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Cover design:
An artificially stained transmission electron micrograph
of thin sectioned dividing bacterial cell.
The DNA in the sister cells and in the dividing area is clearly visible.
Micrograph: Kari Lounatmaa and Pekka Pulkkila

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Foreword

Science and Technology in Finland 1995 is the third statistical publication describing Finnish science and technology. The publication compiles information on the functions, preconditions and resources of science and technology, as well as on the application and economic impacts of science and technology. Corresponding publications have been prepared previously in 1987 and 1989.

A chapter on the internationalisation of science and technology is a new entity as compared with the previous publications.

The Unit for Science and Technology Statistics at Statistics Finland is responsible for the preparation of *Science and Technology in Finland 1995*. The publication was written by Pirjo Niskanen (Chapters 1–4) and Markku Virtaharju Sub-Chapters 5.2–5.3). Sub-Chapter 5.1, dealing with scientific publishing, was written by Terttu Luukkonen of the Technical Research Centre of Finland. Mikael Åkerblom, Ari Leppälahti and Raili Kouvalainen have also participated in the preparation of this publication.

Helsinki, February 1996

Heli Jeskanen-Sundström

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Characteristics and Development Features of Finnish Science and Technology

Education and Labour Market

- Persons with university degrees or other tertiary education numbered more than 413 000 in 1993. The number had increased by almost one-half from 1985. The rate of increase accelerated from 4 per cent a year in the late 1980s to approximately 6 per cent a year in the first half of the 1990s
- The number of doctorates degrees more than doubled during 1985–93. The rate of growth was highest in the social sciences and lowest in the natural sciences
- The number of college engineers has increased at a rate clearly higher than previously
- The share of the natural sciences and engineering in tertiary degrees is relatively high in comparison with other countries
- The number of persons with tertiary education per total labour force is in Finland one of the highest in the OECD countries
- The ratio of the Finnish expenditure on education to the Gross Domestic Product (GDP) in 1992 was the highest in the OECD countries. The share of tertiary education was approximately 31 per cent of total expenditure on education
- Unemployment among persons with tertiary education has increased
- It is increasingly difficult for persons completing their tertiary education to find employment
- Relatively few persons with tertiary education, in particular few holders of doctorates, are employed in the private sector
- The earnings of research and development (R&D) personnel have developed almost in accordance with the overall development of the level of earnings in Finland. The salaries of women with tertiary education are approximately 20–30 per cent lower than the salaries of men with the same level of education

Resources for R&D

- The GDP share of R&D increased from 1.8 per cent to 2.4 per cent during 1989–94. The increase in the share was contributed to by a drop in the GDP after 1991. The share is higher than the average in the OECD countries
- About FIM 10 700 million were spent on R&D in 1993
- R&D expenditure increased on average by 1 per cent a year during 1989–93
- 42 100 persons, of whom one-third were women, were working in R&D functions in 1993
- The share of persons with doctorates education in R&D personnel increased from 14 per cent to 17 per cent during 1989–93
- The number of person-years expended on research per total number of persons gainfully employed is relatively high as compared with other countries
- About 44 per cent of the R&D expenditure in 1993 was incurred in the Metropolitan Helsinki area

R&D in Business Enterprises

- The R&D expenditure of business enterprises, having dropped from 1989, took an upturn after 1991 and the increase between 1993 and 1994 was particularly stong, 18 per cent
- In 1993 the share of business enterprises in total R&D expenditure was 58 per cent, and in total research personnel it was 47 per cent
- Graduate degrees were held in 1993 by 35 per cent of the research personnel in business enterprises
- The GDP share of the R&D expenditure of business enterprises in 1992 was lower than the median of the OECD countries
- The electrical engineering and electronics industry has continually increased its share in the total R&D expenditure of business enterprises. In 1993 its share was already about one-third
- The share of R&D expenditure in the value added portion of industrial output dropped from 5.2 per cent to 4.6 per cent during 1991–93
- In R&D activity of business enterprises the share of public funding is clearly lower than the average in the OECD countries

R&D in Public Sector

- The share of the public sector in total R&D expenditure in 1991 was at the average level of the OECD countries. In Finland the share of the public sector was higher than in Sweden, Norway and Denmark
- The rate of increase of R&D expenditure in the 1990s has been higher in the public sector than in business enterprises and in universities
- Of research personnel in the public sector, the share of holders of higher tertiary degrees has increased, as has the share of persons with doctorates education
- The breakdown by field of science in the public sector has remained relatively constant since 1989. The predominant field of science is engineering, the share of which in 1993 was 39 per cent
- Of total R&D expenditure of the public sector, the share under the administration of the Ministry of Trade and Industry dropped from 52 per cent to 44 per cent during 1989–93

Research in Universities

- The GDP share of the research expenditure of the universities in 1992 was at the average level of the OECD countries
- Growth of the research expenditure of the universities has stalled in the 1990s. It is anticipated that research expenditure will drop owing to cuts made in Government appropriations after 1993
- In 1993 about one-half of the research expenditure of the universities was used on the natural sciences and engineering. The share of engineering has increased in the 1990s
- The share of extramural funding in the research expenditure of the universities increased from 36 per cent to 41 per cent during 1989–93, in the field of engineering to as much as 74 per cent
- The share of extramural funding is at the average level of the OECD countries. In 1991, for example, in Sweden, Great Britain, the United States, Japan, and France the share was higher than in Finland
- The share of holders of doctorates degrees in the research personnel of the universities increased from 29 per cent to 35 per cent during 1989–93

Government R&D Funding

- The rate of increase of Government R&D funding has slowed in the 1990s. During 1989–95, R&D appropriations increased by an average of 3 per cent a year
- The rate of increase of Government R&D funding has in the 1990s been higher than the rate of increase of total Government expenditure
- The share of R&D funding in total Government expenditure is about 3.1 per cent
- In the increases of Government appropriations in the 1990s, priority has been given to the promotion of industry
- Of all Government R&D funding during 1989–95, that under the administration of the Ministry of Trade and Industry has increased its share from 38 per cent to 40 per cent. During the same period the share of the Ministry of Education has dropped from 39 per cent to 37 per cent

International Co-operation in Science and Technology

- International mobility of university researchers has increased in the 1990s. In 1994, the number of Finnish university researchers who went abroad for work or study was about 23 per cent higher than in 1990
- In 1994, the number of visiting researchers who came to Finnish universities was about 38 per cent higher than in 1990
- The most popular western targets for Finnish researcher exchange were the United States, Great Britain, Canada, Germany and France. The most popular target countries in Eastern Europe were Russia, Estonia, Hungary and Poland
- The participation of Finnish researchers in the Third EU Framework Programme for Research remained at a low level
- In 1994 Finland was the 6th most active country in participation in the COST programme
- At the beginning of 1994 Finland was the 8th most active country in participation in the EUREKA programme
- International co-operation has been increased, for example, in space research. Public funding for space research in 1994 amounted to about FIM 146 million, of which the share of ESA co-operation was about 62 %

Scientific Publishing

- In proportion to its population size, Finland is at the OECD average in its publishing activity. Finland is behind Sweden and Denmark, but ahead of Norway and Iceland
- Finns publish more than the average in the OECD countries in the fields of clinical medicine and biomedicine, and of biology
- With respect to both publishing activity and the number of citations, Finland is below the average of the Nordic countries in all disciplines except mathematics, in which Finns publish as much as the Nordic countries on average
- As compared with the other Nordic countries, Finns have the lowest number of internationally co-authored publications

Patenting

- The total number of patents applied for in Finland took an upturn in 1994 after a drop in previous years
- Of all patent applications filed in Finland, the share of foreign applicants was about 62 per cent
- 490 business enterprises applied for patents in 1994
- Of the patent applications filed by business enterprises, the largest product group was electrical engineering products. This group constituted 40 per cent of the applications
- Of the patents granted to foreign applicants, the largest product group was chemical products (38 %)
- Of the inventors named in Finnish patent applications filed by business enterprises, 42 per cent were from the Province of Uusimaa in Southern Finland
- The number of patent applications filed in Finland in 1994 was about 4 per 10 000 population. Of the reference countries, Switzerland and Germany are ahead of Finland
- The share of Finnish applicants in patents granted in the United States to foreign applicants has remained unchanged. The countries which have increased their respective shares the most are Asian countries
- The Finnish balance of patents shows a surplus. The number of patents filed by Finnish applicants abroad was about 2 per cent more than the number of patent applications filed in Finland by foreign applicants
- The dissemination of Finnish technology has increased sharply; with increasing frequency, patents for Finnish inventions are also applied for abroad

Economic Impacts of Science and Technology, and Technology Transfer

- Capital expenditure by manufacturing industries on machinery and equipment took an upturn in 1994
- Total capital expenditure increased most in the manufacture of electrical engineering products and instruments. Total capital expenditure in other industries, with the exception of vehicle manufacture, remained below the 1989 level
- The share of high technology enterprises (output of drugs, computers, telecommunications equipment, and aircraft) in the turnover of manufacturing industry enterprises in 1993 was 6.5 per cent. The share increased by 3 percentage points from 1991
- In 1993 the value of the output of high technology products amounted to about FIM 24 000 million. This output increased by more than FIM 10 000 million from 1991
- The share of the output of high technology products in the total output of the manufacturing industries in 1993 was slightly below 9 per cent
- The value of high technology product exports in 1994 amounted to about FIM 24 000 million. Its share in total exports of goods was 15.5 per cent, which was 1.7 percentage points higher than in the previous year
- The balance of trade surplus of high technology products in 1994 increased to about FIM 1600 million
- The export of high technology products is increasingly concentrated in telecommunications equipment, the share of which in 1994 was nearly 40 per cent of all high technology product exports
- The high technology products imported in largest amounts were data processing equipment, and printed circuits and components
- About 40 per cent of the exports of high technology products were to EU countries, and 35 per cent of the imports were from EU countries
- Of the OECD countries, the share of high technology products in 1993 was highest in the exports of the United States (29 %). The next were Japan (26 %) and Great Britain (25 %). In the exports of Finland the share was 13.8 %, which was slightly higher than the respective share of Sweden (13.5 %)

1 Introduction

1.1 Background

Science and technology have ever more clearly become a strategic resource for the development and management of society. One of the most important functions of economic and social policy in the 1990s has been to develop as a whole, as a national innovation system, the factors affecting the production and exploitation of knowledge and know-how.

The requirement of functioning and fruitfulness of the innovation system have increased the need for knowledge relating to science and technology and to the exploitation of their results. In future the need for knowledge will only increase, since societal pressures for change and international integration will place new demands on the national innovation system and its development.

The preconditions for forming a wide overall picture of the significance of science and technology in our society are today better than ever before. The stock of knowledge has increased, for example owing to the work done in the development of indicators and to the developing of information technology. On the other hand, we are also more aware than previously of the complexity of developments in science and technology.

The present *Science and Technology 1995* compiles statistical data describing the state, development and impacts of science and technology. Through a simultaneous examination of various data, and through international comparisons, an effort is made to create a picture of the strengths and weaknesses of the Finnish innovation system in the area of science and technology.

To understand the overall picture it is necessary to define in greater detail certain terms relating to the topic of the present report. The contents of the publication are closely associated with the concept behind the term 'national innovation system.'

The term **national innovation system** is used in the same meaning as defined in the latest review of the Science and Technology Policy Council of Finland. According to the definition, by 'national innovation system' is meant *the totality of factors affecting the development and exploitation of knowledge and know-how* (Science and Technology Policy Council of Finland 1993, 17).

It is to be noted that the national innovation system is a considerably wider entity than is scientific and technological activity. The functioning of the innovation system is affected not only by science and technology but also by the educational and economic systems, the role of the public sector, the funding sectors, and the domestic business enterprises.

Science and technology indicators are indicators formed from various statistics and other information sources; they describe the functions of science and technology, inputs allocated to them, and their results. In general the indicators do not measure a phenomenon directly; they provide indications of its extent and development. A plurality of indicators and other information sources should be used simultaneously for the interpretation of information and as a support for conclusions.

