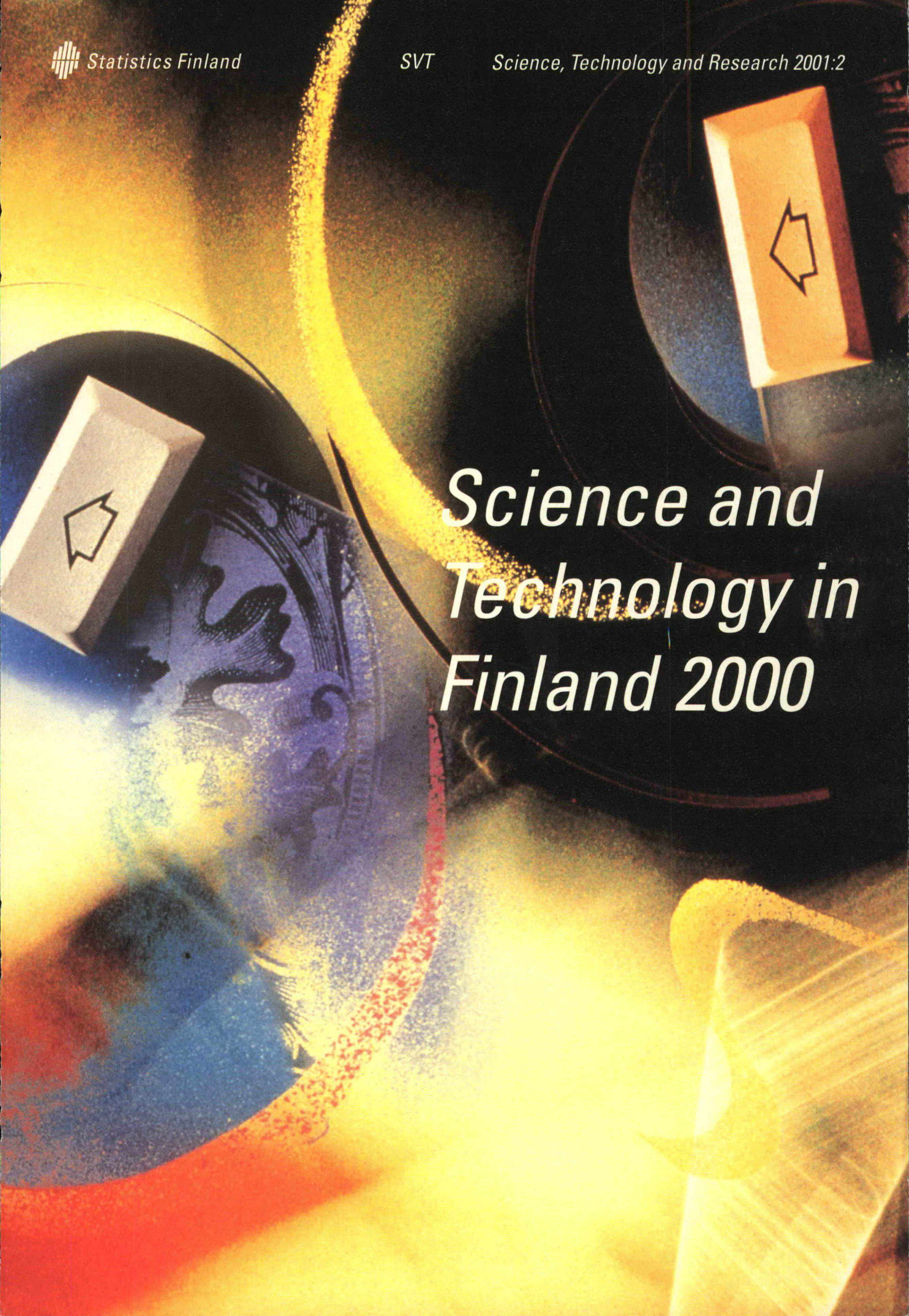
Statistics Finland SVT Science, Technology and Research 2001:2

Science and Technology in Finland 2000



Tilastokeskus
Statistikcentralen
Statistics Finland

SVT

Tiede, teknologia ja tutkimus 2001:2
Vetenskap, teknologi och forskning
Science, Technology and Research

Science and Technology in Finland 2000

Helsinki 2001

Inquiries:

Tero Luhtala
Mikael Åkerblom
Tel. +358-9-17 341

teknologia.tiede@stat.fi

SVT Suomen virallinen tilasto
Finlands officiella statistik
Official Statistics of Finland

Cover graphics: Fennopress Oy

ISSN 1457-1218
= Science, Technology and Research
ISSN 0758-885X
ISBN 951-727-882-9

Hakapaino Oy, Helsinki 2001

Foreword

Science and Technology in Finland 2000 is the fourth in a series of statistical publications by Statistics Finland on Finnish science and technology. The report provides an overview of the general operating environment of science and technology, investment in science and technology as well their outputs and impacts. The sources consulted for this report include both basic statistics and separate surveys; in addition, existing materials have been used to produce new information. The report describes our knowledge-based society as well as the Finnish innovation system from an international comparative perspective.

The report was compiled and edited by Tero Luhtala. The Introduction (Chapter 1) and Summary (Chapter 11) were written by Mikael Åkerblom. Chapter 2 was written by Esko-Olavi Seppälä from the Science and Technology Policy Council of Finland. Markku Virtaharju wrote Chapter 3.4.2 and Ari Leppälahti Chapters 5.2 and 6. Chapter 8 is by Sasu Hälikkä from the Group for Technology Studies of the Technical Research Centre of Finland. Chapters 10.1, 10.2 and 10.4 were written by Lea Parjo, Chapter 10.3 by Samuli Rikama.

Special thanks to all who have contributed to this report.

Helsinki, April 2001

Kaija Hovi
Director, Business Structures

Contents

1 Introduction

Science and technology have an ever greater impact today on society and the economy; indeed their social and economic outcomes and impacts are now receiving at least as much attention as the resources invested in science and technology. Since the 1990s science and technology policy in Finland has increasingly revolved around the concept of the national innovation system, which is defined by the Science and Technology Policy Council (*Review 2000: The Challenge of Knowledge and Know-how)* as a domain for interaction in the production and utilisation of knowledge and know-how built on cooperation between all producers and utilisers of new knowledge. The development of the innovation system rests heavily on cooperation between the different parties involved, often in the form of networks.

Science and technology indicators are key tools in the description of the Finnish knowledge and know-how society: it is through these indicators we can monitor and analyse the innovation system and how it works from different angles, relying on different kinds of statistical materials and parameters extracted from those materials. Statistics on R&D operations have been compiled regularly since 1971. Patents statistics, high technology statistics and bibliometric analyses entered the scene in the 1980s. Innovation studies were introduced in the 1990s, at the same time as research into science and technology more generally was intensified.

Statistics Finland's first *Science and Technology* publication was compiled in 1987; the next two reports were published in 1989 and 1995. Based on science and technology statistics proper as well as on other sources, *the aim of these volumes is to provide an overview of the general operating environment of science and technology, the resources available to them, as well as their outputs and impacts.* Similar reviews are published by a number of countries as well as by the European Commission, providing time series for the description the development of certain phenomena as well as materials for international comparisons. This volume has nine chapters proper in addition to this Introduction and a Summary at the end.

We begin in Chapter 2 by discussing some current issues in science and technology policy. The purpose of science and technology indicators is to provide a sound foundation for discussion on science and technology policy. In this sense Chapter 2 serves as a broader introduction to the analyses in subsequent chapters.

Chapter 3 on the human resources of science and technology draws primarily on educational statistics. Questions concerning the mobility of the highly-educated labour force have received increasing attention in recent years. Some preliminary results from a major ongoing research project that covers all the Nordic countries are reported so far as they apply to Finland.

Chapter 4 discusses the resources of research and development from two different vantage-points, i.e. that of units engaged in R&D and that of government R&D funding. Some of the main findings are reported from a study on Finnish companies' R&D operations abroad and accordingly on foreign companies' R&D activities in Finland. Data are also presented on the trends of government funding for research.

Chapter 5 is about international cooperation in science and technology. Apart from discussing researchers' international mobility, we will be looking at Finland's involvement in international research cooperation – although aspects of internationalisation do appear in most other chapters as well.

Chapter 6 introduces the results of innovation surveys in 1997 and 1999 and compares these findings with data from the Sfinno project run by the Technical Research

Centre, which has explored the background of some key innovations.

Although a patent cannot be taken as a measure of either R&D output or innovations, patents indicators are extremely useful tools in the sense that they are based on extensive time series and on established systems of data collection. Patents indicators can be used to explore trends in development in different technology sectors. Chapter 7 deals with patents.

In some disciplines the output and impacts of scientific research are measured on the basis of the number of papers published and references to citations of publications or patents. Chapter 8 looks into these bibliometric indicators.

The OECD makes a distinction between three types of industry: high technology, medium technology and low technology. This classification is based on R&D intensity. Following the same principle, the OECD has also defined high technology product groups. The analysis presented in Chapter 9 on production in high technology industries and on foreign trade is based on selected data extracted from industrial and foreign trade statistics.

Information and communications technology has been crucial to the success of the Finnish national economy in recent years. Statistics Finland publishes an extensive review on the information society every other year. Chapter 10 provides updates on some of the key data reported in the 1999 volume of *On the Road to the Finnish Information Society*.

The summary in Chapter 11 runs through some of the most important recent trends in development in the Finnish national innovation system.

2 Science and technology policy: current issues

Finnish science and technology policy has traditionally shown a strong orientation to knowledge and know-how. Formerly the tendency used to be to deal separately with education, scientific research and technology, but now a more holistic approach has been gaining ground, which looks at both the producers and end-users of knowledge and know-how within the same frame. Finland has had a pioneering role in developing the national innovation system on the basis of this of holistic perspective.

An examination of the national innovation system comprises education and research in their entirety. In addition, it comprises knowledge-intensive business as well as related expert and funding services. International cooperation in science and technology and the development of that cooperation are important focal areas for policy measures.

One of the key tasks of science and technology policy is to provide for a balanced overall development of the national innovation system and to strengthen its internal relations of interaction. Exchange and cooperation with other sectors in society is another area that has assumed increasing importance. The basic infrastructure for development efforts based on knowledge and know-how is in the last instance created within different policy sectors.

It emerges quite clearly from international comparisons that Finland has been both consistent and highly successful with the long-term development line it has followed in its science and technology policy. However, it is important to recognise that the favourable trends of socio-economic development that draw on knowledge and know-how are not sustained all by themselves. New challenges are presented to education policy, science and technology policy and innovation policy all the time. Under conditions of rapid change it is particularly important to have access to a wide range of statistics and indicators and to continue efforts to develop those tools.

Recent trends in development

One of the most prominent trends in Finland in recent years has been the rapid increase in both public and private research funding. At the same time there has been a strong commitment to raise quality standards and to invest in postgraduate training.

Public R&D funding showed particularly strong growth in 1997–1999: this was a direct consequence of the government's decision in autumn 1996 to invest an additional FIM 1.5 billion into scientific research by the end of 1999. This represented an increase of one-quarter over and above the funding allocated in the 1997 budget proper to scientific research. The extra funds were specifically intended to help improve the innovation system with a view to strengthening the economy, creating new business and generating new jobs. The programme was considered so important that the Ministry of Education and the Ministry of Trade and Industry invited an independent panel of experts to carry out a full assessment of how the monies had been used. The three-year term of the working group ended at year-end 2000.

Private R&D funding has shown rapid growth in Finland ever since 1993. The main force behind this growth has been the electrical and electronics industry, which in 1998 accounted for half of all R&D operations in the private sector; in 1993 the corresponding share was 35 per cent. The industry and its R&D efforts have showed continued strong growth; a new feature is the rapid increase in R&D work done abroad. Today around one-third of all industrial R&D takes place outside the country's own borders, and foreign-based R&D accounts for half of the total growth.

The increase in public research funding also encourages increased investment from the private sector. If public sector funds are properly allocated, that in itself is bound to increase investments by business and industry in domestic R&D. The situation in Finland today is that in spite of the marked increase in public research funding, its share of total research investment has steadily declined and currently accounts for less than 30 per cent of the R&D budget. The explanation lies not only in the growth of private funding from domestic sources, but also in the rapid increase in foreign research funding.

The strong growth of research funding has also led to an increase in the number of research staff. At the same time, perhaps somewhat unexpectedly, the educational level of research staff has been steadily rising. This can be attributed to two main factors: first, to the launch at the beginning of 1995 of systematic postgraduate training through so-called graduate schools; and second, to the increased involvement of women in research in Finland. In 1999 women took more than 500 doctorates, exceeding the total annual number of doctorates completed in the whole country just nine years previously. At the same time women's share of all degrees taken each year increased from around 30 to close on 45 per cent.

In the latter half of the 1990s Finland has invested quite heavily in the quality and quantity of research and product development. Measured in terms of its proportion of GDP, investment in research in Finland is among the highest in the world. Development efforts have included special measures within the field of basic education, bearing in mind the future development needs of the country's information industry. Other significant development projects with important implications for science and technology policy have been carried out in the area of polytechnics, which have now been granted permanent status in the education system. There have been some critical voices suggesting that the development of basic education and infrastructures within the university system have not received sufficient attention. The information industry has made substantial investments to promote the development and application of new information and other technology: the diffusion of this technology throughout the rest of business and industry and society at large are also recognised as an area that warrants further development efforts. In these respects the development of the innovation system has not been an entirely balanced exercise.

Current development challenges

The recession that hit Finland in the early 1990s had profound effects on the structures of society and the economy. Many of the changes are still going on, allowing Finland to take the best possible advantage of the current processes of economic and technological globalisation. Key success factors today are knowledge and know-how in their various forms, and it is over these assets that the fiercest competition is being waged. Knowledge-intensive business is attracted to those areas that can provide high-quality knowledge and know-how. In order to retain their development potential, national economies need further to step up their investments, in both absolute and relative terms, into the production, diffusion and wide-scale utilisation of knowledge and know-how. A key factor in this regard is the efficiency of the innovation system so that the ever greater inputs can be properly allocated and put to the best possible use in society.

In its latest report published at the beginning of 2000 (*Review 2000: The Challenge of Knowledge and Know-how*), the Science and Technology Policy Council of Finland discusses the country's development prospects in the light of these international trends in development. The main concern is to identify those areas where special efforts are needed to make sure Finland remains on a positive development track. The Council has identified five trends in development that are particularly important for future development and that at once are a major challenge to the public sector and further to science and technology policy:

Input into the development of the information industry must remain a clear priority in education, science and technology policies in Finland. It is a major challenge for a small country such as Finland to sustain this achieved strength under conditions of rapid growth.

It is equally important *to develop other key fields* side by side with the information industry. This requires good collaboration between different policy sectors: that is needed to strengthen the innovation and knowledge-based economy and the necessary social, organisational and institutional conditions. At the same time, however, such cooperation also serves other social and cultural development. Education, research and technological development are strategic resources in efforts to resolve development problems and to construct the Finnish information society.

It is essential that the structural change towards an industrial and services structure increasingly based on knowledge and know-how is continued. It is necessary to find *new growth areas* to complement current strengths and in this way to improve the development prospects of businesses operating in these sectors. Areas that are attracting global interest include the bioindustry and knowledge-intensive services. It is also important that *knowledge and know-how already accumulated can be extensively applied* in other fields; this specifically concerns generic telecommunications know-how. As is the case in many other instances, this too entails cooperation between the public and private sectors.

The Science and Technology Policy Council notes that the above requires a determined, comprehensive effort to develop the knowledge and know-how infrastructure:

'The foundation for immaterial and material welfare is built by means of education and research. It is necessary to keep creating new knowledge and know-how throughout the education and research system, and transfer them flexibly to social, economic and cultural development and make them available to citizens. The knowledge base must be continually strengthened to enable it to be utilised on a sustainable basis in the future. The development of university activities and their prerequisites is one key factor in this.'

Science and technology policy conclusions

Development efforts are called for throughout the innovation system; this is the only way it can hope to make progress internationally and respond to current challenges. However, it is important to stress, as the Science and Technology Policy Council does in its report, that the new tasks do not require new organisations. The Finnish innovation system has a good solid structure, and the tasks and functions of different actors within that system can always be adjusted and complemented as the need arises.

In general it is clear that the promotion of science, technology and innovations requires a wide range of measures by the public sector: this is the only way to maintain an economically stable and innovative operating environment for the future. Cooperation with the private sector will also be of key importance to future development efforts.

One area that is a cause of some considerable concern with respect to the *development of knowledge and know-how* in Finland is the availability of basic know-how in mathematics and the natural sciences. The problem has been addressed by launching a special campaign (the LUMA project that is scheduled to run from 1996 to 2002), in which the aim is to raise the level of know-how in these areas to an international standard. The need for know-how has exceeded all expectations, and it has also turned out that there is a shortage of teaching staff. In this, as in all other areas of education, it is indeed necessary to find ways of matching education output and the needs of the labour market more closely. As far as the adult population is concerned this implies a transfer of the principles of life-long learning to practice. One of the challenges that is distinctive of the Finnish case is the need to increase training in support of self-employment; by international comparison levels of entrepreneurship in

Finland are at a particularly low level among academic groups.

The polytechnics system is now fully established in Finland; the last polytechnics were granted their full licences during 2000. Polytechnics have an important part to play in strengthening regional development and promoting business and industry. Their main task is to increase the supply of competent professionals and to upgrade their skills and competencies in such a way that local needs are adequately met.

In a small country such as Finland that relies heavily on knowledge and know-how, one of the most crucial development priorities is to make sure there is the necessary infrastructure for university research and postgraduate training. This requires a long-term commitment to securing the future development potential on as broad a basis as possible and at as high a level of knowledge and know-how as possible. A key factor in this regard is to make sure the necessary funding is available and to have good cooperation with the Academy of Finland. The Academy's role is to further step up efforts to increase high-quality research and expertise in Finland. Key instruments in this include studies on the future development of scientific research as well as reviews of the state and quality of research in Finland.

Programmes aimed at developing research emphasise not only the aspects of quality, efficiency and relevance, but increasingly the impacts of research as well as their evaluation. Uncommitted research funds granted by ministries are the only significant type of public research funding that still remains outside of systematic evaluation. Sectoral ministries are also responsible for the further development of research aimed at supporting industrial clusters and for applying the model of network cooperation to other research programmes.

Technology development has been a priority concern in the public sector throughout the 1990s. This has certainly contributed to the rapid development of the information industry in Finland. The key public sector player in this process has been the National Technology Agency (Tekes) – together with private businesses, research institutes and universities. It is crucially important to make sure that the favourable development can continue. At the same time new challenges are presenting themselves: the National Technology Agency shall support the expansion of knowledge-intensive growth into new areas and step up its efforts to safeguard the growth of research and development at home.

In sum then, the development of the intellectual resources required by scientific research and other expert tasks is in Finland chiefly in the hands of the public sector. It is the public sector that is expected to provide the infrastructures as well as the necessary basic know-how and the people carrying that know-how. How it succeeds in these key tasks depends crucially on the future development of their funding.

Questions concerning the *utilisation of knowledge and know-how* have risen to a new level in science and technology policy. Determined efforts to increase knowledge and know-how have opened up new opportunities to put them to the best possible use both in business and industry and more broadly in society at large. It is necessary to further intensify efforts to utilise the information produced at home and abroad as well as to evaluate this utilisation.

The National Technology Agency also has an important role to play in promoting the dissemination and utilisation of knowledge and know-how. This role involves, among other things, the development of high-quality expert services and the further diffusion of knowledge and know-how in collaboration with the Finnish National Fund for Research and Development (Sitra), Finnvera and Finpro. Additionally, it involves steps to give start-up businesses easier access to the venture capital they need through joint measures of public and private equity investors.

Regional development also relies to an ever greater extent on new knowledge and know-how and on their expert utilisation. Internationally successful projects and development lines are also needed at this level to boost regional development. Universities and polytechnics, business companies, technology centres, centres of expertise and other actors within the innovation system have an important role to play in identifying new regional development potential.

The problem of research funding

As we have seen, both business investment in R&D and public sector spending in research have increased quite dramatically in Finland during the latter half of the 1990s. Today, as we move into the twenty-first century, businesses and information industries in particular are continuing to step up their investment in research and product development, whereas the real growth of research expenditure by the public sector has now come to a halt.

In its '*Review 2000*' report the Science and Technology Policy Council of Finland concludes that a successful response to the challenges that lie ahead of the country – the same challenges that are discussed in this report – calls for an increase in public resources: '*Private and public input are targeted at different parts of the innovation system. However, the performance of the system depends on how well it operates as a whole.*' The most recent trends in development suggest that the operations which are under the public sector's responsibility do not fully meet the requirements of the rapid development in the private sector. Critical areas that have already been mentioned here include basic education and postgraduate training in universities as well as basic research. Other concerns now include the viability of the infrastructures of research and education and, partly related to this, the growing tendency of business companies to outsource research and development to other countries. Steps are also needed to allow for a more efficient utilisation of knowledge and know-how in business companies and elsewhere in society. Ultimately what is at stake here is the future of Finland, its development prospects as a knowledge-based society; and the question of how far the favourable trends since the recession of the early 1990s can be brought to benefit the whole society and all citizens.

3 Human resources

It is widely recognised that sustained economic growth depends essentially on knowledge and know-how, which in turn are products of education and research. Maintaining a broad and high level of education, improving the quality of education and research and fitting together the requirements of labour, education and the changing environment are all key to the promotion of national welfare.

This chapter looks at the human resources of science and technology in Finland. The analysis focuses on the population with tertiary education, the migration of this population segment, tertiary degrees, the supply of labour with tertiary education, job placement, changing jobs and the salaries of people with tertiary education. The data on the human resources in science and technology are drawn from Statistics Finland's population statistics, education statistics, Register of Completed Education and Degrees, employment statistics and wages and salary statistics.

Concepts, definitions and classifications

The analysis comprises persons who have completed a lowest level tertiary degree (corresponds to ISCED Level 5, 5B-programmes[1]), those who have completed a lower or higher tertiary degree (corresponds to ISCED Level 5, 5A-programmes) and those who have completed doctorate level (licentiate and doctorate degrees) training (corresponds to ISCED Level 6). The main focus is on the population aged 15 to 64 because we want to describe the potential of science and technology and at the same time the economically active population. The period under review extends from 1989 to 1998, thus covering the best part of the 1990s.

The launch of the AMK system in Finland in the early 1990s and the first new graduates from polytechnics from 1994 onwards have necessitated a complete overhaul of the educational classification. For this reason the data on education presented in this report are not directly comparable with the figures in the 1995 report. The number of degrees that are classified as representing tertiary education is much higher than in the previous system. In 1994 the number of AMK degrees completed was 68, in 1995 1,638, and by 1998 the figure had climbed to around 7,000.

The classification of educational groups is based on Statistics Finland's revised educational classification[2]. This classification follows as closely as possible the revised Unesco international classification ISCED 1997 with respect to educational fields and the contents of educational degrees. The revision means that the data for different years are not directly comparable. However, the time series for educational data examined in this report are based on the new educational classification.

The classification of disciplines is based on the OECD recommendation, the occupational classification on the Statistics Finland classification[3].

The first section below describes the trends for the *number of people with tertiary education*. The second section provides data on the *number of tertiary degrees completed*. The data presented in these two first sections are based on a separate dataset specially compiled for this

1 Revised International Standard Classification of Education ISCED 1997, Unesco.

2 Finnish Standard Classification of Education 1997, 11th revised edition. Handbooks 1, Statistics Finland, Helsinki 1999 and appendices.

3 Classification of Occupations 1997, revised edition. Handbooks 14, Statistics Finland, Helsinki 1997.

report, in which discipline is derived from the fields of study specified in the educational classification. The next section describes the *migration of people with tertiary education*: this discussion covers both internal and external migration; in the latter case the focus is on migration within the Nordic countries. The fourth section presents data on the *position of the tertiary-educated in the labour markets* on the basis of such data as employment in these strata, job placement and trends in researchers' earnings. A further concern is with the movement of people with tertiary education between jobs, or their labour market mobility. Finally, there is a brief discussion of the economy of education.

3.1 Population with tertiary education

Fastest increase recorded for number of doctorates

The level of education in Finland has continued to rise throughout the 1990s. At year-end 1998 the number of people with tertiary education stood at 860,500, more than one-third up on the figure recorded at the beginning of the decade. In 1998 those with tertiary education (including those with military training) accounted for around one-quarter of the total population aged 15 to 64.

In 1998 a total of 18,900 persons or 2.2 per cent of the population with tertiary education had completed the licentiate or the doctor's degree. Those with a higher tertiary degree (e.g. master's degree) accounted for 22.4 per cent, the remaining three-quarters had completed either a lower tertiary degree or a lowest level tertiary degree.

Table 3.1 illustrates the trends for the number of persons with tertiary education in 1987–1998. The increase began to slow down towards the end of the 1990s: while the average annual increase from 1991 to 1995 was 3.6 per cent, the corresponding figure for 1995–1998 was around 3 per cent.

On the other hand, the number of people with a doctorate level education has been showing somewhat faster growth; this is explained by the number of doctorates which on average has increased by more than seven per cent per annum. At the same time, however, the increase in the number of licentiates and indeed all other tertiary education groups has been slowing down. The increase in the number of doctorates has been evenly spread out across all disciplines. As for licentiates, the numbers have shown the strongest growth in the medical sciences, though overall the increase has been quite modest.

TABLE 3.1
Number of persons with tertiary education (aged 16 to 64, excl. military training) in 1987–1998

Level of education	1998		Annual growth		
			1987–1991	1991–1995	1995–1998
	No.	%	%	%	%
Doctorate level	18 874	2.2	5.7	6.1	6.2
– of which doctors	11 282	1.3	6.0	6.5	7.2
– of which licentiates	7 592	0.9	5.3	5.7	3.4
Higher tertiary level	192 327	22.4	5.0	4.9	4.5
Lower tertiary level and lowest level of tertiary education	649 276	75.5	3.1	3.2	2.5
Total	**860 477**	**100.0**	**3.5**	**3.6**	**3.0**

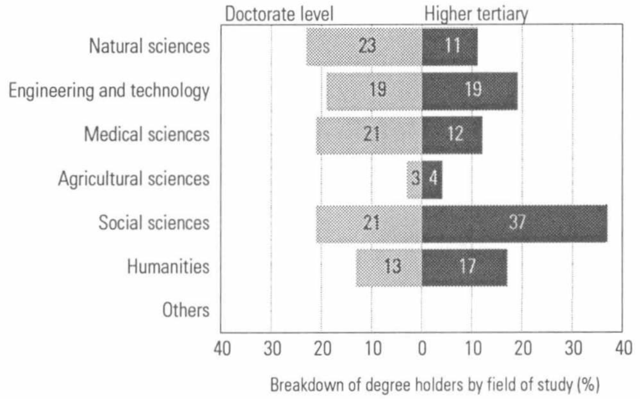


FIGURE 3.1
Doctorate level degrees and higher tertiary degrees by field of study in 1998

More detailed information on the population with tertiary education, including breakdowns by different levels of education, disciplines and gender in 1989–1998, is presented in Appendix Table 3.1.

Social scientists account for over one-third of the population with higher tertiary degrees

In 1998 social scientists accounted for 36 per cent of the population with at least a higher tertiary degree. The next largest group, accounting for almost one-fifth of all, consisted of those with a tertiary degree in engineering and technology. In the category of higher tertiary degrees (most typically the master's degree), social scientists accounted for a higher proportion still, i.e. 37 per cent (see Figure 3.1).

Among those with a doctorate level degree (licentiate or doctorate), though, social scientists were outnumbered by natural scientists. Likewise, the numbers with a degree in medical sciences increased to almost the same level. There are also considerable differences between disciplines in the number of licentiates and doctorates. For instance, 28 per cent of all licentiates have taken their degree in engineering and technology, for doctorates the corresponding figure is only 14 per cent. The situation is the same among social scientists. However, comparisons involving the medical sciences are complicated by the fact that the licentiate in medical sciences corresponds to the graduate degree in other fields of study. In the revised classification of education medical doctors' specialist degrees are classified as higher tertiary degrees.

The number of social scientists as a proportion of people with at least a higher tertiary degree has risen throughout the 1990s. This is explained by the sharp increase in the number of master's degrees completed. At the same time the share of other disciplines has declined to some extent. On the other hand the proportion of those completing doctorate level degrees in engineering and technology, for instance, has increased at the same time by a couple of percentage points.

Well over half of the population with tertiary education are women

At year-end 1998 women accounted for about 56 per cent of all those with a tertiary degree. The proportion of women was highest (almost 58 per cent) among those with a lower tertiary degree or a lowest level tertiary degree. Women were also in the majority (albeit only marginally) among those who had completed a higher tertiary degree. Women account for 31 per cent of those with a doctorate level degree and for 29 per cent of those with a doctorate.

In the humanities women accounted for no less than 72 per cent of the population with a higher tertiary degree (Figure 3.2). Women are

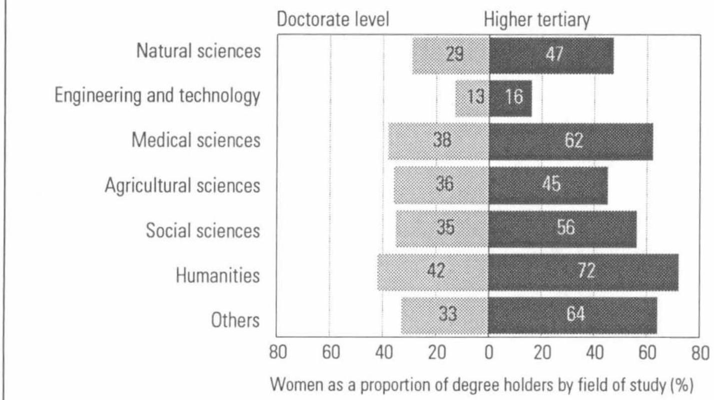


FIGURE 3.2
Women as a proportion of degree holders by field of study and level of education in 1998

also clearly overrepresented in the medical sciences as well as in the category 'discipline unknown'. In engineering and technology the share of women remains low: only one in six completing a higher tertiary degree in engineering and technology is a woman. In engineering and technology 13 per cent of those with a doctorate level degree and 11 per cent with a doctorate were women at year-end 1998.

The proportion of women has clearly increased at all levels of tertiary education throughout the 1990s. Since the beginning of the 1990s the overall increase in the share of women has gone up by 3.4 per cent. The increase has been most noticeable in the number of doctorates, with the numbers rising from 19 to 29 per cent. At the same time the number of women as a proportion of those taking the licentiate has risen from 27 to 34 per cent.

Half of the population with a doctorate level degree live in the region of Uusimaa

In 1998 there were just two regions where the proportion of the population with tertiary education was higher than the average for the whole country (25.2 per cent), i.e. in Uusimaa and (marginally) in Pirkanmaa (Table 3.2). In Central Ostrobothnia and Kainuu, the proportion of those with tertiary education was below 20 per cent. Roughly one-third of the country's tertiary educated population lived in the southernmost region of Uusimaa. This is well above the region's share (26 per cent) of the total population aged 15 to 64. Almost half of the population with a doctorate level degree lives in Uusimaa. Other regions where the proportion of people with a doctorate level degree exceeded the region's share of the total population with tertiary education were Varsinais-Suomi, Pirkanmaa, North Ostrobothnia and Central Finland. Indeed, doctorate level degree holders tend to concentrate not only in and around the metropolitan Helsinki region but also in major university cities such as Turku, Oulu and Kuopio.

Examined on the basis of the statistical grouping of municipalities (Appendix 3.3), there is a clear difference between rural and urban areas. In urban municipalities 29 per cent of the population aged 15 to 64 have tertiary education, while the corresponding figure in rural municipalities is 17 per cent. In semi-urban municipalities the figure is around 22 per cent. Almost three-quarters or 71 per cent of all people with tertiary education live in urban municipalities, yet the proportion of all persons aged 15 to 64 in these municipalities is just 62 per cent.

TABLE 3.2
Population (aged 15 to 64) with tertiary education by region and their proportion of the region's same age population in 1998

Region	Whole population with tertiary degrees		Population with doctorate and licentiate degrees		Proportion of population with tertiary degrees
	No.	%	No.	%	%
Uusimaa	285 716	32.9	9 176	48.6	32.0
Varsinais-Suomi	73 870	8.5	2 045	10.8	25.1
Satakunta	34 216	3.9	229	1.2	21.6
Kanta-Häme	25 486	2.9	263	1.4	23.8
Pirkanmaa	75 171	8.7	1 673	8.9	25.3
Päijät-Häme	28 240	3.2	217	1.1	21.3
Kymenlaakso	27 387	3.2	130	0.7	21.9
South Karelia	19 212	2.2	223	1.2	21.1
Etelä-Savo	22 715	2.6	169	0.9	20.6
Pohjois-Savo	37 509	4.3	738	3.9	22.4
North Karelia	22 799	2.6	471	2.5	20.1
Central Finland	40 670	4.7	985	5.2	23.6
South Ostrobothnia	25 999	3.0	122	0.6	20.7
Ostrobothnia	27 861	3.2	332	1.8	25.0
Central Ostrobothnia	9 104	1.0	75	0.4	19.5
North Ostrobothnia	54 840	6.3	1 487	7.9	23.1
Kainuu	11 888	1.4	85	0.5	19.6
Lapland	28 301	3.3	242	1.3	21.6
Itä-Uusimaa	14 282	1.6	189	1.0	24.7
Åland	3 751	0.4	23	0.1	22.5
Total	**869 017**	**100.0**	**18 874**	**100.0**	**25.2**

3.2 Tertiary degrees

Number of doctorates now exceeds the number of licentiates

Enrolment numbers in educational institutions have increased. The increase in the numbers with tertiary education is explained in part by the growing number of women in education. In particular, a key factor behind the increase in the annual number of tertiary degrees completed is the growing number of women who go on to take a university degree.

In 1998 a total of 39,640 tertiary degrees were awarded in the country, up by a fair 10 per cent or so on the figure for 1989. However, on several occasions during the 1990s the number of degrees has in fact exceeded the 40,000 mark. The number of doctorate level degrees has grown very rapidly. Whereas in 1989 the number of doctoral theses approved was around 400, the figure in 1998 was close on one thousand. The number of licentiates has also sharply increased, although there has been some fluctuation in the figures lately. In 1998 the number of licentiates completed was 63 per cent higher than in 1989. The annual number of doctorates completed exceeded the figure for licentiates for the first time in 1996 (Figure 3.3).

It seems that the peak for the number of licentiates was reached in 1997, whereas the annual number of doctorates is continuing to rise.

In spite of the reforms carried out in upper secondary education and the university syllabus reform, which caused graduation times to increase, the number of higher tertiary degrees completed has shown strong development. In 1998 the number of higher tertiary degrees completed totalled 11,900, or some 40 per cent more than in 1989 (Figure 3.4). The figures have shown rather steady annual growth, but it now seems that since the slowdown in the mid-1990s the pace has been picking up again. The number of lower tertiary degrees and lowest level tertiary degrees completed currently stands at around the same level as at the end of the 1980s. Having said that, the figure for 1998 remained at less than 26,000 compared to more than 30,000 in 1993.

More detailed information on degrees completed, including breakdowns by different levels of education, disciplines and gender in 1989–1998, is presented in Appendix Table 3.2.

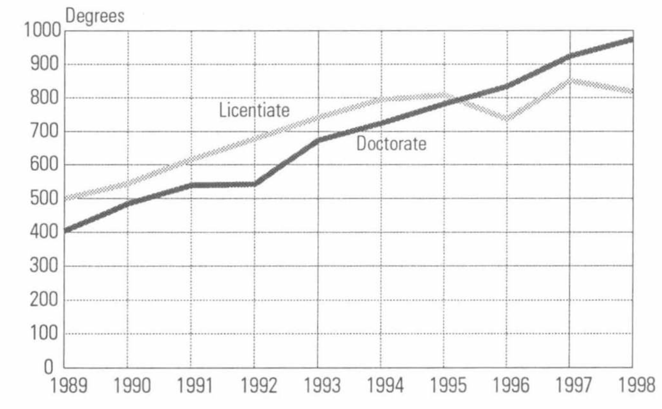


FIGURE 3.3
Doctorate and licentiate degrees in 1989–1998

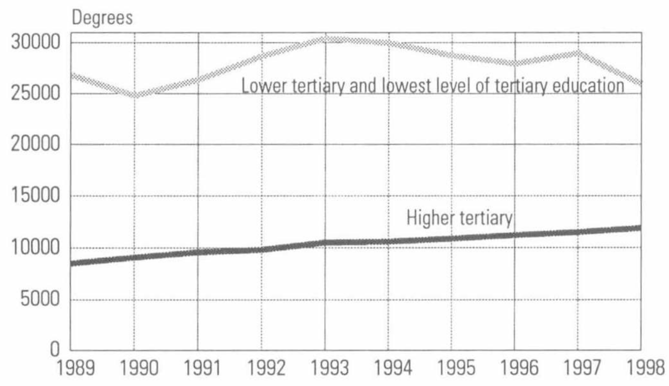


FIGURE 3.4
Higher tertiary degrees, lower tertiary degrees and degrees at the lowest level of tertiary education in 1989–1998

Increase in the number of doctorate level degrees strongest in the agricultural sciences and in the social sciences

In 1998 the medical sciences recorded the largest absolute number of doctoral theses approved. This field of study accounted for 28 per cent of all doctoral theses. Doctoral theses in the natural sciences accounted for 22 per cent, while the social sciences accounted for around one-fifth.

Table 3.3 compares the trends for degrees completed in different fields of study from 1989 onwards. The figures for 1998 are based on an index where 1989=100.

The sharpest increase in the number of doctorates is recorded for the agricultural sciences, where the figures have almost quadrupled from 1989 to 1998. Having said that the absolute numbers in this field are still comparatively low. The number of doctorates in engineering and technology and the social sciences have increased more than three times over during the same period. In the medical sciences, too, the numbers completing their doctorate are also almost twice as high as they were in 1989, even though this field of study has recorded the slowest increase during the period under review.

Almost one-third or 31 per cent of all licentiates were completed in the social sciences, one-quarter in engineering and technology. The increase from 1989 to 1998 has been faster than average in the social sciences, in the medical sciences, in the agricultural sciences and in the humanities. The number of licentiates graduating from the natural sciences has shown some tendency to decrease in recent years. Indeed growing numbers today opt to continue from the master's degree straight to the doctorate; the licentiate is not necessarily required.

Among higher tertiary degrees the sharpest increase is recorded in engineering and technology and in the natural sciences. In these fields the number of engineers and masters graduating today is more than one and a half times greater than in 1989. By contrast the annual number of graduating Masters of Agriculture and Forestry is lower than it was in the late 1980s.

Women also account for a growing share of doctorate level degrees

In 1998 women accounted for 61 per cent of all tertiary degrees completed. The share of women has been rising across the board, at all levels of education and in all fields of study. The increase has been particularly noticeable in the medical sciences: in 1989 women accounted for 35 per cent of all doctorates in these fields, by 1998 the figure had risen to 54 per cent. A couple of exceptions prove the rule: women accounted for 40 per cent of the doctorates taken in the natural sciences in 1989, by 1998 the figure had dropped to around 33 per cent. Furthermore, the proportion of women completing a master's degree in the humanities was slightly lower in 1998 than in 1989, although in both cases the

TABLE 3.3
Increase in doctorate level degrees as compared with higher tertiary degrees in 1989–1998 (1989=100)

Field of study	Licentiate degree	Doctorate degree	Doctorate level degrees, total	Higher tertiary degree
Natural sciences	120	214	160	157
Engineering and technology	149	313	190	162
Medical sciences	200	189	190	140
Agricultural sciences	170	382	281	94
Social sciences	221	310	252	128
Humanities	169	276	202	147
All total	**164**	**242**	**198**	**140**

absolute number of women taking a degree did increase.

The number of doctorates completed by women in 1989 was 138, by 1998 the figure had climbed to 390. Women accounted for 40 per cent of all doctorates. The absolute number tripled in less than a decade. The increase in the number of licentiates completed by women was almost equally rapid. Over one-third or 38 per cent of the doctoral theses completed by women in 1998 were in the field of medical sciences. In the category of licentiates completed by women, the biggest single field of study was represented by the social sciences at 37 per cent. Over 42 per cent of the women completing a higher tertiary degree graduated in the social sciences.

Number of degrees completed in Finland in engineering and technology and the natural sciences among the highest in OECD countries

In all five Nordic countries the annual number of doctorates almost doubled during the 1990s: while the figure in 1990 was 2,300, the corresponding figure for 1998 was 4,500 (Table 3.4). The sharpest increase was recorded in Denmark. Finland came second with an average annual growth rate of nine per cent. In 1998 Finland accounted for 22 per cent of all doctorates completed in the Nordic countries. In Finland the share of the social sciences was higher and that of the agricultural sciences lower than in the other countries. Women accounted for a larger share of all doctorates in Finland

TABLE 3.4
Number of doctorates completed in the Nordic countries in 1990–1998

Year	Finland	Sweden	Norway	Denmark	Iceland	Total
1990	490	1 030	393	410	1	2 324
1992	524	1 259	439	599	3	2 824
1994	701	1 409	551	765	–	3 426
1996	851	1 598	602	817	1	3 869
1998	988	1 883	685	935	3	4 494
1990–1998	**6 414**	**12 822**	**4 803**	**6 506**	**19**	**30 564**

Source: Norwegian Institute for Studies in Research and Higher Education (NIFU)

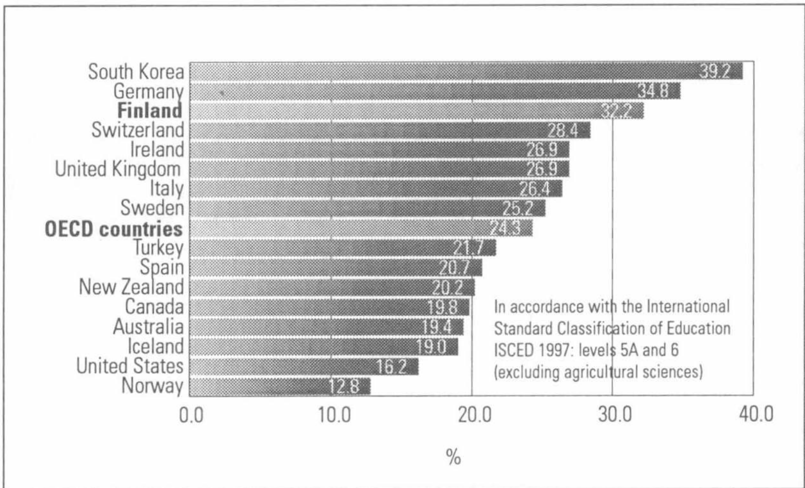


FIGURE 3.5
Tertiary degrees in engineering and technology and in natural sciences as a proportion of all tertiary degrees in selected OECD countries in 1998

Source: OECD Education Database

(40%) than they did in the other Nordic countries (34%). The difference was most outstanding in the case of the medical sciences as well as in the social sciences.

In 1998 degrees completed in engineering and technology and the natural sciences accounted for 32 per cent of all tertiary degrees in Finland (excluding lowest level tertiary degrees). This is the third highest figure in the OECD countries after South Korea and Germany (Figure 3.5). The average for the OECD countries was 24 per cent. All in all it is clear that Finland's current policy line in education is conducive to maintaining and strengthening the competitiveness of the national economy.

3.3 Migration of population with tertiary education

3.3.1 Internal migration

Uusimaa continues to attract population with tertiary education

High levels of migration in the late 1990s have increased regional differences in education. Most of the people on the move are young and well-educated. In 1998 the only regions to record positive net migration of population (over 15) with tertiary education were Uusimaa, Pirkanmaa, Itä-Uusimaa and Åland. Uusimaa has seen its positive net migration increase regularly since 1992 (Figure 3.6). The figure for 1998 at 3,600 was one-third greater than the previous year. Most of the people who move tend to concentrate in and around the metropolitan Helsinki region. Most regions have seen the numbers of residents with tertiary education decline throughout the 1990s. The situation is particularly difficult in Lapland, in eastern Finland and in Satakunta in southwestern Finland. It is also noteworthy that the university cities of Joensuu, Kuopio, Oulu, Tampere and Turku saw a considerable outflow in 1998 of people with a higher tertiary education and with doctorate level degrees.

The main flow of movement among people with tertiary education is from rural into urban areas (Figure 3.6). Urban municipalities have recorded a positive net migration (in-migration –

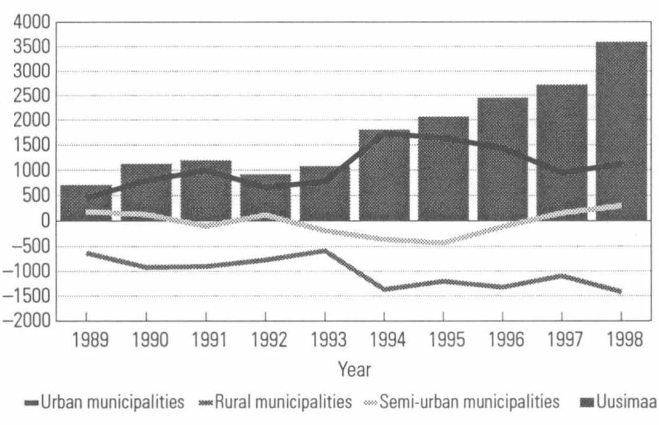


FIGURE 3.6
Net migration of population with tertiary education by statistical grouping of municipalities and in Uusimaa in 1989–1998

out-migration) each year; in 1998 the figure was around 1,100. In recent years rural municipalities have been increasingly deprived of their educational capital with the process of depopulation. In semi-urban municipalities the balance has tended to fluctuate; most recently they have seen a return to positive net migration.

3.3.2 External migration

Most tertiary-educated emigrants from Finland move to Europe

In 1998 a total of 3,421 persons aged 15 to 64 with tertiary education emigrated from Finland: 84 per cent of them or a total of 2,900 people moved to Europe, and the majority or 62 per cent of all went to some other EU country (Table 3.5). The two most popular destinations were Sweden and Norway (Figure 3.7). Norway appealed most particularly to people with a lowest level tertiary education; nurses no doubt represent a large proportion of this group. Some seven per cent of those leaving the country or a total of 252 persons moved to the United States. In terms of their education, less than five per cent or 152 persons emigrating from Finland had a doctorate or licentiate, almost 1,200 had a higher tertiary degree.

Although the number of emigrants with tertiary education has more than tripled since 1993, the overall level of emigration remains quite low. In 1998 no more than 0.4 per cent of the population aged 15 to 64 with tertiary education moved out of Finland. From 1997 to 1998 the number of those leaving went up by 14 per cent; the increase for the EU countries alone was 10 per cent. In relative terms emigration to non-EU European countries increased more sharply, even though the absolute numbers were quite modest.

Age is another factor with an impact on emigration. The likelihood of moving is greatest among young adults. Among emigrants with a tertiary degree some two-thirds were aged under 35 in 1998, 27 per cent were in the age group 25 to 29. The age spread is more balanced for emigrants with a doctorate level degree than for other population groups with tertiary education. Having said that, licentiates and doctorates are in most cases completed at a more advanced age.

Finland records negative net migration for people with tertiary education

In 1998 a total of 2,386 persons aged 15 to 64 with tertiary education moved into Finland. Over 80 per cent of them or 1,945 came from some other European country; Sweden alone accounted for 22 per cent of the immigrants

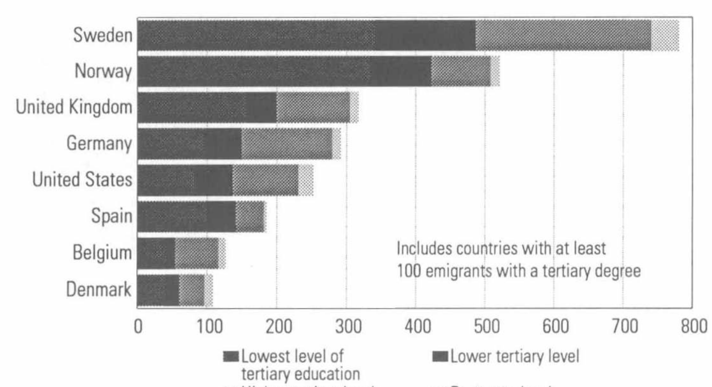


FIGURE 3.7
Emigration of population with tertiary education to selected countries in 1998

TABLE 3.5
Emigrants aged 15 to 64 with tertiary education by country of destination in 1998

Country of destination	Lowest level of tertiary education	Lower tertiary level	Higher tertiary level	Doctorate level	Tertiary level total	%
Europe	1 293	506	962	121	2 882	*84.2*
EU countries	880	375	765	98	2 118	*61.9*
Sweden	342	144	255	39	780	*22.8*
United Kingdom	155	44	106	12	317	*9.3*
Germany	96	53	131	11	291	*8.5*
Rest of Europe	413	131	197	23	764	*22.3*
Norway	333	89	86	13	521	*15.2*
Russia	7	10	20	2	39	*1.1*
Estonia	21	8	25	–	54	*1.6*
Africa	7	3	3	1	14	*0.4*
America	98	64	125	25	312	*9.1*
United States	82	54	95	21	252	*7.4*
Asia	57	37	82	5	181	*5.3*
China	13	11	28	1	53	*1.5*
Oceania	13	3	10	–	26	*0.8*
Australia	13	2	7	–	22	*0.6*
Unknown	5	1	–	–	6	*0.2*
Total	**1 473**	**614**	**1 182**	**152**	**3 421**	***100.0***

(Table 3.6). The second biggest source country was Russia, accounting for 18 per cent of all arrivals. Overall then, the number of immigrants was around one thousand less than the number of those moving out of the country. The number of people moving in from Russia exceeded the number moving out to Russia ten times over. The numbers immigrating from Estonia were also greater than the numbers leaving for Estonia.

Nordic migration increased markedly in the 1990s

Our analysis of the movement of people with tertiary education between the Nordic countries in the 1990s comprises the population aged 20 to 64. It is important to note that the data for immigrants in particular are in some respects incomplete.

