–	–	–	0.9	0.5	2.3	–	–	0.5	3.2
Germany	18.5	12.0	3.5	–	38.8	–	4.6	–	65.4	12.0
Slovakia	–	1.7	–	1.0	1.4	2.6	0.5	0.7	1.8	6.0
Czech Republic	–	2.7	–	1.6	11.1	9.1	–	1.0	11.1	14.4
=invitation grant	–	8.1	–	–	–	12.1	–	–	–	20.2
Ukraine	–	1.0	1.0	–	–	17.8	–	6.0	1.0	24.8
Hungary	0.7	1.0	3.1	11.1	0.7	3.5	–	5.0	4.5	20.6
Belorussia	–	–	–	–	–	2.1	–	2.5	–	4.6
Russia	10.0	12.0	37.5	10.2	2.6	26.0	–	1.0	50.1	49.2
=invitation grant	–	39.8	–	20.3	–	80.8	–	24.0	–	164.9
Estonia	2.2	1.6	3.1	15.9	1.5	2.8	–	–	6.8	20.3
Total	**42.5**	**114.7**	**55.4**	**66.7**	**103.6**	**190.2**	**6.7**	**76.7**	**208.2**	**448.3**
%	20.4	25.6	26.6	14.9	49.8	42.4	3.2	17.1	100.0	100.0

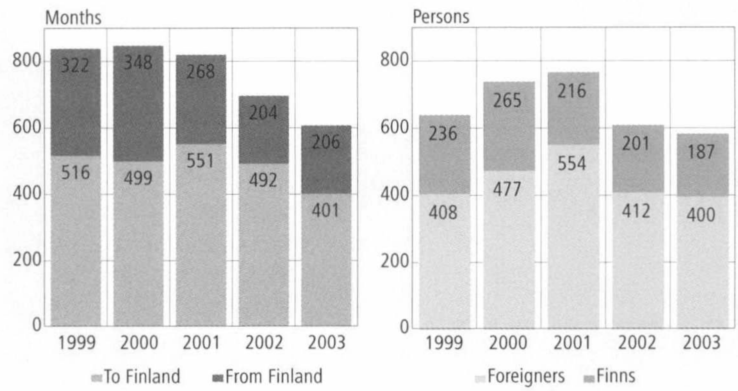
BE Research Council for Biosciences and Environment
CS Research Council for Culture and Society
NE Research Council for Natural Sciences and Engineering
HR Research Council for Health

figure was recorded for the Research Council for Health, although the number of months spent by visiting researchers in Finland was greater here than in the field of the Research Council for Culture and Society (Table 11.4).

The annual balance of bilateral researcher exchange based on Research Council decisions shows a surplus for Finland (Figure 11.1.3): throughout the period from 1999 to 2003, the number of person-months worked by foreign researchers in Finland has exceeded the corresponding number of months that Finnish researchers have worked abroad. The number of visiting researchers both arriving in Finland and leaving Finland has decreased since 2001.[5]

5 The statistics presented in the Figures are based on actual numbers, but the statistics in the Tables for 2003 are based on decisions made by Academy Research Councils. Actual visits do not always last as long as specified in Research Council decisions.

Figure 11.1.3
Researcher exchange based on Academy of Finland bilateral agreements in 1999–2003.
Source: Academy of Finland.



11.1.3 Scholarships from the Centre for International Mobility CIMO

Operating under the Ministry of Education, the Centre for International Mobility (CIMO) is an expert and service organisation that coordinates and manages scholarship and staff exchange programmes and that has responsibility for national implementation of virtually all EU education, culture and youth programmes. It also promotes the teaching and learning of Finnish language and culture at universities abroad. The priority focus in CIMO scholarship programmes is on Russia, Finland's neighbouring states and the countries of Central and Eastern Europe.

CIMO supports international mobility through 13 scholarship programmes. Scholarships are awarded to postgraduate students, researchers and teachers travelling to and from Finland. Furthermore, Finnish experts in science and the arts may apply for grants for visits to foreign countries. In addition to programmes based on Finland's cultural exchange and other bilateral agreements, scholarships are awarded for network cooperation through the Nordic Grant Scheme run by the Nordic Council of Ministers. Finnish students with an academic degree can also apply for grants to participate in a College of Europe Master of European Studies programme.

More than 1,000 scholarships in 2003

In 2003 CIMO awarded a total of 1,074 scholarships. Although most CIMO scholarships are intended for postgraduate students and researchers, support is also provided to students undertaking their first degree.

Almost two-thirds or 63 per cent of all scholarships were granted to students or researchers coming to Finland. The largest number of foreign arrivals came from Russia, Estonia and Hungary (Table 11.1.5). Almost two-thirds of the postgraduate students and researchers studying and working in Finland came from the group of priority countries. Outside of Europe, China continues to account for the biggest share.

A total of 397 grants were awarded to students and researchers leaving Finland for other countries. The most popular destinations were Russia, Hungary and Estonia. Russia accounted for one-quarter of all arrivals from Finland.

Table 11.1.5
Centre for International Mobility scholarship recipients by country in 2003.
Source: Centre for International Mobility (CIMO).

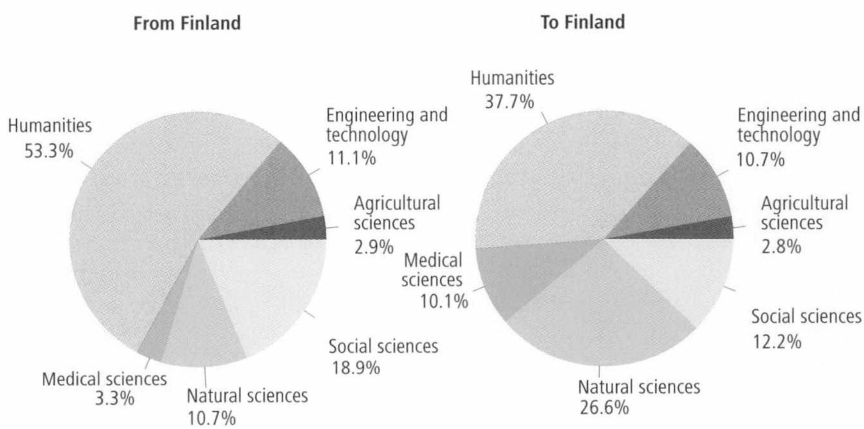
	From Finland	To Finland	Total	
			no.	%
Russia	103	225	328	30.5
Estonia	35	75	110	10.2
Hungary	37	63	100	9.3
Belgium	22	15	37	3.4
Italy	14	23	37	3.4
Poland	10	21	31	2.9
Sweden	22	8	30	2.8
Denmark	20	8	28	2.6
Germany	12	14	26	2.4
China	6	16	22	2.0
France	7	14	21	2.0
Czech Republic	10	10	20	1.9
Lithuania	8	10	18	1.7
Latvia	3	14	17	1.6
United States	10	7	17	1.6
Greece	6	10	16	1.5
India	3	12	15	1.4
Romania	5	10	15	1.4
Spain	4	9	13	1.2
Argentina	7	4	11	1.0
Chile	7	4	11	1.0
Iceland	2	9	11	1.0
United Kingdom	–	11	11	1.0
Slovakia	6	5	11	1.0
Ireland	6	4	10	0.9
Others	32	76	108	10.1
Total	**397**	**677**	**1,074**	**100.0**

Number of scholarship recipients leaving Finland has increased rapidly

In 1999 the number of scholarships awarded was 809, i.e. 265 less than the current figure. The number of Finnish scholarship recipients increased by 62 per cent over four years, while the number of foreign arrivals went up by 20 per cent. During this same period Russia's share of total student and researcher exchange increased by almost 10 percentage points.

The humanities accounted for 43 per cent of all scholarships granted.[6] The figure was even higher for mobility from Finland to other countries (Figure 11.1.4). The natural sciences accounted for 21 per cent, the social sciences for 14 per cent, engineering and technology for 11 per cent, medical sciences for eight per cent and agricultural sciences for three per cent.

Figure 11.1.4
CIMO scholarship recipients[1] by major field of science in 2003.
Source: Centre for International Mobility (CIMO).



1 Excluding mobility within the Nordic Grant Scheme and FIRST programmes.

11.2 European R&D cooperation

Most R&D activities within the EU are organised on a national basis. However it is often impossible for member states to maintain the required level of activity, particularly when faced with the challenges of European competition: cooperation, in these situations, is of paramount importance. The beginnings of R&D cooperation within the EU area can be traced back to research in the nuclear energy field and to the joint projects in coal and steel cooperation in the 1950s.

The aim of EU research cooperation is to strengthen the community's scientific and technological know-how. The EU is also keen to create a more favourable operating environment for R&D activities. Ultimately the aim is to establish an open internal market for research, or the European Research Area ERA. Within this framework the community's objective is to strengthen the networking of European research in different fields and at different levels, to remove remaining barriers to cross-border research cooperation and at the

6 Mobility within the Nordic Grant Scheme and FIRST network programmes is not included in the calculations because of missing data

same time to increase competition in the research markets. The EU has set itself the target of increasing its R&D investment to three per cent of the community's GDP by the year 2010. Each year the EU spends more than four billion euros on R&D: these monies are channelled to business enterprises, research institutes and universities through a system of framework programmes.

The discussion here focuses on the principal forms of European research cooperation, on the EU's R&D programmes and on cooperation in the frameworks of COST, EUREKA and ESA. Other European forums of research cooperation in which Finland is actively involved include the European Science Foundation ESF, the European Laboratory for Particle Physics CERN, the European Molecular Biology Laboratory EMBL and the European University Institute EUI.

11.2.1 EU R&D programmes[7]

Since their launch in 1984, R&D framework programmes have been the EU's most important funding tool for purposes of supporting European research cooperation between business enterprises and research organisations. Finnish involvement in EU framework programmes started on a selective basis in 1987. Since 1995, when Finland joined the EU as a full member, participation has been in the capacity of an equal partner. Priority areas of the current, Sixth Framework Programme include life sciences, information society technologies, nanotechnologies, aeronautics and space, food quality and safety, sustainable development and knowledge-based society.

The declared objectives of EU RTD programmes include the promotion of European know-how, the technological level of industry, and quality of life and welfare in general. The Sixth Framework Programme has the aim of contributing to the creation of a real European Research Area: the programme serves as a funding instrument that will help turn the ERA into reality. The programme budget is 17.5 billion euros, which is almost four per cent of the EU's total budget (2001) and 5.4 per cent of European public investment in research (excluding military research).

RTD projects set up within the Sixth Framework Programme must involve at least three organisations from three different EU countries. Participants in these consortia may be either business enterprises, universities, private or public research institutes or some other group or organisation that conducts or uses research. In practice, however, a consortium in the Sixth Framework Programme will often have to be even more broadly based, for the aim is to encourage ever closer and more concrete research cooperation in Europe. Non-European countries are also eligible for participation.

The main instruments of the Sixth Framework Programme are integrated projects, networks of excellence, targeted RTD projects as well as various types of SME projects. Major projects are the mainstay of the programme, but the EU also provides funding for smaller research projects, researcher mobility, comparative research and networks. Different types of projects have different objectives and different areas of funding.

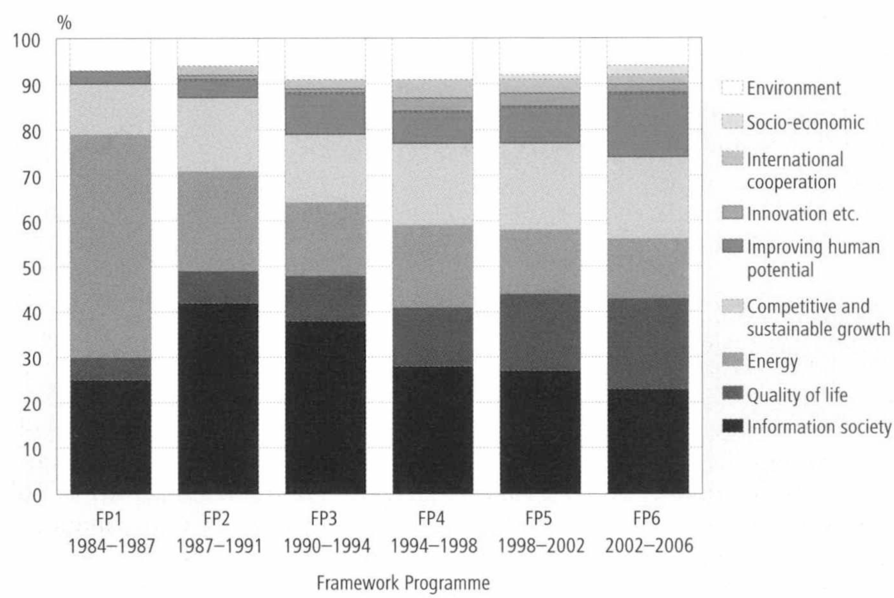
7 Sources: Tekes EU R&D Secretariat : www.tekes.fi/eu: www.cordis.lu

Each new framework programme brings along fresh research ideas and new goals and objectives. The themes of energy, information society, and competitive and sustainable growth have occupied a central place from the very outset. Over the years growing emphasis has been placed upon quality of life and improving human potential, at the same time as the range of priorities has grown wider (Figure 11.2.1).

In terms of its contents the Sixth Framework Programme does not differ very much from the fifth programme that ended in 2002; the results of the Fifth Framework Programme are discussed separately at the end of this Chapter. A preliminary communique on the Seventh Framework Programme in 2007–2010 and its budget framework was published in summer 2004.

Experiences from the EU's Fifth Research Framework Programme are discussed in Chapter 11.3 below.

Figure 11.2.1
Evolution of priorities of the Eeuropean Union RTD Framework Programmes, per cent. Source: European Commission, Key Figures 2002.



11.2.2 COST [8]

COST was established in 1971 to encourage and foster European cooperation in the areas of science and technology. It supports multinational research net-

8 European Co-operation in the Field of Scientific and Technical Research, COST
Sources: Finnish national COST coordinator, Tekes:
www.tekes.fi/eng/co-operation/europe/cost.html;

works by providing nationally funded research projects the opportunity to join broadly based European R&D cooperation. There are currently 34 European member states; Israel is additionally involved as a cooperating state. Participation in COST actions is also open to non-members; the most active countries in this category have been Russian, American and Canadian partners. COST is also involved in the ongoing EU strides to establish the ERA.

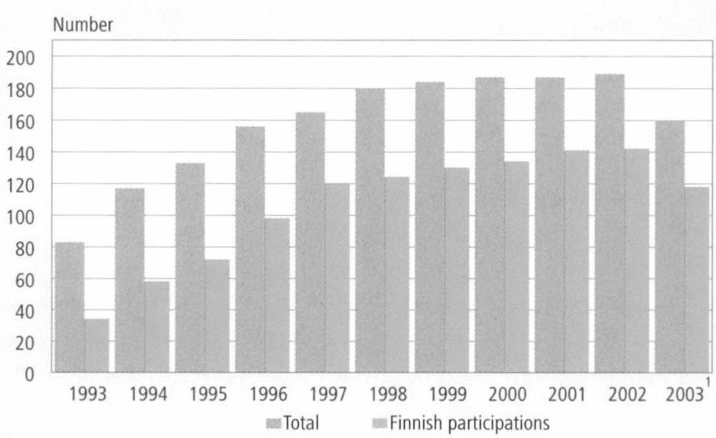
COST does not fund research activities, but it supports the coordination and networking of existing research by covering the costs of cooperation, such as travel and seminar costs and short-term researcher visits. The actual research is funded from national sources. The aim of COST actions is to promote broadly based, multidisciplinary cooperation among researchers with a view to creating research networks and supporting and facilitating the exchange of information. Actions are to involve participants from at least five different COST members. On average they last four years and have participants from 16 countries. It is estimated that the annual volume of research coordinated in COST actions amounts to over two billion euros. A total of almost 30,000 researchers are involved in these actions.

Finland involved in three out of four COST actions

The number of COST actions increased every year throughout the 1990s. In 1993 there were over 80 ongoing COST actions, by the turn of the millennium the figure was almost 2,000 (Figure 11.2.2). Since then the figure has remained at roughly the same level, but because of changes in the way the statistics are compiled the figure for 2003 is no longer comparable to those for earlier years.

Finland has been a member of COST since its inception and is currently involved in about three out of four of all its actions. Finnish participation it at

Figure 11.2.2
COST projects and Finnish participation in 1993–2003.
Source: National Technology Agency Tekes.



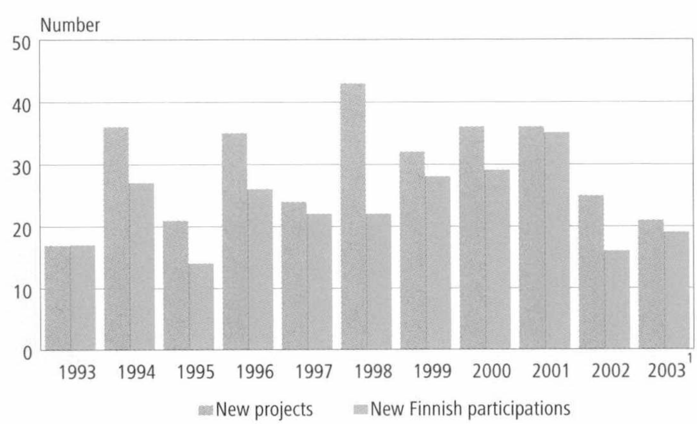
1 New statistical rules

Table 11.2.1
Participation in ongoing COST projects in 2003 by country.
Source: National Technology Agency Tekes.

Country	No. of participations	Participation rate, %	Country	No. of participations	Participation rate, %
Austria	140	74.9	Luxembourg	5	2.7
Belgium	160	85.6	Macedonia (FYROM)	6	3.2
Bulgaria	64	34.2	Malta	12	6.4
Croatia	33	17.6	Netherlands	142	75.9
Cyprus	49	26.2	Non-COST	78	41.7
Czech Republic	106	56.7	Norway	123	65.8
Denmark	128	68.4	Poland	107	57.2
Estonia	11	5.9	Portugal	86	46.0
Finland	136	72.7	Romania	71	38.0
France	171	91.4	Serbia and Montenegro	13	7.0
Germany	174	93.0	Slovakia	48	25.7
Greece	116	62.0	Slovenia	96	51.3
Hungary	125	66.8	Spain	176	94.1
Iceland	15	8.0	Sweden	130	69.5
Ireland	100	53.5	Switzerland	138	73.8
Israel[1]	31	16.6	Turkey	23	12.3
Italy	170	90.9	United Kingdom	174	93.0
Latvia	38	20.3			
Lithuania	48	25.7	**Projects total**	**187**	**100.0**

1 Cooperating state

Figure 11.2.3
Annual new COST actions and Finnish participations in 1993–2003.
Source: National Technology Agency Tekes.

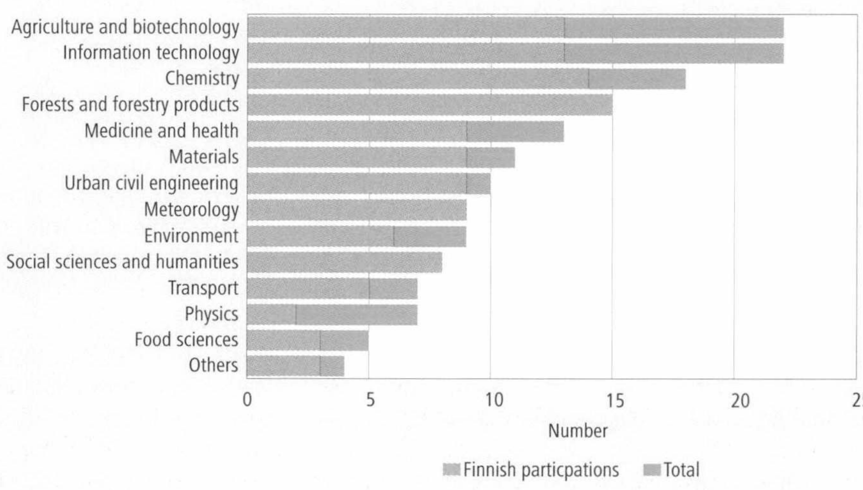


1 New statistical rules

roughly the same level as in Sweden, Denmark, Austria and Switzerland. The most active members are Spain, the United Kingdom and Germany (Table 11.2.1). The number of new actions in which Finland is involved varies from year to year, but in 2003 there was Finnish participation in 19 out of the total of 21 actions (Figure 11.2.3). Four of these 19 new actions were launched and coordinated by Finnish partners.

In 2003 the largest number of actions was recorded in the fields of agriculture and biotechnology and information technology (Figure 11.2.4). Finland has played a particularly active role in the forest cluster, meteorology and social science actions: it was involved in all these fields at the end of 2003.

Figure 11.2.4
COST projects by scientific domains and Finnish participations on 31 Dec 2003.
Source: National Technology Agency Tekes.



Positive experiences from COST actions

The findings of a recent evaluation[9] indicate that the COST programme is considered a useful channel of cooperation for research institutes, universities and government agencies. Research-oriented business enterprises have also been involved in several successful joint projects. Among other things, these projects have paved the way to a global GSM system; established the Reading Weather Station in the UK; developed technology and systems for low-floor buses; and developed a new durable steel material for high-temperature power plant processes.

9 Nissinen Marja & Pirjo Niskanen (1999)

11.2.3 EUREKA [10]

Launched in 1985, EUREKA initiative is a European network for market-oriented R&D that is aimed at strengthening the competitiveness of European businesses. The network currently involves 35 European countries plus the European Union, which is represented by the Commission. Monaco and San Marino became full members on 1 January 2005. Finland is one of the founder members.

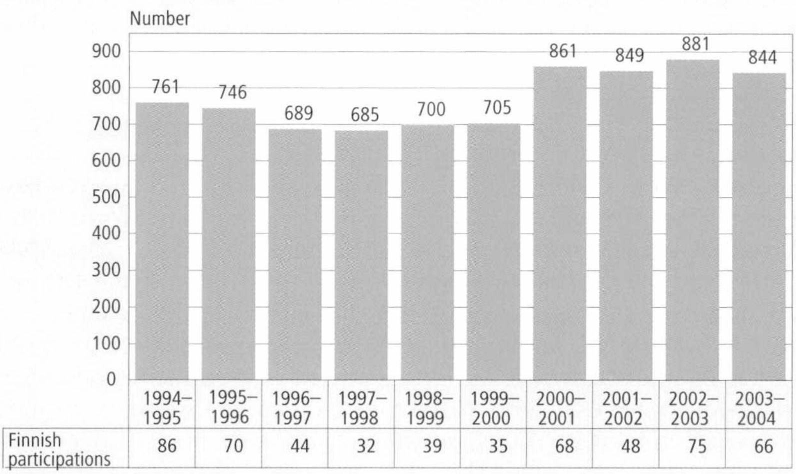
Over the past 19 years business enterprises and public authorities have invested a total of 22 billion euros in EUREKA projects. During this time the network's key role in supporting European industry and technology cooperation has become well established, helping to bolster employment and increase general welfare. According to its new strategic plan, EUREKA will be seeking in the future to intensify collaboration in cluster programmes and within the ERA and also to provide more diversified funding for projects.

EUREKA projects are market-driven, bottom-up projects set up by business companies geared towards the development of high-tech products, processes and services for the global marketplace. There are no rules and limitations with respect to areas of technology. Business enterprises, research institutes and universities can all find their own appropriate avenues of networking and internationalisation from the range of different EUREKA project forms. The partners design and implement the projects according to their own needs and interests and agree amongst themselves on the use of the end-results. Projects can be set up by partners from just two EUREKA members, and organisations from non-members are also eligible to participate. In addition to innovative EUREKA projects, R&D projects may also be created under strategic cluster programmes or thematic umbrella programmes. The average duration of EUREKA projects is 2.5 years and average volume 2.5 million euros. EUREKA is not a funding organisation, but all its projects are funded from national sources. In Finland most of the funding for EUREKA projects comes from the National Technology Agency Tekes, which applies its own funding criteria.

In June 2004 there were a total of 743 ongoing innovative EUREKA projects with a combined value of 2.1 billion euros, and 101 cluster projects with a total budget of 2.7 billion euros (Figure 11.2.5). The French Chair year which ended in June 2004 yielded recorded-breaking results, primarily by virtue of EUREKA's highly successful clusters. During the French Chair the volume of funding for EUREKA projects increased by almost one billion euros; the figure currently stands at about five billion euros.

10 Sources: Finnish EUREKA office, Tekes:
www.tekes.fi/eng/co-operation/europe/eureka.html and

Figure 11.2.5
EUREKA projects and Finnish participations by chair year in 1994–2004.
Source: National Technology Agency Tekes.



Finnish involvement in new projects continuing to increase

During the French Chair from 1 July 2003 to 30 June 2004, a total of 206 new innovative projects with a combined budget of 518 million euros were launched, and six new cluster programmes with a total budget of 3.6 billion euros started up. Furthermore, 25 new cluster projects with a value of 461 million euros were set up. Cluster programmes have assumed great significance in EUREKA's operation: the core of this activity consists of eight programmes in the ICT domain.

Finnish partners joined 25 new projects during the French Chair. These had a combined budget of 174 million euros (Table 11.2.2). The Finnish contribu-

Table 11.2.2
New EUREKA projects and Finnish participations by chair in 1994–2004.
Source: National Technology Agency Tekes and EUREKA Secretariat.

Chair country	Chair year 1.7.–30.6.	New projects total	Finnish participation	Finnish coordinated
Switzerland	1994–1995	147	14	8
Belgium	1995–1996	155	11	4
United Kingdom	1996–1997	164	13	5
Portugal	1997–1998	184	11	3
Turkey	1998–1999	153	15	4
Germany	1999–2000	193	17	6
Spain	2000–2001	253	23	4
Greece	2001–2002	204	10	0
Denmark	2002–2003	181	20	6
France	2003–2004	237	25	6

tion amounted to 39 million euros. The total number of Finnish participations in EUREKA projects was 50, 72 per cent of which were business enterprises. Six of the new projects were coordinated by Finnish partners, and six projects were involved in Tekes technology programmes. Finland accounted for a total of 84 million euros of the EUREKA project portfolio, which was one of the highest figures in Europe relative to GDP.

Highest investment in information technology

Among the 743 innovative projects under way at the end of June 2004, the two biggest categories were medical and biotechnology as well as information technology: both had 160 running projects (Table 11.2.3). There were also more than 100 projects in the category of new materials. In value terms the biggest category was that of information technology, which accounted for over one-fifth of the total budgeted R&D investments of 2.1 billion euros.

Table 11.2.3
Ongoing EUREKA projects by thematic area in June 2004.
Source: EUREKA Secretariat.

Thematic area	Projects	Volume	
	no.[1]	EUR million	% of total
Medical and biotechnology	160	391	18.6
Communications	22	130	6.2
Energy technology	34	74	3.5
Environment	93	179	8.5
Information technology	160	440	20.9
Lasers	15	32	1.5
New materials	127	301	14.3
Robotics-production automation	75	313	14.9
Transport	57	243	11.6
Total	**743**	**2,101**	**100.0**

1 Innovative projects only, no cluster projects

11.2.4 ESA [11]

Finnish space activity started in the mid-1980s in the shape of cooperation agreements with Sweden and the former Soviet Union. Since then Finnish space research has achieved broad international recognition and there has been a major increase in successful business ventures. Each year Finland invests around 40 million euros in space activities. The Finnish space strategy for 2002–2004 places special emphasis on applications that have wider relevance in society, such as satellite positioning and earth observation. Finnish space activi-

11 European Space Agency (ESA).
Sources: Finnish ESA coordinator, Tekes:
www.tekes.fi/eng/co-operation/europe/space.html and ESA website:
www.esa.int/esaCP/index.html

ties are built around the core of ESA programmes as well as national space programmes, which are coordinated by the National Technology Agency Tekes. In addition, space projects are carried out on a bilateral and multilateral basis.

The European Space Agency ESA offers and promotes technology cooperation with business companies and research units. Its mission is to support and coordinate European space research and to strengthen the competitiveness of businesses in this field. The agency contributes to the development of space applications and conducts major space projects that would be beyond individual European countries. All 15 European members[12] contribute to the agency's mandatory space science, general technology and investment programmes. In addition there are several optional programmes where individual countries can themselves decide on the amount of their contribution. The programmes are implemented in the form of commissioned R&D projects undertaken by industry or research institutes in the member countries: these projects might be related to the manufacture of satellite and hardware equipment or system operation.

Finnish partners invest in space science and earth observation

Finland joined the ESA as an associate member in 1987 and as a full member in 1995. Apart from its involvement in all mandatory programmes (science, technology research programme TRP, general studies programme GSP and investments), Finland contributes to an optional technology programme, telecommunications and navigations programmes and to the earth observation programme. Finland's membership fee for 2004 is 2.25 million euros, in addition to which 16.25 million euros have been earmarked for space activities programmes. In 2002 two-thirds of Finland's contributions to ESA went towards space science and earth observation. This figure has remained effectively unchanged over the past few years (Table 11.2.4).

Finnish partners in ESA programmes have contributed to technology and hardware development as well as to the interpretation and use of scientific

Table 11.2.4
ESA funding by the National Technology Agency Tekes and the Ministry of Trade and Industry in 1995–2003.
Source: National Technology Agency Tekes: Space Directory 2003.

Programme	1995	1996	1997	1998	1999	2000	2001	2002	2003
	EUR million								
Space science	6	6	4	4	4	5	5	5	5
Earth observation	4	4	4	5	5	5	5	4.1	5.6
Telecommunications	2	2.5	2.4	2	1	0.5	0.4	0.3	1
Navigation	–	–	–	–	0.1	0.5	0.5	0.4	0.1
General budget	3	2	2	2	2	2	2	2	2.2
Technology programmes	2	2	1	1	1	1	1	1	1.5
Kourou Ariane	0.6	0.5	0.4	0.4	0.5	0.5	0.5	0.7	0.7
Total	**17.6**	**17.0**	**13.8**	**14.4**	**13.6**	**14.5**	**14.4**	**13.5**	**16.1**

12 In addition, Canada participates in some projects under cooperation agreements.

data obtained from satellites. Finland does not currently finance launchers, microgravity or manned space activities.

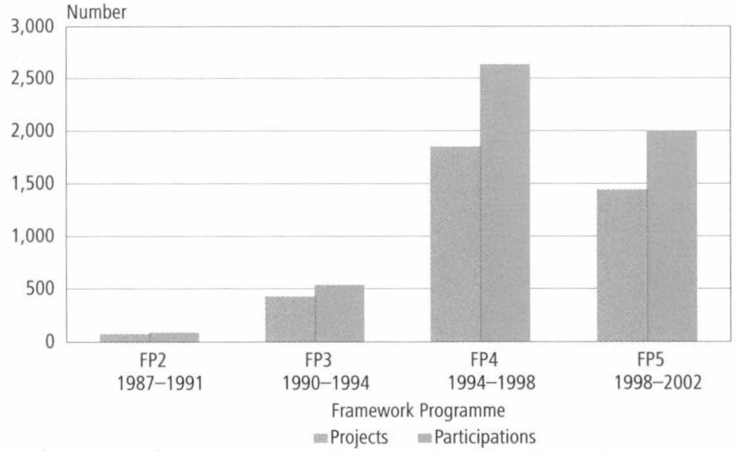
11.3 Benefits of the EU Fifth R&D Framework Programme and national challenges

The benefits of EU framework programmes to Finnish partners have been regularly evaluated since 1998.[13] Most of the data cited here are from the most recent assessment that was completed in May 2004 (Uotila et al. 2004). This assesment was based on project-specific questionnaires and complementary interviews conducted between October 2003 and January 2004. A total of 1,453 questionnaires were sent out; 520 were returned, giving a response rate of 36 per cent. In cases where the partners were involved in several projects, they were requested to provide responses for no more than two. In addition, a total of 15 thematic interviews were conducted and a workshop was organised in January 2004 with 11 Finnish experts taking part. The following provides an overview of the most important results of the evaluation.