By **scientific and technological activity** is meant all systematic activity targeted at the production, advancement, dissemination, and application of scientific and technological knowledge in all fields of science and technology. These include activities such as research and development, education in science and technology (incl. doctorates education), and scientific and technological services.

At their best, science and technology indicators serve as auxiliary tools for decision makers, indicating deficiencies and problem areas in the innovation system. Indicators can be used as a background material in the distribution of resources for R&D. They also provide information on the impacts of science and technology, for example on competitiveness and productivity.

In Finland the production of information concerning science and technology is within the scope of functions of Statistics Finland. Since 1971 Statistics Finland has prepared R&D statistics which contain information on R&D personnel and person-years, R&D expenditure, and R&D funding. In preparing the R&D statistics Finland complies with OECD instructions and recommendations. In the developing and widening of science and technology indicators, Finland has largely followed international examples. In recent years, for example, statistics on innovation activity and on patents and high technology have been targets for development.

1.2 Content of Report

Most of the information in the present report dates from 1993. Some of the information has been published previously in the Education or Science and Technology series of Statistics Finland. As many international comparisons as possible have been incorporated into the presentation; the purpose of the comparisons is to show the similarities and differences between the Finnish science and technology system and those of other countries. Most of the international comparisons are based on OECD statistics. In addition to the Introduction the report contains 4 chapters; at the beginning of each chapter, the indicators and the information sources used in preparing them are introduced. At the end of the report there are appendix tables referred to in the text, as well as a list of references.

Chapter 2 deals with **human resources for science and technology**. These are described, for example, by using statistical data concerning the population with tertiary education, the tertiary degrees awarded, the employment of persons with tertiary education, and the development of the salary level of researchers.

Chapter 3 presents information on **R&D resources and their development**. The chapter contains information on R&D expenditure, research personnel, and R&D funding by the Finnish Government.

A new entity in the report as compared with the previous reports is Chapter 4 dealing with the **internationalisation of science and technology co-operation**, introducing various forms of international science and technology co-operation and the participation of Finns in international science and technology co-operation.

Chapter 5 deals with the **results and economic impacts of science and technology**. These are described, for example, on the basis of information concerning scientific publishing, patenting, and the output of and foreign trade in high technology products.

2 Human Resources

The significance of education and research as factors of long-term, sustained economic growth has been generally recognized in future-oriented economic policies. The possibilities of small countries such as Finland to cope in rapidly changing circumstances are largely dependent on their capacity for innovation. Innovation requires preparedness for change, as well as the development, knowledge and use of best technologies. Only with personnel having know-how can new products be produced and developed. Skills and knowledge can be obtained through training, but they also accumulate through experience. Maintenance of a wide and high level of education, upgrading of the quality of education and research, and co-ordination of work, education and changing circumstances are important methods of promoting national well-being.

This chapter describes the human resources for science and technology in Finland. They are described using indicators formed, for example, in the following areas: 1) population with tertiary education; 2) tertiary degrees; 3) supply of labour with tertiary education and their placement in jobs; 4) salaries of persons with tertiary education. The information regarding the human resources for science and technology is based on data obtained from Statistis Finland statistics on education, register of degrees, statistics on employment, and statistics on salaries.

Concepts, Definitions and Classifications

The present discussion covers persons who have completed lower tertiary vocational education or undergraduate degrees, holders of graduate degrees, and holders of doctorates degrees. Persons below 15 or above 65 years of age have been excluded, since the purpose is to describe potential labour for science and technology.

The classification into educational categories is based on the classification of edùcation of Statistics Finland (Statistics Finland, Handbooks, No. 1, Helsinki 1992). The classification has been prepared according to the same principles of classification as UNESCO's International Standard Classification of Education (ISCED).

The classification into fields of science is based on the OECD recommendation. The classification into professions is based on the classification of professions of Statistics Finland (Statistics Finland, Handbooks, No. 14, Helsinki 1987).

Sub-Chapter 2.1 describes the *development of the number of persons with tertiary education*. Sub-Chapter 2.2 presents information on *tertiary degrees awarded*. The information in these two first sub-chapters is based on separate material prepared for this publication, the fields of science being derived from the fields of education in the classification of education. Sub-Chapter 2.3 presents information on the *position of persons with tertiary education in the labour market*, for example on the basis of employment, placement in profession, and the development of researchers' level of earnings.

2.1 Population with Tertiary Education

In the present sub-chapter, education in accordance with levels 5, 6 and 7 in UNESCO's International Standard Classification of Education (ISCED) is included in tertiary education.

Average Annual Increase of 6 per cent in Number of Persons with Tertiary Education

The rise in the level of education of Finns has continued at a rapid rate also in the 1990s. The number of persons with tertiary education at the end of 1993 was about 413 200, which is over one-third more than in 1985. The proportion of persons with tertiary education in 1993 was about 12 % of the population 15–64 years of age.

Holders of doctorates degrees in 1993 totalled 16 276, i.e. about 4 per cent of all persons with tertiary education. Holders of higher tertiary degrees amounted to about 66 per cent and holders of lower tertiary degrees amounted to 30 per cent. About one-third of all persons with tertiary education had degrees in engineering or the natural sciences.

2.1
Number of persons with tertiary education during 1975–93
(excluding persons above 65 years of age and those with military education)

ISCED	1993	Annual growth 1975–85	Annual growth 1985–90	Annual growth 1990–93
		%	%	%
Doctorates	16 276	5.4	7.0	8.6
– of which engineering and the natural sciences	6 168	6.2	5.8	6.1
Higher tertiary	273 982	4.5	3.5	3.3
– of which engineering and the natural sciences	102 966	5.6	3.6	3.6
Lower tertiary	122 964	2.9	4.6	10.4
– of which engineering and the natural sciences	17 258	11.4	40.0*	26.6*
Total	**413 222**	**4.1**	**3.9**	**5.5**
– engineering and the natural sciences	126 392	5.7	5.1	6.0

* Strong increases partly due to upgrading of certain educational programmes according to ISCED.

Table 2.1 shows the development of the population with tertiary education during 1975–93. The rate of increase in the number of persons with tertiary education has accelerated in the 1990s. During 1990–93 the average annual increase in the number of persons with tertiary education was 5.5 per cent, whereas in 1985–90 it was less than 4 per cent.

The number of persons with lower tertiary education has increased the most since 1990, on average 10 per cent a year. This rate of increase is largely explained by an increase in the number of holders of degrees in engineering and the natural sciences, as can be seen in Table 2.1. The increase has been the second largest in the number of holders of doctorates degrees, about 9 per cent a year. The increase in the number of holders of higher tertiary degrees has been slowed, for example, by the lengthening of periods of education.

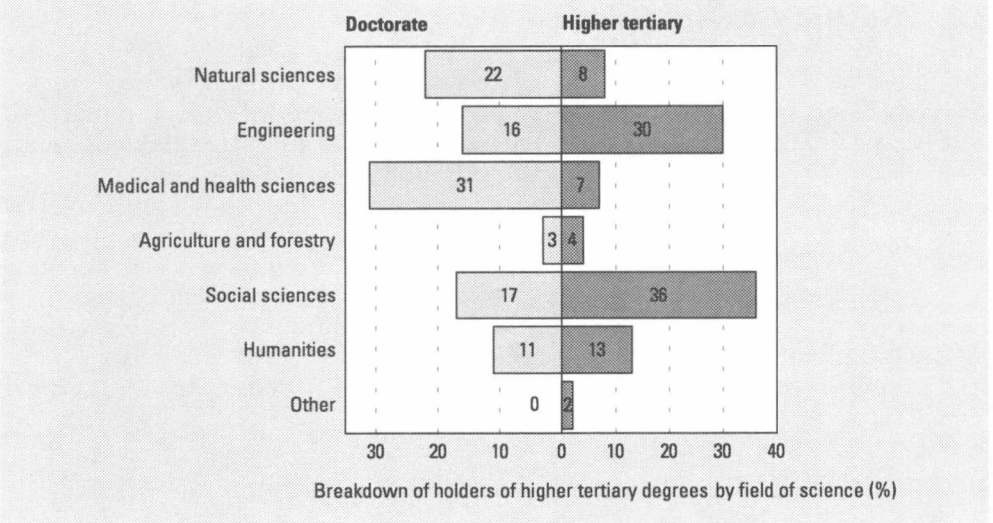
Appendix Table 2.1 shows more detailed data on the population with tertiary education, according to level of education, field of science, and sex, during 1975–93.

One-Third of Holders of higher tertiary Degrees Social Scientists

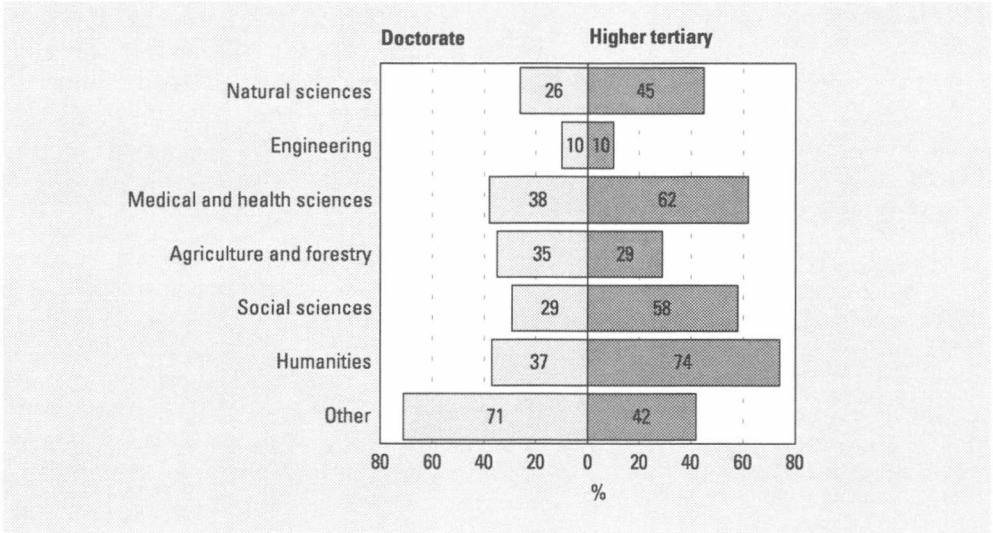
Among holders of higher tertiary degrees, social scientists have increased their share the most drastically since 1985. In 1993, 36 per cent of the holders of higher tertiary degrees had completed their degrees in social sciences. The second highest was the share of holders of degrees in engineering, 30 per cent.

Figure 2.2 shows that doctorates education was clearly more common in the natural and medical sciences than in other fields. The comparison of medicine with other sciences is complicated by a different degree structure; in Finland, the degree of Licentiate in Medicine corresponds to graduate degrees in other sciences.

Natural scientists in 1993 constituted 22 per cent of all holders of doctorates degrees and about 8 per cent of all holders of higher tertiary degrees. Respectively, the share of social scientists was 36 per cent of all holders of higher tertiary degrees and only 17 per cent of all holders of doctorates degrees.



2.2
Holders of doctorate degrees and of higher tertiary degrees by field of science 1993



2.3
Women with higher tertiary degrees by field of science 1993

More than One-Half of All Persons with Tertiary Education Women

Women in 1993 constituted 52 per cent of all persons with tertiary education. The proportion of women was the largest, 73 per cent, among persons with lower tertiary education. Among the holders of higher tertiary degrees the proportion of women was 44 per cent and among the holders of doctorates degrees it was 29 per cent.

In 1992 the proportion of women among the holders of higher tertiary degrees was 48 per cent, which was at the average level of the OECD countries. By contrast, Finland led the OECD countries in a comparison of the proportion of women among all persons with tertiary education.

The proportion of women has in recent years increased especially sharply in the population with doctorates education. The proportion of women among holders of doctorate degrees increased from 17 per cent to 23 per cent during 1985–93. During the same period the proportion of women among holders of licentiate degrees increased from 25 per cent to 29 per cent.