In 1998 a total of some 1,300 persons aged 20 to 64 with tertiary education moved out of Finland into some other Nordic country. Over half of them or 56 per cent moved to Sweden, just over one-third or 36 per cent to Norway. Half of those who left the country had a lowest level tertiary degree, 27 per cent had a higher tertiary degree, and 18 per cent a lower tertiary degree. The remaining five per cent of those leaving had either licentiates or doctorates. Women accounted for 61 per cent of all those who moved out. Among emigrants with a higher tertiary degree and with a doctorate level degree, the share of women was just under half, but they accounted for around 73 per cent of those with a lowest level tertiary degree.

During the same year Finland received from the other Nordic countries some 800 persons with tertiary education. This means that Finland recorded negative net migration, losing 500 people with tertiary education. Almost two-thirds or 64 per cent of the new arrivals came from Sweden, one-quarter from Norway.

The migration flows have almost doubled during the past decade. In 1989 a total of some 700 persons with tertiary education moved from Finland to other Nordic countries. The increase in migration has been sharpest among people with a doctorate level degree: the number of

TABLE 3.6
Immigrants aged 15 to 64 with tertiary education by country of departure in 1998

Country of departure	Lowest level of tertiary education	Lower tertiary level	Higher tertiary level	Doctorate level	Tertiary level total	%
Europe	813	463	605	64	1 945	*81.5*
EU countries	456	212	404	49	1 121	*47.0*
Sweden	215	88	190	23	516	*21.6*
United Kingdom	55	25	35	6	121	*5.1*
Germany	68	35	67	4	174	*7.3*
Rest of Europe	357	251	201	15	824	*34.5*
Norway	143	21	42	3	209	*8.8*
Russia	138	173	102	9	422	*17.7*
Estonia	38	23	25	–	86	*3.6*
Africa	12	10	18	2	42	*1.8*
America	63	33	64	3	163	*6.8*
United States	49	26	52	2	129	*5.4*
Asia	57	69	75	8	209	*8.8*
China	4	7	8	–	19	*0.8*
Oceania	5	3	4	1	13	*0.5*
Australia	3	2	4	1	10	*0.4*
Unknown	3	5	5	1	14	*0.6*
Total	**953**	**583**	**771**	**79**	**2 386**	***100.0***

those with a licentiate or doctorate as a proportion of all emigrants has risen from 2.2 per cent to almost five per cent. At the same time the share of women among emigrants with a doctorate level degree has risen from one-fifth to one-half. However, the number of emigrants with a doctorate level training is still comparatively small, counted as it is in no more than a few dozen.

The most noteworthy trend in the patterns of Finnish-Nordic migration during the 1990s has been the decline in the share of Sweden in the movement both in and out of Finland. In 1989 Sweden accounted for 85 per cent of total migration (both in- and out-migration), by 1998 the figure was down to 59 per cent. Indeed, the share of Norway has been increasing sharply at Sweden's expense. While in 1989 no more than

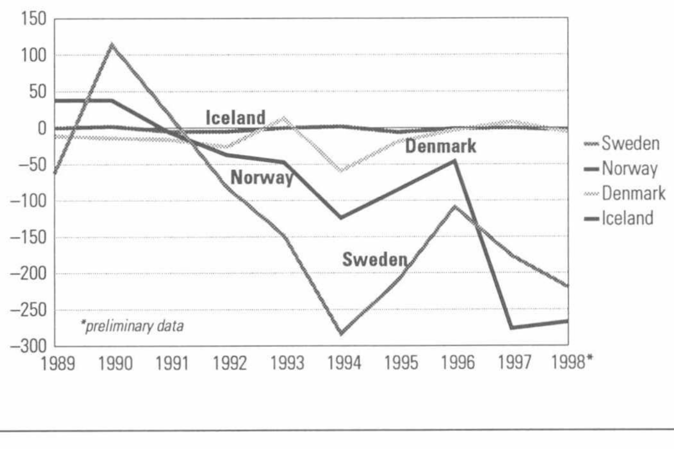


FIGURE 3.8
Net migration of the tertiary-educated population aged 20 to 64 between Finland and other Nordic countries in 1989–1998

some 40 people moved out to Norway, the figure by 1998 had increased more than ten times over to 460. Norway has gained in popularity especially in the latter half of the 1990s. During the past few years there has also been a noticeable increase in the numbers moving from Norway into Finland.

Finland has shown positive net migration (at 140 persons) only in 1990 – although even in this year the numbers moving out with a doctorate level degree exceeded the corresponding number of immigrants. The number of people with tertiary education moving into Finland from Denmark and Iceland has been at roughly the same level as the numbers moving in the opposite direction throughout the 1990s. At the same time Finland has recorded negative net migration with Sweden and Norway (Figure 3.8).

3.4 Population with tertiary education and employment

3.4.1 Job placement of people with tertiary education

Population with tertiary education increased to account for over 30 per cent of labour force

In 1997 the population with tertiary education accounted for 30 per cent of the labour force aged 15 to 64[4]. The numbers who have completed at least a lower tertiary degree as a proportion of the labour force has almost doubled from 1989 to 1997, now standing at just over 13 per cent. In relative terms the sharpest increase has been recorded for the number of those with a lower tertiary degree.

At year-end 1997 almost three-quarters or 71 per cent of the Finnish population aged 15 to 64 were in the labour force. In 1997 exactly one in three of the two million or so employed people aged 15 to 64 had a tertiary degree. Fifteen per cent of all had at least a lower tertiary degree, of which 0.8 per cent had a doctorate level degree. The trends since the early 1990s have been similar to those seen in the whole labour force.

People with tertiary education are active in the labour market

Employment statistics for 1997 indicate that 87 per cent of the population aged 15 to 64 with tertiary education were either working or claiming benefits and looking for work. The corresponding figure for people with only basic education was around 55 per cent (Figure 3.9). Of the one million or so people aged 15 to 64 not in the labour force, 11 per cent had tertiary education at year-end 1997.

In 1998 almost 44 per cent of those with tertiary education were employed in public administration and social services. Almost half of the employed population in these sectors had

4 The population is divided on the basis of their principal activity into two groups, i.e. those in the labour force and those not in the labour force. The labour force comprises the employed population and those out of work. Those not in the labour force comprise the population aged 0 to 14, students, pensioners, conscripts and conscientious objectors as well as others (e.g. those doing domestic work).

tertiary education (Table 3.7). In financial intermediation and insurance, too, almost half of the active labour force had a tertiary degree. In other industries the figures were around 20 per cent. One in six of the population with tertiary education worked in financial intermediation and insurance or in manufacturing. Compared to 1989 the number of people with tertiary education as a proportion of the gainfully employed population has slightly increased in all industries with the exception of agriculture and forestry and construction.

Examined by employer sector (Appendix 3.4), almost half of the population with tertiary education were engaged in the private sector (Table 3.8). However, three in five of those with a doctorate level degree were in the State's employ (including private non-profit sector). When the municipal sector is included in the analysis, almost 80 per cent of those with a doctorate level degree were employed in the public sector in 1997. Over half of those with a lowest level tertiary degree and lower tertiary degree were in the business enterprise sector.

Finland fares reasonably well in an international comparison of the numbers with tertiary education as a proportion of the labour force aged 25 to 64 (Figure 3.10). The figure for

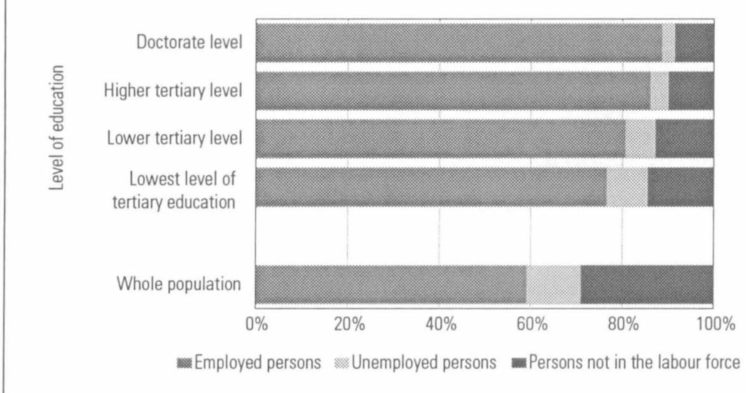


FIGURE 3.9
Population aged 15 to 64 with tertiary education by principal activity as at 31 December 1997

TABLE 3.7
Employed persons with a tertiary degree by industry in 1989 and 1998

Industry	1989		1998*	
	Holders of tertiary degrees	Proportion of employed in industry, %	Holders of tertiary degrees	Proportion of employed in industry, %
Public administration, social services	237 299	41.2	307 297	47.8
Financial intermediation and insurance	89 502	36.4	115 567	46.1
Trade, hotels and restaurants	62 465	17.0	81 000	25.4
Manufacturing	92 081	17.5	112 458	24.9
Transport	21 295	13.1	30 287	19.1
Construction	27 070	15.3	21 587	17.8
Agriculture and forestry	19 287	9.6	16 384	14.3
Other or industry unknown	24 722	21.6	18 238	28.8
Total	**573 721**	**24.2**	**702 818**	**33.1**

** preliminary data*

Finland is 33 per cent, which means the country ranks among the top OECD members in Europe. All other Nordic countries are also among the top nations in this comparison.

Unemployment rate in the population with tertiary education half the corresponding figure for the whole labour force

Education reduces the risk of unemployment. Periods of unemployment are also shorter for people with tertiary education. At year-end 1998 Statistics Finland's employment statistics indicated that 57,000 out of the unemployed population of 374,000 or 15.3 per cent were people with tertiary education. Preliminary data for the same time point show that the unemployment rate for the population with tertiary education (as a proportion of the labour force aged 15 to 74) is 7.5 per cent. At this point in time the unemployment rate for the whole labour force was 15 per cent, for those with no post-comprehensive schooling 22 per cent. Examined by level of education, there were also considerable differences within the population with tertiary education. Among those who had completed the licentiate or doctorate, only 2.5 per cent were unemployed, but at the same time

TABLE 3.8
Employed persons with a tertiary degree by employer sector and level of education in 1997

Level of education	Total		State*		Municipality		Business enterprises		Other or unknown	
	No.	%	No.	%	No.	%	No.	%	No.	%
Lowest level of tertiary education	370 582	100.0	46 566	12.6	100 974	27.2	197 221	53.2	25 821	7.0
Lower tertiary level	128 030	100.0	12 952	10.1	41 968	32.8	66 018	51.6	7 092	5.5
Higher tertiary level	162 285	100.0	37 198	22.9	57 851	35.6	60 404	37.2	6 832	4.2
Doctorate level	15 935	100.0	9 473	59.4	3 172	19.9	2 970	18.6	320	2.0
Total	**676 832**	**100.0**	**106 189**	**15.7**	**203 965**	**30.1**	**326 613**	**48.3**	**40 065**	**5.9**

** incl. private non-profit sector*

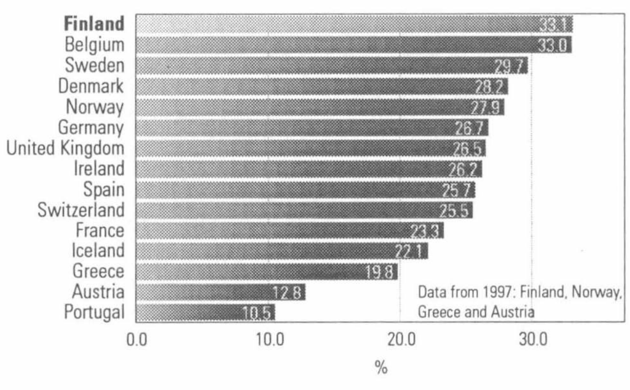


FIGURE 3.10
Persons with a tertiary degree as a proportion of the labour force aged 25 to 64 in selected OECD countries in 1998

Source: OECD Education Database

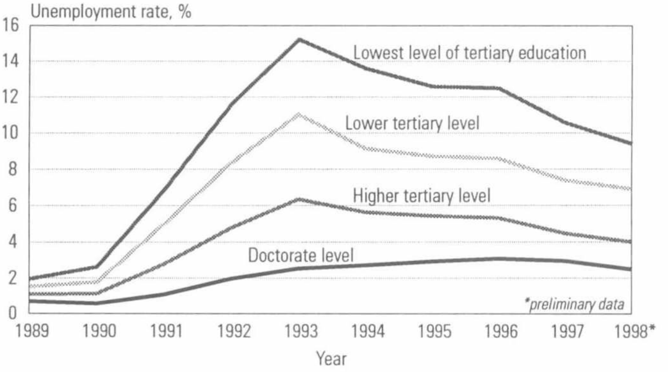


FIGURE 3.11
Unemployment among persons (aged 15 to 74) with a tertiary degree by level of education in 1989–1998

almost four times as many people with a lowest level tertiary degree were out of work.

Tertiary-educated people were by no means unaffected by the wave of unemployment that followed with the recession in the early 1990s (see Figure 3.11). The unemployment rate peaked in 1993 when the average figure for those with a tertiary degree was 12.2 per cent. Since then the figures have dropped by five percentage points, but even so this is still quite some way from the situation of virtual full employment in 1989: at that time only 1.7 per cent of the population with tertiary education were out of work, while the figure for the whole labour force was 4.4 per cent.

Figure 3.12 shows the unemployment rates in 1998 for persons with a higher tertiary degree by specific types of degree; less common degrees have been collapsed into degree categories. Unemployment was highest among Masters of Fine Art and architects at over eight per cent. The lowest figures at less than two per cent were recorded for teachers and persons with a medical degree. Unemployment was also at a

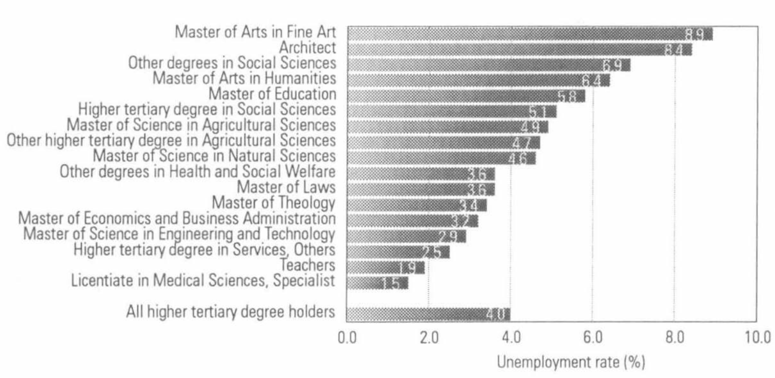


FIGURE 3.12
Unemployment rates among persons (aged 15 to 64) with a higher tertiary degree by type of degree in 1998

relatively low level in service industries[5] and among others with a higher tertiary degree and Masters of Science in Engineering and Technology.

3.4.2 Labour market mobility in the population with tertiary education

Analysis of the mobility of the population with tertiary education provides crucial information on how the national innovation system is working. When they change jobs, people take along with them the knowledge and competencies they have accumulated in their training and in their previous job. The growth and development of a given sector in society, its stagnation or decline will largely depend on whether that sector is a net recipient in the mobility of competent, educated people or whether qualified staff are moving out of the branch.

Using the measure of mobility rate[6], the discussion below looks at the internal mobility of the population with tertiary education in the 1990s. We begin with an overview of how the economic environment is associated with the mobility of the educated population, and then move on to describe the associations of mobility with different background variables[7]. Next, we proceed to examine mobility within and between different industries[8]. Finally, the Chapter concludes with a brief description of the job placement of tertiary-educated people who are out of work and who are not in the active labour force. The results are based on data compiled from Statistics Finland's employment statistics for 1989–1998.

Mobility slowed down with the recession, picked up with economic revival

During the period from 1989 to 1998 the Finnish economy went through some quite exceptional and dramatic fluctuations (Figure 3.13). In the late 1980s the economy was booming, with annual GDP growth standing at around five per cent. Then suddenly, in the early 1990s, recession set in and GDP figures plummeted. Economic revival got under way in 1994, and by

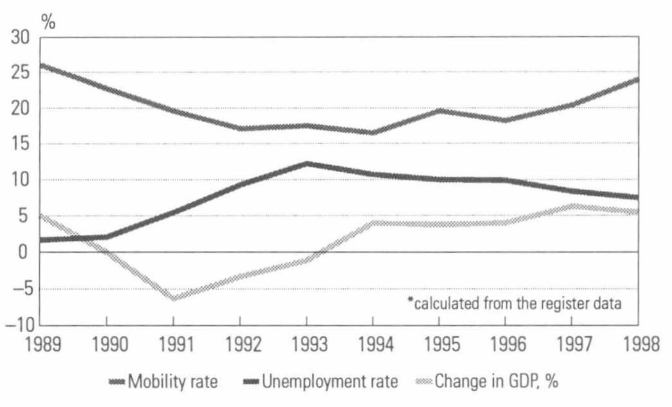


FIGURE 3.13 Mobility and unemployment among population with tertiary education and change in GDP in 1989–1998

5 E.g. Master of Sport Sciences and those with a military training.
6 Number of persons having changed jobs since the previous year as a proportion of gainfully employed population.
7 Industry, employee's gender, age, level of education.
8 IT industries, manufacturing, service industries, public sector.

the end of the period the growth rate was back to the figures recorded before the recession. Unemployment rates among the population with tertiary education followed the same pattern as the business trends, although they did certainly not suffer as badly as the rest of the population. In 1993 their unemployment rate peaked at 12 per cent, when the figure for the rest of the population was close on 25 per cent.

The mobility rate began to decline during the years of recession, only to rise again with economic revival. At times of recession it is obviously much harder for people to find new jobs and they are therefore less likely to change jobs. What is more, the changes that have taken place in Finland's production structures, with the growing prominence of technology-oriented industries, have also affected the demand for labour power: to an ever greater extent now the demand is for people with tertiary qualifications. Another factor contributing to increased mobility is the increasing availability of better jobs.

Education and age have an impact on mobility, gender less so

Around one-fifth of the employed population with tertiary education changed jobs every year in 1989–1998. The mobility of gainfully employed people with tertiary education is somewhat higher than in the rest of the employed population in Finland. In 1998 some 24 per cent of those with tertiary education changed jobs, the figure for other employed groups was 21 per cent.

The mobility rates for men and women did not differ significantly during the period under review. In 1989 the mobility of men (27.5%) was around three percentage points higher than that of women (24.6%). By the end of the period women's mobility (24.7%) was close on two percentage points higher than the corresponding figure for men (23.1%). During the depths of recession there were no gender differences. The trends have been quite similar for different levels of education.

TABLE 3.9
Mobility rates* of the population (aged 20 to 74) with tertiary education by age and level of education in 1989–1998

Age	Mobility rate, %									
Level of education	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Aged 20 to 34										
Total	**35.0**	**30.3**	**25.3**	**21.9**	**22.6**	**22.4**	**26.8**	**25.9**	**28.0**	**31.9**
Doctorate level	35.0	31.7	29.4	27.2	23.1	23.2	32.2	32.5	30.3	32.5
Higher tertiary level	39.8	33.2	28.8	25.9	27.6	26.3	32.6	30.2	32.2	35.2
Lower tertiary level	33.2	28.0	24.1	21.1	21.1	21.3	26.3	27.1	30.9	32.8
Lowest level of tertiary education	33.9	30.0	24.4	20.6	21.0	21.0	24.5	23.6	25.5	30.2
Aged 35 to 74										
Total	**21.1**	**18.5**	**16.7**	**14.8**	**15.2**	**14.0**	**16.7**	**15.1**	**17.3**	**20.8**
Doctorate level	25.8	28.5	27.1	25.2	17.7	16.3	24.5	24.9	22.2	24.8
Higher tertiary level	21.8	19.7	18.4	16.0	17.7	15.2	19.0	17.4	20.1	24.4
Lower tertiary level	21.2	18.6	16.6	14.9	14.7	13.9	15.9	14.3	16.7	19.5
Lowest level of tertiary education	20.5	17.5	15.4	13.6	14.2	13.4	15.6	13.9	15.9	19.4
All										
Total	**26.1**	**22.7**	**19.6**	**17.1**	**17.5**	**16.5**	**19.6**	**18.2**	**20.4**	**24.0**
Doctorate level	26.9	28.9	27.4	25.4	18.3	17.2	25.5	25.8	23.3	25.8
Higher tertiary level	28.0	24.2	21.8	19.1	20.8	18.5	23.1	21.2	23.7	27.6
Lower tertiary level	24.6	21.1	18.4	16.2	16.0	15.2	17.9	16.9	19.8	22.6
Lowest level of tertiary education	25.9	22.5	18.9	16.2	16.6	15.9	18.5	17.0	18.9	22.7

** those having changed jobs since the previous year/employed persons*

Mobility decreases with age. In the age group 20 to 34 the mobility rates were some ten percentage points higher than in the age group 35 to 74 (Table 3.9). Examined by level of education, the mobility of the employed population with a doctorate level or higher tertiary degree has been at a higher level than in the rest of the educated population, and the difference has tended to increase during the period under review. Mobility in the groups with a lower tertiary degree and a lowest level tertiary degree has remained comparatively stable throughout the period and only started to increase in 1998.

Mobility clearly highest in the IT sector

The mobility of staff with tertiary education has been consistently higher in IT sectors[9] than in other branches (Figure 3.14). Also, these sectors did not see mobility rates drop as low as other industries during the recession. In manufacturing[10] mobility rates dropped at the height of recession to around one-half of the figures recorded at the beginning of the period under review: by this time they were lower than in any other branch. Mobility in manufacturing has only started to rise again towards the end of the period concerned. In the public sector mobility rates have been at around 20 per cent for most of the period. However even in the public sector mobility rates have begun to climb again towards the end of the period.

Jobs changes usually within the same industry

Table 3.10 illustrates the between-industry mobility of the gainfully employed population with tertiary education from 1997 to 1998. As we can see most of the mobility takes place within the same industry. Mobility is most clearly concentrated in public and private services (including education and research), where 92 per cent of those who changed jobs in 1998 had worked in the same sector in the previous year. Most of the people moving into the public sector came from services (e.g. trade,

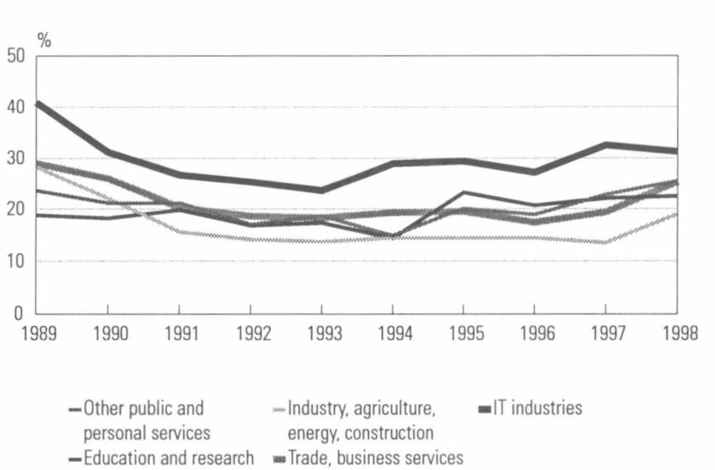


FIGURE 3.14 Mobility rates of the population with tertiary education by industry in 1989–1998

9 Computing machinery and telecommunications equipment manufacture, telecommunication services, computer and related activities.

10 Including agriculture, mining and quarrying, energy, construction.

TABLE 3.10
Mobility* of employed persons with tertiary education by industry from 1997 to 1998

From industry in 1997	To industry in 1998					
	IT industries	Manufacturing etc.	Trade etc.	Education and research	Other public and personal services	Total
No.						
IT industries	6 228	390	839	350	160	7 967
Manufacturing (excl. IT industries), agriculture and forestry, mining and quarrying, energy, construction	896	17 160	4 603	709	1 122	24 490
Trade, hotels and restaurants, transport, business services, other services	2 201	3 942	35 064	1 235	2 777	45 219
Education and research	596	939	1 446	17 955	2 892	23 828
Other public and personal services	533	1 421	3 332	2 891	42 934	51 111
Total	**10 454**	**23 852**	**45 284**	**23 140**	**49 885**	**152 615**
Proportion, %						
IT industries	59.6	1.6	1.9	1.5	0.3	5.2
Manufacturing (excl. IT industries), agriculture and forestry, mining and quarrying, energy, construction	8.6	71.9	10.2	3.1	2.2	16.0
Trade, hotels and restaurants, transport, business services, other services	21.1	16.5	77.4	5.3	5.6	29.6
Education and research	5.7	3.9	3.2	77.6	5.8	15.6
Other public and personal services	5.1	6.0	7.4	12.5	86.1	33.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

** those having changed jobs since the previous year/employed persons*

business activities). A total of some 4,200 people moved into the IT sector from other branches, primarily from services. Some 1,100 highly-educated people moved from the public sector into IT sectors.

Job placement of persons with tertiary education

Table 3.11 describes the gainfully employed persons with tertiary education who were not employed[11] during the year preceding the analysis. In 1998 some 60,000 persons with tertiary education entered the labour market, with the unemployed accounting for 41 per cent, students for 37 per cent and others for 22 per cent. This number was almost twice as high as that recorded during the years of recession at the beginning of the decade. It should be noted, though, that the number of immigrants in the Table is probably too low on account of missing data on education.

11 Unemployed, people not in the labour force, immigrants.

TABLE 3.11
Entry into the labour market among the population* with tertiary education by industry in 1989–1998

Industry	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
IT industries										
Total	**855**	**752**	**505**	**773**	**1 019**	**2 130**	**2 505**	**2 037**	**2 811**	**2 777**
Unemployed	89	69	70	300	465	960	972	563	799	720
Students	564	511	282	340	355	814	1 087	1 069	1 444	1 529
Others	183	154	136	122	174	339	413	347	496	441
Immigrants	19	18	17	11	25	17	33	58	72	87
Manufacturing (excl. IT industries), agriculture and forestry, mining and quarrying, energy, construction										
Total	**6 861**	**6 393**	**4 358**	**5 454**	**7 557**	**11 295**	**10 422**	**9 447**	**10 730**	**9 201**
Unemployed	1 459	1 263	1 101	2 747	4 202	6 726	5 074	3 999	4 874	3 770
Students	3 321	3 084	1 745	1 508	2 038	2 887	3 407	3 467	3 723	3 446
Others	1 926	1 905	1 418	1 128	1 243	1 607	1 840	1 841	1 985	1 818
Immigrants	155	141	94	71	74	75	101	140	148	167
Trade, hotels and restaurants, transport, business services, other services										
Total	**10 177**	**9 036**	**7 045**	**8 779**	**11 857**	**17 054**	**16 553**	**15 787**	**17 335**	**17 118**
Unemployed	1 831	1 547	1 507	3 980	6 048	9 463	7 741	6 403	7 167	6 373
Students	4 994	4 374	3 095	2 600	3 218	4 215	5 057	5 620	5 986	6 453
Others	3 154	2 931	2 308	2 097	2 497	3 253	3 576	3 536	3 941	4 000
Immigrants	198	184	135	102	94	123	179	228	241	292
Education and research										
Total	**5 041**	**5 234**	**5 530**	**6 384**	**5 717**	**7 580**	**8 943**	**8 726**	**8 877**	**8 558**
Unemployed	809	914	1 043	1 996	2 337	3 538	4 019	3 353	3 680	3 160
Students	2 280	3 063	3 321	3 588	2 647	3 139	3 766	4 105	3 806	4 088
Others	1 889	1 162	1 082	736	677	860	1 052	1 161	1 289	1 194
Immigrants	63	95	84	64	56	43	106	107	102	116
Other public and personal services										
Total	**12 161**	**12 422**	**12 527**	**12 622**	**11 833**	**17 368**	**18 460**	**21 171**	**19 987**	**19 287**
Unemployed	1 687	1 499	1 890	3 670	4 827	8 450	8 998	9 666	10 343	9 384
Students	6 169	6 739	6 735	6 143	4 271	6 063	6 251	7 607	5 758	5 845
Others	4 129	3 994	3 765	2 705	2 678	2 793	3 122	3 725	3 723	3 868
Immigrants	176	190	137	104	57	62	89	173	163	190
Unknown										
Total	**2 490**	**2 175**	**2 085**	**2 736**	**3 296**	**4 524**	**4 381**	**3 450**	**3 588**	**2 728**
Unemployed	367	322	501	1 236	1 382	2 585	2 420	1 584	1 631	1 107
Students	619	604	590	608	768	904	940	885	779	622
Others	1 452	1 217	968	875	1 126	999	992	942	1 139	956
Immigrants	52	32	26	17	20	36	29	39	39	43
All										
Total	**37 585**	**36 012**	**32 050**	**36 748**	**41 279**	**59 951**	**61 264**	**60 618**	**63 328**	**59 669**
Unemployed	6 242	5 614	6 112	13 929	19 261	31 722	29 224	25 568	28 494	24 514
Students	17 947	18 375	15 768	14 787	13 297	18 022	20 508	22 753	21 496	21 983
Others	12 733	11 363	9 677	7 663	8 395	9 851	10 995	11 552	12 573	12 277
Immigrants	663	660	493	369	326	356	537	745	765	895

** those who in the previous year were unemployed, not in the labour force and immigrants*

The majority or some 70 per cent of those out of work were people with a lowest level tertiary degree. Those with a lower tertiary degree accounted for 17 per cent, those with a higher tertiary degree for 14 per cent and those with a doctorate level degree for less than one per cent. These figures have been relatively constant throughout the period from 1989 to 1998. About half of the students who were employed had a lowest level tertiary degree, those with a lower tertiary degree accounted for 23 per cent, those with a higher tertiary degree for 26 per cent and those with a doctorate level degree for around one per cent.

3.4.3 Wages and salaries of the population with tertiary education

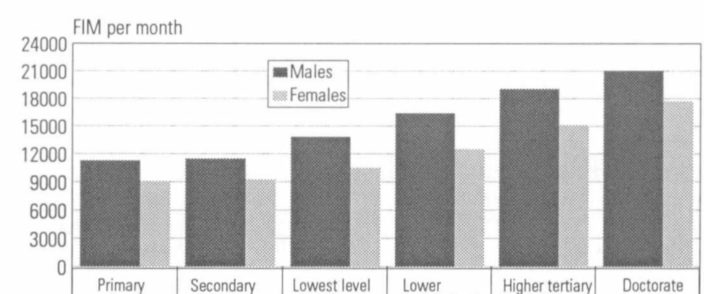
Level of education has a major influence on earnings

Education has a clear impact on earnings. In 1998 the mean monthly income of wage earners in full-time employment was FIM 11,667. A salaried employee with a doctorate level degree earned almost twice as much as an employee with a upper secondary education (Figure 3.15). Women earned some 20 per cent less than men. Level of education influences the difference in earnings levels. The gender difference in average earnings was smallest among employees with a doctorate level degree. The earnings of women with a doctorate level degree were 84 per cent of the salary of men with a corresponding education. It should be noted, though, that the differences between salaries at different educational levels are largely due to the influence of occupation and industry.

Earnings levels also continue to rise for a longer period of time among those with tertiary education. The earnings of employees with a university degree reach their highest level shortly before retirement. This suggests that work experience has a significant impact on earnings.

Highest earnings recorded for males with a doctorate level degree in health and social welfare

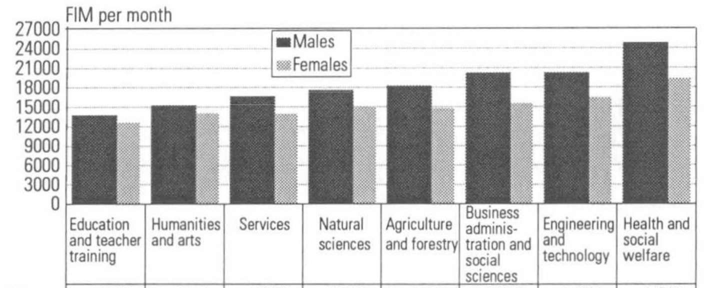
In 1998 the average monthly earnings of the population aged 20 to 64 with a higher tertiary degree and a doctorate level degree were FIM 17,400. The group with the highest earnings (averaging FIM 21,700 a month) were people with an education in health and social welfare: in this branch a male employee with a doctorate level degree earned FIM 25,900 and a woman FIM 21,000 a month. The gender difference in earnings was highest precisely among those with an education in health and social welfare and in business administration and the social sciences (Figure 3.16). In these sectors women's earnings were around 77 per cent of the earnings of men.



	Primary education (1, 2)	Secondary education (3,4)	Lowest level of tertiary education (5B)	Lower tertiary level (5A)	Higher tertiary level (5A)	Doctorate level (6)
All	10217	10462	11799	14687	17145	20092
Males	11266	11469	13823	16394	19042	21036
Females	9061	9224	10504	12480	15073	17693

Level of education (corresponds to ISCED 97 codes)

FIGURE 3.15
Monthly earnings of full-time employees by level of education and gender in 1998



	Education and teacher training	Humanities and arts	Services	Natural sciences	Agriculture and forestry	Business administration and social sciences	Engineering and technology	Health and social welfare
All	12942	14411	16353	16513	16711	17817	19664	21710
Males	13765	15263	16687	17620	18253	20218	20230	24840
Females	12586	14020	13955	14992	14739	15483	16400	19331

FIGURE 3.16
Monthly earnings of the population aged 20 to 64 with a higher tertiary degree or a doctorate level degree by field of education and gender in 1998

The difference between men and women was smallest among those with an education in the educational sciences and the humanities. In these sectors, too, men earned over one thousand marks more than women.

Wages in manufacturing have risen somewhat more slowly than overall earnings

One of the key factors with respect to the appeal of R&D work and the availability of competent research personnel is the pay level relative to other occupations. The discussion below compares the earnings of researchers employed in the manufacturing industry and universities with those in other groups.

During the period from 1990 through to 1999 the wages and salaries of personnel in industrial research and development have increased on average by three per cent a year, which is roughly the same as the increase recorded for all industrial employees (Table 3.12). During the 1990s women's earnings have risen more sharply than those of men. In 1999 the average monthly earnings of employees in industrial research and development was FIM 15,600. The average earnings of all white-collar employees in industry were FIM 14,300.

TABLE 3.12
Earnings of industrial R&D personnel in 1990–1999

1990=100	Research and analysis*			Average for industrial employees		
	Males	Females	Total	Males	Females	Total
1990	100	100	100	100	100	100
1991	105	106	105	105	106	106
1992	105	106	104	106	108	106
1993	108	108	107	109	111	109
1994	112	113	111	113	117	114
1995	121	123	121	121	126	122
1996	123	125	123	124	131	125
1997	122	128	123	126	134	128
1998	127	132	128	123	138	127
1999	131	136	131	130	146	135

* *Research and analysis: such as work at technical and scientific problems, corporate planning, statistical and other analysis and geological research.*

Earnings of university teachers have shown moderate growth

The earnings of university teachers have shown much slower growth between 1990 and 1999 than those of industrial R&D personnel. The average annual increase has been two per cent. In the State sector the earnings of all salaried personnel have on average increased somewhat more rapidly (Table 3.13). The earnings of lecturers and assistants have grown much faster than those of professors. The marked increase in associate professors' earnings from 1998 to 1999 is not, however, reflected in the average pay levels of university teaching staff because the total number of associate professors is no more than a few dozen. In 1999 university teachers earned on average FIM 16,900 a month, professors FIM 23,800 a month, or twice as much as assistants.

TABLE 3.13
Earnings of university teachers in 1990–1999

1990=100	Professors*	Associate professors	Lecturers, teachers	Assistants	Univerisity teachers, on average	Government employees, on average**
1990	100	100	100	100	100	100
1991	105	104	107	106	106	105
1992	105	104	106	106	100	107
1993	106	103	107	109	102	107
1994	106	104	108	110	103	108
1995	111	109	112	114	108	111
1996	113	110	113	117	111	115
1997	113	110	113	116	112	118
1998	108	111	116	120	117	122
1999	109	127	119	123	120	125

* *incl. rectors and directors*
** *monthly paid personnel in the central government sector*

3.5 Expenditure on education

Close on one-third of the education budget goes to tertiary education

In 1998 the total education budget was around FIM 39.5 billion[12], of which tertiary education accounted for around 29 per cent. The majority or 89 per cent of the expenditure on tertiary education was allocated to universities (lower and higher tertiary degrees) and doctorate level studies, the remaining 11 per cent to lowest level tertiary education. Educational expenditure remained roughly unchanged compared to the previous year. However, the share of tertiary education increased during 1998 by a couple of percentage points, while in value terms the figures went up by nine per cent. This increase was recorded for the university (lower and higher tertiary degrees) and doctorate level, while expenditure on lowest level tertiary education declined.

12 Source: International data collection on education statistics UOE (UNESCO, OECD, Eurostat)

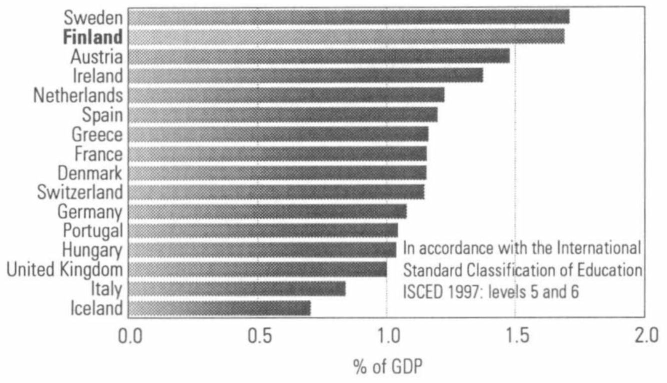


FIGURE 3.17
Expenditure on tertiary education as a proportion of GDP in selected OECD countries in 1997

Source: OECD Education Database

Finland spends somewhat more money on education than OECD countries on average. In 1997 educational expenditure as a proportion of GDP in Finland was 6.3 per cent, while the average for the OECD countries was 5.8 per cent. At the same time the share of tertiary education in Finland was 1.7 per cent. In this respect, too, Finland along with Sweden ranks among the leading European OECD countries (Figure 3.17), with quite a wide margin. In the OECD educational expenditure relative to GDP has risen from 1995 through to 1997 on average by a couple of tenths of a per cent, but in Finland its share has declined by roughly the same amount.

APPENDIX 3.1
Population with a tertiary degree (aged 16 to 64, excl. military training) by level of education, field of study and gender in 1989–1998

Level of education (ISCED 97 code) Field of study	1989		1993		1997		1998	
	Total	of which women	Total	of which women	Total	of which women	Total	of which women
All total	**639 003**	**333 382**	**734 524**	**395 135**	**838 780**	**463 475**	**860 477**	**478 244**
Doctor (6)								
All	**6 265**	**1 207**	**8 071**	**1 884**	**10 542**	**2 957**	**11 282**	**3 286**
Natural sciences	1 529	283	1 948	422	2 536	660	2 705	719
Engineering and technology	734	34	985	77	1 426	153	1 543	170
Medical sciences	2 224	479	2 852	762	3 516	1 206	3 723	1 331
Agricultural sciences	253	72	313	100	383	124	415	143
Social sciences	881	170	1 141	273	1 590	444	1 737	515
Humanities	641	168	829	249	1 078	366	1 147	404
Field unknown	3	1	3	1	13	4	12	4
Licentiate (6)								
All	**4 974**	**1 326**	**6 188**	**1 800**	**7 367**	**2 402**	**7 592**	**2 565**
Natural sciences	1 357	391	1 586	497	1 657	561	1 646	563
Engineering and technology	1 257	117	1 673	177	2 042	281	2 124	313
Medical sciences	102	68	134	93	188	140	208	160
Agricultural sciences	129	47	147	57	155	61	154	59
Social sciences	1 339	383	1 669	541	2 138	805	2 234	881
Humanities	790	320	979	435	1 187	554	1 226	589
Higher tertiary degree (5A)								
All	**126 740**	**56 301**	**152 586**	**72 193**	**183 927**	**91 985**	**192 327**	**97 380**
Natural sciences	14 420	6 318	16 820	7 586	19 886	9 281	20 875	9 860
Engineering and technology	24 670	2 962	28 634	3 888	34 367	5 355	35 822	5 724
Medical sciences	17 010	9 389	19 380	11 333	22 010	13 526	22 898	14 246
Agricultural sciences	6 022	2 264	6 512	2 632	7 251	3 228	7 388	3 341
Social sciences	42 222	19 959	54 533	27 952	68 293	37 546	71 842	40 107
Humanities	22 336	15 369	26 651	18 764	31 948	22 938	33 330	23 992
Field unknown	60	40	56	38	172	111	172	110
Lower tertiary degree (5A) and lowest level of tertiary education (5B)								
All	**501 024**	**274 548**	**567 679**	**319 258**	**636 944**	**366 131**	**649 276**	**375 013**

APPENDIX 3.2
Tertiary degrees completed (excl. military training) by level of education, field of study and gender in 1989–1998

Level of education (ISCED 97 code) Field of study	1989		1993		1997		1998	
	Total	of which women	Total	of which women	Total	of which women	Total	of which women
All total	**36 246**	**20 750**	**42 355**	**26 571**	**42 234**	**25 536**	**39 640**	**24 251**
Doctor (6)								
All	**404**	**138**	**673**	**251**	**924**	**370**	**974**	**390**
Natural sciences	100	40	130	41	201	65	214	70
Engineering and technology	47	5	96	18	150	26	147	22
Medical sciences	146	52	242	114	259	148	274	147
Agricultural sciences	11	5	28	9	36	12	42	20
Social sciences	62	21	106	40	168	74	192	84
Humanities	38	15	70	29	110	45	105	47
Field unknown	–	–	1	–	–	–	–	–
Licentiate (6)								
All	**500**	**167**	**742**	**274**	**851**	**339**	**818**	**371**
Natural sciences	132	48	174	66	195	67	158	60
Engineering and technology	139	15	185	29	201	41	207	52
Medical sciences	20	16	17	16	28	24	40	36
Agricultural sciences	10	2	19	10	13	4	17	6
Social sciences	116	52	214	93	278	137	256	138
Humanities	83	34	133	60	136	66	140	79
Higher tertiary degree (5A)								
All	**8 505**	**4 536**	**10 506**	**5 807**	**11 499**	**6 587**	**11 900**	**6 856**
Natural sciences	906	438	1 122	536	1 237	630	1 422	735
Engineering and technology	1 308	239	1 755	376	2 015	441	2 115	447
Medical sciences	1 248	721	1 555	957	1 606	1 093	1 749	1 196
Agricultural sciences	284	140	276	148	464	270	266	161
Social sciences	3 438	2 033	4 050	2 499	4 384	2 831	4 416	2 916
Humanities	1 318	965	1 710	1 264	1 793	1 322	1 932	1 401
Field unknown	3	–	38	27	–	–	–	–
Lower tertiary degree (5A) and lowest level of tertiary education (5B)								
All	**26 837**	**15 909**	**30 434**	**20 239**	**28 960**	**18 240**	**25 948**	**16 634**

APPENDIX 3.3
Statistical grouping of municipalities

Statistics Finland introduced a new statistical grouping of municipalities in 1989. The new classification allows for more accurate distinctions between urban and rural areas than did the administrative classification of cities and other municipalities.

The municipal classification divides municipalities into three categories according to the proportion of people living in urban settlements and the population of the largest urban settlement:

- Urban municipalities
- Semi-urban municipalities
- Rural municipalities

Urban municipalities include those municipalities in which at least 90 per cent of the population lives in urban settlements or in which the population of the largest urban settlement is at least 15,000.

Semi-urban municipalities are municipalities in which at least 60 per cent but less than 90 per cent of the population lives in urban settlements and in which the population of the largest urban settlement is at least 4,000 but less than 15,000.

Rural municipalities include those municipalities in which less than 60 per cent of the population lives in urban settlements and in which the population of the largest urban settlement is less than 15,000; and those municipalities in which at least 60 per cent but less than 90 per cent of the population lives in urban settlements and in which the population of the largest settlement is less than 4,000.

A list of all municipalities, types of municipalities and changes that have occurred in them are included in the publication '*Municipalities and Regional Divisions Based on Municipalities*' (Handbooks 28, Statistics Finland).

APPENDIX 3.4
Employer sector

The classification of employer sector applied in this report is based on the official Statistics Finland's classification of sectors '*Classification of Sectors 2000*' (Handbooks 5, Statistics Finland).

The classification used in the present report makes a distinction between the following four employer categories:

- State: central government, non-profit institutions serving households and the Bank of Finland
- Municipal sector: local government
- Business enterprise sector: non-financial corporations (public and private) and housing corporations, financial and insurance corporations (excluding the Bank of Finland), social security funds and employer and other own-account workers
- Other or unknown: employees and unknown

4 Resources for R&D

Investment in technological know-how and in finding ways to make the best possible use of new knowledge is crucially important to the competitiveness of the national economy and to social development more generally.

This chapter describes the resources of research and development (R&D) in Finland. The discussion is based on the latest data available on R&D personnel, number of R&D person-years and R&D expenditure. In addition, time series covering the 1990s are consulted.

Most of the figures presented in this chapter are drawn from R&D statistics, which have been compiled at Statistics Finland since 1971. Covering R&D operations within Finland, the statistics are based on data collected from business enterprises, universities, AMK institutions and central university hospitals as well as various public sector organisations. They are compiled in line with EU recommendations as well as the guidelines set out in the OECD manual[1]. Statistics on the university sector include data for central university hospitals from 1997 and for AMK institutions or polytechnics from 1999 onwards.

Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D is a term covering three activities: basic research, applied research, and experimental development.

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation 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 existing knowledge gained from research and/or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

One of the problems with statistics describing R&D is that its definition is open to different interpretations in different units: that definition is necessarily rather loose and therefore it is always down to each individual informant how they want to interpret it and what they consider to be included in R&D. Where comparisons are made across different years it should be borne in mind that statistics today are more comprehensive and detailed than they were earlier. As far as the business enterprises are concerned it should also be noted that while many companies operate in several different industries, their responses concern the whole group's operation.

Chapters 4.1 and 4.2 deal with the *development of R&D resources in general.* Chapters 4.3, 4.4 and 4.5 provide detailed information on *R&D activities in the public (government) sector, university (higher education) sector and business enterprises.* Chapter 4.6 reports on findings from research on the *internationalisation of R&D in business enterprises.* Finally, Chapter 4.7 looks at the *development of government R&D funding* in the 1990s. The data concerning expenditure on R&D in Finland are based mainly on surveys carried out by Statistics Finland. The data on funding are based on figures provided by the Academy of Finland. The primary source of international comparative data is the OECD[2].

1 The Measurement of Scientific and Technological Activities, Frascati Manual 1993, OECD 1994.

2 Main Science and Technology Indicators No. 1 & 2, 2000, OECD.

4.1 Total R&D expenditure

R&D resources have increased rapidly in Finland during the past few years

Finland is investing more and more money in R&D. During the period from 1991 to 1999, R&D input has almost doubled in real terms (Table 4.1). In 1999 a total of more than FIM 23 billion was spent on R&D activities. The average annual growth rate from 1991 through to 1999 has been around 9 per cent (again in real terms), while the figure for 1995–1999 is 14 per cent: clearly the pace has been picking up during the latter half of the decade. Not only has R&D in business enterprises gathered momentum, but R&D expenditure has also been growing in the university sector; by contrast the figures for the public sector have shown little changes. It is estimated that in 2000, this strong growth has brought the sum total of R&D expenditure to almost FIM 26 billion.

Finland's R&D intensity ranks among the highest in the world

The amount of money spent on R&D as a proportion of GDP, is one of the most common indicators used in country comparisons of research investment. 'Research and development' is not always understood and defined in the same way, however, so this is by no means an unproblematic measure. Nonetheless the indicator does provide quite a useful picture of the inputs in science and technology in different countries.

During the 1990s the GDP share of R&D expenditure has shown hardly any growth in the major industrial countries. In Germany, France and the United Kingdom the figures have in fact declined (Figure 4.1). Finland, on the other hand, has steadily increased its R&D input throughout the 1990s: the GDP share of R&D expenditure increased from 2.04 per cent in 1991 to 3.19 per cent in 1999. Finland now ranks among the top countries in the world alongside Japan, South Korea, Sweden and the United States. The latest estimates suggest that the GDP share of R&D expenditure in Finland is the second highest in the world. In the 1990s Finland along with Ireland and South Korea showed the fastest growth in national R&D

TABLE 4.1
R&D expenditure by sector, annual changes in expenditure in real terms (index 1991=100) and GDP share of R&D expenditure in 1991–1999

	Business enterprises		Public sector****		University sector*		Total		GDP share of R&D expenditure*** %
	FIM million	index** 1991=100	FIM million	index** 1991=100	FIM million	index** 1991=100	FIM million	index** 1991=100	
1991	5 798	100	2 126	100	2 248	100	10 172	100	2.04
1993	6 234	104	2 258	103	2 185	94	10 677	102	2.17
1995	8 166	128	2 226	96	2 524	102	12 916	116	2.30
1997	11 396	176	2 430	102	3 446	137	17 272	152	2.72
1998	13 395	201	2 639	108	3 911	151	19 945	170	2.89
1999	15 720	234	2 795	113	4 547	168	23 062	196	3.19

* Incl. university central hospitals since 1997 and polytechnics since 1999; the effect of the research volume of polytechnics (FIM 162.7 million) recorded for the first time was removed from the growth calculation for 1999.
** Deflated by the GDP market price index
*** GDP 1999, Statistics Finland's preliminary data
**** Incl. private non-profit sector

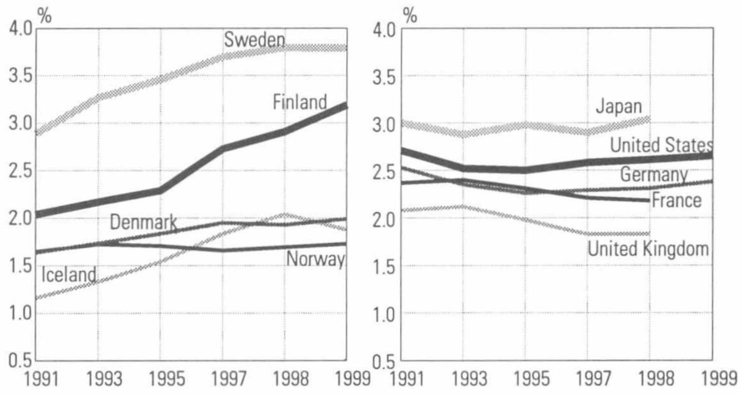


FIGURE 4.1
Development of the GDP share of R&D expenditure in the Nordic countries and selected OECD countries in 1991–1999

Partly preliminary data or estimates
Source: Main Science and Technology Indicators No. 2, 2000, OECD

intensity in the OECD group. Heading this table, Sweden has recorded almost equally rapid growth as Finland. Iceland and Denmark have also been making progress, whereas in Norway the figures have remained more or less unchanged. It is estimated that in 2000, the GDP share of R&D expenditure in Finland will be 3.3 per cent.