Increase in number of participations has come to a halt

Finnish partners were involved in a total of 1,444 research projects under the EU Fifth Framework Programme for Research and Technological Development, as well as in 135 projects under the EU Fusion programme, which in Finland is funded through the Tekes FFUSION 2 programme. These data are based on statistics updated in February 2004. Both the number of Finnish participations and

Figure 11.3.1
Finnish participations in EU's Framework Programmes.[1]
Source: Finnish Secretariat for EU R&D.



1 Excluding Fusion projects based on contracts of association between EURATOM and Tekes.

13 Luukkonen & Niskanen (1998); Luukkonen & Hälikkä (2001); Niskanen (2001)

Table 11.3.1
Finnish participations in the EU Fifth Framework Programme by type of organisation. Source: Finnish Secretariat for EU R&D.

Program acronyms	Major companies	SMEs	Univer-sities	Research institutes	Others[2]	Total
	no.					
Quality of Life and Management of Living Resources(QoL)	24	49	220	164	38	496
Information Society Technologies (IST)	106	105	115	94	48	468
Competitive and sustainable growth	77	138	58	117	21	411
Sub-programme Energy (Environment, energy and sustainable development)	25	16	12	33	7	93
Sub-programme Environment (Environment, energy and sustainable development)	10	15	87	92	14	218
Fusion – Key Action 2 Nuclear Fission (EURATOM)	13	1	5	41	2	62
Confirming the International Role of Community Research (INCO)	0	2	20	28	6	56
Promotion of Innovation and Encouragement of SME Participation	1	14	3	3	9	30
Improving Human Research Potential and the Socio-Economic Knowledge Base (IHP)	2	2	124	23	18	169
Fusion – Key Action 1 Controlled thermonuclear fusion (EURATOM)	3	2	50	69	0	124
Total	**261**	**344**	**694**	**665**	**163**	**2,127**
Share	12 %	16 %	33 %	31 %	8 %	100 %
Success rate	33 %	29 %	27 %	32 %	26 %	

1 Projects based on contract of association between EURATOM and Tekes; excludes EFET projects. (EFET=European Fusion Engineering and Technology).
2 Includes central and local government authorities and organisations, hospitals, associations.

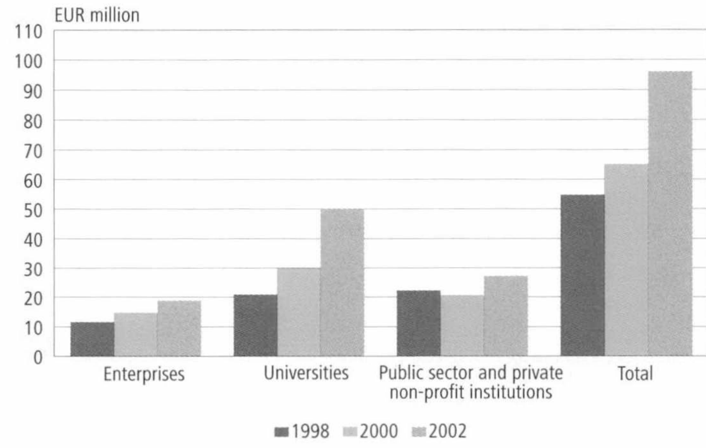
the number of projects in the Fifth Framework Programme decreased compared with the previous programme (Figure 11.3.1). However the volume of research funding obtained through the framework programmes has increased, which may indicate that the average size of projects has increased. This interpretation is also supported by the interview data. Indeed it seems that the level of participations has now passed the peak and the number of complete first-timers is lower than before.

Ever since the earliest programmes the most active participants have been universities and research institutes. In the Fifth Framework Programme universities were the most active participants, accounting for 33 per cent of all participations including Fusion projects (Table 11.3.1). Compared to the previous programme the share of universities and SMEs had increased, while that of major corporations had decreased.

According to the research statistics for 2002 over one-half of the R&D funds received by Finland from the EU were allocated to R&D within the university sector. Business enterprises accounted for 28 per cent and the public sector for 20 per cent. In relative terms EU funding had the greatest significance to R&D funding in the university sector. In 2002 EU funding accounted for 5.4 per cent of all the research funds available in this sector, including core budget funding and external funding. The corresponding figure for the business sector was 0.6 per cent and for public sector organisations 5.1 per cent. Compared to other sources of external funding for research in the university sector, EU funding has shown the fastest growth.

Compared to figures for 1998, EU funding as a proportion of R&D expenditure has increased most rapidly in the university sector. In nominal terms R&D funding from the EU increased by 58 per cent from 1998 to 2002, while the corresponding figure in the business sector was 38 per cent and in the public sector 18 per cent.

Figure 11.3.2
Development of EU funding in 1998–2002 by performer of research.
Source: Statistics Finland, Research and Development Unit.



Selectivity rules in EU cooperation

For the most part the experiences of Finnish participants in the Fifth Framework Programme have been positive. More than one half of the respondents to the inquiry thought their EU project had been a success. Reports of major problems were also rare. All in all it is felt that the benefits of EU research cooperation are greater than the costs. Satisfaction with the cost-benefit ratio was the highest at universities, where two-thirds of the respondents felt that the benefits of their EU project had been greater than its costs.

Before Finland joined the EU and even during the early stages of membership, Finnish partners were eager to join virtually any project: access to European research networks and the new contacts were considered important assets in their own right. Nowadays a more selective approach has been adopted. Currently it is increasingly typical that the benefits of involvement are weighed against its strategic significance vis-à-vis one's own research or organisation.

The number of complete first-timers involved in EU framework programmes is also on the decline: more than one-half of the respondents to the inquiry concerning the Fifth Framework Programme said they had previous experience of cooperation in framework programmes.

The main obstacles to participation were similar to those before: the high workload involved in project preparation, project administration and in some cases the low probability of being accepted. The growing size of projects also presents a new challenge for EU cooperation and particularly for project coordination.

Significance of EU funding increased

Finnish partners take the view that EU funding is increasingly important to project implementation. Over 70 per cent of the respondents to the inquiry said they believed the project would not have been carried out without EU funding; the corresponding figure for the Fourth Framework Programme was 54 per cent. Views on the added value generated by EU funding did not differ between the different types of organisation. However, EU research funding is not a substitute for, but rather complementary to national funding. On the one hand the greater importance attached to EU funding may reflect the increasing significance of internationalisation in research more generally, on the other hand it may also be an indication of the growing difficulties of obtaining national research funding.

Companies are keen to find new collaborative partners in and to strengthen their research expertise

Access to funding is not in itself the most important decisive factor for participation in a framework programme, but other benefits are weighed increasingly often. For companies, one of the major considerations is the opportunity to gain new contacts and thereby new customers and markets. EU research cooperation also provides an opportunity for companies to monitor scientific and technological developments in key fields.

EU projects have great strategic significance with respect to companies' future choices. Cooperation can help them keep track of current business trends, focus their own R&D activities on the basis of these trends and create completely new product development concepts.

According to the inquiry, EU projects rarely deliver immediate economic benefits in the shape of new products, patents or other commercially measurable results. However it is noteworthy that on average, Finnish enterprises felt there were more commercially significant results than in the previous framework programmes. This might reflect a more general shift towards market-driven research in the EU Framework Programmes. It is also likely that learning experiences of the participation have facilitated the attainment of immediate benefits, such as new or improved products.

EU projects are mainly regarded as precompetitive. Commercial benefits are not normally expected until 1–3 years after completion of the project. Patents or licences are mentioned as project outputs less often. More than half of the company respondents indicated that their EU project had no plans to protect its results by trademarks, copyrights or patents. Company respondents considered the precompetitive nature of EU projects crucial if there is also to be cooperation with rival companies.

EU projects help to create critical mass in research

One of the most important benefits of the EU Framework Programmes is that they have facilitated creating critical mass in fields of research where there is not enough national know-how or funding.

According to the Finnish respondents, the scientific standard and research orientation of EU projects varies. Over 60 per cent of the respondents thought their own EU project had been of a high international standard. Less than one-fifth took a critical view. One in five respondents described their project as basic research oriented, compared to no more than one in ten in the previous inquiry. However the inference cannot be drawn that framework programmes are now becoming more basic research oriented. Rather, it may be assumed that the demands and requirements attached to EU projects are less rigorous now in terms of expected outputs, which leaves greater scope for projects with a basic research orientation.

Increased awareness of the significance of societal objectives

Apart from the goals of knowledge enhancement and improved competitiveness, the EU Framework Programmes, since FP4, have also set societal objectives, such as the improvement of living conditions, the environment and health care. However, it has proved extremely difficult to evaluate and measure the attainment of these objectives.[14]

Among the societally relevant objectives derived from EU policies, those mentioned most often in connection with EU research projects were environmental issues, questions related to health care, public health and nutrition, as well as energy saving and supply. By contrast it seems that EU research projects have only limited relevance as far as employment, ageing population or urbanisation are concerned. Indeed in the future it is important that greater attention is paid to the question of what kind of societal issues can be successfully addressed by means of research and who are involved in setting the targets for research.

One of the most important observations in the survey is that there is increased awareness among partners about the significance of societal objectives as a criterion for research funding. It also seems that participants take an increasingly positive attitude towards these objectives. Many of the interviewees expressed the view that the attainment of economic benefits cannot be the only criterion for granting public support for research.

Increased interaction between national and EU programmes

The chances of Finnish research organisations to take part in future EU Framework Programmes will depend most crucially on national efforts to maintain high scientific standards of research and to provide adequate research facilities.

14 See Kuitunen & Hyytinen (2004)

Furthermore, broadly based consortia require considerable administrative work, which in turn means that project coordination in particular requires an increasingly professional approach.

From company perspective, a need arises for more effective utilisation of the knowledge and expertise gained in the EU projects. More than half of the company respondents said they used the results in their own business. From this point of view it is considered crucial that funding is made available for the development of commercially viable ideas, for the promotion of marketing and for cooperation with key experts on the commercialisation process. More effective national utilisation of EU Framework Programmes also requires that there is increased interaction and a clearer division of labour between national, EU and other international research programmes.

12 Information and communication technology

Information and communication technology (ICT) rapidly gained in significance in Finland during the 1990s. The contribution of ICT based industries or the so-called information sector to the national economy increased considerably. The information sector showed strong expansion, and turnover figures within the sector developed more dynamically than in other industries. All this meant that the performance of the information sector as a proportion to the total volume of business and industry increased rapidly. The employment role of the sector strengthened as well.

This trend began to taper off after the turn of the millennium, but the information sector has hardly lost any of its significance. In the past few years its contribution to production, foreign trade and employment has remained at a consistently high level.

Finland is regarded as a major ICT producer, but the use of information and communication technology has also increased and become an integral part of people's everyday life here – not only in the workplace but also in households and among private consumers. Having said that, it seems clear that the full potential of information and communication technology has not yet been exploited in Finland.

Information and communication technology impacts economic and social development in various ways, both directly and indirectly. ICT opens up new opportunities for communication, data transfer and the retrieval and processing of information. ICTs have become significant production technologies with major efficiency and productivity benefits. ICT use also changes old ways and habits: it shapes the structures of production, paves the way to e-commerce and online services, and changes the way people communicate with one another. On the other hand the application of ICT to its full potential also requires changes. All the benefits it has to offer cannot be reaped simply by taking the technology on board. As was pointed out in one survey on the productivity impacts of ICT, 'organisational changes are one possible reason why some companies have successfully adopted the tools of the new economy and contributed to the growth of the national economy and national wealth'.[1]

The above provides only a few examples of the many ways in which ICT impacts economic and social changes. There is clearly no disputing the fact that ICT has a key role to play in modern society and in its development. It is expected that in the future, ICT applications in particular will create an abundance of new opportunities.

Statistics Finland has been following the development of the Finnish information society for a number of years now. The first compilation report on the subject was published in 1997 (On the Road to the Finnish Information Society I); this was followed by reports in 1999, 2001 and 2003 (On the Road to the Finnish In-

1 Statistics Finland (2003a), original source: Maliranta & Rouvinen (2003a,b).

formation Society II-IV).[2] This Chapter looks at recent trends and developments in different aspects of the information society from the vantage-point of information and communication technology. The discussion is based largely on the same indicators and definitions as used in the reports just mentioned.

Section 12.1 below provides an overview of business activities in this sector, i.e. on how Finland has developed as an ICT producer (the development and extent of the information sector, the production and foreign trade of ICT products and the employment role of the information sector). The next section then proceeds to examine the basic infrastructure of information and communication technology, first from the point of view of the technical infrastructure (e.g. subscriptions), then from the angle of competence (education). Finally, sections 12.3 and 12.4 look at the use of ICT in business companies and among private consumers: to what extent do companies use information technology and how have households and consumers adopted new information and communication technologies.

12.1 Business activities, production and foreign trade in the information sector

12.1.1 Defining the information sector

The increasing significance of information and communication technology has also given rise to a growing need to describe developments from the vantage-point of ICTs. Standard international definitions have by now been adopted in a number of areas, which has improved access to international comparative data.

International guidelines are available for the definition of goods and services production of the information or ICT sector. The industries classified as goods and service production in the information sector were defined by the OECD for the first time in the late 1990s. In its own descriptions of the information society, Statistics Finland has applied a definition of the information sector in which goods and service production industries are based on the OECD guidelines, but which additionally includes content production. In the absence of international guidelines the definition of content production in the information sector is national.

The industries classified under goods and service production in the information sector on the basis of the OECD guidelines and the industries classified under content production on the basis of the definition used in Finland, are as follows:[1]

Goods production

3001	Manufacture of office machinery
3002	Manufacture of computers and other information processing equipment
3130	Manufacture of insulated wire and cable
3210	Manufacture of electronic valves and tubes and other electronic components

2 In addition, Statistics Finland has published several surveys, studies and statistics on consumer use of information and communication technologies.

3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3330	Manufacture of industrial process control equipment

Service production

51432	Wholesale of radio and television goods
5184	Wholesale of computers, computer peripheral equipment and software
51862	Wholesale of telecommunication equipment and electronic components
642	Telecommunications
7133	Renting of office machinery and equipment, including computers
72	Computer and related activities

Content production

221	Publishing
7413	Market research and public opinion polling
7414	Business and management consultancy activities
744	Advertising
921	Motion picture and video activities
922	Radio and television activities
924	News agency activities

In some cases it is necessary to describe and define the information sector in broader terms. Employment surveys, for example, have sometimes adopted **a broad definition of the information sector,** whereby it is taken additionally to include **the following industries of content production:**

222	Printing and service activities related to printing
223	Reproduction of recorded media
71401	Renting of videotapes
73	Research and development
7485	Secretarial and translation activities
(923	Other entertainment activities)
(925	Library, archives, museums and other cultural activities)

1 Statistics Finland (2002a).

There is also an OECD recommendation for a classification of ITC goods[1], the main groups of which are:

Telecommunications equipment,
Electronic components
Audio and video equipment
Computers and related equipment
Other ICT goods

To facilitate time series examinations, development in the output of ICT goods is described in this publication against a previously used definition of information technology products, in which the main groups are:[2]

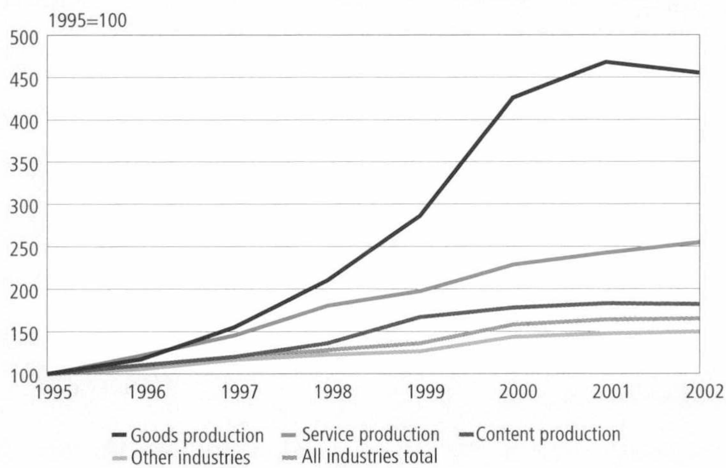
Communications equipment	Consumer electronics
Computers	Office machines
Industrial electronics	Electronic components

1 OECD (2003d)
2 For a more detailed description of product groups, see e.g. Statistics Finland (2003a).

12.1.2 Business activities in the information sector[3]

From 1995 onwards, business activities in the information sector expanded and developed more rapidly than in other industries. From 1995 to 2002, turnover in the information sector more than tripled, compared to a one and a half fold increase in other industries. During the same period the number of enterprises in the information sector increased by 39 per cent as opposed to 18 per cent in other areas of business. The same pattern was repeated with personnel numbers: in the information sector personnel numbers increased from 1995 to

Figure 12.1.1
Development of turnover in the information sector (goods, service and content production), in other industries and all industries in 1995–2002, 1995=100.
Source: Statistics Finland, Business Register.



3 The data for section 12.1.2 come from Statistics Finland's Business Register. The data up to 2001 are based on the 1995 industrial classification (SIC95) and the data for 2002 on the 2002 industrial classification (SIC2002).

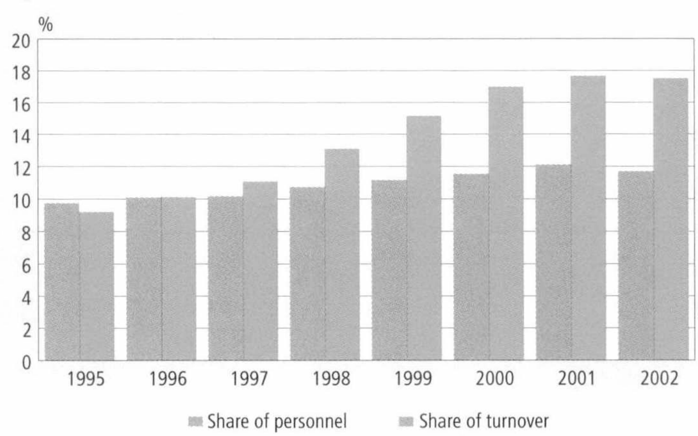
2002 by more than 40 per cent, while the corresponding increase in other industries was 17 per cent.

Business developed favourably in both the information sector and other industries up to 2001, but 2002 saw a slowdown in growth. Measured in terms of turnover, the information sector and business in general showed only marginal growth in 2002. Business turnover began to decrease in manufacturing industry, especially in the production of goods in the information sector. In service production, by contrast, turnover continued to grow in 2002.

In 2002 the total number of enterprises in Finland stood at 226,600. Their combined turnover amounted to 274 billion euros and they employed more than 1.3 million persons. In 2002 there were some 15,900 enterprises in the information sector, with 153,700 personnel and a combined turnover of almost 49 billion euros. The information sector thus accounted for 17.5 per cent of total business turnover, while the figure in 1995 was around 9 per cent. Measured in terms of turnover, the information sector showed particularly strong growth in the late 1990s; by 1999 its share of the total figure had risen to 15 per cent. In 2000–2002 the proportion has remained at around 17–18 per cent (Appendix 12.1).

In an international comparison the value added of the ICT sector (goods and service production) as a proportion of total business value added has been relatively high in Finland. In 2000 the ICT sector's share of total business value added in the OECD countries ranged from 5 per cent to 16.5 per cent. In Finland the figure was 16.4 per cent, the second highest after Ireland. The average figure for all OECD countries was 9.8 per cent and for EU countries 8.7 per cent.[4]

Figure 12.1.2
Information sector personnel and turnover as a percentage of personnel and turnover in all enterprises.
Source: Statistics Finland, Business Register.



4 OECD (2003c).

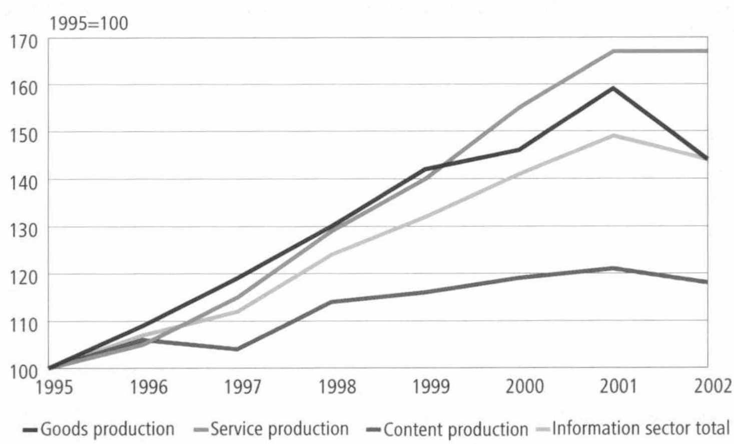
Goods, service and content production in the information sector

The information sector comprises a wide range of different types of business enterprise – after all the activities in this sector range from the manufacture of equipment to wholesale and from telecommunications services to content production. Many industries within the information sector, such as telecommunications and the manufacture of telecommunication equipment, have developed vigorously in recent years. Rapid advances in technology have helped to further the development of the information sector by expanding markets and opening up new opportunities for entirely new lines of business.

Content production accounts for the largest number of enterprises in the information sector. On average these firms are relatively small, however, which means that content production has the least prominent employment role of the three branches of production. The combined turnover of content production is considerably lower than the figures for goods production and service production. The highest turnover is recorded for goods production, where the number of enterprises is comparatively low but the average enterprise size is quite large. Turnover in goods production increased no less than 4.5-fold from 1995 to 2002, and in 2002 goods production accounted for 54 per cent of total turnover in the information sector. Service production is by far the biggest employer in the information sector: in 2002 it accounted for 44 per cent of total personnel in this sector. Turnover statistics for different industries within the information sector are shown in Appendix 12.2.

Goods production in the information sector involved a total of some 700 enterprises in 2002. Their combined turnover amounted to just over 26 billion euros and they provided employment to more than 44,000 people. Goods pro-

Figure 12.1.3
Development of personnel numbers in goods, service and content production in the information sector from 1995 to 2002, 1995=100.
Source: Statistics Finland, Business Register.



duction developed favourably up to 2001, but 2002 saw a dip in both personnel numbers and turnover. The single biggest industry in goods production is the manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy (including mobile phones), which in 2002 accounted for 91 per cent of turnover in information sector goods production. The industry has grown very rapidly indeed: while in 1995 it reported a turnover of less than 3.5 billion euros, the figure for 2001 and 2002 was around 24 billion euros. The manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy is also the single most important employer in information sector goods production: in 2002 it accounted for two-thirds of total employment in goods production.

Production of the information sector goods has emerged as a very significant industry. In 1995 it accounted for around one-quarter of total metal industry turnover, by 2000–2002 the share had grown to around one-half. In 1995 enterprises in information sector goods production accounted for less than 10 per cent of total industry turnover, by 2000–2002 for one-quarter.

Information sector service production, which comprises wholesale industries, telecommunications and computer and related activities, involved some 5,400 enterprises in 2002. They had a combined turnover of almost 16 billion euros and some 67,600 employees. The single biggest employer in service production is computer and related activities, which in 2002 accounted for more than one-half of the personnel in information sector service production. Measured in terms of turnover, however, the most significant industry is telecommunications, which in 2002 accounted for 40 per cent of the turnover generated by service production in the information sector.

Information sector content production, which includes publishing, motion picture and video activities, and radio and television activities, involved almost 9,800 enterprises in 2002. On average these are relatively small companies, however. In 2002 they provided employment to some 42,000 persons and their combined turnover was 6.2 billion euros. The single most significant industry in content production is publishing, which accounted for around 40 per cent of both total turnover and personnel in content production in 2002.

Information sector establishments by region

Data on establishments provide one useful way to chart the regional distribution of business activities. As can be seen in Table 12.1.1, business in the information sector is heavily concentrated in the region of Uusimaa.

In 2002 half of all information sector establishments were located in Uusimaa. Over half or 55 per cent of the personnel in this sector worked in Uusimaa, and the region accounted for 57 per cent of the sector's turnover. Other significant regions in this analysis are Varsinais-Suomi, Pirkanmaa and North Ostrobothnia around the cities of Turku, Tampere and Oulu, respectively.

Information sector establishments typically account for a few per cent of all establishments within their region, but in Uusimaa the proportion in 2002 was 12.6 per cent. In 2002 almost 19 per cent of all personnel working in establishments in

Uusimaa were engaged in the information sector. The information sector was a major employer in North Ostrobothnia, too: in 2002 the proportion of people working in this sector stood at 17.2 per cent.

Table 12.1.1
Information sector,establishments, personnel and turnover by region in 2002. Source: Statistics Finland, Business Register.

Region (NUTS3)[1]	Establishments			Personnel			Turnover			
	number	% break-down	% of all industries	number	% break-down	% of all industries	1,000 euros	% break-down	% of all industries	Turn-over/ per-son 1,000 euros
Whole country	**17,873**	**100.0**	**7.1**	**148,619**	**100.0**	**11.6**	**47,529,315**	**100.0**	**17.5**	**319.8**
Uusimaa	8,973	50.2	12.6	81,840	55.1	18.7	27,279,455	57.4	24.0	333.3
Itä-Uusimaa	239	1.3	5.0	606	0.4	3.2	85,159	0.2	1.3	140.5
Varsinais-Suomi	1,305	7.3	5.5	12,568	8.5	10.8	8,056,171	16.9	32.0	641.0
Satakunta	427	2.4	3.7	2,058	1.4	3.8	254,223	0.5	2.4	123.5
Kanta-Häme	329	1.8	4.3	1,693	1.1	4.6	204,567	0.4	3.5	120.8
Pirkanmaa	1,428	8.0	6.5	13,770	9.3	12.1	3,971,445	8.4	19.3	288.4
Päijät-Häme	547	3.1	5.6	2,143	1.4	4.4	265,776	0.6	3.7	124.0
Kymenlaakso	342	1.9	4.3	1,281	0.9	2.9	206,638	0.4	2.4	161.4
South Karelia	276	1.5	4.7	1,360	0.9	4.6	224,592	0.5	3.4	165.1
Etelä-Savo	305	1.7	4.0	1,089	0.7	3.8	142,482	0.3	3.8	130.8
Pohjois-Savo	501	2.8	4.7	3,233	2.2	7.0	497,853	1.0	6.7	154.0
North Karelia	270	1.5	3.8	1,322	0.9	4.6	214,770	0.5	4.8	162.5
Central Finland	659	3.7	5.7	4,939	3.3	9.0	960,602	2.0	10.2	194.5
South Ostrobothnia	344	1.9	3.3	1,111	0.7	2.9	154,768	0.3	2.4	139.3
Ostrobothnia	497	2.8	5.3	2,430	1.6	6.0	414,149	0.9	5.2	170.4
Central Ostrobothnia	139	0.8	4.0	577	0.4	4.2	89,242	0.2	3.4	154.6
North Ostrobothnia	740	4.1	5.0	13,573	9.1	17.2	3,988,986	8.4	27.8	293.9
Kainuu	138	0.8	4.0	1,308	0.9	9.7	159,921	0.3	7.9	122.3
Lapland	329	1.8	3.6	1,305	0.9	3.9	208,641	0.4	3.2	159.9
Åland	85	0.5	4.7	413	0.3	4.7	149,875	0.3	9.9	362.6

1 Regional classification system of the European Union (NUTS)

12.1.3 Production in the information sector

Goods production in the information sector can be described by product category. This is not possible for service and content production because relevant data are not available by product, nor do we have access to time series data on the value of production at an appropriate level of accuracy. For service and content production, one option is to study the development of industries with a representative volume.

There is also an OECD definition for ITC goods, but to facilitate time series examinations this publication still uses a previously applied definition of information technology products.

The manufacture of IT products increased every year until 2000; since then, in 2001–2002, the value of production remained unchanged at the level recorded in 2000. In 1995 the value of IT product manufacture totalled around 5.9 billion euros, and in 2000–2002 the figure has been in the region of 14.6 billion euros. The value of IT products as a proportion of the value of total manufacturing industry has increased quite sharply: in 1995 they accounted for 9 per cent of the total value, while in 2002 the figure was 18 per cent.

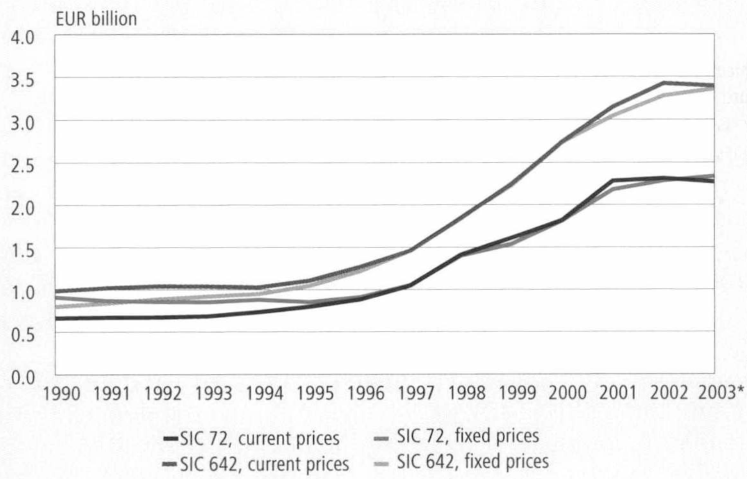
Communications equipment is by far the most significant product group among IT products. In 1995 the value of production in the category amounted to four billion euros, or 68 per cent of the total value of IT production. In 2000–2002 the value of communications equipment production was around 13.6 billion euros, and it now

Changes in the value added of computer and related activities (SIC 72) and telecommunications (SIC 642) serve to illustrate the development of service production in the information sector. In the first half of the 1990s the annual value added of these industries was less than one billion euros, but from the mid-1990s onwards the figure began sharply to increase in both industries. This trend levelled off after 2000, especially in computer and related activities. In 2003 value added in computer and related activities was almost three times higher and in telecommunications just over three times higher than in 1995.

Table 12.1.2
Manufacture of IT products in Finland by product group in 1995 and 1999–2002, EUR million.
Source: Statistics Finland, Commodity Statistics.