Figure 2.3 shows that women with doctorates degrees are concentrated in the medical and health sciences and in the natural sciences. Women with higher tertiary degrees, for their part, are concentrated in the social sciences and the humanities.

The proportion of women among the holders of doctorates degrees in engineering in 1993 was less than 10 per cent. About 38 per cent of the holders of doctorates degrees in the medical and health sciences were women. Among the holders of higher tertiary degrees, the proportion of women was 58 per cent in the social sciences and 74 per cent in the humanities.

Number of Persons with Tertiary Education Highest in Province of Uusimaa

More than one-third of the holders of tertiary degrees (incl. those with military degrees) lived in the Province of Uusimaa in Southern Finland in 1993. In proportion to the population 15–64 years of age, the share of persons with tertiary education was clearly highest in the Province of Uusimaa, 18 per cent, which was 6 percentage points higher than the average in Finland, 12 per cent.

2.4
Population with tertiary education (15–64 years of age), and share in the population of the same age group by province 1993

Province	Population with tertiary education (15–64 years of age)		Share of persons with tertiary education in the population 15–64 years of age
		%	%
Uusimaa	158 125	37.6	17.5
Turku and Pori	52 132	12.4	11.2
Häme	55 341	13.2	11.4
Kymi	21 117	5.0	9.5
Mikkeli	12 513	3.0	9.2
Northern Karelia	11 007	2.6	9.4
Kuopio	17 648	4.2	10.3
Central Finland	19 526	4.6	11.5
Vaasa	27 495	6.5	9.6
Oulu	31 507	7.5	10.7
Lapland	12 594	3.0	9.2
Aaland	1 651	0.4	10.1
Total	**420 656**	**100.0**	**12.4**

Migration of Population with Tertiary Education Minor

In 1993, the balance of migration of the population with tertiary education was positive only in the Province of Uusimaa; 1 080 persons with tertiary education moved to the Province of Uusimaa. The largest migration losses were experienced by the provinces of Oulu and Lapland.

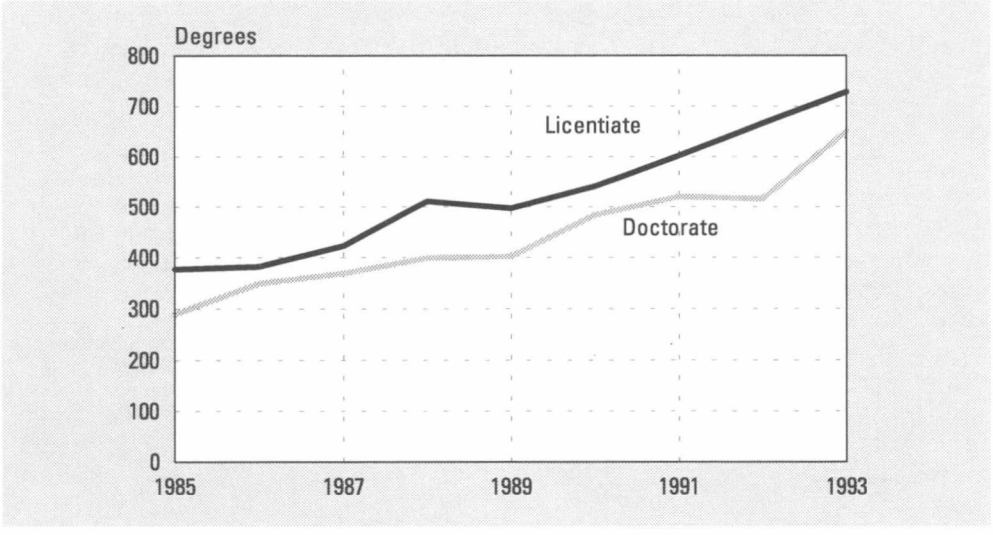
Emigration from Finland is minor. In 1993, a total of 1 014 persons above 15 years of age and with tertiary education emigrated from Finland; this is 0.2 per cent of the 15 to 64-year-old population with tertiary education. A total of 538 of the emigrants had graduate, licentiate, or doctorate degrees.

2.2 Tertiary Degrees

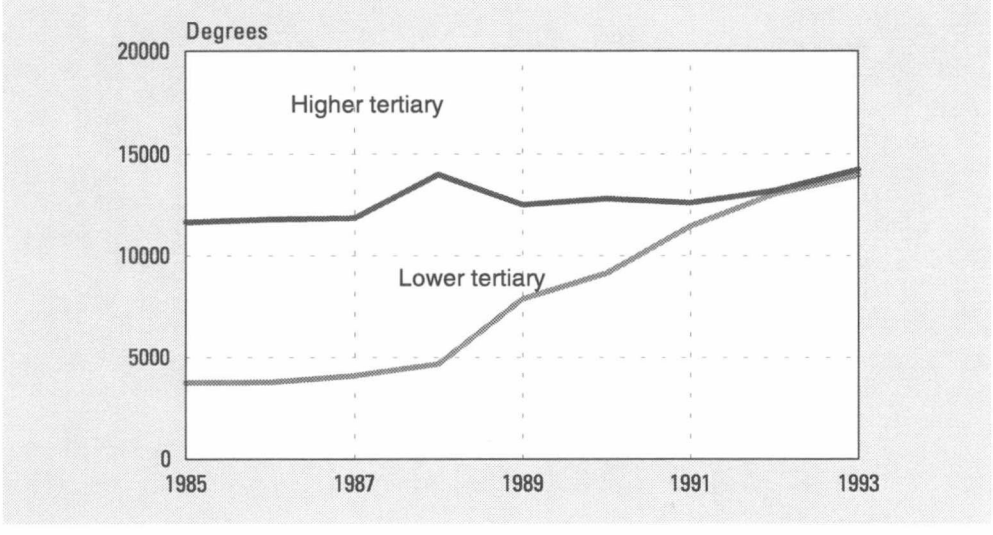
The number of tertiary degrees awarded in 1993 amounted to 30 070, which is nearly twice as many as in 1985. The number of doctorates degrees awarded in particular increased. In 1993, a total of 650 doctoral theses were approved, twice the number in 1985. The increase in the number of licentiate degrees awarded was almost equally sharp (Figure 2.5).

The number of higher tertiary degrees increased at a clearly slower rate than did the number of doctorates degrees; this is in part due to a secondary school reform and to a lengthening of education periods in consequence to the revision of degree requirements in universities. The total number of higher tertiary degrees awarded in 1993 was 14237, which is about one-fifth more than in 1985. The number of lower tertiary degrees nearly quadrupled from 1985 to 1993 (Figure 2.6).

Appendix Table 2.2 shows more detailed data on degrees awarded by level of education, field of science, and sex, in the years 1985 and 1990–93.



2.5
Doctorate and licentiate degrees 1985–93



2.6
Higher tertiary and lower tertiary degrees 1985–93

Increase in Number of doctorates Degrees Strongest in Social Sciences

The number of doctoral theses approved in 1993 was highest in the medical and health sciences (232); this was one-third of all doctoral theses approved. The second largest number of doctorate degrees were completed in the natural sciences (126), i.e. about one-fifth.

Table 2.7 shows a comparison of the numbers of degrees completed, by field of science, from 1985 onwards. The figures for 1993 have been indexed so that the initial level in all is 100.

The increase in doctorate degrees awarded was strongest in the social sciences, in which the number of doctorates tripled from 1985 to 1993. During the same period, the number of doctorate degrees awarded in the natural sciences increased least.

Of all licentiate degrees, 29 per cent were in the social sciences and 25 per cent in engineering.

From 1985 to 1993, the numbers of licentiate degrees awarded increased at a rate more rapid than average in the fields of medicine, the social sciences, and the humanities. The humanities accounted for the largest proportion of the increase in graduate degrees awarded.

The level of education of women has risen in recent years at a more rapid rate than that of men. Between 1985 and 1993 women increased their share in doctorate degrees awarded from 28 per cent to 37 per cent, of licentiate degrees awarded from 31 per cent to 37 per cent, and of graduate degrees awarded from 54 per cent to 56 per cent.

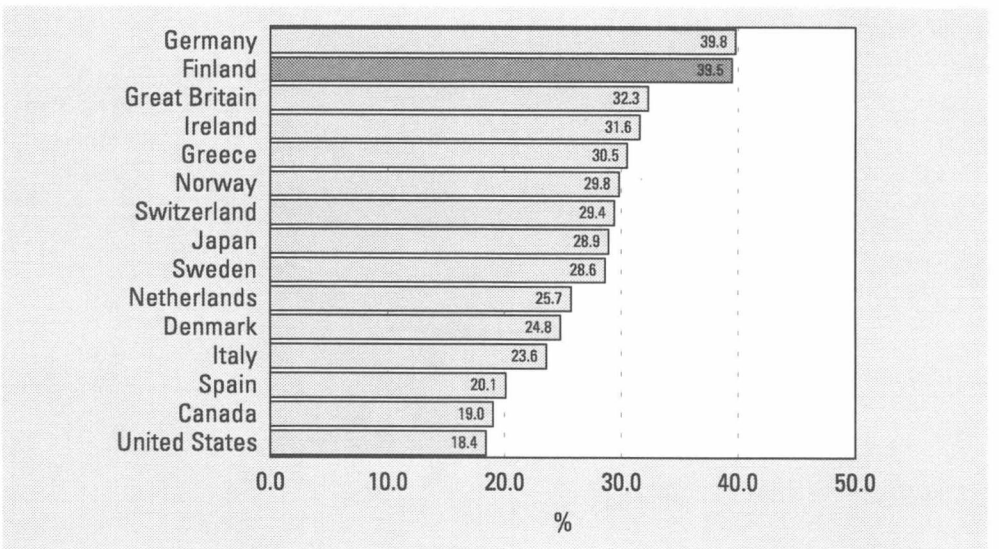
Women's share of doctorates awarded was highest in the medical sciences, 46 per cent, and lowest in engineering, 19 per cent.

Share of Degrees in Engineering and Natural Sciences in Finland Second Highest in OECD Countries

In Finland the share of engineering and the natural sciences in all university degrees was 40 per cent, a figure which was the second highest in the OECD countries in 1992.

2.7
Increase in doctorate degrees as compared with graduate degrees by field of science 1985–93 (1985=100)

Field of science	Licentiate degree	Doctorate degree	Doctorate degrees total	Graduate degree
Natural sciences	147	162	153	144
Engineering	189	209	195	124
Medical and health sciences	267	244	246	105
Agriculture and forestry	158	175	168	85
Social sciences	219	368	252	144
Humanities	245	225	238	167
Total	**193**	**224**	**207**	**135**



2.8
Share of degrees in engineering and the natural sciences in higher tertiary degrees[1] in certain OECD countries 1992

Source: *OECD/INES*

1 In accordance with the International Standard Classification of Education (ISCED): Higher education, levels 6 and 7

Slightly Less than One-Third of Education Expenditure Spent on Tertiary Education

The total expenditure on education in 1992 amounted to about FIM 30 500 million, in which the share of tertiary education was about 31 per cent. The real expenditure on tertiary education had increased by almost 10 per cent from the previous year, while the total expenditure on education had decreased by 0.4 per cent.

The rate of real increase of education expenditure during 1985–91 was clearly more rapid than the rate of increase of students. During this period the real growth of education expenditure was about 4 per cent a year, whereas the increase in the number of students was 1.2 per cent. The growth of education expenditure stalled in 1992, but the growth of the number of students has continued even subsequently. The data on the expenditure on the educational system are based on the school cost register of the National Board of Education, the national accounts data, and data from the National Student Financial Aid Centre.

The OECD countries in 1992 spent on average 6.1 per cent of their GDP on education, the shares in the various countries ranging from 4.8 per cent to 7.9 per cent. The GDP share of the education expenditure of Finland was 7.9 per cent, which was the highest in the OECD countries.

2.3 Persons with Tertiary Education and Their Employment

2.3.1 Job Placement of Persons with Tertiary Education

Persons with Tertiary Education about 15 per cent of Total Labour Force

The share of persons with tertiary degrees in the *labour force* (gainfully employed and unemployed) has increased at a steady rate since the 1980s. In the labour force 15 to 64 years of age in 1993, persons with tertiary degrees amounted to 15 per cent, which shows an increase of 4 percentage points over 1985. In 1993, 6 per cent of the labour force were holders of higher tertiary degrees.