In volume terms Finland's R&D expenditure is at a rather low level when compared to other OECD countries. In 1998 Finland accounted for no more than 0.6 per cent of the combined R&D budget of all OECD countries. By far the two biggest spenders, the United States and Japan together accounted for over 60 per cent of the OECD's R&D expenditure (Table 4.2). Germany accounts for just over eight per cent, which makes it the biggest EU country in this comparison.

Japan and the United States both spend more money on R&D than is the average figure for the OECD group (USD 18,511 million) and also have a higher than average R&D intensity. Finland and Sweden, on the other hand, form a very different group with a small volume of R&D expenditure but high R&D intensity. The United Kingdom's R&D expenditure is higher than average, but its R&D intensity is lower than the OECD average.

Business enterprises increasingly significant both in performing and funding R&D

The past decade has also seen quite significant structural changes in R&D. With the rapid increase in R&D expenditure by the business enterprise sector, an ever greater share of all R&D work is done in business enterprises, both in Finland and in other OECD countries. In 1991 R&D in business enterprises accounted for 57 per cent of all R&D expenditure, in 1999 the corresponding figure was 68 per cent (Table 4.3). The main engine behind this growth in the business sector was the electronics industry. In 1997 the business enterprise sector already accounted for over 70 per cent of R&D expenditure in Sweden, the United States, Ireland, Belgium, Japan and South Korea. The share in Finland in 1998 was slightly below the OECD average.

The business enterprise sector not only carries out a greater share of all R&D but also covers a growing proportion of its funding. In 1991 the business enterprises covered some 54 per cent of total R&D expenditure, by 1999 the figure was almost 66 per cent. In 1999 only four per cent of the business enterprises' funding went to projects outside that sector. The relative

TABLE 4.2
Indicators of R&D expenditure in selected OECD countries in 1998

	R&D expenditure	Proportion of R&D expenditure in OECD area	GDP share of R&D expenditure	Business enterprises' proportion of R&D expenditure	Percentage of R&D expenditure financed by government**
	USD million	%	%	%	%
EU	144 990	28.0	1.8	63.6	36.0
Germany	43 557	8.4	2.3	67.9	34.9
France	27 880	5.4	2.2	62.0	40.2*
United Kingdom	23 445	4.5	1.8	65.8	31.1
Italy	12 613	2.4	1.0	53.7	51.1
Netherlands	7 392	1.4	2.0	54.2	37.9
Sweden*	6 845	1.3	3.7	74.8	25.2
Spain	6 117	1.2	0.9	52.1	38.7
Belgium*	4 271	0.8	1.8	71.4	24.9
Austria	3 477	0.7	1.8	–	39.4
Finland	**3 246**	**0.6**	**2.9**	**67.2**	**30.0**
Denmark	2 604	0.5	1.9	62.6	36.1*
Ireland*	1 084	0.2	1.4	73.1	22.2
Portugal*	946	0.2	0.6	22.5	68.2
Greece*	722	0.1	0.5	25.6	53.5
Other OECD countries					
United States	226 653	43.7	2.6	74.6	30.7
Japan	92 663	17.9	3.0	71.2	19.3
South Korea	16 981	3.3	2.6	70.3	22.9*
Canada	12 367	2.4	1.6	62.0	31.9
Australia	6 759	1.3	1.5	45.1	47.8
Mexico*	2 442	0.5	0.3	19.7	71.1
Poland	2 259	0.4	0.7	41.5	59.0
Turkey*	1 997	0.4	0.5	32.3	53.7
Norway*	1 952	0.4	1.7	56.9	42.9
Czech Republic	1 680	0.3	1.3	64.6	36.8
New Zealand*	752	0.1	1.1	28.2	52.3
Hungary	720	0.1	0.7	38.4	56.2
Iceland	141	0.0	2.0	36.6	55.9
OECD Total	**518 114**	**100.0**	**2.2**	**69.2**	**30.7**

Part of data preliminary or estimates
** Data from 1997*
*** Proportion of public administration in R&D funding of universities, research institutes and business enterprises. Does not include public loans.*
Source: Main Science and Technology Indicators No. 2, 2000, OECD

significance of other sectors has accordingly declined. During the 1990s the share of public funding[3] has dropped by more than 13 percentage points. In 1999 its total volume was around FIM 7.3 billion, or close on one-third of total R&D expenditure (Table 4.4). The share of funding from foreign sources has fluctuated during the 1990s.

In 1998 business enterprises accounted for the largest share of total R&D expenditure in

3 Public funding comprises research funded by public administration and the private non-profit sector, general and other funding for universities as well as product development subsidies and loans for business enterprises.

Japan, where the figure was 73 per cent. The figure for Finland was around the OECD average (62%), but clearly higher than in the EU countries on average (55%). The share of the business enterprises remained below 40 per cent in Hungary, Iceland and Poland[4].

Public funding accounted for the largest part of R&D expenditure in Mexico (71%), Portugal (68%) and Poland (59%). In Finland the share of public funding in 1998 was around the average for OECD countries, but well below the EU average.

TABLE 4.3
Proportion of R&D expenditure by performer and funding sector in 1991–1999

	Business enterprises		Public sector*		University sector**		Foreign countries***	Total	
	performer	funder	performer	funder	performer	funder	funder	performer	funder
	%	%	%	%	%	%	%	%	%
1991	57.0	53.8	20.9	29.2	22.1	15.7	1.3	100.0	100.0
1993	58.4	54.5	21.1	30.8	20.5	12.9	1.8	100.0	100.0
1995	63.2	57.7	17.2	25.9	19.6	12.0	4.5	100.0	100.0
1998	67.2	62.1	13.2	23.1	19.6	9.7	5.1	100.0	100.0
1999	68.2	65.5	12.1	22.2	19.7	9.3	3.0	100.0	100.0

* *Incl. PNP (private non-profit sector)*
** *Incl. university central hospitals since 1997 and polytechnics since 1999*
*** *In responses from major corporations funding received from the corporation's foreign enterprises is understood to be own funding, which diminishes the proportion of foreign funding*

TABLE 4.4
R&D expenditure by performer sector and source of funding in 1999

Performer	Source of funding: Business enterprises		Public sector*		University sector**		Foreign countries***		Total	
	FIM million	%	FIM million	%	FIM million	%	FIM million	%	FIM million	%
Business enterprises	14 504	92.3	992	6.3	–	–	224	1.4	15 720	100.0
Public sector	392	14.0	2 201	78.7	–	–	202	7.2	2 795	100.0
University sector	214	4.7	1 933	42.5	2 141	47.1	258	5.7	4 547	100.0
Total	**15 111**	**65.5**	**5 127**	**22.2**	**2 141**	**9.3**	**684**	**3.0**	**23 062**	**100.0**

* *Incl. PNP (private non-profit sector)*
** *Incl. university central hospitals since 1997 and polytechnics since 1999*
*** *In responses from major corporations funding received from the corporation's foreign enterprises is understood to be own funding, which diminishes the proportion of foreign funding.*

4 Data not available for several OECD countries.

Top four regions account for four-fifths of all R&D expenditure

In 1999 the region of Uusimaa in the south of the country accounted for 45 per cent of total R&D expenditure (Table 4.5). The figure for Pirkanmaa was 14, North Ostrobothnia 11 and Varsinais-Suomi 10 per cent. Together, these top four regions accounted for 80 per cent of the country's total R&D expenditure. The two regions that have shown the strongest growth since 1995 are Pirkanmaa and North Ostrobothnia. The share of Uusimaa has declined most, by some three percentage points.

The trends of R&D expenditure from 1995 to 1999 have been most favourable in Pirkanmaa and South Ostrobothnia. In both these regions expenditure has increased in real terms by an average 25 per cent a year. Only two regions have shown negative trends during the same period, i.e. Åland and Kanta-Häme.

Public sector R&D is heavily concentrated in the region of Uusimaa, which in 1999 accounted for 65 per cent of the R&D expenditure in this sector. In the business enterprise and university sector the regional differences are less pronounced: in both cases Uusimaa accounted for 42 per cent of their R&D expenditure. Pirkanmaa accounted for 16 per cent of the business enterprise R&D expenditure. Varsinais-Suomi, Pirkanmaa and North Ostrobothnia each represented 13 per cent of R&D expenditure in the university sector.

TABLE 4.5
R&D expenditure by region in 1999 and 1995

Region	R&D expenditure in 1999					R&D expenditure in 1995		Real* annual change %
	Business enterprises	Public sector	University sector	Total		Total		
	FIM million	FIM million	FIM million	FIM million	%	FIM million	%	1995–1999
Uusimaa	6 662	1 812	1 929	10 403	45.1	6 242	48.3	12.1
Itä-Uusimaa	326	0	–	326	1.4	304	2.4	0.3
Varsinais-Suomi	1 544	78	610	2 231	9.7	1 307	10.1	12.7
Satakunta	324	10	15	350	1.5	251	1.9	7.1
Kanta-Häme	103	150	14	267	1.2	270	2.1	–1.7
Pirkanmaa	2 478	210	567	3 255	14.1	1 254	9.7	25.2
Päijät-Häme	207	1	13	221	1.0	137	1.1	11.2
Kymenlaakso	221	2	4	227	1.0	168	1.3	6.4
South Karelia	192	12	97	301	1.3	216	1.7	7.2
Etelä-Savo	81	20	27	128	0.6	66	0.5	16.4
Pohjois-Savo	179	74	247	500	2.2	297	2.3	12.4
North Karelia	117	44	159	320	1.4	188	1.5	12.6
Central Finland	552	136	241	928	4.0	452	3.5	18.1
South Ostrobothnia	128	3	14	145	0.6	56	0.4	25.1
Ostrobothnia	447	4	45	496	2.1	349	2.7	7.7
Central Ostrobothnia	42	11	1	54	0.2	22	0.2	23.4
North Ostrobothnia	1 966	160	473	2 599	11.3	1 091	8.4	22.5
Kainuu	53	10	24	87	0.4	61	0.5	7.8
Lapland	97	58	68	222	1.0	180	1.4	4.0
Åland	3	0	–	3	0.0	4	0.0	–8.7
Total	**15 720**	**2 795**	**4 547**	**23 062**	**100.0**	**12 916**	**100.0**	**14.0**

** Deflated by the GDP market price index*

R&D largely concentrated in the leading sub-regional units of each region

Within regions, however, there is a very clear tendency for R&D to concentrate in and around the largest sub-regional units. For instance, in 1999 Helsinki and its environs accounted for fully 99 per cent of the R&D expenditure in the Uusimaa region; in North Ostrobothnia the sub-regional unit of Oulu accounted for 96 per cent of R&D spending; and in Pirkanmaa Tampere and environs accounted for 94 per cent of the spending in Pirkanmaa region. In Varsinais-Suomi, there are two such centres: Turku (accounting for 62% of R&D expenditure in the region) and Salo (32%).

This tendency seems to be gathering momentum. In 1995 the three biggest sub-regional units in the country accounted for 64 per cent of total R&D investment, by 1999 the figure was 69 per cent (Table 4.6). On the other hand the share of the largest sub-regional unit, i.e. Helsinki, has declined, while the figures for Tampere and Oulu districts have increased quite substantially, in the case of Tampere by almost five percentage points. Helsinki accounted for 41 per cent, Tampere and environs for 19 per cent and Oulu and environs for 14 per cent of the increase of more than FIM 10 billion recorded from 1995 to 1999. In relative terms the biggest increase during this same period happened in the sub-regional unit of Äänekoski, where R&D expenditure showed an average annual real growth of 43 per cent.

Per capita R&D expenditure in 1999 was by far the highest in Oulu and environs at FIM 14,700. This was more than three times higher than the mean for the whole country (FIM 4,500). Salo and Tampere sub-regional units also recorded figures in excess of FIM 10,000. In addition to these three sub-regional units, others recording an R&D intensity over and above the average for the whole country were Helsinki, Äänekoski, Jyväskylä, Turku, Vaasa and Porvoo.

TABLE 4.6
R&D in the largest sub-regional units by R&D expenditure in 1999 and 1995

Sub-regional unit	R&D expenditure in 1999		R&D expenditure in 1995		Real* annual change of R&D expenditure %	R&D expenditure per inhabitant 1999
	FIM million	%	FIM million	%	1995–1999	FIM/inh.
Helsinki	10 275	44.6	6 139	47.5	12.2	8 829
Tampere	3 072	13.3	1 133	8.8	26.6	10 516
Oulu	2 498	10.8	1 041	8.1	22.8	14 669
Turku	1 393	6.0	851	6.6	11.6	4 970
Jyväskylä	746	3.2	394	3.1	15.7	5 593
Salo	723	3.1	360	2.8	17.4	11 703
Vaasa	429	1.9	304	2.4	7.5	4 862
Kuopio	387	1.7	229	1.8	12.4	3 575
Porvoo	309	1.3	296	2.3	–0.3	4 711
Joensuu	265	1.1	145	1.1	14.6	2 904
Pori	254	1.1	174	1.4	8.5	2 175
Lahti	211	0.9	129	1.0	11.6	1 266
Lappeenranta	204	0.9	140	1.1	8.3	2 968
Äänekoski	162	0.7	37	0.3	42.7	6 696
Kotka-Hamina	154	0.7	111	0.9	7.0	1 724
Whole country	**23 062**	**100.0**	**12 916**	**100.0**	**14.0**	**4 465**

** Deflated by the GDP market price index*

Labour costs account for over half of R&D expenditure

In 1999 wages and salaries accounted for 53 per cent of total R&D expenditure. The share of labour costs was highest in the public sector and lowest in business enterprises (Table 4.7). The share of salaries exceeded 60 per cent in the private non-profit sector and in AMK institutions. In 1991 over half or 56 per cent of all R&D expenditure was spent on wages and salaries.

TABLE 4.7
Salaries as a proportion of R&D expenditure by sector in 1999

Sector	Expenditure total	Salaries	
	FIM million	FIM million	%
Business enterprises	**15 720**	**8 027**	**51.1**
Manufacturing	12 854	6 535	50.8
Other industries	2 866	1 492	52.1
Public sector	**2 795**	**1 638**	**58.6**
Government administrative sectors	2 539	1 493	58.8
Other public institutions	87	40	46.0
Private non-profit sector	169	105	62.1
University sector	**4 547**	**2 582**	**56.8**
Universities	3 966	2 251	56.8
University central hospitals	419	232	55.5
Polytechnics	163	98	60.5
Total	**23 062**	**12 247**	**53.1**

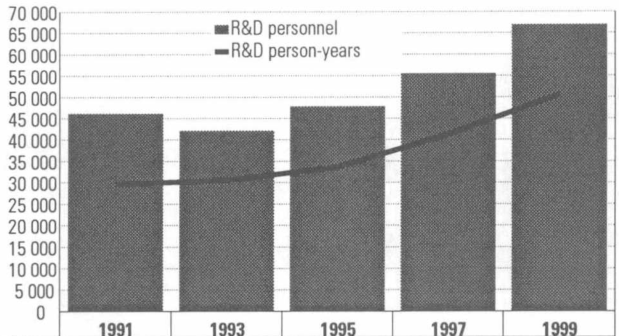
4.2 R&D personnel

Over half of R&D personnel in the business enterprise sector

In 1999 a total of 67,000 people were involved in R&D, over half of them or 54 per cent in business enterprises, 30 per cent in the university sector and 16 per cent in the public sector. Women accounted for almost one-third of R&D personnel. The proportion of women was considerably higher in the public (46%) and university sector (45%) than in business enterprises (22%). The numbers working in R&D have continued to rise throughout the 1990s and in 1999 stood at almost 21,000 more than in 1991 (Figure 4.2). Even if staff working at university hospitals and polytechnics are excluded from these calculations, the average annual growth during the period concerned is over four per cent. The share of women during this period has increased by one and a half percentage points.

Finland ranks among top OECD countries in the number of R&D person-years as well

In 1999 the total number of R&D person-years (full-time equivalent – FTE) recorded in Finland was 50,600, of which business enterprises accounted for 55 per cent, the university sector for 29 per cent and the public sector for 16 per cent. Since 1991 the number of person-years has increased even faster than the number of personnel, by an average of almost seven per cent a year. The university and business enterprise sectors have accounted for most of



	1991	1993	1995	1997	1999
R&D personnel	46 181	42 111	47 866	55 490	66 965
R&D person-years	29 575	30 527	33 634	41 256	50 604

FIGURE 4.2
R&D personnel and R&D person-years in 1991–1999

Incl. university central hospitals since 1997 and polytechnics since 1999

this increase. During the past decade personnel with an academic degree have accounted for an ever greater proportion of the total number of R&D person-years; in 1991 the figure was 47 per cent, in 1999 50 per cent. If staff with AMK qualifications and college engineers are included in the figures, the proportion of staff with a higher education is clearly higher at 65 per cent. The proportion of R&D personnel with a university education was highest (70%) in the university sector. Staff with AMK qualifications and college engineers accounted for one-quarter of the person-years recorded in business enterprises.

Apart from the GDP share of R&D, another useful indicator for purposes of international comparison is the number of R&D person-years as a proportion of the employed population. In 1998 the figure for Finland (18.4) was one of the highest in the OECD and substantially higher than in the EU countries on average (9.4 in 1997). All other Nordic countries also fare quite well in this comparison (Figure 4.3), although it

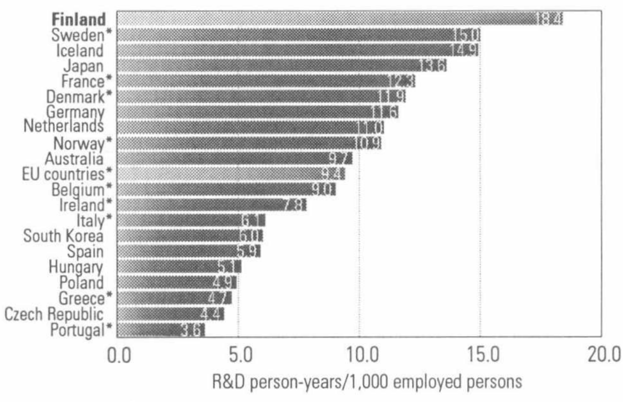


FIGURE 4.3
R&D person-years per one thousand employed population in selected OECD countries in 1998

*Partly preliminary data or estimates; *data from 1997*
Source: Main Science and Technology Indicators No. 2, 2000, OECD

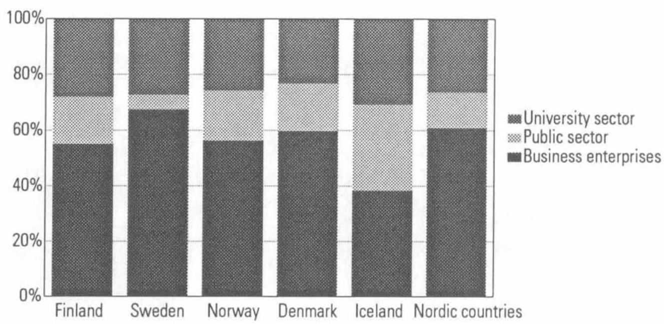


FIGURE 4.4
R&D person-years by sector (%) in the Nordic countries in 1999

Percentages are based on estimates
Source: Nordic Statistical Yearbook 2000, vol. 38. Nord 2000:1. Nordic Council of Ministers, Copenhagen 2000

should be noted that the United States is not included in the statistics.

Business enterprises accounted for the majority of R&D person-years in Sweden (Figure 4.4). In the Nordic countries business enterprises accounted on average for 61 per cent of all R&D person-years in 1999. Sweden does not have a major public sector research institute comparable to the Technical Research Centre in Finland, which goes some way towards explaining the high figure of 67 per cent. In Iceland the share of the public sector was considerably higher than in other countries at over 30 per cent, while the Nordic average was around 13 per cent. Iceland relies very heavily on its fishing industry and as yet there are very few companies in the country that engage in R&D. Nonetheless the most significant change that has happened in the Nordic countries during the 1990s is that business enterprises in Iceland has almost doubled its share of the total number of R&D person-years.

4.3 R&D in the public sector

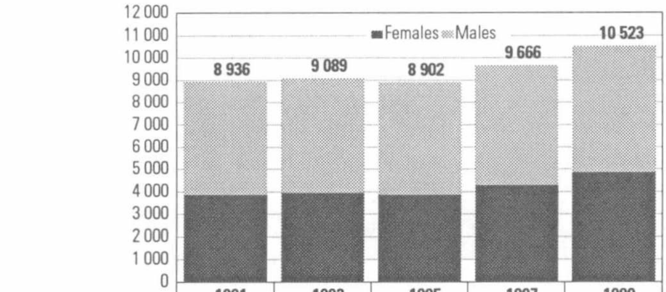
Number of R&D personnel now in excess of 10,000

In 1999 the public sector[5] employed a total of more than 10,500 people in R&D tasks. The figure was more or less constant through the first part of the 1990s, but from 1995 onwards the number has gone up by 1,600 (Figure 4.5). During the latter half of the decade the average annual growth has been in the region of four per cent. Women accounted for 46 per cent, which is somewhat more than earlier during the 1990s.

Among personnel working in R&D, 12 per cent had a doctorate and 44 per cent had some other academic degree. Among men, the figures for 1999 were 16 per cent and 48 per cent; and for women eight and 40 per cent, respectively. In 1991 the share of doctors was less than nine per cent, the figure for other academic degrees was 41 per cent.

In 1999 the total number of R&D person-years was 7,900 (Figure 4.6). Following the slight depression in the early 1990s, the number

5 Public administration, other public institutes and institutions and the private non-profit sector. Municipalities and joint municipal authorities are not covered by the statistics.



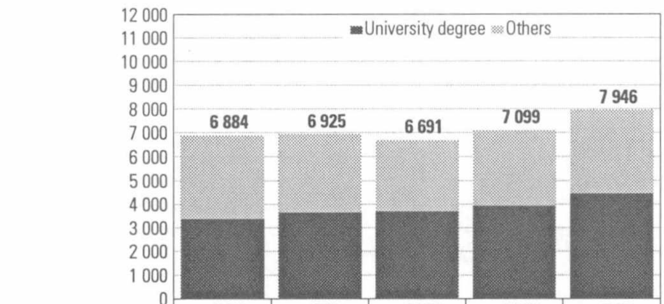
	1991	1993	1995	1997	1999
Males	5 043	5 115	5 030	5 357	5 670
Females	3 893	3 974	3 872	4 309	4 853
Proportion of females, %	44	44	43	45	46

FIGURE 4.5
Public sector R&D personnel by gender in 1991–1999

of R&D person-years has increased since 1995 at an average annual rate of four per cent per annum. From 1991 to 1999 the share of R&D person-years accounted for by staff with an academic degree has increased by seven percentage points. At the same time the share of those with a doctorate has risen from nine per cent to almost 13 per cent.

Engineering and technology by far the biggest field of study

In an analysis of the number of R&D person-years in the public sector, engineering and technology has accounted for the largest proportion throughout the 1990s. Together, engineering and technology and the agricultural sciences account for 60 per cent of all R&D person-years (Table 4.8), although the share of the agricultural sciences has declined by six percentage points since 1991. Nowadays the medical sciences as well as the social sciences account for a greater proportion of R&D person-years. In 1999 there were three fields of study whose individual shares exceeded one-tenth of the total number of R&D person-years in the public sector: the figures for electrical engineering, agriculture and food sciences and forest sciences were around 11 per cent.



	1991	1993	1995	1997	1999
Others	3 478	3 246	2 992	3 143	3 499
University degree	3 406	3 679	3 699	3 956	4 447
Proportion of university degrees, %	49	53	55	56	56

FIGURE 4.6
Public sector R&D person-years by education in 1991–1999

TABLE 4.8
R&D person-years in public sector by field of study in 1991, 1995 and 1999

Field of study	1991	1995	1999	
	%	%	%	No.
Natural sciences	16.1	17.3	16.0	1 269
Engineering and technology	39.1	40.4	37.2	2 952
Medical sciences	7.4	10.2	13.7	1 086
Agricultural sciences	28.5	22.8	22.6	1 793
Social sciences	5.9	6.8	8.7	693
Humanities	2.9	2.4	1.9	153
Total	**100.0**	**100.0**	**100.0**	**7 946**

R&D expenditure increased since 1995

In 1999 public sector R&D expenditure totalled FIM 2.8 billion, up by 0.7 billion on the figure for 1991. In real terms this marks an increase of 13 per cent. This growth has come during the latter half of the 1990s. In regional terms public sector R&D is very much concentrated in Uusimaa: the region accounts for almost two-thirds of both R&D expenditure, R&D personnel and R&D person-years.

R&D most extensive in the administrative field of the Ministry of Trade and Industry

In 1999 public administration accounted for over 90 per cent of public sector R&D expenditure. Other public institutions accounted for three per cent, the private non-profit sector (PNP) for six per cent. The share of the private non-profit sector has doubled since 1991, but part of this is explained by the revisions of the sectoral classification between 1998 and 1999. Measured in terms of R&D expenditure the main R&D forces in the public administration sector are agencies under the Ministry of Trade and Industry (which account for 44% of public administration R&D expenditure). Other administrative branches which invest more heavily in R&D are agencies under the Ministry of Agriculture and Forestry and the Ministry of Social Affairs and Health. The sharpest growth during the 1990s has been recorded for agencies under the Ministry of Transport and Communications, the Ministry of Defence and the Ministry of Social Affairs and Health (Table 4.9): in all these cases R&D expenditure has more than doubled since 1991. On the other hand the Ministry of Education and the Ministry of Agriculture and Forestry have seen their R&D

TABLE 4.9
Public sector R&D expenditure by sector in 1991, 1995 and 1999

Sector	1991		1995		1999	
	FIM million	%	FIM million	%	FIM million	%
Government administrative sectors	**1 969**	**92.6**	**2 043**	**91.8**	**2 540**	**90.9**
Prime Minister's Office	1	0.1	2	0.1	0	0.0
Ministry of Justice	5	0.3	5	0.2	8	0.3
Ministry of the Interior	0	0.0	1	0.1	0	0.0
Ministry of Defence	85	4.0	116	5.2	193	6.9
Ministry of Finance	38	1.8	35	1.6	50	1.8
Ministry of Education	45	2.1	30	1.3	32	1.1
Ministry of Agriculture and Forestry	551	25.9	497	22.3	496	17.7
Ministry of Transport and Communications	42	2.0	58	2.6	121	4.3
Ministry of Trade and Industry	915	43.1	945	42.5	1 127	40.3
Ministry of Social Affairs and Health	179	8.4	276	12.4	419	15.0
Ministry of Labour	2	0.1	4	0.2	0	0.0
Ministry of the Environment	104	4.9	74	3.3	93	3.3
Other public institutions	**87**	**4.1**	**107**	**4.8**	**87**	**3.1**
Private non-profit sector	**69**	**3.2**	**76**	**3.4**	**169**	**6.0**
Total	**2 125**	**100.0**	**2 226**	**100.0**	**2 795**	**100.0**

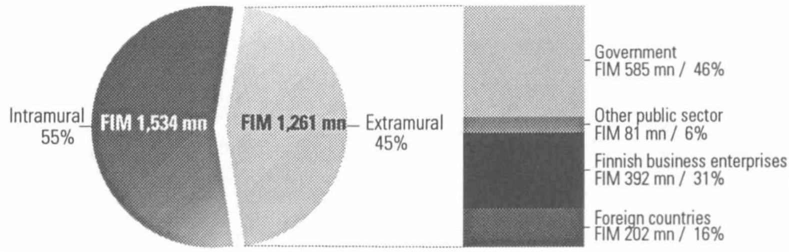


FIGURE 4.7 Funding of public sector R&D expenditure in 1999

expenditure decline during the same period. In the latter case the figure has dropped by eight percentage points in less than a decade.

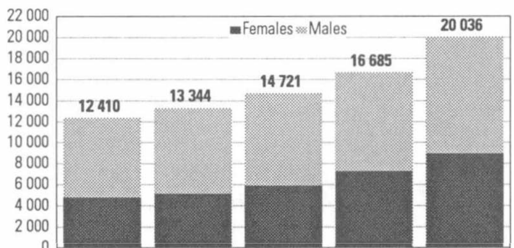
Significance of extramural funding has increased

In 1999 extramural funding accounted for 45 per cent of public sector R&D expenditure (Figure 4.7). Public administration accounted for almost half of public sector units' R&D funding that came from other than core budget funds. Domestic companies accounted for almost one-third of extramural funding, foreign sources for 16 per cent. The significance of extramural funding has clearly increased because in 1991 its share was 34 per cent. At the same time the amount of foreign funding as a proportion of extramural funding has tripled.

4.4 R&D in the university sector

University R&D personnel now numbers over 20,000

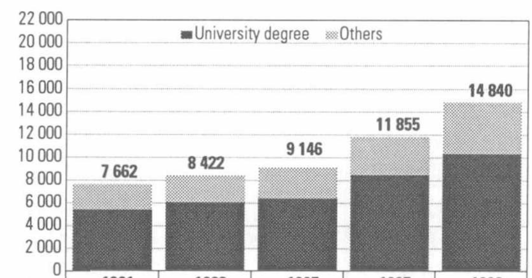
In 1999 a total of some 20,000 persons were involved in university sector R&D. Women accounted for 45 per cent. Both the total number of R&D personnel and the share of women has steadily increased throughout the 1990s (Figure 4.8). In 1999 staff numbers were 60 per cent



	1991	1993	1995	1997	1999
Males	7 621	8 145	8 755	9 404	11 061
Females	4 789	5 199	5 966	7 281	8 975
Proportion of females, %	39	39	41	44	45

FIGURE 4.8 University sector R&D personnel by gender in 1991–1999

FIGURE 4.9
University sector R&D person-years by education in 1991–1999



	1991	1993	1995	1997	1999
Others	2 207	2 324	2 665	3 337	4 445
University degree	5 455	6 098	6 481	8 518	10 395
Proportion of university degrees, %	71	72	71	72	70

higher than in 1991. Over four-fifths or 86 per cent of the R&D personnel worked in universities, eight per cent in central university hospitals and six per cent in AMK institutions.

Over one-third or 34 per cent of R&D personnel in 1999 had a postgraduate education. In 1991 the proportion was marginally higher at 35 per cent. Among men staff with a doctorate or licentiate accounted for 41 per cent, among women the corresponding figure was 25 per cent. The figure for women has been increasing over the years because the corresponding shares in 1991 were 43 per cent and 22 per cent, respectively.

The total number of R&D person-years in 1999 was 14,800, of which the vast majority or 13,600 were done in universities. The number of R&D person-years in central university hospitals was 800, in AMK institutions 500. During the 1990s the number of R&D person-years has been increasing more rapidly than personnel numbers, and in 1999 it was almost double the figure recorded in 1991 (Figure 4.9). However, the share of R&D person-years by staff with an academic degree has remained unchanged.

R&D expenditure has shown rapid growth in the latter half of the 1990s

In 1999 the university sector's R&D expenditure totalled FIM 4.5 billion. Central university hospitals accounted for FIM 419 million, AMK institutions for FIM 163 million. The figures overall have shown rapid growth during the 1990s. From 1991 to 1999, the university sector's R&D expenditure increased in real terms by 68 per cent[6]. This increase has happened during the latter half of the decade and is explained primarily by the growth of extramural funding.

The university sector's share of total R&D expenditure has declined during the 1990s. In 1991 the sector accounted for some 22 per cent, in 1999 for less than one-fifth (19.7%) of R&D expenditure. Excluding the R&D expenditure of university hospitals, the sector's share in 1999 was 17.3 per cent. The university sector's share of all R&D expenditure in Finland in 1998 (19.6%) was higher than the average for the OECD (17.1%), but somewhat lower than the average for all EU countries (20.6%).

The University of Helsinki has accounted for roughly one-quarter of the R&D expenditure of all *universities* throughout the 1990s, although the share did rise sharply from 1998 to 1999 to almost 29 per cent (Table 4.10). At the same time the R&D expenditure at the University of Helsinki exceeded the one billion mark (climbing to FIM 1.1 billion). The Helsinki University of Technology accounted for over 13 per cent and the University of Oulu for almost

6 This figure does not include the effect of the increase in the research volume through AMK institutions, which were included in the statistics for the first time in 1999.

TABLE 4.10
University sector R&D expenditure, proportions of universities and proportion of extramural funding in 1999

University	R&D expenditure		Proportion of extra-mural funding
	FIM (1,000)	%	%
University of Helsinki	1 135	28.6	47.9
University of Turku	346	8.7	46.6
Åbo Akademi University	158	4.0	50.8
University of Oulu	419	10.6	41.4
University of Tampere	230	5.8	42.0
University of Jyväskylä	234	5.9	50.7
Helsinki University of Technology	524	13.2	61.8
Helsinki School of Economics and Business Administration	47	1.2	26.1
Swedish School of Economics and Business Administration	23	0.6	25.9
Turku School of Economics and Business Administration	35	0.9	49.0
University of Vaasa	43	1.1	24.9
Lappeenranta University of Techonology	89	2.3	41.7
Tampere University of Technology	271	6.8	61.8
University of Kuopio	178	4.5	45.7
University of Joensuu	138	3.5	42.1
University of Lapland	48	1.2	34.1
Sibelius Academy	17	0.4	27.7
University of Art and Design Helsinki UIAH	24	0.6	40.7
Theatre Academy	6	0.2	9.0
Universities	**3 966**	**100.0**	**48.4**
University central hospitals	419		96.1
Polytechnics	163		73.4
Total	**4 547**		**53.7**

11 per cent of universities' R&D spending. Together, the five biggest universities accounted for some 60 per cent of the whole sector's R&D expenditure.

Natural sciences and medical sciences predominant in the Nordic countries

The breakdown of R&D expenditure by field of study has remained effectively unchanged from 1997 to 1999[7]. However, the share of the natural sciences has increased by almost two percentage points to 28.3 per cent, while the figure for the medical sciences has declined by roughly the same amount. These two fields of study accounted for over half of the R&D expenditure in this sector (Table 4.11). The relative shares of fields of study are slightly different when we narrow the focus to *universities* (Figure 4.10). In this analysis natural sciences account for almost one-third of R&D expenditure, while the figure for medical sciences is markedly lower.

In a Nordic comparison the natural sciences were the strongest field of study in 1997 not only in Finland but also in Denmark, where they accounted for over one-third of all university sector R&D expenditure (Figure 4.11). In Sweden and Norway the medical sciences recorded the largest share, in Iceland engineering and technology. The share of agricultural sciences was smallest in Finland.

7 Comparisons with the situation prior to 1997 are not meaningful because of differences in field of study classifications.

TABLE 4.11
R&D expenditure in university sector and extramural funding by field of study in 1999

Field of study	R&D expenditure		Extramural funding		
	FIM million	proportion, %	proportion of R&D exp., %	enterprises' prop. of ext. fund., %	proportion of R&D person-years, %
Natural sciences	1 287	28.3	53.6	7.6	64.3
Engineering and technology	868	19.1	60.0	18.4	72.0
Medical sciences	1 080	23.8	63.0	10.4	65.8
Agricultural sciences	111	2.4	65.1	2.4	76.6
Social sciences	812	17.9	43.7	9.6	60.5
Humanities	389	8.5	31.8	1.0	51.3
Total	**4 547**	**100.0**	**53.7**	**10.5**	**64.8**

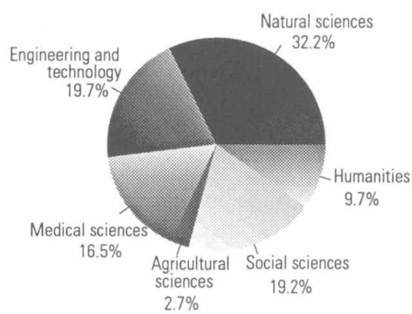


FIGURE 4.10
Universities' R&D expenditure by field of study in 1999

(excl. university central hospitals and polytechnics)

Extramural funding highly significant

Extramural funding for university sector R&D exceeded the amount of university appropriations in the government budget for the first time in 1999; the figure was around 54 per cent. Extramural funding accounted for over 48 per cent of universities' R&D expenditure, for 73 per cent of AMK institutions' expenditure and for 96 per cent of the R&D expenditure of central university hospitals.

The main source of extramural funding is the Academy of Finland. In 1999 Academy funding amounted to some 581 million, accounting for around 24 per cent of extramural funding (Figure 4.12). Funding from the National Technology Agency (Tekes) amounted to FIM 499 million or just over one-fifth. Business enterprises supported university R&D with funding worth FIM 256 million; domestic companies accounted for the bulk of this (84%). The graduate school programme run by the Ministry of Education accounted for just over three per cent of all external funding. The Ministry of Social Affairs and Health alone accounted for the majority (89%) of the extramural funding of university hospitals. In Figure 4.12, over half of the category 'other public funding' comes precisely from the Ministry of Social Affairs and Health.

The significance of extramural funding varies widely between individual *universities*. In 1999 its share was highest at the Helsinki

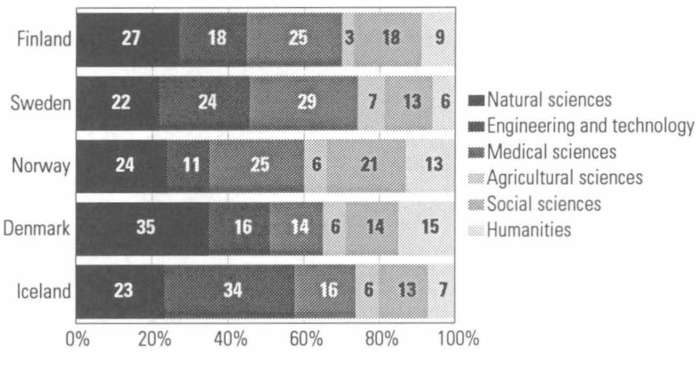


FIGURE 4.11
University sector R&D expenditure by field of study (%) in the Nordic countries in 1997

Source: Smith, Valdemar (ed.), Nordisk FoU-statistik for 1997 og statsbudgetanalyse 1999. The Danish Institute for Studies in Research and Research Policy 2000.

University of Technology and the Tampere University of Technology (at 62% in both). By contrast only less than one-tenth of the funding for the Theatre Academy comes from outside sources.

The significance of extramural funding also varies in different fields of study (see Table 4.11 above). In 1999 at least 60 per cent of the R&D in the agricultural sciences, medical sciences and engineering and technology was funded from external sources. In the humanities and social sciences general university funding accounted for a larger share of total R&D funding than extramural funding. Measured in terms of R&D person-years the share of extramural funding was considerably higher, and its share in all fields of study was at least one-half.

The significance of extramural funding has clearly increased during the 1990s; in 1991 it still accounted for no more than 33 per cent of R&D expenditure. There have been major changes in the relative weight of different funding bodies during the past decade. For instance in 1991 the Academy of Finland accounted for almost 42 per cent of extramural

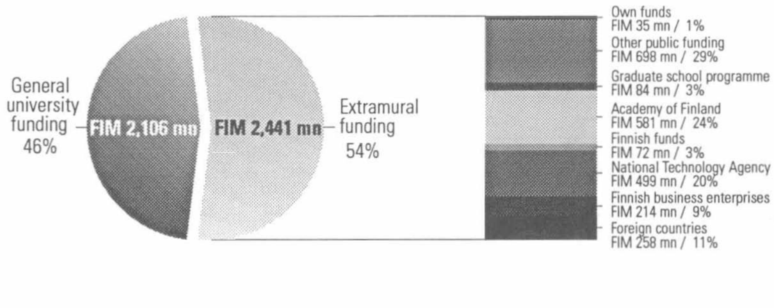


FIGURE 4.12
Funding for university sector R&D in 1999

funding, while the figure for the National Technology Agency was no more than 11 per cent. Today the relative contributions of the two organisations are more or less the same. During the same period the share of universities' own funds has declined from nine to around one per cent.

Co-operation with business enterprises on the increase

The close collaboration that universities have with business and industry is widely considered an important asset that deserves to be supported and promoted. In practice this co-operation assumes the form of R&D projects that are funded by business enterprises as well as jointly funded projects in which businesses are directly involved. Horizontal R&D co-operation aimed at the development of core functions is also common.

R&D funding provided by business enterprises to universities tripled from 1991 to 1999; in real terms the growth stood at 159 per cent. Funding from the National Technology Agency has been a particularly important factor in the increased co-operation. However, the amount of funding from domestic and foreign companies as a proportion of all extramural funding has not increased since 1991, but that has remained at just over 10 per cent. As for AMK institutions (for which the statistics are now compiled for the first time), it would seem that the role of business enterprises in their R&D funding is slightly above the average for the sector as a whole (17% of extramural funding).

The significance of business enterprise funding is greatest in the field of engineering and technology, where it accounted for over 18 per cent of all extramural funding in 1999. Funding from business enterprises had no significant impact in the humanities or agricultural sciences. Funding from foreign companies as a proportion of total business enterprise support was over one-half in the medical sciences, in other fields of study it was insignificant.

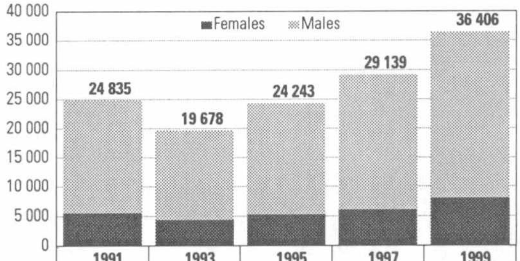
4.5 R&D in business enterprises

The pace of technological development and the ever shorter lifespan of products is forcing business enterprises to step up their investment in R&D. They also use subcontractors and partners in R&D. A growing proportion of R&D today is carried out in the form of informal network co-operation among business. This, however, is not covered by any statistics.

Number of R&D personnel and R&D person-years increased sharply in the 1990s

In 1999 a total of 36,400 persons worked in the business enterprise sector R&D in Finland, with women accounting for 22 per cent of this number. Manufacturing accounted for 76 per cent of the R&D personnel, and 45 per cent of the business enterprise R&D personnel worked in the electronics industry. In the food and chemical industry women accounted for over half of the R&D personnel. In the metal and engineering industry women accounted for no more than eight per cent of the R&D personnel. Staff numbers have risen rapidly following the recession of the early 1990s: in 1999 the number of R&D personnel was twice as high as the figure in 1993 (Figure 4.13). The proportion of women has remained unchanged through this period.

Between 1995 and 1999 the number of personnel has grown most in the electronics industry. In relative terms, however, the growth rate has been fastest in construction, where the number of R&D personnel increased by 65 per cent (Table 4.12). The only industry where the



	1991	1993	1995	1997	1999
Males	19 219	15 283	18 849	23 066	28 381
Females	5 616	4 395	5 394	6 073	8 025
Proportion of females, %	23	22	22	21	22

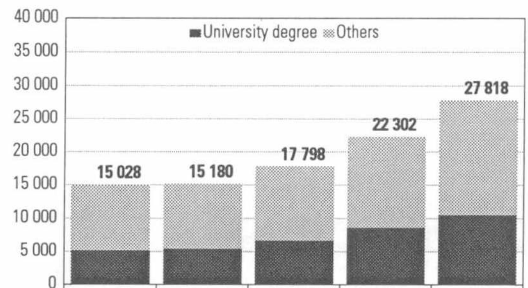
FIGURE 4.13
Business enterprise R&D personnel by gender in 1991–1999

figures dropped at the same time was wood processing.

The total number of R&D person-years in 1999 was 27,800. Following the stagnation in the early part of the 1990s the number of R&D person-years has shown rapid growth (Figure 4.14). From 1993 to 1999, the number of R&D person-years went up by 83 per cent. In absolute terms the number of R&D person-years showed the sharpest growth on the figures for 1995 in the electronics industry. In percentage terms the growth was strongest in research and

TABLE 4.12
Business enterprise R&D personnel and R&D person-years by industry in 1995 and 1999

Industry	R&D personnel 1995 No.	R&D personnel 1999 No.	Change 1995–1999 %	R&D person-years 1995 No.	R&D person-years 1999 No.	Change 1995–1999 %
Manufacturing total	**18 839**	**27 546**	**31.6**	**14 417**	**22 334**	**54.9**
Food industry (SIC 15-16)	745	845	11.8	542	607	12.0
Textile, clothing and leather industry (SIC 17-19)	177	247	28.3	117	169	44.3
Wood processing industry (SIC 20-21)	1 196	1 112	–7.6	860	917	6.6
Chemical industry (SIC 23-25)	3 103	3 397	8.7	2 616	2 864	9.5
Metal and mechanical industry (SIC 27-29,34-35)	3 847	4 981	22.8	2 493	3 333	33.7
Electronics industry (SIC 30-33)	9 129	16 215	43.7	7 457	13 974	87.4
Other manufacturing	642	749	14.3	332	471	41.8
Electricity, gas and water supply (SIC 40-41)	268	304	11.8	159	157	–1.3
Construction (SIC 45)	252	716	64.8	125	275	119.9
Wholesale and retail trade (SIC 50-52)	270	658	59.0	179	400	123.2
Transport, storage and communication (SIC 60-64)	778	1 783	56.4	601	1 275	112.2
Computer and related activities (SIC 72)	1 299	1 969	34.0	675	1 243	84.2
Research and development (SIC 73)	722	1 516	52.4	560	1 275	127.6
Other business activities (SIC 74)	1 485	1 541	3.6	866	657	–24.2
Other industries	330	372	11.4	216	203	–5.9
Business enterprises total	**24 243**	**36 406**	**33.4**	**17 798**	**27 818**	**56.3**



	1991	1993	1995	1997	1999
Others	9 858	9 727	11 118	13 627	17 263
University degree	5 170	5 453	6 680	8 675	10 555
Proportion of university degrees, %	34	36	38	39	38

FIGURE 4.14
Business enterprise R&D person-years by education in 1991–1999

development as well as in construction. In other business activities the number of R&D person-years was one-quarter lower than in 1995.

Proportion of personnel with academic degree has remained more or less unchanged

Following the growth recorded in the first half of the 1990s it would seem that the proportion of R&D person-years accounted for by personnel with an academic degree has stabilised at close on 40 per cent. In manufacturing staff with an academic degree accounted on average for 35 per cent of all R&D years in 1999. The highest figure was recorded in publishing at 66 per cent. In electricity, gas and water supply academic employees accounted for 57 per cent of all R&D person-years.

R&D expenditure has shown strong growth

In 1999 business enterprises invested a total of FIM 15.7 billion in R&D, of which manufacturing accounted for FIM 12.9 billion or around 82 per cent. The figures have shown strong growth in the 1990s. In real terms R&D investment in business enterprises increased from 1991 by 134 per cent.

In 1999 Uusimaa accounted for over 42 per cent of business enterprises' R&D expenditure, Pirkanmaa for around 16 per cent and North Ostrobothnia for almost 13 per cent. In these biggest regions R&D expenditure as a proportion of the whole country's expenditure was greater than these regions' shares of total R&D personnel and R&D person-years. In small regions the situation was the exact opposite. In all regions there has been strong growth since 1995 on all three indicators. The only region where the number of R&D personnel and R&D person-years has decreased is that of Kainuu in the north of the country.

A recent report[8] found that in 1997, Sweden accounted for 52 per cent of the business enterprise R&D expenditure in the Nordic countries; the figure for Finland was 19 per cent, for Denmark 16 per cent and Norway 11 per cent. R&D investment by business enterprises was consistently and substantially higher in Sweden than the Nordic average throughout the 1990s. During the past decade R&D intensity has clearly increased in Finland and Iceland, but dropped in Norway (Figure 4.15).

Electronics industry predominant

Table 4.13 illustrates the R&D expenditure for different industries. The most outstanding

8 Smith, Valdemar (2000): A Comparison of Business Enterprise R&D. In 'Science and Technology Indicators for the Nordic Countries 2000'. A collection of articles (manuscript), p. 35–51.

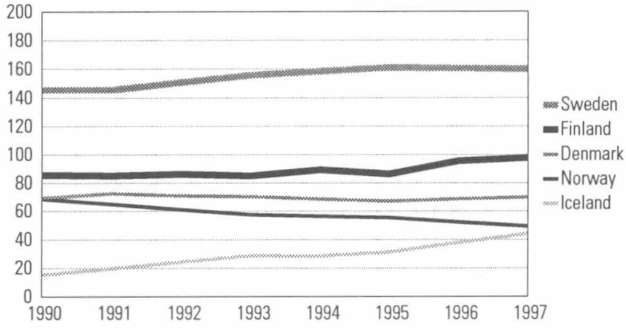


FIGURE 4.15
Relative R&D intensity in business enterprises in the Nordic countries in 1990–1997, Nordic countries=100

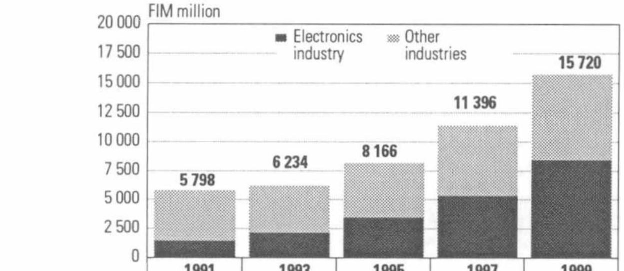
Source: Smith, Valdemar (2000). A Comparison of Business Enterprise R&D

feature in the trends of R&D expenditure during the 1990s has been the steady increase in the role of the electronics industry. At the beginning of the decade the industry accounted for one-quarter of the business enterprise R&D expenditure, but by 1999 the figure had climbed to 54 per cent (Figure 4.16). At the same time as the share of the electronics industry has increased, the figures for all other industries have come down during the latter half of the 1990s.