Product group	1995	1999	2000	2001	2002
	EUR million				
Communications equipment	3,999.4	10,152.7	13,634.1	13,528.5	13,625.1
Consumer electronics	174.9	106.5	100.4	93.5	86.7
Computers	864.1	590.8	63.7	72.6	67.4
Electronic components	601.0	396.8	469.5	503.2	409.3
Office machines	4.3	3.7	–	–	–
Industrial electronics	249.1	385.7	401.6	408.5	437.7
Total	**5,892.7**	**11,636.2**	**14,669.3**	**14,606.3**	**14,626.3**

Figure 12.1.4
Value added in telecommunications (SIC 642) and computer and related activities (SIC 72) in 1990–2003 in current and fixed (2000) prices, EUR billion.*
Source: Statistics Finland, National Accounts.



12.1.4 Foreign trade in IT products

Imports and particularly exports of IT products as a proportion of Finnish foreign trade increased sharply during the 1990s. In 1990 IT products accounted for 7 per cent of total exports and for 13 per cent in 1995. The figure continued to climb until 2000, when it stood at 25 per cent. Since then exports of IT products as a proportion of total exports has fallen back somewhat; in 2003 the share was around 21 per cent. In imports the situation has not developed in quite the same way as in exports. In 1990 IT products accounted for 10 per cent of total imports. The figure then peaked at 19 per cent in 2000, but in 2001–2003 the trend has been reversed. In 2003 the proportion was down to 14 per cent.

The value of foreign trade in IT products increased until 2000, when exports amounted to 12.5 billion euros and imports to almost 7 billion euros. In 2001–2003 the value of foreign trade has slightly decreased. In 2003 the value of IT exports was 9.5 billion euros and the value of imports 5.2 billion euros. In the 1990s exports of IT products increased much more rapidly than imports of IT products. The trade balance came out of deficit in 1995, and since then the surplus continued to increase up to 2000 when the figure peaked at 5.5 billion euros. In 2003 the balance of trade surplus was 4.3 billion euros.

Table 12.1.3
Foreign trade in IT products by product group and total foreign trade in 1990, 1995 and 1999–2003, EUR million.
Source: National Board of Customs, ULTIKA.

Product group	1990	1995	1999	2000	2001	2002	2003
	EUR million						
Communications equipment							
Exports	548.8	2,389.6	6,664.9	10,513.1	8,653.4	8,632.9	8,087.3
Imports	297.5	476.3	1,070.6	2,300.6	2,056.3	1,699.7	1,711.2
Balance of trade	251.3	1,913.3	5,594.3	8,212.5	6,597.1	6,933.1	6,376.1
Consumer electronics							
Exports	153.4	169.0	121.5	114.5	139.2	163.2	134.7
Imports	245.7	239.8	345.3	476.4	370.0	360.4	358.4
Balance of trade	–92.3	–70.8	–223.8	–361.9	–230.8	–197.2	–223.7
Computers							
Exports	208.7	768.1	801.2	440.9	363.7	304.4	262.6
Imports	615.1	1,078.9	1,511.6	1,406.3	1,380.9	1,274.4	1,154.5
Balance of trade	–406.3	–310.8	–710.4	–965.4	–1,017.2	–969.9	–891.9
Office machines							
Exports	7.4	16.0	23.0	19.0	24.2	19.6	21.0
Imports	107.1	91.3	139.4	122.2	144.5	125.2	121.3
Balance of trade	–99.7	–75.3	–116.4	–103.2	–120.3	–105.7	–100.2
Industrial electronics							
Exports	184.0	258.2	589.8	698.6	740.1	757.3	604.4
Imports	217.8	334.2	379.8	465.8	492.2	454.2	374.8
Balance of trade	–33.8	–76.0	210.0	232.8	248.0	303.1	229.6
Electronic components							
Exports	67.4	167.5	461.7	689.0	482.9	419.0	420.3
Imports	262.0	1,217.0	1,509.0	2,180.4	1,778.5	1,773.4	1,471.7
Balance of trade	–194.6	–1,049.5	–1,047.3	–1,491.4	–1,295.6	–1,354.5	–1,051.4
IT products, total							
Exports	**1,169.7**	**3,768.4**	**8,662.1**	**12,475.1**	**10,403.5**	**10,296.3**	**9,530.3**
Imports	**1,745.3**	**3,437.6**	**4,955.7**	**6,951.7**	**6,222.3**	**5,687.4**	**5,191.9**
Balance of trade	**–575.5**	**330.8**	**3,706.4**	**5,523.4**	**4,181.2**	**4,608.9**	**4,338.4**
Other products							
Exports	15,872.2	25,836.2	30,583.4	37,009.2	37,396.9	36,797.9	36,676.1
Imports	15,582.6	18,183.8	24,735.5	29,885.7	29,668.4	29,722.4	31,173.7
Balance of trade	289.6	7,652.4	5,848.0	7,123.5	7,728.5	7,075.5	5,502.4
Foreign trade, total							
Exports	**17,042.0**	**29,604.6**	**39,245.5**	**49,484.3**	**47,800.4**	**47,094.1**	**46,206.4**
Imports	**17,327.9**	**21,621.4**	**29,691.2**	**36,837.4**	**35,890.7**	**35,409.8**	**36,365.6**
Balance of trade	**–285.9**	**7,983.2**	**9,554.4**	**12,646.9**	**11,909.7**	**11,684.4**	**9,840.8**

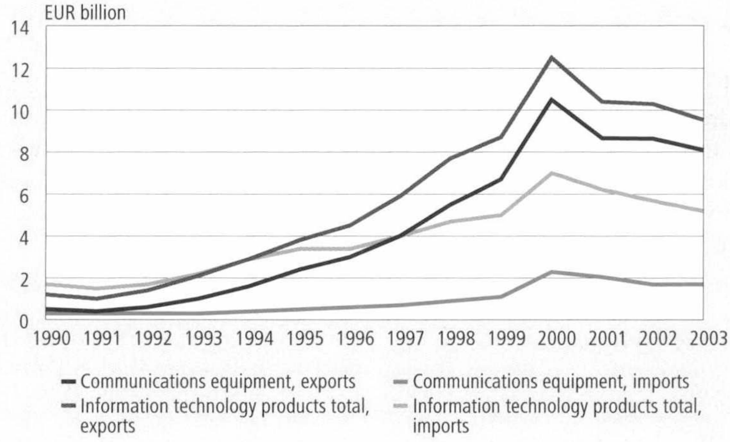
The biggest single export category in IT products is communications equipment. In 2003 exports in this product group amounted to 8.1 billion euros. Communications equipment accounted for 85 per cent of all IT exports and for almost 18 per cent of all Finnish exports.

The major categories of IT imports in the 1990s were computers and electronic components, but in recent years communications equipment has emerged as an increasingly significant import category. Indeed in 2003 communications equipment was the single biggest category of IT imports. The value of imports stood at 1.7 billion euros, or 33 per cent of total imports of IT products. The three biggest import categories of IT imports, i.e. communications equipment, electronic components and computers, together accounted for 84 per cent of the value of IT imports in 2003.

The only IT product groups where Finland has shown a surplus in its foreign trade are communications equipment and in recent years industrial electronics. In all other IT product groups the foreign trade balance has been in deficit.

Since the mid-1990s Finnish imports and exports of IT products as a proportion of total foreign trade have been among the highest in the OECD countries. In recent years IT products have been the most significant foreign trade category in Ireland, where they accounted for almost 40 per cent of exports and for 34 per cent of imports in 2001. Other countries where IT products are key export and import categories include the Netherlands, the United Kingdom, Japan and in recent years China.[5]

Figure 12.1.5
Value of communications equipment exports and imports and the value of total IT product exports and imports in Finland in 1990–2003, EUR billion.
Source: National Board of Customs, ULTIKA.



5 E.g. Statistics Finland (2003a), original source: OECD (2002d).

Table 12.1.4
Exports of IT products as a proportion of total exports and imports of IT products as a proportion of total imports in 1995, 1997, 1999 and 2001, per cent. Source: OECD.

Country	Exports/total exports, %				Imports/total imports, %			
	1995	1997	1999	2001	1995	1997	1999	2001
Ireland	27.5	30.5	32.7	39.3	26.8	27.4	31.1	34.2
Finland	12.9	16.3	21.8	21.5	15.3	14.7	16.5	17.1
Netherlands	12.6	16.9	21.1	20.4	14.4	18.9	23.6	22.6
United Kingdom	16.6	16.3	19.0	19.8	15.9	15.5	17.7	16.7
Luxembourg	..	..	9.7	14.2	..	..	10.0	13.4
Sweden	12.0	15.8	18.1	12.7	14.9	15.4	15.4	14.3
France	8.6	10.2	10.9	10.6	10.5	11.5	12.2	12.0
Germany	8.1	8.5	9.3	10.2	10.9	10.8	12.7	14.1
Austria	5.1	6.1	7.0	8.6	8.1	9.1	11.1	10.7
Denmark	6.8	7.8	8.2	8.4	11.2	12.0	12.6	13.0
Portugal	6.1	5.5	6.9	8.2	8.0	7.7	9.1	9.6
Belgium	4.6	5.0	5.5	6.1	5.4	6.4	7.3	7.7
Spain	4.9	4.8	5.4	5.3	8.0	8.5	9.6	8.8
Italy	5.6	5.0	5.0	5.3	9.0	9.3	10.0	9.2
Greece	1.3	1.9	2.8	3.7	5.3	6.1	8.8	7.5
EU	**9.5**	**10.5**	**12.0**	**12.5**	**11.3**	**12.0**	**13.7**	**13.6**
Japan	27.3	25.9	25.4	24.3	12.4	13.8	15.8	16.8
United States	17.8	18.7	21.6	21.0	19.7	18.8	18.5	16.6
China	10.7	12.7	16.7	21.0	13.2	14.1	21.3	23.7
Switzerland	5.8	5.9	6.2	6.0	9.6	9.7	11.0	10.0
Canada	6.4	7.0	6.6	5.8	14.4	13.8	14.1	13.2
Norway	3.0	3.0	3.4	2.8	10.4	9.8	10.8	11.2
Iceland	0.1	0.1	0.1	0.2	8.3	8.4	9.1	8.7

12.1.5 The information sector as an employer

Finland's employed labour force at year-end 1989 numbered 2,374,000, but this figure dropped sharply during the recession of the early 1990s. Following the recession the numbers in employment increased consistently year on year, although in 2001 and 2002 only marginally. At year-end 2002 the employed workforce in Finland was 2,242,000, i.e. still lower than the figure recorded before the recession.

In the late 1980s a total of 103,000 persons were employed in the information sector; the figure for the broadly defined information sector (see the definition above under 12.1.1) was 159,000. The information sector was certainly not unaffected by the recession, but here the numbers in the workforce recovered to exceed the pre-recession level immediately after the mid-1990s. In the information sector the employed workforce increased year on year until 2001, but in 2002 this trend was reversed. The numbers in the workforce dropped by around three per cent on the figure one year previously, in the broadly defined information sector by around two per cent.

In 1989 the information sector accounted for 4.3 per cent of the employed workforce and in 1995 for 5.2 per cent. The figure increased throughout the latter half of the 1990s, and in 2000–2002 it stood at around seven per cent.

People employed in the broadly defined information sector as a proportion of the total employed workforce was 6.7 per cent in 1989 and 7.6 per cent in 1995. In the broadly defined information sector, too, the figure has risen consistently year on year: in 2000–2002 it was around 9.5 per cent.

Since the mid-1990s the numbers in employment have increased far more rapidly in the information sector than in other industries. Initially the figures increased most rapidly in goods production, but since the late 1990s the fastest growth has been recorded in service production.

Indeed service production is the most significant employer in the information sector. In 2002 it provided employment to 69,000 persons, while the figures for both goods production and content production were around 44,000. If we consider the broadly defined information sector, the most significant employer is content production. In 2002 a total of almost 96,000 persons worked in industries falling under the broad definition of content production.

Table 12.1.5
Employed labour force in the information sector in 1989 (SIC 88) and 1995–2000 (SIC 95), 2001–2002 (SIC 2002).
Source: Statistics Finland, Regional Employment Statistics.

Industry	1989	1995	1996	1997	1998
Information sector	102,843	100,439	104,492	116,754	132,686
Goods production	22,998	28,835	31,914	36,656	40,035
Service production	44,638	38,966	38,860	43,576	50,716
Content production	35,207	32,638	33,718	36,522	41,935
Information sector, broad	158,979	147,442	152,314	165,930	184,394
Goods production	22,998	28,835	31,914	36,656	40,035
Service production	44,638	38,966	38,860	43,576	50,716
Content production, broad	91,343	79,641	81,540	85,698	93,643
All industries	**2,373,747**	**1,932,752**	**1,957,144**	**2,037,997**	**2,132,704**

Industry	1999	2000	2001	2002
Information sector	145,612	160,008	162,681	157,232
Goods production	44,377	46,814	46,305	43,766
Service production	56,977	66,849	71,514	69,009
Content production	44,258	46,345	44,862	44,457
Information sector, broad	196,935	212,039	213,196	208,443
Goods production	44,377	46,814	46,305	43,766
Service production	56,977	66,849	71,514	69,009
Content production, broad	95,581	98,376	95,377	95,668
All industries	**2,173,885**	**2,228,557**	**2,235,317**	**2,242,303**

Figure 12.1.6
Change in the numbers employed in the information sector and all industries in 1995–2002, 1995=100.
Source: Statistics Finland, Regional Employment Statistics.

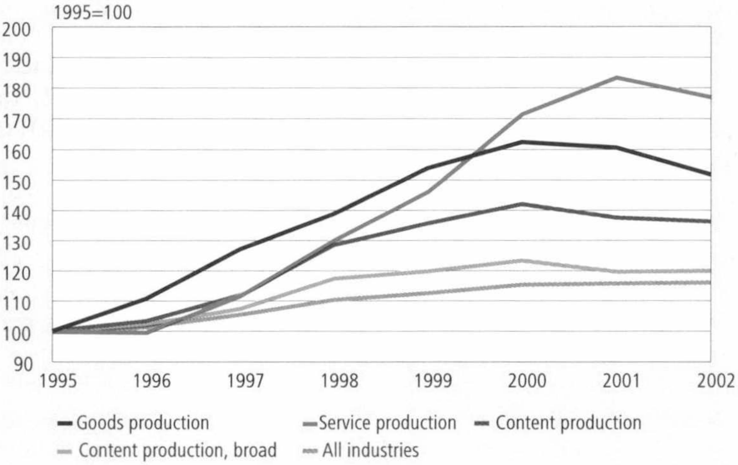
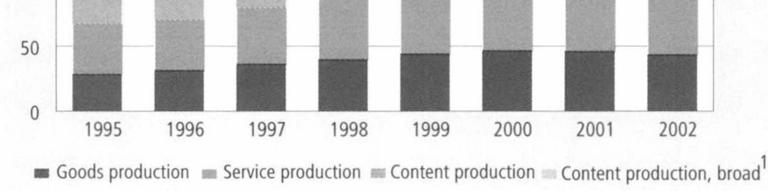


Figure 12.1.7
Numbers employed in the information sector in 1996–2002.
Source: Statistics Finland, Regional Employment Statistics.



1 Numbers employed in industries representing content production only according to the broad definition of information sector.

12.2 ICT infrastructure

12.2.1 ICT and technical infrastructure

Effective ICT use requires an adequate infrastructure in the shape of high-powered hardware and data communications links. With the continuing development of contents and services and the steady growth of information flows, the basic infrastructure, such as data and communication networks and user interfaces, will also need to have a greater data transfer capacity.

Indeed we have seen rapid advances in recent years in networks, interfaces and hardware. One example of the development of more efficient connections is provided by optical fibre, which can offer a significantly improved data transfer capacity compared to traditional copper cable. In Finland the use of optical fibre to build grid networks has increased very rapidly in recent years. At year-end 2003 the overall distance of installed optical fibre was three times greater than the corresponding distance in the mid-1990s.[6]

Wireless network technologies are not yet in widespread use, but wireless data transfer looks set to become one of the key technologies of the future. One prominent trend in communication and data transfer is the increasing convergence of different technologies: the digital format of data contents means that these contents can now be accessed on different types of terminal. It is evident that this tendency towards greater convergence is gradually blurring the boundary lines between telecommunication, information technology and mass communication.

People in Finland have always been keen and quick to adopt new technology and new modes of communication. This was particularly apparent in the 1990s during the early proliferation of mobile media and the Internet. In recent years it seems that this enthusiasm has waned somewhat: broadband services, for example, did not get off to a very brisk start. Nonetheless the basic infrastructure is there in place and it is safe to say that information and communication technology is in quite widespread use in Finland today. The number of mobile phone subscriptions relative to population is very high, a large proportion of households have a computer and Internet connection, businesses make extensive use of information technology, and PCs and Internet connections are increasingly commonplace in the workplace. IT use is also common in the public sector, including educational institutions and universities.

The basic ICT infrastructure is shaped and influenced by technological advances and by the ensuing changes in people's consumption habits and changes in ICT uses. For instance, as more and more phone calls today are made over mobile phone networks, the use of the fixed landline network for the transmission of phone calls has begun to decrease. A similar shift is taking place in the use of Internet services from dial-up to broadband connections.

6 Statistics Finland (2004b).

Fixed telephone subscriptions and broadband connections

In an international comparison Finland has not had a particularly high density of fixed telephone subscriptions. Relative to population the figure has been around the OECD average in recent years, but much lower than in the other Nordic countries, for example. In 2001 there were on average 54.3 fixed telephone lines per 100 population in the OECD countries, while the figure in Finland was 54 per 100 population and in Sweden, Norway and Denmark over 70 per 100 population.[7]

The number of fixed telephone lines in Finland peaked in the late 1990s at around 2.85 million. Since then the number has dropped back to some extent. At year-end 2003 the total number of fixed lines was 2.57 million, or 49 connections per 100 population. The total number of fixed telephone connections includes the public telephones maintained by teleoperators, which in 2003 numbered no more than 5,800. In the mid-1990s there were still 25,000 public phones, but the growing penetration of mobile phones has greatly reduced the demand.

Although fixed landlines have to some extent been superseded by mobile phones and although broadband is used more and more often now for Internet connections, there has been no significant drop in the total number of fixed telephone lines. However, since the number of ISDN subscriptions has increased year on year, and since these subscriptions (or more precisely the number of ISDN channels extracted from the number of ISDN subscriptions[8]) are

Table 12.2.1
Fixed telephone lines, change from previous year, number of subscriptions per 100 population and number of ISDN channels as a proportion of fixed lines in 1990 and 1995–2003. Source: Statistics Finland (2002–2003), Ministry of Transport and Communications (1990–2001).

Year	Subscriber lines	Change, %	Subscriber lines/100 pop.	Share of ISDN channels, %
1990	2,669,697		53.4	
1995	2,799,379		54.7	0.8
1996[1]	2,801,924	0.1	54.6	3.0
1997	2,850,374	1.7	55.4	7.0
1998	2,841,497	−0.3	55.1	10.8
1999	2,850,305	0.3	55.1	16.8
2000	2,848,809	−0.1	55.0	21.6
2001	2,806,172	−1.5	54.0	23.3
2002[2]	2,725,607	−2.9	52.4	26.1
2003	2,567,592	−5.8	49.2	30.9

1 Revision of the compilation basis of statistics
2 Number of primary ISDN subscriber lines has been multiplied by 30 to obtain number of channels (multiplier used in 2001 was 25)

7 OECD (2003e).

8 ISDN (Integrated Services Digital Network) is a system for digital data transmission that can use several channels over a single telephone line. For purposes of counting the total number of fixed telephone lines, ISDN subscriptions are converted into channels so that they correspond mathematically to traditional telephone lines. Basic rate ISDN subscriptions are therefore multiplied by two (two independent data transmission channels) and primary rate ISDN sub-scriptions (max. 30 data transmission channels) are multiplied by 30.

included in the total number of telephone lines, it is clear that the number of traditional fixed landlines has declined somewhat more rapidly than the overall number of fixed telephone lines. In 2003 there were a total of some 225,000 basic rate ISDN subscriber lines in Finland, compared to around 200,000 in 2000. In 2003 the number of primary rate ISDN subscriber lines was about 11,500 and in 2000 some 8,600.

The dwindling significance of fixed line telephony is clearly illustrated by the changes in the number of phone calls made. In the late 1990s and even around the turn of the millennium a total of some 3.5 billion phone calls were made each year over the local telephone network, but by 2003 that number had dropped to around 2.5 billion. Almost one-quarter of all calls from fixed lines were to a mobile phone network.[9]

Government communications policy in Finland is aimed at creating a sound foundation for an efficient communication infrastructure, at increasing the supply and availability of broadband services and ultimately at supporting the provision of advanced information society services. In January 2004 the government adopted a resolution on a national broadband strategy which aims to ensure that by the end of 2005, everyone in Finland shall have access to affordable, high-speed data transfer connections with comprehensive regional coverage. In quantitative terms the aim is that there should be one million broadband connections in the country (all technologies).[10]

The take up of broadband services got off to a rather slow start in Finland, but the pace began to quicken in 2002. In 2003 the demand for broadband connections continued to strengthen, and their number more than doubled within the space of one year. The most common technologies used in Finland are DSL and cable modem connections.[11] So far other broadband technologies have remained less prominent.

Table 12.2.2
Teleoperators' DSL connections and cable modems in 2000–2003.
Source: Statistics Finland (2002–2003), Ministry of Transport and Communications (2000–2001)

Year	DSL-subscriptions[1]	Cable modems[2]
2000[3]	10,000	..
2001	61,467	..
2002	183,482	54,000
2003	379,305	87,304

1 Mainly ADSL subscriptions
2 Number of cable modems also includes those provided by operators outside the telecommunications industry.
3 Partly estimated

9 Statistics Finland (2004b).
10 Ministry of Transport and Communications (2003), see also www.mintc.fi and www.laajakaistainfo.fi
11 DSL (Digital Subscriber Line) is a technology for transmitting digital information at a high bandwidth on ordinary phone lines, i.e. copper wire. A cable modem is a device that allows high-speed access to the Internet and data services via a cable television network.

The number of broadband connection continued to increase in 2004. According to data compiled by the Finnish Communications Regulatory Authority, there were a total of almost 600,000 broadband connections at the beginning of July, by the beginning of October the figure had climbed further to around 670,000.[12]

In June 2002 the average number of broadband connections in all OECD countries was 3.8 per 100 inhabitants, by the end of 2003 the figure had risen to 7.3. The density of connections varies widely from country to country. In December 2003 South Korea had 23.3 connections per 100 population, many

Table 12.2.3
Broadband connections in OECD countries per 100 population in December 2003. Source: OECD.

Country	DSL	Cable modern	Other	Total
	per 100 inhabitants			
Australia	2.2	1.3	0.1	3.5
Austria	3.5	4.2	0.0	7.7
Belgium	7.6	4.5	0.3	12.3
Canada	7.0	7.8	0.0	14.8
Czech Republic	0.1	0.3	0.0	0.5
Denmark	8.8	3.6	0.7	13.1
Finland	7.8	1.6	0.1	9.5
France	5.3	0.6	0.0	6.0
Germany	5.5	0.1	0.1	5.6
Greece	0.1	0.0	0.0	0.1
Hungary	1.1	1.0	0.7	2.6
Iceland	14.1	0.2	0.2	14.5
Ireland	0.6	0.1	0.1	0.8
Italy	3.7	0.0	0.4	4.1
Japan	8.1	1.9	0.7	10.7
Korea	14.4	8.4	0.4	23.2
Luxembourg	2.9	0.5	0.1	3.4
Mexico	0.2	0.1	0.0	0.3
Netherlands	5.7	5.9	0.0	11.6
New Zealand	2.3	0.1	0.2	2.6
Norway	6.4	1.5	0.1	8.0
Poland	0.4	0.4	0.0	0.8
Portugal	1.8	3.0	0.0	4.8
Slovak Republic	0.1	0.1	0.2	0.3
Spain	4.1	1.3	0.0	5.4
Sweden	6.4	2.3	2.1	10.8
Switzerland	6.6	4.8	0.0	11.4
Turkey	0.1	0.1	0.0	0.1
United Kingdom	3.1	2.3	0.0	5.4
United States	3.3	5.7	0.8	9.8
OECD	**4.2**	**2.7**	**0.4**	**7.3**

12 Finnish Communications Regulatory Authority, www.ficora.fi

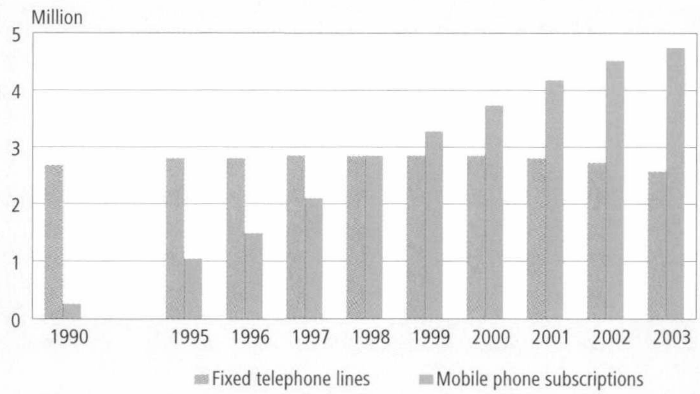
other countries had no more than a few connections per 100 population. In summer 2002 the number of broadband connections in Finland relative to population was still below the OECD average, but the increased demand for broadband connections during 2003 significantly drove up the density in Finland, beyond the average for the OECD countries.[13]

Internet penetration is often measured on the basis of the number of subscribers. One potential difficulty in measuring the total number of Internet subscriptions lies in the definition of free subscriptions, because comparative statistical data are not necessarily available on subscriptions that are in active use. Indeed instead of the total number of Internet subscriptions, many statistical sources measure the number of Internet subscribers. Data compiled by the OECD indicate that in 2001, Finland had 18.3 fixed network Internet subscribers per 100 population, while the average for all EU countries was 16.8 and for the OECD countries 18.7. The number of fixed network Internet subscribers is markedly higher in the other Nordic countries. In 2001 the figure in Iceland was as high as 60 per one hundred population, in Norway 27.4, in Denmark 37.8 and in Sweden 32.[14]

Mobile phone subscriptions

The volume of mobile communication services has grown consistently in Finland year on year. The number of phone calls and call minutes are continually increasing, and at the same time the use of value added services such as SMS messages is also growing. In 2003 a total of some 3.4 billion phone calls were made from mobile phones in Finland, almost one billion more than the number of phone calls from fixed networks.[15]

Figure 12.2.1
Number of fixed phone lines and mobile phone subscriptions in 1990 and 1995–2003. Source: Statistics Finland (2002–2003), Ministry of Transport and Communications (1990–2001).



13 OECD, www.oecd.org
14 OECD (2003e).
15 Statistics Finland (2004b).

Ever advancing mobile technology provides an excellent platform for the development of new kinds of services. GPRS[16] technology was launched in Finland in 2001, and 2003 saw the introduction of EDGE[17] technology. The first third generation mobile networks were put into commercial use in autumn 2004.

In the 1990s Finland was one of the world leaders in mobile communications. The number of mobile phone subscriptions increased rapidly, and by the end of 1998 there were 55 subscriptions per 100 population in the country.

Table 12.2.4
Mobile phone subscriptions, change from previous year and subscriptions per 100 population in 1980–2003.
Source: Statistics Finland (2002–2003), Ministry of Transport and Communications (1980–2001).

Year	Mobile subscriptions			Change from previous year, %	Subscrip-tions/100 pop.
	Digital	Analogue[1]	Total		
1980	–	23,482	23,482		0.5
1981	–	28,278	28,278	20.4	0.6
1982	–	33,880	33,880	19.8	0.7
1983	–	42,226	42,226	24.6	0.9
1984	–	52,010	52,010	23.2	1.1
1985	–	67,639	67,639	30.0	1.4
1986	–	85,300	85,300	26.1	1.7
1987	–	105,860	105,860	24.1	2.1
1988	–	138,160	138,160	30.5	2.8
1989	–	190,031	190,031	37.5	3.8
1990	–	257,872	257,872	35.7	5.2
1991	–	319,137	319,137	23.8	6.4
1992	3,308	382,713	386,021	21.0	7.6
1993	19,111	470,063	489,174	26.7	9.6
1994	110,155	565,410	675,565	38.1	13.2
1995	380,703	658,423	1,039,126	53.8	20.4
1996	830,585	646,391	1,476,976	42.1	28.8
1997	1,523,356	568,435	2,091,791	41.6	40.6
1998	2,498,793	347,192	2,845,985	36.1	55.2
1999	3,073,943	199,490	3,273,433	15.0	63.4
2000	3,672,762	55,863	3,728,625	13.9	72.0
2001	4,137,337	38,250	4,175,587	12.0	80.4
2002	4,516,772	–	4,516,772	8.2	86.8
2003	4,747,126	–	4,747,126	5.1	90.9

1 By the end of 2002, the analogue mobile communications system was wound up in Finland.

16 GPRS (General Packet Radio Service) is a GSM-based packet switched data transmission technology.

17 EDGE (Enhanced Data Rates for GSM Evolution) is a technology that enables packet switched data transmission over GSM networks at high speed.

The number of mobile phone subscriptions has continued to increase year on year, and at year-end 2003 there were a total of more than 4.7 million subscriptions in Finland, or 91 per 100 inhabitants. About 80 per cent of these subscriptions are in the name of private households. The majority of Finnish subscriptions are contract subscriptions, which means they are billed in arrear. In 2003 no more than five per cent of all subscriptions were prepaid, which in many other countries are quite popular. In the other Nordic countries, for instance, pre-paid subscriptions are far more common than in Finland. In 2001 prepaid subscriptions accounted for 37 per cent of all mobile phone subscriptions in Iceland and Denmark, for 41 per cent in Norway and 49 per cent in Sweden.[18]

In an international comparison Finland has had a comparatively high subscription penetration rate. The numbers have climbed to a fairly high level in many other countries as well. In many European countries, for exampe, the figure is in excess of 80 subscriptions per 100 population. At year-end 2001 the average number of mobile phone subscriptions in the OECD countries was 53.9 per 100 population, while in the EU countries the corresponding figure was 74.3 per 100 population. According to figures released by the International Telecommunication Union ITU, the average number of subscriptions in Europe in 2003 was 55.4 per 100 population, while in Asia the figure was 15 and in Africa 6.2 subscriptions per 100 population. [19]

Computers

Some statistical data are available on computers and computer use, including figures for the number of households that have access to a computer, but it is

Table 12.2.5
Computers in selected countries in 2002.
Source: ITU.

	Computers	
	Thousands	/100 pop.
United States	190,000	65.9
Singapore	2,590	62.2
Sweden	5,556	62.1
Denmark	3,100	57.7
Australia	11,100	56.5
Korea[1]	26,741	55.8
Norway	2,405	52.8
Canada	15,300	48.7
Iceland	130	45.1
Finland	2,300	44.2
Germany	35,600	43.1
Hongkong	2,864	42.2
United Kingdom	23,972	40.6
Japan	48,700	38.2
France	20,700	34.7

1 Data from 2003

18 OECD (2003e).
19 ITU and OECD (2003e).

difficult to give any exact figures on the overall number of computers that are in active use.

Several international organisations monitor and compile statistics on the number of computers in use and the number of computers relative to population. However the figures quoted in different sources vary widely, partly because they use different definitions in compiling their data.