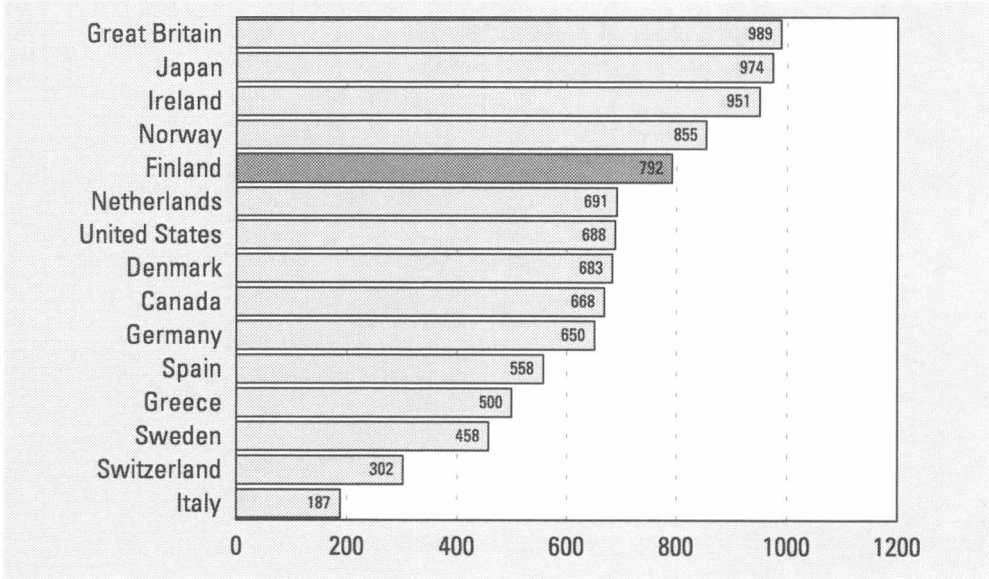
Of the *gainfully employed* population, 338 000 persons, i.e. 17 per cent, had tertiary degrees in 1993. The share of persons with tertiary education had increased by 6 percentage points since 1985. Among the gainfully employed, almost 7 per cent had higher tertiary degrees and 0.7 per cent had doctorates education.

In 1993 the proportion of persons with tertiary education was highest in social services and public administration, in which 31 per cent had tertiary education. The proportion of persons with tertiary education was second highest in industry. Since 1985 the share of persons with tertiary education in the gainfully employed population has increased most in the social services and in industry.

It can be seen in Figure 2.10 that in 1992 Finland was one of the top OECD countries in a comparison of the share of persons with higher tertiary education in sciences and engineering in the labour force 25–34 years of age.

2.9
Gainfully employed persons with tertiary education by industry 1985 and 1993

Industrial classification	1985	Share in total gainfully employed	1993	Share in total gainfully employed
	1000 persons	%	1000 persons	%
Social services and public administration	165	24.2	200	31.1
Industry	39	6.5	47	11.1
Financial and insurance activity	27	17.3	41	19.6
Commerce, food service and accommodation industry	21	5.9	25	8.2
Agriculture and forestry	4	1.4	8	4.6
Construction	8	4.5	8	6.4
Transport and communications	8	4.3	9	5.7
Total	**272**	**11.2**	**338**	**16.6**



2.10
Holders of higher tertiary degrees in sciences and engineering per labour force 25–34 years of age (100 000 persons) in certain OECD countries

2.11
Gainfully employed persons with tertiary education by employer sector and by education level 1993

Education level	Total		State	Municipality	Private
		%	%	%	%
Lower tertiary and undergraduate	179 800	100	13	47	40
Graduate	120 900	100	21	36	43
Doctorate	13 900	100	57	26	17
Total	**314 600**	**100**	**17**	**41**	**42**

Examined by employer sector, the share of persons with tertiary education was an ample 12 per cent in the private sector and 28 per cent in the public sector. Of all persons with tertiary education, 58 per cent, and of all holders of doctorates degrees, up to 83 per cent were employed in the public sector.

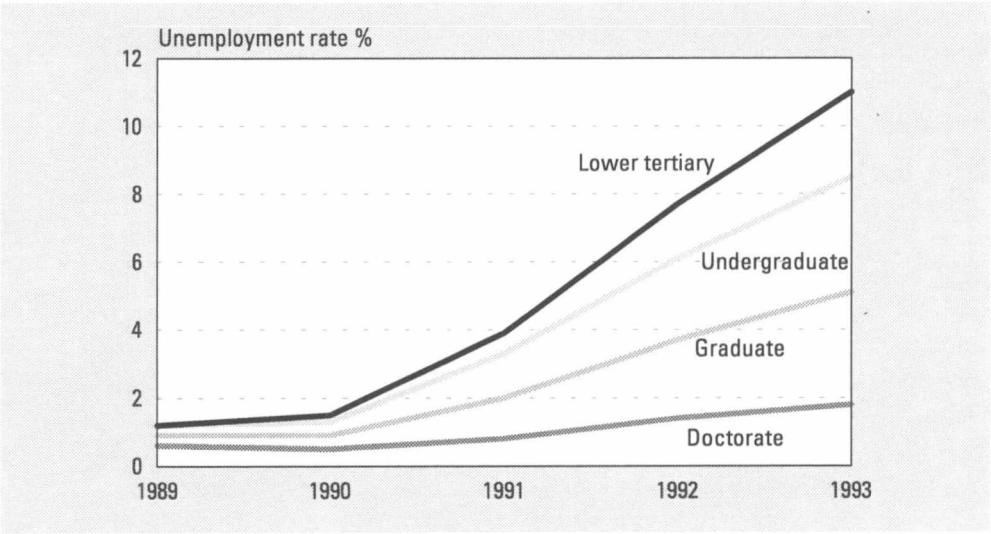
Of Persons with Tertiary Education, about One-Half in Technological, Scientific, and Educational or Other Humanistic Professions

In 1993, a total of 307 000 persons, 15 per cent of all gainfully employed persons (15–64 years of age), were working in technological, scientific, and educational or other humanistic professions. Among these persons, 52 per cent had tertiary education, which was 5 percentage points higher than in 1988.

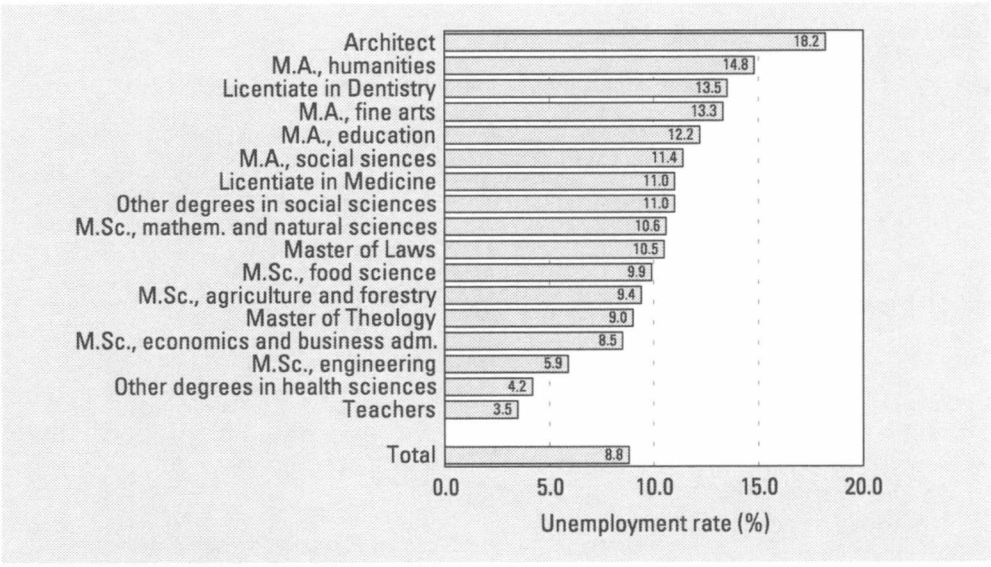
The proportion of persons in technological, scientific, and educational or other humanistic professions was highest in the social services and public administration, 27.5 per cent. The proportion was second highest in industry, 15 per cent.

Unemployment Rate of Persons with Tertiary Education 8.0 per cent in 1993

The economic depression of recent years has ever more clearly hit also the educated labour force. At the end of 1993, 30 000, i.e. about 6.7 per cent, of the 530 000 unemployed in Finland had tertiary education. Among the labour force with tertiary education, the rate of unemployment (proportion of the unemployed in the labour force) was 8.0 per cent at the end of 1993, whereas the figure in 1990 had been 1.1 per cent. The unemployment rate of men was 9 per cent and of women 7 per cent. It is increasingly difficult for young people completing their education to find employment. In 1993 the unemployment of persons who had completed tertiary degrees within the five previous years was almost twice that of the total population with tertiary degrees.



2.12
Unemployment rates of persons with tertiary education (20–64 years of age) by education level 1989–93



2.13
Unemployment rates of holders of graduate degrees by degree 1993. Degrees completed in five preceding years

An examination according to the level of education shows that the unemployment rates of holders of lower tertiary or undergraduate degrees were about twice those of holders of graduate degrees. Holders of doctorates degrees have also had to face increasing unemployment. Of holders of doctorates degrees, 273 were unemployed at the end of 1993, and their unemployment rate was 1.8 per cent (Figure 2.12). According to data from the Ministry of Labour, the number of unemployed job-seekers with doctorates degrees at the end of 1994 was as high as 409.

Figure 2.13 shows the unemployment rates of holders of graduate degrees earned in the five preceding years. It should be noted that in this figure certain degrees with small numbers of degree-holders have been combined into groups.

The list of the unemployed is headed by architects, of whom more than 18 per cent were unemployed in 1993. Unemployment rates below the average are represented by teachers, Masters of Science in Engineering and Masters of Science in Economics and Business Administration, as well as by the group 'other degrees in health sciences,' which here include Licentiates in Veterinary Medicine, Masters of Pharmacy, and Masters of Health Care.

2.3.2 Salaries of Persons with Tertiary Education

One factor affecting the attraction of R&D and the availability of professionally skilled research personnel is the development of the level of earnings in research work in proportion to earnings in other professions. The development of the level of earnings of researchers working in industry and universities is examined below in proportion to that of other groups.

Development of Earnings of Researchers in Industry in Harmony with Overall Levels

In industry the salaries of researchers during 1985–94 increased on average by 6 per cent a year, a rate which corresponds to the average increase in earnings of white-collar personnel in industry.

Salary Development of University Teachers Remained at Rate of Overall Development of Earnings in Government Service

The salaries of university teachers increased during 1985–93 at a slightly slower rate than did the salaries of researchers employed in industry. However, the development of the level of earnings of university teachers was almost as rapid as the average salary development of Government employees. The development of the earnings of lecturers has been slightly more rapid than that of professors and assistants.