Figure 4.17 demonstrates the outstanding growth of the electronics industry when compared to other industries. In real terms the

TABLE 4.13
Business enterprise R&D expenditure by industry in 1995, 1997 and 1999

Industry	1995		1997		1999	
	FIM million	%	FIM million	%	FIM million	%
Manufacturing total	**6 632**	**81.2**	**9 159**	**80.4**	**12 854**	**81.8**
Food industry (SIC 15-16)	326	4.0	297	2.6	320	2.0
Textile, clothing and leather industry (SIC 17-19)	43	0.5	61	0.5	75	0.5
Wood processing industry (SIC 20-21)	373	4.6	436	3.8	454	2.9
Chemical industry (SIC 23-25)	1 085	13.3	1 170	10.3	1 323	8.4
Metal and mechanical industry (SIC 27-29,34-35)	1 302	15.9	1 673	14.7	2 014	12.8
Electronics industry (SIC 30-33)	3 349	41.0	5 367	47.1	8 450	53.8
Other manufacturing	155	1.9	155	1.4	219	1.4
Electricity, gas and water supply (SIC 40-41)	75	0.9	176	1.5	166	1.1
Construction (SIC 45)	57	0.7	98	0.9	147	0.9
Wholesale and retail trade (SIC 50-52)	73	0.9	154	1.4	250	1.6
Transport, storage and communication (SIC 60-64)	263	3.2	416	3.7	658	4.2
Computer and related activities (SIC 72)	255	3.1	248	2.2	559	3.6
Research and development (SIC 73)	427	5.2	542	4.8	660	4.2
Other business activities (SIC 74)	277	3.4	388	3.4	303	1.9
Other industries	107	1.3	215	1.9	122	0.8
Business enterprises total	**8 166**	**100.0**	**11 396**	**100.0**	**15 720**	**100.0**



	1991	1993	1995	1997	1999
Other industries	4 289	4 051	4 687	6 029	7 270
Electronics industry	1 509	2 183	3 479	5 367	8 450
Proportion of electronics industry, %	26	35	43	47	54

FIGURE 4.16
Business enterprise R&D expenditure and share of electronics industry in 1991–1999

industry's R&D expenditure has increased almost five-fold from 1991 to 1999, while at the same time all other industries have shown only slow growth or even a declining trend. In the food industry R&D expenditure has actually declined in nominal terms compared to 1995.

Even by international standards the electronics industry's share of total R&D investment in Finland is at a very high level. Comparative data indicate that the average figure for the EU countries in 1997 was 17 per cent, for the Nordic countries 25 per cent. By this time the figure in Finland was close on 50 per cent. On the other hand the investment by other than manufacturing industries in R&D is lower in Finland than in many other OECD countries. In the other Nordic countries there is no single industry that has been as dominant as the electronics industry has been in Finland. The medical industry has a prominent role in Denmark and in Sweden.

Telecommunications products and services by far the biggest product group

Electronic circuits, telecommunications equipment and telecommunications represented the

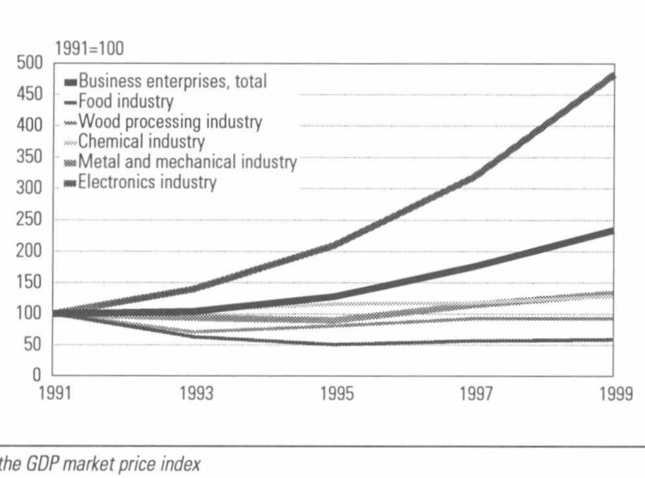


FIGURE 4.17
Development of business enterprise R&D expenditure in real* terms in selected manufacturing industries in 1991–1999

Deflated by the GDP market price index

TABLE 4.14
R&D expenditure in the biggest product groups in 1999, proportions in 1991, 1995 and 1999 and index 1991=100

	1991	1995	1999		Index 1991=100		
	pro-portion, %	pro-portion, %	pro-portion, %	FIM million	1991	1995	1999
Electronic circuits, telecommunications equipment and telecommunications	17.0	33.6	53.1	8 346	100	278	846
Electrical machines and equipment	4.7	6.3	4.8	762	100	190	279
Pharmaceuticals	4.9	5.1	4.1	646	100	145	226
Pulp, paper and paper products	8.2	4.7	3.2	503	100	82	106
Computer and related activities	4.5	3.9	2.8	443	100	123	169
Instruments and precision products	5.4	3.9	2.0	311	100	103	100
Industrial chemicals	6.0	4.1	1.8	287	100	96	83
Total business enterprise R&D expenditure	**100.0**	**100.0**	**100.0**	**15 720**	**100**	**141**	**271**

biggest product group in 1999, accounting for over half of the business sector's R&D expenditure. The second largest group was that of electrical machinery and equipment, accounting for around five per cent. Telecommunications products and services are also the category whose share has shown the strongest growth in recent years. At the same time as the R&D expenditure in the category has increased from around FIM one billion in 1991 to the current figure of FIM 8.4 billion, its share has tripled (Table 4.14). Many other categories have at the same time seen their shares decline. For instance, industrial chemicals were still the third largest group in 1991, today they are no longer even on the top ten list.

R&D is concentrated in large enterprises

In 1999 there were almost 2,500 enterprises[9] with more than ten employees that were engaged in R&D actions. Over one-third or 39 per cent of these were enterprises with 10–49 staff. R&D is heavily concentrated in large enterprises: companies with more than 500 employees accounted for almost three-quarters or 71 per cent of total R&D expenditure in the business enterprise sector. 74 per cent of enterprises with a staff of over 250 had R&D operations. In enterprises with 10–49 staff the proportion was 17 per cent, in enterprises with 50–249 staff 47 per cent. In the electronics industry 55 per cent of businesses with a staff of ten or more were engaged in R&D. In trade, transport and construction, the figures remained at below ten per cent.

In the Nordic countries not only Finland but also Sweden shows a similar tendency for business enterprise R&D expenditure to concentrate heavily in large enterprises. In both countries there are a few enterprises with an extremely prominent role. In Sweden enterprises with more than 500 employees accounted for 90 per cent of the sector's R&D expenditure in 1999. A recent survey[10] indicated that high R&D intensity is associated with a concentrated R&D structure. In Finland the ten biggest enterprises[11] together accounted for 55 per cent of R&D expenditure, in Sweden the corresponding figure was 47 per cent.

Majority of R&D expenditure funded intramurally by company or corporation

In 1999 90 per cent of the business enterprise R&D was funded intramurally by the company

9 Independent company or corporation.
10 See footnote 8
11 See footnote 9

or corporation. This figure has increased to some extent because in the early 1990s it stood at around 87 per cent. The corresponding average for the OECD in 1998 was 87 per cent, for the EU countries 82 per cent and for Japan as high as 97 per cent. The National Technology Agency (Tekes) accounted for just over half of extramural funding, domestic business enterprises for over one-fifth (Figure 4.18).

Support through public R&D funding (National Technology Agency, Finnvera, the Regional Development Fund, public administration, local municipalities and loans and subsidies) as a proportion of funding for business enterprise R&D has decreased by 3.3 percentage points since 1991 (Table 4.15). This is explained by the sharp increase in intramurally-funded R&D within the electronics industry. In other industries the share of public R&D funding has increased to some extent during the past decade.

TABLE 4.15
Public funding as a proportion of business enterprise R&D expenditure in 1991, 1995 and 1999

	1991	1995	1999
	%	%	%
Electronics industy	13.4	5.1	3.1
Other industries	8.2	10.3	9.7
Total	9.6	8.1	6.3

Labour costs about half of all R&D expenditure

Wages and salaries are the biggest single expense item in business enterprises' R&D budget. In 1999 they totalled FIM eight billion, or 51 per cent of R&D expenditure. This share has remained at roughly the same level throughout the 1990s. The next-biggest items were other operating costs (18%) and purchased services (11%). The share of costs related to buildings, materials and equipment and other acquisitions was less than 10 per cent.

Almost two-thirds of R&D consists of product development

In 1999 almost two-thirds or 63 per cent of business enterprise R&D expenditure went to product development, 31 per cent to the development of processes and production methods and the remaining six per cent to research with no immediate product or process application. The structure of expenditure has changed considerably because in the early 1990s some three-quarters of the money still went directly to the development of new products. In

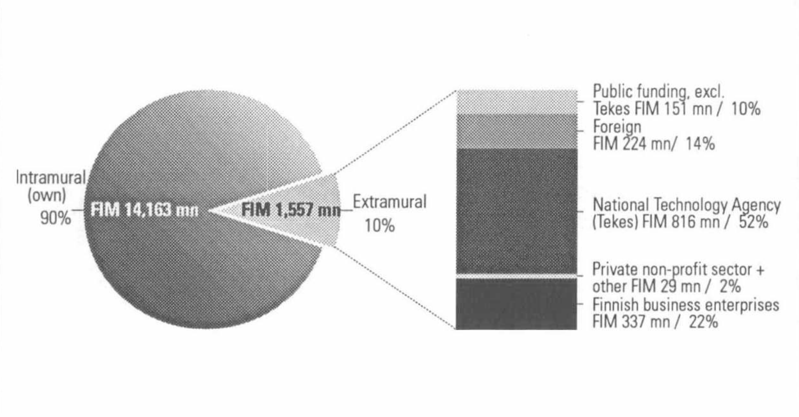


FIGURE 4.18
Funding of business enterprise R&D expenditure in 1999

1999 the share of R&D directly related to products was highest at almost 90 per cent in the manufacture of vehicles, instruments and textiles. In the production of basic metals 64 per cent of R&D consisted of development related to processes. In agriculture, forestry and fishing, the share was even higher at 71 per cent. In manufacturing the highest proportion of R&D with no concrete product or process application was recorded in pulp and paper manufacture, in other industries in post and telecommunications, where the figure was 19 per cent.

4.6 The internationalisation of business enterprise R&D

A time of globalisation and rationalisation

In the 1990s enterprises have had to adapt to an increasingly competitive business environment by way of globalisation and rationalisation. The internationalisation of business and the growing role of multinational corporations are basically the outcome of the production of immaterial products. These commodities include the know-how produced within the domain of research and development. Traditionally business enterprise R&D has not shown as strong an international orientation as production and marketing, but it follows the general trends in development. With the rapid increase in cross-border investments by high technology business, it would seem that internationalisation is gathering momentum.

There are three main reasons why the globalisation of R&D is of current interest. Firstly, technological know-how is crucially important with respect to competitiveness in any industry. Secondly, the liberation of trade and the deregulation of capital movements have paved the way to the growth of global markets and resources. Furthermore, the rapid development of information technology has made it possible to co-ordinate and monitor the operation of multinational corporations on a global scale and at the same time allowed for global technology strategies.

Most enterprises have foreign-based R&D operations in those areas where they are strong at home. Increasing numbers of Finnish firms are relocating their R&D operations abroad in an attempt to take advantage of the most advanced know-how and technology in the field. In the electronics industry in particular, the R&D units of foreign firms located in Finland are here to serve the global markets in their own special areas of expertise.

The discussion below takes a closer look at some of the changes that have taken place during the 1990s in the internationalisation of business enterprises' R&D operations. The text reports the results of a joint project[12] of the Research Institute of the Finnish Economy (Etla), Statistics Finland and the Technical Research Centre, which studied the foreign R&D operations of Finnish firms[13] and on the other hand the Finnish operations of subsidiaries of foreign firms[14].

4.6.1 Internationalisation of R&D in Finnish firms

Surveys concerning Finnish firms' R&D abroad were directed to two different groups of firms: 19 largest Finnish industrial multinational companies and to some 500 other large and medium-sized companies. The coverage of these

12 Pajarinen, Mika & Pekka Ylä-Anttila (eds.). Cross-border R&D in a small country. The Case of Finland. Taloustieto Oy, Helsinki 1999.

13 Koskinen, Jussi. Internationalization of R&D in Finnish firms. In 'Cross-border R&D in a small country', p. 11–39.

14 Pajarinen, Mika. Foreign firms and their R&D in Finland. In 'Cross-border R&D in a small country', p. 91–134.

two surveys was about 86 per cent of total industrial R&D made by Finnish companies in Finland in 1998, measured in terms of R&D expenditure.

Internationalisation of R&D quite heavily concentrated in major companies

Major companies accounted for over 90 per cent of Finnish' firms R&D expenditure abroad in 1998. However, production remains far more international than R&D, for instance, both in Finland and in the other Nordic countries. In 1998 the total R&D expenditure of the enterprises included in the study was FIM 13.3 billion, of which FIM 3.4 billion or 26 per cent was spent through R&D units abroad (Table 4.16). In major Finnish companies the proportion of foreign-based R&D was 31 per cent, in other large and medium-sized companies nine per cent. 23 per cent of R&D personnel were located abroad. The proportion of foreign-based R&D personnel was consistently smaller than the share of international R&D expenditure with the exception of the major companies in the metals, engineering and electronics industry and other companies in the non-manufacturing industry.

Metals, engineering and electronics account for four-fifths of foreign-based R&D expenditures

In an analysis comprising all companies the proportion of foreign-based R&D expenditure was highest in other manufacturing industry with 35 per cent. The proportion was at least one-fifth in all industries represented by major companies. It was highest in the other manufacturing industry, where it was as high as 73 per cent. In other large and medium-sized companies the proportion of foreign-based R&D expenditure was highest (16 per cent) in the metals, engineering and electronics industry. In all other industries it was five per cent or less. Measured by foreign-based R&D personnel, then the metals, engineering and electronics industry is the most internationalised industry. This industry accounted for up to 80 per cent of all foreign-based R&D expenditure.

TABLE 4.16
R&D expenditure, personnel and foreign shares in 1998 in the companies included in the study

Industry	R&D expenditure (FIM million)			R&D personnel		
	All companies	Major companies*	Other large and medium-sized companies	All companies	Major companies*	Other large and medium-sized companies
Wood processing	580	500	80	1 410	1 050	360
– foreign share, %	18	21	0	11	15	0
Chemical	1 200	730	470	2 670	1 310	1 360
– foreign share, %	25	38	5	14	26	2
Metals, engineering and electronics	10 030	8 690	1 340	20 390	16 610	3 780
– foreign share, %	27	29	16	27	30	12
Other manufacturing	820	370	450	2 060	750	1 310
– foreign share, %	35	73	4	25	61	3
Non-manufacturing	710	–	710	2 370	–	2 370
– foreign share, %	4	–	4	4	–	4
Total	**13 340**	**10 290**	**3 050**	**28 900**	**19 720**	**9 180**
– foreign share, %	**26**	**31**	**9**	**23**	**30**	**7**

** 19 large multinational companies*

Most of the foreign-based R&D expenditure is concentrated in Europe

Most of the foreign-based R&D investments by Finnish-owned companies are performed in European countries. In 1998 Europe accounted for around two-thirds, North America for 29 per cent. The share of Asia and Australia was four per cent. However, there are quite notable differences in this geographical breakdown between different industries. In the chemical industry foreign-based R&D investment was least Eurocentric, with North America accounting for about half of R&D expenditure. The United States was recognisably the most significant single host country in this comparison, accounting for 27 per cent of R&D expenditure abroad. The figure for the Great Britain was 16 per cent, for Germany 15 per cent and for Sweden 13 per cent.

Foreign-based investment showed strong growth in the late 1990s

Investment in foreign-based R&D has increased. In 1998 major companies performed 31 per cent of aggregate R&D expenditure abroad, while the proportion in 1993 was 28 per cent (Table 4.17). The share actually decreased in the mid-1990s mainly as a result of the strengthening of the Finnish markka, but then increased by five percentage points from 1997 to 1998. This increase was attributable to the metals, engineering and electronics industry: 85 per cent of the total increase in foreign-based R&D expenditure in 1993–1998 occurred in this industry. Nonetheless foreign-based R&D expenditure in this industry as a proportion of its total R&D expenditure hardly increased at all during these years. In other manufacturing industries(e.g. food industry and the manufacture of non-metallic mineral products), by contrast, the proportion of foreign-based R&D expenditure increased at the same time from 45 to 73 per cent.

Number of foreign-based R&D personnel has shown uninterrupted growth

Unlike the proportion of foreign-based R&D expenditure, the share of foreign-based R&D personnel has increased steadily in major companies during the period from 1993 to 1998. The proportion now is 30 per cent, with the number standing at around 6,000. In the wood processing industry the share has increased 2.5-fold over during the period under review. In volume terms the growth has been sharpest in the metals, engineering and electronics industry.

TABLE 4.17
R&D expenditure, personnel and foreign shares in 1993–1998 in the major companies included in the study

Industry	R&D expenditure (FIM million)				R&D personnel			
	1993	1995	1997	1998	1993	1995	1997	1998
Wood processing	310	420	470	500	1 020	1 140	1 070	1 050
– foreign share, %	12	15	20	21	6	9	13	15
Chemical	550	560	710	730	1 380	1 310	1 380	1 310
– foreign share, %	34	32	38	38	19	21	25	26
Metals, engineering and electronics	2 300	3 850	6 400	8 690	5 130	9 400	13 540	16 610
– foreign share, %	27	24	23	29	24	24	26	30
Other manufacturing	180	280	350	370	470	690	720	750
– foreign share, %	45	63	75	73	35	54	62	61
Total	**3 340**	**5 110**	**7 930**	**10 290**	**8 000**	**12 540**	**16 710**	**19 720**
– foreign share, %	**28**	**26**	**26**	**31**	**22**	**24**	**27**	**30**

In 1998 the number of foreign-based R&D personnel in the industry was four-fold compared to 1993. The majority or 69 per cent of the foreign-based R&D personnel worked in European countries in 1998. The figure for North America was 26 per cent and for Asia and Australia five per cent.

Motivation to support local production and marketing

Some three-quarters of the foreign-based R&D units of major companies had been merged with the corporations before 1994, usually through an acquisition. In 1997 almost half or 46 per cent of the major companies' R&D units located abroad were support units focused on giving support to local production and marketing. 41 per cent were development units with R&D focused on the whole business division or its line of business and 13 per cent were R&D centres serving the whole group. In the metals, engineering and electronics industry R&D centres accounted for 21 per cent, in all other industry sectors the corresponding figure was under ten per cent.

Demand-side factors such as giving support to local production and marketing and getting into closer contact with important markets were widely regarded in major companies as the most important motives for the internationalisation of R&D activities. In other large and medium-sized companies co-operation with local enterprises was also regarded as crucially important. However, supply-side factors such as acquiring technology and good availability of skilled R&D personnel seem to have an increasingly important influence. Foreign-based R&D units are today increasingly engaged both in developing new technologies and monitoring technological development abroad. All in all the internationalisation of R&D operations is crucially important to business competitiveness.

According to data from 1997 the most important co-operation partners for major companies' foreign-based R&D units were the group's R&D centre (62% of the responses mentioned this option), customers (55%), the group's other R&D units and affiliates in Finland (52%).

Swedish firms have advanced further with the internationalisation of R&D

A corresponding Swedish survey concerning the situation in 1997[15] shows that the 20 largest Swedish manufacturing groups are more internationalised than their 19 Finnish counterparts. In Swedish major groups foreign R&D expenditure accounted for 36 per cent and foreign-based R&D person-years for 39 per cent in 1997; the corresponding figures for the major companies in Finland in 1998 were around 30 per cent. In both countries the majority of foreign-based R&D personnel work in Europe (in Finland 69% and in Sweden 62%), and the three top countries are also the same: the United States, the United Kingdom and Germany. Likewise, the R&D investments in major Swedish companies are concentrated in the metals, engineering and electronics industry.

Investment survey shows that foreign-based R&D is growing rapidly

Data published by the Confederation of Finnish Industry and Employers (TT) also confirms that the growth of R&D in Finnish enterprises is largely attributable to foreign operations. The investment survey[16] carried out in April 2000 mainly among businesses in included the TT business tendency survey sample shows that in 1998 almost 23 per cent of the R&D expenditure by the manufacturing industry was spent abroad, in 1999 the figure was over 28 per cent and in 2000 enterprises were *planning* to spend 33.6 per cent abroad. This would mean an increase of 168 per cent in industrial R&D expenditure abroad from 1998 to 2000, while input in Finland would be up by 55 per cent.

During the period from 1998 to 2000 North America is becoming an almost equally important target of R&D investments as the European Union. The share of North America is

15 NUTEK & Statistics Sweden (1999). Forskning och utveckling i internationella företag (Research and development in international companies) 1997, Nv 18 SM 9901.

16 Investment survey, May 2000. Confederation of Finnish Industry and Employers.

set to increase within the space of just a couple of years from 35 to 42 per cent, at the same time as the figure for the EU will drop from 58 to 49 per cent. Less than one-tenth of all R&D expenditure currently goes to other countries, mainly Asia.

It is estimated that from 1998 to 2000, foreign R&D expenditure by the metal and electronics industry as a proportion of total foreign-based expenditure of business enterprises is going to rise from 82 to 94 per cent. At the same time the figures for other all industries are set to decline.

During the same time period the number of foreign-based R&D personnel is set to increase by 73 per cent, the figure for those working in Finland by 34 per cent.

4.6.2 Foreign firms and their R&D in Finland

The figures reported in this section are based on the first more detailed study that has been done on foreign firms' R&D activities in Finland. The material utilised included Statistics Finland's R&D statistics for 1997 and to some extent estimates concerning 1998, as well as the results of innovation surveys. As foreign-owned are defined those firms where over 50 per cent of the voting rights are in the control of a foreign owner. They are thus Finnish affiliates of a foreign parent company.

Foreign firms have a positive impact on economy

As yet investments by foreign-owned firms in Finland have been quite modest, but they have intensified the national economy during the 1990s. It would seem that foreign ownership has a positive influence on the development of the Finnish economy. Foreign firms often have positive spillover effects; these include the diffusion of technology in its new forms, which may benefit the whole economy.

Study results suggest that foreign firms are inclined to invest in industries at a relatively high level of technology, which points at their willingness to make good use of existing technological knowledge and know-how. Subsidiaries of foreign multinational corporations have been growing very rapidly following acquisitions especially in high technology industries.

In 1997 there were in Finland a total of some 1,800 foreign-owned firms, which employed a total of over 100,000 people[17]. These affiliates accounted for less than one per cent of all companies in the country, but for some nine per cent of the total business sector employment. In other words foreign-owned firms were larger than average, and the shares increased with increasing company size. Over half of the foreign affiliates were active in the wholesale and retail trade sectors.

Foreign-owned firms perform R&D more often than firms in Finland, on average

In 1997 some 140 or eight per cent of all foreign affiliates performed R&D in Finland[18]. R&D activity was concentrated in manufacturing firms, where more than one in three foreign affiliates had R&D. The proportion of foreign-owned firms with R&D operations was larger than the corresponding proportion for all firms in the country. Measured in terms of both R&D expenditure and personnel number the most important foreign-owned firms in Finland came from Sweden, the United States and Switzerland. The share of US-owned companies has been increasing in recent years.

Majority or 60 per cent of the total foreign affiliates' R&D expenditure in Finland focuses on telecommunications and other electrical engineering products, as is the case among

17 103,865 in 1997, 127,127 in 1998.

18 According to a company interview carried out by Taloustutkimus Oy in June 2000 among foreign-owned firms in Finland, 45% of these were engaged in R&D. However this figure is not directly comparable to the data collected by Statistics Finland. Source: Pajarinen, Mika & Pekka Ylä-Anttila. Countries Compete for Investment – Finnish Technology Attracts Foreign Firms, p. 30. ETLA, Series B 173, Helsinki 2001.

Finnish-owned firms. Foreign affiliates' accounted for 14 per cent of total R&D spending in this product group in Finland. Other major product groups are machinery and equipment as well as chemicals and pharmaceuticals.

Most of the R&D spending of foreign-owned firms is concentrated in large firms, and in 1997 nearly 90 per cent of the expenditure was allocated to product development. Process development accounted for ten per cent, basic research for less than one per cent. The figures for Finnish-owned firms were 77, 16 and seven per cent, respectively.

The total number of personnel in foreign-owned firms in 1998 was 3,300. On average, the R&D personnel in foreign affiliates has had a somewhat higher level of education than that in the group of Finnish-owned firms. Around 43 per cent of the personnel in the former category and 38 per cent in the latter category had a university degree.

R&D by foreign-owned firms in Finland is concentrated in high technology

Foreign-owned firms have increased their share of total business sector R&D expenditure in Finland during the past decade; the figure currently stands at 14 per cent compared to less than ten per cent in 1990. Most of the increase took place in the early 1990s, during the latter half of the decade the trends have tended to fluctuate more. In 1998 total expenditure amounted to FIM 1.9 billion (in 1995 some FIM 1.2 billion). High technology industries[19] account for around 80 per cent of all expenditure, and in these industries foreign-owned firms have accounted for a larger than average proportion of all R&D expenditure. R&D by foreign-owned firms in Finland is thus mainly concentrated in high technology. On the other hand the role of foreign-owned firms in such branches as the food, textiles and forest industries has been minor, although increasing as a result of recent mergers and acquisitions. In the chemical industry and in construction-related sector, too, foreign-owned firms have increased their share of R&D expenditure. During the past decade foreign firms have acquired many Finnish construction sector firms.

In 1991–1998 R&D expenditure showed slower growth in foreign-owned enterprises than in Finnish companies. Nonetheless subsidiaries that have operated in Finland for a longer period of time did show strong growth. R&D expenditure has also increased in the Finnish subsidiaries taken over by foreign enterprises in the early 1990s following the change in ownership.

Majority of foreign-owned firms plan to increase their R&D in Finland

A recent company interview[20] shows that over 80 per cent of foreign-owned firms that already had R&D operations in Finland also had plans to step up their R&D effort. Accordingly 14 per cent of the firms that still did not have any R&D operations in Finland were planning to start R&D. In particular, major companies and export-oriented companies were planning to increase they R&D investment.

4.7 Government R&D funding

The Academy of Finland has since 1975 prepared annual surveys on the development of government funding for R&D (Government Budget Appropriations or Outlays for R&D – GBAORD). The Academy's budget analysis provides up-to-date information on government

19 E.g. electronics and telecommunications equipment and manufacturing of chemicals and pharmaceuticals.

20 See footnote 18

funding for R&D in different administrative sector and organisations and also according to the social policy orientation of R&D.

The budget analysis is aimed at assessing the objectives of the government and different ministries with respect to supporting R&D. The estimates of government R&D funding are based on appropriations specified in the budget proposal. In addition, the Academy reviews the future plans of ministries and research-funding organisations. R&D expenditure in universities is estimated using Statistics Finland's R&D statistics, which are used to extract the proportion to be used for R&D purposes.

Owing to differences in the way the Academy's budget analysis and Statistics Finland's R&D statistics are compiled, the two sets of figures are not the same. The data on government R&D funding are based on the Academy's annual review. The latest of these reviews[21] concerns the year 2000.

Some 4.6 per cent of government expenditure goes to R&D

In its budget proposal for 2000 the government earmarked a total of FIM 7.6 billion to R&D, which represents 4.6 per cent of total government expenditure excluding the costs of national debt (Table 4.18). Nominal funding remained at more or less the same level as one year previously, but in real terms the amount of funding dropped by some two per cent.

In nominal terms government R&D funding has increased from 1991 to 2000 by 60 per cent, at the same time as all government expenditure (excl. the costs of national debt) has remained more or less unchanged. The government's supplementary R&D funding in 1997–1999 significantly raised the level of government R&D funding. Today, Finland ranks among the world's leading countries in terms of its investment in R&D. From 1996 to 1997 R&D funding increased in real terms by no less than 23 per cent. The year 1997 thus marks an important turning-point as far as R&D funding is concerned. Although the annual real change in funding has fluctuated during the 1990s, sometimes increasing and sometimes declining, the overall figures shows an annual increase of some five per cent.

The government is committed to further increasing its funding for R&D in 2001–2004.

TABLE 4.18
R&D appropriations in government budgets in 1991–2000

Year	Government expenditure (excl. debt)	R&D funding	R&D funding as a proportion of government expenditure	Real change	
				Government expenditure	R&D funding
	FIM million	FIM million	%	%	%
1991	161 890	4 755	2.9		
1992	176 983	4 993	2.8	7.3	2.9
1993	185 220	5 240	2.8	6.5	4.9
1994	175 825	5 275	3.0	–5.6	–1.3
1995	173 747	5 532	3.2	–2.0	3.9
1996	170 393	5 582	3.3	–2.5	–1.7
1997	165 476	7 039	4.3	–3.5	23.1
1998	163 281	7 430	4.6	–2.7	2.9
1999	164 212	7 584	4.6	2.9	0.1
2000	165 097	7 604	4.6	–1.4	–1.7

21 Kolu, Timo: Research and Development Funding in the 2000 State Budget Proposal. Publications of the Academy of Finland 1/00. Edita, Helsinki. Corresponding publications for 1997–1999 have also been used.

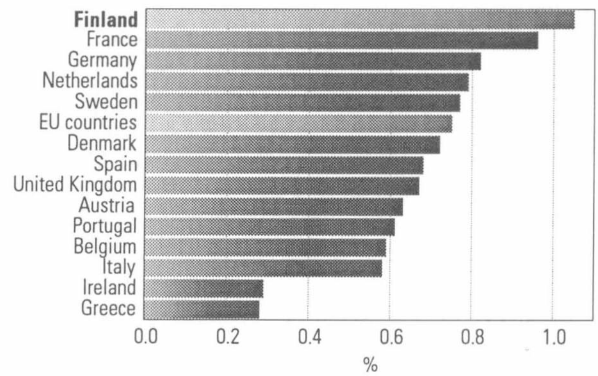


FIGURE 4.19
GDP share of total government R&D appropriations in EU countries in 1999

Source: Eurostat

In 1999 the GDP share of total government R&D appropriations in Finland was the highest in the EU. The average GDP share in the 15 EU countries was 0.75 per cent, with Finland the only Member State recording a figure over and above one per cent. The country that came closest to Finland's GDP share of 1.05 per cent was France. Greece and Ireland clearly stand apart as the two countries with the lowest share of GBAORD (Figure 4.19). Finland has been consistently above the EU average since 1991, and the GDP share has remained fairly stable. In many other countries the share has declined, for instance in Sweden and France quite dramatically so. In Portugal the GDP share has shown the strongest growth during the 1990s. In Norway the figure in 1999 was the same as the EU average.

National Technology Agency is the most important funding body

The bulk of government R&D funding is channelled through the Ministry of Education and the Ministry of Trade and Industry (Figure 4.20). In the budget for 2000 both account for almost 40 per cent of total R&D funding. Nine per cent of the funding is channelled through the Ministry of Social Affairs and Health. During

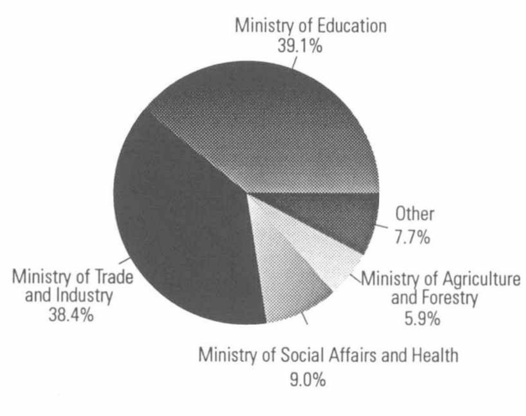


FIGURE 4.20
Breakdown of government R&D funding by administrative sector in 2000

Source: Academy of Finland

the 1990s the shares have increased most clearly for the Ministry of Trade and Industry, the Ministry of Social Affairs and Health and the Ministry of Labour.

The National Technology Agency under the Ministry of Trade and Industry is the single most important source of public funding for R&D, accounting for around one-third of all government funding allocated to R&D. Institutions of higher education account for 26 per cent of all R&D funding, State research institutes for 17 per cent, the Academy of Finland for 12 per cent and central university hospitals for around five per cent. The share of other R&D funding is nine per cent, which includes R&D funds from ministries and their central agencies (excluding the Academy of Finland and the National Technology Agency) as well as certain fees for international co-operation.

The National Technology Agency aims to raise and maintain the level of Finnish technology and improve the competitiveness of Finnish industry. During the period from 1991 to 2000, the resources made available to the Agency have increased 2.5-fold (Figure 4.21). The average real growth in its resources has been nine per cent a year. During the same period in 1991–2000, the annual real increase in the R&D resources of institutions of higher education was around 2.5 per cent, while the Academy's resources have increased by some six per cent. On average the budget resources of State research institutes have decreased each year by a couple of per cent, other government R&D funding by even more, around 3.5 per cent a year. The sharp decrease in other funding is explained by the State Real Estate Board being transformed into a publicly-owned corporation, which in 1999 implied a transfer of over FIM 200 million to other research organisation categories.

Industry and technology appropriations have increased throughout the 1990s

Classified by the objective of research, the biggest single category of R&D funding is represented by the general advancement of science, accounting for some 38 per cent (Figure 4.22). This category comprises for instance universities' and the Academy's research appropriations in their entirety. The second largest category, accounting for some 28 per cent, is represented by the promotion of industry. Both health research and energy account for seven per cent, agriculture and forestry for some five per cent.

R&D appropriations for the promotion of industry has increased throughout the 1990s: the share of this category has risen by some four percentage points between 1991 and 2000. The figures for 2000 concerning the promotion of

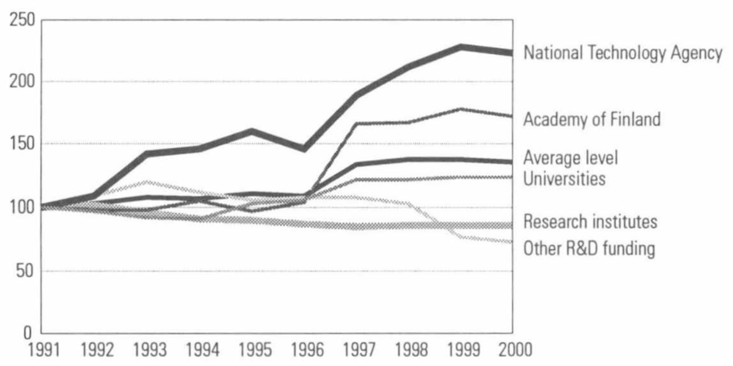


FIGURE 4.21
Real development of government R&D funding by research organisation in 1991–2000 (1991=100)

Source: Academy of Finland

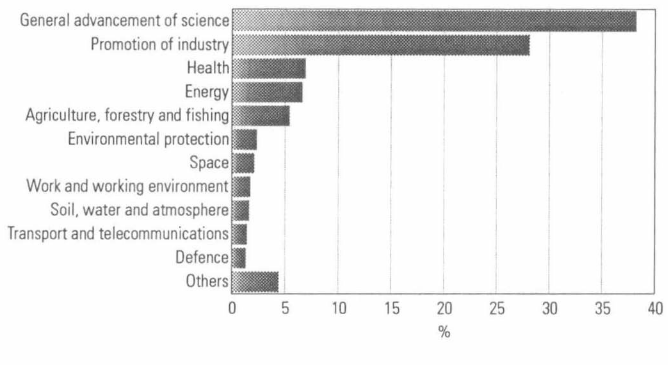


FIGURE 4.22 Breakdown of government R&D funding by objective in 2000

Source: Academy of Finland

industry and energy R&D are not final, however. Apart from the promotion of industry and technology, the main accent in the late 1990s has been on energy and health research; in relative terms their shares have shown the fastest growth. The share of health research today is almost twice as high as the figure for 1991. This is explained by the increase in R&D appropriations for central university hospitals: this increased almost three-fold with the introduction of a separate sub-item in the budget. The special government subsidies for central university hospitals have been included in the figures since 1997. The growth of the general advancement of science has caught up with promotion of industry by the end of the decade.

R&D funding for agriculture and forestry has declined steadily throughout the 1990s and up to the present day: the share of this field has dropped from nine per cent to around five, and even in nominal terms it is now getting less money than at the beginning of the decade. The share of R&D in transport and telecommunications has dropped to one-half during the same period of time. This is explained by the decrease in R&D expenditure included in the Ministry of Transport and Communications road appropriations.

Appendix Tables 4.1–4.3 provide detailed information on government R&D funding by research organisation, administrative sector and research objective in 1991–2000.

Funding for international research co-operation

In 1999 the government allocated some FIM 120 million to supporting international R&D co-operation and membership fees. The true costs incurred to the government from international R&D co-operation are greater than that, however, because the data are not fully comprehensive. International co-operation is also funded through the budget of agencies and institutes such as the National Technology Agency and the Academy of Finland. However it is extremely difficult to separate these costs from other expenditure. The figures do not include the costs of participation in EU R&D programmes, which are covered through Finland's membership fees. Another item missing from the figure is the cost of universities' international R&D co-operation.

APPENDIX 4.1
Government R&D appropriations by research organisation in 1991–2000

Research organisation	FIM million (at current prices)				Percentage			
	1991	1995	1999	2000	1991	1995	1999	2000
Universities	1 345	1 457	1 922	1 960	28.3	26.3	25.3	25.8
University central hospitals	–	–	360	353	–	–	4.7	4.6
Academy of Finland	449	459	925	911	9.4	8.3	12.2	12.0
National Technology Agency	931	1 564	2 445	2 444	19.6	28.3	32.2	32.1
State research institutes	1 248	1 183	1 237	1 267	26.2	21.4	16.3	16.7
Other R&D funding	782	869	695	669	16.4	15.7	9.2	8.8
Total	**4 755**	**5 532**	**7 584**	**7 604**	**100.0**	**100.0**	**100.0**	**100.0**

The funding of the National Technology Agency includes the financial responsibilities and appropriations since 1993 and that of the Academy of Finland from 1997.

APPENDIX 4.2
Government R&D appropriations by administrative sector in 1991–2000

Administrative sector	FIM million (at current prices)				Percentage			
	1991	1995	1999	2000	1991	1995	1999	2000
Ministry of Foreign Affairs	87	69	45	53	1.8	1.2	0.6	0.7
Ministry of Justice	4	6	6	6	0.1	0.1	0.1	0.1
Ministry of the Interior	10	9	32	23	0.2	0.2	0.4	0.3
Ministry of Defence	68	115	108	97	1.4	2.1	1.4	1.3
Ministry of Finance	30	71	39	36	0.6	1.3	0.5	0.5
Ministry of Education	1 896	2 059	2 939	2 970	39.9	37.2	38.8	39.1
Ministry of Agriculture and Forestry	479	453	448	448	10.1	8.2	5.9	5.9
Ministry of Transport and Communication	171	183	181	169	3.6	3.3	2.4	2.2
Ministry of Trade and Industry	1 534	2 093	2 917	2 916	32.3	37.8	38.5	38.4
Ministry of Social Affairs and Health	323	344	680	686	6.8	6.2	9.0	9.0
Ministry of Labour	9	11	36	53	0.2	0.2	0.5	0.7
Ministry of the Environment	144	119	153	145	3.0	2.1	2.0	1.9
Prime Minister's Office	2	2	2	2	0.0	0.0	0.0	0.0
All total	**4 755**	**5 532**	**7 584**	**7 604**	**100.0**	**100.0**	**100.0**	**100.0**

1991–1999: state budget and supplementary budgets, 2000: state budget.
Rearrangement of Government real estate administration caused a FIM 228 million imputed increase in R&D funding in 1995 and a FIM 96.2 million increase in 1996.
Transfer to responsibility calculation at the Academy of Finland and revision of calculation bases of university R&D expenditure produces an about FIM 270 million increase in R&D funding.
R&D expenditure of university hospitals raised funding by around FIM 350 million and removal of funding by the Nordic Council of Ministers lowered funding by approximately FIM 40 million.

APPENDIX 4.3
Government R&D appropriations by objective in 1991–2000

Objective	FIM million (at current prices)				Percentage			
	1991	1995	1999	2000	1991	1995	1999	2000
Agriculture, forestry and fisheries	423	395	433	410	8.9	7.1	5.7	5.4
Promotion of industry	1 158	1 753	2 388	2 140	24.3	31.7	31.5	28.1
Energy	173	195	245	500	3.6	3.5	3.2	6.6
Defence	68	115	104	100	1.4	2.1	1.4	1.3
Soil, water and atmosphere	88	67	128	125	1.8	1.2	1.7	1.6
Social policy and services	856	879	1 267	1 268	18.0	15.9	16.7	16.7
Transport and telecommunications	144	163	104	107	3.0	3.0	1.4	1.4
Housing and communities	25	29	78	51	0.5	0.5	1.0	0.7
Environmental protection	153	141	166	173	3.2	2.5	2.2	2.3
Work and working environment	83	84	102	127	1.7	1.5	1.3	1.7
Health care	181	195	530	524	3.8	3.5	7.0	6.9
Social security	76	83	76	71	1.6	1.5	1.0	0.9
Education	8	11	9	9	0.2	0.2	0.1	0.1
Culture	44	45	60	64	0.9	0.8	0.8	0.8
International relations	64	43	52	59	1.3	0.8	0.7	0.8
Other social functions	80	84	89	83	1.7	1.5	1.2	1.1
General advancement of science	1 845	2 007	2 866	2 903	38.8	36.3	37.8	38.2
Universities	1 345	1 457	1 922	1 960	28.3	26.3	25.3	25.8
Other general advancement of science	499	550	944	943	10.5	9.9	12.4	12.4
Space	145	122	155	158	3.1	2.2	2.0	2.1
All total	**4 755**	**5 532**	**7 584**	**7 604**	**100.0**	**100.0**	**100.0**	**100.0**

1991–1999: state budget and supplementary budgets, 2000: state budget.

5 International co-operation in science and technology

One of the most important ways of developing scientific research and its intellectual resources is to promote international co-operation and researcher exchange. For a small country such as Finland it is absolutely essential to take an active part in science and technology co-operation. It is only during the 1990s that internationalisation has begun in earnest in the Finnish research community. By the end of the decade the further diversification of research co-operation was recognised as one of the key objectives in the development of the science system: new agreements of co-operation have been signed, involvement in international research programmes has been increased and international exchange of researchers promoted. In the business enterprise sector, too, R&D operations are increasingly relocated to foreign countries. The internationalisation of R&D is discussed in Chapter 4.

The first section below describes the international mobility of Finnish researchers and efforts to promote that mobility on the basis of data on researcher exchange from universities, the Academy of Finland and the Centre for International Mobility (CIMO). We then move on to look at key forms of European research co-operation in which Finland is involved. Finland remains committed to improving its research co-operation not only with other EU member states, but also with such countries as the United States, Japan, Russia, other Nordic countries and the countries of Central and Eastern Europe.

5.1 International mobility of researchers

In today's increasingly global environment researcher exchange has become an integral part of international scientific collaboration. The discussion below sheds light on the international mobility of Finnish university teachers and researchers as well as on the work done by foreign teachers and researchers in Finland. The data concerning universities are drawn from the University Information System (KOTA) maintained by the Ministry of Education. The data on funding decisions by the Academy of Finland have been compiled by the science organisation's International Relations Unit. Finally, the data on CIMO scholarship programmes have been provided by the organisation's information services.

5.1.1 University personnel exchange

In 1999 teachers and researchers from Finnish universities made a total of 825 visits lasting one month or longer to foreign universities. The average duration of these visits was 4.3 months. The figures varied quite widely between different universities. On average the visits by staff from the University of Vaasa lasted around six months, while teaching and research staff from the University of Lapland usually stayed for no more than one month. These data concern all departmental staff from professors to laboratory engineers. In addition the figures also cover Academy of Finland researchers, other full-time research staff hired for at least six months as well as researchers receiving senior fellow grants from the Academy.

In 1999 Finnish universities received a total of 1,170 visits by foreign teachers and researchers. This figure does not include foreign staff hired on a permanent basis nor students studying for a postgraduate degree. The average duration of these visits was 4.6 months. Foreign teachers and researchers spent on average 7.2 months at the University of Kuopio, those who came to the Theatre Academy no more than 1.4 months.

Examined in terms of the number of people involved, personnel exchange was highest at the University of Helsinki, which accounted for one-fifth of all visits by teachers and researchers (Table 5.1). The Helsinki University of Technology accounted for 14 per cent, the University of Turku for 13 per cent.

On average six per cent of the teaching and research faculty[1] of universities took part in exchange programmes in 1999. The figures were highest for the universities of Tampere (8.5%), Turku (8.1%), Helsinki (7.5%) and Oulu (7.2%).

The popularity of teacher and researcher exchange increased throughout the early 1990s and reached its peak in 1995 (Figure 5.1). In particular, the number of visits by foreigners to Finnish universities increased markedly. The figures have tended to fluctuate somewhat during the latter part of the decade but the overall trend has seen the numbers decline, which is probably explained by the decrease in general university funding. From 1990 to 1999, however, the numbers from Finland to foreign countries increased by 12 per cent, at the same time the flow in the other direction increased by 44 per cent.

TABLE 5.1
Teacher and researcher exchange by university in 1999

University	From Finland*	To Finland**	Total	
	Number	Number	Number	%
University of Helsinki	231	166	397	19.9
Helsinki University of Technology	92	190	282	14.1
University of Turku	107	156	263	13.2
University of Oulu	101	126	227	11.4
University of Jyväskylä	70	137	207	10.4
Tampere University of Technology	26	160	186	9.3
University of Tampere	74	38	112	5.6
Åbo Akademi University	36	52	88	4.4
University of Kuopio	25	62	87	4.4
University of Joensuu	14	43	57	2.9
Lappeenranta University of Technology	7	14	21	1.1
Helsinki School of Economics and Business Administration	12	6	18	0.9
University of Vaasa	10	2	12	0.6
Swedish School of Economics and Business Administration	6	3	9	0.5
University of Industrial Arts	5	3	8	0.4
Theatre Academy	3	5	8	0.4
University of Lapland	2	3	5	0.3
Turku School of Economics and Business Administration	2	3	5	0.3
Sibelius Academy	2	1	3	0.2
Academy of Fine Arts	–	–	–	0.0
Total	**825**	**1 170**	**1 995**	**100.0**

** Work or postgraduate studies of at least one month's duration of university staff at universities or research institutes abroad.*
*** Foreign researchers having worked at the university's institutes for at least one month in the course of a year.*
Source: Ministry of Education

1 Including postgraduate students at graduate schools.

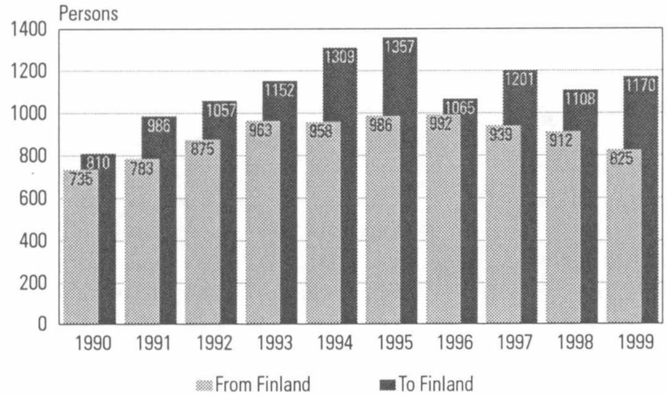


FIGURE 5.1
Number of participants in international teacher and researcher exchange of universities in 1990–1999

Source: Ministry of Education

The share of the University of Helsinki has declined considerably during the past decade. In 1994 it still accounted for over 31 per cent of total researcher exchange. On the other hand the figures for the universities of Jyväskylä and Turku have clearly increased between 1990 and 1999: for Jyväskylä the figures have gone up from four to over ten per cent, for Turku from eight to over 13 per cent. There have been no marked changes over the years in the average duration of visits, which has been within the range of four to five months.

The top two disciplines in terms of the number of visits were the natural sciences and engineering and technology, both accounting for 29 per cent of the total exchange in 1999. The figures were even higher for the number of visits from foreign countries into Finland. What is more, the share of these fields is currently much higher than at the beginning of the 1990s. In 1990 medical sciences accounted for around 19 per cent of total exchange, the figure now has dropped to less than nine per cent.

5.1.2 The role of the Academy of Finland in the promotion of researcher mobility

The Academy of Finland awards grants to support researchers working in foreign countries. Funding for international researcher exchange is nowadays an important part of research appropriations, centres of excellence in research, research programmes, targeted programmes and grants awarded to senior fellows and postdoctoral researchers. However, it is extremely difficult to get a clear picture of international mobility among researchers today because the field is so widely dispersed. The figures presented here are based on funding decisions taken by the Academy's Research Councils in 1999. Academy funding accounts for a large part of international researcher exchange today. Judging by the average size of the grants awarded by the Academy for researcher exchange, a total of some FIM 100–130 million is spent each year on promoting researcher mobility[2].

2 The State and Quality of Scientific Research in Finland, Publications of the Academy of Finland 7/00, p.22.

In 1999 the Academy's four Research Councils:

- Research Council for Culture and Society (CS);
- Research Council for Natural Sciences and Engineering (NSE);
- Research Council for Health (H); and
- Research Council for Environment and Natural Resources (ENR)

awarded a total of 208 grants to support researchers working abroad (Table 5.2). The value of these grants added up to around FIM 20.7 million, with the total duration of the stays amounting to 2,565 months. Over one-third or 36 per cent of the grants were for work in the United States, over 19 per cent for work in the United Kingdom. The Research Council for Health accounted for almost 40 per cent of the total number of grants and the number of researcher-months and for 23 per cent of the volume of funding. However, both the Research Council for Environment and Natural Resources and the Council for Culture and Society accounted for a larger proportion of funding, the figure for the former being 37 per cent and for the latter over 30 per cent. In addition, FIM 0.6 million was allocated to support the work of 12 foreign researchers invited to work in Finland.