Finland ranks high in these comparisons. The number of computers relative to population is higher than average, although Finland's ranking varies widely depending on the source quoted.[20] According to ITU data for 2002, there were a total of some 2.3 million computers in Finland, which translates into 44 computers per 100 population.

Cable television subscriptions and digital television

At year-end 2003 the total number of cable television subscriptions in Finland was 1.1 million: 47 per cent of all Finnish households and 56 per cent of all television households were connected to a cable television network.[21]

Digital television was launched in Finland in August 2001. After a slow start, household penetration of digital receivers has now begun to accelerate. In November 2003 some nine per cent of households had a digital set-top box or a digital television, and less than four per cent had a satellite digital receiver. By August 2004 these figures had risen to around 15 per cent and 6 per cent, respectively.[22]

ICT investments and expenditure

ICT investments have a major impact on economic growth. As well as creating key infrastructure for economic activities, i.e. providing networks for other information and communication applications, information and communication technologies are also in themselves an increasingly important part of production capacity (cf. investment in IT goods, communication equipment and particularly in software). The contribution of ICT investment to gross fixed capital formation varies widely from country to country. Different countries also vary in terms of the level of investment in IT equipment, communication equipment and software. On average, from the early 1980s to the turn of the millennium, investment in information and communication technologies has doubled in the OECD countries.[23]

According to figures released by the European Information Technology Observatory EITO (Table 12.2.6), Sweden recorded by far the highest level of ICT expenditure as a proportion of GDP in 2003. Finland ranked eighth in this comparison. In recent years, according to this same source, ICT expenditure as a proportion of GDP has decreased almost across the board. The most notable exception is Japan, where ICT expenditure as a proportion of GDP has slowly edged upwards. In money terms, however, ICT expenditure relative to population increased in most countries from 2002 to 2003. Telecommunication ex-

20 See e.g. ITU, www.itu.int and World Competitiveness Yearbook 2004.
21 Statistics Finland (2004b), original source: Finnish Cable Television Association.
22 Statistics Finland, Consumer Barometer.
23 OECD (2003c)

penditure relative to population increased in virtually all countries, whereas in many cases IT expenditure decreased to some extent.

Table 12.2.6
ICT expenditure as a proportion of GDP in 2000–2003.
Source: EITO

	2000	2001	2002	2003		
	ICT expenditure total %	ICT expenditure total	ICT expenditure total	ICT expenditure total	of which information expenditure	telecommunication expenditure
Sweden	9.60	9.49	9.18	8.84	4.56	4.28
United Kingdom	8.88	8.73	8.36	8.07	4.24	3.83
Yhdysvallat	9.38	8.63	8.19	7.90	4.62	3.28
Switzerland	8.24	8.27	7.94	7.85	4.31	3.54
Japan	7.14	7.41	7.75	7.80	3.51	4.29
Netherlands	8.50	8.08	7.55	7.30	3.75	3.55
Portugal	7.56	7.59	7.10	6.96	2.10	4.86
Finland	7.54	7.21	7.06	6.93	3.57	3.35
Denmark	7.19	6.96	6.74	6.62	3.46	3.16
Belgium/Luxembourg	6.68	6.94	6.62	6.48	2.98	3.50
Austria	6.57	6.69	6.49	6.42	3.02	3.40
Germany	6.60	6.44	6.15	6.06	3.02	3.04
Norway	6.38	6.25	5.91	6.00	3.47	2.52
France	6.33	6.40	6.17	5.95	3.29	2.66
Spain	6.28	5.94	5.61	5.43	1.77	3.66
Greece	6.06	5.93	5.60	5.29	1.32	3.97
Ireland	7.22	6.55	5.88	5.29	2.00	3.29
Italy	5.47	5.55	5.38	5.29	1.96	3.33

12.2.2 ICT and competence – IT and media education

In order that the full potential of information and communication technology can be tapped, it is necessary to have the appropriate know-how in place: people need new skills and new competencies. The importance of lifelong learning is underlined by the constant changes in the workplace, including the adoption of new technologies. Indeed, to top up the skills and competencies gained in basic education, employees are turning increasingly to adult education and other forms of on-the-job learning. Nonetheless it is important that even the regular education system can keep up with the pace of change in the world of work and satisfy its changing needs. The increasing use of information and communication technology and the growth of the ICT sector have in fact prompted the education system to respond and adjust its priorities. For such fields as content production which rely heavily on the application of information and communication technology, it is important that the necessary skills and competencies are taught in the regular education system.

After comprehensive school, the Finnish education system consists of upper secondary education and tertiary education. **Upper secondary education** consists of upper secondary school education and initial vocational education, which provide qualifications for post-graduate studies leading to polytechnic and university degrees. **Tertiary education** includes polytechnics and universities.

Persons with a degree or qualification refers to those who have completed degrees at upper secondary schools, vocational institutions, polytechnics or universities as well as those who have completed initial, further or specialist vocational qualifications in the form of competence-based qualifications.

The description below focuses on education in the information technology and media fields, which are the most representative of ICT intensive training. The data are drawn from Statistics Finland's Register of University Students, Register of Completed Education and Degrees and Employment Statistics, and they are classified using Statistics Finland's educational classifications. The number of new students in information technology and media studies has increased sharply in recent years, as indeed has the number of graduates from these fields of study. These trends clearly attest to the growing significance of ICT-oriented fields of study.

Almost 13 per cent of new students now enter IT and media studies

In 2002 some 131,000 new students entered the Finnish education system. More than one in ten of these studdents or 12.7 per cent started a programme in IT and media studies. The number of new students in IT and media studies increased up to 2001, but in 2002 the figure dropped by two per cent on the previous year. In 2002 over two-thirds or 68 per cent of all new IT and media students were men. The number of men starting a programme in this field continued to increase, but the number of women decreased. Since 1997 the number of men starting a programme in IT and media studies has increased more than 1.5 times over, while the corresponding number of women has more than tripled.

Table 12.2.7
New students in IT and media studies in 1997–2002.[1]
Source: Statistics Finland, Education Statistics.

	New students total	Information technology and media studies			
		Men	Women	Total	% of new students
1997	109,507	6,727	1,720	8,447	7.7
1998	113,433	8,040	2,433	10,473	9.2
1999	125,362	9,194	3,955	13,149	10.5
2000	131,202	9,346	5,170	14,516	11.1
2001	128,766	11,153	5,944	17,097	13.3
2002	131,487	11,326	5,424	16,750	12.7

1 As from 2002 new polytechnic students are defined as including those reporting being either present or absent; previously only those students who reported being present were counted as new students.

Figure 12.2.2
Development of the number of new IT and media students from 1997 to 2002, 1997=100.
Source: Statistics Finland, Education Statistics.

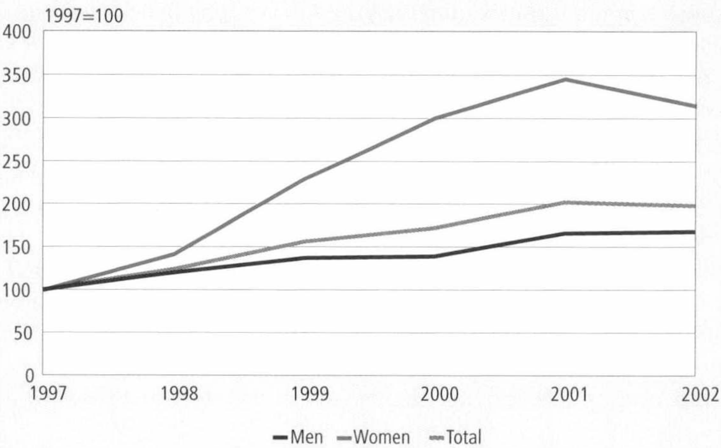


Table 12.2.8
New IT and media students by field and level of education in 1997–2002.
Source: Statistics Finland, Education Statistics.

Field/level of education	1997	1998	1999	2000	2001	2002
Humanities and arts	786	1,006	1,716	1,955	2,468	2673
Upper secondary level	279	449	1,095	1,264	1,521	1,695
Tertiary level	507	557	621	691	947	978
Social sciences, business and law	1,170	1,739	2,242	2,546	2,726	2,791
Upper secondary level	–	–	–	18	32	48
Tertiary level	1,170	1,739	2,242	2,528	2,694	2,743
Natural sciences	1,221	1,470	2,501	5,281	6,023	5,834
Upper secondary level	–	–	1,515	4,172	4,693	4,545
Tertiary level	1,221	1,470	986	1,109	1,330	1,289
Engineering and technology	5,270	6,258	6,690	4,734	5,880	5,452
Upper secondary level	1,913	2,199	2,786	692	714	598
Tertiary level	3,357	4,059	3,904	4,042	5,166	4,854
Total	**8,447**	**10,473**	**13,149**	**14,516**	**17,097**	**16,750**
Level of education						
Upper secondary level	2,192	2,648	5,396	6,146	6,960	6,886
Men	1,869	2,220	3,707	3,435	3,856	4,008
Women	323	428	1,689	2,711	3,104	2,878
Tertiary level	6,255	7,825	7,753	8,370	10,137	9,864
Men	4,858	5,820	5,487	5,911	7,297	7,318
Women	1,397	2,005	2,266	2,459	2,840	2,546

In 2002, 59 per cent of all new IT and media students were enrolled in tertiary level programmes. The number of new students in IT and media studies at the tertiary level has increased more than 1.5 times over since 1997. At upper secondary level the number of new students more than tripled from 1997 to 2002.

Number of degrees completed in IT and media studies continued to rise in 2002

In 2002 the total number of post-comprehensive degrees and qualifications completed in Finland stood at 126,700. This was higher than the corresponding figure for previous years; in 2001, for instance, the number was 122,900.

The numbers completing degrees and qualifications in IT and media studies in 2002 were significant higher than one year previously. The total number of

Table 12.2.9
Persons completing degrees in IT and media studies in 1997–2002.
Source: Statistics Finland, Education Statistics.

	Education in IT and media studies			
	Men	Women	Total	Osuus tutkinnoista[1]
1997	3,203	906	4,109	5.0
1998	3,345	888	4,233	5.0
1999	4,216	1,099	5,315	6.1
2000	4,674	1,952	6,626	7.7
2001	5,329	2,482	7,811	9.0
2002	5,859	2,971	8,830	9.8

1 Per cent of degrees completed at vocational institutions, polytechnics and universities

Figure 12.2.3
Development of the number of degrees in IT and media studies in 1997–2002, 1997=100.
Source: Statistics Finland, Education Statistics.

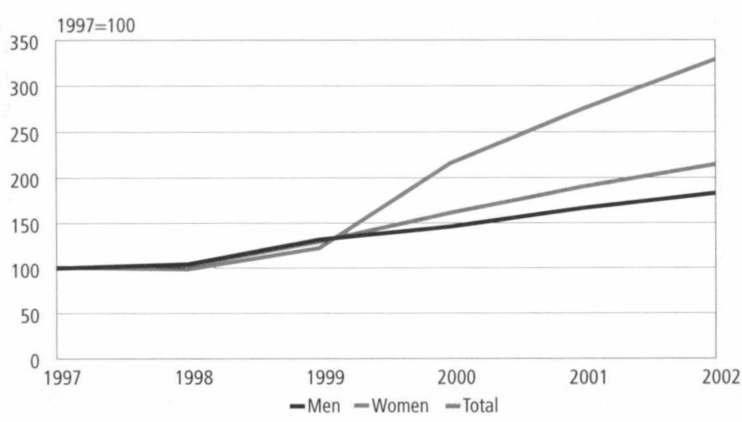


Table 12.2.10
Degrees completed in IT and media studies in 1997–2002 by field and level of education and by gender.
Source: Statistics Finland, Education Statistics.

Field/level of education	1997	1998	1999	2000	2001	2002
Humanities and arts	172	343	405	778	930	1,245
Upper secondary level	30	191	272	484	498	796
Tertiary level	142	152	133	294	432	449
Social sciences, business and law	906	507	512	686	986	1 294
Upper secondary level	0	0	0	0	16	70
Tertiary level	906	507	512	686	970	1,224
Natural sciences	600	640	849	1,830	2,208	2,655
Upper secondary level	5	18	139	983	1,630	2,168
Tertiary level	595	622	710	847	578	487
Engineering and technology	2,431	2,743	3,549	3,332	3,687	3,636
Upper secondary level	1,370	1,696	2,199	2,035	2,166	2,044
Tertiary level	1,061	1,047	1,350	1,297	1,521	1,592
Total	**4,109**	**4,233**	**5,315**	**6,626**	**7,811**	**8,830**
Men	3,203	3,345	4,216	4,674	5,329	5,859
Women	906	888	1,099	1,952	2,482	2,971
Upper secondary level total	1,405	1,905	2,610	3,502	4,310	5,078
Tertiary level total	2,704	2,328	2,705	3,124	3,501	3,752

degrees and qualifications was 8,800, 13 per cent up on the figure for 2001. IT and media degrees accounted for almost 10 per cent of all degrees and qualifications completed at vocational institutions, polytechnics and universities.

IT and media graduates continue to have better success finding work than other graduates

In recent years people completing degrees in IT and media studies have had better success than graduates from other fields in finding work within a few years of graduation. However, there are some signs now that the placement situation of IT and media graduates is getting slightly worse, while the situation of other graduates has improved.

Table 12.2.11
Employment of persons completing post-comprehensive degrees and qualifications by age within a few years of graduation at year-end 1999, 2001 and 2002.
Source: Statistics Finland, Education Statistics.

Age	Employed persons as a percentage of graduates					
	Total			Information technology and media studies		
	1999*	2001*	2002*	1999*	2001*	2002*
Total	**58.4**	**62.6**	**63.4**	**74.2**	**72.6**	**71.5**
–24	44.0	47.3	47.4	50.3	47.1	44.1
25–34	79.6	82.6	82.7	88.9	87.0	85.0
35–44	82.7	85.4	86.2	85.1	82.9	82.1
45–	81.9	83.2	84.5	82.5	76.7	80.6
Men	56.2	58.4	59.1	72.4	70.0	68.9
–24	38.9	39.9	39.2	48.4	43.7	39.9
25–34	84.1	85.6	85.8	90.0	88.0	86.3
35–44	85.0	86.3	86.7	87.7	82.7	80.9
45–	79.9	80.3	82.9	80.2	76.5	79.9
Women	60.2	65.9	66.8	81.3	80.2	78.5
–24	48.2	53.4	54.1	67.9	67.7	63.6
25–34	75.7	80.3	80.1	85.5	84.0	81.6
35–44	81.4	84.9	86.0	79.3	83.3	84.0
45–	82.7	84.6	85.2	86.3	77.0	81.4

12.3 Information technology and its use in enterprises

This section discusses the use of information technology in enterprises: how widely have business companies adopted information technology, how do they make use of the Internet? A further concern is with experiences of data security problems and with the prevalence of e-commerce in business enterprises. The data are drawn from Statistics Finland's annual survey on the use of information technology and e-commerce in enterprises, which has been developed under Eurostat coordination.[24]

The prevalence of information technology in enterprises

Table 12.3.1 describes the prevalence of IT use in business enterprises by enterprise size category. The general tendency is for the use of information technology to increase with the size of the enterprise. As can be seen in the table,

24 The statistics cover main categories D, F-I and K and certain sections from main categories E and O of the standardard industrial classification. The survey comprises enterprises with at least five employees. For more details, see e.g. Statistics Finland (2004c).

Table 12.3.1
IT use in enterprises by enterprise size in spring 2004, per cent of enterprises with at least five employees.
Source: Statistics Finland, Use of Information Technology in Enterprises.

	Enterprise size All, at least 5 employees	At least 10 employees	5–9 employees	10–19 employees	20–49 employees	50–99 employees	At least 100 employees
Computer	96	98	95	97	98	99	100
Local area network (LAN)	71	79	62	70	84	93	97
Internet	94	97	92	95	97	99	99
Homepage	62	75	48	67	77	92	93
Broadband	63	70	56	61	73	83	93
ISDN	23	23	23	22	23	21	25
Modem	22	22	23	24	18	19	23
Intranet	27	36	18	27	34	52	74
Extranet	13	18	8	12	16	28	42
EDI[1]	8	12	4	6	10	17	39
Internet-sales[1]	17	19	15	19	17	21	28
Internet-purchases[1]	68	70	66	67	68	76	85

1 Data from 2003

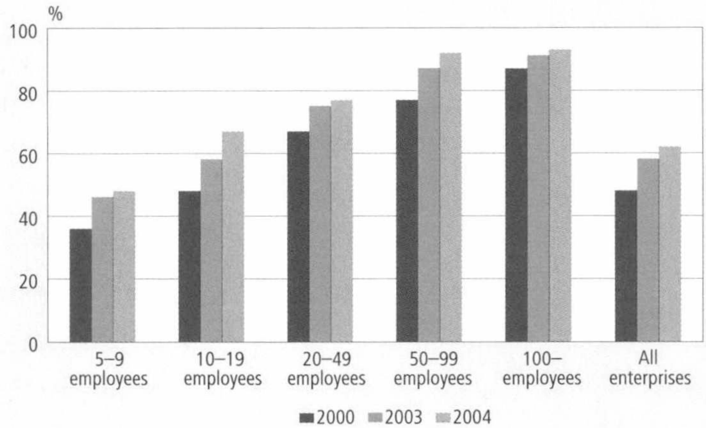
94 per cent of all enterprises with more than five employees had an Internet connection in spring 2004. In enterprises with a staff of more than 20, virtually all had access to the Internet.

Access to broadband has increased rapidly in business enterprises. In spring 2004 almost two-thirds or 63 per cent of all enterprises covered in the statistics had a broadband connection (compared to 54 per cent in 2003), in enterprises with at least 100 employees the figure was 93 per cent. In spite of the proliferation of broadband access, almost one-quarter of the enterprises included in the survey still had an ISDN connection and telephone modem.[25] The use of these technologies had decreased very rapidly, however, because in 2003 almost one-third of all enterprises were still using ISDN and telephone modems. In spring 2004, 71 per cent of enterprises with more than five employees had a local area network; the corresponding figure for enterprises with a staff of more than 50 was over 90 per cent.

In spring 2004 almost two-thirds or 62 per cent of enterprises had their own website. In the smallest category of enterprises with 5–9 employees, only less than one-half had their own website, whereas among enterprises with more than 50 employees nine in ten had set up a website. Between 2000 and spring 2004, the number of enterprises with their own website has gone up by 14 percentage points (Figure 12.3.1).

25 Note that one enterprise may have several different types of connections in use.

Figure 12.3.1
Enterprises running their own website in 2000 and 2003 and spring 2004, proportion of enterprises with at least five employees by size of enterprise.
Source: Statistics Finland, Use of Information Technology in Enterprises.



Intranet and extranet are clearly less common in enterprises than Internet connections. There was no change in the proportion of enterprises reporting the use of intranet and extranet from spring 2003 to spring 2004. In spring 2004, 27 per cent of enterprises had an intranet (a private network within the enterprise), no more than 13 per cent had an extranet (a network accessible to the enterprise and designated clients or other partners).

Table 12.3.2 describes the prevalence of IT use in enterprises by industry. For examle, broadband access, LAN and websites are most common in post and telecommunications, wholesale and business and other activities.

A comparison of EU countries (including Norway) shows that Internet and intranet use were more common in Finnish enterprises than in most other EU countries in 2002 (Figure 12.3.2). In Denmark and Sweden Internet use was almost equally common as in Finland. Figure 12.3.3 shows that broadband connections were also relatively common in Finnish enterprises.

Table 12.3.2
IT use in enterprises by industry in spring 2004.
Source: Statistics Finland, Use of Information Technology in Enterprises.

	All (at least 5 employees) %	Manufacturing	Construction	Trade of motor vehicles	Wholesale trade and commission trade	Retail trade	Hotels and restaurants	Transport	Post and telecommunications	Business and other services
Computer	96	98	93	97	100	99	90	93	98	97
Local area network (LAN)	71	77	52	72	89	71	53	55	83	82
Internet	94	95	92	92	98	96	87	90	98	97
Homepage	62	73	36	55	83	51	52	41	83	77
Broadband	63	64	47	68	80	68	44	45	89	77
ISDN	23	24	27	15	20	27	33	22	21	17
Modem	22	20	31	21	17	22	30	28	14	17
Intranet	27	27	21	18	38	30	19	16	69	35
Extranet	13	12	5	18	17	23	9	6	31	17
EDI[1]	8	13	3	12	16	8	..	6	14	3
Internet-sales[1]	17	17	7	16	28	16	24	12	39	21
Internet-purchases[1]	68	70	59	68	71	64	59	58	80	80

1 Data from 2003

Figure 12.3.2
Percentage of enterprises using the Internet and intranet in selected EU countries and Norway in 2002.
Source: Eurostat, Statistics on the Information Society in Europe.

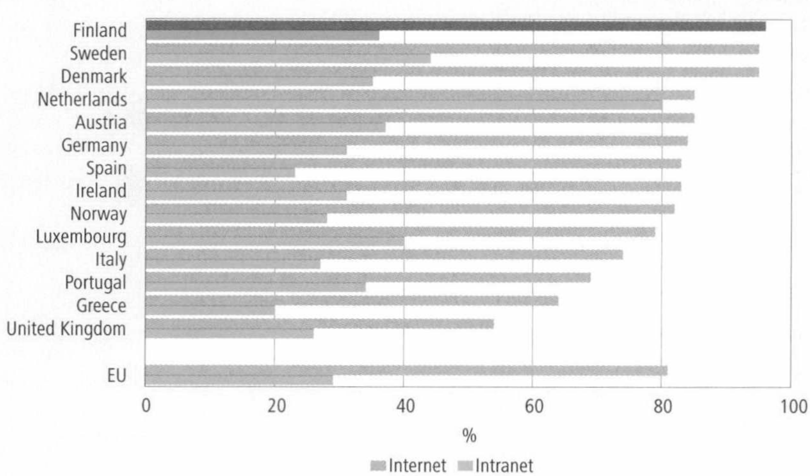
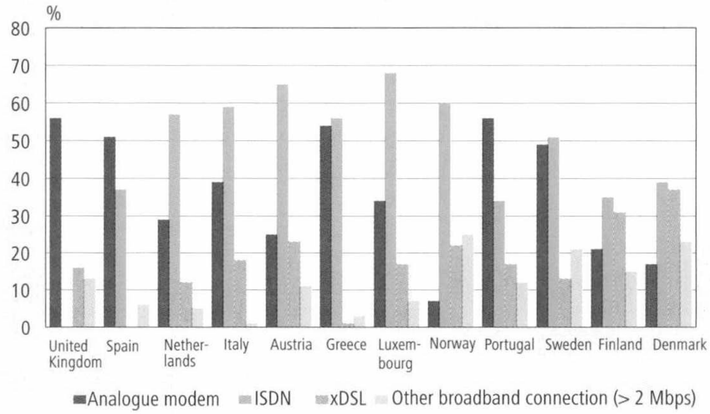


Figure 12.3.3
Percentage of enterprises using the Internet by type of connection in selected EU countries and Norway in 2002.
Source: Eurostat, Statistics on the Information Society in Europe.



Purposes of Internet and website use

The Internet is widely used among enterprises for banking and financial services and for the acquisition of information from the authorities: 90 per cent of all enterprises with Internet access say they use it for these purposes (Figure 12.3.4). Websites, then, are used primarily for purposes of marketing, posting product specifications and actual trading (Figure 12.3.5).

Figure 12.3.4
Purposes of Internet use in spring 2004, percentage of enterprises with at least five employees and Internet access.
Source: Statistics Finland, Use of Information Technology in Enterprises.

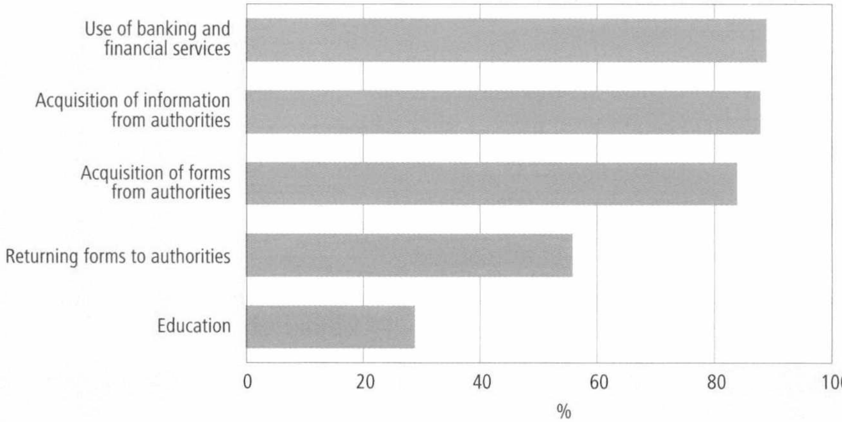
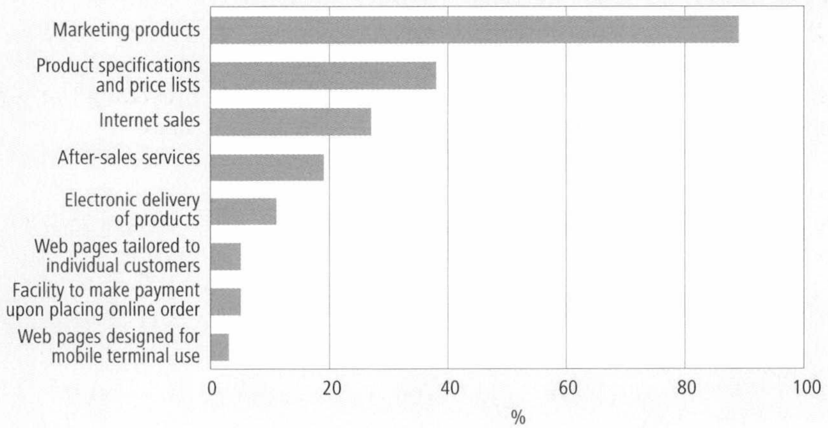


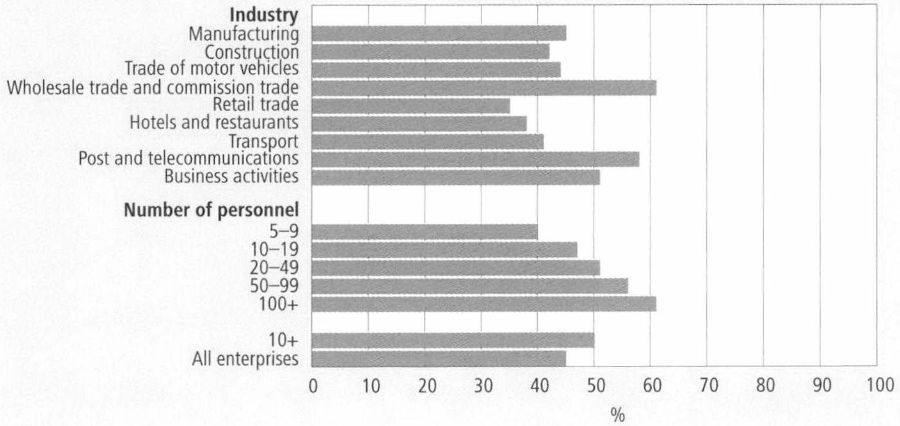
Figure 12.3.5
Purposes of website use in enterprises in spring 2004, percentage of enterprises with at least five employees and their own website.
Source: Statistics Finland, Use of Information Technology in Enterprises.



Data security a priority concern for enterprises

With the growth of Internet use and e-business it has become more and more important for enterprises to make sure they have appropriate data security mechanisms in place. Any problems with data security may effectively hamper the use and application of information technology to its full potential. Data se-

Figure 12.3.6
Computer virus attacks resulting in loss of information or working time during the 12 months preceding the survey, spring 2004, per cent of enterprises.
Source: Statistics Finland, Use of Information Technology in Enterprises.



curity problems and the precautions taken to maintain data security add to the costs of IT use. Most enterprises, however, are well aware of the risks involved and have taken all possible measures to protect their network environment. In 2003, for example, 85 per cent of enterprises with at least five employees were using antivirus software and 59 per cent had installed a firewall.[26]

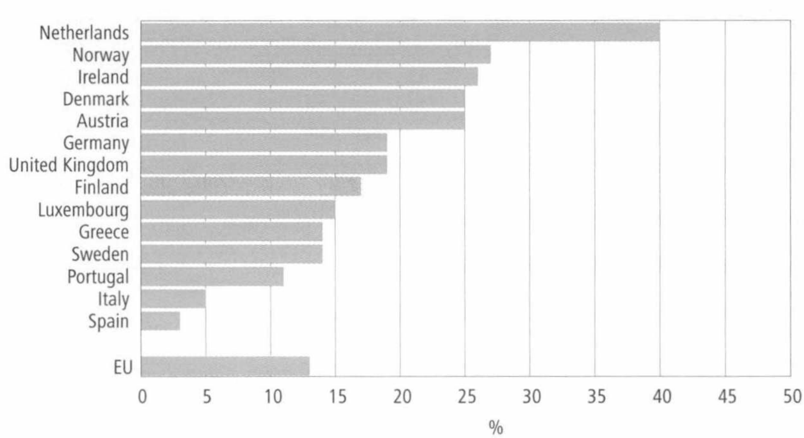
It seems that problems caused by computer viruses have increased: in spring 2003 about one-third of all enterprises reported losses of information or working time due to virus attacks during the 12 months preceding the survey. In spring 2004 the corresponding figure was up to 45 per cent.

E-commerce (Internet commerce and EDI[27])

The number of enterprises engaging in e-commerce in Finland remains comparatively low. In 2003 no more than 17 per cent of all enterprises with at least five employees reported engaging in Internet commerce, and just 8 per cent used EDI. As might be expected, e-commerce increases with increasing enterprise size, both in the case of Internet commerce and EDI use (cf. Table 12.3.1).

Comparative data for the EU show that in 2001, only relatively few enterprises sold their products and services over the Internet: on average 13 per cent of all enterprises in the EU countries engaged in Internet commerce. The figure exceeded 20 per cent in just a handful of countries. The highest figure was recorded in Holland at 40 per cent.

Figure 12.3.7
Enterprises with Internet sales in 2001, per cent of enterprises with Internet access. Source: Eurostat, Statistics on the Information Society in Europe.



26 Statistics Finland (2003c).
27 Electronic Data Interchange, business-to-business electronic transfer of commercial and administrative data.

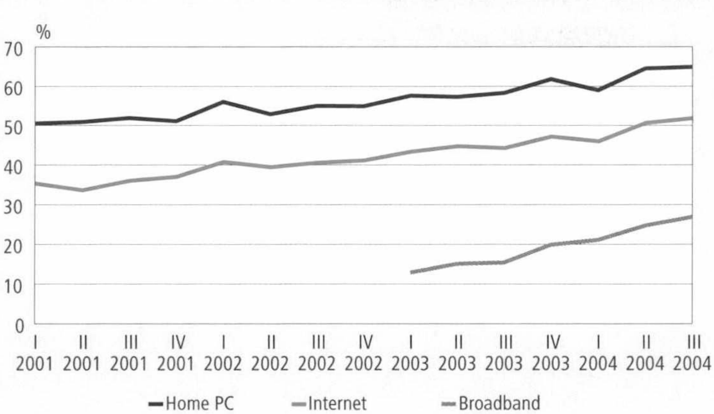
12.4 How do people in Finland use information and communication technology?