2.14
Level of earnings of R&D Personnel in industry 1985–94

1985=100	Research work proper	Research assistance	Administrative industrial employees, average
1985	100	100	100
1986	117	115	106
1987	118	119	113
1988	129	123	123
1989	148	145	133
1990	160	159	143
1991	162	153	151
1992	162	154	152
1993	166	156	155
1994	173	162	171

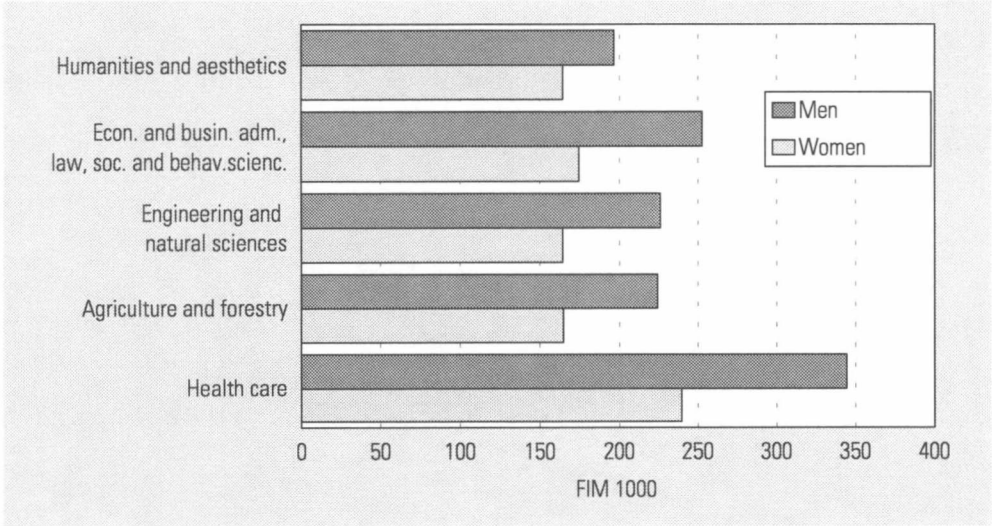
2.15
Level of earnings of university teachers 1985–93

1985=100	Professors	Associate professors	Lecturers	Assistants	Government employees, average
1985	100	100	100	100	100
1986	105	107	120	105	107
1987	112	113	123	113	116
1988	126	125	129	124	129
1989	136	134	138	131	137
1990	149	151	147	143	150
1991	157	158	156	151	158
1992	158	158	159	153	161
1993	158	157	160	156	160

Women's Salaries about 20–30 per cent Lower than Men's

In 1991 the average annual earnings of persons with tertiary degrees were about twice the earnings of persons with only secondary education. The annual earnings of women were about 20–30 per cent lower than those of men. Salary differences between women and men increased as the educational level increased.

In 1990 the annual earnings of the 20- to 64-year-old population with graduate degrees or with doctorates education were on average FIM 215 000. Persons with education in the field of health care had on average the highest earnings. The salary levels of men and women were farthest apart in the field of health care and in the fields of economics and business administration, law, social sciences, and behavioral sciences.



2.16
Annual earnings of the population with graduate or doctorate degrees (20–64 years of age) by field of education and by sex 1990

3 Resources for R&D

The factor which has had the most concrete impact on the preconditions of research and development (R&D) in the 1990s has been the economic depression. The present chapter deals with the development of the resources for R&D from the 1980s to the early 1990s. At the same time an attempt is made to assess the impacts of the depression on the resources for R&D. For this reason, the year selected as the initial year for most of the statistical comparisons is 1989, which was a clear turning point in the development of the R&D expenditure.

Statistics Finland has prepared statistics on R&D activities for every second year since 1971. The statistics are based on inquiries made to business enterprises, the public sector, and the universities.

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 konwledge to devise new applications.

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

Applied research is also orginal 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 practical experience, that is directed to producing new materials, products and devices; to installing new prosesses, systems and services; or to improving substantially those already produced or installed.

A difficulty involved in statistics depicting R&D consists of possibly differing interpretations of the definition in different units. In connection with an inquiry it is possible to give only general instructions for the delineation of R&D activity. Thus the application of the definition remains in practice with the providers of information.

The statistics are prepared in accordance with the recommendations of the OECD, and they concern only R&D work done in Finland. The recommendations have been published in a manual (OECD: *The Measurement of Scientific and Technical Activities*, Paris 1993). The OECD collects every second year detailed data on R&D activities in its member countries. The international R&D data in the following discussion are based on the OECD publication *Main Science and Technology Indicators* (Paris 1995). The R&D statistics publication of the Nordic Industrial Fund have been used in the Nordic comparisons.

Sub-chapters 3.1 and 3.2 deal with the *development of the resources for R&D in general.* Sub-chapters 3.3, 3.4 and 3.5 present detailed data on the *R&D expenditure of business enterprises, the public sector, and the universities*. The last sub-chapter deals with the development of R&D funding by the Finnish Government in the 1990s. The data on R&D activities in Finland are based on data previously published by Statistics Finland in the Science and Technology series. The data on Government R&D funding are based on surveys conducted by the Academy of Finland.

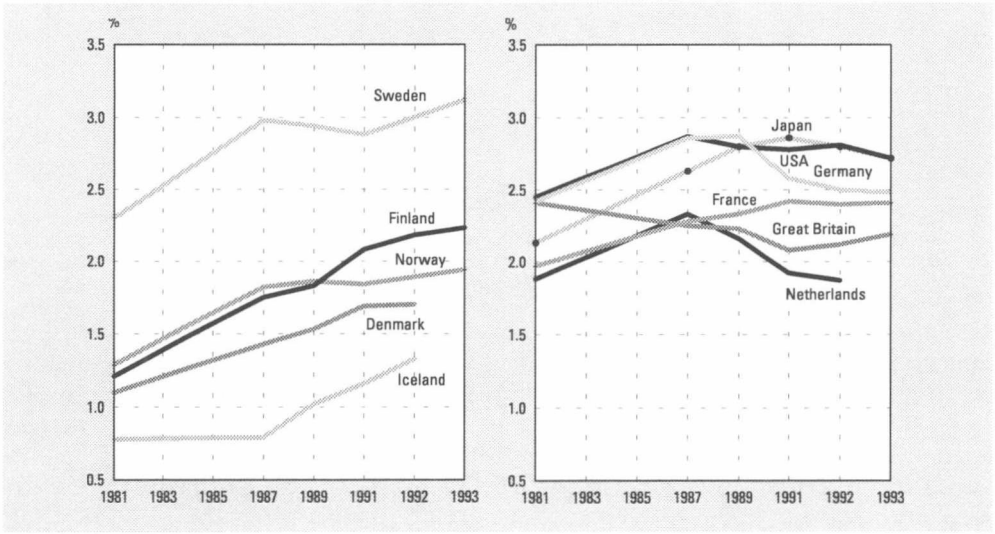
3.1 Total R&D Expenditure

GDP Share of R&D Expenditure 2.4 per cent in 1994

The R&D expenditure in proportion to the GDP is the most commonly used indicator in comparisons of the research inputs of different countries. However, the indicator involves a great deal of uncertainty and arbitrariness merely for the reason that the term 'research and development' is not always used in the same meaning. Nevertheless, the indicator gives indications of the input of each country into scientific and technological work in proportion to the wealth of the respective country.

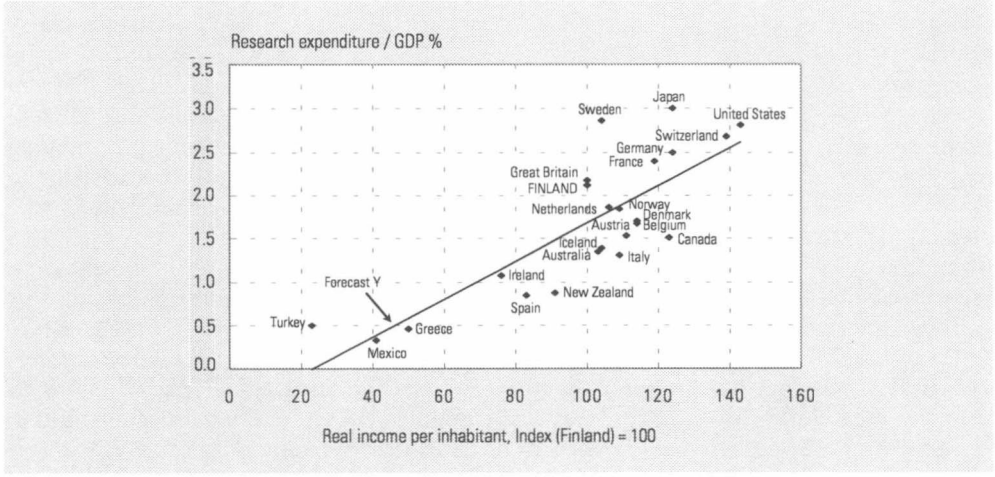
The growth of the GDP share of R&D expenditure has slowed in most industrial countries in the 1990s. In countries carrying out a great deal of research, such as the United States, Japan, Germany and the Netherlands, the increase in the input into research has stalled or even dropped in the 1990s. The input into research by Finland, by contrast, has increased also in the 1990s. In Sweden the increase in the input into research has been even more rapid than in Finland, but in Norway it has been slower than in Finland. Appendix Table 3.1 shows the GDP shares of R&D expenditure in certain OECD countries during 1981–93.

The GDP share of R&D increased in Finland from 1.8 per cent to 2.4 per cent during 1989–94. The decreasing of the GDP after 1991 for its part increased the GDP share of research. The increase of R&D expenditure was particularly strong be-



3.1
Development of the GDP share of R&D in the Nordic Countries and certain OECD countries 1981–93

Source: *OECD, Paris 1995*



3.2
R&D input and real income per inhabitant in certain industrialised countries 1992

tween 1993 and 1994, almost 11 per cent. Business enterprise R&D expenditure grew 18 per cent, while R&D expenditure in the other sectors remained more or less on the same level. The increase in Business enterprise R&D is largely explained by the continued strong increase in R&D expenditure of the electrical engineering and electronics industry, in 1994 29 per cent.

As the most detailed data on R&D are only available for 1993, this has been the most recent reference year for the remaining part of chapter 3.

The R&D input of Finland (in proportion to the GDP) in the 1990 has risen above the average of the OECD countries. The median of the GDP share of R&D in the OECD countries was about 1.7 per cent in 1992. The Science and Technology Policy Council of Finland in its latest statement regarding R&D policy proposed that research funding should be increased in real terms so as to increase the GDP share of Finnish input into R&D to 2.7 per cent by 1997 (Science and Technology Policy Council of Finland 1993, 56).

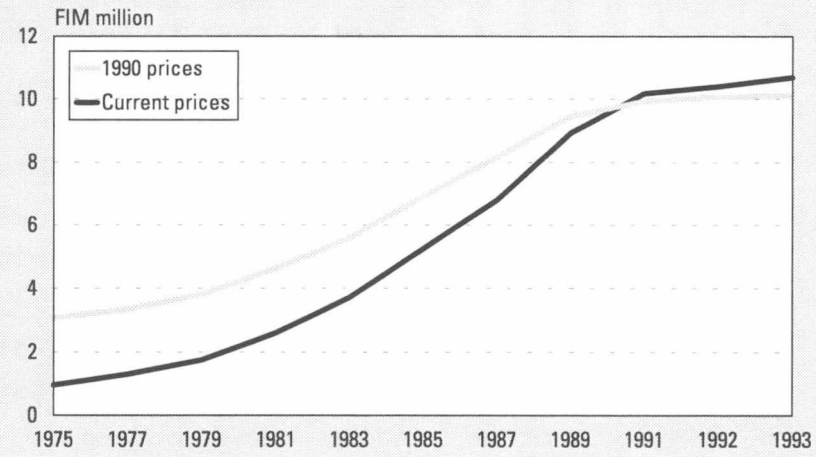
Figure 3.2 shows the order of certain OECD countries in a comparison of the input into R&D in proportion to the real income of inhabitants in 1992. The real income has been indexed so that the figure for Finland is 100. By using this indicator, Japan and Sweden use relatively most funds for R&D also in proportion to the real income of their citizens. Finland places above the average of the OECD countries.

The GDP share of R&D is somewhat increased by the expenditure on military research. For example in 1993 the GDP share of research, excluding military research, was 2.2 per cent in the United States and 1.9 per cent in Great Britain. Military research hardly affects the GDP shares of R&D of small OECD countries and Japan.

Of the total R&D expenditure of the world in 1993, the share of North America was about 43 per cent, of Asia 20 per cent, of Europe 23 per cent, and of the former Soviet Union 12 per cent.

Increase in R&D Funding Share of Public Sector

The ratio of private to public R&D funding in Finland has long been 60:40. In the early 1990s the share of public funding has been on the increase, and in 1993 it was 43 %. The public sector (incl.