The Academy of Finland has bilateral agreements of research co-operation with science organisations in a number of different countries. In 1999 a total of 304 decisions were made within the framework of these agreements. The Research Council for Natural Sciences and

TABLE 5.2
Grants awarded by the Academy of Finland for research abroad and funding decisions by Research Council in 1999

Country	Research Council										
	CS		NSE		H		ENR		Total		Share
	Number	Months	Number	Months	Number	Months	Number	Months	Number	Months	%
United States	16	179	10	152	39	505	9	166	74	1 002	35.6
United Kingdom	17	152	6	43	11	166	6	105	40	466	19.2
Canada	3	25	3	43	5	60	4	59	15	187	7.2
France	3	32	2	28	6	72	1	12	12	144	5.8
Italy	12	124	–	–	–	–	–	–	12	124	5.8
Netherlands	5	35	1	18	1	12	3	39	10	104	4.8
Sweden	1	12	5	36	3	30	1	6	10	84	4.8
Germany	4	40	–	–	2	32	2	28	8	100	3.8
Australia	1	12	–	–	3	36	2	34	6	82	2.9
Belgium	–	–	–	–	5	60	1	12	6	72	2.9
Norway	1	14	1	12	–	–	2	29	4	55	1.9
China	–	–	–	–	1	12	1	16	2	28	1.0
Estonia	1	12	1	12	–	–	–	–	2	24	1.0
Switzerland	1	9	1	12	–	–	–	–	2	21	1.0
Austria	–	–	–	–	–	–	1	30	1	30	0.5
Russia	–	–	–	–	1	14	–	–	1	14	0.5
Spain	–	–	1	10	–	–	–	–	1	10	0.5
Ireland	1	9	–	–	–	–	–	–	1	9	0.5
Israel	–	–	–	–	1	9	–	–	1	9	0.5
Total	**66**	**655**	**31**	**366**	**78**	**1 008**	**33**	**536**	**208**	**2 565**	**100.0**
Share of grants, %	31.7	25.5	14.9	14.3	37.5	39.3	15.9	20.9	100.0	100.0	

Source: Academy of Finland

Engineering accounted for almost 45 per cent of these decisions. The total duration of researcher visits based on these agreements was 25,099 days, of which 15,453 were in Finland and 9,646 abroad (Table 5.3). Russia accounted for the largest share of total exchange, around 39 per cent; some two-thirds of this consisted of time spent by Russian researchers in Finland on special invitation grants[3]. The single most popular destination for Finnish researchers was Germany, which accounted for around one-fifth of total researcher exchange; the majority (89%) of this consisted precisely of Finnish researchers' visits to Germany.

TABLE 5.3
Researcher mobility on the basis of bilateral agreements by Research Council, days in 1999

Country	Research Council, days								Total	
	CS		NSE		H		ENR			
	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland
Agreements with quotas for numbers of days and/or persons										
Bulgaria	14	71	60	60	21	–	56	21	151	152
Japan	–	60	360	620	876	–	–	21	1 236	701
China	18	40	224	212	–	–	110	21	352	273
South Korea	–	90	30	35	90	–	–	–	120	125
Poland	106	129	166	219	140	3	258	68	670	419
Rumania	35	27	51	21	–	–	–	–	86	48
Slovakia	–	40	82	28	–	–	–	–	82	68
Czech Republic	20	81	141	159	19	70	139	–	319	310
Hungary	154	304	142	99	258	–	6	28	560	431
Russia	261	1 107	932	136	–	7	448	100	1 641	1 350
= invitation grant*	925	–	3 450	–	800	–	1 725	–	6 900	–
Estonia	372	257	124	63	60	–	40	7	596	327
Total	1 905	2 206	5 762	1 652	2 264	80	2 782	266	12 713	4 204
Agreements in which the parties pay their own participation costs										
Netherlands**	–	–	–	–	–	345	–	–	–	345
Latvia	42	77	–	–	90	–	–	–	132	77
Lithuania	–	62	90	8	–	–	–	–	90	70
Germany	180	616	360	2 156	–	308	–	1 320	540	4 400
Taiwan	–	210	–	32	–	7	–	90	–	339
Ukraine	–	201	1 088	–	–	–	270	–	1 358	201
Byelorussia	–	–	–	10	20	–	600	–	620	10
Total	222	1 166	1 538	2 206	110	660	870	1 410	2 740	5 442
Total, all	**2 127**	**3 372**	**7 300**	**3 858**	**2 374**	**740**	**3 652**	**1 676**	**15 453**	**9 646**

** These grants are awarded to Finnish researchers who may invite Russian colleagues to do research in Finland.*
*** The Academy of Finland does not receive data concerning researchers arriving from the Netherlands.*
Source: Academy of Finland

3 These grants are awarded to Finnish researchers who may invite Russian colleagues to do research in Finland.

The Academy of Finland also supports international researcher mobility through its Centre of Excellence Programme. In 1995–1998 the 51 units applying for centre of excellence status received visits lasting two weeks or longer from a total of 54 countries. The total duration of these visits was 413 research person-years. Almost half of the researchers who worked in Finland came from five countries, i.e. China, Russia, Germany, the United Sates and the United Kingdom. At the same time Finnish researchers visited a total of 31 different countries, with a total duration of 324 research person-years. Three out of four visits were made to the top five destinations, i.e. the United States, Germany, the United Kingdom, Canada and Sweden.[4]

5.1.3 Scholarships awarded by CIMO

The Centre for International Mobility (CIMO) supports international mobility through various scholarship programmes intended for postgraduate students and researchers:

- programmes based on culture exchange and other bilateral agreements signed by Finland;
- programme intended for foreign postgraduate students and young researchers; and
- the Nordic Grant Scheme run by the Nordic Council of Ministers for co-operation with the Baltic countries and Northwest Russia

In 1999 a total of 809 grants were awarded through these programmes, both for long-term postgraduate studies and for shorter researcher visits. The figures do not include short-term visits within the context of the co-operation networks (18 in all) funded from programmes run by the Nordic Council of Ministers. The total value of the grants amounted to around FIM 12 million.

Some 70 per cent of the grants, 564 in all, were awarded to researchers coming into Finland. The largest number of arrivals came from Russia, Hungary and Estonia (Table 5.4). A key objective of CIMO's scholarship programmes is to strengthen the appreciation of Finnish postgraduate studies primarily in the Baltic countries and Russia and in the countries of Central Eastern Europe. The majority or 60 per cent of the postgraduate students and researchers who visited Finland were represented the group of countries singled out as priority target group. China was still the biggest non-European country.

A total of 245 scholarships were awarded for exchange from Finland to other countries. The most popular destinations were Hungary and Russia. Every other researcher chose either one or the other of these countries or one from the group of the third most popular countries, i.e. Italy, Belgium and Spain.

The humanities and social sciences accounted for the largest proportion of all scholarships awarded, i.e. 60 per cent (Figure 5.2). The natural sciences and biotechnology accounted for 22 per cent, engineering and technology for 10 per cent and medical sciences for eight per cent.

4 Apropos 1/2000, the Academy of Finland magazine, p.9.

TABLE 5.4
Scholarships awarded by the Centre for International Mobility for postgraduate studies and researcher visits by country in 1999

Country	From Finland	To Finland	Total Number	Total %	Country	From Finland	To Finland	Total Number	Total %
Russia	33	139	172	21.3	Sweden	4	4	8	1.0
Hungary	39	75	114	14.1	Slovakia	2	6	8	1.0
Estonia	–	47	47	5.8	Denmark	3	5	8	1.0
Germany	14	20	34	4.2	Australia	–	6	6	0.7
Italy	18	15	33	4.1	Canada	–	6	6	0.7
Belgium	16	13	29	3.6	Norway	3	3	6	0.7
China	7	22	29	3.6	Mexico	2	3	5	0.6
Poland	5	21	26	3.2	United States	–	5	5	0.6
Spain	16	7	23	2.8	Iceland	2	2	4	0.5
Czech Republic	6	15	21	2.6	South Korea	2	2	4	0.5
France	8	12	20	2.5	Moldova	–	4	4	0.5
United Kingdom	5	12	17	2.1	Singapore	4	–	4	0.5
Greece	8	7	15	1.9	Egypt	1	2	3	0.4
Ireland	7	5	12	1.5	Cuba	–	3	3	0.4
Israel	8	4	12	1.5	Malesia	3	–	3	0.4
Japan	–	12	12	1.5	Mongolia	–	3	3	0.4
Netherlands	3	8	11	1.4	Luxembourg	2	–	2	0.2
India	2	9	11	1.4	Thailand	2	–	2	0.2
Austria	7	4	11	1.4	Argentina	–	1	1	0.1
Lithuania	–	11	11	1.4	Ecuador	–	1	1	0.1
Bulgaria	3	7	10	1.2	Indonesia	1	–	1	0.1
Portugal	2	8	10	1.2	Jordania	–	1	1	0.1
Rumania	2	8	10	1.2	Macedonia	–	1	1	0.1
Turkey	3	7	10	1.2	Tunisia	–	1	1	0.1
Switzerland	2	7	9	1.1	Ukraine	–	1	1	0.1
Latvia	–	8	8	1.0	Byelorussia	–	1	1	0.1
					Total	**245**	**564**	**809**	**100.0**

Source: CIMO

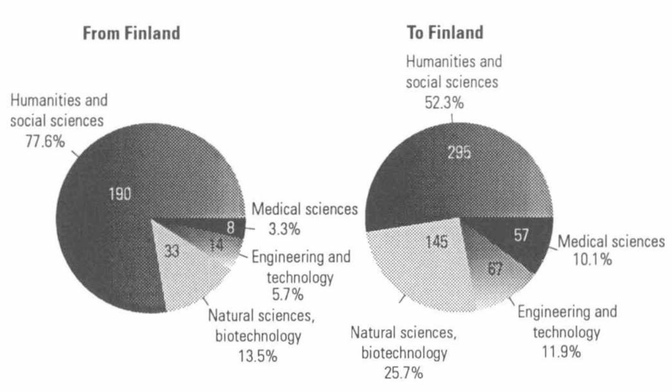


FIGURE 5.2
CIMO scholarships by field of study in 1999

Source: CIMO

5.2 European research co-operation

The main focus with respect to European research co-operation is on its three key forms, i.e. EU research programmes as well as co-operation through COST and EUREKA. Other fora of European research co-operation in which Finland is involved include the European Organization for Nuclear Research (CERN), the European Molecular Biology Laboratory (EMBL), the European Science Foundation (ESF) and the European Space Agency (ESA).

5.2.1 EU research and development programmes[5]

Research framework programmes are the European Union's most important form of R&D co-operation. All in all measures related to R&D policy account for around four per cent of the Community's annual budget. The EU's R&D co-operation can be traced back to the research that was started in the 1950s in the field of nuclear energy and to joint research projects in coal and steel. The launch of R&D framework programmes in 1984 marked an important step in organising and expanding this co-operation. Finland has been involved in EU research programmes since 1987, and participation has increased substantially since Finland joined the Union as a full member in 1995. The Fourth Framework Programme launched in 1995 was the first in which Finnish organisations were involved on the same scale as other EU Member States. A total of 2,637 Finnish organisations were involved in 1,850 projects; the corresponding figures in the Third Framework Programme were 538 and 427, respectively.

The aim of the EU's R&D programmes is to raise the level of European know-how and technological expertise and to promote people's quality of life and overall well-being. The Union's research projects are international undertakings in the sense that they must involve partners from at least two Member States, or from one Member State and one of the 16 Associated States. The partners may also be business companies, universities, research institutes or some other research group. For the main part the framework programmes are jointly funded. The work is organised in the form of research projects, with the EU accounting for 50 per cent of funding; demonstration projects in which EU accounts for 35 per cent of funding; and concerted action in which the EU covers project overhead costs.

Almost 2,700 Finnish organisations involved in the Fourth Framework Programme

The budget for the Fourth Framework Programme was FIM 78.5 billion. The Finnish organisations involved represented 2.9 per cent of all participations from the EU-15 area (which totalled 92,000; see Table 5.5). Finland's involvement in the EU's research co-operation is more extensive than might be assumed on the basis of the country's own R&D investment: in 1998 Finland accounted for around 2.3 per cent of the EU countries' R&D expenditure. The situation in Sweden, for instance, is exactly the opposite: its share of R&D expenditure was 4.7 per cent, its share of participations 4.3 per cent.

Business enterprises account for almost 40 per cent of programme organisations

Half of the partners in the EU's Fourth Framework Programme came from universities and research institutes, business enterprises accounted for 38 per cent. The proportion of

5 Sources: Luukkonen, Terttu & Sasu Hälikkä (2000). Knowledge Creation and Knowledge Diffusion Networks. Tekes, Publications of the Finnish Secretariat for EU R&D 1/2000;
www.tekes.fi/eu
www.cordis.lu

TABLE 5.5
Participations in the EU's 4th Framework Programme 1994–1998 by member state and by specific programme

Specific Programmes	EU	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	Luxembourg	Netherlands	Austria	Portugal	**Finland**	Sweden	United Kingdom
Agriculture and Fisheries	5 412	254	248	552	251	533	740	191	470	–	494	125	200	182	262	910
Biotechnology	3 374	167	127	580	47	193	547	70	273	2	384	58	33	60	179	654
Environment and Climate	4 685	149	162	687	213	362	616	49	603	8	415	118	107	143	239	814
Biomedicine and Health	2 811	132	104	423	52	121	447	37	325	1	243	56	28	82	173	587
Marine Science and Technology	1 345	51	81	148	40	103	230	37	115	–	109	6	47	24	59	295
Standards, Measurements and Testing	2 603	156	107	456	76	152	314	52	226	4	213	66	74	83	148	476
Non-Nuclear Energy	8 018	328	440	1 255	470	681	946	149	736	44	595	275	294	238	294	1 273
Targeted Socio-Economic Research	1 113	52	41	123	58	89	135	30	105	4	105	35	51	43	59	183
Industrial and Materials Technologies	13 579	668	285	2 440	413	995	2 030	236	1 448	26	973	278	433	333	627	2 394
Nuclear Fission Safety	1 503	96	25	325	13	104	241	12	143	1	105	24	5	78	88	243
Thermonuclear Fusion	750	39	28	273	11	23	93	10	86	6	38	11	19	27	30	56
Information Technologies	10 513	445	262	1 817	551	902	1 649	237	1 314	27	538	256	242	248	364	1 661
Transport	2 505	120	79	374	134	167	366	29	256	–	251	83	57	106	110	373
Advanced Communication Technologies	6 722	421	151	1 100	421	538	1 033	281	754	13	314	100	212	260	168	956
Telematics	14 680	743	452	1 954	1 069	1 173	1 922	516	1 596	73	1 016	337	466	526	647	2 190
International cooperation	3 321	240	97	460	126	237	530	46	338	2	265	71	91	83	132	603
Dissemination and Optimisation of Results	3 376	185	81	472	161	411	456	92	461	53	160	125	127	61	175	356
Training and Mobility of Researchers	5 704	223	136	772	203	377	1 101	106	472	5	382	100	96	60	178	1 493
Total	**92 014**	**4 469**	**2 906**	**14 211**	**4 309**	**7 161**	**13 396**	**2 180**	**9 721**	**269**	**6 600**	**2 124**	**2 582**	**2 637**	**3 932**	**15 517**
%	100.0	4.9	3.2	15.4	4.7	7.8	14.6	2.4	10.6	0.3	7.2	2.3	2.8	2.9	4.3	16.9

Source: Key Figures 2000. Science, Technology and Innovation. European Commission, Research Directorate and Eurostat, Brussels.

research organisations in Finland exceeds the EU average, while the figures for business enterprises and universities is below the average (Table 5.6). One relevant factor here is the key role of the Technical Research Centre (VTT) in the Finnish research system. The business sector is most prominent in joint projects involving Germany, Austria and Italy; the United Kingdom and Sweden for their part are mainly involved through their universities.

TABLE 5.6
Participation in the EU's 4th Framework Programme 1994–1998 by type of organisation, % of total for country

Country	Business Enterprises	Universities & higher education institutions	Research organisations	Others	Total
	%	%	%	%	%
Belgium	33.7	33.4	15.9	16.9	100.0
Denmark	36.3	23.8	26.8	13.1	100.0
Germany	43.7	23.7	23.0	9.6	100.0
Greece	36.9	30.1	18.8	14.2	100.0
Spain	37.6	24.6	20.8	16.9	100.0
France	39.7	14.2	32.2	13.9	100.0
Ireland	32.7	35.4	13.7	18.3	100.0
Italy	41.3	22.1	23.3	13.4	100.0
Luxembourg	45.8	0.4	14.5	39.4	100.0
Netherlands	32.7	27.9	26.7	12.7	100.0
Austria	41.5	29.0	15.9	13.7	100.0
Portugal	33.0	28.3	23.0	15.7	100.0
Finland	34.3	24.5	28.8	12.4	100.0
Sweden	32.6	39.9	16.1	11.5	100.0
United Kingdom	34.4	38.5	15.7	11.4	100.0
EU-15	**37.6**	**26.9**	**22.3**	**13.1**	**100.0**

Source: Key Figures 2000. Science, Technology and Innovation. European Commission, Research Directorate and Eurostat, Brussels.

Finnish organisations mainly involved in telematics and advanced communication technologies

In terms of the number of organisations involved the biggest EU programmes were in the fields of telematics, industrial and materials technologies and information technologies. In relative terms Finnish organisations were most actively involved in programmes in the fields of telematics (accounting for 20 per cent of Finnish participations compared to 16 per cent for all) and advanced communication technologies (10 and 7 per cent, respectively). Participation in programmes related to training and mobility of researchers was well below the EU average (2 and 6 per cent). The involvement of Finnish partners in industrial and materials technologies as well as in information technologies programmes was also somewhat below average.

Assessments based on a questionnaire study[6] indicate that Finnish organisations involved in the Fourth Framework Programme were for the main part satisfied with the results of their co-operation. The benefits were greatest for the project co-ordinators, which were obviously most strongly committed to their respective programmes. Partners from the non-profit sector recorded somewhat more problems than others. In the case of inter-company co-operation the accent was more on vertical (e.g. networks of subcontractors) than on horizontal (between rival companies) co-operation. All in all, however, the Fourth Framework Programme has promoted the internationalisation of R&D in Finnish organisations and the international visibility of research.

6 See Luukkonen & Hälikkä (2000).

The calls for the Fifth Framework Programme were announced in 1999. The budget for the programme is almost FIM 90 billion. Key themes include the quality of life, information society, competitive and sustainable growth, energy and the environment.

5.2.2 COST[7]

Founded in 1971, COST is a framework for scientific and technical co-operation in Europe. It supports multinational research networks by providing research projects with national funding an opportunity to join broadly-based European R&D co-operation. There are 32 European member states, with Israel additionally involved as an associate member. Partners from outside the framework may also join network projects; the most active participants in this category have been US, Canadian and Russian organisations.

COST is not a funding body proper, but its primary goal is to support networking by covering the costs incurred by partners involved, such as travel and seminar costs and short-term researcher visits. The research work itself is funded from national sources. The operation is based on joint projects, and the aim is to promote extensive, diverse and multidisciplinary co-operation among researchers with a view to creating research networks and to exchanging and harmonising information. A typical project will run for five years and involve 15 countries. The annual volume of the research co-ordinated through the projects is estimated at around FIM 12 billion.

Finland involved in two out of three COST actions

The number of COST actions increased sharply during the 1990s. At the beginning of the decade the number of ongoing actions was around 50, by the beginning of 2000 the figure had climbed to close on 200 (Figure 5.3). Finland has been a member since COST was founded in 1971 and is currently involved in around two out of three of all its actions (Table 5.7). Participation is at

TABLE 5.7
Participation in COST actions by country in 2000

Country	Participations, number	Participation rate, %
Austria	134	81.7
Belgium	144	87.8
Bulgaria	8	4.9
Croatia	24	14.6
Cyprus	21	12.8
Czech Republic	66	40.2
Denmark	119	72.6
Estonia	–	0.0
Finland	114	69.5
France	132	80.5
Germany	153	93.3
Greece	89	54.3
Hungary	104	63.4
Iceland	14	8.5
Ireland	84	51.2
Israel*	15	9.1
Latvia	22	13.4
Lithuania	17	10.4
Luxembourg	2	1.2
Malta	3	1.8
Netherlands	120	73.2
Norway	96	58.5
Poland	64	39.0
Portugal	87	53.0
Rumania	50	30.5
Slovakia	24	14.6
Slovenia	69	42.1
Spain	153	93.3
Sweden	106	64.6
Switzerland	113	68.9
Turkey	16	9.8
United Kingdom	148	90.2
Actions, total	**164**	**100.0**

**Co-operating non-COST-member state*
Source: The National Technology Agency (Tekes)

7 European Co-operation in the Field of Scientific and Technical Research, COST;
Sources: National COST co-ordinator in Finland, Tekes: www.tekes.fi/eng;
The programmes' international web pages at www.netmaniacs.com/cost

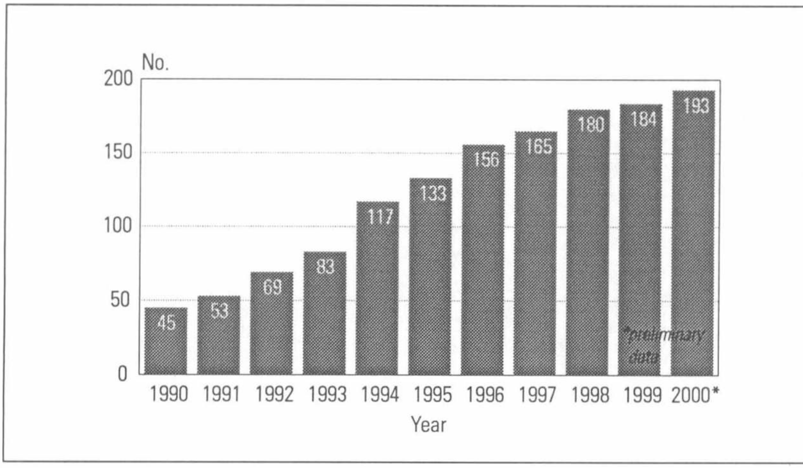


FIGURE 5.3
COST actions in 1990–2000

Source: The National Technology Agency (Tekes)

about the same level as in Sweden and Denmark. Since the mid-1990s Finland has each year joined some 20–30 new actions.

In 2000 the largest number of actions was recorded in the scientific domain of agriculture and biotechnology (Figure 5.4). Finland has been particularly active in actions in forests and forestry products, urban civil engineering and meteorology; during 2000 it was involved in actions in all these scientific domains.

Positive experiences from COST actions

In an evaluation of the COST programme[8] Finnish partners stressed that their goals were to obtain new research knowledge, to exchange results and to establish new contacts with research colleagues. Less importance was attached to training needs or to taking advantage of participation later for instance in the acquisition of research funding. For the most

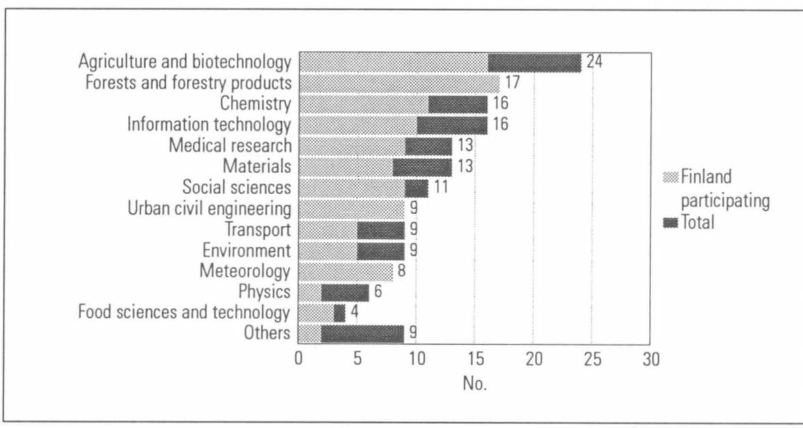


FIGURE 5.4
COST actions by scientific domain and Finnish participation in 2000

Source: The National Technology Agency (Tekes)

8 Nissinen, Marja & Pirjo Niskanen (1999). COST – Scientific Co-operation on Researchers' Terms. A Study of Finnish Participation. VTT Publications 388. Espoo.

part partners were at least satisfied with how the actions had succeeded.

COST has proved to be an important channel of co-operation for research institutes, universities and government agencies. R&D-oriented business enterprises have also been involved in a number of successful joint projects. Concrete outcomes of COST actions include the basic foundation required for the global GSM system; the founding of the Reading meteorological station in the UK; the development of low-floor bus equipment and systems; and the development of high-temperature resistant steel for power plant applications.

5.2.3 EUREKA[9]

The EUREKA initiative provides for European business enterprises, research institutes and universities a flexible and rapid channel of co-operation for the development of new products, processes or services. The overall objective in the EUREKA project programme is to strengthen the technological competitiveness of European countries. The programme was launched in 1985 and it currently involves 29 European countries as well as the European Union through Commission representation. EUREKA is not a funding organisation, but projects are funded from national sources. The practice of public funding varies widely between different member states. In Finland the public funding of EUREKA projects is mainly channelled through the National Technology Agency (Tekes).

EUREKA is founded on two basic pillars: conventional and cluster projects. So-called conventional projects are projects that involve SMEs, the duration and size of which are smaller than in major strategic projects that have emerged primarily in the IT sector. Cluster projects are a more recent type of project that were introduced in 1998: these are typically run by large enterprises, but they are networked with research institutes and SMEs. The total number of conventional projects currently under way is around 700, the number of broader, strategic cluster projects is nine. The research investment in ongoing EUREKA projects totals some EUR 4.5 billion.

Finnish partners active in strategic cluster projects

Finnish partners have recently shown increased interest in EUREKA projects. Participation from Finland has been on the rise and the value of participations is now approximating the peak levels reached in the early 1990s. In the 48 conventional projects that were under way at year-end 2000, there were 86 Finnish partners; 30 of these were through SMEs and 25 through research institutes. The total investment by Finnish partners totals EUR 22.7 million. In addition, Finland is represented in all nine

TABLE 5.8
Finnish participation in new EUREKA projects by Ministerial Conference in 1990–2000

Conference	Year	Total	Finnish co-ordinated
Rome	1990	13	4
The Hague	1991	17	3
Tampere	1992	20	5
Paris	1993	27	10
Lillehammer	1994	19	9
Interlaken	1995	14	7
Brussels	1996	10	3
London	1997	12	5
Lisbon*	1998	9	3
Istanbul	1999	14	4
Hannover	2000	17**	6

** Incl. cluster projects*
*** 8 conventional projects, 9 cluster subprojects*
Source: The National Technology Agency (Tekes)

9 Sources: The National Technology Agency (Tekes),The Finnish EUREKA Office: www.tekes.fi/eng;
EUREKA Secretariat: www.eureka.be

ongoing cluster projects, either in their administration or in the actual fieldwork. Finnish partners were involved in 10 cluster subprojects. The total volume of these subprojects is EUR 310.7 million, of which Finnish partners account for EUR 25.8 million. The total number of Finnish participations in these broad strategic projects is 16, with six businesses and three research institutes involved. The total volume of Finnish participation in ongoing EUREKA projects in 2000 was EUR 48.5 million. At the ministerial meeting in 2000 Finnish organisations expressed their interest in 17 new projects (Table 5.8).

The number of ongoing joint projects almost doubled during the first half of the 1990s. By the end of the decade the number of projects has stabilised at around 700 (Figure 5.5).

Investment heaviest in information technology

In 2000 there were a total of 705 conventional joint projects under way, with a budgeted R&D investment of almost EUR 2.4 billion. In numerical terms the largest number (141) of projects was recorded in medical and biotechnology (Table 5.9). Other branches where the number of projects exceeded the one hundred mark were environment and information technology as well as robotics. In value terms the largest field was information technology, which accounted for almost one-quarter of all budgeted R&D investments.

TABLE 5.9
Ongoing EUREKA projects by technological area in 2000

Technological area	Projects*, number	Volume, EUR million	Volume, Share, %
Medical and biotechnology	141	327	13.8
Communications	28	268	11.3
Energy technology	38	113	4.8
Environment	119	309	13.1
Information technology	119	548	23.2
Lasers	12	59	2.5
New materials	89	182	7.7
Robotics and production automation	105	361	15.3
Transport	54	199	8.4
Total	**705**	**2 366**	**100.0**

*Excl. cluster projects or their subprojects
Source: The National Technology Agency (Tekes)

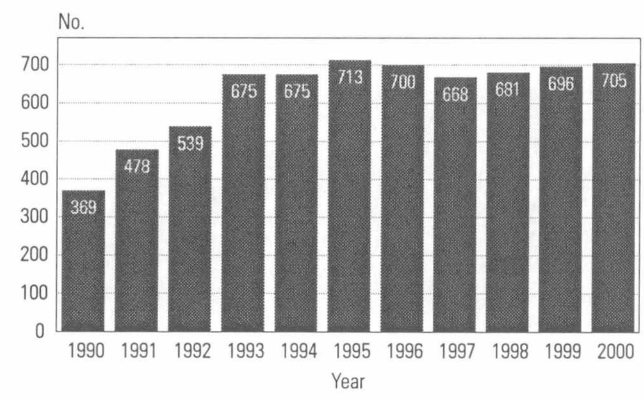


FIGURE 5.5
Ongoing EUREKA projects in 1990–2000

*Excl. cluster projects or their subprojects
Source: The National Technology Agency (Tekes)

6 Innovation activities of enterprises

Statistical indicators of innovation are designed to measure business renewal with respect to the development of new products and production methods. The most sophisticated statistics available concern commercial innovations, which is also the main focus in this chapter. Innovation studies collect information on the evolution of new innovations, on the costs of developing innovations as well as on their economic impacts. One of the motives for the development of innovation indicators has been the need to fill in the picture of technological development with more detailed information on R&D and patenting. In other words, while R&D expenditure tells us how much is being invested in development efforts and the number of patents tells us what is happening in terms of applications of new technologies and methods, the main concern in innovation studies is with the outcome of renewal, with the new products and new production processes introduced to the market.

Since the statistical measurement of new innovations is always open to interpretation, it is useful to begin here with some comments on how the datasets used have been defined and on the problems of data collection.

Different methods of compiling statistics on innovations

The concept of innovation carries strong positive connotations: innovation is widely recognised as important to maintaining the competitiveness of business enterprises and the national economy as a whole. For research purposes, though, it is difficult to provide a coherent and concrete definition of the concept. Since it is clearly not feasible to define all new products that are brought to the marketplace as innovations, we need to have a set of criteria with which to define different degrees of novelty. These definitions are inevitably open to interpretation, which means that respondents in innovation surveys will not necessarily understand the concepts in the way that those designing the questionnaires would want them to.

As is the case with other economic statistics, there are also international guidelines for compiling innovation statistics[1]. The OECD's so-called Oslo Manual defines an innovation as a technologically new product, service or production method. Organisational or management innovations are excluded from the definition. 'Technological', then, means that changes simply to the design or appearance of a product do not meet the criteria of innovation. In practice the relevant information is such that cannot be extracted from operational accounting; therefore it is necessary to rely on the respondents' subjective assessments.

Given the inherent complexity of the phenomenon of innovation, it is not possible by any statistical description to capture all its aspects. Indeed case studies and research projects applying the methods of different disciplines have had a major role to play in research in this field. There are also various approaches in economic research to innovation, which provides the foundation for statistical innovation indicators; examples include the neoclassical and evolutionary approach. One of the classics of innovation economics is Joseph Schumpeter, whose work provides the foundation for the distinction between the innovation-oriented 'object' and the company-oriented 'subject' research methods. In Finland the former method has been applied among others in the so-called Sfinno project run by the VTT Group for Technology Studies, the

1 Proposed guidelines for collecting and interpreting technological innovation data – 'The Oslo manual', OECD 1997.

latter in the company surveys carried out by Statistics Finland and Eurostat.

Studies of innovation in firms can apply ordinary business survey methods. The datasets used by Statistics Finland are based on samples drawn from the Business Register and the responses obtained have been weighted to describe the whole population of enterprises in question[2]. The 1996 innovation survey was carried out as a separate enquiry, data collection for 1998 was organised in conjunction with the R&D survey. Both these surveys comprise companies with more than 10 employees in manufacturing and certain service sectors. The choice of an appropriate unit of analysis for the innovation survey is problematic because although it is usually within the business enterprise that a given innovation is realised, the innovation process will usually involve a complex web of research institutes, universities and global corporations. In other words, the number of enterprises engaged in innovation, for instance, may well describe the diffusion of technological know-how rather than the actual creation of new technology[3]. The dataset collected for the Sfinno project is based on individual innovations during the period from 1985 to 1998, which have been identified from journals and annual reports of major corporations and by using expert assessments[4]. However, this means that the material cannot be weighted up to the level of the population in the same way as in a survey sample. All in all, a total of almost 1,500 innovations from some 950 companies were included in the Sfinno dataset. Although the method does not allow us to estimate the total number of innovations, it does yield detailed information on the most significant innovations. Two-thirds of the innovations in this dataset were entirely new to the companies that brought them to the marketplace[5].

Technology and innovation

One of the key issues in the identification of an innovation is to establish how far the product or process concerned should be based on a new technology or an application of scientific knowledge – or whether innovations should also be included in the statistics that are based on new applications of existing knowledge or on new designs only.

The sensitivity of innovation surveys to the definitions applied is clearly apparent when we compare Statistics Finland's 1991 survey to the datasets compiled in 1996 and 1998[6]. In 1991 an innovation was defined as a product whose structure or characteristics had been improved; in the following two surveys the criterion of novelty was complemented (in line with the guidelines issued by the OECD and Eurostat) with the requirement of *technological* innovation. This resulted in a sharp decline in the proportion of manufacturing firms reporting product innovations from 46 per cent to 24–28 per cent. The inclusion of the technology criterion also resulted in a decline in the number of firms reporting innovations in traditional industries. The study by the VTT Group for Technology Studies also highlights the differences in the nature of innovations in different industries. Innovations in the electronics industry, in the chemical industry and in software development are most typically characterised by the commercialisation of a

2 Innovaatiotutkimus 1996 (Finnish Innovation Survey 1996, in Finnish only). Science and Technology 1998:3, Statistics Finland.

3 OECD's basic criterion for innovation is its novelty from the point of view of the firm producing it; it does not need to be new in the marketplace, nor is it even required that it has been developed by the firm itself.

4 Palmberg, C., Leppälahti, A., Lemola, T. & Toivonen, H. (1999). Towards a better understanding of innovation and industrial renewal in Finland – a new perspective. VTT Group for Technology Studies, Working Papers 41/99. Espoo.

5 For the results of the VTT survey, see Palmberg, C., Niininen, P., Toivanen, H. & Wahlberg, T. (2000). Industrial Innovation in Finland. VTT Group for Technology Studies, Working Papers 47/00. Espoo.

6 Leppälahti, A. (2000). Comparisons of Finnish Innovation Surveys. Science, Technology and Research 2000:1. Statistics Finland.

TABLE 6.1
Technological know-how associated with the development of innovations

Industry	Number	Commercialisation of core technology %	Development and adaptation of components and modules %	Development of production processes %	Commercialisation of service concepts %	Other %
Total	**621**	**35**	**40**	**16**	**4**	**5**
Mining and quarrying	3	67	33	0	0	0
Food products	28	32	21	29	11	7
Textiles, wearing apparel, footwear	7	14	14	57	0	14
Wood and wood products	8	13	38	50	0	0
Pulp, paper and paper products	24	33	25	38	4	0
Publishing and printing	4	50	25	0	25	0
Oil, chemicals, rubber and plastic	55	45	22	20	2	11
Non-metallic mineral products	7	29	29	43	0	0
Basic metals, fabricated metal products	38	26	50	18	0	5
Machinery and equipment	114	33	49	13	4	1
Electrical equipment	97	44	44	6	0	5
Transport equipment	17	24	59	18	0	0
Other manufacturing, recycling	9	33	44	22	0	0
Electricity, gas and water supply	6	17	83	0	0	0
Construction	10	10	30	30	10	20
Wholesale and retail trade	47	30	57	6	2	4
Computer related activities	53	42	38	6	9	6
Architectural, engineering and technical services	45	38	33	22	4	2
Research and development	9	22	33	44	0	0
Other services	33	36	24	15	18	6
Holding companies	6	0	50	17	17	17

Source: VTT, Sfinno database

certain core technology, in metal products the accent is on the development and fitting together of different kinds of components and in the food industry on know-how related to production methods (Table 6.1). In other words, the technology-oriented definition emphasises the differences between industries and does not seem adequately to reflect the renewal of those industries where innovations typically consist of other than technologically new products.

The following describes some of the findings from the material collected by Statistics Finland in 1998 and from the innovation survey by the Technical Research Centre of Finland VTT.

Electronics industry and telecommunications rely heavily on new products

In 1996–1998 around one-third of all companies introduced a product or service innovation on the markets or introduced a significantly improved production method. In manufacturing firms with more than 10 personnel, 18 per cent of their turnover was based on technological product innovations, in service industries the share of innovative turnover was no more than six per cent.

Measured in terms of the proportion of innovating firms and particularly in terms of turnover based on innovations, the most innovative industry in Finland is the electrical and optical equipment industry (Table 6.2). In 1998 almost three-quarters of its turnover came from technological innovations introduced in 1996–1998. Another statistic that underlines the role of this industry is that it accounted for some 65 per cent of total innovative turnover in manufacturing. Another industry where the frequency of technological innovations exceeds the average is that of machinery and equipment. The chemical industry has a large number of innovating enterprises, but the share of innovative turnover is low. Indeed, the accent in chemical industry innovation is clearly on developing new processes. In the service sector the one branch that clearly stands out is telecommunications, where 40 per cent of turnover comes from product or service innovations. Computer-related activities have a fairly large number of innovating firms, but as is the case in the chemical industry, innovations account only for a small proportion of turnover. The level of industrial innovation is lowest in the food industry, in mechanical wood processing and in publishing and printing. In other industries the figures recorded for energy supply and transport remain below the average. The material collected by the Technical Research Centre suggests a similar structure, with the highest frequency of innovations recorded for the electronics industry, machinery and equipment and software.

TABLE 6.2
Industrial innovation and turnover from product innovations by industry in 1998

Main group Industry	Number	Product or service innovations %	Process innovations %	Product or process innovations %	Turnover from product or service innovations %
Total	**2 117**	**30**	**22**	**34**	**18**
Manufacturing, total	**1 391**	**28**	**22**	**34**	**25**
Food products, beverages, tobacco	119	18	19	22	8
Textiles, wearing apparel, footwear, leather goods	68	22	14	29	8
Wood products	89	10	14	18	5
Pulp, paper and paper products	42	23	19	28	9
Publishing and printing	98	16	17	26	9
Oil, chemicals, rubber and plastic	147	43	33	47	7
Non-metallic mineral products	53	31	18	33	17
Basic metals, fabricated metal products	207	18	18	24	15
Machinery and equipment	245	45	28	48	25
Electrical products, optical equipment	192	56	39	61	73
Transport equipment	52	38	23	40	15
Other manufacturing	79	30	16	37	13
Other industries, total	**726**	**33**	**24**	**36**	**6**
Electricity, gas and water supply	60	9	10	10	3
Construction	74	41	37	43	4
Wholesale and commission trade	93	41	20	45	2
Land, water and air transport	50	12	20	22	5
Telecommunications	39	35	23	39	38
Computer related activities	114	53	42	55	9
Architectural, engineering and technical services	120	31	20	34	9
Other business activities	51	40	22	40	4
Other industries	125	26	21	29	5

From basic idea to innovation in two years

VTT's Sfinno project also measured the amount of time that firms in different industries spent on developing innovations. It was found that the time from initial concept to commercialised product is shorter than average most notably with software innovations: around 70 per cent of all innovations were completed within less than two years (Table 6.3). However, it would seem that development times are also comparatively short in low-tech industries: foods, clothing and wood products manufacturing. It should be noted though that in these sectors the number of innovations is comparatively small, i.e. the rapid throughput time is not reflected in the number of innovating firms. Less than half of the innovations in the electronics industry were completed within two years, but one-fifth required at least six years of development before the initial concept had been transformed into a marketable product.

Large enterprises are frequent innovators, small innovating firms are intensive

The associations between company size and innovation have been extensively researched. It has been shown that large enterprises have the advantage of a greater capacity for risk-taking and for intramural funding, while smaller companies have greater flexibility in the application of new ideas. In an examination of the proportions of innovating enterprises it should be borne in mind that since a firm is innovative if it has only one product or process innovation, large enterprises with a wide product range are for this reason more likely to be

TABLE 6.3
Time from basic idea of the innovation to commercialisation by industry

Industry	Number	Same year %	1–2 years %	3–5 years %	6–9 years %	10+ years %
Total	**610**	**6**	**44**	**32**	**12**	**6**
Mining and quarrying	–	–	–	–	–	–
Food products	29	14	48	21	17	0
Textiles, wearing apparel, footwear	7	0	86	0	14	0
Wood and wood products	8	0	63	38	0	0
Pulp, paper and paper products	22	18	36	32	9	5
Publishing and printing	4	25	50	25	0	0
Oil, chemicals, rubber and plastic	53	2	34	30	13	21
Non-metallic mineral products	7	0	43	43	14	0
Basic metals, fabricated metal products	37	11	41	35	11	3
Machinery and equipment	113	5	51	31	8	4
Electrical equipment	97	2	44	34	12	7
Transport equipment	18	17	39	28	11	6
Other manufacturing, recycling	8	13	25	63	0	0
Electricity, gas and water supply	6	0	17	17	50	17
Construction	10	0	50	40	0	10
Wholesale and retail trade	47	4	43	32	19	2
Computer related activities	54	11	56	24	6	4
Architectural, engineering and technical services	44	5	41	41	7	7
Research and development	9	0	33	11	44	11
Other services	31	3	32	48	10	7
Holding companies	6	0	50	17	33	0

Source: VTT, Sfinno database

TABLE 6.4
Innovation and turnover from product innovations by firm size in 1998

Main group Personnel size	Number	Product or service innovations	Process innovations	Product or process innovations	Turnover from product or service innovations
		%	%	%	%
Total	**2 117**	**30**	**22**	**34**	**18**
Manufacturing, total	**1 391**	**28**	**22**	**34**	**25**
10–19	255	19	12	23	5
20–49	389	22	15	27	6
50–99	267	37	34	48	7
100–249	259	42	36	51	13
250–499	109	59	44	66	15
500+	112	80	69	82	31
Other industries, total	**726**	**33**	**24**	**36**	**6**
10–19	170	36	21	38	18
20–49	176	35	27	37	9
50–99	102	30	25	33	3
100–249	156	24	19	28	5
250–499	67	30	29	36	4
500+	55	44	46	51	7

classified as innovating than SMEs. Indeed in manufacturing both the number of innovating firms and the share of innovative turnover increases steadily with company size: in companies with more than 500 employees 82 per cent indicated that they were engaged in innovation (Table 6.4). In service industries, on the other hand, the difference is only seen in firms with more than 500 employees – and even here we only find an increase in the proportion of innovating firms. In fact in the service sector the share of turnover attributable to innovations is highest in small firms with a staff of 10–19.

The significance of innovation to an enterprise can be assessed by calculating the proportion of turnover due to innovations separately for firms that have introduced a product innovation to the markets. On this indicator it would seem that the most intensive innovators in manufacturing are the smallest and

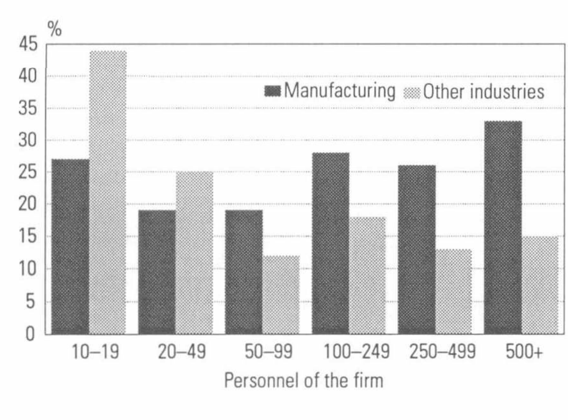


FIGURE 6.1
Turnover from product innovations by firm size, firms with product innovations

largest firms with at least 100 employees (Figure 6.1). In the service industries innovations account for almost half of the turnover of small firms with less than 20 staff that have made product or service innovations. Innovation intensity declines with increasing company size; in firms with more than 50 staff the figure drops below 20 per cent. The crucial significance of the success of an innovation for small firms investing in innovation is clearly seen in the results of the Sfinno project, according to which product innovations accounted for over half of the turnover in 60 per cent of innovating enterprises with less than 10 employees.

Technological innovations reported by every other company in the EU countries

Eurostat has co-ordinated two innovation surveys among EU Member States; Finland took part in the latter of these surveys[7]. Data collection for CIS2 took place in 1997–1998. The methodological solutions and the data collection form were harmonised as far as possible to ensure maximum comparability between the participating countries. The response rates in the different countries ranged from around 24 per cent to over 90 per cent[8].

All in all, around half of the firms with more than 20 employees had introduced a technologically new product or a new production method (Figure 6.2). The number of innovative firms is highest in Ireland, Denmark, Germany and Austria; the frequency of innovations is lowest in Portugal, Spain, Belgium and Finland.

The low figure recorded for Finland is quite surprising considering its high GDP share of R&D expenditure and in view of the fact that total expenditure on innovation as a proportion of business turnover is second highest in Finland after Sweden. Even firms in the electronics industry fall short of the EU average. On the other hand, different industries are rank-ordered in very much the same way in Finland as in other Member States, i.e. the largest number of innovating firms is found in the chemical industry, in machinery and equipment and in the electronics industry. The reason why Finland stands apart from all other EU countries in the area of manufacturing, lies in the category of small firms with 20–250 employees: these firms record a much smaller number of innovations than other EU countries. By contrast, enterprises with more than 250 employees produced innovations equally often as their European

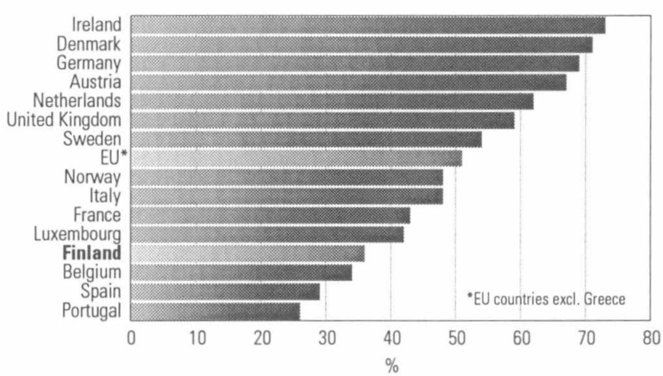


FIGURE 6.2
Proportion of innovative manufacturing firms in different countries

Source: CIS2, the Second Community Innovation Survey, New Cronos database

7 Second Community Innovation Survey, CIS2.

8 Some of the results have been published in Eurostat's New Cronos database. At the time of writing this, it contained data on all EU Countries except Greece (14), as well as on Norway.

rivals. In the service sector there is no corresponding difference; both SMEs and large enterprises lag just as far behind the EU's average level (see Appendix Tables 6.1, 6.2 and 6.3).

Volume of innovation is high, while number of innovating firms is low in Finland

There are two different sides to the picture of the innovation scene in Finland: on the one hand, it is clear that efforts are being invested in innovation and that product innovations do generate considerable business turnover, but on the other hand, the number of technologically innovating firms is lower than elsewhere in the EU. One possible explanation for the relatively low proportion of innovating firms could lie in the inherent difficulty of international comparison – even with harmonised statistical methods. People in different countries do not necessarily understand the concepts used in the same way. These measurement problems notwithstanding, it is clear that the high innovation expenditure in Finland is explained by its concentration in large enterprises in the forest and electronics industry; in the SME category the turnover share of innovation expenditure is among the lowest in the EU. In other words, it would seem that innovation in Finland is essentially in the hands of a small group of highly intensive innovators. Accordingly, the low figure recorded for the electronics industry in comparison with other EU countries would reflect the fact that there are large numbers of Nokia-driven subcontractors in this field that have no independent development efforts of their own. Having said that, the key role of the electronics industry at the national level is clearly reflected both in R&D expenditure and in the innovation statistics.

It should be noted that the macro-level statistical analysis above overlooks at least two factors that are relevant to the development and impact of innovations. Firstly, for budget reasons neither CIS2 nor Statistics Finland have been able to carry out a comprehensive analysis of the smallest firms with less than 10 employees. Yet it is often these firms that are most interesting in terms of their role in the application of new technologies and in product development. One indication of this is that around one-third of the innovations in the Sfinno database were commercialised by enterprises with less than 10 employees. The innovation survey carried out by Statistics Finland in 1996 included a separate sample of small firms with less than 10 employees in selected high-tech industries. In the electronics sector 35 per cent of these microcompanies reported product innovations (the corresponding share for companies with more than 10 employees was 45 per cent), in machinery and equipment the corresponding figures were 17 and 34 per cent.

Secondly, the technological significance of innovations and the extent of diffusion vary. An innovation may only be applicable by the firm that has developed it, or it may rapidly spread throughout the economy with considerable multiplier effects. In this regard the measurement of sales volumes for one particular year is a relatively limited indicator. Concrete examples of important recent Finnish innovations can be found at the websites run by the Foundation for Finnish Inventions[9] or the INNOFINLAND Project[10].