In the past few years, most people in Finland have started using new information and communication technologies on a daily basis. This section describes the ownership and use of ICTs in Finland as well as people's attitudes towards the information society. The main focus is on data from 2004. We begin by looking at how ownership and use of ICTs have developed over the period from 1996 to 2004. During this time Finland has evolved into an information society, in many different respects. Next, a description is given of the use of computers and the Internet in the workplace. This is followed by a discussion of e-commerce and how it has changed from 2001 to 2004. Finally, a review is included of public opinion and attitudes towards the information society, particularly from the point of view of involvement and marginalisation.

12.4.1 Household ownership of ICT in 1996–2004

In August 2004 almost two in three (65%) households in Finland had a computer. Over half (52%) had access to the Internet (Figure 12.4.1). Household ownership of computers and Internet access has increased by some 20 percentage points over the past four years: in August 2000, 47 per cent of households had a computer and 32 per cent had Internet access. Broadband connections have spread very rapidly over the past two years. More than one-quarter (27%) of Finnish households now have a broadband connection, which means that more than half of all household Internet subscriptions are broadband.

Figure 12.4.1
Per cent of households with a home computer, Internet access and broadband connection from the beginning of 2001, quarterly.
Source: Statistics Finland, Consumer Barometer.



Household size has a significant impact on the ownership of a home computer and Internet connection. Computers and Internet connections are far more common in 3–4 person households than in 1–2 person households. This has been the case throughout the period under review from autumn 1996 to spring 2004. During this period three-person households have been closing the gap to bigger households both in terms of computer and Internet ownership (Figures 12.4.2 and 12.4.3).

Virtually all (95%) Finnish households have a mobile phone. Earlier surveys have found that it is common for households to have more than one mobile phone. It is unlikely that the penetration of mobile phones will rise any further, but most purchases will be for new hand sets. It will be interesting to monitor the future segmentation of the mobile phone market and to see whether groups with different lifestyles will opt to purchase different kinds of phones.

New mobile phone models and camera mobiles in particular have been selling briskly in 2004. After a slow launch phase, sales of the WAP/GPRS/G3 phone also began to gather pace in 2004. In August 2004, 28 per cent of households in Finland owned a WAP/GPRS/3G phone. Camera phones have proliferated extremely rapidly. In August 2004 the proportion of households that had a camera phone was 14 per cent, compared to just over three per cent one year previously (Figure 12.4.4).

Figure 12.4.2
Per cent of households with a computer from autumn 1996 to spring 2004 by household size.
Sources: Statistics Finland, The Finns and the Future Information Society surveys in 1996 and 1999, Net commerce survey 2002 and Consumer Barometer 2004.

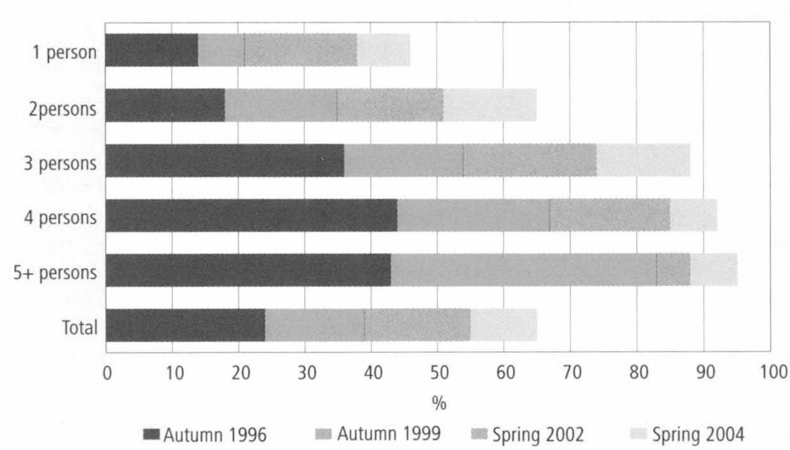


Figure 12.4.3
Per cent of households with Internet access from autumn 1996 to spring 2004 by household size.
Sources: Statistics Finland, The Finns and the Future Information Society surveys 1996 and 1999, Net commerce survey 2002 and Consumer Barometer 2004.

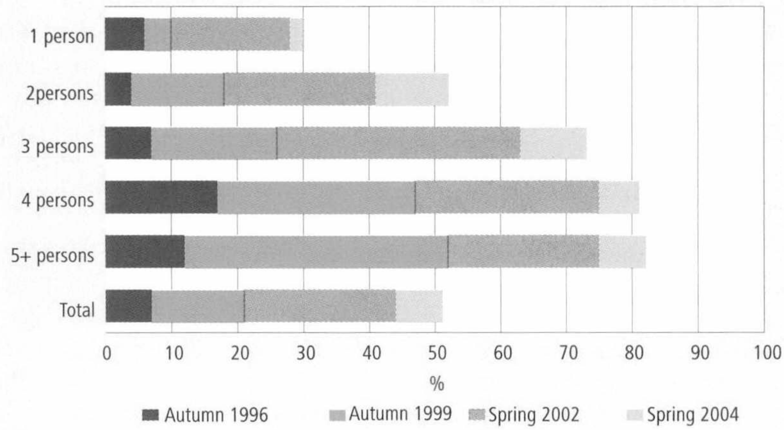


Figure 12.4.4
Proliferation of the WAP/GPRS/3G phone and camera phone from February 2002 to August 2004, quarterly, per cent of all households.
Source: Statistics Finland, Consumer Barometer.

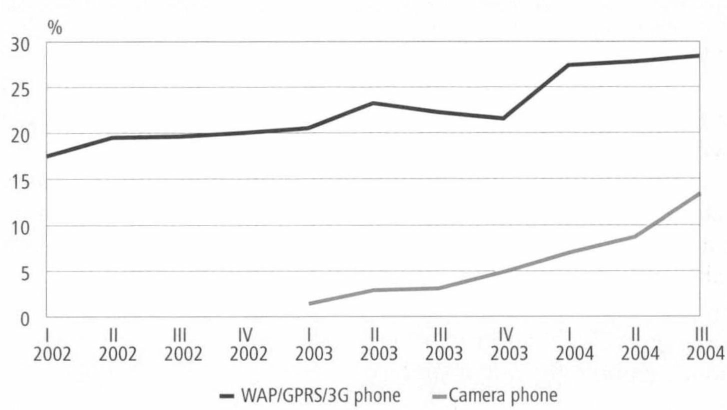
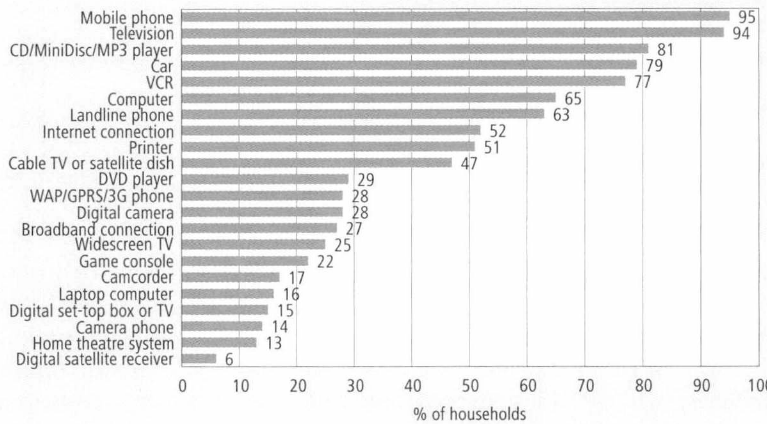


Figure 12.4.5 describes in closer detail the penetration of certain appliances in Finnish households. As we can see, the mobile phone ranks alongside television as the most common household appliance. Almost two in three households have a landline phone. In August 2004, 15 per cent of Finnish households had a digital set-top box.

Figure 12.4.5
Penetration of selected household appliances in August 2004, per cent of all households.
Source: Statistics Finland, Consumer Barometer.



12.4.2 Computer, Internet and mobile phone use in spring 2004

Mobile phone, camera phone and WAP/GPRS/3G phone

The data below on the use of mobile phones, home computers and Internet are based on telephone interviews carried out in April 2004. The survey[28] describes ICT use and capabilities in Finland as well as people's attitudes towards the information society. A total of more than 3,100 Finnish residents aged 15–74 were interviewed.

Most people in Finland have their own mobile phone. In the age group 15–40, almost everyone has a mobile phone, but ownership decreases with advancing age. Having said that, mobile phone use has recently been increasing among older age groups as well (Table 12.4.1).

In April 2004 more than 3.5 million people or 91 per cent of the Finnish population aged 15–74 had their own mobile phone. Among men 93 per cent and among women 89 per cent have the use of their own mobile phone. Among men over 40, nine in ten have a mobile phone, among women in the same age bracket the figure is 82 per cent. The gender difference is greater among pensioners.

The proportion of people using Internet or WAP services on their mobile phone increased significant in early 2004. In April almost 670,000 persons – some 19 per cent of mobile phone users – said they browsed www or WAP

28 EU harmonised.

Table 12.4.1
Mobile phone in own use, per cent.
Source: Statistics Finland, Net Commerce Surveys in 2002–2004.

Age group	Autumn 2002		Autumn 2003		Spring 2004	
	Men	Women	Men	Women	Men	Women
	%					
–39	98	96	97	99	99	99
40–49	95	88	98	95	95	94
50–59	88	83	95	88	91	87
60–74	79	57	83	67	81	63
Total	**93**	**85**	**94**	**90**	**93**	**89**

pages using their mobile. The figure for men was 24 per cent, for women 14 per cent. In the age group under 40, the number of users with access to mobile Internet or WAP services was three times higher than in the age group over 40. In the Helsinki area almost one in four mobile phone users used Internet or WAP services, whereas in sparsely populated rural areas the corresponding proportion was only around one in seven. Only just over one-fifth of all mobile Internet users agreed fully or to some extent with the statement that mobile Internet or WAP use had become a habit.

Almost six per cent of mobile phone users, i.e. some 200,000 persons in Finland had a camera phone in spring 2004. The figure was highest among young men. Men had a camera phone twice as often as women, and persons under 40 had a camera phone three times as often as those over 40.

Use of mobile phone services

It is still quite rare for people to use their mobile phone for the payment of purchases. In 2002 no more than one per cent of Internet enabled mobile phone users in Europe had used their phone for making payments, in North America the corresponding figure was three per cent. In Japan this was somewhat more common: 12 per cent of Internet enabled mobile phone users had paid for their purchases by phone. The use of banking services via mobile phone was also rare. In Europe three per cent had used their Internet enabled phone for banking[29]. In Finland five per cent of mobile phone users and 11 per cent of users of the Internet and WAP services via their mobile phone had made payments using their phone during the three months preceding the survey in spring 2004.

Will the picture message emerge as a success story comparable to the text message? It has not been a very promising start because according to interviews carried out in spring 2004, the use of camera phones for picture taking was still rather uncommon. One in ten camera phone owners had never used their phone to take pictures since the beginning of January. One in four of those who had used the camera feature had taken ten pictures or less. The numbers

29 Statistics for Mobile Commerce,
http://www.epaynews.com/statistics/mcommstats.htm

who had used their camera phone to send pictures was also comparatively low: just 58 per cent of camera phone owners had sent pictures from the phone to another mobile, to an e-mail address or a website.

Downloadable ringing tones and logos have not gained very widespread popularity. These services are used most often by young women. Changing ringing tones and logos for which a fee is charged has become a habit for no more than five per cent of mobile phone users. Playing games on the mobile is just as infrequent as changing ringing tones and logos.

In spring 2004, 15 per cent of mobile phone users or some half a million people had sent group text messages since the beginning of January. Almost one-third or 29 per cent had received group text messages. Women are more active than men (19 vs 12%) in terms of sending group text messages, whereas among recipients there are no gender differences. Persons under 40 both send and receive group text messages more often than those over 40. Group text messages were used for work purposes only quite rarely, i.e. by 18 per cent of those who had sent or received group text messages. Almost half or 46 per cent had used the service for information about leisure activities. Over time this mobile phone service may well become an important means of contact and communication in the field of voluntary work, for instance.

Three-quarters or 75 per cent of mobile phone users had their own e-mail address. Some six per cent of them, or a total of 145,000 persons had used their mobile phone to read e-mails. Almost three in four or 73 per cent rated this mobile phone service as necessary or rather necessary.

Internet use

In spring 2004, some 70 per cent of persons aged 15–74 or a total of 2.7 million people had used the Internet during the three months preceding the survey, i.e. since January. From early 2002 through to the end of 2003, the number of Internet users showed hardly any change at all, but in spring 2004 the numbers began to rise again. In autumn 2003 the proportion of users stood at 65 per cent of persons aged 15–74.

The gender gap has all but disappeared: in spring 2004, 70 per cent of men and 71 per cent of women had used the Internet (Table 12.4.2). The number of users has increased in all age groups. In relative terms the sharpest increase has occurred in the age group over 50.

Table 12.4.2
Internet use by gender and age group in spring 2004, per cent.
Source: Statistics Finland, Net Commerce Survey spring 2004.

	15–19 %	20–29	30–39	40–49	50–59	60–74	Total	Number of users
Women	98	95	92	81	61	17	71	1,376,000
Men	97	93	86	75	54	30	70	1,354,000
Total	**98**	**94**	**89**	**78**	**58**	**23**	**70**	**2,730,000**

However Internet use remains lowest in the oldest age groups, both among men and women. Women aged 30–59 use the Internet more often than men in the same age group. The biggest difference between men and women is seen after age 60. Over half of all persons who used the Internet at home said they used their connection daily or almost daily, while one-tenth used the Internet once a month or less often.

According to the interviews in spring 2004, people living in the Helsinki area were more active Internet users than people from other major cities (Turku, Tampere, Oulu, Kuopio, Jyväskylä, Lahti and Pori) or elsewhere in Finland. In the population aged 15–74 who lived in the Helsinki area, 80 per cent said they had used the Internet during the three months preceding the interview. However the number of Internet users has increased in all regions.

The proportion of Internet users has increased quite steadily in all age groups since the end of 2000. In 2000 there were clear differences between age groups in the proportions of Internet users, but these differences have narrowed down to some extent in all age groups except those aged 60 or over. As we can see in Figure 12.4.6, Internet use decreases with advancing age. Among persons under 50, Internet use is at a consistently high level.

Figure 12.4.7 illustrates the development of the proportion of Internet users in different age groups by gender from autumn 2002 to spring 2004. During this 18-month period Internet use has increased among women to a greater extent than among men in all age groups. It is noteworthy that in relative terms older women's Internet use has increased most in comparison to men of the same age. Among men over 40 Internet use has increased only marginally or remained unchanged. The only age group where a greater proportion of men than women used the Internet in spring 2004 was the age group over 60.

Figure 12.4.6
Internet use during the three months preceding the interview in different age groups from autumn 2000 to spring 2004, per cent.
Source: Statistics Finland, Net Commerce Survey.

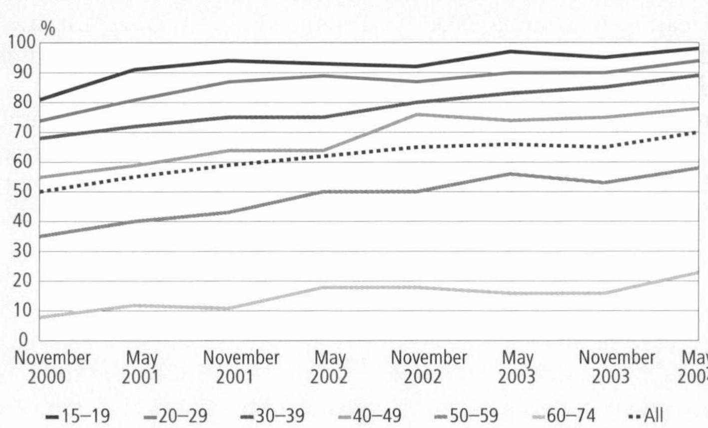
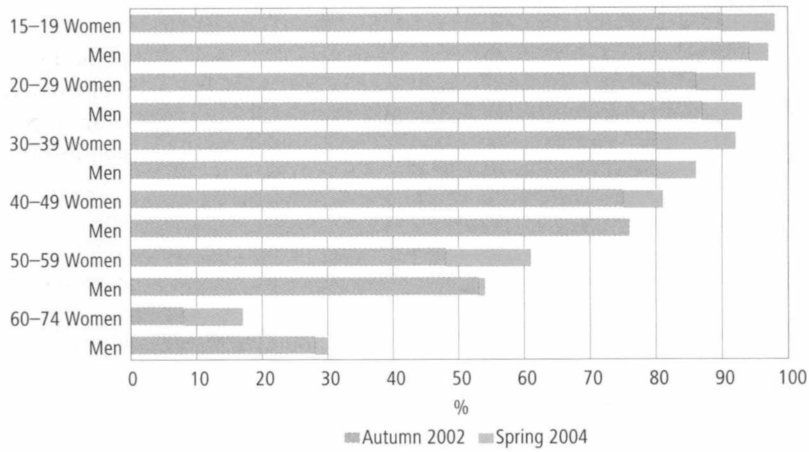


Figure 12.4.7
Internet use during the past three months in autumn 2002 and in spring 2004 by gender and age group, per cent.
Source: Statistics Finland, Net Commerce Survey.



Purposes of Internet use

E-mail was the most common form of Internet use in spring 2004. Among Internet users almost nine in ten had sent or received e-mails. More than two in three had used online banking services. Together with other financial and insurance services, electronic banking is indeed quite common in present-day Finland. Half of all Internet users had read online magazines, and just over half had browsed travel and accommodation websites. Almost two-thirds of Internet users had visited the websites of local or central government authorities (Table 12.4.3). Buying or ordering products and services, online banking and e-mail use had all increased clearly since spring 2003. Internet phone calls have also increased, although they are not yet by any means very common: only 5 per cent of Internet users had made online phone calls.

Internet search engines have gained much popularity, especially among young users. In the age group under 40, 62 per cent fully agreed with the statement that 'The use of Internet search engines has become routine for me', among persons over 40 the figure is 39 per cent. One in three Internet users (32%) relax by surfing the web: the proportion in the age group 15–29 is one-half, in the age group 30–49 one in four and in the age group 50–74 one in seven.

Women use the Internet for study purposes more often than men. Men, for their part, read online magazines more often than women. Playing and downloading games, listening to and downloading music, listening to the radio and watching television as well as chatting were all uses typical of young men. Online banking and the use of other financial and insurance services are more

Table 12.4.3
Internet uses in spring 2004, per cent of Internet users.
Source: Statistics Finland, Net Commerce Survey.

Purpose of use	%
Sending or receiving e-mail	88
Searching information about goods and services	84
Online banking	71
Browsing or searching for information on local or central government websites	62
Browsing travel and accommodation websites	60
Reading online magazines	52
Buying or ordering products and services (excluding shares/financial services)	37
Downloading images	37
Searching for a job or sending job applications	31
Listening to music online or downloading music on PC or other device	30
Studying at school, university or other institution	29
Chatting or writing on discussion boards	25
Playing games online	23
Listening to the radio or viewing television	17
Other financial and insurance services (e.g. buying shares)	16
Downloading games	11
Selling goods, products and services (online fleamarkets etc.)	11
Doing adult or further education courses	8
Internet phone calls	5
Doing courses aimed at improving job prospects	4
Video conferencing	4

common in urban than rural areas. Browsing travel and accommodation services is most common in the Helsinki area and among persons over 40.

Studying online

Among full-time students who had used the Internet in the past 12 months, the proportion who had used it for study purposes during the past term (at the time of the inquiry in April 2004) was 86 per cent. Over half or 55 per cent of those who had used the Internet for study purposes felt that the information they had found on the web was very useful to their studies, 45 per cent described it as rather useful.

How, then, do students use the Internet for study purposes? The majority (83%) of students who had visited the website of an educational institution since the beginning of the autumn term had studied the training courses available. Almost half (48%) had registered on a course or other training programme via the Internet and about the same proportion had looked up exam results. Two in three (67%) had been in touch with their teacher via e-mail and 15 per cent of Internet users had received tutoring online. Almost one-third or 28 per cent had completed exercises related to studying online. Roughly the same number of 32 per cent had been in touch with other students on the same course via an electronic forum.

More than one in ten (12%) full-time students who had used the Internet for study purposes since the beginning of the autumn term, had attended online courses since September. Online courses refer here to studies where most of the tuition is provided on a platform specifically designed for online teaching. Positive experiences were reported by 30 per cent of the students and rather positive experiences by 51 per cent. About 15 per cent of online students reported negative experiences. Among those who had not taken any online courses or who had not visited the website of an educational institution since the beginning of the autumn term, 4 per cent said they would be very interest to attend such a course, 48 per cent were rather interested and 40 per cent were not at all interested.

12.4.3 Computer and Internet use in the workplace

Approximately 80 per cent of the employed labour force had used a computer in the workplace during the preceding three months in spring 2004. Computer use in the workplace is somewhat more common among persons aged over 40 than in the age group of under 40, where 78 per cent had used a computer. Apparently the job tasks of the youngest employees require the use of information technology almost to the same extent as the jobs of older age groups. Equally small differences were seen between age groups in Internet use in the workplace. Three out of four of the employed labour force had used the Internet at work. The vast majority of those who had used a computer at the workplace had also used the Internet.

Figure 12.4.8
Per cent of the employed labour force who had used a computer in the workplace during the preceding three months in spring 2004 by age group.
Source: Statistics Finland, Net Commerce Survey.

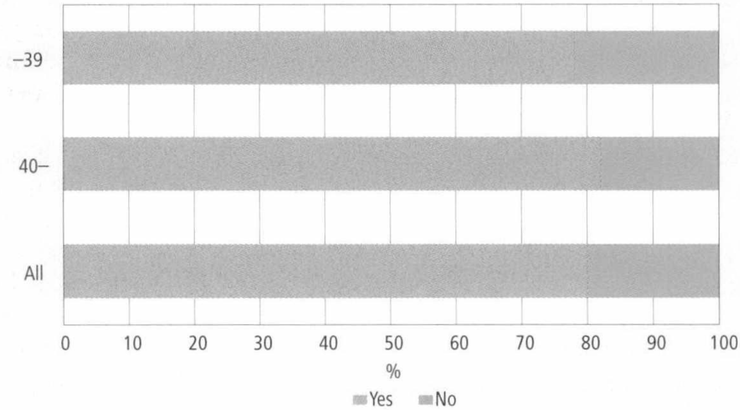
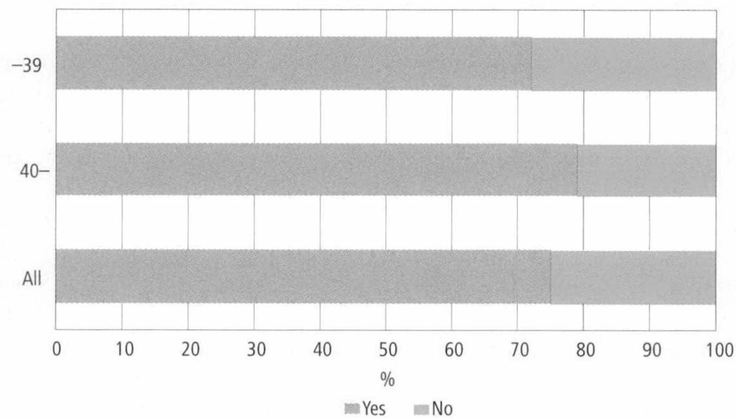
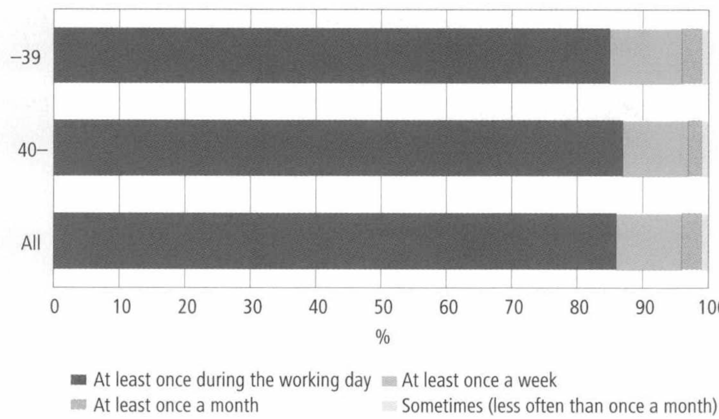


Figure 12.4.9
Per cent of the employed labour force who had used the Internet in the workplace during the preceding three months in spring 2004 by age group.
Source: Statistics Finland, Net commerce survey.



More than four in five (86%) of those who had used a computer in the workplace during the preceding three months had done so at least once during the working day. Roughly one in ten had used a computer at least once a week and only one in twenty less often than weekly. Persons aged under 40 use computers approximately as often as persons aged over 40.

Figure 12.4.10
Frequency of computer use in the workplace in spring 2004 during the preceding three months by age group, per cent of workplace computer users.
Source: Statistics Finland, Net commerce survey.

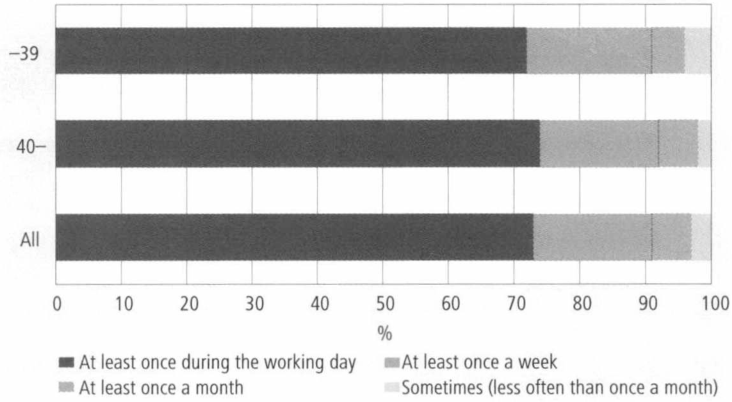


Almost three in four (73%) of those who had used the Internet in the workplace during the preceding three months had accessed the Internet at least once during the working day. Roughly one in five had used the Internet at least once a week and less than one in ten less often than once a week. Persons aged over 40 use the Internet somewhat more often than young people.

Active computer use in the workplace is clearly associated with active computer use at home. Among those persons who use a computer on a daily or weekly basis in their workplace, almost 54 per cent use a computer at home every day. Among those who use a computer in the workplace once a month or less often, some four in ten use a computer at home every day. No more than some 10 per cent of daily workplace users say they use a computer at home once a month or less often. The figures above concern people who have used a computer in the workplace and at home during the past three months.

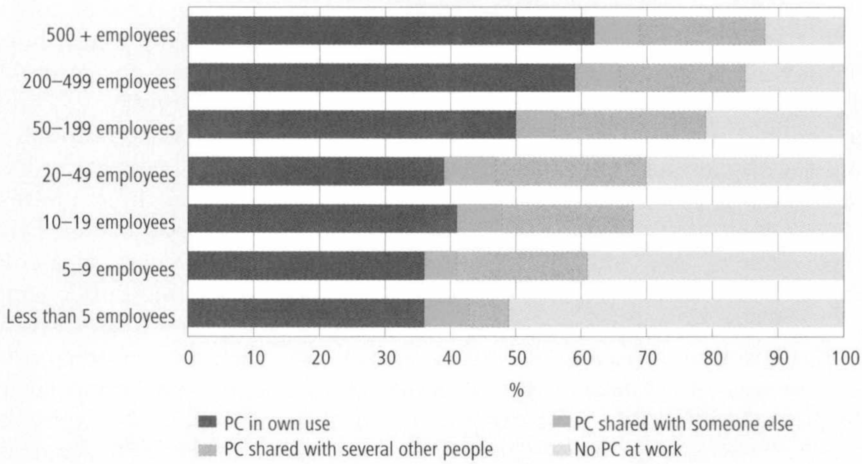
According to a study carried out in connection with the 2002 Labour Force Survey, some 67 per cent of people in the labour force had access to a computer in the workplace (Figure 12.4.12). In both the private and public sector the prevalence of computer use increased in direct proportion to the size of the organisation. In organisations with a staff of more than 500, personal computer use was clearly more common in the private sector (66%) than in the public sector (52%). By contrast the figures for those with no access to a computer in the workplace were higher in the private than the public sector regardless of the size of the organisation. In the public sector shared computer use was more common than in the private sector almost without exception.[30]

Figure 12.4.11
Frequency of Internet use in the workplace in spring 2004 during the preceding three months by age group, per cent of workplace Internet users.
Source: Statistics Finland, Net commerce survey.



30 Ylitalo (2004)

Figure 12.4.12
Computer use by size of workplace, per cent of active labour force in 2002, all workplaces.
Source: Statistics Finland, Labour Force Survey, autumn 2002.



12.4.4 Online shopping

Number of online shoppers continues to rise

Online shopping has increased rapidly since autumn 2003. In spring 2004 a total of 790,000 persons, i.e. more than 20 per cent of the population aged 15–74 and 29 per cent of Internet users had shopped online (Figure 12.4.13). From autumn 2003 to spring 2004, the figure had risen by some 150,000 persons. By spring 2004 a total of 1.3 million people in Finland had bought something on the Internet. In addition, 280,000 persons had gambled online during the three-month study period. Almost half of them had additionally purchased goods or services online. Almost 2.3 million persons, or 59 per cent of the population aged 15–74 had searched the Internet to find information on products and services.

The numbers who had shopped online as a proportion of Internet users ranged from 26 per cent in the Helsinki area to 17–20 per cent in other municipalities. The difference between the Helsinki area and other areas has narrowed down both in Internet use, the search for product information and online purchases (Figure 12.4.14). The gender difference in online shopping had already disappeared by autumn 2003. In spring 2004, around 20 per cent of men and women had shopped online. In autumn 2001, 12 per cent of men aged 15–74 and 8 per cent of women in this age bracket had shopped online.

Figure 12.4.13
Per cent of persons aged 15–74 who had made online orders or purchases during the preceding three months.
Source: Statistics Finland, Net Commerce Survey.