3.3
Development of R&D expenditure in Finland 1975–93 (in current and 1990 prices)

universities) in 1993 funded R&D with a total of FIM 4600 million. The share of the public sector increased by 4 percentage points from 1989. Funding by business enterprises in 1993 was 55 per cent, by foreign funders 1.8 per cent, and by others 0.6 per cent. The increase in the share of the public sector has been affected above all by the decrease in R&D funding by business enterprises up to 1991. The cuts in Government appropriations will show in the development of public R&D funding only after 1991.

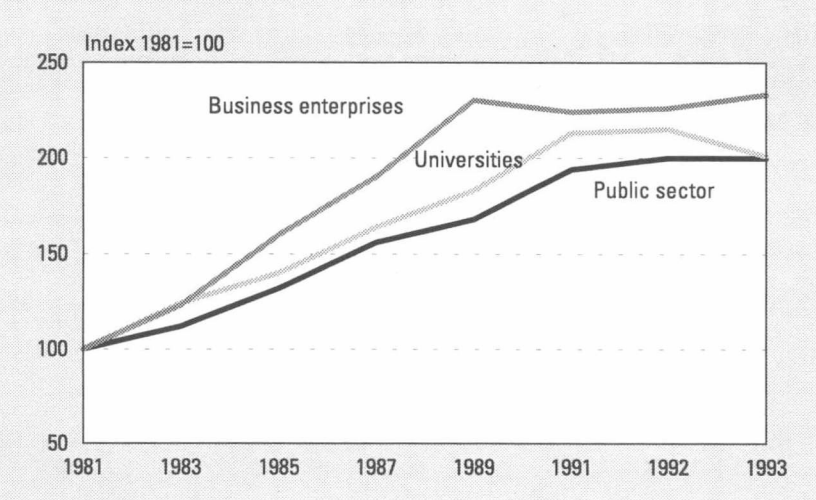
In 1993 the proportion of public R&D funding going to business enterprises was about 13 per cent, to universities 44 per cent, and to the rest of the public sector 43 per cent. A considerable proportion of the increase in public R&D funding was allocated to the R&D activities of business enterprises. In 1993 only 5 per cent of the funding by business enterprises was allocated to industries other than their own. Appendix Table 3.2 shows data on the R&D expenditure according to the site of research and the source of funding in 1989 and in 1993.

In an international comparison the share of Finnish public R&D funding is at the average level of the OECD countries. In Norway, Iceland, France, and the Netherlands the share of public R&D funding in 1991 was higher than in Finland (Appendix Table 3.1).

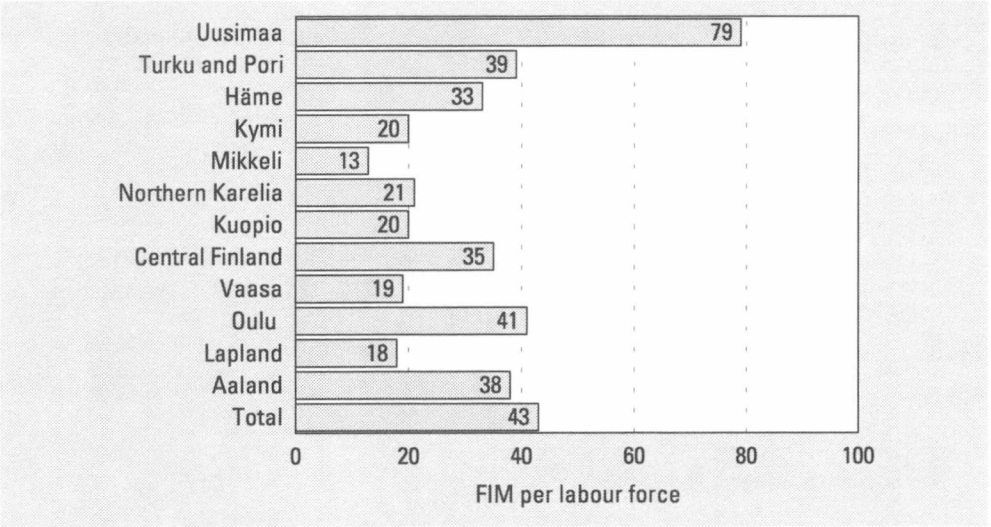
Annual Real Growth of R&D Expenditure about 1 per cent

Expenditure on R&D activity in 1993 was about FIM 10 700 million, which in real terms was 7 per cent more than in 1989. The growth is partly explained by a change in the bases of preparation of statistics. Without this computational addition, the change from 1989 is about 4 per cent. The average annual real growth of the R&D expenditure during 1989–93 was about 1 per cent, whereas during 1983–87 it was about 10 per cent.

In 1993, the share of total R&D expenditure incurred in business enterprises was 58 per cent, in the public sector 21 per cent, and in the universities 21 per cent. As compared with 1989, the share of business enterprises had decreased by 3 percentage points.



3.4
Real development of R&D expenditure by performer sector 1981–93 (1981 = 100)



3.5
R&D expenditure per labour force by province 1993

The R&D expenditure of business enterprises in real terms decreased by about 3.5 per cent during 1989–91, but after 1991 the development again took an upturn. The average annual growth of the R&D expenditure of business enterprises during 1989–93 was about 0.3 per cent, while during the same period the R&D expenditure of the public sector increased on average by 3 per cent and that of the universities by 1 per cent a year (taking into account the changes in the bases for preparing the statistics).

Appendix Table 3.3 shows the R&D expenditure by performer sector from 1971 onwards.

Half of R&D in Province of Uusimaa

R&D activity was concentrated in the Metropolitan Helsinki area (in the Province of Uusimaa), where about 44 per cent of total R&D expenditure was incurred. The share of the Metropolitan Helsinki area in the expenditure has increased by almost 5 percentage points since 1989. However, the share of the Province of Uusimaa as a whole decreased by about 4 percentage points during the period between 1989 and 1993. The total share of the provinces of Uusimaa, Turku and Pori, and Häme in the total R&D expenditure was 76 per cent in 1989 and 75 per cent in 1993. The regions which increased their shares most in addition to the Metropolitan Helsinki area were the Province of Turku and Pori and the Province of Oulu.

Figure 3.5 shows the R&D expenditure per labour force, by province. In proportion to the labour force, the R&D expenditure of the Province of Uusimaa was twice the average. Of the other provinces, the provinces of Turku and Pori and of Oulu spent relatively more funds for R&D than did the other provinces, with the exception of Uusimaa.

Concentration was greatest in the public sector; about 62 per cent of the R&D expenditure of the public sector was incurred in Uusimaa. However, the share of Uusimaa in public sector R&D decreased by almost 5 percentage points from 1989. More detailed data regarding the breakdown of the R&D expenditure among provinces are shown in Appendix Table 3.4.

Salaries More than One-Half of R&D Expenditure

In 1993, salaries constituted about 58 per cent of the R&D expenditure. About 33 per cent was other operating expenditure and 9 per cent was capital expenditure. Capital expenditure in particular was decreased by the economic depression, and as a result the share of capital expenditure in the R&D expenditure decreased by about 6 percentage points from 1989.

3.2 R&D Personnel

Average Annual Increase of 2 per cent in Research Person-Years

Research person-years in 1993 amounted to 30 527. The number of person-years had increased on average by 1.7 per cent a year from 1989. The business enterprise sector accounted for 50 per cent of the person-years, the public sector for 23 per cent, and the universities for 27 per cent.

Total R&D Personnel 42 100 in 1993

In 1993 a total of 42 100 persons were working in R&D functions; this was about 8 per cent more than in 1989. Women constituted 32 per cent of the R&D personnel, which was a somewhat lower figure than in 1989. The share of women was highest in the public sector, i.e. 44 per cent, in the universities it was 39 per cent, and in business enterprises 22 per cent.

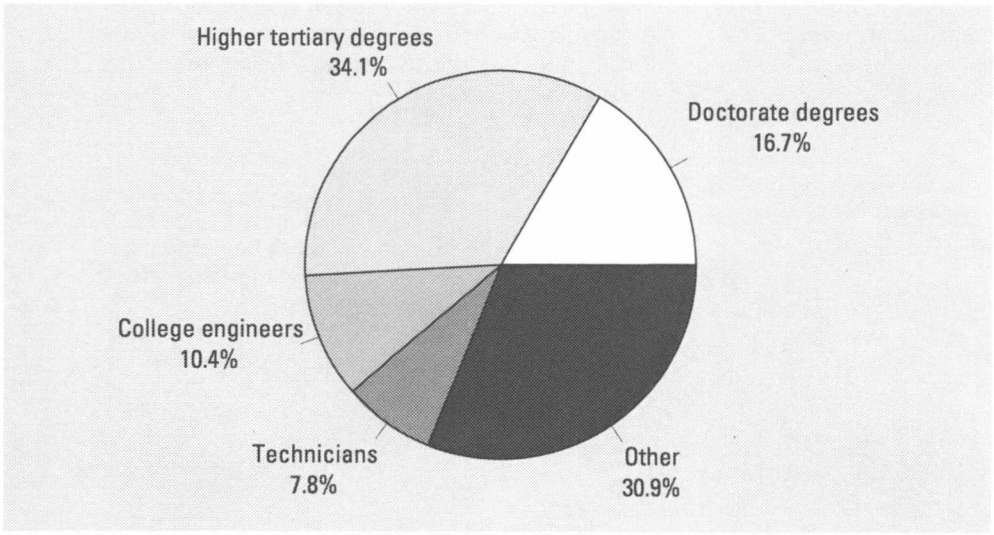
About 40 per cent of all persons under 65 years of age holding doctorate or licentiate degrees and 12 per cent of those holding at least graduate degrees were involved in R&D work in 1993. The proportion of holders of doctorate or licentiate degrees in R&D personnel increased by 3 percentage points from 1989. A total of 48 per cent of the total R&D personnel held at least graduate degrees.

Women constituted 24 per cent of the research personnel with doctorate or licentiate degrees, a figure 4 percentage points higher than in 1989. Of holders of other higher tertiary degrees women constituted 32 per cent, of technicians and college engineers 10 per cent, and of persons in the lowest educational categories about one-half.

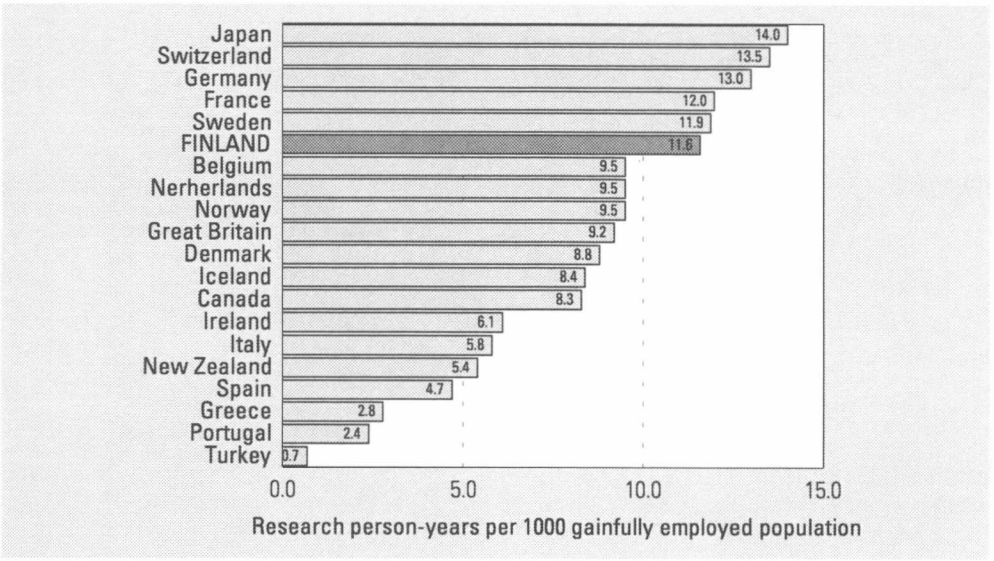
Data on R&D personnel are presented in Appendix Table 3.5.