9 http://www.innofin.com/

10 http://innosuomi.iaf.fi/english.html

APPENDIX 6.1
Enterprises with product innovations by industry and country

	EU*	Belgium	Denmark	Germany	Spain	France	Ireland	Italy	Luxembourg	Netherlands	Austria	Portugal	Finland	Sweden	United Kingdom	Norway	**Total**
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	**%**
Manufacturing	51	34	71	69	29	43	73	48	42	62	67	26	36	54	59	48	**51**
Food products, beverages, tobacco	50	27	73	68	22	45	65	59	15	58	67	25	25	38	58	47	**50**
Textiles, wearing apparel, footwear, leather goods	35	28	55	62	18	30	58	32	–	49	55	19	37	45	56	45	**35**
Wood products, pulp and paper, publishing and printing	45	30	70	59	21	32	68	45	43	53	62	23	30	45	51	36	**45**
Oil products, chemicals, chemical products	70	46	93	75	62	68	79	61	53	85	71	77	61	61	81	76	**70**
Rubber and plastic products	51	34	63	67	31	49	79	44	51	67	45	36	44	57	53	54	**51**
Basic metals, metal products	48	39	58	59	25	31	68	54	44	53	68	19	31	41	56	43	**48**
Machinery, equipment	68	44	80	84	46	63	89	61	70	80	80	36	41	73	63	64	**68**
Electrical equipment	69	51	88	78	55	61	88	56	50	74	87	80	51	75	76	65	**69**
Transport equipment	57	41	85	72	46	49	88	47	–	60	78	19	36	58	63	44	**56**
Other manufacturing	48	25	60	69	23	38	71	53	–	57	82	17	22	59	44	51	**48**
Electricity, gas and water supply	36	58	48	38	37	24	–	36	–	58	22	36	19	23	64	24	**35**
Services	40	13	30	46	–	31	58	–	48	36	55	28	24	32	40	22	**40**
Wholesale trade	34	10	27	39	–	–	52	–	37	36	58	26	15	29	33	18	**34**
Transport and communications (excl. telecommunications)	24	9	13	26	–	11	33	–	57	21	54	28	16	19	34	5	**24**
Telecommunications	65	27	100	100	–	52	86	–	–	74	81	45	79	51	60	56	**65**
Financial intermediation	54	13	48	69	–	45	67	–	43	40	55	43	28	56	49	44	**54**
Computer related activities	68	41	89	71	–	52	73	–	88	68	69	53	63	55	81	50	**68**
Architectural, engineering and technical services	55	43	36	61	–	39	78	–	76	52	20	30	31	47	38	38	**55**

** excl. Greece*
Source: CIS2, the Second Community Innovation Survey, New Cronos database

APPENDIX 6.2
Enterprises with product or process innovations by company size and country

	EU*	Belgium	Denmark	Germany	Spain	France	Ireland	Italy	Luxembourg	Netherlands	Austria	Portugal	Finland	Sweden	United Kingdom	Norway	**Total**
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	**%**
Manufacturing	**51**	**34**	**71**	**69**	**29**	**43**	**73**	**48**	**42**	**62**	**67**	**26**	**36**	**54**	**59**	**48**	**51**
20–49	44	33	64	63	21	34	68	44	21	54	59	22	26	43	54	39	**44**
50–49	58	34	76	70	43	48	78	57	52	71	73	30	40	61	59	56	**58**
250+	79	51	91	85	76	75	85	73	85	84	88	52	77	79	81	77	**79**
Services	**40**	**13**	**30**	**46**	–	**31**	**58**	–	**48**	**36**	**55**	**28**	**24**	**32**	**40**	**22**	**40**
20–49	37	11	24	41	–	25	60	–	45	32	54	28	22	29	40	20	**36**
50–49	49	21	45	60	–	33	49	–	55	45	58	27	30	48	37	26	**48**
250+	73	55	71	83	–	73	87	–	83	71	74	52	43	45	55	50	**73**

** excl. Greece*
Source: CIS2, the Second Community Innovation Survey, New Cronos database

APPENDIX 6.3
Innovation expenditure as a proportion of turnover by firm size and country

	EU*	Belgium	Denmark	Germany	Spain	France	Ireland	Italy	Netherlands	Austria	Portugal	Finland	Sweden	United Kingdom	Norway	**Total**
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	**%**
Manufacturing	**3.7**	**2.1**	**4.8**	**4.1**	**1.8**	**3.9**	**3.3**	**2.6**	**3.8**	**3.5**	**1.7**	**4.3**	**7.0**	**3.2**	**2.7**	**3.7**
20–49	2.5	2.1	10.4	3.3	1.0	1.4	2.8	2.4	3.0	4.4	1.8	1.6	2.6	3.3	2.2	**2.5**
50–49	2.3	1.4	3.5	2.4	1.6	2.2	3.2	2.2	1.8	3.1	1.9	1.6	2.7	2.9	2.8	**2.3**
250+	4.2	2.3	4.5	4.4	2.2	4.9	3.7	3.1	4.6	3.5	1.6	5.1	8.2	3.2	2.8	**4.2**
Services	**2.8**	**1.2**	**4.7**	**3.0**	–	**1.2**	**2.1**	–	**1.6**	**3.0**	**1.1**	**2.4**	**3.8**	**4.0**	**3.5**	**2.8**
20–49	2.9	0.9	2.6	3.1	–	0.8	6.0	–	2.4	2.8	2.1	3.6	1.1	6.9	2.2	**2.9**
50–49	2.4	2.7	1.5	2.5	–	1.0	1.2	–	2.4	3.9	1.6	3.0	6.1	2.7	1.2	**2.3**
250+	2.8	1.1	6.3	3.0	–	1.5	2.9	–	1.3	2.7	0.7	1.8	5.0	3.7	5.4	**2.9**

** excl. Greece and Luxembourg*
Source: CIS2, the Second Community Innovation Survey, New Cronos database

7 Patenting

Patent statistics as technology indicators

In this chapter technology outputs are described by reference to patents statistics. We will be looking not only at domestic but also international patenting and examining various different indicators. Chapter 8 below will further deal with the issue of patents citations.

A patent is a fixed-term exclusive right to exploit an invention commercially granted by the State to the inventor or the holder of the inventor's rights.

A patent is formal recognition that the new innovation incorporates essentially new technology and technical know-how that lends itself to industrial application. As far as business enterprises are concerned patents are an indicator of the output of their R&D operations. However, not all patents lead to commercial application; for instance, the technology involved may be too difficult to develop for industrial production, or the marketing of the final product may be too difficult.

One of the advantages of using patents statistics as an indicator of technology output is that there is an abundance of data available that allow for easy international comparison over extended periods of time. The material also lends itself to different types of processing. One factor that does complicate comparisons is that the grounds on which patents are granted vary between different countries, and there may also be considerable differences in the rules and regulations governing patents.

Patent indicators provide a clearer picture than most other technology indicators of the associations between R&D activities and innovation because the patent ties in more or less directly with the innovation. However, in most cases patents statistics provide only a partial or rather incomplete picture of the new technology because not all new innovations are patented or can be patented. One of the factors that may deter applicants is that the process itself is slow and may last years. There is also the cost factor: the costs of applying for and maintaining a patent may run up to thousands of euros.

The economic significance of patents varies. Sometimes business enterprises 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 business enterprises 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; a patent is a patent. The significance of patenting to the national economy or to an individual business enterprise may be considerable: investments into the development of patents may be paid back several times over.

Material and definitions

The data on patents applied and granted are based on figures obtained from the National Board of Patents and Registration on national and international patents in Finland. The Tables describing Finnish applications for external patents include the patents granted or applications filed in the countries concerned as well as those processed through the European Patent Office EPO. In addition, we have used data from the United States Patent and Trademark Office (USPTO).

The most important agreements in this field are the European Patent Convention (EPC) and the Patent Cooperation Treaty (PCT). Patents based on the EPC are applied through the EPO or an agency authorised by the Office. Patent applications may be filed for all or just some

Member States. Patents applied for through the system come into the public domain 18 months after the application has been filed. The patent may be granted after this period. European patents granted by the EPO provide the same protection to the invention as one obtained directly from a national patent authority. Finland joined the EPC in 1996, although even before that Finnish organisations and individuals were able to apply for a European patent through the EPO. In the statistics, Finland's membership of the Convention is reflected in the marked decrease in the number of patent applications filed by foreigners in Finland.

7.1 Patenting in Finland

Number of applications from foreign countries has decreased considerably

In 1999 a total of 3,083 patent applications were filed in Finland (Table 7.1). The figure was roughly the same as one year previously, but 54 per cent lower than in 1995 when the number of patent applications in Finland reached its peak. The number of domestic applications has remained high, but the figure for applications received from foreign countries has dropped below 400. In 1999 only one in eight applications came from foreign countries. Throughout the first half of the 1990s foreign applications accounted for around two-thirds, and in 1997 for almost half of all applications. In recent years the largest number of patent applications has been received from the United States (around one-third) and Germany and Sweden, both accounting for over 10 per cent. Today most applications for a Finnish patent are filed with the EPO. In 1998, for instance, Finland was mentioned in some 62,000 EPO applications.

More than two in three domestic applications filed by business enterprises

More than two-thirds or 69 per cent of all domestic patent applications were filed by companies and associations, the rest by private individuals. The number of patent applications filed by business enterprises and associations increased by a few dozen on the figures for one year previously, while the figure for private persons dropped accordingly. The number of

TABLE 7.1
Patent applications filed in Finland in 1990–1999

Year	Domestic applicants			Foreign applicants	Total
	Private person	Business enterprise/ association	Domestic total		
1990	708	1 360	2 068	4 414	6 482
1991	863	1 315	2 178	4 013	6 191
1992	803	1 247	2 050	3 948	5 998
1993	891	1 316	2 207	3 770	5 977
1994	938	1 404	2 342	3 871	6 213
1995	855	1 426	2 281	4 481	6 762
1996	970	1 454	2 424	3 286	5 710
1997	784	1 626	2 410	2 258	4 668
1998	884	1 818	2 702	434	3 136
1999	847	1 851	2 698	385	3 083

applications filed by business enterprises as a proportion of the total figures has risen sharply during the past few years and was higher in 1999 than at any other time during the 1990s.

In 1999 the number of business enterprises filing patent applications was 561. This figure has shown some increase during the latter half of the 1990s. Patenting is quite heavily concentrated: in 1999 the 20 biggest patent applicants accounted for about half of all patents filed by business enterprises and associations. Most business enterprises only filed one patent application.

Nonetheless by international comparison the share of private persons was comparatively high in Finland; this is largely explained by the 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].

Almost one in four patent applications from the section of electricity

In an examination based on the International Patent Classification (IPC), the largest single category of domestic patent applications (accounting for almost 24 per cent) was the section of electricity (Figure 7.1). The next biggest section was represented by performing operations and transporting, accounting for 19 per cent of all applications. Among foreign applications the biggest category was chemistry and metallurgy, accounting for 24 per cent of all applications; the section of electricity was almost equally large. While on average every eighth patent application came from a foreign country, the proportion in chemistry and metallurgy was much higher at 29 per cent.

Table 7.2 illustrates the breakdown of patent applications in Finland by a more detailed technology classification[2]. The biggest categories of patent applications in 1999 were telecommunications technology (18.7%), construction technology (11.7%) and paper manufacture and printing (8.0%). Both domestic and foreign patent applications were concentrated in the field of telecommunications (18.8% and 18.2%). Construction technology did not account for a very large proportion of foreign applications. By contrast large numbers of foreign applications were received in the category of biotechnology and genetic engineering (14.8%).

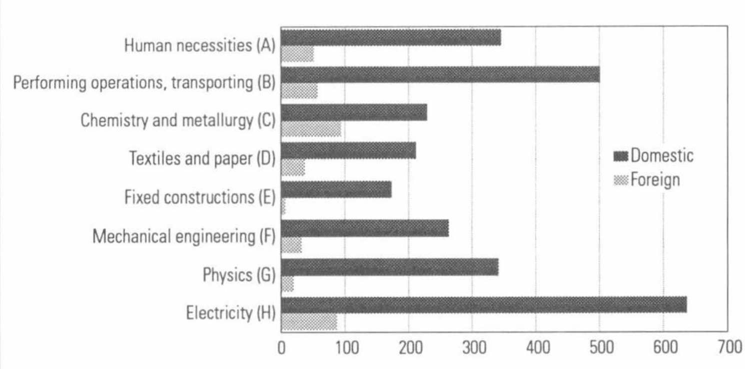


FIGURE 7.1
Patent applications filed in Finland by IPC section in 1999

1 The State and Quality of Scientific Research in Finland. Publications of the Academy of Finland 7/00, p.107.

2 Engelsman, E.C. & A.F.J. van Raan. The Netherlands in modern technology: a patent-based assessment, 1991.

The share of patent applications in biotechnology and genetic engineering as well as in organic and polymer chemistry has declined noticeably since 1995. This is due to the sharp decrease in the number of foreign applications. Nonetheless the share of foreign applications is still the highest in these fields at around 40 per cent. The share of applications in telecommunications has doubled during the latter half of the 1990s.

TABLE 7.2
Patent applications filed in Finland by field of technology in 1995, 1997 and 1999

Field of technology	1995		1997		1999					
					Total		Domestic		Foreign	
	No.	%	No.	%	No.	%	No.	%	No.	%
Mining and quarrying, civil engineering, construction materials, air-conditioning, waste management	637	9.4	445	9.5	360	11.7	348	12.9	12	3.1
Manufacture of paper, printing	389	5.8	295	6.3	247	8.0	210	7.8	37	9.6
Textiles, clothing, leisure, textile industry machinery	162	2.4	109	2.3	65	2.1	63	2.3	2	0.5
Biomedicine	291	4.3	164	3.5	86	2.8	77	2.9	9	2.3
Agriculture, food, beverages, tobacco	276	4.1	216	4.6	133	4.3	115	4.3	18	4.7
Biotechnology and genetic engineering, pharmaceutics	696	10.3	486	10.4	143	4.6	86	3.2	57	14.8
Organic chemistry, petrochemistry	719	10.6	428	9.2	83	2.7	46	1.7	37	9.6
Polymeric materials (polymer chemistry)	223	3.3	86	1.8	36	1.2	22	0.8	14	3.6
Manufacture and application of polymers	183	2.7	87	1.9	39	1.3	29	1.1	10	2.6
Inorganic chemistry	131	1.9	59	1.3	29	0.9	28	1.0	1	0.3
Coating, crystal growth	43	0.6	20	0.4	23	0.7	22	0.8	1	0.3
Process technology, separation and combination of substances	304	4.5	189	4.0	123	4.0	110	4.1	13	3.4
Mechanical technology, machine construction, weapons	202	3.0	125	2.7	117	3.8	103	3.8	14	3.6
Material treatment, working machines	285	4.2	216	4.6	145	4.7	125	4.6	20	5.2
Treatment of goods, transfer gears, robots	372	5.5	215	4.6	141	4.6	126	4.7	15	3.9
Transport, traffic	229	3.4	157	3.4	135	4.4	128	4.7	7	1.8
Motors, turbines, pumps	159	2.4	99	2.1	76	2.5	65	2.4	11	2.9
Electric power, nuclear technology	93	1.4	71	1.5	53	1.7	45	1.7	8	2.1
Electrical equipment	164	2.4	99	2.1	61	2.0	52	1.9	9	2.3
Lasers	3	0.0	1	0.0	–	–	–	–	–	–
Optical equipment	34	0.5	26	0.6	26	0.8	23	0.9	3	0.8
Instruments, control gear	125	1.8	82	1.8	83	2.7	82	3.0	1	0.3
Metrology, sensors	262	3.9	173	3.7	174	5.6	164	6.1	10	2.6
Computing	51	0.8	68	1.5	72	2.3	70	2.6	2	0.5
Data storage	8	0.1	4	0.1	1	0.0	1	0.0	–	–
Telecommunications	638	9.4	679	14.5	578	18.7	508	18.8	70	18.2
Image transfer	34	0.5	19	0.4	11	0.4	8	0.3	3	0.8
Electronics, electronic components	49	0.7	50	1.1	43	1.4	42	1.6	1	0.3
Total	**6 762**	**100.0**	**4 668**	**100.0**	**3 083**	**100.0**	**2 698**	**100.0**	**385**	**100.0**

The region of Uusimaa dominates the patents scene as well

The regional breakdown of patent applications can be studied on the basis of the inventor's address as reported in the application. In 1999 business enterprises with an address in the region of Uusimaa accounted for 39 per cent of all domestic applications filed by businesses (Table 7.3). However the share of the region dropped by a couple of percentage points compared to 1995. The share of Pirkanmaa climbed to over 15 per cent. The figures for both North Ostrobothnia and Central Finland were around seven per cent. The share of Varsinais-Suomi was surprisingly low in view of the fact that the population in the region is the same as in Pirkanmaa. The figures for Pirkanmaa increased from 1995 to 1999 by four percentage points. During the corresponding period the share of North Ostrobothnia dropped by a couple of percentage points, that of Varsinais-Suomi by one percentage point.

The number of patent applications from the regions of Uusimaa, North Ostrobothnia and Varsinais-Suomi as a proportion of all business enterprises' applications in 1999 was considerably smaller than these regions' shares of business enterprise R&D expenditure (42.4%, 12.5% and 9.8%). Central Finland's share of patent applications was much higher than its share of R&D expenditure (3.5%).

TABLE 7.3
Domestic patent applications filed by business enterprises in Finland by inventor's address by region in 1995, 1997 and 1999

Region	1995		1997		1999	
	Number	%	Number	%	Number	%
Uusimaa	588	41.2	657	40.4	727	39.3
Itä-Uusimaa	30	2.1	28	1.7	32	1.7
Varsinais-Suomi	99	6.9	133	8.2	110	5.9
Satakunta	39	2.7	36	2.2	40	2.2
Kanta-Häme	33	2.3	25	1.5	33	1.8
Pirkanmaa	159	11.2	201	12.4	287	15.5
Päijät-Häme	42	2.9	41	2.5	52	2.8
Kymenlaakso	49	3.4	48	3.0	48	2.6
South Karelia	12	0.8	8	0.5	15	0.8
Etelä-Savo	26	1.8	25	1.5	41	2.2
Pohjois-Savo	33	2.3	30	1.8	33	1.8
North Karelia	23	1.6	22	1.4	21	1.1
Central Finland	87	6.1	108	6.6	127	6.9
South Ostrobothnia	20	1.4	21	1.3	25	1.4
Ostrobothnia	33	2.3	23	1.4	37	2.0
Central Ostrobothnia	7	0.5	5	0.3	9	0.5
North Ostrobothnia	127	8.9	157	9.7	131	7.1
Kainuu	4	0.3	10	0.6	5	0.3
Lapland	7	0.5	10	0.6	18	1.0
Åland	1	0.1	2	0.1	1	0.1
Domestic total	**1 389**	**97.4**	**1 590**	**97.8**	**1 792**	**96.8**
Foreign	33	2.3	38	2.3	59	3.2
Unknown	4	0.3	–	–	–	–
Total	**1 426**	**100.0**	**1 626**	**100.0**	**1 851**	**100.0**

TABLE 7.4
Patent applications* by business enterprises and associations by IPC section and region in 1999

A) Percentage breakdown by patent section

Region	**Total**	IPC section**							
		A	B	C	D	E	F	G	H
Uusimaa	**39.3**	32.7	31.3	45.8	25.3	20.6	25.4	39.3	54.4
Itä-Uusimaa	**1.7**	1.3	2.2	6.5	0.5	3.1	0.7	0.4	1.4
Varsinais-Suomi	**5.9**	8.5	6.5	3.9	6.3	9.3	6.3	5.2	4.9
Satakunta	**2.2**	3.3	3.7	4.6	4.7	5.2	1.4	0.9	0.0
Kanta-Häme	**1.8**	3.3	3.7	1.3	1.6	3.1	2.1	0.4	0.7
Pirkanmaa	**15.5**	12.4	16.7	7.2	15.3	16.5	14.1	19.7	16.3
Päijät-Häme	**2.8**	2.0	6.2	2.6	0.5	3.1	7.7	2.6	0.7
Kymenlaakso	**2.6**	4.6	4.3	2.0	7.9	1.0	5.6	0.9	0.0
South Karelia	**0.8**	1.3	0.0	0.0	0.5	0.0	2.8	0.9	1.0
Etelä-Savo	**2.2**	5.9	4.0	2.0	3.2	2.1	2.1	0.4	0.9
Pohjois-Savo	**1.8**	5.2	2.2	2.0	0.5	5.2	1.4	3.1	0.0
North Karelia	**1.1**	2.0	2.5	0.7	0.5	2.1	0.7	2.2	0.3
Central Finland	**6.9**	1.3	3.1	3.3	26.8	5.2	15.5	9.6	1.7
South Ostrobothnia	**1.4**	3.9	2.8	0.0	0.0	8.2	0.0	0.0	0.3
Ostrobothnia	**2.0**	2.6	3.1	0.0	3.2	0.0	5.6	1.7	1.0
Central Ostrobothnia	**0.5**	0.7	0.6	2.0	0.0	1.0	1.4	0.4	0.0
North Ostrobothnia	**7.1**	5.2	2.2	5.2	0.5	6.2	3.5	8.3	13.5
Kainuu	**0.3**	0.0	0.0	0.0	0.5	1.0	0.7	0.9	0.0
Lapland	**1.0**	2.0	1.5	2.6	0.0	2.1	0.7	1.3	0.0
Åland	**0.1**	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic total	**96.8**	98.7	96.6	91.5	97.9	94.8	97.9	98.3	97.2
Foreign	**3.2**	1.3	3.4	8.5	2.1	5.2	2.1	1.7	2.8
Total	**100.0**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

B) Percentage breakdown by region

Region	Total	IPC section**							
		A	B	C	D	E	F	G	H
Uusimaa	100.0	6.9	13.9	9.6	6.6	2.8	5.0	12.4	42.8
Itä-Uusimaa	100.0	6.3	21.9	31.3	3.1	9.4	3.1	3.1	25.0
Varsinais-Suomi	100.0	11.8	19.1	5.5	10.9	8.2	8.2	10.9	25.5
Satakunta	100.0	12.5	30.0	17.5	22.5	12.5	5.0	5.0	0.0
Kanta-Häme	100.0	15.2	36.4	6.1	9.1	9.1	9.1	3.0	12.1
Pirkanmaa	100.0	6.6	18.8	3.8	10.1	5.6	7.0	15.7	32.4
Päijät-Häme	100.0	5.8	38.5	7.7	1.9	5.8	21.2	11.5	7.7
Kymenlaakso	100.0	14.6	29.2	6.3	31.3	2.1	16.7	4.2	0.0
South Karelia	100.0	13.3	0.0	0.0	6.7	0.0	26.7	13.3	40.0
Etelä-Savo	100.0	22.0	31.7	7.3	14.6	4.9	7.3	2.4	12.2
Pohjois-Savo	100.0	24.2	21.2	9.1	3.0	15.2	6.1	21.2	0.0
North Karelia	100.0	14.3	38.1	4.8	4.8	9.5	4.8	23.8	9.5
Central Finland	100.0	1.6	7.9	3.9	40.2	3.9	17.3	17.3	7.9
South Ostrobothnia	100.0	24.0	36.0	0.0	0.0	32.0	0.0	0.0	8.0
Ostrobothnia	100.0	10.8	27.0	0.0	16.2	0.0	21.6	10.8	16.2
Central Ostrobothnia	100.0	11.1	22.2	33.3	0.0	11.1	22.2	11.1	0.0
North Ostrobothnia	100.0	6.1	5.3	6.1	0.8	4.6	3.8	14.5	58.8
Kainuu	100.0	0.0	0.0	0.0	20.0	20.0	20.0	40.0	0.0
Lapland	100.0	16.7	27.8	22.2	0.0	11.1	5.6	16.7	0.0
Åland	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic total	**100.0**	**8.4**	**17.4**	**7.8**	**10.4**	**5.1**	**7.8**	**12.6**	**31.0**
Foreign	100.0	3.4	18.6	22.0	6.8	8.5	5.1	6.8	27.1
Total	**100.0**	**8.3**	**17.5**	**8.3**	**10.3**	**5.2**	**7.7**	**12.4**	**30.9**

** Inventors named, gross (the same person can be named in several applications)*
*** A: Human necessities, B: Performing operations, transporting, C: Chemistry and metallurgy, D: Textiles and paper, E: Fixed constructions, F: Mechanical engineering, lighting, heating, weapons, blasting, G: Physics, H: Electricity*

Patent applications by business enterprises

In the category of *domestic* patent applications filed by business enterprises, the share of Uusimaa was highest (56%) in the section of electricity. Uusimaa also accounted for a large proportion (46%) of patents in chemistry and metallurgy. Pirkanmaa accounted for the largest share or one-fifth of all applications in the physics section. Almost 14 per cent of patent applications in the section of electricity came from North Ostrobothnia. It is also noteworthy that Central Finland accounted for large proportions (27% and 16%) of the patent applications in the section of textiles and paper and in the mechanical engineering. The breakdowns by region are shown in Table 7.4A. However, the percentages have been computed from all applications, not just domestic applications.

In 1999 almost one-third of all domestic patent applications filed by business enterprises were in the section of electricity (Table 7.4B). The second highest figure (17%) was recorded for performing operations and the third highest (13%) for physics. Among applications filed by business enterprises in the region of Uusimaa, the electricity section accounted for 43 per cent and the performing operations and transporting section for 14 per cent. The same sections dominated in Pirkanmaa and Varsinais-Suomi. In North Ostrobothnia the section of electricity accounted for as large a proportion as 59 per cent of all applications. Central Finland, for its part, specialises in patent applications in textiles and paper: this sector accounted for 40 per cent of all the applications in this region. The number of patent applications by business enterprises in other regions remained comparatively low.

Number of foreign patents granted has declined

In 1999 a total of almost 1,750 patents were granted (Table 7.5). Foreign patents accounted for 51 per cent of the total figure. In 1995 the number of patents awarded was still 2,346, or one-quarter more than today. The number of patents granted to domestic applicants has remained unchanged, whereas the number of patents granted to foreign applicants has dropped by 40 per cent as a result of the decline in the number of applications in previous years.

Some three in four patents in the textiles and paper section and in the section of electricity were granted to domestic applicants (Figure 7.2). In chemistry and metallurgy, 84 per cent of all patents were granted to foreign applicants. Of the patents granted to domestic applicants around one-quarter were in the section of electricity, one-fifth in the performing operations and transporting section. The breakdown for patents

TABLE 7.5
Patents granted in Finland in 1995, 1997 and 1999

IPC section	1995			1997			1999		
	Total	Domestic	Foreign	Total	Domestic	Foreign	Total	Domestic	Foreign
Human necessities (A)	305	86	219	284	99	185	262	108	154
Performing operations, transporting (B)	455	206	249	440	227	213	288	171	117
Chemistry and metallurgy (C)	649	79	570	459	90	369	438	70	368
Textiles and paper (D)	179	84	95	172	67	105	130	101	29
Fixed constructions (E)	153	89	64	122	69	53	72	42	30
Mechanical engineering, lighting, heating, weapons, blasting (F)	188	77	111	183	105	78	148	79	69
Physics (G)	201	94	107	200	114	86	120	70	50
Electricity (H)	216	148	68	440	321	119	284	209	75
Total	**2 346**	**863**	**1 483**	**2 300**	**1 092**	**1 208**	**1 742**	**850**	**892**

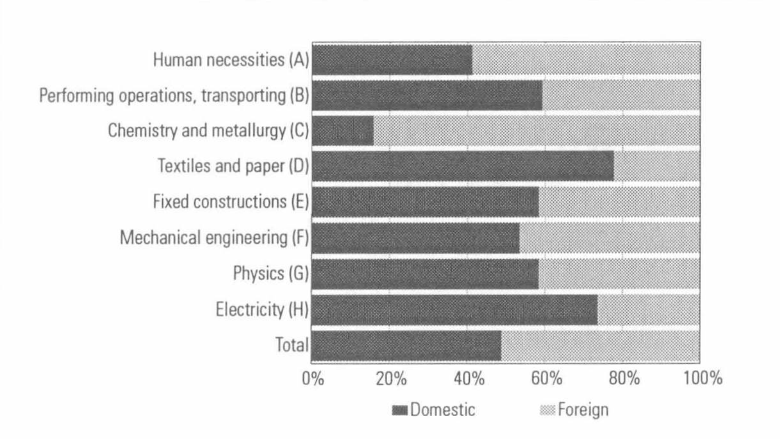


FIGURE 7.2
Patents granted to domestic and foreign applicants in Finland in 1999

granted to foreign applicants was quite different: 41 per cent of these patents were in chemistry and metallurgy, 17 per cent in the human necessities section. The total number of patents granted in these four sections was markedly higher than in the four other sections.

In 1999 the total number of patents in force in Finland was 19,500, or roughly the same as in 1996 but almost 3,000 more than in 1990. The annual fees for patents in 1999 totalled FIM 41.25 million, in 1990 the figure was FIM 35.45 million.

7.2 International patenting

International comparisons

In 1997 some 4.6 domestic patent applications were filed per 10,000 population in Finland. The only OECD countries with higher figures were Germany (5.5) and Sweden (4.7) (Figure 7.3). The average ratio for all EU Member States was 2.5. The figure for Finland has increased to some extent since 1990. The strongest growth has been recorded in Norway, Sweden and the United States. By contrast in Switzerland, Austria, the United Kingdom and the Netherlands,

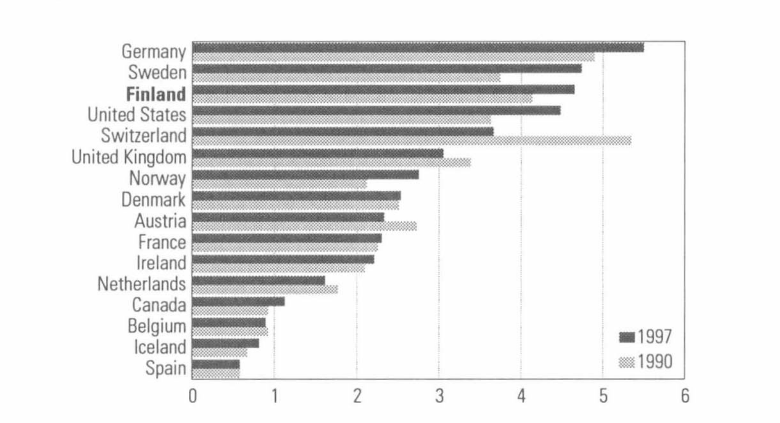


FIGURE 7.3
Domestic patent applications per 10,000 population in selected OECD countries in 1990 and 1997

Source: Main Science and Technology Indicators No. 1, 2000, OECD the number of domestic patent applications per capita has been declining. The decline has been particularly sharp in Switzerland, dropping by 31 per cent compared to 1990.

According to a communication published by the European Commission[3] Finland recorded the highest per capita number of high technology patent applications in 1999. The number of applications per one million population in Finland was 69.6, while the average for the EU countries was 14.9. Sweden ranked second in this comparison (41.7), the Netherlands third (26.8). Other countries with rates exceeding the EU average were Germany, Denmark, France and the United Kingdom; outside the EU the United States recorded a figure above this average.

European patenting showing strong growth

The European patent system was established in 1978 and since a period of slow growth in the early 1980s has emerged as an increasingly important channel of patenting.

In 1998 the EPO received a total of some 900 patent applications from Finland (Table 7.6). This figure was almost three times higher than in 1990. In a comparison of IPC sections the fastest growth was recorded for applications in the section of electricity: here the number of applications filed in 1998 was 403, or eight times more than in 1990. Whereas at the beginning of the decade the section accounted for around 15 per cent of all applications, the figure had now climbed to 45 per cent. Although the number of applications in all sections increased during the period under review, the only two sections showing an increase in relative terms were those of electricity and physics. The physics section showed an increase of 11 per cent, the second biggest section of performing operations and transporting almost 13 per cent. Examined by field of technology, 38 per cent of all applications were in the telecommunications category. The country mentioned most frequently in EPO applications was Germany, which was identified in almost all (99%) applications. On average, the applications listed 14 countries.

In 1996–1998 Finland has accounted for an average of one per cent of all European patent applications. The share of Finland and other small EU Member States has been rising in

TABLE 7.6.
European patent applications by Finnish applicants in 1990–1998

IPC section	1990		1992		1994		1996		1997		1998	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Human necessities (A)	32	10.1	42	11.2	39	9.5	69	9.7	73	8.9	74	8.2
Performing operations, transporting (B)	70	22.2	87	23.2	87	21.2	122	17.2	128	15.6	114	12.6
Chemistry and metallurgy (C)	53	16.8	51	13.6	50	12.2	71	10.0	78	9.5	69	7.6
Textiles and paper (D)	34	10.8	29	7.7	40	9.8	46	6.5	58	7.1	63	7.0
Fixed constructions (E)	16	5.1	22	5.9	17	4.1	23	3.2	22	2.7	37	4.1
Mechanical engineering, lighting, heating, weapons, blasting (F)	39	12.3	42	11.2	25	6.1	38	5.4	33	4.0	43	4.8
Physics (G)	23	7.3	43	11.5	51	12.4	67	9.4	70	8.5	102	11.3
Electricity (H)	49	15.5	59	15.7	101	24.6	273	38.5	359	43.7	403	44.5
Total	**316**	**100.0**	**375**	**100.0**	**410**	**100.0**	**709**	**100.0**	**821**	**100.0**	**905**	**100.0**

3 Innovation & Technology Transfer, November 2000 (Special Edition). The European Commission.

recent years (Table 7.7). Germany stands out as by far the biggest European EPO patent applicant; likewise France (second) and the United Kingdom (third) stand out from the rest of the field. The EU countries' share of all EPO patents in 1998 (47%) is roughly the same as the combined shares of the United States (26%) and Japan (21%). The figures for the EU and Japan have been rising in recent years, those for the US have been declining.

At the time of writing updated information was not available on European patents granted, but preliminary data[4] published earlier indicated that in 1998, the number granted to Finnish applicants was 346.

In 1999 the largest number of Finnish applications were for patents in Germany, France and the United Kingdom (Table 7.8). In recent years the number of external applications from Finland has increased in all the most important patenting countries. The figures have grown most rapidly for applications to Denmark and Austria. In both these countries the number of applications from Finland doubled compared to 1995. The number of patents granted to Finnish applicants has also increased in the latter half of the 1990s. By far the biggest number of patents was granted in the United States.

TABLE 7.7
Selected countries' share of European patent applications

	Share of all EPO applications, %	
	1993–1995	1996–1998*
Germany	19.45	19.54
France	8.04	7.34
United Kingdom	5.64	5.55
Italy	3.77	3.71
Netherlands	2.28	2.39
Sweden	1.61	1.98
Belgium	1.18	1.29
Austria	1.09	1.11
Finland	0.84	1.02
Denmark	0.63	0.73
Spain	0.56	0.59
Ireland	0.09	0.14
Greece	0.05	0.04
Luxembourg	0.04	0.03
Portugal	0.02	0.02
EU countries	**45.30**	**45.41**
United States	**27.94**	**27.47**
Japan	**18.27**	**18.26**

**1998 preliminary data*
Source: Key Figures 2000. Science, Technology and Innovation. European Commission, Research Directorate and Eurostat, Brussels.

Foreign patenting in the United States has shown rapid growth

The US patenting system is different from the Finnish system in the sense that only the information on patents granted is in the public domain. Judging by the rapid increase in the number of patents granted in the United States, the country continues to enjoy a strong position as a technologically sophisticated research nation and market area.

In 1999 a total of 153,500 patents were granted in the United States (Table 7.9). Foreign applicants accounted for 45 per cent of this figure. The combined share of EU countries was 15 per cent, Japan's 21 per cent. Almost 70,000 patents were granted to foreign applicants, over half more than in 1995. Japan's share of the patents granted to foreign applicants has long been by far the highest. In 1999 Japan accounted for around 45 per cent of all patents granted to foreign applicants. The second biggest country by a wide margin was Germany, accounting for 13 per cent.

Finland accounts for around one per cent of foreign patents granted in the United States; this figure has remained more or less unchanged throughout the 1990s. In numerical terms, however, the figures have been rising very rapidly indeed. The 650 patents or so recorded in 1999 were up by 81 per cent on the figure for 1995. By international comparison the growth rate recorded for Finland is extremely high, but the fastest growth of all is found for the number

4 Teknologian soveltaminen ja siirto 1998 (Application and transfer of technology 1998, in Finnish only). Science, Technology and Research 1999:1, p. 15. Statistics Finland, Helsinki.

TABLE 7.8
Patent applications filed by Finnish applicants and patents granted to Finnish applicants in selected OECD countries in 1995, 1997 and 1999

	1995		1997		1999	
	Filed	Granted	Filed	Granted	Filed	Granted
Sweden	513	277	707	302	843	330
Norway	159	46	190	27	234	1
Denmark	330	171	366	179	678	205
Germany	605	309	787	348	927	380
Austria	365	237	419	219	749	239
Switzerland	350	214	377	180	689	204
France	595	302	768	339	916	376
United Kingdom	578	295	563	290	903	355
United States	–	358	–	452	–	649
Japan	297	69	270	84	308	98

of US patents granted to Danish applicants: 145 per cent from 1995 to 1999. Other Scandinavian countries also rank close to the top in this comparison, because the growth rates for Sweden and Norway are close to the figures of Finland. However, the growth has been rapid across the board, so the countries' shares of the patents granted in the United States have hardly changed.

Over one-third or 39 per cent of the patents granted to Finnish applicants in the United States were in the section of electricity, 16 per cent in the performing operations and transporting section.

TABLE 7.9
Patents granted to selected OECD countries as a proportion of total foreign patents in the United States in 1995, 1997 and 1999

	1995		1997		1999	
	Number	%	Number	%	Number	%
Japan	21 764	47.6	23 179	46.1	31 101	44.7
Germany	6 600	14.4	7 008	13.9	9 337	13.4
France	2 821	6.2	2 958	5.9	3 820	5.5
United Kingdom	2 478	5.4	2 678	5.3	3 572	5.1
Italy	1 078	2.4	1 239	2.5	1 492	2.1
Sweden	806	1.8	867	1.7	1 401	2.0
Switzerland	1 056	2.3	1 090	2.2	1 280	1.8
Netherlands	799	1.7	808	1.6	1 247	1.8
Australia	459	1.0	478	1.0	707	1.0
Finland	358	0.8	452	0.9	649	0.9
Belgium	397	0.9	515	1.0	648	0.9
Denmark	199	0.4	333	0.7	487	0.7
Austria	337	0.7	376	0.7	479	0.7
Norway	130	0.3	142	0.3	224	0.3
Spain	148	0.3	177	0.4	222	0.3
Foreign patents total	**45 680**	**100.0**	**50 276**	**100.0**	**69 578**	**100.0**
All total	**101 419**		**111 983**		**153 485**	

Source: U.S. Patent and Trademark Office

7.3 Other patent indicators

The development of patenting in different countries can be compared by using indicators based on the numbers of patent applications. The Tables describing patent indicators in various OECD countries are from an OECD publication[5], which also includes data on applications based on international patent conventions. However, a large proportion of these do not lead to valid patents.

Abbreviations used:
NA = Total number of patent applications filed in a certain country
DA = Domestic patent applications
FA = Foreign patent applications
EA = External patent applications (Patent applications filed abroad)

The DA/NA ratio (the ratio of domestic to all patent applications) describes technological independence in terms of patenting. The closer to one the ratio is, the less dependent the country is on foreign technology. According to this indicator, Finland's dependence on foreign technology has increased each year during the 1990s, especially during the latter half of the decade. Among the countries included in the analysis the only ones with a smaller autosufficiency ratio than Finland's are Belgium, Denmark and Austria (Table 7.10).

The increasing trends of internationalisation are most clearly reflected in the growing number of international patent applications in most countries. Applicants apply for an international patent in all potential market areas 'just to be sure'. Only in Japan has the number of domestic applications as a proportion of all patent applications been consistently higher than in other countries. The United States and Germany also stand apart from the rest of the OECD countries in terms of their technological dependence.

TABLE 7.10
Ratio of domestic to all patent applications (autosufficiency ratio) in selected OECD countries in 1990–1997

	1990	1991	1992	1993	1994	1995	1996	1997
Finland	0.17	0.16	0.14	0.14	0.12	0.09	0.04	0.03
Sweden	0.07	0.07	0.07	0.08	0.08	0.07	0.07	0.05
Norway	0.08	0.07	0.07	0.07	0.06	0.05	0.05	0.04
Denmark	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02
Germany	0.33	0.35	0.35	0.36	0.36	0.35	0.35	0.33
Austria	0.05	0.05	0.05	0.04	0.04	0.03	0.03	0.02
Switzerland	0.08	0.07	0.07	0.07	0.06	0.06	0.04	0.03
France	0.16	0.17	0.16	0.16	0.15	0.15	0.14	0.13
Netherlands	0.05	0.04	0.04	0.04	0.03	0.04	0.04	0.03
Belgium	.	0.02	0.02	0.02	0.02	0.02	0.01	0.01
United Kingdom	0.21	0.22	0.21	0.21	0.20	0.19	0.17	0.15
United States	0.52	0.50	0.50	0.53	0.52	0.53	0.49	0.52
Canada	.	0.06	0.07	0.08	0.06	0.06	0.05	0.06
Japan	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84
EU countries	**.**	**0.21**	**0.21**	**0.20**	**0.19**	**0.17**	**0.15**	**0.11**
OECD total	**0.41**	**0.41**	**0.38**	**0.37**	**0.35**	**0.35**	**0.30**	**0.24**

Source: Main Science and Technology Indicators No.1, 2000, OECD

5 Main Science and Technology Indicators No. 1, 2000, OECD.

Finland's balance of patents shows a slight deficit

The EA/FA ratio is an indicator of the balance of patent applications. The ratio indicates how many applications from a country are filed abroad in proportion to the foreign applications filed in the country concerned.

In 1997 Finland's patent balance showed a deficit of seven per cent. Including international patent applications, Finnish applicants filed a total of 76,200 applications abroad. At the same time 81,500 foreign applications were filed in Finland. In 1995 Finland's balance of patents still showed a strong surplus, at a record level of 218 per cent. Although the number of patent applications from Finland to foreign countries has shown rapid growth in recent years, the growth in the number of foreign applications filed in Finland has been faster still. Compared to 1995 the number of foreign patent applications from Finland almost doubled by 1997, but the number of foreign applications filed in Finland quadrupled.

The balance of patents has fluctuated quite considerably in other countries, too (Table 7.11). In Norway it would seem that the trends have been in completely the opposite direction to those seen in Finland. According to data from 1997 Norway ranks among the nations with the largest surplus in their balance of patents. The surplus in Sweden is also well above the EU average. The deficit in Denmark is higher than in Finland, as it is in Austria and Belgium. In recent years the balance of patents in leading industrial countries such as the United States, Japan and Germany, has shown a very significant surplus.

Dissemination of technology developed in Finland has increased several times over

Table 7.12 describes the development of the ratio between external patent applications and domestic applications, or the rate of diffusion of the country's patent applications in 1990–1997. This EAt/DAt-1 ratio is an indicator of the dissemination of technology which depicts the proportion of inventions for which patents are also applied abroad. The idea behind the ratio is that an external application concerning an invention is filed with a delay of about one year from the filing of the domestic application.

TABLE 7.11
Ratio of external to foreign patent applications in selected OECD countries in 1990–1997

	1990	1991	1992	1993	1994	1995	1996	1997
Finland	0.94	1.19	1.02	1.79	1.74	2.18	0.83	0.93
Sweden	0.60	0.70	0.74	0.96	1.17	1.63	1.89	1.91
Norway	0.48	0.51	0.63	0.65	0.70	0.84	0.93	2.26
Denmark	0.30	0.42	0.40	0.52	0.68	0.84	0.88	0.74
Germany	2.45	2.31	2.54	2.72	2.95	3.27	3.28	4.84
Austria	0.23	0.25	0.28	0.28	0.30	0.38	0.34	0.31
Switzerland	0.79	0.79	0.84	0.93	0.86	1.06	1.26	1.24
France	1.01	1.01	1.06	1.10	1.19	1.36	1.47	1.96
Netherlands	0.56	0.66	0.71	0.80	1.02	1.14	1.36	1.26
Belgium	0.19	0.21	0.19	0.26	0.33	0.37	0.38	0.37
United Kingdom	1.12	1.26	1.38	1.71	2.19	2.59	2.70	3.22
United States	3.49	3.68	4.43	5.60	6.44	7.90	10.54	14.28
Canada	0.54	0.57	0.63	0.69	1.14	1.30	1.43	1.84
Japan	2.98	3.00	2.79	2.69	2.78	2.87	3.20	5.72
EU countries	**0.65**	**0.72**	**0.69**	**0.78**	**1.00**	**1.31**	**1.25**	**1.44**
OECD total	**1.21**	**1.29**	**1.31**	**1.42**	**1.62**	**1.79**	**1.85**	**2.12**

Source: Main Science and Technology Indicators No.1, 2000, OECD

TABLE 7.12
Ratio of external patent applications to domestic patent applications of previous year (rate of diffusion) in selected OECD countries in 1990–1997

	1990	1991	1992	1993	1994	1995	1996	1997
Finland	5.0	6.4	6.1	11.4	13.5	19.0	24.4	34.5
Sweden	8.0	9.0	10.1	12.6	14.8	20.9	27.7	38.6
Norway	5.2	6.6	8.9	9.3	12.0	16.4	21.7	50.0
Denmark	9.1	11.4	14.2	16.7	25.2	30.6	38.0	46.4
Germany	4.9	4.6	5.0	5.0	5.7	6.2	6.8	10.1
Austria	4.2	4.5	5.5	5.6	6.4	9.6	11.1	13.9
Switzerland	8.8	8.9	11.8	12.4	12.8	16.5	23.5	37.9
France	5.3	5.0	5.5	5.7	6.5	7.9	9.5	14.0
Netherlands	9.5	11.1	19.9	20.9	28.8	34.3	37.7	43.5
Belgium	8.9	9.4	11.6	15.0	16.5	22.7	26.7	35.3
United Kingdom	4.0	4.4	5.1	6.4	8.7	11.0	12.6	17.6
United States	3.6	3.6	4.7	5.4	6.4	7.9	9.5	14.8
Canada	6.2	8.0	11.5	10.5	12.0	20.9	26.6	35.4
Japan	0.4	0.4	0.4	0.4	0.4	0.5	0.6	1.1
EU countries	**2.4**	**2.7**	**2.9**	**3.2**	**4.5**	**6.0**	**8.0**	**10.6**
OECD total	**1.8**	**1.8**	**2.2**	**2.5**	**3.0**	**3.8**	**4.3**	**6.2**

Source: Main Science and Technology Indicators No.1, 2000, OECD

In all the OECD countries included in the analysis the number of external patent applications has increased much faster than the corresponding figure for domestic applications. In Finland the ratio of external patent applications to domestic applications in 1997 was 34.5. The dissemination of Finnish technology abroad has increased seven-fold compared to 1990. In 1997 the number of Norwegian external patent applications was 50 times as great as the number of domestic applications. Denmark and the Netherlands also stood clearly apart from the rest of the field. In general it may be noted that small countries with a high level of R&D intensity apply for external patents to a much greater extent than others for domestic patents. In Japan the number of external patent applications exceeded the number of domestic applications for the first time.

It is increasingly common to apply for a patent in foreign countries as well. The trend is similar in Scandinavia, as well as in other industrial countries. Economic integration has meant that patent applications are filed in several different countries at the same time. However, it is important to note that not all patents applied through different patent treaties lead to an actual patent application or to a patent being granted to the invention submitted.

8 Finnish science in a bibliometric analysis

8.1 Introduction

Publishing is an integral part of scientific research. A bibliometric study of scientific publishing can help to shed important light on different aspects of research activities: who is doing what kind of research, where and with whom, and how widely the research results are spreading. This kind of quantitative analysis of publishing is known as bibliometrics.

The main sources for bibliometric analyses consist of databases that provide systematic data about published research. The most common bibliometric indicators are the numbers of publications and citations. The former may be used to measure the output of research, the latter its visibility and impact. Scientific collaboration can be studied through analyses of co-authorship. Co-words appearing in different articles and co-citation allow us to study the development of different fields of specialisation and the involvement of different individuals or institutions in this process.

Bibliometric methods have also been applied to the study of patenting, because patent registers comprise similar types of data as citation databases such as who is the inventor, what is the inventor's affiliation, what are the references in the patent to scientific literature and other patents. Patents also provide useful insights into disciplines which do not publish very often in the scientific literature; these typically include applied sciences, the results of which often have commercial applications. A study into citations occurring in patents helps to throw light on the significance of scientific research and inventions to the development of new technology.

The use of bibliometric indicators for purposes of scientific evaluation is not entirely unproblematic. For instance, attention in the scientific literature does not necessarily mean that the research is of high quality. On the other hand, not all high-quality research is published in widely circulated journals, nor does it automatically get the attention it deserves. Although they do provide the most comprehensive view of scientific publishing, citation databases can never offer a full and balanced coverage of all disciplines or language areas. Publishing practices also differ between disciplines to such an extent that it is impossible to make direct comparisons.

Nonetheless bibliometric indicators do provide a powerful tool for science studies when their results are combined with other sources of information on scientific research. Bibliometric indicators measure aspects of science that are widely accepted as important and meaningful. More often than not it is considered desirable that research has high visibility. If a research result or an article is cited in another publication, it is reasonable to assume that someone has noticed it and considered it worth mentioning. Articles published in the most highly respected journals usually receive more attention than others, and these publications also have stricter quality criteria. Therefore to some extent papers published in these kinds of journals may serve as quality indicators.

Data on patents do have their limitations, though. For instance, not all significant inventions are patented at all, either because this is not possible or because the inventor does not want to patent. Patenting activity also varies from field to field.

The survey and its sources

This chapter summarises the main findings of a study completed in summer 2000 by the VTT Group for Technology Studies[1]. This is the most comprehensive bibliometric study to date of Finnish science.

This study is based on data as recorded by the Science Citation Index (SCI), maintained by the Institute for Scientific Information (ISI) and includes all papers by Finnish scientists from 1981–1998; and on US Patent data, which includes information on all Finnish patents from 1986–1998 in the US patent system. For international comparisons, statistical data, already available from both these databases, were also used[2]. The time period in the latter case is restricted to the years 1981 to 1998.

The SCI is the only database which provides full information on all authors' affiliation and addresses. It lists the articles published in the most cited journals in the natural, medical and engineering sciences. The weaknesses of the index include its poor coverage of other than English-language journals and a nearly complete absence of books. In the humanities and social sciences publishing is more widely scattered across different language and cultural areas, and therefore the corresponding databases – the Social Sciences Citation Index and the Arts and Humanities Citation Index – are even more selective in geographical and linguistic terms. These have been excluded from the analysis altogether.