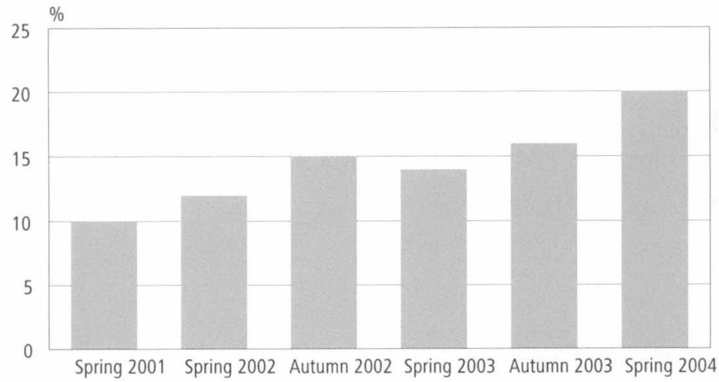
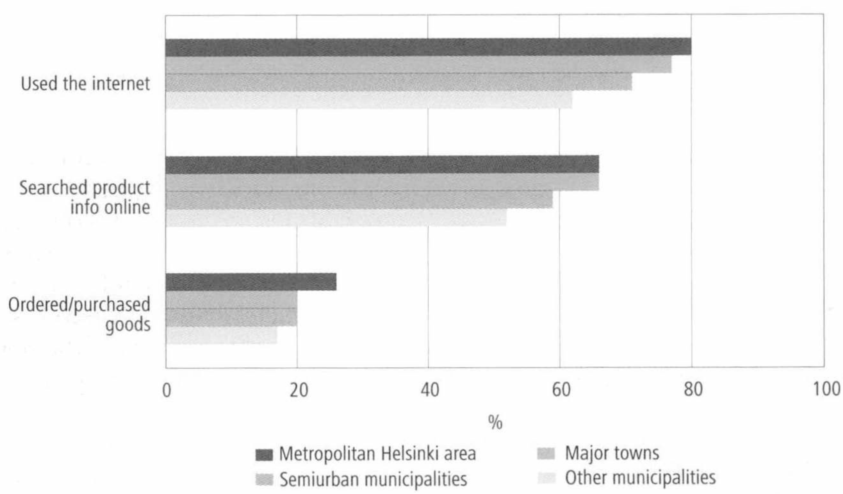


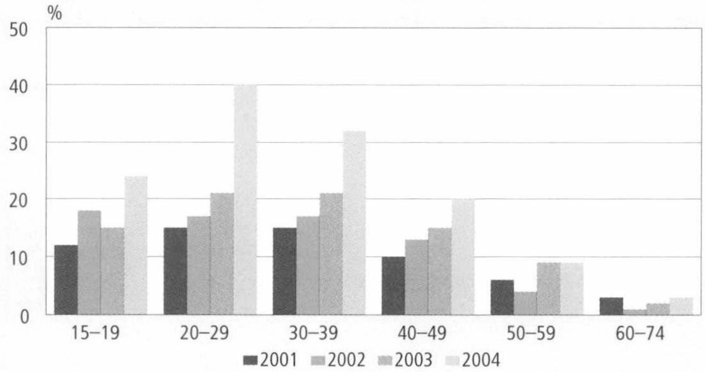
Figure 12.4.14
Per cent of persons aged 15–74 who had used the Internet and shopped online during the preceding three months by place of residence in spring 2004.
Source: Statistics Finland, Net commerce survey.



In spring 2004 70 per cent of those who had bought or ordered something online were aged under 40. There has been no change in the proportion of online shoppers aged over 50, although their share of Internet users has slightly increased. Persons aged 50–74 accounted for 11 per cent of all Internet users who had shopped online, while their proportion of the total population was 39 per cent. If we look at the proportion of those who have shopped online by age group, we find that the number of shoppers increased during the early part of the year most particularly in the age group of 20–29 years, where four in ten had bought something on the Internet (Figure 12.4.15).

Ninety per cent of those who had placed orders over the Internet had done so during the past 12 months, 56 per cent had done so since the beginning of January. More than 40 per cent of online shoppers had made three or more purchases during the past three months.

Figure 12.4.15
Per cent of persons aged 15–74 who had shopped online during the preceding three months by age group in spring 2001 – spring 2004.
Source: Statistics Finland, Net Commerce Survey.



Volume of online shopping

The number of purchases made online increased sharply in the latter half of 2003 and in early 2004. In spring 2004 the total value of online purchases and orders by individual consumers stood at close to 530 million euros. In value terms online shopping has more than doubled compared to autumn 2003. Annually, if e-commerce remained at the same level as in spring 2004, this would translate into orders and purchases worth a total of around 2.1 billion euros. The number of buyers and people placing orders has shown the fastest growth in products with the highest average price, such as travel and hotel bookings.

Around one-third had spent less than 100 euros online, one in four had spent more than 500 euros. Roughly one in three online shoppers had made purchases from abroad.

There is no question that the amount of money people have spent on the Internet has increased, but the exact sums should be considered with some caution. In spring 2004 the interview method was revised so that the data were collected by regional telephone interviews rather than by centralised telephone interviewing. It is possible that the spring 2004 interview has reached a larger number of online shoppers than the previous surveys.

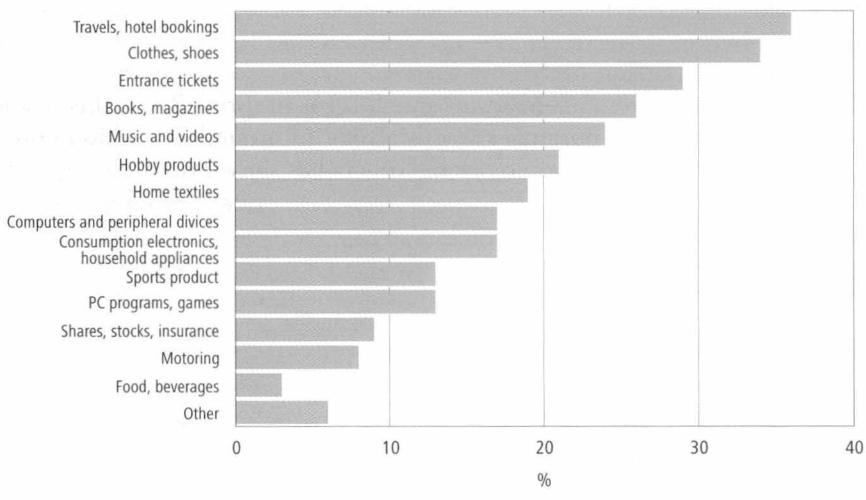
Product groups in online shopping

Online purchases may consist of physical products that are delivered to the consumer in a package, or services that are not brought to the consumer's door by mail. In autumn 2000, as many as four in five purchases were still for physical products. In spring 2004 less than two-thirds of all online purchases were for physical goods. Although goods purchases as a proportion of total Internet shopping have decreased somewhat, the volume of goods purchases has continued to increase.

In spring 2003 books and magazines were the most popular product category in Internet shopping, but by spring 2004 the situation had changed. Tickets to events, travel and hotel bookings showed the fastest growth in the early part of the year (Figure 12.4.16). Services are booked and bought online mainly because of the convenience in terms of time savings; no doubt the wider range of services on offer goes some way towards explaining this growth as well. The number of Internet users buying shares, bonds and insurance policies has more than doubled, but this product category does still not rank among the most popular in terms of the number of buyers. There has also been rapid growth in the number of people buying home textiles and computer software and games. It is only very rarely that people buy food on the Internet.

Persons under 40 have bought music, films or videos and clothes and shoes on the Internet more often than those over 40. Travel and hotel bookings appear more often on the shopping lists of persons over 40.

Figure 12.4.16
Online shopping by product category in spring 2004, per cent of all buyers. Source: Statistics Finland, Net Commerce Survey.



Problems and obstacles to online shopping

For the most part the people who had made online purchases felt that they had had no problems (76%). The main reported difficulty was with delivery times: 15 per cent complained that the products ordered did not always arrive on time. Other problems were far less common. Five per cent said that the product ordered had never arrived, and the same number said there had been uncertainty about product warranty. Over three per cent indicated that the product they received was not what they had ordered.

Among the respondents who said they had never shopped online, the most common reason was that they preferred to go to the shops so that they could see for themselves what they were buying: nine out of ten respondents who did not buy online quoted this reason. Almost four in five indicated that they have 'no need' to buy on the Internet. More than two-thirds reported that they were suspicious about giving their personal and credit card details over the Internet. Technical problems were quoted less often. Three in four Internet users fully agreed with the statement that 'Advertisements posted on the Internet fail to encourage me to go online shopping'. In the age group over 40 more than four in five fully agreed with this statement, among those under 40 the proportion was two-thirds. No more than ten per cent of Internet users disagree with this statement.

12.4.5 Opinions and attitudes towards the information society

Involvement in and marginalisation from the information society

This, the final section of Chapter 12 discusses the themes of involvement and marginalisation that have come very much to the fore with the emergence of the information society. Involvement describes the individual's attachment to the surrounding community. It refers to the community member's presence and participation in processes that are considered important in the community. This is essentially a sense of shared experience rather than something that finds expression only in practical activities and participation. Underlying this discussion and debate on involvement are various problems that are eroding the very foundation of society, such as marginalisation and exclusion. In the present stage of social development, i.e. in the information society, the question of citizen participation or involvement can be seen in a new light.[31] The concept of digital divide or marginalisation is a real and current concern because new ICT applications in services may become a new generator of inequality.

From what angle should the question of marginalisation in the information society be approached? How should marginalisation be measured? Is it the experience of marginalisation that counts, or should we try to find some objective measure? If an individual does not have access to a computer and the Internet, does this imply marginalisation? What if this individual is not interested in getting a computer and Internet connection even if he or she could afford to? What if this individual has a computer and Internet connection but does not use e-mail? Non-ownership of IT appliances is not yet, in itself, proof of marginalisation as opposed to inclusion. As Nurmela and Viherä[32] observe, it

31 Anttiroiko (2003)

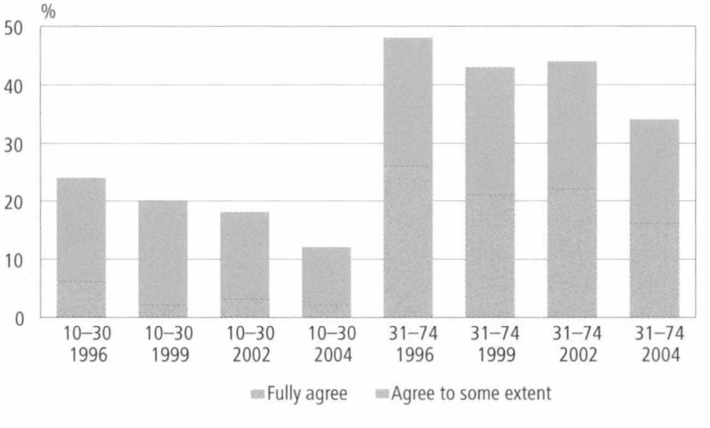
is unclear from what people are being marginalised. The theme of marginalisation needs to debated and discussed in more concrete terms: we need to know what exactly it means in different contexts.

If marginalisation is measured in terms of IT ownership or IT use, then the trends over the past few years certainly do not lend support to the thesis of marginalisation. More than 90 per cent of people in Finland today have a mobile phone. More than half of all households have Internet access. Regional differences in IT use have narrowed and in general the gap between population groups in terms of access to information technology has been reduced.

In 2002 more than four in five mobile phone owners regarded the mobile as an indispensable means of communication within the family and among friends. Giving up one's mobile could thus present an increased risk of being excluded, especially if the necessity of the mobile phone is explained by being reachable all the time in a way that is not possible with a landline phone. Nonetheless more than one in three mobile phone users opted to switch off their phone during their leisure time in order to secure some peace and quiet.

Questionnaire surveys suggest that experiences of marginalisation from the information society have decreased in recent years. The sense of being left out has been measured by the statement 'I feel completely overwhelmed by the advance of new information technology'. Experiences of marginalisation decreased in Finland in the late 1990s, stagnated in the early 2000s, and have now started to decrease again (Figure 12.4.17). A strong sense of marginalisation from information technology has been exceptional among persons under 30 throughout the

Figure 12.4.17
Experiences of managing in the information society ('I feel completely overwhelmed by the advance of new information technology') in 1996, 1999, 2002 and 2004, per cent of age group 10–30 and 31–74.
Sources: Statistics Finland, Finns as ICT users (spring 2004), Leisure Survey 2002, The Finns and the Future Information Society 1996–1999.



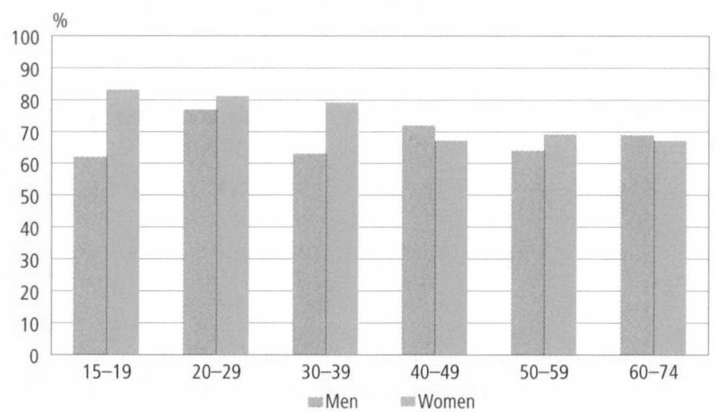
32 Nurmela & Viherä (2004)

period under review. Their experiences of being left out have decreased in recent years, and men under 30 have felt least excluded all the time. The experience is most pronounced among persons over 60.

In spring 2004 one-half (50%) of the population aged 15–74 who used e-mail at least weekly fully agreed and just over one-fifth (22%) agreed to some extent with the statement that 'With e-mail you contact people that you otherwise wouldn't'. In other words, almost four in five feel that e-mail is an important form of contact and communication. Perhaps somewhat surprisingly the most optimistic view on the prospects of e-mail is taken by women aged under 30: in this age bracket 61 per cent of women fully agree with the statement, while the corresponding proportion among men under 30 and women and men over 30 is less than one-half (Figure 12.4.18). It is also surprising to see that the optimism of older people who use e-mail is almost as great as that of young women. The differences by level of urbanisation are quite marginal, although city dwellers do take a somewhat more optimistic view than people in rural areas. In general people take a rather positive view on e-mail as a form of contact and communication. It would have been interesting to compare this with attitudes to other means of communicating.

ICT use among pensioners aged under 75 (730,000 persons) remains at a low level: only one in five people in this group say they are regular Internet users. Over the past two years there has been no increase in the proportions using a computer, the Internet or e-mail. Life in retirement, it seems, revolves very much around familiar habits and practices: clearly it is felt that new media and new channels of social interaction can offer nothing so essentially novel

Figure 12.4.18
Per cent of respondents who agreed fully or to some extent with the statement 'With e-mail you contact people that you otherwise wouldn't' in spring 2004, by age group and gender.
Source: Statistics Finland, Finns as ICT users (spring 2004).



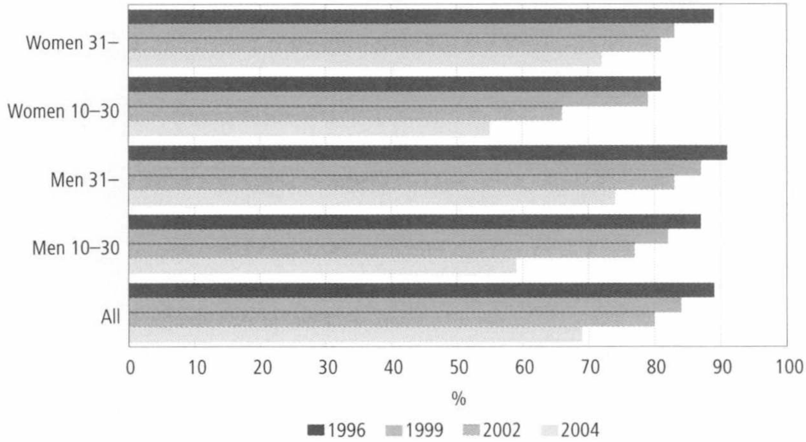
that pensioners would feel it is worthwhile to go out and buy this new technology or learn how to use it.[33] It seems that the public Internet access points that were expected to encourage people to start using the Internet, have only increased Internet use among those who were active users to start with.

Almost half of the respondents who used the Internet during the preceding three months in spring 2004 said they felt the Internet had stimulated their interest to explore and learn about social and political issues. This is particularly true among younger people. Persons under 40 agree with this statement fully or to some extent more often than persons over 40. There are no differences here between men and women. It seems that through this stimulating effect, the Internet could help to promote grassroots participation in social and political issues.

Running daily errands

Attitudes to the use of remote services (via e-mail, SMS messages or by letter) have become more positive during the period from 1996 to 2004 (Figure 12.4.19). In the past two years the change in attitudes has been considerable. Nonetheless around two-thirds of Finnish people aged 15–74 still favour the conventional mode of customer service contact, i.e. by phone or face-to-face over the counter. More than four in five (84%) persons with their own e-mail address prefer to receive their bills by ordinary mail rather than e-mail, in the age group over 50 the proportion is somewhat higher than in those under 50.

Figure 12.4.19
Running daily errands (per cent of respondents under and over 30 who agree fully or to some extent with the statement 'I prefer to run my errands by phone rather than by computer or letter' by gender) in 1996, 1999, 2002 and 2004.
Sources: Statistics Finland, Finns as ICT users (spring 2004), Leisure Survey 2002, The Finns and the Future Information Society 1996–1999.



33 Sirkiä & Nurmela & Mustonen (2004)

As for banking services, the idea of electronic bills has not yet caught on. Indeed it is essential that the existing standard of services is maintained so that people who do not use the Internet can continue to receive the services they require by phone and over the counter. The principle of equality is paramount to the development of remote services.

Attitudes to different modes of service provision and ways of running errands were inquired in 2004 by phone, whereas previously the data were always collected in face-to-face interviews. In addition the wording of the question was slightly revised in spring 2004. It is possible that these changes have had some impact on the comparability of the figures for 2004 and earlier data, but in any case it is clear that attitudes towards electronic services are more favourable than before.

It can be generally concluded that people in Finland take a rather optimistic view on the Internet as a source of information and electronic services and as a facilitator of new contacts. Experiences of an information overflow, in the light of interview surveys, seem to be receding. Marginalisation from the information society would not seem to be a significant problem, at least as a phenomenon separate from other marginalisation due to lack of income or low level of education.[34] The persistence of the differences between population groups possibly gives some cause for concern. Pensioners remain largely sidelined from the mainstream of information society, whereas students and people in the active labour force are ever more active participants. However there are no alarming signs of real marginalisation.

34 Nurmela & Viherä (2004)

Appendix Table 12.1
Number of enterprises, personnel and turnover (EUR million) by industry 1995–2002.
Source: Statistics Finland, Business Register.

	1995	1996	1997	1998	1999	2000	2001	2002
Goods production								
Number of enterprises	604	661	688	705	689	687	703	702
Personnel	30,824	33,588	36,761	40,084	43,800	45,123	49,051	44,274
Turnover, EUR million	5,750.5	6,755.8	8,923.6	12,073.4	16,459.1	24,491.1	26,910.6	26,187.9
Service production								
Number of enterprises	3,725	4,112	4,491	4,696	4,803	5,161	5,279	5,390
Personnel	40,508	42,678	46,476	52,230	56,539	62,704	67,694	67,614
Turnover, EUR million	6,158.8	7,532.9	8,975.7	11,145.8	12,174.5	14,079.1	14,985.3	15,733.1
Content production								
Number of enterprises	7,099	7,611	8,328	8,839	8,956	9,261	9,510	9,786
Personnel	35,410	37,537	36,767	40,212	41,091	42,223	42,742	41,775
Turnover, EUR million	3,374.3	3,716.1	4,034.7	4,600.3	5,629.0	6,007.3	6,162.1	6,157.2
Information sector total								
Number of enterprises	11,428	12,384	13,507	14,240	14,448	15,109	15,492	15,878
Personnel	106,742	113,803	120,004	132,526	141,430	150,050	159,487	153,663
Turnover, EUR million	15,283.5	18,004.9	21,934.0	27,819.5	34,262.5	44,577.5	48,058.0	48,078.2
Forest industry (SIC 20-21)								
Number of enterprises	3,010	3,148	3,257	3,244	3,140	3,124	3,048	3,010
Personnel	68,849	68,953	69,939	70,098	70,079	69,605	67,902	66,230
Turnover, EUR million	15,442.4	15,199.1	18,124.4	18,842.4	18,970.6	21,562.2	19,684.0	19,851.0
Metal industry (SIC DJ - DM)								
Number of enterprises	9,525	10,188	10,578	10,671	10,492	10,493	10,718	10,656
Personnel	164,124	172,991	181,381	187,819	192,008	196,567	204,944	200,271
Turnover, EUR million	23,408.4	26,500.7	30,222.8	34,124.3	37,586.1	50,267.9	54,704.9	53,316.5
Manufacturing total (SIC D)								
Number of enterprises	23,633	25,095	26,023	26,347	25,715	25,687	25,780	25,423
Personnel	391,280	397,392	409,938	417,721	419,889	423,491	426,309	416,754
Turnover, EUR million	63,904.4	66,857.1	75,499.4	79,058.9	83,483.6	102,232.7	105,209.5	103,979.1
Private sector services (SIC 50-74, 804, 85, 90,92,93)								
Number of enterprises	132,548	143,461	150,328	154,999	155,626	158,007	159,296	160,744
Personnel	582,771	601,254	630,973	665,396	692,509	714,258	722,470	731,936
Turnover	86,384.7	93,543.9	103,500.0	112,962.2	120,508.5	134,958.6	132,698.2	143,477.0
All industries total								
Number of enterprises	189,458	203,358	213,230	219,273	219,515	222,817	224,847	226,593
Personnel	1,095,799	1,127,235	1,181,134	1,235,054	1,268,658	1,301,418	1,318,654	1,315,073
Turnover, EUR million	165,882.9	177,668.1	197,771.6	212,381.2	225,797.3	261,995.8	271,662.6	274,294.6

Appendix Table 12.2
Enterprises' turnover by industry 1995–2001 (SIC-95) and 2002 (SIC 2002). EUR million.
Source: Statistics Finland. Business Register.

		1995	1996	1997	1998	1999	2000	2001	2002
		EUR million							
Production of goods									
3001	Manufacture of office machinery	1.5	1.3	1.8	2.0	3.3	2.2	4.4	4.9
3002	Manufacture of computers etc.	937.1	807.3	1,157.0	1,160.2	1,146.9	388.8	68.4	43.1
3130	Manufacture of insulated wire and cable	298.4	390.5	360.3	363.1	369.4	452.5	480.8	388.4
3210	Manufacture of electronic valves etc.	385.9	473.6	426.8	493.6	473.2	548.2	606.1	505.2
3220	Manufacture of television and radio transmitters etc.	3,443.7	4,397.1	6,132.5	9,221.7	13,547.1	21,975.4	24,288.8	23,952.1
3230	Manufacture of television and radio receivers etc.	211.2	141.0	210.2	204.3	149.8	300.9	415.8	180.9
3320	Manufacture of instruments for measuring, checking etc.	293.2	328.2	377.1	394.2	450.7	505.6	549.4	626.9
3330	Manufacture of industrial process control equipment	179.5	216.8	257.9	234.1	318.7	317.5	496.9	486.4
Total		**5,750.5**	**6,755.8**	**8,923.6**	**12,073.4**	**16,459.1**	**24,491.1**	**26,910.6**	**26,187.9**
Production of services									
51432	Wholesale of radio and television goods	302.7	729.9	875.2	637.3	866.1	688.4	680.0	705.6
51840	Wholesale of computer hardware (51641, SIC-95)	1,903.4	2,416.9	2,977.9	3,302.0	3,570.0	3,820.7	3,905.7	3,509.8
51862	Wholesale of telecommunication equipment etc. (51652, SIC-95)	655.2	520.9	706.9	1,072.0	1,073.5	1,193.0	999.3	1,174.8
642	Telecommunications	1,776.6	2,139.1	2,610.0	3,439.1	3,678.4	4,824.3	5,396.3	6,302.8
7133	Renting of office machinery etc.	16.9	33.2	43.3	60.4	39.7	53.5	50.1	54.3
72	Computer and related activities	1,504.0	1,692.9	1,762.4	2,635.0	2,946.7	3,499.3	3,954.0	3,985.9
Total		**6,158.8**	**7,532.9**	**8,975.7**	**11,145.8**	**12,174.5**	**14,079.1**	**14,985.3**	**15,733.1**
Content production									
221	Publishing	1,805.2	1,878.7	1,955.1	2,099.8	2,266.8	2,304.0	2,447.9	2,468.9
7413	Market research and public opinion polling	43.6	55.9	68.7	66.3	89.9	98.7	103.4	101.9
7414	Business and management consultancy activities	477.7	629.8	731.1	924.2	934.0	1,152.1	1,106.7	1,190.5
744	Advertising	326.5	384.2	450.1	561.9	1,333.8	1,396.0	1,439.3	1,369.0
921	Motion picture and video activities	123.5	142.2	194.6	220.0	236.9	261.5	277.6	253.2
922	Radio and television activities	557.1	581.8	588.0	678.3	718.3	742.2	736.4	724.6
924 News agency activities		40.7	43.6	47.2	49.8	49.3	52.8	50.8	49.0
Total		**3,374.3**	**3,716.1**	**4,034.7**	**4,600.3**	**5,629.0**	**6,007.3**	**6,162.1**	**6,157.2**
Information sector total		**15,283.5**	**18,004.9**	**21,934.0**	**27,819.5**	**34,262.5**	**44,577.5**	**48,058.0**	**48,078.2**
20–21	Forestry	15,442.4	15,199.1	18,124.4	18,842.4	18,970.6	21,562.2	19,684.0	19,851.0
27–35	Metalworking industry	23,408.4	26,500.7	30,222.8	34,124.3	37,586.1	50,267.9	54,704.9	53,316.5
15–37	Manufacturing total	63,904.4	66,857.1	75,499.4	79,058.9	83,483.6	102,232.7	105,209.5	103,979.1
Private services (SIC 50-74, 804, 85, 90,92,93)		86,384.7	93,543.9	103,500.0	112,962.2	120,508.5	134,958.6	138,834.2	143,477.0
All branches total		**165,882.9**	**177,668.1**	**197,771.6**	**212,381.1**	**225,797.3**	**261,995.8**	**271,662.6**	**274,294.6**

13 Biotechnology

According to the provisional statistical definition developed by the OECD, biotechnology is 'the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services'. Although it is commonly associated in the public debate with gene technology, biotechnology actually comprises a wide range of techniques at different levels of sophistication and with many different areas of application. Biotechnology may be described as the 'technology of life' that is based on the molecular and cellular phenomena that lay the foundation of the living environment.

Humans have made use of biotechnological processes for thousands of years, without necessarily understanding the underlying mechanisms. Examples include the use of bread yeast, wine and cheese making, and traditional plant breeding. Since the late twentieth century, however, the pace of technological development has continued to accelerate, and research is now paving the way to a deeper molecular understanding of the phenomena involved – and by the same token to a wider range of technological applications. Examples of current biotechnology applications include the manufacture of vaccines and certain medical drugs, various diagnostic methods, the use of enzymes in industrial processes and the genetic engineering of plants.

Biotechnology – a key technology

Biotechnology is emerging as one of the few modern technologies that carries all the hallmarks of a key technology, i.e. one that is capable of challenging existing processes on a broad front that cuts across the whole of society by offering more efficient or environmentally friendlier alternatives. Key technologies are also capable of generating new areas of application and new business opportunities. The end-user, for instance the consumer will not necessarily recognise the features of the technology used in the end product. One example of an emerging key technology some one hundred years ago was the use of electricity. Another, current example is provided by information technology, which is still evolving but which already has opened up revolutionary new frontiers. The only other new potential key technology on the horizon is nanotechnology, but that field is still very much in its infancy.

One of the new areas of application opened up by biotechnology is bioinformatics, which uses computational methods to analyse biological data. The integration of biological data and medicine has created the concept of biomedicine, and together with precision mechanics at the micrometre level biotechnology is opening up new doors in the development of analytic tools. It is increasingly difficult to draw boundary lines between different areas of technology, with new innovations being introduced at the intersections of these areas. Another distinctive feature of novel technology areas is their heavy dependence on basic research carried out at universities and research institutes, which lends added importance to the collaboration between basic research and the businesses working on application development. A high risk of failure is another characteristic of young technology areas.

In the last instance, however, the success of any technology depends on its approval and acceptance among consumers and citizens. In the case of biotechnology, GM plants have met with fierce resistance especially in Europe, and medical applications of stem cells and cloning techniques have also given rise to public concern. All this highlights the importance of having open exchange and dialogue between ordinary citizens and the people developing the technology, and the importance of addressing the relevant ethical, social and legislative issues at as early a stage as possible.

What is a biotechnology company?

A distinction can be made between two main types of biotechnology companies: those working to develop biotechnology processes and products and those applying biotechnology methods in their production processes (Hermans, 2004). In the public debate, 'biotechnology companies' refers to the former category of firms.

The rapid technological advances seen in recent years in biotechnology and other closely related fields has opened up new business as well as research opportunities. The field that has made the most determined efforts to exploit these new opportunities is biomedicine, where a closer understanding of molecular mechanisms is making it possible to target the underlying causes of diseases instead of aiming simply to alleviate the symptoms. Given the pace at which research and new techniques are developing, the various actors involved need to show great flexibility and adaptability – qualities that are not necessarily among the main strengths of the global pharmaceuticals industry. This has opened up a niche for small specialised businesses, which already are doing much of the early research in drug development. Small development companies are also farming out part of their research work, and consequently the whole sector is characterised by strong networking.

All biotechnology companies spend a large proportion of their turnover on R&D, and all have to contend with the risk of failure in development. On the other side of the coin, the expected profits can be phenomenal. This is liable to create a heavy dependence on outside sources of venture capital, especially during the early stages of business development. When the value of the business begins to rise, there are two main exit ways for venture capital: either to sell the business or to have it listed on the stock exchange. Building up a turnover is a slow process, and during the company's 'death valley' period it will often generate considerable losses. In the medical drugs sector, for example, it has taken most biotechnology companies more than ten years to turn in a profit; during that period ownership rearrangements are more a rule than an exception. In other fields of biotechnology the time spans may be shorter and the sums involved smaller.

Given the key role of R&D activities, it is clear that business companies' immaterial assets and particularly their know-how is of paramount importance. The proportion of R&D staff and graduates with a doctorate level degree is very high. Leaning heavily on the foundation of science, biotechnology places more emphasis than other fields on the management of know-how and on close cooperation with academic research. In many cases business survival dictates that new innovations be protected by means of patents, which are used to build up a complex protective structure around the core innovation. The number of patents is often used as a measure of innovation, but this involves various difficulties of both definition and demarcation. Furthermore, in the case of businesses that offer know-how services, patents are a less relevant measure.

The markets for biotechnology products are almost without exception international, with customers often including major corporations that have global operations. Especially in the medical drugs sector SMEs do not have the resources to develop and bring their products to the marketplace, but they will leave the most expensive stages such as large-scale clinical trials to their business partners. Business turnover comes from milestone payments as specified in the company's agreements of cooperation and ultimately from royalty fees, which constitute the bulk of turnover potential in development projects. The further the company is prepared to carry the risks and the costs of the development effort, the greater the potential profits. All told, the average development costs for one medical drug are counted in hundreds of millions of euros. On the other hand, annual sales of the most successful drugs can amount to billions of euros. With the royalties to drug development companies standing at 8–12 per cent, a successful development project can yield a very substantial turnover indeed.

Business models, however, are in a constant state flux, partly as a consequence of the sharp changes in the availability of capital funding. More and more often now, businesses aim to generate independent turnover at as early a stage as possible, and the format of cooperation agreements and their timing vary widely. Outside the field of drug development, biotechnology companies are often in the position to bring their products closer to the market by themselves, which means that business models once again are different.