In a Nordic comparison, the share of women in R&D personnel in 1991 was highest in Finland, 29 per cent. In Sweden women constituted 26 per cent of R&D personnel, in Iceland 24 per cent, and in Norway and Denmark 20 per cent.

The ratio of research person-years to the gainfully employed population is, alongside the GDP share, one of the indicators commonly used in international comparisons. The figure for Finland in 1991 was 12 research person-years per 1000 gainfully employed inhabitants, which was at the top level of the OECD countries. The United States does not prepare statistics on research person-years, and therefore its data are lacking in Figure 3.7.



3.6
Research personnel by education level 1993



3.7
Research person-years per one thousand gainfully employed population in certain OECD countries 1991

Source: *OECD, Paris 1995*

3.3 R&D in Business Enterprises

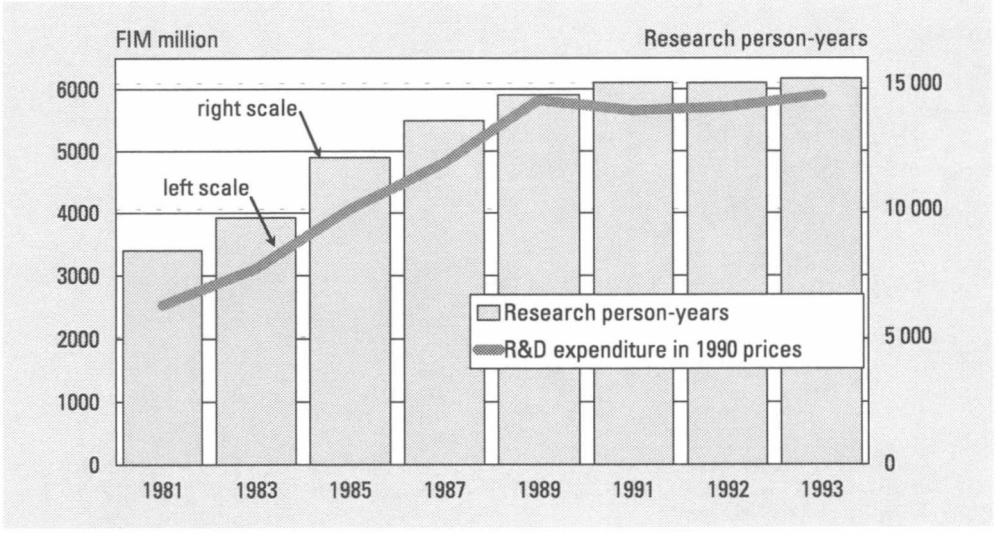
The expenditure on R&D performed in business enterprises in 1993 amounted to FIM 6100 million, of which the share of the manufacturing industries was FIM 5269 million, i.e. 85 per cent. The real R&D expenditure of business enterprises increased from 1989 by about 4 per cent.

The number of research person-years increased from 1989 at an annual rate of about one per cent. In 1993 the total number of research person-years was 15 180. The share of holders of higher tertiary degrees in the research person-years done was 36 per cent, i.e. about the same as in 1989.

Business enterprises performing R&D work totalled 1545. R&D is strongly concentrated in large enterprises. About two-thirds of the R&D expenditure of business enterprises was incurred in business enterprises with more than 500 employees. The combined total share of the ten business enterprises with the largest numbers of personnel was 46 per cent of the total R&D expenditure. However, in recent years the share of small and medium-sized business enterprises has increased somewhat. The share of enterprises with fewer than 50 employees increased from 5.8 per cent in 1989 to 11.5 per cent in 1993. The increase in the share is largely explained by an improvement of the coverage of statistics on small business enterprises.

In Finland the research input of business enterprises in 1992, as measured by the GDP share, was lower than the median (1.57 %) of the OECD countries. The respective figure for Finland was 1.24 per cent (cf. Appendix Table 3.6).

Table 3.9 shows the research expenditure figures for the industries with the most significant research expenditures, and their shares in the research expenditure of the total business enterprise sector in 1993. The electrical engineering and electronics industry continues to be the largest among the industries, about one-third of the R&D expenditure of business enterprises. The impact of the R&D expenditure of the electrical engineering and electronics industry on the total R&D expenditure development of the business enterprise sector has increased in recent years. Without the R&D expenditure of the *electrical engineering products and instruments* industry the R&D expenditure of the manufacturing industries would have decreased from 1989.



3.8
Research person-years and R&D expenditure of business enterprises 1981–93 (in 1990 prices)

3.9
R&D expenditure of business enterprises by principal industry 1993

Industry	R&D expenditure FIM million	Share in total R&D expenditure %
Manufacturing industries total	**5 269**	**85**
Electrical engineering products, instruments	2 182	35
Chemicals, chemical products	902	15
Machinery, equipment	710	11
Metals	328	5
Foodstuffs, beverages, tobacco	305	5
Pulp, paper, paper products	270	4
Other manufacturing industries	572	10
Other industries	**965**	**15**
Total R&D expenditure of business enterprises	**6 234**	**100**

Largest Product Groups

Electronic circuits and telecommunications equipment were the largest product group in 1993. Their share in the R&D expenditure of business enterprises was about 15 per cent. The share of telecommunications equipment was 9 per cent, of chemical products including drugs 11 per cent, of pulp and paper 5 per cent. The group which has increased its share most in recent years is telecommunications.

In a Nordic comparison, the proportion of high technology products in the R&D expenditure of business enterprises in 1991 was smallest in Finland, 42 per cent, and highest in Sweden, 77 per cent. The respective proportions were 55 per cent in Norway and in Denmark, and 46 per cent in Iceland. In the present discussion, high technology products include drugs, computers and office appliances, electrical engineering products, instruments, telecommunications, and vehicles.

The share of high technology products increased in Finland to 47 per cent from 1991 to 1993, while the respective shares in Sweden and Norway somewhat decreased. For Denmark and Iceland, 1993 data were not available at the time the present report was being prepared.

Share of R&D Expenditure 4.6 per cent of Output Value Added

R&D expenditure in proportion to the value added of industrial output increased steadily until 1991, but has slowed subsequently. The proportion dropped from 5.2 per cent in 1991 to 4.6 per cent in 1993. R&D expenditure in proportion to the value added varies greatly from one product group to another. The value added share was highest in the radios and televisions product group, 43 per cent. In oil refining and the graphic industry the share was less than one per cent.

Continued Increase in Share of Extramural R&D Funding

In 1993, about 83 per cent of the R&D activity of business enterprises was funded intramurally. In 1989 the respective figure had been 91 per cent; the share of extramural funding thus increased by 8 percentage points.

As compared with previous statistics, research funding by the European Union is now included as a new item in extramural funding; business enterprises reported that in 1993 they had received about FIM 6.5 million.

The share of public funding for the R&D of business enterprises has in Finland been clearly smaller than in the other Nordic countries or in the largest industrialized countries. The median of the share of public funding in the OECD countries in the early 1990s has been about 13 per cent, whereas the respective figure for Finland in 1993 was 6 per cent. Of the Nordic countries, the share of public funding was highest in Norway, 16 per cent.

Sharp Increase in Expenditure on Purchased R&D Services

Expenditure on R&D services commissioned and purchased from others by business enterprises in 1993 amounted to FIM 1181 million, which was 19 per cent of the total R&D expenditure of business enterprises. The respective proportion in 1989 was 5 per cent. Most, about one-half, of the R&D purchases were from other units of the same corporation. Business enterprises collaborated clearly more with research institutes than with universities (cf. Appendix Table 3.7).

Salaries Largest Expenditure Item

Salaries constitute the largest expenditure item in the R&D activities of business enterprises. The share of salary expenditure in 1993 was about 56 per cent. During the economic depression, business enterprises have clearly reduced capital expenditure on construction, which can be seen as an increase in the relative share of salary expenditure.

3.10
R&D expenditure in the six largest product groups 1993, shares 1989–93

Product group	Expenditure 1993	Share 1993	Share 1991	Share 1989
	FIM million	%	%	%
Electronic circuits and telecommunications equipment	918	14.7	15.3	12.1
Telecommunications	585	9.4	1.8	3.0
Electrical appliances and apparatus	422	6.8	4.7	6.5
Industrial chemicals	354	5.7	6.0	6.9
Drugs	348	5.6	4.9	4.6
Pulp, paper, and paper products	340	5.4	8.2	6.4

Product Development Major Proportion of R&D Activity

Three-fourths of the R&D expenditure of business enterprises is allocated to product development and slightly more than one-fifth to the development of processes and production methods. The remaining four per cent is allocated to basic or applied research without a direct product or process application.

Nearly One-Fourth of Business Enterprise R&D Performed Abroad

Internationalisation of R&D activities was strong in Finnish business enterprises at the end of the 1980s. In 1992, 29 per cent of the R&D expenditure of the twenty largest corporations was incurred in units located abroad. The respective share in 1987 was only 15 per cent. According to a survey of Statistics Finland, based on inquiries to business enterprises, it was estimated that in 1992 Finnish large and medium-sized industrial enterprises had nearly 600 R&D units, of which 190 were located abroad. Finnish business enterprises had the largest number of R&D units in Sweden (39). The number of Finnish R&D units in the United States, Great Britain and Germany was more than 20. More than one-half of the R&D units located abroad had been established after 1987.

It is estimated that nearly one-fourth of the R&D expenditure of business enterprises is incurred in units located abroad. The share of foreign R&D expenditure varies according to the industry and the size of the enterprise. In large corporations the share of the expenditure on R&D activity abroad in 1992 was largest in the machines and transport equipment industry, 47 per cent. For the clay, glass and stone products industry the share of foreign R&D was also relatively high, 40 per cent. In other large and medium-sized business enterprises the share of foreign R&D expenditure exceeded 50 per cent in the chemical industry.

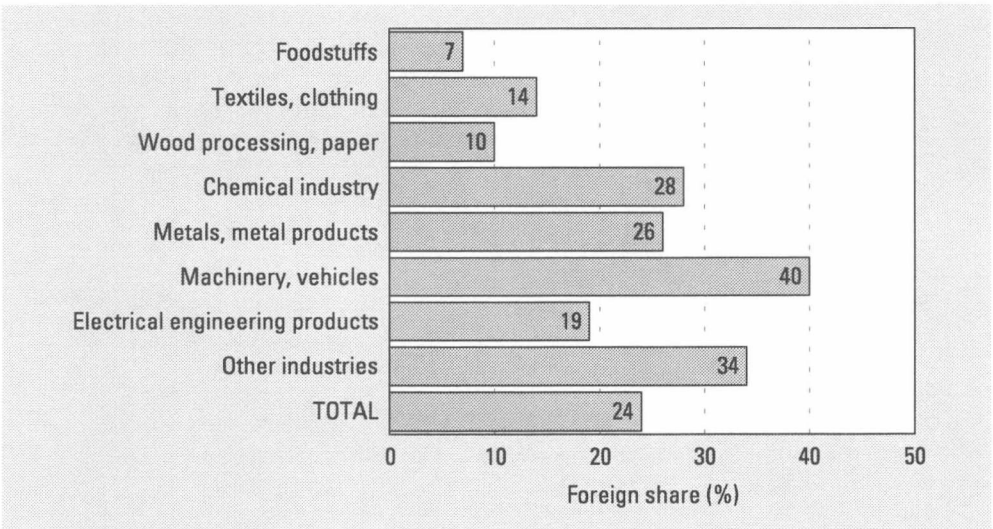
About one-fourth of the foreign R&D expenditure of Finnish business enterprises was incurred in Sweden. The share of the United States was about 23 per cent, of Great Britain 14 per cent, and of Germany 12 per cent.

About one-third of both domestic and foreign units of large Finnish corporations reported that they had participated in international research programmes. The participation of domestic units in EUREKA projects was somewhat more common than participation in EU projects. In foreign units the situation was the reverse.

According to a corresponding survey conducted in Sweden, the share of foreign R&D units in the R&D expenditure had also increased clearly in Swedish multinational enterprises, although not at quite as rapid a rate as in Finland. It was estimated that in 1990 Swedish business enterprises incurred about 17 per cent of their R&D expenditure in R&D units located abroad. The respective figure for Finland was 24 per cent in 1992.