The data on patenting were drawn from the US patent system, which is the most comprehensive system of its kind. Since the United States is the single most important market area for new technology, we may assume that its patent register covers the most significant inventions from all over the world.

8.2 Results

Numbers of Finnish papers and citations have both shown strong growth

The number of papers written by Finnish authors as a proportion of all articles in the SCI database has increased from 0.68 per cent in 1989 to 0.92 per cent in 1998 (Figure 8.1). Since the SCI only indexes well-known and esteemed journals, we may conclude that Finnish authors publish in esteemed international journals to a greater extent than before. A similar trend can be observed for all other Nordic countries.

Finland is the only Nordic country that has shown an increase in its relative citation impact. In other words, Finnish papers now receive more citations than before: the relative citation rate is 20 per cent over and above the average number of world citations (Figure 8.2). Measured on this indicator Finland is catching up with Sweden and Denmark, which have traditionally led the field for Scandinavia and recorded figures well above the world average. The increase in the relative citation rate of Finnish papers is explained by the fact that Finnish scientists today publish more often than before in journals with a higher impact factor. The impact factor of a journal measures the average short-term citation rate of the papers published in the journal in question. Journals with a high impact factor are often the most visible and most respected in their fields.

Articles of medical sciences account for the largest share

Forty per cent of the Finnish papers listed in the SCI are studies in medical sciences. Medical sciences are equally predominant in the publication record of scientists from other Nordic countries. Although medicine has a

1 Persson, Olle, Terttu Luukkonen & Sasu Hälikkä: A Bibliometric Study of Finnish Science. Working Papers 48, VTT Group for Technology Studies, Espoo 2000.

2 The statistics on SCI have been compiled by the ISI, on patents by Computer Horizons Inc (CHI).

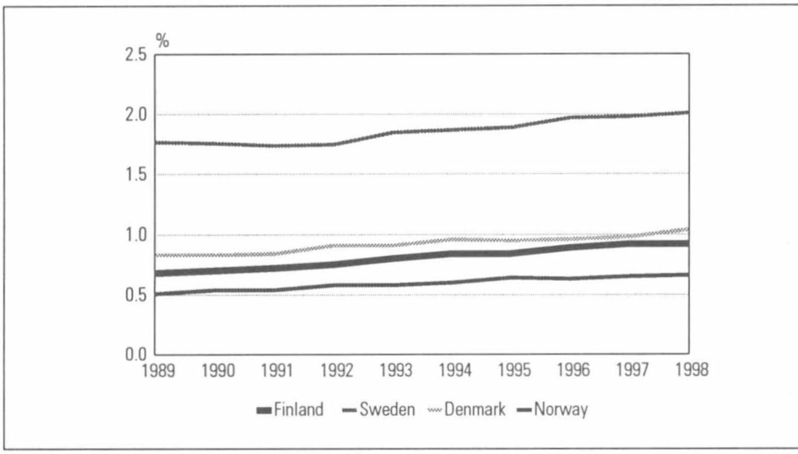


FIGURE 8.1
The Nordic countries' share of world papers

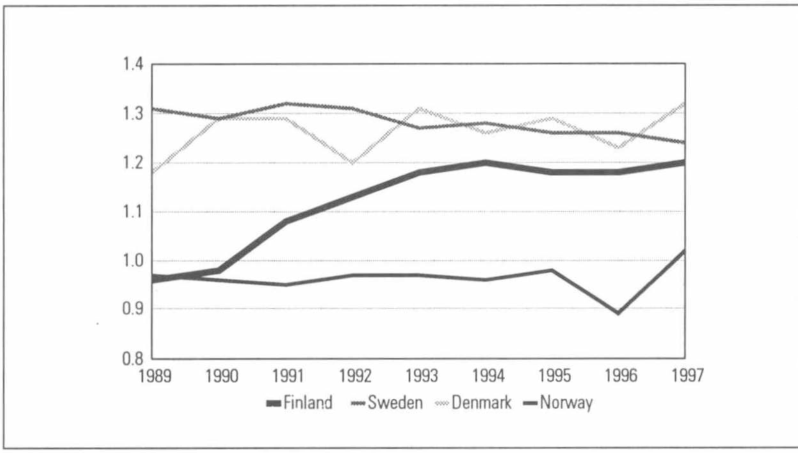


FIGURE 8.2
Relative citation impact of Nordic papers (world average is equal to 1)

strong role in Finland, it should be noted that medical journals are exceptionally well covered in the SCI, and also that articles represent the most popular format of publishing in medical sciences. Furthermore, English does not have the same predominant status in all disciplines. For this reason country comparisons should be made within individual disciplines.

Finnish medicine performs extremely well on other indicators as well. When the number of citations received by Finnish-authored articles is compared with the average citation impact in each discipline, the best results are often recorded precisely for medicine and physics.

International collaboration accounts for a growing proportion of papers published

There has been a strong tendency in recent years towards increasing research collaboration both between science organisations and internationally. In particular, scientists in smaller countries such as Finland carry out research with international collaborators to an ever greater extent, and this is reflected in their publications. Whereas in 1989, 24 per cent of all published papers by Finnish scientists were co-authored with one or more international partners, the figure for 1998 was markedly higher at 40 per

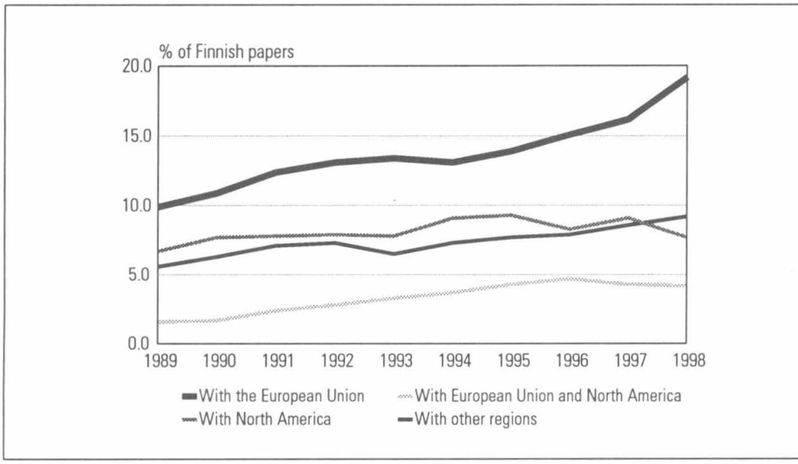


FIGURE 8.3
Co-authored papers as a proportion of all publications

cent. Collaboration has increased most noticeably with scientists from EU countries, although the single most important partner country is still the United States (Figure 8.3).

Almost half of all Finnish articles come from the region of Uusimaa

Bibliometric tools also provide useful insights into the regional breakdown of research in Finland. About half of all Finnish-authored articles listed in the SCI come from the region of Uusimaa. However the share of the metropolitan capital region has shown some tendency to decline at the expense of other regions (Figure 8.4). Regional analyses clearly show there is a positive correlation between output and the relative citation impact, so that the regions with the highest level of output also record higher relative citation impact than regions with a low level of output. To some extent this result also applies to individual institutions, because often there is only one organisation that produces a large number of articles within a specific discipline in each area. In other words, those who produce more scientific papers receive more attention on average than those who produce fewer.

University sector dominates the output

Four in five Finnish articles are produced within the university sector (Figure 8.5). Research institutes account for around 14 per cent of all

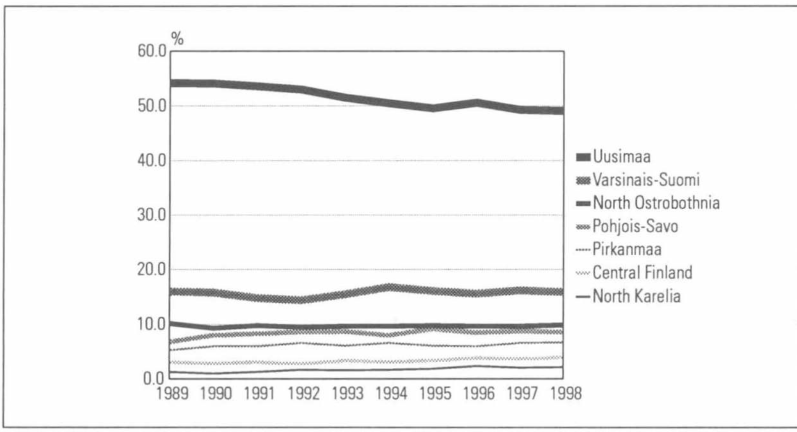


FIGURE 8.4
Regional breakdown of papers published: the seven most productive regions

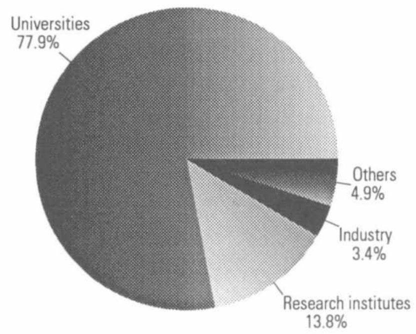


FIGURE 8.5
Papers by sector in 1998

articles published; industry and other organisations[3] for fewer than five per cent each. The relative shares of these sectors have remained more or less the same throughout the 1990s. Most of the articles produced by all sectors are in the field of medical sciences. In relative terms universities are most active in the natural sciences and in basic research while industry is most active in engineering and applied research. The profile of research institutes lies somewhere in between the university sector and industry.

TABLE 8.1
Five most productive organisations in different sectors: number of papers published between 1989–1998

Sector	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	**Total**
Universities											
University of Helsinki	1 401	1 541	1 526	1 633	1 768	1 964	2 013	2 236	2 384	2 312	18 778
University of Turku	533	545	541	598	690	807	835	874	1 019	961	7 403
University of Oulu	417	410	467	450	553	555	658	648	698	710	5 566
University of Kuopio	278	331	397	403	492	489	564	596	644	628	4 822
University of Tampere	226	242	263	312	285	329	343	348	434	412	3 194
Research institutes											
National Public Health Institute	163	181	213	242	282	283	391	419	466	432	3 072
Technical Research Centre of Finland	122	111	148	169	193	173	202	193	193	203	1 707
Finnish Institute of Occupational Health	99	84	119	114	108	111	133	134	130	143	1 175
Finnish Forest Research Institute	19	26	24	31	52	69	84	92	77	111	585
Finnish Meteorological Institute	20	27	33	16	35	56	38	60	59	66	410
Industry											
Orion	27	47	56	69	56	64	47	53	85	63	567
Alko	30	34	29	41	44	49	38	23	17	6	311
Neste	21	12	13	21	40	28	24	20	29	10	218
Farmos	28	58	17	3	0	1	0	0	0	0	107
Leiras	14	11	13	13	14	22	22	16	16	16	157

3 Non-profit organisations that are not universities or research institutes.

Measured in terms of the number of papers published, by far the most productive individual organisation is the University of Helsinki: on average it produces more articles than the three next productive universities taken together (Table 8.1). The most productive research institute is the National Public Health Institute; in industry, the medical industry comes out on top.

In all fields of study, papers published within the university sector have a higher journal impact factor than other sectors (Table 8.2). The main reason for this is that universities focus on basic research, while other sectors carry out more applied research: in basic research the journal impact factors[4] are on average higher. This does not tell us anything about the quality of research in different fields of study, but only about citation practices and citation frequencies.

Inter-sectoral collaboration has increased to some extent

Inter-sectoral co-operation can be studied by analysing co-authored articles. One in five articles published in 1998 involved co-operation among authors or organisations from at least two different sectors, while the figure in 1989 was somewhat lower at 18 per cent. For industry in particular, collaboration with universities is extremely important: over half or 56 per cent of all papers published in industry in 1998 were produced jointly with universities.

Patent citations in different fields show variable trends

Patents reflect the output of technological research and innovation. The US patent system identifies a total of 3,700 Finnish patents[5] that were granted between 1989–1998. During the 1990s telecommunications has rapidly emerged as the leading sector which patents (Figure 8.6).

The relative weight of industrial branches in different countries can be studied by comparing their shares of the patents granted in each country. In this comparison the Finnish wood and paper industry clearly stands apart from the rest: its share of all Finnish patents is 2.5 times greater than the share of this sector of all world patents. Other industries where Finnish patenting exceeds the world average are industrial process equipment and medical equipment as well as non-metallic mineral products (glass, clay, cement, etc.).

TABLE 8.2
Journal impact factors in different sectors and fields of study

Field of study	Universities	Industry	Others	Research institutes	**Total**
Engineering and materials	4.2	2.3	3.6	2.9	3.5
Life sciences	11.8	10.7	10.9	11.7	11.6
Multidisciplinary publications	10.5	6.8	10.1	8.2	9.7
Natural sciences (mathematics, physics and chemistry)	9.2	7.5	6.7	8.0	9.0
Total	**11.0**	**8.5**	**10.7**	**10.3**	**10.7**

4 The journal impact factor indicates how often the papers in the journal concerned are cited 1–2 years after publication. The journal impact factor is used here to estimate the real citation level.

5 Involving at least one Finnish inventor.

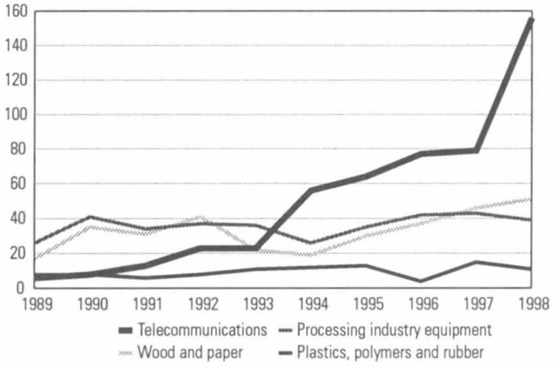


FIGURE 8.6
Number of patents in selected industries

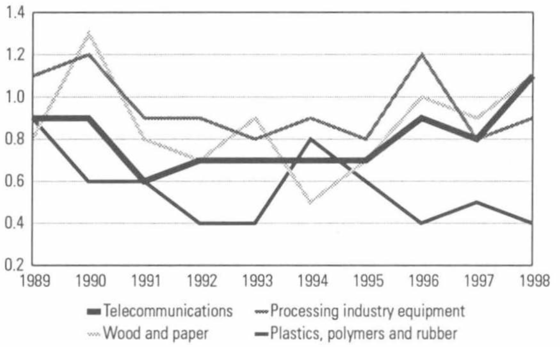


FIGURE 8.7
Relative citation impact of Finnish patents in selected technological fields (world average is equal to 1)

In the context of patents, the relative citation impact refers to the number of times a patent is cited in other patents. The relative citation impact of Finnish patents is lower than the world average. Figure 8.7 shows the development of the relative citation impact for the three technological fields with the highest number of patents (telecommunications, process industry equipment and wood and paper). The development of the impact in the plastics, polymers and rubber branch has been quite exceptional. In 1986 the relative citation impact for this technological field was still 2.5, but since then the figure has dropped to an extremely low level even though the number of patents has remained virtually unchanged.

Patent collaboration liveliest with North America

Patent data also provide a useful measure of the internationalisation of companies. Indeed the share of patents produced through international collaboration is on the increase. Figure 8.8 shows that collaboration is at a particularly high level with North America, but there is also increasing collaboration with European partners.

In some ten per cent of all patents assigned to a Finnish company, the inventor has a foreign address. This proportion has shown some growth during the period under review (1989–1998). Similarly, the inventor is Finnish in some ten per cent of patents, in which the assignee is a foreign company.

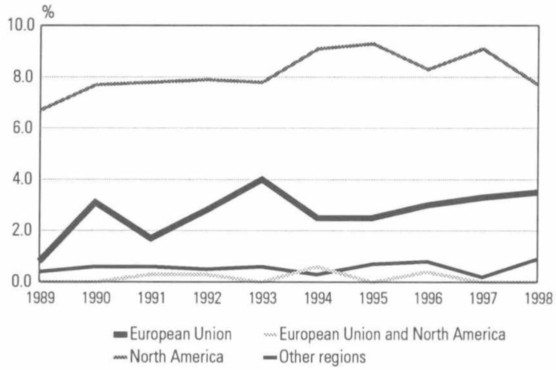


FIGURE 8.8
Finnish patents involving international collaboration as a proportion of all Finnish patents

8.3 Conclusions

The picture that is drawn of Finnish science by bibliometric indicators is quite a positive one: Finland has clearly gained a stronger position in terms of publishing activity, international visibility and its impact on other research.

Bibliometric analysis shows that Finnish research has shown a strong tendency towards internationalisation during the 1990s. There is more collaboration than earlier both between scientific organisations and internationally. Collaboration has increased most particularly with European researchers, although the United States remains the most significant country with respect to research co-operation. Measured in terms of the number of citations, the field of study that receives the most international attention is that of medical sciences.

The data in the US patent system on Finnish patents show that international co-operation has also increased in technical R&D, although less clearly so than in scientific research. By far the largest proportion of patents that have been produced through international collaboration have involved American partners. As expected, telecommunications has emerged as by far the most active sector in terms of patenting activity.

9 Production and foreign trade of high technology products

R&D activities generate new knowledge and new technology. In industry, the introduction and application of this knowledge and technology is seen in the development of new production processes and products as well as in growing foreign trade in technology-intensive products. In this chapter technology application and technology transfer are discussed from the vantage-point of high technology products and foreign trade. We also have indicators to describe the development of the structure and volume of foreign trade as well as competitiveness and success in the international science and technology-intensive markets.

High technology industries comprise the aerospace industry, computers and office machinery, electronics and telecommunications equipment and pharmaceuticals. The industry and product categories employed are based on OECD definitions from 1997. Appendix 9.1 lists the different industries by level of technology. A list of current high technology products and product groups[1] is given in Appendix 9.2.

The material concerning industrial enterprises has been drawn from Statistics Finland's business register and the data on the output of high technology products from industry statistics. The foreign trade data are from the OECD's international trade statistics and from the ULTIKA database maintained by the National Board of Customs.

9.1 Output of high technology products

Business enterprises in high technology industries showing strong turnover growth

Sustained economic growth in recent years has resulted in an increase in the number of business enterprises in manufacturing and in their personnel numbers and turnover (Table 9.1). In 1998 the number of enterprises in the manufacturing industry exceeded the figure for 1995 by 2,700, the number of personnel was up by almost 28,000. In other words the number of enterprises has increased within the space of just a few years by over 11 per cent, staff numbers by seven per cent. In 1995–1998 business turnover increased by almost one-quarter from FIM 380 billion to FIM 470 billion. The average annual growth was seven per cent.

The number of high technology enterprises as a proportion of all manufacturing enterprises, their personnel number and turnover increased clearly from 1995 to 1998. The increase was most noticeable for the share of turnover, which increased from less than nine per cent to 15 per cent. Turnover more than doubled at the same time from FIM 32.7 billion to FIM 69.8 billion, with the average annual growth standing at 29 per cent. In 1998 the turnover of high technology industries increased even more rapidly, rising by

1 High technology products and industries as well as their different definitions are discussed in detail in the publication 'Production and foreign trade of high-technology products in Finland'. Statistics Finland. Science and Technology 1996:5, p. 22–24.

TABLE 9.1
Manufacturing industry enterprises by technology level in 1995 and 1998

Technology level	1995						1998					
	No.	%	Personnel	%	Turnover FIM million	%	No.	%	Personnel	%	Turnover FIM million	%
High	316	1.3	30 530	8.0	32 707	8.6	389	1.5	38 802	9.5	69 837	14.9
– Pharmaceuticals	20		5 816		4 045		26		6 009		4 685	
– Computers and office machinery	54		3 838		5 580		57		2 797		6 910	
– Electronics and telecommunications equipment	231		19 860		22 770		293		28 919		57 765	
– Aerospace	11		1 016		311		13		1 077		477	
High medium	5 014	21.2	95 365	25.0	84 132	22.1	5 435	20.6	102 841	25.1	103 775	22.1
Low medium	6 768	28.6	86 163	22.5	92 233	24.3	7 762	29.5	97 692	23.8	98 614	21.0
Low	11 536	48.8	170 099	44.5	170 887	45.0	12 761	48.4	170 693	41.6	197 838	42.1
Total	**23 634**	**100.0**	**382 158**	**100.0**	**379 959**	**100.0**	**26 347**	**100.0**	**410 028**	**100.0**	**470 063**	**100.0**

37 per cent on the year before. In 1998 high technology industries employed almost 39,000 persons. In 1995 the number of personnel was around 30,500. The increase in personnel number was thus quite rapid, averaging eight per cent per annum. Both the number of business enterprises, number of personnel and turnover increased most in electronics and telecommunications equipment. In these sectors turnover for 1998 was 2.5 times as high as in 1995.

Value of production in high technology industries has increased almost tenfold in less than a decade

The breakdown of the value of manufacturing industries' output by technology level in 1991 and 1999 is shown in Figure 9.1. This examination differs from the analysis above in that the figures have been calculated from industry-specific data on enterprises' production units[2]. In 1991 high technology industries accounted for

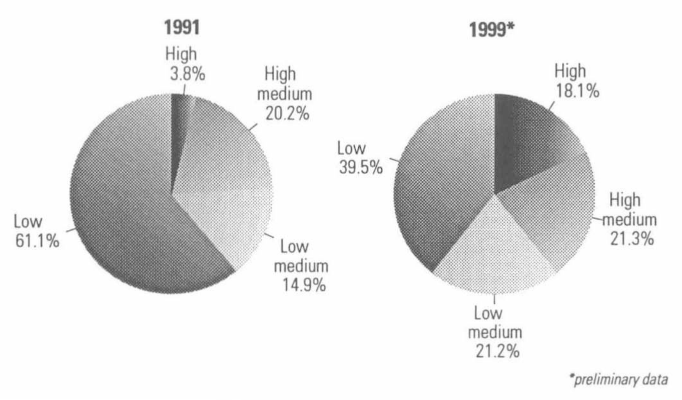


FIGURE 9.1
Breakdown of output in manufacturing production units by technology level in 1991 and 1999

2 The figures on production/output are based on Statistics Finland's industrial statistics. The value of production/output is measured in terms of total gross value.

less than four per cent of the total gross value of industrial manufacturing; by 1996 the figure had risen to over 10 per cent, in 1999 it was 18 per cent. In 1991–1999 the value of production in high technology industries grew at a markedly faster rate than that of other industries. The average annual growth during this period was 33 per cent. According to preliminary data the value of production in 1999 was in excess of FIM 90 billion, while the figure in 19991 was only around one-tenth (FIM 9.3 billion) of that.

The biggest high technology product group throughout the 1990s has been that of electronics and telecommunications equipment. At the same time this has also been the fastest-growing product group. The growth has been particularly sharp in recent years. On the basis of Statistics Finland's working day adjusted index, the volume of production in the electronics and telecommunications equipment increased from November 1999 to November 2000 by 79.3 per cent. Production of pharmaceuticals was up by 3.5 per cent, while output in aerospace products declined somewhat (-2.9%). During the same period output in all manufacturing increased by 19.1 per cent.

9.2 Finnish foreign trade in high technology products

Exports of high technology products account for one-fifth of Finland's total exports

During the 1990s high technology exports as a proportion of total Finnish exports increased more than three times over from six per cent in 1991 to 20.4 per cent in 1999. The share of high technology exports exceeded the figure for imports for the first time in 1997. Imports of high technology products as a proportion of total imports also increased during the 1990s from around 12 per cent to 18 per cent. Estimates published by the National Technology Agency (Tekes) indicate that in 2000, the share of high technology exports increased to 23.0 per cent of total exports, in imports the figure reported is 18.6 per cent (Figure 9.2).

Surplus in high technology foreign trade continues to grow

In 1999 the value of high technology exports from Finland totalled around FIM 47.4 billion. Although this growth has slowed down compared to earlier years, the value of exports is almost nine per cent higher than one year previously. At the same time the increase recorded in total exports of industrial products was less than one per cent. In 1999 the value of

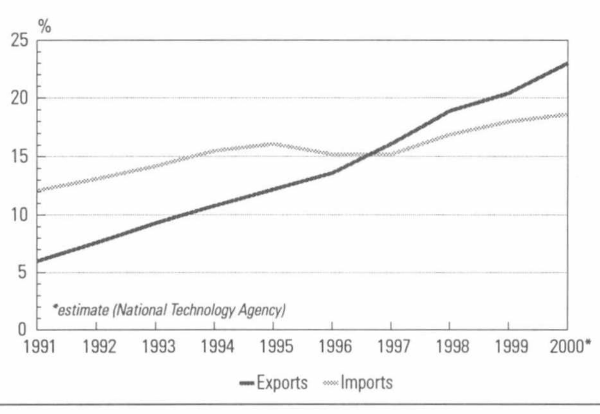


FIGURE 9.2
Finnish high technology exports and imports as a proportion of total exports and imports in 1991–2000

other than high technology exports decreased to some extent. The rapid growth of high technology exports is clearly illustrated by the fact that in 1999, the value of exports was over eight times higher than in 1991, when the current growth trend started (Table 9.2). The value of exports increased from 1991 to 1999 on average by 31 per cent a year.

The value of high technology imports in 1999 was almost FIM 31.6 billion. In 1991–1999 the value of imports increased on average by 15 per cent a year, or around half the figure for the growth of exports. However in 1999 the growth of imports was at roughly the same level as the growth of exports. In 1999 the value of imports was three times the figure for 1991.

TABLE 9.2
Foreign trade in Finnish high technology products by product group in 1991–1999

Product group	FIM million	1991	1992	1993	1994	1995	1996	1997	1998	1999
Aerospace	Exports	31	56	60	121	258	67	434	353	124
	Imports	776	452	857	977	933	1 215	701	1 149	1 639
	Trade balance	–745	–396	–797	–856	–675	–1 148	–267	–796	–1 514
Computers and office machinery	Exports	1 331	2 412	3 480	4 304	4 543	4 399	5 637	5 444	4 682
	Imports	3 020	3 462	4 284	5 543	6 351	6 132	7 010	9 094	8 776
	Trade balance	–1 689	–1 049	–805	–1 239	–1 808	–1 733	–1 373	–3 650	–4 093
Electronics and telecommunications equipment	Exports	2 195	3 422	6 035	8 891	13 105	16 881	22 711	31 903	35 653
	Imports	2 752	3 215	4 476	6 541	8 129	8 114	9 608	11 678	12 722
	Trade balance	–557	207	1 558	2 350	4 976	8 768	13 103	20 225	22 931
Pharmaceuticals	Exports	95	104	146	121	93	109	124	154	153
	Imports	472	518	658	630	642	691	681	773	812
	Trade balance	–377	–414	–511	–510	–549	–582	–557	–619	–659
Scientific instruments	Exports	1 488	1 652	2 009	2 309	2 526	2 732	3 592	3 873	4 235
	Imports	1 493	1 622	1 645	1 794	1 929	2 147	2 317	2 537	2 807
	Trade balance	–5	30	364	516	597	585	1 275	1 336	1 428
Electrical machinery	Exports	133	179	243	274	253	268	400	662	1 194
	Imports	229	325	459	644	981	958	1 405	2 007	2 933
	Trade balance	–96	–146	–216	–369	–729	–690	–1 005	–1 345	–1 738
Chemicals	Exports	94	121	172	194	259	244	264	280	275
	Imports	477	569	690	725	795	713	834	881	784
	Trade balance	–383	–448	–518	–531	–535	–469	–570	–601	–509
Non-electrical machinery	Exports	141	122	193	312	521	644	723	816	729
	Imports	685	557	535	867	687	966	671	915	935
	Trade balance	–545	–435	–342	–556	–166	–323	52	–99	–206
Armaments	Exports	64	85	104	119	183	124	103	185	360
	Imports	744	1 724	1 088	920	269	658	917	257	158
	Trade balance	–681	–1 640	–984	–801	–86	–534	–814	–72	202
High technology products total	**Exports**	**5 571**	**8 153**	**12 442**	**16 645**	**21 741**	**25 467**	**33 989**	**43 670**	**47 406**
	Imports	**10 649**	**12 443**	**14 692**	**18 641**	**20 716**	**21 593**	**24 144**	**29 290**	**31 565**
	Trade balance	**–5 078**	**–4 290**	**–2 250**	**–1 996**	**1 025**	**3 874**	**9 845**	**14 380**	**15 841**
Other products	Exports	87 270	99 310	121 671	137 518	154 280	160 867	177 696	186 899	185 195
	Imports	77 095	82 504	88 475	101 906	107 839	120 360	135 049	143 529	144 278
	Trade balance	10 175	16 806	33 195	35 613	46 441	40 508	42 647	43 370	40 917
Foreign trade total	**Exports**	**92 842**	**107 463**	**134 112**	**154 163**	**176 021**	**186 334**	**211 685**	**230 569**	**232 601**
	Imports	**87 744**	**94 947**	**103 167**	**120 547**	**128 555**	**141 952**	**159 193**	**172 819**	**175 843**
	Trade balance	**5 098**	**12 515**	**30 945**	**33 617**	**47 466**	**44 382**	**52 492**	**57 750**	**56 759**

In 1999 the export-import ratio of Finnish high technology was 1.5; at the beginning of the decade the figure was around 0.5 (Table 9.3). The positive balance of foreign trade has shown particularly rapid growth since 1995, when exports exceeded imports for the first time (Figure 9.3).

Balance of foreign trade in electronics and telecommunications equipment shows a surplus of almost FIM 23 billion

Exports in the biggest high technology product group, i.e. that of electronics and telecommunications equipment, continued to show strong growth in 1999. The total value of exports rose to almost FIM 36 billion (see Table 9.2

TABLE 9.3
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 and 1999

Product group	1991			1995			1999		
	Exports %	Imports %	Exports/ Imports	Exports %	Imports %	Exports/ Imports	Exports %	Imports %	Exports/ Imports
Aerospace	0.6	7.3	0.04	1.2	4.5	0.28	0.3	5.2	0.08
Computers and office machinery	23.9	28.4	0.44	20.9	30.7	0.72	9.9	27.8	0.53
Electronics and telecommunications equipment	39.4	25.8	0.80	60.3	39.2	1.61	75.2	40.3	2.80
Pharmaceuticals	1.7	4.4	0.20	0.4	3.1	0.14	0.3	2.6	0.19
Scientific instruments	26.7	14.0	1.00	11.6	9.3	1.31	8.9	8.9	1.51
Electrical machinery	2.4	2.2	0.58	1.2	4.7	0.26	2.5	9.3	0.41
Chemicals	1.7	4.5	0.20	1.2	3.8	0.33	0.6	2.5	0.35
Non-electrical machinery	2.5	6.4	0.21	2.4	3.3	0.76	1.5	3.0	0.78
Armaments	1.1	7.0	0.09	0.8	1.3	0.68	0.8	0.5	2.28
Total high technology	100.0	100.0	0.52	100.0	100.0	1.05	100.0	100.0	1.50
Value (FIM billion)	5.6	10.6		21.7	20.7		47.4	31.6	

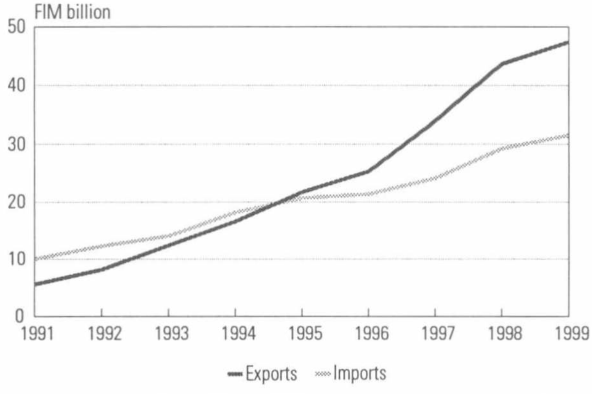


FIGURE 9.3
Value of Finnish foreign trade in high technology products in 1991–1999

above). This was FIM 3.8 billion or almost 12 per cent more than one year previously. One year earlier the growth rate was as high as 40 per cent. Electronics and telecommunications equipment accounted for over 75 per cent of high technology exports (Figure 9.4).

The value of electronics and telecommunications equipment exports increased more than 16 times over in 1991–1999, with the average annual increase in exports standing at 42 per cent. The surplus in the balance of foreign trade in this particular product group has also increased noticeably. The balance showed a surplus for the first time in 1992, standing at around FIM 200 million. In 1999 the balance of foreign trade in electronics and telecommunications equipment showed a surplus of FIM 22.9 billion. Electronics and telecommunications equipment now account for 40 per cent of the total surplus of FIM 56.8 billion in Finnish foreign trade.

In 1999 the value of exports in the second largest product group, i.e. that of computers and office machinery, was close on FIM 4.7 billion; the figure for the third biggest group, scientific instruments, was around FIM 4.2 billion. The value of exports in the group of electrical machinery exceeded FIM one billion, which was 80 per cent more than one year previously. Exports of computers and office machinery were down by 14 per cent from the figure one year previously, exports of scientific instruments showed an increase of nine per cent.

The biggest import groups in 1999 were represented by electronics and telecommunications (FIM 12.7 billion), computers and office machinery (FIM 8.8 billion) and scientific instruments (FIM 2.8 billion). The product group of electrical machinery was the third largest category, with the value of imports amounting to close on FIM three billion. This figure more than doubled in the space of two years.

The deficit in foreign trade has increased in most other product groups

The deficit in the balance of trade in the category of computers and office machinery in 1999 was in excess of FIM four billion. This deficit was at a record level, more than three-fold compared to 1997. In the groups of electrical machinery and in aerospace products, the deficits were also quite substantial: the figure for the former was FIM 1.7 billion, for the latter FIM 1.5 billion. The deficit in the aerospace group was almost twice as large as one year previously. Indeed there were only three groups that recorded a surplus: electronics and telecommunications equipment (export-import ratio 2.80), scientific instruments (1.51) and armaments (2.28). The overall significance of the latter group, it has to be stressed, is very minor. In 1999 the export-import ratio was weakest in the aerospace (0.08) and pharmaceuticals (0.19) product groups. Without electronics and telecommunications

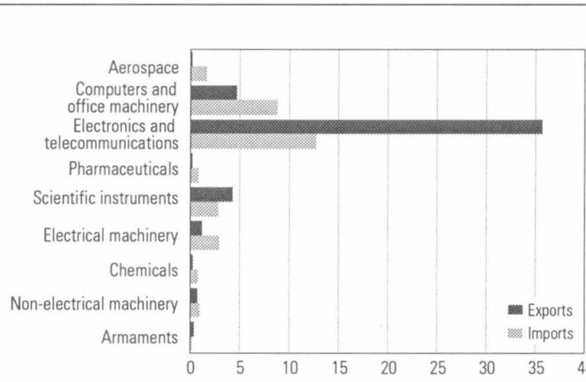


FIGURE 9.4
Value of Finnish foreign trade in high technology products by product group in 1999

equipment Finland's high technology balance of trade would be more than FIM seven billion in the red.

Over half of high technology exports to EU countries, balance of trade with Asian countries and NAFTA shows a deficit

There have been major changes during the 1990s in the breakdown of Finland's foreign trade in high technology by country groups as well as in the value of this trade. These are explained, on the one hand, by the success that Finland has enjoyed in international high technology trade and, on the other hand, by the enlargement of the European Union and the social problems experienced by the countries of Eastern Europe. Finland's decision to join the European Union in 1995 together with Sweden and Austria has led to significant changes in the relative shares of the EU and EFTA countries in Finland's foreign trade and in the value of that trade.

By far the biggest foreign trade partner for Finland in 1999 was the EU (Table 9.4 and Figure 9.5). Finnish high technology exports to EU countries amounted to FIM 24.7 billion, imports to FIM 14.6 billion. Exports to EU countries increased during the 1990s 12 times over; at the same time imports increased three times over. In 1999 the EU countries accounted for over half or 51.7 per cent of Finnish high technology exports. This figure has remained at roughly the same level throughout the latter half of the 1990s. The export-import ratio with the EU countries was 1.69.

TABLE 9.4
Breakdown of Finnish foreign trade in high technology products in 1991, 1995 and 1999 and export-import ratio in 1999 by country group

Country group	1991		1995		1999		
	Exports %	Imports %	Exports %	Imports %	Exports %	Imports %	Exports/ Imports
EU	40.6	39.9	51.3	44.1	51.7	46.0	1.69
EFTA	25.3	15.4	4.4	2.6	5.1	2.0	3.83
Rest of Europe	10.3	2.1	12.1	3.0	15.6	3.8	6.23
NAFTA	7.8	23.2	7.3	20.7	5.7	17.8	0.48
Asian countries	11.6	19.1	20.8	29.3	16.4	29.7	0.83
Other countries	4.4	0.2	3.9	0.3	5.4	0.7	11.17

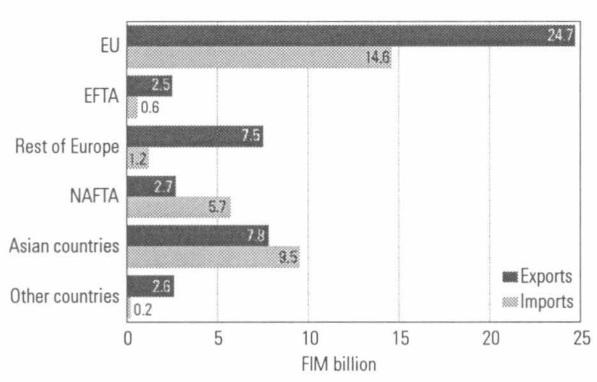


FIGURE 9.5
Value of Finnish foreign trade in high technology products by country group in 1999

In 1999 the second biggest export market for Finnish high technology was represented by the Asian countries, with the value of exports standing at over FIM 7.8 billion. Exports to non-EU and non-EFTA Europe (mainly Eastern Europe) was at almost the same level. In 1990 high technology exports to Eastern European countries were still at roughly the same level as exports to EU countries. However, foreign trade dried up in the early 1990s, but in recent years it has been showing strong growth again. The value of exports to these countries almost tripled to FIM 7.5 billion from 1995 to 1999. The surplus in the Finnish balance of trade with Eastern European countries has been relatively high throughout the 1990s; in 1999 the export-import ratio was 6.23.

High technology exports have shown more or less equally rapid growth during the 1990s in trade with the EU countries, Asia, other Europe and other countries. In all these market areas exports increased at least ten times over from 1991 to 1999. Finland's export-import ratio with Asian countries has been negative in all other years during the 1990s except 1996 and 1997. The trade balance deficit increased somewhat from 1998 to 1999. In 1999 the balance of trade showed a deficit of FIM 1.6 billion, while the export-import ratio was 0.83.

Trade with the NAFTA group (the United States, Canada and Mexico) has also shown a deficit. The deficit for 1999 was FIM 2.9 billion, the export-import ratio 0.48. However compared with the early years of the 1990s the ratio describing the balance of trade with NAFTA (0.16 in 1990) has developed in Finland's favour.

High technology exports are less concentrated in the group of major trade partners

Finland's high technology exports are quite heavily concentrated, although less so than earlier in the 1990s. In 1999 the 15 biggest export countries accounted for almost 70 per cent of Finnish exports (Table 9.5). When the

TABLE 9.5
High technology exports and imports: Finland's main trade partners in 1999

Exports	FIM million	%	Imports	FIM million	%
United Kingdom	4 056.4	8.6	United States	5 480.1	17.4
Germany	4 027.5	8.5	Japan	4 814.7	15.3
Sweden	2 942.1	6.2	Germany	4 503.3	14.3
France	2 674.7	5.6	United Kingdom	2 947.7	9.3
Italy	2 573.5	5.4	Netherlands	1 841.9	5.8
China	2 403.1	5.1	Sweden	1 464.4	4.6
United States	2 303.4	4.9	Ireland	1 072.1	3.4
Netherlands	2 067.5	4.4	China	1 016.5	3.2
Estonia	2 012.2	4.2	France	909.4	2.9
Switzerland	1 493.9	3.2	South Korea	866.8	2.7
Austria	1 387.0	2.9	Taiwan	777.4	2.5
Hongkong	1 330.9	2.8	Estonia	627.9	2.0
Denmark	1 289.7	2.7	Denmark	605.5	1.9
Turkey	1 269.0	2.7	Malaysia	538.0	1.7
Spain	1 079.3	2.3	Italy	508.2	1.6
Total	**32 910.3**	**69.4**	**Total**	**27 974.0**	**88.6**
Other countries	**14 496.1**	**30.6**	**Other countries**	**3 591.1**	**11.4**
Total exports	**47 406.4**	**100.0**	**Total imports**	**31 565.1**	**100.0**

group is further expended to the 20 biggest export markets, the proportion rises further to four-fifths. In value terms exports to the United Kingdom and Germany amounted to more than FIM four billion. Exports of high technology products to the seven next-biggest countries, including among others Estonia, amounted to FIM 2–3 billion in each country.

The value of exports has increased in all major trade partners towards the end of the 1990s. The United Kingdom has remained the most significant export market for Finnish high technology throughout the latter half of the 1990s, even though its share has dropped from 13.3 per cent in 1995 to 8.6 per cent in 1999. Sweden's share has also declined noticeably, by five percentage points during the past few years. Estonia, on the other hand, has steadily become a more and more important trade partner for Finland. From 1995 to 1999, exports to Estonia increased 3.5 times over, or by 249 per cent. The fastest increase in exports, however, was recorded in trade with China (+341%). Overall exports to Italy and France also showed strong growth. Measured in terms of the value of foreign trade, exports increased most to Germany (FIM 2.4 billion) and China (FIM 1.9 billion). There has been quite sharp annual fluctuation in the value of exports to individual countries and in the shares of these countries. Favourable trends have seen Russia emerge as the ninth biggest export market in 1998, accounting for just over three per cent, but one year later in 1999 Russia's ranking dropped to eighteenth. The value of Russian exports dropped from FIM 1.4 billion to less than one billion. However the most significant change in the late 1990s was the relegation of Japan from the list of Finland's top export markets. In 1995 Japan was still the fifth biggest export market, in 1999 it had dropped to the 29th place. At the same time the value of exports plummeted from FIM 1.2 billion to 0.4 billion.

Value of high technology imports from Japan has shown fastest growth

High technology imports are more concentrated than exports. In 1999 the 15 biggest countries accounted for 89 per cent of Finnish imports. The four biggest countries – the United States, Japan, Germany and the United Kingdom – alone accounted for 56 per cent. Compared to 1995 imports increased in relative terms most from the Netherlands, by 241 per cent. In value terms the strongest growth was recorded for imports from Japan (FIM 2.0 billion), Germany (FIM 1.7 billion) and the United States (FIM 1.4 billion). Imports from China and Malaysia almost doubled from 1998 to 1999. In 1999 imports from Estonia and Hong Kong, for which strong growth was recorded earlier in the 1990s, showed a sharp decline of 20 per cent. Imports of high technology products from France dropped ever more, by 45 per cent.

Surplus in high technology foreign trade largest with Italy, France and Sweden; and deficit largest with Japan and the United States

In 1999 Finland's high technology foreign trade showed the largest surplus with Italy (FIM 2.1 billion), France (FIM 1.8 billion) and Sweden (FIM 1.5 billion). Finland's high technology export-import ratio with Italy was 5.06, with France 2.94 and with Sweden 2.01. Finland's exports also show a surplus in excess of one billion with China, Estonia, the United Kingdom, Austria and Switzerland. Among major trade partners Finland's high technology foreign trade showed the largest surplus (measured in terms of the export-import ratio) with Russia (6.98).

In 1999 the deficit in Finland's high technology foreign trade was largest with Japan (FIM 4.4 billion) and the United States (FIM 3.2 billion). The export-import ratio with Japan was 0.08, with the United States 0.42. The deficit with both countries has increased since 1995, for Japan by as much as 172 per cent.

The positive balance in Finland's high technology foreign trade is to a greater extent than before explained by the surplus shown in trade with the EU countries (excluding Ireland and Germany) and with the rest of Europe. Trade with the other major high technology producers, i.e. the United States and Japan, shows a very clear deficit.

9.3 High technology foreign trade in OECD countries

Finland's high technology exports as a proportion of total exports has grown faster in the 1990s than in any other OECD country

With the exception of Spain and Italy all other OECD countries have seen an increase in their high technology exports as a proportion of total exports since 1991 (Table 9.6). Similarly, high technology imports as a proportion of total imports have increased throughout the OECD but not in Spain. During the 1990s high technology has accounted for by far the largest proportion of total exports in Ireland, where in 1998 the figure was over 37 per cent. In the United States, Japan, the United Kingdom and the Netherlands, too, high technology accounted for over 20 per cent of total exports in 1998. The share of exports was next highest in Finland, which in 1999 exceeded the 20 per cent mark. In 1998 high technology products accounted for less than five per cent of total exports from Portugal, Greece and Norway.

In 1998 high technology imports as a proportion of total imports was highest (as in the case of exports) in Ireland (34%), which clearly stood apart from the rest of the field. The figure was second highest in the Netherlands (23%). In other countries the share remained below one-fifth, although the United States and the United Kingdom did get close to that proportion. The share of high technology imports remained at one-tenth or less only in Belgium, Portugal, Spain and Greece.

Finland's high technology exports as a proportion of total exports has grown faster in both absolute and relative terms in the 1990s

TABLE 9.6
High technology product exports and imports as a proportion of total exports and imports in selected OECD countries in 1991, 1995 and 1998

Country	1991		1995		1998	
	Exports	Imports	Exports	Imports	Exports	Imports
	%	%	%	%	%	%
Finland	6.0	12.1	12.4	16.1	18.9	17.0
Sweden	11.1	13.4	12.9	16.5	16.9	17.8
Denmark	9.6	12.0	10.1	12.3	12.5	12.9
Germany	11.6	12.7	11.6	12.8	13.2	15.8
Austria	7.9	10.0	7.7	10.3	9.8	12.8
Netherlands	10.6	12.2	15.2	16.4	21.4	22.9
Belgium	4.1	5.7	5.8	6.6	6.5	8.7
France	14.6	12.8	15.2	13.3	18.3	15.8
United Kingdom	17.9	15.5	20.7	17.8	23.2	18.9
Ireland	27.0	18.1	32.9	28.7	37.2	34.2
Spain	5.8	11.7	5.5	9.0	5.5	10.0
Portugal	3.2	7.8	4.5	9.2	3.6	9.9
Italy	7.4	10.7	7.4	10.8	7.4	12.2
Greece	1.4	6.4	3.1	6.9	4.3	10.4
EU countries	**11.3**	**12.0**	**12.5**	**13.1**	**14.9**	**15.6**
Norway	3.6	11.0	3.7	12.4	4.8	12.9
Switzerland	14.6	12.3	16.0	14.7	18.0	16.2
United States	25.2	15.9	24.0	20.0	28.7	19.5
Canada	8.9	15.2	9.0	16.6	10.2	16.4
Japan	23.3	9.9	25.3	14.8	24.6	18.3

than in any other OECD country. In 1991 high technology products accounted for six per cent of Finland's total exports; at this time the only countries with a lower figure were Greece, Portugal, Norway, Belgium and Spain. In 1998 the share of high technology exports had tripled to around 19 per cent, thus standing at 13 percentage points higher than at the beginning of the decade. The Netherlands and Ireland also recorded growth of at least 10 percentage points at the same time. In both these countries high technology imports as a proportion of total imports have grown fastest since 1991, in Ireland by 16 and in the Netherlands by 11 percentage points.

The United States and Japan have held on to their position as the biggest exporters of high technology products

The United States and Japan have long been the two countries with by far the largest volume of foreign trade in high technology (Table 9.7). In 1998 the total value of US high technology foreign trade stood at over FIM 2,000 billion, while the figure for Japan was almost FIM 800 billion. The value of Germany's total high technology trade was only some FIM three billion less than Japan's. However, high technology exports from the EU countries in 1998 exceeded the combined figure for the United States and Japan by some FIM 160 billion. One factor that undermines the comparability of these figures is that the statistics on EU exports include trade among EU Member States. If internal trade (which was quite lively) were excluded, the figures would be markedly lower.

In 1998 the value of high technology exports from the United States exceeded FIM 1,000 billion. The value of US exports increased from 1991 to 1998 quite considerably, or by some 157 per cent. The value of Japanese high technology exports was over FIM 500 billion. The increase

TABLE 9.7
Foreign trade in high technology products in selected OECD countries in 1991, 1995 and 1998

Country	1991			1995			1998		
	Exports FIM bn	Imports FIM bn	Exports/ Imports	Exports FIM bn	Imports FIM bn	Exports/ Imports	Exports FIM bn	Imports FIM bn	Exports/ Imports
Finland	5.6	10.7	0.52	21.7	20.7	1.05	43.7	29.3	1.49
Sweden	24.7	27.0	0.91	43.7	44.3	0.99	74.4	60.9	1.22
Denmark	14.5	16.6	0.87	22.2	24.4	0.91	32.0	31.8	1.01
Germany	188.4	199.7	0.94	265.6	259.6	1.02	383.6	396.6	0.97
Austria	13.1	20.6	0.63	19.5	29.6	0.66	31.9	45.9	0.69
Netherlands	57.1	61.9	0.92	117.3	112.6	1.04	191.6	191.5	1.00
Belgium	19.5	27.7	0.70	42.6	43.9	0.97	60.7	76.0	0.80
France	125.5	119.3	1.05	188.1	157.8	1.19	292.7	241.5	1.21
United Kingdom	131.4	131.5	1.00	209.5	206.0	1.02	338.2	322.3	1.05
Ireland	26.3	15.3	1.72	62.7	40.3	1.56	127.4	80.9	1.58
Spain	13.6	44.0	0.31	21.8	44.4	0.49	32.6	73.3	0.44
Portugal	2.1	8.3	0.26	4.6	13.4	0.34	4.6	19.5	0.24
Italy	50.7	78.8	0.64	74.4	95.6	0.78	95.2	139.8	0.68
Greece	0.5	5.6	0.09	1.5	7.7	0.19	2.5	15.9	0.16
EU countries	**672.8**	**767.1**	**0.88**	**1 095.1**	**1 100.3**	**1.00**	**1 710.9**	**1 725.1**	**0.99**
Norway	4.9	11.3	0.43	6.8	17.8	0.38	10.4	25.7	0.41
Switzerland	36.1	33.1	1.09	56.9	51.4	1.11	75.9	69.2	1.10
United States	405.8	326.5	1.24	570.9	672.1	0.85	1 042.1	983.5	1.06
Canada	43.3	72.6	0.60	70.7	118.6	0.60	117.3	175.7	0.67
Japan	294.8	94.6	3.11	488.5	216.5	2.26	510.2	273.4	1.87

in the value of Japanese exports at the same time was markedly slower (+73%). In fact the value of high technology exports from Japan has remained more or less unchanged since 1995. The next-biggest high technology export countries in 1998 were Germany, the United Kingdom and France. The Netherlands, Ireland and Canada also recorded exports in excess of FIM 100 billion.