Problems in the statistical analysis of biotechnology

The task of defining and demarcating the young and fast developing discipline of biotechnology is extremely difficult, and there still exists no universally accepted definition. Any attempt at a more detailed definition will inevitably be outdated even before it has been properly adopted. It may be virtually impossible to assess the exact role of biotechnology in a given industrial process, nor is the end-product necessarily regarded as a 'biotechnological product' or the industrial enterprise as a 'biotechnology company'. Examples include the wood processing and the food industry, and in the pharmaceuticals industry it is also difficult to distinguish between biotechnological and other R&D activities. In basic research, too, it is difficult to pinpoint the work that represents 'biotechnology', as new areas of research are continuing to evolve on the interfaces of existing lines of inquiry. This being the situation, assessments of the number of enterprises in this sector, levels of R&D investment, public funding, the number of patents, etc., have also varied quite widely, which is also seen between the sources quoted here. Another difficulty apart from those stemming from the lack of a universal definition is that traditional classifications, such as the standard industrial classification, do not recognise biotechnology at all.

Mindful of these problems, the OECD has developed a recommendation for the statistical analysis of biotechnology that all the OECD countries are urged to take on board. These recommendations are here applied for the first time in Finland to the compilation of statistical data on R&D activities in biotechnology.

International situation

The undisputed world leader in biotechnology application is the United States, where businesses are estimated to have a headstart of 10–20 years compared to their European rivals. In Europe, the pharmaceuticals industry is one of the first and most active branches to make use of biotechnology. However Europe has progressively fallen behind in the competition with the US, whose massive investments in the development of this sector means it has established a firm lead in many areas of biotechnology application and especially in commercial exploitation. The main problem in Europe is fragmentation, which is reflected both in approval procedures for biotechnology products, drug pricing systems, patenting procedures and in the creation of scientific critical mass and networks of cooperation.

Nevertheless Europe has now overtaken the US in terms of the number of biotechnology companies (Table 13.1). Turnover figures for Europe remain modest, however, and in 2003 the combined turnover and staff number of European biotech companies fell back for the first time in the industry's history[1]. In the United States the industry is well established, even though it remains in the red, and fluctuations follow normal business cycles. Since 2000, which marked a peak year in funding, the industry has been badly affected by the re-

Table 13.1
Development of the biotechnology sector in the US and Europe in 1998–2003. Source: Ernst & Young, 2004.

	Listed companies		Change 1998–2003, %	
	USA	Europe	USA	Europe
Turnover, EUR million	35,854	7,465	115	754
R&D expenditure	13,567	4,233	101	556
Net loss	3,244	548	71	58
Employees	146,100	32,470	38	184
	No. of companies		Change 1998–2003, %	
	USA	Europe	USA	Europe
Listed companies	314	96	–1	41
Private	1,159	1,765	16	59
Total	1,473	1,861	12	58

1 Ernst & Young (2004)

cession in world financing markets, which is still ongoing in Europe. During this period companies have had very much to concentrate on their core business, and almost half of all European companies have just 1-2 years' worth of cash reserves. Just over 10 per cent of European companies have more than five years' cash reserves. In the United States almost 40 per cent of businesses have more than five years' cash reserves, and indeed here the level of capital investment has already returned to the level prior to the financial recession[2].

Europe is also facing increasingly stiff competition from China and certain other Asian countries. Even though the US and Europe are still ahead of the competition by virtue of their technological superiority, the gap is rapidly closing. Already the growing presence of Asian countries is reflected in increasing competition for the interest of venture investors. In 2003 the combined turnover of the 120 biotechnology companies in the Asian-Pacific countries increased by nine per cent and their R&D expenditure by ten per cent[3]. Some analysts believe that Asia is now emerging as the most serious rival to the United States ahead of Europe.

Europe, however, has a major strength in training and education. In 2002, EU-15 produced a much larger number of tertiary degrees in the natural sciences and engineering (36% of all degrees in the OECD countries) than the United States (24%). The margin was even wider in the case of PhDs, with the corresponding figures standing at 51 and 24 per cent[4]. However, Europe is unable to retain the staff it is training, but a large proportion of graduates are lured to American universities, research institutes and businesses. A deeply sceptical public opinion in Europe towards GM foods, for instance, has meant that the focus of agrobiotechnological research and product development has also shifted to the United States.

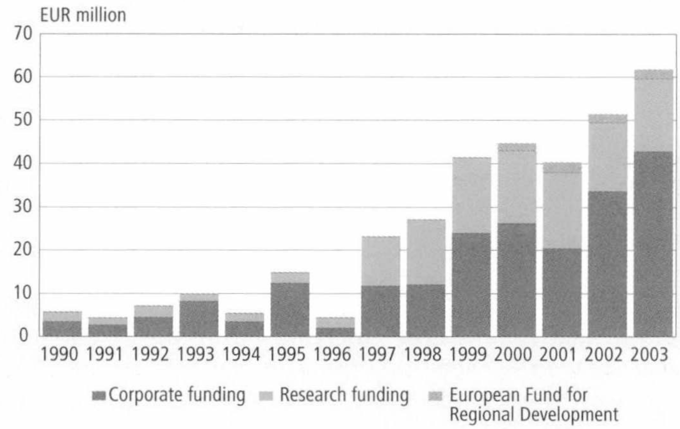
On the other hand the ongoing process of EU enlargement towards the East is opening up new opportunities especially in the clinical testing of drugs. It is also believed that the Nordic countries' competitiveness and know-how resources have not yet been utilised to their full potential[5]. There is a burning need for new and more effective treatments and medical drugs, and that need is only getting greater with the continuing ageing of the population in the industrial world. In 2003 the number of drug molecules on which listed European biotechnology companies were running late-stage clinical trials increased from around 50 to almost 70, while six drugs reached the market[6]. In spite of their difficulties, then, biotechnology companies have also achieved some significant goals.

The situation in Finland

Biotechnology was identified as a national priority area in Finland in the late 1980s, which saw the launch of the first national programmes. Investments in this area were significantly stepped up in the latter half of the 1990s. The two

2 Ernst & Young (2004)
3 Ernst & Young (2004)
4 OECD (2001)
5 Cap Gemini Ernst & Young (2004)
6 Ernst & Young (2004)

Figure 13.1
Biotechnology funding from the National Technology Agency Tekes 1990–2003. Source: National Technology Agency Tekes.



major funding bodies in the Finnish innovation system are the Academy of Finland and the National Technology Agency Tekes, in addition to which the Finnish National Fund for Research and Development Sitra has also had a key role in supporting new start-up companies in the biotechnology sector. In 1999–2003, the total amount of public monies channelled to this sector through Tekes and the Academy of Finland added up to almost 400 million euros[7], of which Tekes accounted for some 340 million. The sharp increase in Tekes funding since the late 1990s has continued in the new millennium (Figure 13.1). Funding from Tekes to the private business sector has amounted to some 208 million euros. As Tekes has accounted for around 50 per cent of all corporate funding, the total sums involved in these business projects have been in the region of 350–400 million euros.

Table 13.2 shows the private business sector's investment in biotechnology R&D by industry in 2003. In spite of the high level of public investment, biotechnology accounted for no more than 2.4 per cent of total R&D expenditure by business companies. However in the chemical industry (which includes the pharmaceuticals industry) and the R&D industry, biotechnology R&D expenditure was at a much higher level (10.1 and 22.7 per cent). The proportion of enterprises with less than 50 and less than 250 employees is noticeably large. The figures in Table 13.3 illustrate the R&D intensity as well as the large proportion of personnel with a doctorate level training in the industry. Public funding as a proportion of R&D expenditure is comparatively high.

In 2003 total R&D expenditure in the public sector (public administration, government research institutes and private non-profit sector) stood at 515.4 million euros, with biotechnology accounting for 16.6 million euros. The substantial investments made by the university sector must also be included in the

7 Luukkonen (2004)

Table 13.2
Biotechnology R&D activities in business enterprises in 2003.
Source: Statistics Finland, Research and Development Unit.

	R&D expenditure total	Biotechnology's R&D expenditure	Biotechnology's share of R&D expenditure	Proportion of public funding
	EUR million	EUR million	%	%
Enterprises engaging in biotechnology R&D	223.7	84.9	38.0	13.4
Other enterprises	3,304.3	–	–	4.9
Total	**3,527.9**	**84.9**	**2.4**	**5.4**

Table 13.3
Enterprises engaging in biotechnology R&D and other enterprises with R&D activities in 2003.
Source: Statistics Finland, Research and Development Unit.

	R&D personnel total	of which persons with persons with degree	other university degree	other education	R&D expenditure/ employees
	no.	%			EUR million
Enterprises engaging in biotechnology R&D	2,394	13.2	34.5	52.2	16.0
Other enterprises	37,695	4.5	37.8	57.7	7.7
Total	**40,089**	**5.0**	**37.6**	**57.4**	**8.0**

figures for the overall Finnish investment in biotechnology. Of the 961,7 million euros R&D expenditures in the higher education sector the proportion of biotechnology was 82,5 million. Thus, the total volume of biotechnology R&D in Finland in 2003 was 184,0 million euros.

Why does Finland invest in biotechnology?

What, then, is the rationale behind these heavy investments in what is a highly competitive and high-risk technology sector? Finland's efficient public health care system and positive public attitude towards research provide a sound foundation. In 2002 the natural sciences and medicine accounted for 83.8 per cent of all Finnish scientific publications[8], and based on an international comparison of citation indices the scientific standard of this work is very high: the investments in this field have clearly helped to increase the volume and raise the quality standards of scientific publications (Table 13.4 and 13.5)[9]. Given

8 Academy of Finland (2003b)
9 See also Academy of Finland (2002)

Table 13.4
Publishing in certain biosciences in Finland and selected OECD countries in 1988–2002, number of publications per 10,000 population.
Source: Academy of Finland, The State and Quality of Scientific Research in Finland.

	Molecular biology and genetics			Biology and biochemistry		
	1988–1992	1993–1997	1998–2002	1988–1992	1993–1997	1998–2002
United Kingdom	1.2	1.8	2.0	3.8	4.5	4.4
Japan	0.4	0.7	0.9	2.1	2.3	2.4
France	0.9	1.3	1.4	2.7	3.0	3.1
Sweden	1.7	2.2	2.6	7.1	7.8	8.4
Germany	0.9	1.1	1.3	2.4	2.4	2.7
Finland	1.2	1.8	2.3	3.7	4.8	6.0
United States	1.3	1.8	1.9	4.1	4.0	3.8

Table 13.5
Impact factors in certain biosciences in Finland and selected OECD countries in 1988–2002, impact factor = number of citations / number of publications.
Source: Academy of Finland, The State and Quality of Scientific Research in Finland.

	Molecular biology and genetics			Biology and biochemistry		
	1988–1992	1993–1997	1998–2002	1988–1992	1993–1997	1998–2002
United Kingdom	11.6	14.4	15.0	6.2	7.2	8.4
Japan	6.6	8.5	10.8	5.0	5.4	6.1
France	9.7	11.3	12.3	4.9	5.9	6.9
Sweden	8.0	10.7	11.8	6.3	6.9	7.7
Germany	11.7	12.5	13.5	5.8	7.2	8.3
Finland	8.7	12.8	12.2	5.2	6.5	7.5
United States	14.4	17.1	17.3	8.2	9.4	9.9

the added benefits of a high proportion of people with a tertiary education, a low level of corruption and other factors contributing to general efficiency and welfare in society, Finland has recently been ranked as one of the most favourable biotechnology business environments in Europe[10]. At the same time, however, the volume of business in the technology sector in Finland is low, indicating an existence of untapped high-level potential. The lack of experienced business experts and the acquisition of capital funding remain major challenges for business companies.

Finnish research and product development in biotechnology are concentrated in five university cities, each of which has a somewhat different profile and its own biocentre. Helsinki boasts the largest volume and the broadest scope of activities, but it is not using its full potential to support and facilitate the start-up of new businesses. Turku has a large number of pharmaceuticals companies and specialises in drug development, Kuopio more broadly in the

10 Cap Gemini Ernst & Young (2004)

health sciences. Tampere's area of special expertise is in biomaterials and medical technology, while Oulu has strong know-how in bioprocesses. In addition to these five major centres, Joensuu and Jyväskylä have university research in the field of biotechnology.

Biotechnology companies operate in different sectors, the biggest of which are drugs, diagnostics and research services (Figure 13.2). Biomaterials and functional foods represent two new, fast-developing sectors. The Finnish pharmaceuticals industry has made good use of biotechnology to launch its own original drugs in the marketplace, and small drug development firms also have several drug molecules at different stages of development. Some of these firms have agreements of cooperation with major international players in this field, and the first interim targets with their associated milestone payments have now been reached. Promising headway has also been made in diagnostics and biomaterials. In the SME category one drug development company and one equipment manufacturer have been listed on the Helsinki Stock Exchange, one British-Finnish company developing gene therapy is listed on the London Stock Exchange and one biomaterial company on Nasdaq.

In a European comparison of the number of biotechnology companies, Finland ranked ninth in 2003 with an estimated 72 companies (Figure 13.3). Employment in Finnish SMEs within this sector, however, remains rather modest (Table 13.6), and their small or non-existent turnover means these businesses are deeply in the red (Figure 13.4). The companies are still relatively young, most of them have been founded in 1997–2003 (Figure 13.5). The start-up of new companies has slowed down with the capital funding crisis in the early 2000s.

Figure 13.2
Sectoral breakdown of Finnish biotechnology companies in 2003.
Source: Luukkonen, T., 2004.

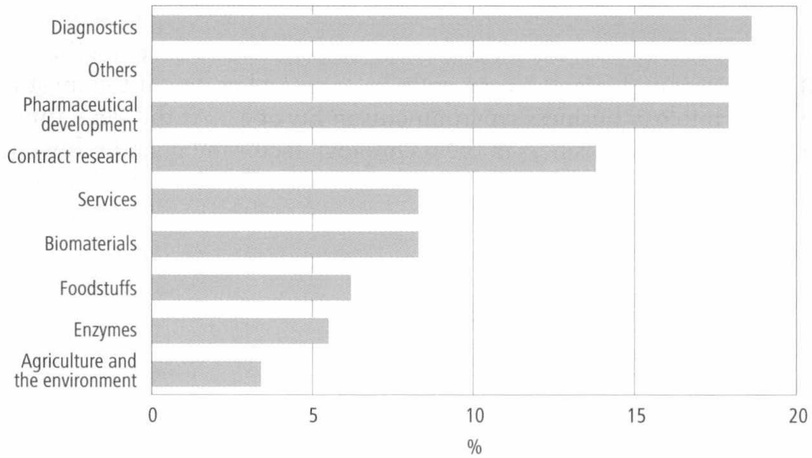


Figure 13.3
Number of European biotechnology companies by country in 2003.
Source: Ernst & Young, 2004.

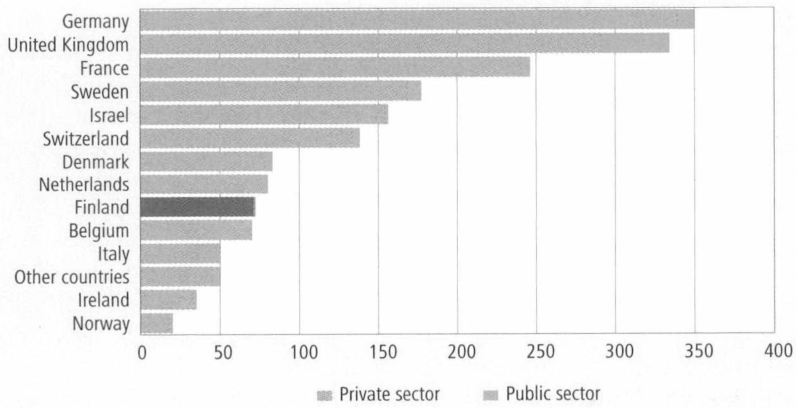


Table 13.6
Parameters describing Finnish biotechnology companies in 2001.
Source: Hermans, 2004.

Number of enterprises	110
Turnover, EUR million	200
Value added, EUR million	90
Exports, EUR million	120
Personnel	2,000

Figure 13.4
Profitability breakdown of Finnish biotechnology companies.
Source: Luukkonen, T., 2004.

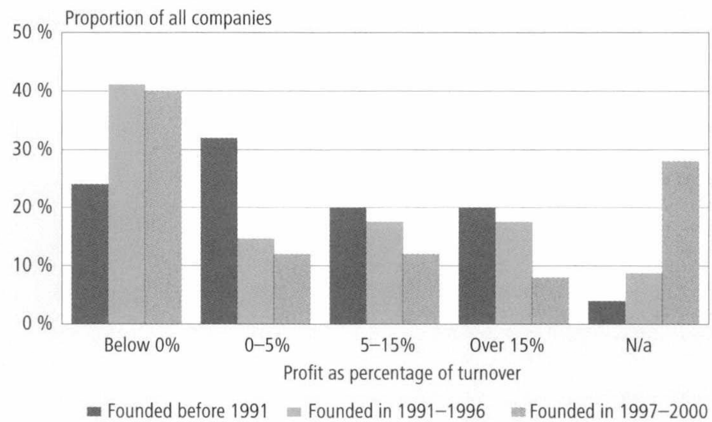
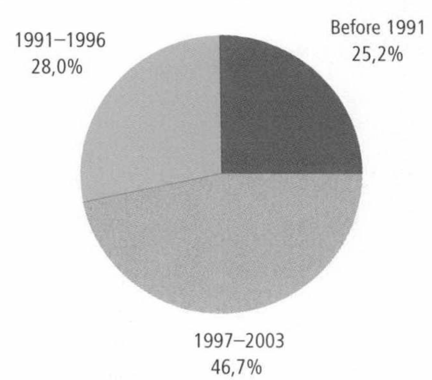


Figure 13.5
Breakdown of Finnish biotechnology companies by year established in 2003.
Source: Finnish Bioindustries, 2003.



A comparison of Finnish biotechnology companies in the pharmaceuticals industry with all SMEs clearly highlights some distinctive characteristics of this industry (Table 13.7). Staff numbers are still typically rather small. Turnover and exports remain virtually non-existent, and the companies are very young. R&D spending as a proportion of total expenditure is very high, and the majority of firms have patents.

Table 13.7
Comparison of Finnish biotechnology companies in the pharmaceuticals industry and all small and medium-sized enterprises in 2001.
Source: Luukkonen, T., 2004.

		Biotechnology SMEs in pharmaceuticals industry breakdown, %	SMEs total breakdown, %
Number of personnel	less than 5	33	44
	5–20	38	41
	over 20	29	15
	total	100	100
Turnover, EUR million	less than 0.2	45	15
	0.2–1.5	40	56
	1.6–8.0	12	24
	over 8.0	2	5
	total	100	100
Exports as % of turnover	0	43	70
	0–1	2	22
	2–5	7	4
	6–10	0	2
	over 10	45	3
	n/a	2	0
	total	100	100
Age of enterprise, years	0–2	14	5
	3–4	21	9
	5–24	64	70
	over 24	0	16
	total	100	100
R&D expenditure as % total turnover, %1	0	5	53
	0–1	2	23
	2–5	5	13
	6–10	7	3
	over 10	79	6
	n/a	2	0
	total	100	100
Enterprise has patents or is applying for patents	yes	74	6
	no	26	94
	total	100	100
Enterprise's expected annual turnover growth over next 5 years, %2	less than 0	0	1
	0–1	2	31
	2–5	0	20
	6–10	10	23
	over 10	86	21
	n/a	2	5
	total	100	101
Observations in sample total	no.	42	754

The future of the industry?

The development of new biotechnology based business still presents a host of challenges to Europe. The big question is whether there is enough capital in Europe to keep the industry momentum going or whether European companies will be taken over by their American counterparts. In any event it is clear that their survival and continued development will require bigger unit sizes.

It is also crucial for Finnish basic research to strengthen its international contacts. In order that our research results can be put to more effective use, patenting legislation applied to universities must be clarified and technology transfer mechanisms intensified, and systems need to be introduced to ensure there is adequate capital funding for new start-up businesses. R&D in this field is a long-term commitment and calls for great patience on the part of investors. The National Technology Agency Tekes and the Academy of Finland have so far remained patient and persistent in their funding policies, whereas the role of the Finnish National Fund for Research and Development Sitra is now in flux.

Finnish enterprises themselves are very optimistic about the future. Over the next five years the industry is expecting its turnover to increase by an average of around 20 per cent a year, biomaterials companies are forecasting increases of up to 50 per cent a year (Table 13.7)[11]. These expectations of sustained growth are based on strengthening demand in the global markets. In Europe, however, continued uncertainty in the financial market has left many companies in a precarious situation, and at least some bankruptcies seem inevitable. As the situation in Europe picks up, it is only to be hoped that Finland's highly rated business environment[12] will finally begin to live up to its promise. It is estimated that it will take the biotechnology sector 15–50 years to reach the same level of significance in national economic terms as is currently the case with the electronics industry and the wood processing industry[13]. The lack of accuracy about this estimate is due simply to the large number of unknown quantities with respect to the pace of development in this field.

In order that the potential of biotechnology could be better realised in the national economy, special attention needs to be paid to other areas of application than just drug development. In the medium term it is expected that much of the potential of biotechnology will be realised in large-scale industrial processes. An OECD report published in 2001 reviewed the extent of biotechnology use in industrial applications and the savings achieved[14]. In some cases energy consumption was down by as much as 80 per cent, and process emissions into the atmosphere and waterways were cut by 80–90 per cent. There is no doubt that biotechnology will revolutionise industrial production. It has huge potential in foodstuffs production, and already it is having a major impact in health care. But first, Finnish and European companies will have to find the ways and avenues in which to realise these great potentials.

11 See also Hermans (2004)
12 Gap Gemini Ernst & Young (2004)
13 Hermans (2004)
14 OECD (2001)

14 Nanotechnology

14.1 What is nanotechnology?

Nanotechnology refers to the science and technology that operate at the level of atoms, molecules and macromolecules, where distances range from one nanometre to one hundred nanometres (1–100 nm). The word nano comes from the Greek nanos, meaning 'dwarf'. One nano means one-billionth, one nanometre accordingly is one-billionth of a metre (1 nm = 10^{-9} = 0.000000001 m). The width of human hair is approximately 80,000 nm. The concept of nanotechnology was coined by Tokio Science University Professor Norio Taniguchi in 1974. However the beginnings of nanotechnology date back to Richard Feynman and his famous lecture delivered at Caltech in 1959, 'There is plenty of room at the bottom', in which he describes the possibilities of nanoscale technology.[1]

Among the key factors driving the development of nanotechnology are the rise of knowledge-value society, changes in research investments, investments in high technology, the stimulating effect of unique products on industrial de-

Nanotechnology milestones

1959	Richard Feynman delivers his lecture 'Plenty of Room at the Bottom'
1974	Norio Taniguchi coins the term 'nanotechnology'
1981	Heinrich Rohrer and Gerd Karl Binnig invent the scanning tunnelling microscope, receive the Nobel Prize five years later
1985	Richard Smalley, Robert Curl and Harold Kroto discover the C60 fullerene, receive the Nobel Prize 11 years later
1986	The atomic force microscope (AMF) is invented In his book 'Engines of Creation', Eric Drexler envisions the possibilities of nanotechnology
1987	Theodore A. Fulton and Gerald J. Dolan develop the first single-electron transistor at Bell Laboratories
1988	William deGrado and his group design and engineer the first protein at DuPont laboratories
1989	The word 'IBM' is written with 35 xenon atoms
1991	Sumio Iijima invents carbon nanotubes at the NEC research laboratory
1993	First nanotechnology laboratory opened at Rice University in the US
1997	Nadrian Seeman at New York University demonstrates first DNA-based nanomechanical device
1999	Yale scientists Mark Reed and James M. Tour develop a molecular switch
2000	United States launches first national nanotechnology initiative
2001	IBM and Delft University create the first transistor and logic circuit made of nanotubes

1 Feynman, Richard P. 1999 [1995] 'There's Plenty of Room at the Bottom', In Jeffrey Robbins (ed.), The Pleasure of Finding Things Out: The Best Short Works of Richard P. Feynman, Cambridge, Massachusetts: Perseus Publishing, pp. 117–139.

velopment, the needs for product minituarisation and cleaner production processes as well as the demands of the information and communications sector.

Two approaches

Nanotechnology is an enabling technology that has links with various different industries. Integrating physics, chemistry and biology in a multidisciplinary approach, nanotechnology aims to develop applications that take advantage of nanoscale phenomena using two different methods of minituarisation, i.e. a top-down and a bottom-up method.

In minituarisation, the geometry and size of the structural component is created in a controlled fashion using lithography, an electron beam, stamping or some other corresponding technique. This will usually yield a flat or two-dimensional structure. However three-dimensional structures can also be created by techniques of membrane layering; an example is provided by quantum mining lasers. The ongoing IT revolution is in turn based on the exponential minituarisation of semiconductor transistor and microcircuit technology. Up to the present day, shrinking circuit size and increasing circuit efficiency have followed a pattern now known as Moore's law: according to Gordon Moore, the first president of Intel Corporation, the information processing capacity of microprocessors, relative to their cost, doubles roughly every 18 months. As the line width of microprocessors continues to shrink, we are now beginning to reach the limits imposed by the physical structure of the materials used. Therefore, in the next decade ahead, new solutions will need to be developed. Nano and molecular electronics seem to offer one possible way ahead.

In the bottom-up approach, nanostructures are built up atom by atom, or molecule by molecule. A major breakthrough in this method was achieved in 1990 when Don Eigler and Erhard Schweizer used a scanning tunnelling microscope to move 35 xenon atoms around in a nickel surface to write the word 'IBM'.[2] However this method of moving individual atoms is desperately slow. Indeed K. Eric Drexler has proposed the use of nanoscale assemblers for purposes of accurately moving and combining atoms and molecules.[3] One possible solution is self-organisation where the base molecules assemble themselves into bigger molecules or supramolecules, which in turn may further re-form as structures, with self-organisation thus occurring at two different hierarchic levels. The structures produced by these self-organised molecular reactions have an inborn capacity for self-correction – something that is ordinarily associated only with living organisms.

14.2 Funding for nanotechnology

Public funding for nanotechnology (Table 14.2.1) has increased sharply over the past ten years. Several countries have ongoing research programmes in this field. The United States launched its national nanotechnology initiative in

2 D.M. Eigler and E.K. Schweizer (1990).

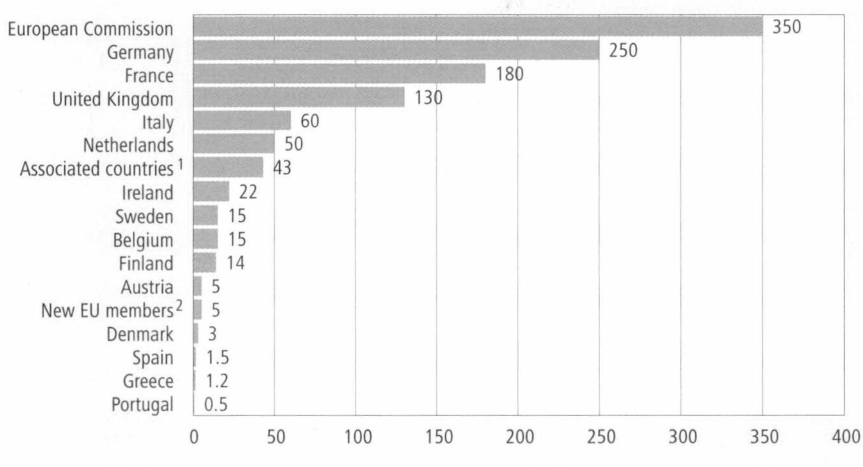
3 K. Eric Drexler (1986).

Table 14.2.1
Public funding for nanotechnology in Europe, Japan, the United States and other countries in 1997-2005, EUR million.[4]

Area	1997	1998	1999	2000	2001	2002	2003	2004	2005
	EUR million								
Europe[1]	126	151	179	200	225	400	1,120	–	–
Japan	120	135	157	245	465	650	810	875	
United States	116	190	255	270	422	710	770	849	982
Other countries[2]	70	83	96	110	380	520	511	–	–
Total	**432**	**559**	**687**	**825**	**1,492**	**2,280**	**3,211**	**4,600**[3]	**–**

1 EU-15 plus Switzerland, Israel and Norway (states associated to the Sixth Framework Programme)
2 Countries with R&D activity in nanotechnology (e.g. Australia, Canada, China, Eastern Europe, Russia, Korea, Singapore and Taiwan
3 Nanotech Report 2004, LUX RESEARCH

Figure 14.2.1
Volume of nanotechnology funding in EU-15 countries, selected new EU members and key states associated to the Sixth Framework Programme and EC funding in 2003, million euros.[5]



1 Switzerland, Israel, Norway
2 Latvia, Lithuania, Slovenia, Czech Republic

4 Source: National Technology Agency Tekes calculation (Several sources: M.C. Roco, International Strategy for Nanotechnology Research and Development. Journal of Nano-particle Research 3: 353-360, 2001; Bundesministerium für Bildung und Forschung, Nanotechnologie in Deutschland Standortbestimmung, 2002; Communication form the Commission, Towards a European Strategy for Nanotechnology, 2004).

5 Sources: Asia (APNF, ATIP, nABACUS); Europe (Bundesministerium für Bildung und Forschung (Germany), Enterprise Ireland, Secretariat General for Research (Greece), In-spection générale de l'administration de l'éducation nationale et de la recherche (France), Nanoforum, national contact points (NCP), CORDIS nanotechnology database; United States (NSF); various other sources.

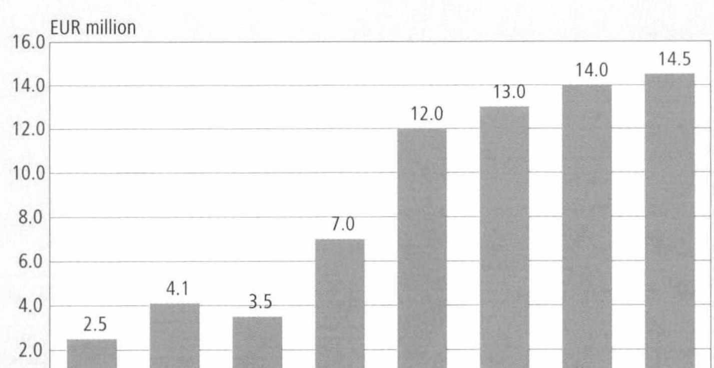
2000, and Japan identified nanotechnology as a priority focus for research in 2001. The European Union has supported the development of nanotechnology among other things through its Sixth Framework Programme for Research. It is estimated that in 2004, global public investment in nanotechnology R&D will amount to approximately 4.6 billion euros, while the total value of nanotechnology investments will rise to a record level of 8.4 billion euros.[6]

In Finland all public funding for nanoscience and nanotechnology is channelled through the Academy of Finland and the National Technology Agency Tekes. In 2003 Tekes awarded 10 million euros to support R&D projects in nanotechnology, the total costs of which were 15.5 million euros. Academy funding for nanotechnology amounted to around 4.1 million euros. The level of funding for nanotechnology has remained unchanged for the past four years.

Funding in Finland

Research and education in nanotechnology requires exceptionally sophisticated laboratory facilities and equipment. Indeed there are several ongoing and recently completed infrastructure projects in Finland. A joint project of the Helsinki University of Technology and VTT Finland, Micronova in Otaniemi comprises a total floor area of approximately 15,000 square metres, with high-quality clean room facilities amounting to 2,600 square metres. In autumn 2004 a new 10-million euro Nanoscience Center was opened in Jyväskylä, which has received a total of 3.65 million euros to spend on laboratory equipment in 2004–2006. In Oulu, nanotechnology has been integrated as part of development efforts in microtechnology. In 2005 the work will be completed on Tietotalo 2 (gross floor

Figure 14.2.2
Public funding for nanoscience and nanotechnology in Finland in 1997–2004, million euros.
Source: National Technology Agency Tekes.



* Estimate 1 Sept 2004

6 Nanotech Report 2004, LUX RESEARCH.

area 10,000 square metres), which will include 500 square metres of clean room facilities for the University of Oulu Micro and Nanotechnology Centre. The budget for the building complex totals 13.4 million euros, with 1.6 million euros going towards the Micro and Nanotechnology Centre.

14.3 Patenting

In the wake of the rapid growth of nanotechnology there has also been a growing interest to protect innovations in this field. Small size does not in itself qualify for patent protection, and the multidisciplinary nature of nanotechnology causes much difficulty for patenting authorities. Under commission by the National Technology Agency Tekes, VTT Information Service carried out a review of the nanotechnology patenting situation in June 2004, including comparisons with seven other countries: Sweden, Denmark, the Netherlands, the United Kingdom, Germany, the United States and Japan. The search profile used in the Derwent World Patent Index yielded a total of 18,707 patent families (separate inventions) in the field of nanotechnology in 1990–2002. Finnish patents accounted for no more than 30 of this total. According to the results of a Tekes business survey, 24 Finnish enterprises have patents in the field of nanotechnology. The number of nanotechnology patents in Sweden was 104 and in Denmark 41. Relative to population, the largest number of patents in Europe have been awarded in Sweden, Finland and Germany.

The largest number of nanotechnology patents is recorded for the United States (6,329), followed by Japan (3,874), China (2,902), Germany (1,747), Korea (1,003), France (712), the United Kingdom (439) and Russia (241).

Figure 14.3.1
Number of nanotechnology patents (patent applications and patents issued) in 1990–2001.
Source: Derwent World Patent Index.

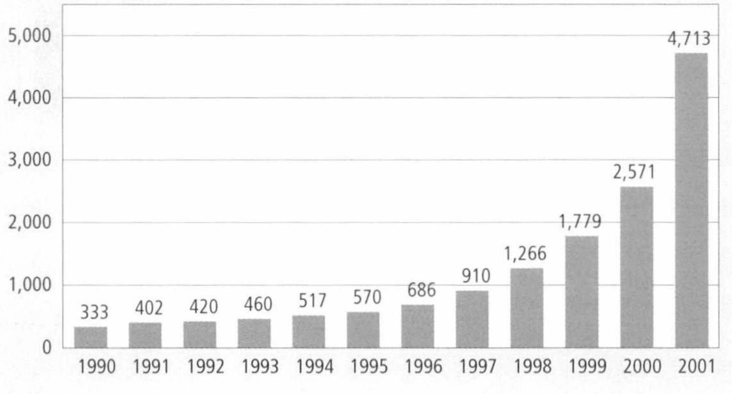
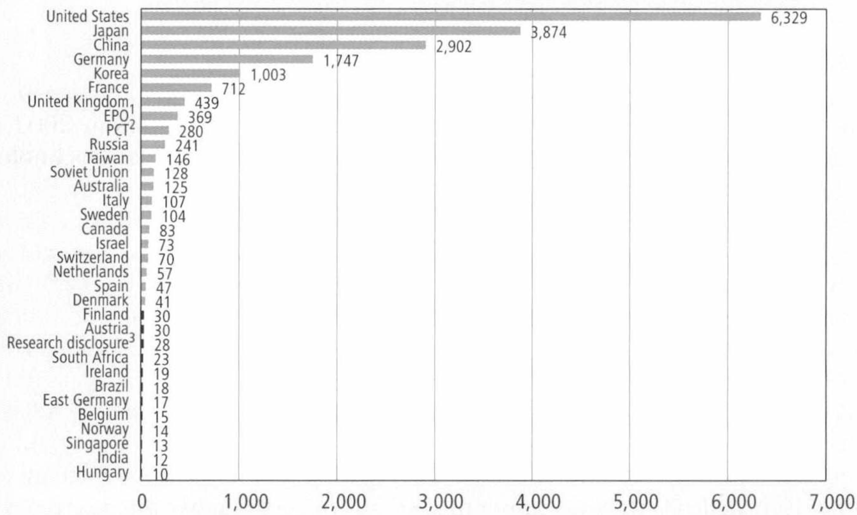
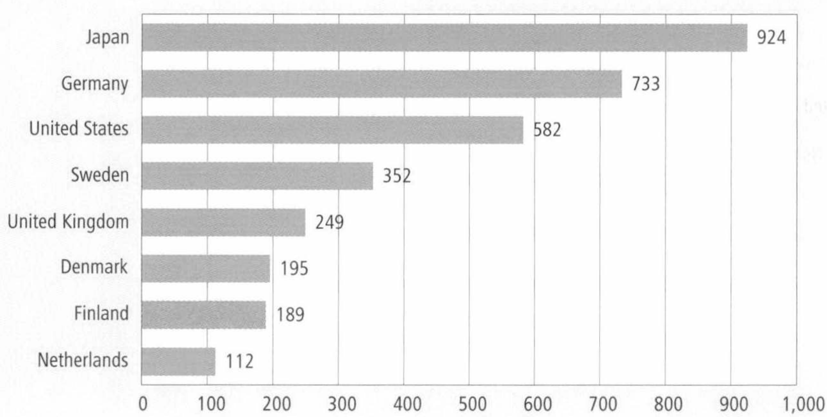


Figure 14.3.2
Number of nanotechnology patents (patent applications and patents issued) by country in 1990–2001.
Source: Derwent World Patent Index.



1 EPO = European Patent Office
2 PCT = Patent Co-operation Treaty
3 Alternative to full-blown patent protection

Figure 14.3.3
Number of nanotechnology patents (patent applications and patents issued) relative to GDP by country in 1990–2001.
Source: Derwent World Patent Index.



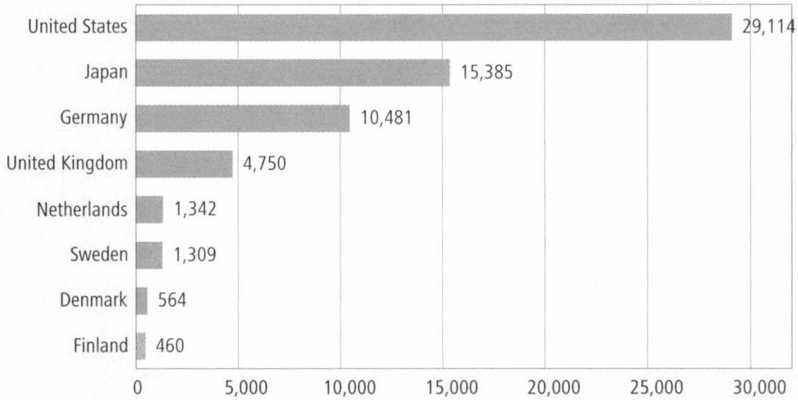
The two biggest patenting categories are basic electronic devices (H01) as well as medicine and veterinary medicine. Introduced in 2000, the new nanotechnology patent category B82 has grown very rapidly, and comprises 1,834 patents (1990–2002). The fastest-growing patenting areas are chemicals, pharmacy and semi-conductor devices.

14.4 Publications

The third European report on science and technology indicators in 2003 includes a survey of the 50 most active countries in the field of nanotechnology in 1997–1999.[7] Measured by the number of articles published, this list is headed by the United States; the next most active publishers are Japan, Germany, China, France and the United Kingdom. Finland ranks 26th in this comparison. Europe as a whole is a strong player in nanoscience: in 1997–1999 the EU accounted for 32 per cent of all scientific publications in this field, while the figure for the United States was 24 per cent and for Japan 12 per cent.

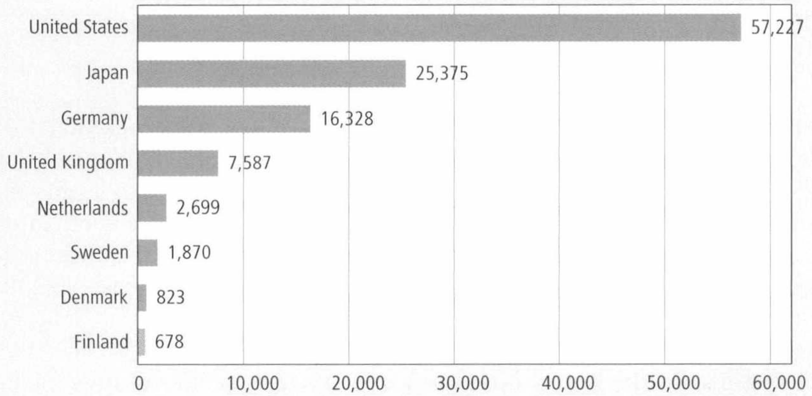
For reasons of expedience the bibliographic review carried out by VTT Information Service was confined to two databases: INSPEC, the world leading database in the field of physics, electronics and computer science; and CAplus, the biggest database in chemistry, biotechnology and materials.[8] As expected the number of publications was highest in the United States, Japan and Germany.

Figure 14.4.1a
Number of nanotechnology publications (physics, electronics and computer science) by authors' location in 1990–2003.
Source: INSPEC database.



7 European Commission (2003a), http://www.cordis.lu/indicators/third_report.htm
8 Patentti- ja bibliografiaselvitys – Osa 3. Julkaisujen analysointi, Riitta Metsäkoivu, VTT Tietopalvelut.

Figure 14.4.1b
Number of nanotechnology publications (chemistry, biotechnology and materials) by authors' location in 1990–2003.
Source: CAplus database.



In Finland the number of nanotechnology publications has shown steady growth. Relative to population, Finland ranks 9th in an international comparison, ahead of the United States, Japan and the United Kingdom. The Finnish units with the largest number of nanotechnology publications listed in the INSPEC database (1990–2003) are the Helsinki University of Technology (154), the University of Helsinki (59), VTT Finland (48), the University of Jyväskylä (46), the University of Turku, the University of Oulu and Tampere

Figure 14.4.2a
Number of nanotechnology publications (physics, electronics and computer science) in 1990–2003.
Source: INSPEC database.

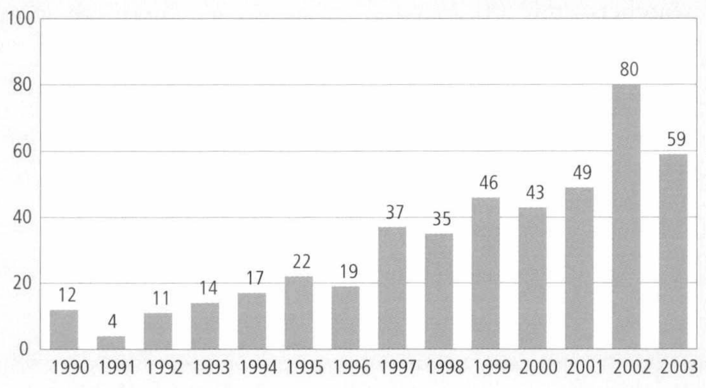
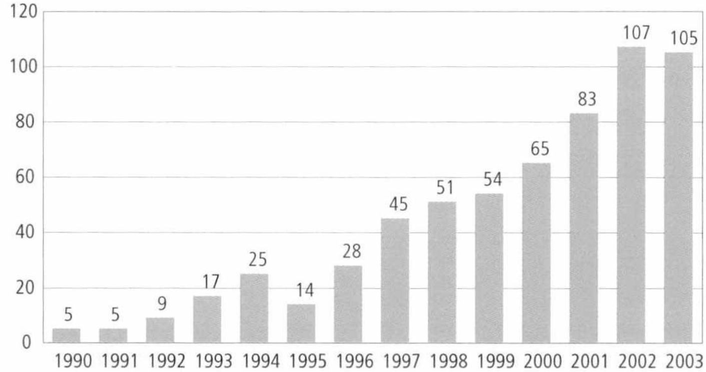


Figure 14.4.2b
Number of nanotechnology publications (chemistry, biotechnology and materials) in 1990–2003.
Source: CAplus database.



University of Technology. For chemistry, biotechnology and materials, the CAplus database (1990–2003) gives the following results: the Helsinki University of Technology (174), VTT Finland (63), the University of Helsinki (59), the University of Turku (55), the University of Jyväskylä, Tampere University of Technology, Åbo Akademi University and the University of Oulu.

14.5 Human resources and business activities

The number of people working in the field of nanotechnology in Finland today is around 300–500, but it is expected that this figure will rise sharply in the near future. The number of researchers in nanosciences and technologies and in other closely related fields is around 400, including some 30 professors, 80 postdoc researchers and 200 postgraduate students. There are some 25 research groups in the country, five of which are Academy of Finland centres of excellence. Much of their work consists of basic experimental and theoretical research in physics, chemistry, biology and technology, but there is also quite a lot of applied research (e.g. in electronics and information technology, biotechnology, chemical industry, forest industry). Research in these fields is largely concentrated in the Helsinki region, Tampere, Jyväskylä, Oulu, Turku and Joensuu. The main centres of research are the Helsinki University of Technology, VTT units in Espoo and Oulu as well as the universities of the cities just mentioned and their research units: the Oulu Micro and Nanotechnology Centre (MNT Oulu), the NanoScience Center Jyväskylä, the Optoelectronics Research Centre in Tampere and Micronova at the Otaniemi campus.

There are more than 60 nanotechnology-related companies in Finland.[9] Operations range from established nanotechnology businesses to applied research. Nanotechnology applications at different stages of development can be found in all industries, but the electronics industry and the chemical industry have the most advanced and established products.

14.6 The economic significance of nanotechnology and its development prospects

Research and application in the field of nanotechnology depend closely on a networked, know-how driven business environment. Nanotechnology cannot be directly compared to biotechnology or e-business, for instance. In the absence of any regulatory frameworks, the process of bringing products to the marketplace is much easier in nanotechnology. Furthermore, in contrast to the dot-com business, nanotechnology businesses are based on the strong foundation of science, research and technology, i.e. they own the intellectual property rights of nanoinnovations.

It is estimated that global demand for nanoscale materials, tools and devices in 2003 amounted to USD 7.6 billion.[10] The sector is growing at an annual rate of 30.6 per cent, and by 2008 demand is projected to reach USD 28.7 billion.

Projections are that during the first decade of the millennium, the markets for nanostructure materials will reach 340 million euros, with annual growth continuing at a rate of around 30 per cent until 2020.[11] According to Global Information Inc.,[12] the financial expectations of the smart materials segment are set to exceed. Figures released by BASF Future Business, for their part, indicate that traditional nanotechnology accounted for 85 per cent of the sales of nanomaterials and nanosurfaces in 2001, and further that the share of pigments and dispersions will remain higher over the next 10 years. It is believed that the chemical industry will be the main driving force in the commercialisation of new nanomaterials. The global markets for nanobiotechnology applications are projected to increase to USD 300 billion over the next 12 years.[13]

The world nanoelectronics markets are worth hundreds of billions of euros. In 1999 the global electronics markets were estimated at 935 billion euros, while the figure for semi-conductors was 136 billion euros (the forecasts for 2004 are 1,433 billion euros and 296 billion euros, respectively).[14] Indeed this sector is the prime mover behind the current development drive in

9 Source: National Technology Agency Tekes, (Nanoteknologia suomalaisessa yrityskentässä, Pekka Koponen ja Janne Jutila, Spinverse Consulting Oy, 2004).

10 Business Communications Company, Inc. Nanotechnology: A Realistic Market Evaluation 2004. See also D&MD Publications, Drug & Market Development Publications, 2002; New Dimensions for Manufacturing. A UK Strategy for Nanotechnology (2002).

11 Naoya Kobayashi (2001)

12 Global Information Inc., Technical Insights Inc. 2002 (http://www.gii.co.jp/).

13 D&MD Publications, Drug & Market Development Publications, 2002.

14 Technology Roadmap for Nanoelectronics, Future & Emerging Technologies (FET), "2nd Ed. R. Compañó, 2000.

Table 14.6.1
Global nanotechnology markets by sector in 2002–2015, USD billion.
Source: Development of Nanotechnology Markets Worldwide by Applications 2002–2006–2010–2015. Helmut Kaiser Consultancy, www.hkc22.com, 2004.

	2002	2006	2010	2015
	USD billion			
Materials	39.1	108	179	279.2
Electronics	52	129	160	246.4
Biotechnology	4.9	18.4	84	172.5
Chemicals	4.4	14	43	82.1
Aviation	3.4	12	22	57.5
Modelling tools	3.6	7	9.1	16.4
Sustainable development	3.2	11.5	19.8	37
Total	**110.6**	**299.9**	**516.9**	**891.1**

nanotechnology. The low dielectricity constant of new materials and the development and application of nanoelectronics processes will be among the most crucial competition factors of the future.

Finland has a strong and globally credible electronics cluster in the nanotechnology field. Nanoelectronics is a major emerging area of research today where quantum dot and photonic crystal technologies, for example, are expected to produce significant breakthroughs in data communications technology in the shape of high-powered lasers and integrated optics applications. Leading edge R&D work is ongoing in the forest industry, but the medium-range impacts of nanotechnology here will remain rather limited. Nanotechnology applications in the field of paper manufacturing technology include durable materials, smart surfaces and new manufacturing technologies. There are also some extremely interesting developments on the interface between the paper and electronics industry, where projects are under way to develop printable electronics, RFID tags and other short-range radio solutions as well as related reader devices and systems. Some of the most sophisticated nanotechnology applications are to be found in the chemical industry: nanoparticles and catalysts are used in various processes, and work is continuing to explore the use of enzyme and other solutions. In oil refining processes nanotechnology is applied in much the same way as in the chemical industry. Nanotechnology should also have important applications in saving energy and in the use of new energy sources, although business in these areas still remains insignificant in Finland. Advances in the metal industry and engineering are expected through new surface finishings and plastic and composite materials. Other interesting industries include defence and space technology, vehicle production and the construction industry.

Medical applications include diagnosis systems, accurate dosing systems as well as nanomaterials in implants and tissue technology. Nanotechnology's system know-how also provides fresh impetus for the development of biotechnology. The growing need for health information will inevitably promote convergence between the area of diagnostics and the electronics industry.

Summary

This volume compiles a selection of statistical data describing different aspects of science and technology in Finland. Most of the international comparisons here are based on data collected by the OECD and Eurostat. The indicators used primarily describe science and technology resources as well as concrete outputs, such as patents and scientific publications. The data presented lend support to the general view that Finland is one of the world leaders in terms of investment in the production of new knowledge and the development of technological applications. The population's high level of education, government research funding and an active science policy that stresses the importance of national know-how and expertise, have all combined to create a sound platform for Finland's current status as a high-tech country whose special strengths lie in information and communication technology. The reverse side of this particular strength is that the electronics industry and the so-called ICT sector are also very dominant; technology indicators in other industries show hardly any signs of growth and development. It is also important to bear in mind that the statistics presented here are mainly indicative of a strong science and technology infrastructure; less is known about impacts.

Science and technology have strong human resources

The number of tertiary degree holders as a proportion of the working-age population has increased considerably since the early 1990s. The numbers with a postgraduate degree holders have doubled during the period under review, even though recent reforms in the degree system have driven down the number of Licentiate's degrees completed. The number of new PhDs, on the other hand, has risen very sharply. Young PhDs are liable to make frequent job changes. The proportion of women among tertiary degree holders and especially postgraduate degree holders has also increased. The principal source of net immigration of highly educated individuals into Finland is Russia. Finland ranks among the top EU countries in a comparison of the proportion of people with a higher education or which are working in science and technology occupations. Measured in terms of working hours dedicated to R&D, Finland has the highest research intensity in the whole OECD area. Investment in higher education as a proportion of GDP is also at a high level. In an OECD comparison Finnish student performance in mathematics and science is clearly above average.

- higher education expenditure as a proportion of GDP was 1.7 per cent in 2001, the OECD average was 1.4 per cent
- persons with a tertiary education accounted for 27 per cent of the working-age population, 57 per cent of them were women in 2002
- in the age group 25–34, 39 per cent had a tertiary degree, OECD average 28 per cent

- the total number of new PhD graduates in 2002 was around 1,200, no significant difference between the number of men and women
- almost 20 per cent of persons with a tertiary degree were employed in industry, among persons with a postgraduate degree only nine per cent
- in Finland 40 per cent of the population had a higher education or were engaged in S&T occupations; the EU-25 average was 30 per cent

High level of government R&D funding

The sums allocated in the Finnish state budget for research and development are among the highest in the European Union; other top spenders are France and Sweden. The two biggest administrative branches in this comparison are the Ministry of Education and the Ministry of Trade and Industry (including the National Technology Agency Tekes). Most of the funds go towards supporting the general advancement of knowledge.

- public research funding as a proportion of GDP in Finland is one per cent, the average for EU countries is 0.75 per cent
- the total volume of funding in 2004 is over 1.5 billion euros, 4.5 per cent of central government expenditure
- 42 per cent of the funding goes towards the general advancement of knowledge, 26 per cent goes to industry

Rapid growth in R&D expenditure came to a halt in the early 2000s

Finland's relative R&D investment is the second highest in the EU after Sweden. The Nordic countries, Germany, France and Belgium are all among the top EU performers in this comparison. Mediterranean countries and new EU member states all record a low level of R&D expenditure as a proportion of GDP. The figures in Finland showed dynamic growth throughout the 1990s, climbing from two per cent in 1991 to 3.4 per cent in 2000. Since then the growth in R&D expenditure has tapered off. In 1991–2002 the contribution of business enterprises to R&D investment increased from 57 to 70 per cent, the share of government research institutes dropped by one-half and that of universities decreased by three percentage points. The sub-regional unit of Helsinki accounts for easily the largest share of R&D input, but relative to population and production the most research intensive sub-regional units are Oulu, Salo and Tampere. The electronics industry accounts for the bulk of R&D in the business enterprise sector: R&D expenditure in the industry increased sixfold in 1991–2003. Especially in recent years R&D expenditure has increased rapidly in computer and related activities as well, whereas in other industries growth has been sluggish.

- R&D expenditure as a proportion of GDP was 3.5 per cent in Finland in 2002, the EU-15 average was 1.9 per cent, the corresponding figure for the United States was 2.6 per cent and for Japan 3.1 per cent

- the business enterprise sector accounted for 70 per cent of R&D expenditure, higher education for 20 per cent and the government sector for 10 per cent
- public funding accounted for 26 per cent of R&D expenditure in Finland, 30 per cent in the OECD area, 34 per cent in EU countries
- Helsinki sub-regional unit accounted for 44 per cent of R&D expenditure, Tampere for 13 per cent and Oulu for 11 per cent in 2002
- the major fields of scientific research at universities were the natural sciences and medical sciences (25 per cent each), in the government sector engineering (34 per cent)
- the electronics industry accounted for 56 per cent of total R&D expenditure in the private business sector in 2003

Patents

A patent is a fixed-term exclusive right commercially to exploit an invention granted to the inventor or the holder of the inventor's rights. Three-quarters of all domestic patent applications were filed by enterprises or associations. The largest number of patent applications was recorded in the performing operations and transporting section as well as in the electricity section. Since Finland acceded to the European Patent Convention the number of applications filed with the European Patent Office has become an increasingly important indicator. Relative to population, Finland and Sweden have the highest number of EPO applications after Switzerland. Finnish inventors submit joint patent applications most often with German, Swedish and American partners.

- in 2003 a total of 527 enterprises or associations applied for a domestic patent
- telecommunications accounted for 14 per cent of domestic applications, building and civil engineering for 10 per cent
- the region of Uusimaa accounted for 39 per cent of domestic applications, Pirkanmaa ranked second with a share of 15 per cent
- a total of 310 European patent applications were submitted from Finland per one million population, the highest figure was recorded for Switzerland at 460; Sweden recorded 312 EPO applications and Germany 301
- 41 per cent of Finnish EPO applications were related to telecommunications technology

Number of innovating enterprises in Finland around the EU average

In 2002 the electronics industry (62 per cent) and the chemical industry (59 per cent) had the largest proportion of enterprises with innovation activity, new products or processes or projects aimed at innovation. In computer and related activities the proportion of innovating enterprises was even somewhat higher at 67 per cent. Innovation activity was at a low level in the textile industry, wood processing, transport and construction. Compared to 2000, the latest figures showed a decrease in innovation activity. According to the harmonised EU innovation survey, the proportion of innovating enterprises in Finland is around the EU average. However Finnish innovating enterprises showed the highest level of active involvement in joint R&D and other innovation projects.

- 41 per cent of manufacturing enterprises engaged in innovation activity in 2002
- 70 per cent of turnover in the electronics industry was based on innovations in 2002, the overall figure for manufacturing was 27 per cent
- the proportion of innovating enterprises in selected EU countries in 2000 was as follows: Finland 45 per cent, Germany 61 per cent, Austria 49 per cent, Sweden 47 per cent, Denmark 44 per cent and Spain 28 per cent

High technology business and foreign trade have great significance

The turnover of high technology industries and foreign trade in high technology products showed strong growth throughout the 1990s. This trend slowed down in the early 2000s, when foreign trade actually began to decline. In Finland high technology industries account for a larger proportion of industrial jobs than in the EU on average. Finnish exports of high technology products are also higher than in other EU countries except Ireland and the UK, although Far Eastern countries and the United States are the strongest exporters. The single biggest category of high technology business and foreign trade in Finland is electronics and telecommunications equipment, where the balance of trade shows a strong surplus. The biggest deficit is recorded in computers and office machinery.

- 13 per cent of all manufacturing jobs were in high technology industries in 2002, the manufacture of telecommunications equipment accounted for 64 per cent of these jobs
- high technology products accounted for one-fifth of total exports, electronics and telecommunications accounted for 83 per cent of this in 2003
- electronics and telecommunications equipment accounted for just under one-half of high technology imports, another major import category was represented by computers and office machinery, which accounted for 20 per cent of high technology imports
- EU countries accounted for 41 per cent of Finnish high technology exports, the share of Asia has risen to 28 per cent

Scientific publishing has increased clearly since the early 1990s

The number of Finnish scientific publications, the number of citations they received and the number of citations as a proportion of citations received by all OECD publications increased briskly and steadily throughout the 1990s. This growth slowed down somewhat around the turn of the millennium. Finland ranks fourth in an OECD comparison of the number of scientific publications relative to population, and the number of citations received by Finnish publications is also higher than the OECD average. The natural sciences and medical sciences account for the bulk of Finnish publications, although publications in agriculture and forestry performed best in an OECD comparison.

- Finland accounted for 0.81 per cent of OECD publications in 1990, in 2002 the figure was 1.14 per cent
- the number of citations received as a proportion of all OECD citations was 0.72 in 1990 and 1.20 in 2002
- the number of publications in 2002 was 14 per 10,000 population, the OECD average was six
- natural sciences and medical sciences accounted for 84 per cent of publications

International science and technology cooperation

The number of visits by Finnish university teachers and researchers to foreign countries has declined continually since 1995. At the same time the number of visits by foreign teachers and researchers to Finland has remained more or less unchanged. Researcher exchange is largely concentrated in the fields of engineering and natural sciences. The most popular destinations for researchers with Academy of Finland grants are the United States and the UK. Russia accounts for the largest number of researcher visits to Finland under bilateral agreements of cooperation. Finland is actively involved in European research programmes such as COST, Eureka and ESA. Since the initial stages of strong growth, Finnish involvement in EU framework programmes has now levelled off. For the most part Finnish experiences of the framework programmes are positive

- university teachers and researchers made 579 visits lasting one month or longer from Finland in 2003, the corresponding number of visits to Finland was 1,088
- engineering and the natural sciences accounted for 67 per cent of all visits from Finland and for 77 per cent of visits to Finland
- the most popular destination for people travelling from Finland with an Academy of Finland grant was the United States, which accounted for 30 per cent of the total sum of grants, followed by the UK at almost 20 per cent
- Russia accounted for around 40 per cent of all researchers arriving in Finland under bilateral exchange programmes
- Finland is involved in three out of four COST actions
- Finnish partners were involved in 1,444 projects under the EU Fifth Research Framework Programme

ICT has emerged as a significant technology

The role of information and communication technology increased rapidly during the 1990s. The information sector showed strong growth and the production and foreign trade of IT products increased significantly. This growth tapered off in the early 2000s, but the contribution of information and communication technology to the national economy is still at a rather high level. Apart from the fact that Finland is a strong ICT producer, information and communication technology is also in widespread use in the country. Most people today have access to a mobile phone, computer and the Internet, and information technology is widely used in business enterprises as well. Recently broadband has proliferated quite rapidly.

- the information sector accounted for 17–18 per cent of total business turnover in 2000–2002, while the figure in 1995 was 9 per cent
- the value of IT product manufacture in 2000–2002 was around 14.6 billion euros a year, well over twice the figure in 1995 (5.9 billion euros); IT products also account for a much greater share of foreign trade than previously
- communications equipment is the most significant product group among IT products, accounting for 93 per cent of IT production in 2002
- the number of broadband subscriptions has increased rapidly in 2003 and during 2004: at year-end 2002 the number of subscriptions was only less than 200,000, but by the end of 2003 the figure was close to half a million and in summer 2004 around 670,000
- in 2002 degrees in IT and media studies accounted for almost 10 per cent of all postcomprehensive degrees completed
- 94 per cent of enterprises with five or more employees have Internet access, some 62 per cent have their own website and 17 per cent sell their products over the Internet
- IT use is very common in major enterprises, almost all enterprises with 50 employees or more have an Internet connection, more than 90 per cent have their own website and well over 20 per cent sell their products over the Internet
- in spring 2004 70 per cent of people aged 15–74 in Finland had used the Internet during the three months preceding the survey
- the Internet is used mostly for e-mail and searching product data, but recently e-commerce has been growing more rapidly as well: in spring 2004 more than 20 per cent of the population aged 15–74 had shopped online

Biotechnology and nanotechnology are gathering momentum

For a number of years now, biotechnology has been the subject of high expectations. Another potential key technology is nanotechnology. Biotechnology was first identified as a national priority area in Finland in the late 1980s, and public funding in this area has continued steadily to increase ever since. In the field of nanotechnology recent investments have mostly concentrated on laboratory facilities, equipment and other infrastructure. In both these fields Finland is a relatively strong producer of scientific publications. Business activity is still comparatively modest, but in biotechnology R&D has developed quite strongly.

- biotechnology funding from the National Technology Agency Tekes and the Academy of Finland in 1990–2003 amounted to almost 400 million euros
- biotechnology research expenditure in 2003 totalled 185.5 million euros
- public funding for nanotechnology amounts to almost 15 million euros a year
- the estimated number of biotechnology companies is around 110
- the number of companies active in nanotechnology in 2004 is estimated at around 60

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Tables

Appendix tables

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