Finland records OECD's fastest increase in the value of its high technology exports

In 1991–1998 the increase in the value of high technology exports was fastest in Finland, Greece and Ireland. On average the value of Finnish exports went up by 34 per cent, of Greek exports 26 per cent and Irish exports 25 per cent a year. Greek exports, though, still remain at a comparatively low level. The countries next in line in terms of high technology exports growth were the Netherlands (on average 19% a year), Belgium (18%) and Sweden (17%). The average annual growth for both the EU area and the United States was 14 per cent. The rate of growth picked up during the latter half of the decade.

The biggest high technology importers in 1990–1998 were the United States, Germany and the United Kingdom. During this period the average annual increase in the value of imports was fastest in Ireland (at around 27% a year), the Netherlands (17%) and the United States (17%). The annual increase in imports in Finland (16%) was somewhat faster than the average in the EU (12%).

Throughout the 1990s the surplus of foreign trade in high technology has been clearly highest in Japan. In 1998 Japan's export-import ratio was 1.87. The export-import ratio was also high in Ireland (1.58) and Finland (1.49). The ratio for Japan has declined from 1991 to 1995 considerably. The US high technology balance of trade, on the other hand, has shown a surplus after an interim period of a few years. During the latter half of the decade the EU's export-import ratio has remained at around 1.00.

Finland's high technology export-import ratio was only 0.52 in 1991. The only countries recording lower figures at this time were Greece, Portugal, Spain and Norway. In 1995 Finland overtook Sweden at the same time as the country's high technology balance of trade showed a surplus for the first time. Indeed the development of Finland's export-import ratio has been clearly the strongest in the whole OECD group.

Specialisation in high technology exports differs widely between EU countries

The indices shown in Table 9.8 describe the specialisation of EU countries in high technology exports. The analysis is based on the relative specialisation index[3], in which the values vary within the range of ±1 depending on the country's foreign trade specialisation. In 1998 the EU countries that specialised most clearly in high technology exports were Ireland, the United Kingdom and the Netherlands; their specialisation indices were 0.43, 0.22 and 0.18, respectively. Finland, France and Sweden also recorded positive indices; for all other EU countries the figure was negative. The weakest specialisation in high technology exports was recorded by Portugal, Greece and Spain. Finland's specialisation index was still marginally negative in 1995.

Examined by product group, high technology exports are most specialised in countries where the index for a certain product group is highest both within a country and in comparison with other countries (these figures are in boldface and underlined in the Table). Examined by product

---

3 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 rate of specialisation is positive. The higher the positive value, 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 9.8
High technology exports by product group in EU countries in 1998: index of relative specialisation

Country	Aero-space	Computers and office machinery	Electronics and tele-communi-cations equipment	Pharma-ceuticals	Scientific instru-ments	Electrical machinery	Chemicals	Non-electrical machinery	Arma-ments	High tech exports total
Ireland	–0.53	**0.68**	0.42	0.54	–0.21	0.11	–0.79	–0.92	–1.00	0.43
United Kingdom	0.20	0.27	0.20	0.00	0.19	0.38	0.14	0.21	**0.56**	0.22
Netherlands	–0.60	**0.50**	0.05	–0.10	0.10	0.00	0.01	–0.32	0.08	0.18
Finland	–0.87	–0.24	**0.48**	–0.87	0.05	–0.10	–0.69	–0.23	–0.14	0.12
France	**0.47**	–0.10	0.04	–0.03	–0.09	–0.27	0.27	–0.17	–0.23	0.10
Sweden	–0.06	–0.64	**0.39**	–0.19	0.05	–0.20	–0.73	0.08	–0.45	0.06
Germany	0.02	–0.26	–0.11	–0.26	**0.18**	0.12	0.11	0.17	–0.47	–0.06
Denmark	–0.66	–0.40	–0.08	**0.56**	0.18	–0.32	–0.12	–0.70	–0.78	–0.09
Austria	–0.53	–0.59	–0.02	**0.19**	–0.22	0.01	–0.53	–0.02	0.15	–0.21
Italy	–0.33	–0.49	–0.41	0.01	–0.38	–0.28	–0.35	**0.11**	0.07	–0.34
Belgium	–0.78	–0.46	–0.44	**0.20**	–0.48	–0.45	–0.13	–0.35	–0.58	–0.40
Spain	–0.78	–0.51	–0.47	**–0.12**	–0.45	–0.58	–0.27	–0.19	–0.21	–0.46
Greece	–0.30	–0.84	–0.49	–0.41	–0.79	–0.86	–0.19	–0.97	**0.04**	–0.55
Portugal	–0.80	–0.85	–0.49	–0.47	–0.49	–0.29	–0.62	–0.93	**0.14**	–0.62

The index of 'relative specialisation': (the country's share of EU countries' high technology exports / the country's share of EU countries' total exports - 1) / (the country's share of EU countries' high technology exports / the country's share of EU countries' total exports + 1).
The figures in bold represent the highest value in each country. The underlined figures are the highest values of each product group. On the product group level, high technology exports are relatively most specialised in countries where the index of a certain product group is the highest both by country and as compared to other countries (these figures are given both in bold and underlined in the table).

group, Finnish high technology exports were oriented more strongly than in other countries to electronics and telecommunications; in Denmark to pharmaceuticals; in France to aerospace; in Ireland to computers and office machinery; and in the United Kingdom to armaments.

Other distinctive features of exports were the predominance of pharmaceuticals not only in Denmark but also in Belgium, Austria and Spain, and the key role of armaments not only in the United Kingdom but also in Portugal and Greece. Germany specialised in scientific instruments and Sweden in telecommunications equipment. Computers and office machinery are important to high technology exports from the Netherlands (figures in boldface).

APPENDIX 9.1
OECD industry definitions and codes

High technology industries:

- Aerospace (353)
- Computers, office machinery (30)
- Electronics and telecommunications equipment (321, 322)
- Pharmaceuticals (244)

High-medium technology industries:

- Scientific instruments (33)
- Electrical machinery (2971, 31, 323)
- Motor vehicles (34, 352)
- Chemicals (24 excluding 244)
- Non-electrical machinery (29 excluding 2971)

Low-medium technology industries:

- Shipbuilding (351)
- Petroleum refining (23)
- Other transport equipment (354, 355)
- Rubber and plastic equipment (25)
- Non-metallic mineral products (26)
- Basic metals (27)
- Other manufacturing (36 excluding 361)
- Fabricated metal products (28)

Low technology industries:

- Food, beverages (15, 16)
- Textiles and clothing (17, 18, 19)
- Wood and furniture (20, 361)
- Pulp and paper (21)
- Publishing, printing (22)
- Recycling (37)

(The figures in brackets refer to the industry codes of the Finnish Standard Industrial Classification 1995)

Source:

STI working papers 1997/2, Thomas Hatzichronoglou: Revision of the high technology sector and product classification, OECD

APPENDIX 9.2
High technology product groups and SITC rev. 3 codes

This table is based on the new OECD classification of 1995. Product group codes marked with an asterisk indicate a group representing the highest category of R&D intensity ("leading-edge" products). The R&D intensity of these products is over 8.5 per cent.

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 1000V
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

10 Development of the information society

The development of the information society is opening up increased opportunities for self-improvement, human interaction and grassroots influence. In an international comparison Finland ranks among one of the world's leading countries in this respect. This chapter describes the recent developments in Finland in the area of information and communications technology and in business activities in the IT sector.

One of the most significant trends in the diffusion of information technology is the development of information networks and the spread of network connections throughout society. The continued development of the information society requires that all members of society have not only the necessary hardware but also the skills that are needed to use that hardware. New information and communications technology has usually been adopted in Finnish households at the same pace regardless of the appliance in question. The only exception to this rule is the mobile phone (Figure 10.1). In 1995 and 1996, the number of mobile phones in Finnish homes increased more rapidly than any other information or communications technology appliance.

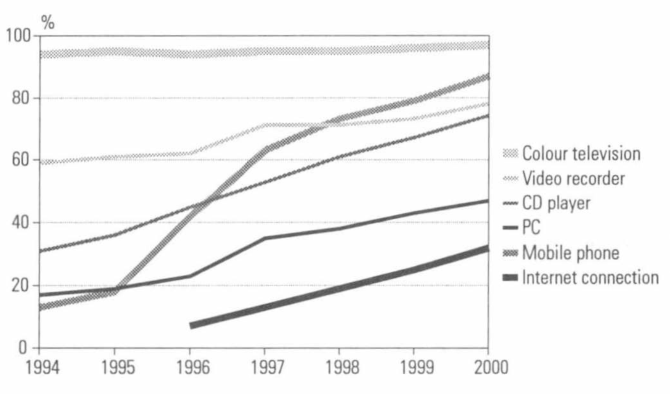


FIGURE 10.1 Penetration of selected appliances, per cent of households

Source: Statistics Finland: Household Budget Survey, Consumer Survey 1997-

10.1 Mobile phones

Mobile phone subscriptions have increased several times over

Mobile phones, home PCs and their network connections are the appliances that are most commonly associated with the development of the information society. Their numbers have proliferated during the latter half of the 1990s. The number of mobile phone subscriptions increased almost 15 times over within the space of one decade (Table 10.1).

TABLE 10.1
Total number of mobile phone subscriptions and subscription density at year-end in 1990–1999 and an estimate for 2000

Year	Mobile telephone subscriptions total	Subscriptions/ 100 inh.
1990	257 872	5.2
1991	319 137	6.4
1992	386 021	7.6
1993	489 174	9.6
1994	675 565	13.2
1995	1 039 126	20.4
1996	1 502 003	29.3
1997	2 162 574	42.0
1998	2 946 948	57.1
1999	3 363 589	65.2
2000*	3 754 700	72.6

Source: Telecommunications statistics 2000;
**Mobile Communications, estimate on 1 June 2000*

Finland has highest subscription density

Finland's mobile phone density (72.6) has long been the highest in Europe (Figure 10.2). Outside Europe, the countries that come closest to Finland are Hong Kong and Israel, which at year-end 1999 had 56.5 and 55.6 mobile phone subscriptions respectively per 100 inhabitants. High densities were also recorded in Singapore (42.0), Australia (40.4), Japan (38.2), the United States (30.3) and Canada (22.2).

Finland is an exceptional case in the sense that the number of mobile phone subscriptions exceeded the number of wired telephone extensions as early as December 1998. The number of wired extensions peaked in 1997, since then the increase in the telephone density has been attributable to the growing number of mobile phone subscriptions. Almost three in four households had a fixed telephone line in August 2000. At the same time 87 per cent of all households had at least one mobile phone[1]. Only two per cent of Finnish households had no phone at all.

Four households in five have a mobile phone

At least in present-day Finland mobile phones are very much regarded as personal appliances, so in this sense it is justified to study their numbers relative to the total population. Another common approach is to take households as the unit of analysis: in this case the mobile phone is regarded as a household appliance comparable to television sets or freezers, for instance.

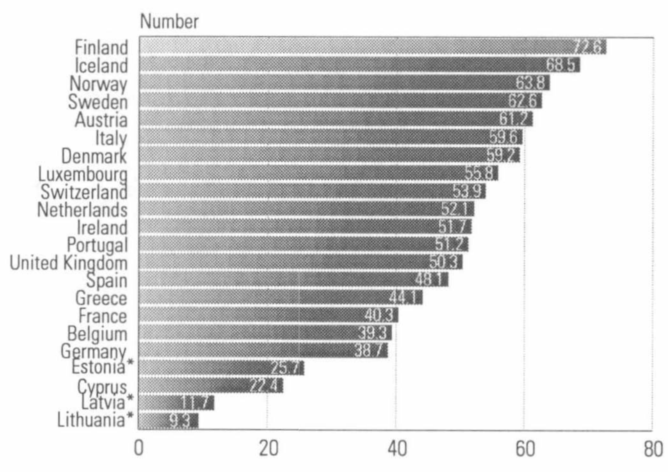


FIGURE 10.2
Mobile phones per 100 inhabitants in Europe as at 1 June 2000

*Sources: Mobile Communications; *Global Mobile 6/1999*

1 Consumer Survey 8/2000, unpublished tables. Statistics Finland.

TABLE 10.2
Mobile phone, PC and Internet connection by household type, per cent of all households

Household type	Mobile phone	Home PC	Internet connection
1 person aged under 30	93	34	19
1 person aged 30–39	83	33	10
1 person aged 40–59	64	22	9
1 person aged 60+	33	3	0
1-person households total	**66**	**21**	**10**
2 persons aged under 30*	91	49	29
2 persons aged 30–49*	97	49	28
2 persons aged 50–64*	86	35	27
2 persons aged 65+*	63	22	2
Single parent, 2 persons	82	39	18
2-person households total	**80**	**35**	**18**
3 persons	90	54	28
4 persons	98	69	47
5+ persons	95	83	52
All households	**78**	**39**	**21**

**the group defined by the age of its oldest member*
Source: Statistics Finland, Reviews 2000/5

TABLE 10.3
Use of mobile phones and SMS messages by age and gender (%)

Age	Mobile phone in use		Uses SMS messages	
	Males	Females	Males	Females
15–19	77	77	79	80
20–29	87	85	84	87
30–39	81	72	73	69
40–49	72	62	50	56
50–59	68	50	53	28
60+	39	19	18	8
Total	**73**	**61**	**58**	**51**

Source: Statistics Finland, Reviews 2000/5

At year-end 1999 over three-quarters or 78 per cent of Finnish households[2] had at least one mobile phone (Table 10.2). The larger the number of people in the household, the more likely it is they will have at least one mobile phone. On the other hand the younger the people in the household, the more often they will have a mobile phone, a PC and an Internet connection. Among people over 60 who live alone, the number of mobile phones is quite high compared to the number of home PCs and Internet connections.

It seems that ownership of mobile phones is lowest among elderly women. In particular, they rarely use SMS messaging services (Table 10.3). In 1999 a total of more than 650 million SMS messages were sent in Finland. At the same time the number of phone calls from GSM phones was in excess of two million, while fixed line calls numbered over 3.5 million[3].

10.2 Home PCs and Internet connections

PCs in almost every other home

In August 2000 almost every other home in Finland (47%) had a personal computer. The proportion of households with an Internet connection was around one-third (32%). According to the same source[4] the proportion of households with a PC in spring 1999 was 43 per cent, the figure for Internet connections was 22 per cent.

2 Nurmela, Juha, Risto Heinonen, Pauli Ollila & Vesa Virtanen: Mobile Phones and Computer as Parts of Everyday Life in Finland. Reviews 2000/5, Statistics Finland.
3 Telecommunications statistics 2000.
4 See footnote 1.

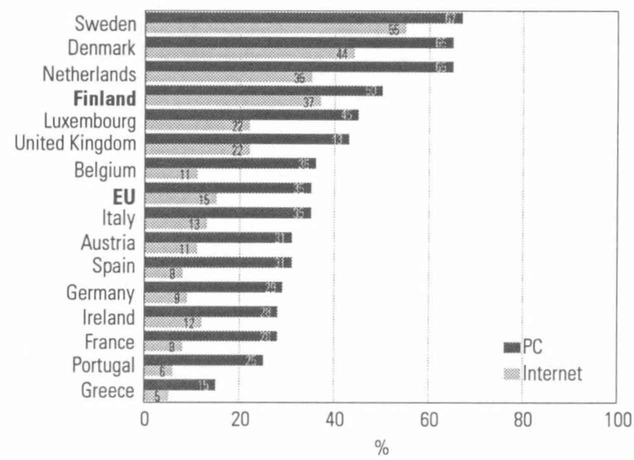


FIGURE 10.3
Access to a PC and to the Internet, per cent of the population aged 15 and over, spring 1999

Source: Eurobarometer No. 51, 1999

Access to PC and the Internet depends closely on age

PC use at work or at school is common especially in the Nordic countries and the Netherlands (Figure 10.3). In Finland public libraries offer free access to the Internet, although sometimes users may have to queue. However, in spite of this service, not all people are aware that they can also go to the library to use the Internet.

Access to a PC and the Internet varies widely above all according to age. Over half of the population who attend school or are employed have access to a PC, whereas in the age group over 60 only a very small proportion can use PCs or access the Internet (Figure 10.4). The differences between men and women are considerable, even among those who are employed.

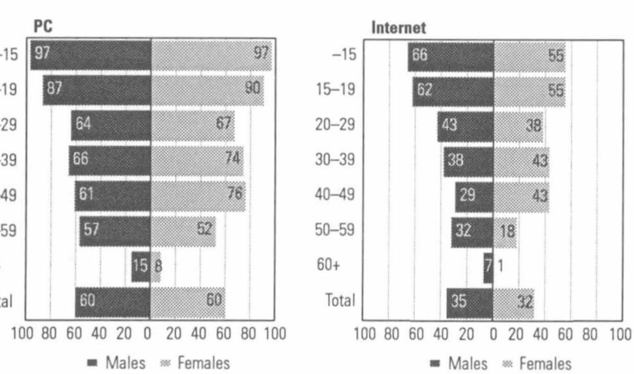


FIGURE 10.4
Access to a PC and to the Internet, per cent by gender and age, winter 1999

Source: Statistics Finland, Reviews 2000/5

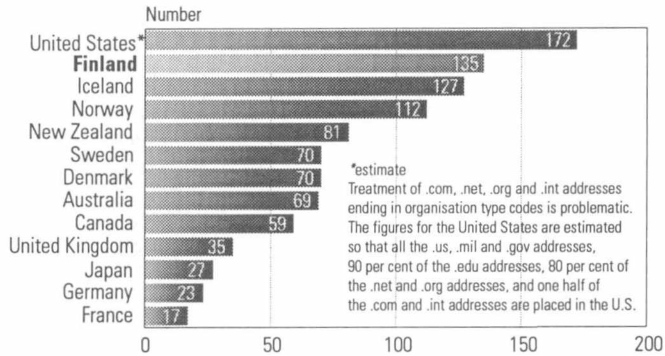


FIGURE 10.5
Internet connections (hosts) per 1,000 inhabitants, July 2000

Source: Network Wizards, Internet Domain Survey

Finland has the second highest number of Internet connections per 1,000 inhabitants

In spite of its technical weaknesses the measure of Internet hosts per one thousand inhabitants (Figure 10.5) is used here for purposes of describing the country's general infrastructure. This figure describes the number of Internet addresses ending in that country's country code per one thousand population.

10.3 IT use in enterprises

Enterprises that do not use information technology are rare exceptions

According to Statistics Finland's business survey[5] 97 per cent of all enterprises with at least 10 employees indicated that they used information technology in their operation (Figure 10.6). Well over four-fifths or 87 per cent said they used the Internet, and a further 9 per cent reported that they would be beginning to use the Internet during 2000. In 1999 external e-mail was used by 80 per cent of all enterprises, by the end of 2000 it was estimated the figure will be 88 per cent.

In 1999 electronic data interchange (EDI) was in use in some 18 per cent of Finnish enterprises, with 7 per cent reporting that they will be taking it into use during 2000.

Almost every enterprise uses the Internet to search information

The most common use of the Internet among enterprises was for purposes of searching information (Figure 10.7). By 1999, 87 per cent of those enterprises that had access to the Internet had used it to retrieve information. By the end of 2000, 95 per cent of all enterprises

5 All the results reported here concern enterprises with 10 or more employees using IT. The figures have been raised to correspond to the total levels for the pertinent economic activities or size classes. The results are reported in closer detail in "Internet use and e-commerce in enterprises". Science, Technology and Research, 2000:2. Statistics Finland.

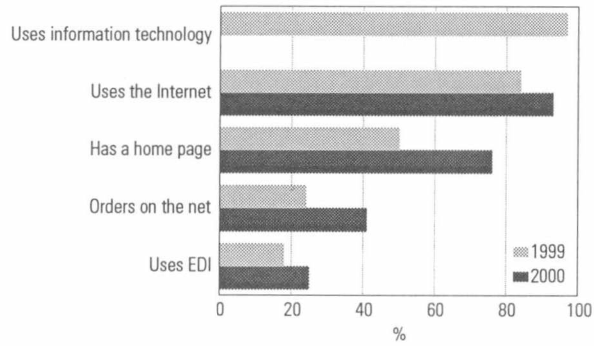


FIGURE 10.6
Use of information technology in enterprises, proportion of all enterprises with at least 10 employees

had used the Internet to search information, or were planning to do so.

70 per cent of Finnish enterprises reported that they had transferred files via the Internet in 1999 or earlier. Almost two-thirds or 60 per cent of enterprises said they monitored the home pages of their competitors. Almost 40 per cent indicated that they had used the net to deal with public authorities, over 20 per cent that they had recruited personnel. It was expected that communication with authorities would increase during 2000.

Enterprises interested in using commercial databases and in data on prices

Enterprises had most often used the Internet to consult commercial databases or services and to monitor prices (Figure 10.8): almost half of all enterprises reported these purposes. Some 40 per cent of all enterprises had ordered goods or services online. Online payments were still used quite infrequently, with less than 30 per cent reporting that they had used the service.

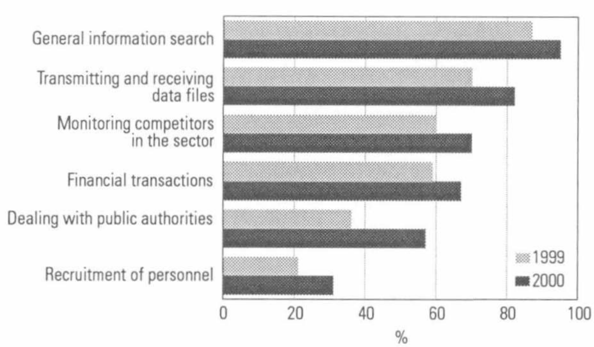


FIGURE 10.7
Internet usage, proportion of enterprises with at least 10 employees using the Internet

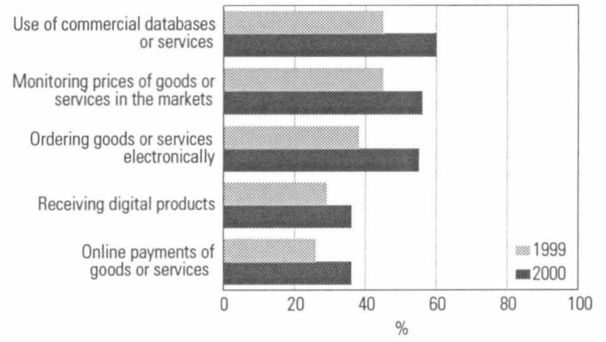


FIGURE 10.8
Use of Internet services by enterprises, proportion of enterprises with at least 10 employees using the Internet

Internet gaining greater significance as a marketing channel for enterprises

Enterprises have been more active in using Internet services than in offering their own products via the Internet. Over half or 53 per cent of Internet users had their own home pages in 1999, by the end of 2000 it was estimated the figure will be 81 per cent. The analysis below only covers those enterprises that had home pages or that were planning to open home pages during 2000.

Some 60 per cent of Finnish enterprises actively marketed their products or services via their home pages (Figure 10.9). Around 40 per cent provided access to product catalogues, price lists etc., but only around one-fifth had a service that allowed customers to buy online or offered after sales support.

It was expected that the Internet services offered by business enterprises will increase during 2000. Over 90 per cent of all enterprises indicated that they marketed products or services on their home pages in 2000 or earlier. The number of enterprises with online sales and after sales support was expected to double in 2000 compared to the previous year.

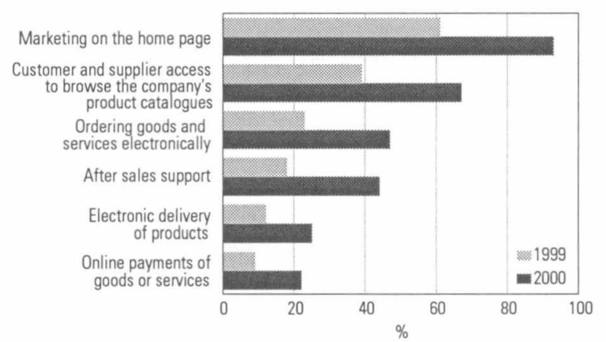


FIGURE 10.9
Enterprises providing Internet services, proportion of enterprises with at least 10 employees and home pages on the Internet

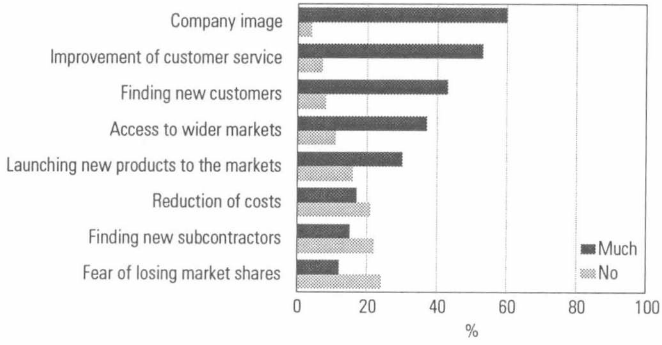


FIGURE 10.10
Factors connected with e-commerce with 'no' or 'much' importance, proportion of enterprises with at least 10 employees and home pages on the Internet

Online sales important to company image

About one-fifth of enterprises with at least 10 employees and home pages on the Internet were of the opinion that other businesses are most important with respect to e-commerce. Only 10 per cent of these enterprises felt that households and the public sector were of major significance. 11 per cent of the enterprises indicated that other businesses are insignificant as online customers. Accordingly, households were insignificant to 40 per cent of the enterprises, the public sector to around one-quarter of the enterprises.

Two in three enterprises that had home pages on the Internet were of the opinion that company image is a critical factor with respect to the Internet and e-commerce (Figure 10.10): in other words the majority of enterprises are of the opinion that the availability of online services significantly improves the enterprise's image. Another key factor with regard to e-commerce was improved customer service and flexibility (53%). Over 40 per cent of the enterprises with home pages considered the finding of new customers via the Internet as an important factor, over one-third referred to the importance of access to wider markets.

10.4 Enterprises in the information sector

Large-scale enterprises typical in the information sector

Although business in the information sector has expanded rapidly during the 1990s, the number of enterprises operating in this sector still remains quite low. In 1998 less than 15,000 enterprises or no more than 6.5 per cent of all Finnish enterprises operated in the information sector (Figure 10.11). However, one in ten employees or a total of more than 130,000 people worked in enterprises operating in the information sector, and the share of turnover and wages and salaries in these enterprises is greater still.

Business enterprises operating in the information sector are highly heterogeneous. Large companies are typical of rapidly developing branches such as the manufacture of telecommunications equipment, telecommunications and computer and related activities. In 1998 a total of some 700 enterprises were engaged in IT sector

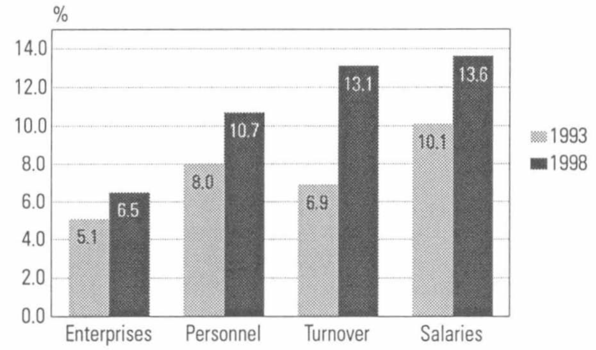


FIGURE 10.11
Information sector enterprises, personnel, turnover and salaries as a proportion of all enterprises in 1993 and 1998

Source: Statistics Finland, Business Register

manufacture, generating a combined turnover of more than FIM 71 billion. The enterprises employed more than 40,000 people. The most significant sector in production of goods was the manufacture of television and radio transmitters and other similar appliances (including mobile phones), where turnover had increased fivefold since 1993.

The recent increase in production of goods can be described on the basis of monthly data for the manufacture of electro-technical products and instruments (Figure 10.12). Since 1998 the growth has continued to gather momentum, and exports have grown even faster than domestic turnover.

Production of services accounts for largest share

Production of services is the biggest employer in the information sector, employing over 52,000 people. Over 22,000 of them worked in computer and related activities, almost 19,000 in telecommunications. The number of new jobs created in production of services between 1996 and 1998 was some 10,000.

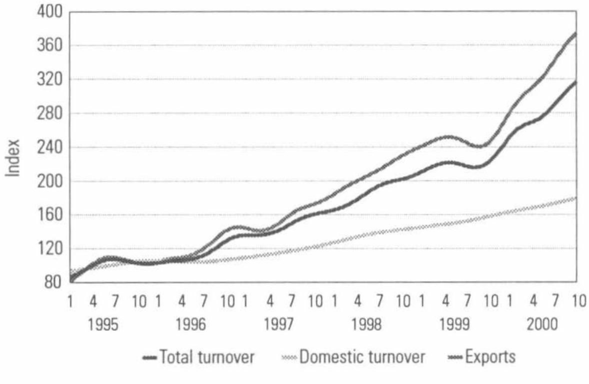


FIGURE 10.12
Manufacture of electro-technical products and instruments (SIC 30–33), turnover index 1995=100

Source: Statistics Finland, short term business trends

The number of new enterprises set up in the field of content production was greater than in other branches of the information sector, although the number of employees and turnover in these enterprises have been quite modest. The biggest employers in 1998 were publishing (15,600 persons), business and management consultancy activities (7,600 persons) and radio and television activities (7,200 persons).

IT business quite heavily concentrated in regional terms

One enterprise may have different business units in different parts of the country. The discussion below draws on regional data from Statistics Finland's Business Register for 1994 and 1998.

IT business is still quite heavily concentrated in certain regions (Table 10.4). The region of Uusimaa accounts for over half of the sector's personnel and turnover. Varsinais-Suomi accounts for some ten per cent of the whole country's personnel number, but for almost one-quarter of the turnover in the Finnish IT sector. Pirkanmaa accounts for a somewhat larger share of the total personnel number than North Ostrobothnia, but establishments in the Oulu region account for a larger proportion of turnover than those in and around Tampere.

The significance of the information sector to the regional economy is greatest in Varsinais-Suomi, where almost one-third of the turnover in the region's businesses comes from the information sector. In the region of Uusimaa the share is close on one-fifth, in North Ostrobothnia almost 17 per cent. In Pirkanmaa the figure is around ten per cent.

The number of establishments in the IT sector increased in all regions from 1994 to 1998, in the whole country by around one-third. The number of personnel working in the

TABLE 10.4
IT sector establishments, their personnel and turnover by region in 1994 and 1998 and change (%)

Region	Establishments*			Personnel			Turnover		
	1994	1998	change	1994	1998	change	1994	1998	change
	Number	Number	%	Number	Number	%	FIM mn	FIM mn	%
Uusimaa	5 855	7 824	34	44 496	65 259	47	41 205	88 823	116
Itä-Uusimaa	124	183	48	484	563	16	278	409	47
Varsinais-Suomi	776	1 107	43	8 237	12 002	46	11 856	37 486	216
Satakunta	291	390	34	1 569	1 749	11	719	1 145	59
Kanta-Häme	228	293	29	1 279	1 550	21	622	955	54
Pirkanmaa	948	1 234	30	7 106	9 675	36	3 990	9 735	144
Päijät-Häme	384	522	36	2 049	2 134	4	975	1 509	55
Kymenlaakso	221	296	34	1 114	1 224	10	762	1 094	44
South Karelia	198	253	28	1 142	1 021	–11	651	734	13
Etelä-Savo	207	251	21	1 150	972	–15	609	695	14
Pohjois-Savo	326	449	38	2 223	2 662	20	1 281	2 023	58
North Karelia	193	255	32	990	944	-5	482	749	55
Central Finland	411	548	33	2 792	4 045	45	1 629	3 785	132
South Ostrobothnia	213	275	29	934	890	–5	527	657	25
Ostrobothnia	307	406	32	1 551	1 917	24	825	1 492	81
Central Ostrobothnia	67	114	70	297	327	10	184	170	–7
North Ostrobothnia	509	625	23	6 412	9 259	44	5 198	10 482	102
Kainuu	102	105	3	1 039	1 154	11	606	644	6
Lapland	220	264	20	1 211	1 203	–1	707	954	35
Åland	53	73	38	255	278	9	128	235	84
Total	**11 633**	**15 467**	**33**	**86 330**	**118 825**	**38**	**73 232**	**163 775**	**124**

** ancillary establishments not included*
Source: Statistics Finland, Business Register

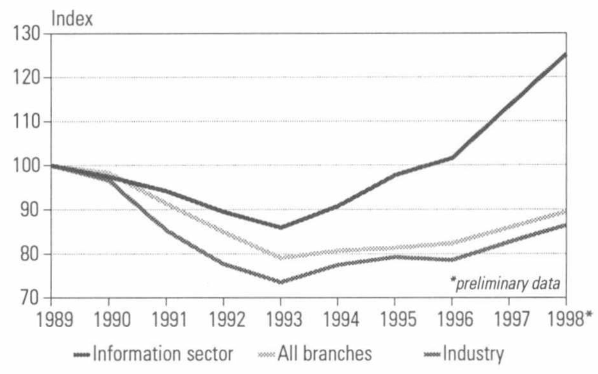


FIGURE 10.13
Annual changes in employment in 1989–1998 (1989=100)

Source: Statistics Finland, Regional employment statistics

information sector dropped in some regions and increased primarily in those regions where the numbers were high to start with. Central Finland also ranks among the fastest-growing regions with respect to the increase in the number of IT sector personnel and turnover.

Number of personnel in information sector has increased rapidly during the latter half of the 1990s

At year-end 1989 the total employed labour force in Finland stood at 2,374,000. However, economic recession caused the number to drop by year-end 1993 to 1,878,000. During the past years of economic recovery the figure has been rising again, and by year-end 1998 the number of persons employed was around 2,126,000 (preliminary data).

The figures for the whole economy are still well short of level recorded during the pre-recession years; especially in industry it seems that the number of persons employed has remained permanently at around the same level as was recorded during the recession (Figure 10.13). Since year-end 1995 the number of persons employed has increased by almost 193,000 persons (10%).

During the same period the number of people working in the information sector has increased by some 28,000 (28%). The numbers have shown particularly rapid growth for production of goods (computers, mobile phones, TV sets, electronic components, etc.). The number of jobs in the information sector as a proportion of all jobs in 1989 was 4.3 per cent, in 1998 6.1 per cent (Table 10.5).

TABLE 10.5
Labour force employed in 1995–1998

	1995	1996	1997	1998*
All branches	1 932 752	1 957 144	2 037 997	2 125 535
Industry	412 950	409 648	430 736	449 881
Services	1 240 491	1 273 423	1 327 241	1 374 022
Information sector	**100 439**	**104 492**	**116 754**	**128 728**
Production of goods	28 835	31 914	36 656	39 170
Production of services	38 966	38 860	43 576	48 299
Content production	32 638	33 718	36 522	41 259

**preliminary data*
Source: Statistics Finland, Regional employment statistics

APPENDIX 10.1
IT sector industries[6]

Production of goods

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
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

Production of services

51432	Wholesale of radio and television goods
51641	Wholesale of computer hardware
51652	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

6 Standard Industrial Classification 1995, Handbooks 4, Statistics Finland.

11 Summary

Statistical indicators on the innovation system

This report provides a statistical overview of the Finnish innovation system in the 1990s. It describes the development of the human resources required in science and technology and the resources available to research and development. The impacts of the investments made are assessed in the light of data on patents, publications, citations, innovations and high technology. There is also a separate discussion on the development of the information society and on international R&D co-operation.

Number of persons with doctorate level education rising sharply

During the 1990s the number of persons with tertiary education have increased on average by three per cent a year. The numbers who have completed a doctorate have risen by as much as seven per cent a year. In 1998 there were more than 11,000 people in the working-age population with a doctorate. In 1998 a total of almost 1,000 doctoral theses were approved, almost twice as many as in 1990. During the period from 1989 to 1998 the proportion of women in the population with tertiary education has increased from 52 per cent to 56 per cent. At the same time their proportion of those with a doctorate has risen from 19 per cent to 29 per cent.

In 1998 half of the population with a doctorate level degree lived in the region of Uusimaa. The corresponding proportion for the population with tertiary education is around one-third. Large numbers of people with tertiary education are also moving into the southernmost region of the country. In 1998 the region of Uusimaa recorded a positive net migration of 3,600, up by one-third on the figure one year previously. In 1998 a total of some 3,400 people with tertiary education moved out of the country; 152 of them had a doctorate level degree. The most popular destinations for people with a doctorate level degree were Sweden and the United States. For all tertiary educated groups the second most popular destination was Norway.

Almost half of the employed population in public administration and social services as well as in financial intermediation and insurance have tertiary education. The corresponding proportion in manufacturing is around one-quarter.

The unemployment rate in the population with doctorate level education increased in the first half of the 1990s to around three per cent; since then the figures have come down to some extent. In 1993 unemployment among those with a higher tertiary degree was over six per cent, by 1998 the figure has dropped to some four per cent. Unemployment was highest among Masters of Fine Art and architects (in excess of eight per cent), lowest among medical doctors and teachers (less than two per cent).

Almost one-quarter of the population with tertiary education changed jobs in 1998. Mobility was lowest during the recession in 1992 at 17 per cent. Mobility among people with doctorate level education and those with a higher tertiary degree has been somewhat higher. Mobility is clearly highest in the IT sector.

In 1998 the average monthly income of people with doctorate level education was around FIM 20,000; the corresponding figure for people with a higher tertiary degree was FIM 17,000. The average income of a person with at least a higher tertiary degree in the field of education and teacher training was less than FIM 13,000, while the corresponding figure in the health and social welfare sector was almost FIM 22,000. The average incomes of R&D personnel in industry have shown somewhat slower growth in the 1990s than the earnings of all salaried employees in industry. Likewise, the average earnings of university teachers have risen somewhat more slowly than the salaries of all government employees (civil servants).

R&D expenditure more than doubled during the 1990s

Research and development has grown rapidly during the 1990s. Average annual growth has been nine per cent, but towards the end of the decade the figure was 14 per cent, suggesting increased investment levels. The GDP share of R&D expenditure has increased from 2.0 per cent in 1991 to 3.2 per cent in 1999. Finland's GDP share of R&D expenditure is the second highest in the world after Sweden. Preliminary estimates suggest that the same rate of growth is set to continue in 2000.

Most of the increase in R&D expenditure is explained by the increase in business enterprise sector R&D expenditure, which rose during the 1990s by an average 11 per cent a year. Business enterprises' share of R&D expenditure increased from 57 per cent in 1991 to 68 per cent in 1999. This increase is explained almost entirely by the growth in the electronics industry. R&D expenditure in the electronics industry has shown very strong growth since 1991, almost five-fold by 1999. R&D expenditure in the metal and mechanical industry and in the chemical industry has shown slow growth during the 1990s. In other industries R&D expenditure has remained more or less unchanged or decreased to some extent.

Public sector R&D expenditure has recorded an annual average growth in the 1990s of no more than just over one per cent. The sector's share of total R&D expenditure has dropped from over 20 per cent at the beginning of the decade to no more than 12 per cent. R&D expenditure in the university sector has risen more by virtue of increased extramural funding. The average annual increase in this sector stands at around six per cent.

In regional terms the R&D activities in Finland are highly concentrated, and it seems that this tendency is set to continue. The three biggest sub-regional units (Helsinki, Tampere and Oulu) together accounted for 69 per cent of total R&D expenditure in 1999. Per capita R&D expenditure was highest in Oulu and environs.

Finnish research showing a stronger international orientation

A clear indication of the current strong trend of internationalisation in R&D is provided by the number of visits by university researchers. In 1999 university teachers or researchers made a total of 825 visits lasting one month or more to foreign universities. The highest number (231) was recorded for the University of Helsinki, but academic staff from the universities of Turku and Oulu also made more than 100 such visits. At the same time 1,170 foreign researchers visited Finnish universities. The Helsinki University of Technology was the main destination of visits to Finland.

The Academy of Finland invests in promoting the international mobility of researchers. In 1999 it awarded a total of 208 grants to support researchers working abroad. The Centre for International Mobility (CIMO) awarded 809 scholarships for long-term postgraduate studies and for shorter researcher visits. Over half of these scholarships or 564 were awarded for purposes of supporting foreign researchers working in Finland. The largest number of arrivals came from Russia, Hungary and Estonia.

Finland's involvement in the EU's research programmes is at a somewhat higher level than is its share of the Union's R&D expenditure. A total of 2,637 Finnish organisations were involved in the Fourth Framework Programme through 1,850 projects; the corresponding figures for the Third Framework Programme were 538 organisations and 427 projects. In relative terms Finnish participation was highest in telematics and advanced communication technologies.

There has also been a marked increase in co-operation through COST during the 1990s. The number of actions has quadrupled and Finland is involved in around two-thirds of all actions. Finland has been particularly active in actions in the forest and forestry products, urban civil engineering and meteorology. During the past few years there has also been growing interest in EUREKA co-operation. In the 48 conventional projects that were ongoing at year-end 2000, the number of Finnish partners involved stood at 86. In addition, Finland was represented in all nine ongoing major cluster projects. The total volume of Finnish participation in ongoing EUREKA projects amounted to almost FIM 300 million (EUR 48.5 million).

One-third of firms have innovations

In 1996–1998 around one-third of all business enterprises in Finland brought a new product or service to the markets, or introduced a new or essentially improved production method. In manufacturing companies with more than ten staff, 18 per cent of turnover was based on technological innovations, in service industries the share of innovative turnover was six per cent. The most innovative branch was the electronics industry, where almost three-quarters of the turnover in 1998 came from technological innovations introduced in 1996–1998.

There is a clear association between company size and innovation in manufacturing. In small firms with less than 20 staff, 23 per cent had an innovative product or service or introduced a new or essentially improved production method. The corresponding figure for enterprises with more than 500 staff was 82 per cent. No corresponding difference could be seen in service industries.

Finland's ranking is surprisingly poor in the EU's Second Innovation Survey that covers the period from 1994 to 1996. The only countries that record a lower innovation intensity than Finland are Belgium, Spain and Portugal (Greece is not included in the comparison). On average, every other enterprise in the EU area has technological innovations; for Finland the proportion in 1996 was just over one-third. The low figures recorded for Finland are mainly explained by low number of innovations in SMEs. In addition, the figures may be due to the stricter interpretation applied in Finland for the concept of innovation, or the concentration of innovation in a small number of large enterprises.

Data collected by the Technical Research Centre indicate that less than half of all innovations matured from the initial concept into a marketable product within two years. Less than one-third of the projects were completed within five years. In three cases out of four the most important areas of technological know-how related to the development of innovations were the development and adaptation of components or modules and the commercialisation of core technology.

Finland active in filing patent applications

The number of domestic patent applications has grown by an average of three per cent in the 1990s. On the other hand, the number of foreign applications has sharply decreased because nowadays most applications are channelled through the European Patent Office (EPO). The per capita number of domestic patent applications in Finland is third highest after Germany and Sweden. Telecommunications technology is the biggest single field of technology in terms of the number of patents filed; it accounts for 18 per cent of all patent applications. This share has also doubled in the latter part of the 1990s.

In 1999 the region of Uusimaa accounted for almost 40 per cent of all patent applications filed by domestic business enterprises. Compared to 1995 this figure has come down by a few percentage points. At the same time the share of Pirkanmaa has increased to more than 15 per cent. Generally speaking patenting is somewhat less concentrated than R&D.

Over one-third or 38 per cent of all 900 EPO patent applications from Finland were in the telecommunications category. Finland and other small countries have increased their share of all EPO applications during the 1990s. Finland's share of patents granted in the United States has also increased during the latter half of the decade. Some other countries have also seen an increase in their share of US patents; one example is Denmark.

Papers by Finnish scientists have ever greater international visibility

Papers written by Finnish authors are published more and more often in respected international journals. Their share of all papers in the SCI database has risen from 0.68 per cent in 1989 to 0.92 per cent in 1998. Forty per cent of the Finnish papers listed in the database are studies in medical journals. Finnish papers now also receive more citations than before; the relative citation rate is 20 per cent higher than the world average. Finland has now caught up with Denmark and Sweden.

International collaboration accounts for a growing proportion of all papers published. In 1998, 40 per cent of all published papers by Finnish scientists were co-authored with one or more international partners; the corresponding figure in 1989 was 24 per cent. Collaboration has increased most with the EU countries, although the single most important partner country is still the United States. There is also closer co-operation than before between different sectors (universities, research institutes and industry). One in five articles published in 1998 involved co-operation among authors or organisations from at least two different sectors. Over half of all papers of industry were produced together with universities.

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

High technology output and foreign trade has shown extremely rapid growth in the 1990s. The value of production in high technology industries has increased almost ten times over. The biggest and fastest-growing product group has consistently been that of electronics and telecommunications equipment, where the volume of production increased from November 1999 to November 2000 by almost 80 per cent.

High technology exports increased as a proportion of total exports from six per cent in 1991 to over 20 per cent in 1999. Foreign trade in high technology products shows a surplus. At the end of the decade exports exceeded imports by 50 per cent; in the early 1990s exports still accounted for no more than half of imports. The surplus is explained by trade in the electronics and telecommunications equipment. In some other product groups the balance of trade shows a deficit. For instance, the deficit in foreign trade in computers and office machinery stands at around FIM four billion, and the figure has been rising sharply in recent years.

Over half of Finland's high technology exports go to the EU countries. In this category Finland's foreign trade shows a significant surplus. The balance of trade with Asia and NAFTA, on the other hand, shows a deficit. The main export markets for Finland's high technology products are the United Kingdom, Germany and Sweden, although the share of both the UK and Sweden has been on the decline. China and Estonia have emerged as significant buyers of Finnish high technology. The United States, Japan and Germany are the top three importers of Finnish high technology.

Finland's high technology exports as a proportion of total exports have grown faster in the 1990s than in any other OECD country. In relative terms the Netherlands and Ireland have recorded almost the same rate of growth for their exports. In 1998 high technology exports from Ireland, the United States, Japan, the United Kingdom and the Netherlands accounted for a larger proportion of total exports than was the case in Finland.

Finland leads the way in the development of the information society

Finland is one of the world's leading countries in terms of the development of the information society. The number of mobile phones increased almost 15 times over within the space of a decade, and the mobile phone density in the country is the highest in the world. Four households out of five now have a mobile phone. Almost every other household has a PC. The number of Internet connections in Finland per 1,000 population is the second highest in the world after the United States.

In 1999 virtually all or 97 per cent of the business enterprises with at least 10 employees said they used information technology. Around 87 per cent used the Internet and 80 per cent used external e-mail. It is estimated that the latter shares have increased by some 8–9 percentage points in 2000. Almost all enterprises indicated that they used the Internet for the purpose of searching general information. The role of the Internet as a marketing channel has clearly increased. It was estimated that some four enterprises out of five had home pages at year-end 2000.

Biotechnology: the industry of the future

Work is still under way to develop an international statistical system covering the field of biotechnology, and therefore there is not yet enough information to write a separate article on the subject. According to the Finnish Bioindustry Association there are 120 Finnish enterprises in this sector, three of which are major pharmaceutical enterprises. In 1999 their turnover added up to some FIM 1.3 billion, and they had a personnel of more than 8,000. The three major pharmaceutical enterprises accounted for roughly half of this. The units in this sector tend to be quite research-intensive, and around half of them are Centres of Excellence. There are biotechnology know-how centres in Helsinki, Turku, Kuopio and Oulu. The number of research teams active in the field of biotechnology is 180, and there are 19 graduate schools.

In conclusion

Virtually all indicators included in this review show that Finland has been making good progress during the 1990s. Having said that, the country has relied quite heavily in its development on the electronics industry and other information sectors. R&D expenditure in other industrial sectors has not shown the same kind of growth. The increase in university sector R&D expenditure is explained by the growth of extramural funding. General funding for research has remained more or less unchanged. In particular, greater investment will be needed in the future to raise levels of know-how in mathematics and the natural sciences. Biotechnology and knowledge-intensive services might be among the strongest areas of growth in the future. In any event, it is clear that globalisation and networking among researchers will have a major impact on the development of the Finnish innovation system during the decade ahead.

List of figures, tables and appendices

Figures

Tables

Appendices

The publication **Science and Technology in Finland 2000** describes the recent development of science and technology by using a number of different indicators.

- Population with tertiary education, employment, mobility and salaries
- Research and development in business enterprises, in the public sector and in the university sector, internationalisation of R&D, government R&D funding
- International mobility of researchers
- Patenting
- Bibliometric indicators
- Output of and foreign trade in high technology products

The publication also contains reviews on current issues of science and technology policy and on the information society, presents the results of innovation surveys and gives information on Finland's participation in international research co-operation.

More information on the statistics on science, technology and information society at:
http://www.stat.fi/tk/yr/tttiede_en.html

Tilastokeskus, myyntipalvelu
PL 4V
00022 TILASTOKESKUS
puh. (09) 1734 2011
faksi (09) 1734 2500
myynti.tilastokeskus@tilastokeskus.fi
www.tilastokeskus.fi

Statistikcentralen, försäljningstjänsten
PB 4V
00022 STATISTIKCENTRALEN
tfn (09) 1734 2011
fax (09) 1734 2500
myynti.tilastokeskus@stat.fi
www.stat.fi

Statistics Finland, Sales Services
P.O.Box 4V
FIN-00022 STATISTICS FINLAND
Tel. +358 9 1734 2011
Fax +358 9 1734 2500
myynti.tilastokeskus@stat.fi
www.stat.fi

ISSN 1457–1218
= Science, Technology and Research
ISSN 0785–885X
ISBN 951–727–882–9
Tuotenro 9492
B00

9 789517 278829