One explanation for the lower figure for Sweden is the great weight of the transport equipment industry in the Swedish figures. If the transport equipment industry is excluded from the comparison, the share of the foreign R&D units of enterprises in the R&D expenditure is higher in Sweden than in Finland.

There are clear differences between Sweden and Finland in the breakdown of the foreign R&D activities of multinational business enterprises. More than 60 per cent of the R&D expenditure of the foreign units of Swedish enterprises is incurred in EU countries, whereas the respective figure for Finland is about 44 per cent. The share of the USA is approximately equal for both countries. On the other hand, the significance of the EFTA, especially owing to the membership of Sweden, is considerably greater for Finland than for Sweden.



3.11
Foreign share of R&D expenditure in large corporations and in other large and medium-sized business enterprises by industry 1992

3.4 R&D in Public Sector

The expenditure on R&D activities in the public sector[1] (excl. universities) in 1993 amounted to FIM 2 258 million. The real increase in the R&D expenditure of the public sector from 1989 to 1993 was 19 per cent (when the calculation bases are taken into consideration, the real growth was about 13 %).

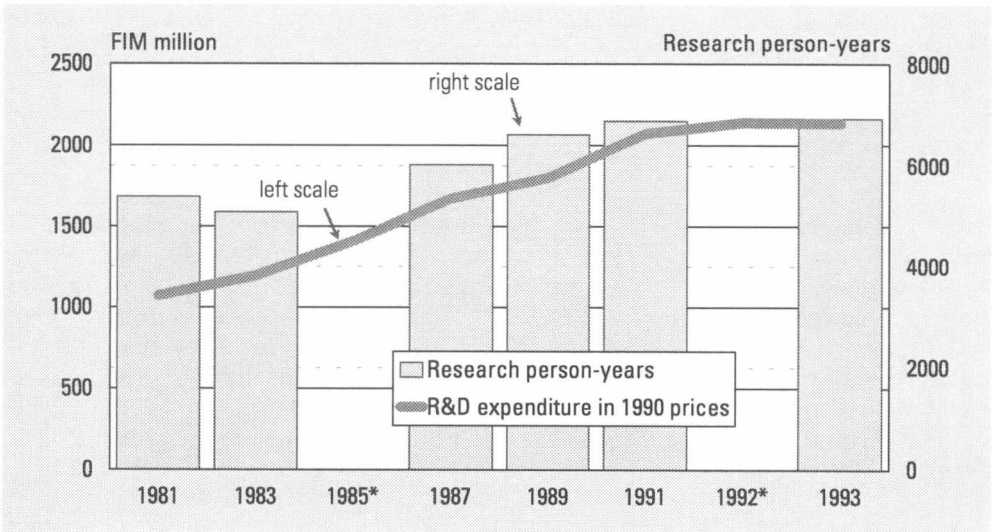
The total number of research person-years done in 1993 was 6 925. The share of holders of higher tertiary degrees was 53 per cent of the research person-years, a somewhat higher figure than in 1989. The proportion of holders of doctorates degrees in the research personnel has also increased.

R&D Activities Most Extensive in Administrative Field of Ministry of Trade and Industry

Somewhat over 44 per cent of the R&D work under the administration of the national Government was performed in institutions under the Ministry of Trade and Industry. Between 1989 and 1993 the share of this ministry decreased by about 8 percentage points. The share of the Ministry of the Environment in the R&D expenditure also decreased. The Ministry of Social Affairs and Health and the Ministry of Agriculture and Forestry increased their shares to the greatest extent.

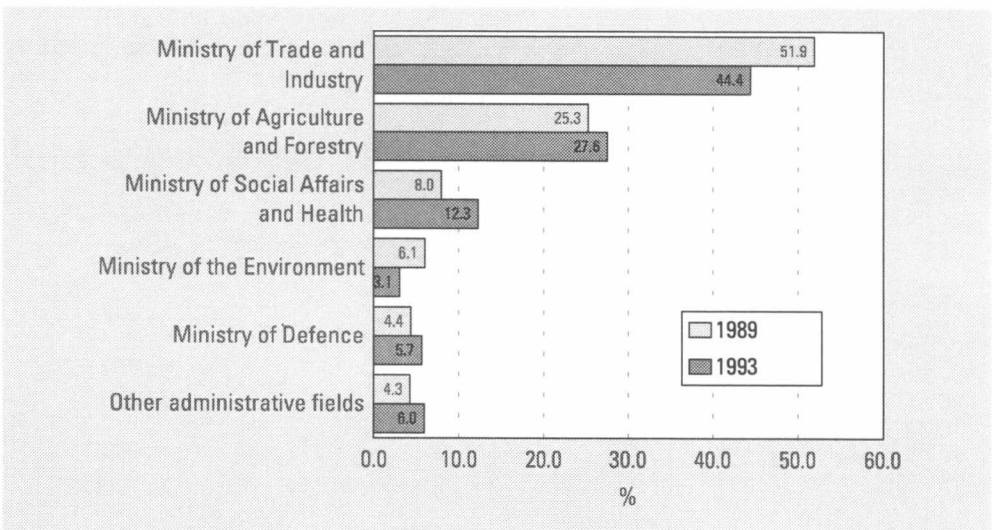
Share of Engineering Largest

The breakdown of R&D in the public sector remained more or less unchanged from 1989 onwards. The predominant field continued to be engineering. As compared with 1989, the share of the humanities had decreased slightly. The share of the medical and health sciences had increased.



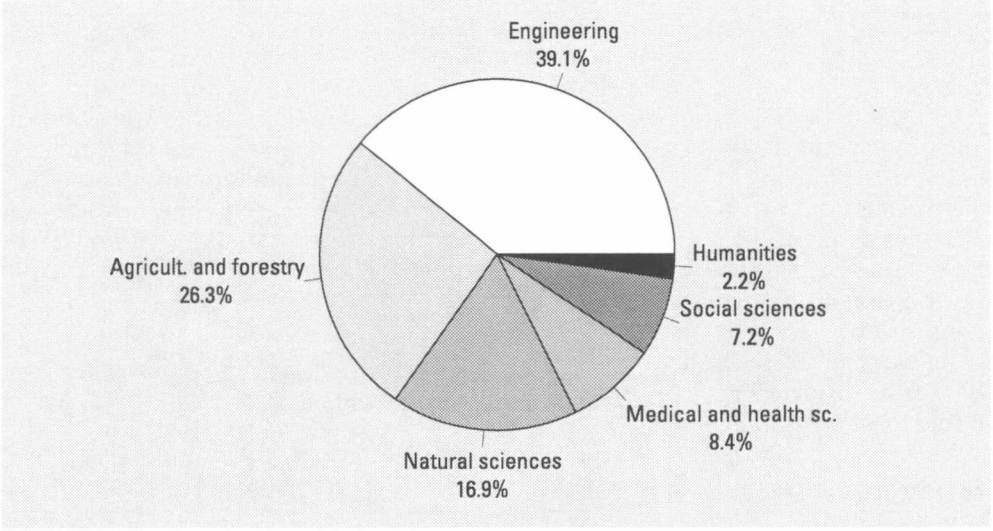
3.12
Research person-years and R&D expenditure in the public sector 1981–93 (in 1990 prices)

* No statistical data on research person-years



3.13
R&D expenditure in the public sector by administrative field 1989 and 1993

[1] Includes the administrative fields of the national Government, public institutions, and the private non-profit sector.



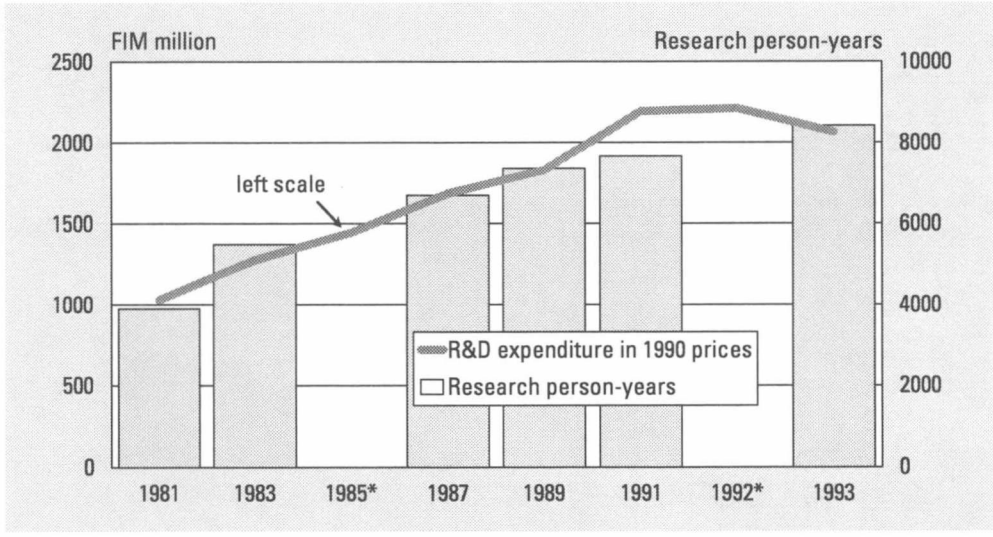
3.14
Research person-years in the public sector by field of science 1993

The share of public sector R&D work (excluding the universities) in the total R&D expenditure in 1991 was at the average level of the OECD countries. In, for example, Sweden (4 %), Norway (20 %), Denmark (18 %), the United States (10 %), and Germany (15 %) the R&D expenditure share of the public sector was smaller than in Finland (21 %).

3.5 Research in Universities

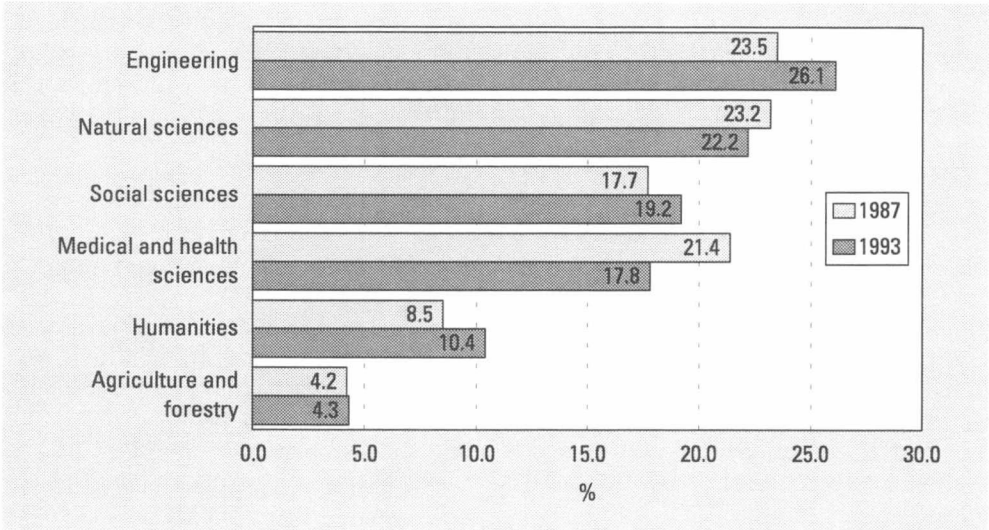
The R&D expenditure of the universities in 1993 amounted to FIM 2185 million, which was 21 per cent of the total R&D expenditure. The real expenditure had decreased by about one percentage point from 1989, when the changes in the statistical bases are taken into consideration. The number of research person-years done was 8422, which was approximately equal to the figure for 1989 (taking into consideration the statistical bases).

Measured in terms of the GDP, the Finnish R&D input into university research in 1991 was about 0.46 per cent, which corresponds to the average of the OECD countries. Closest to Finland were Norway, the Netherlands, Germany, the United States, and Austria. In Sweden (0.79 %), Switzerland (0.57 %) and Japan (0.53 %) the shares were higher than in Finland (cf. Appendix Table 3.5).

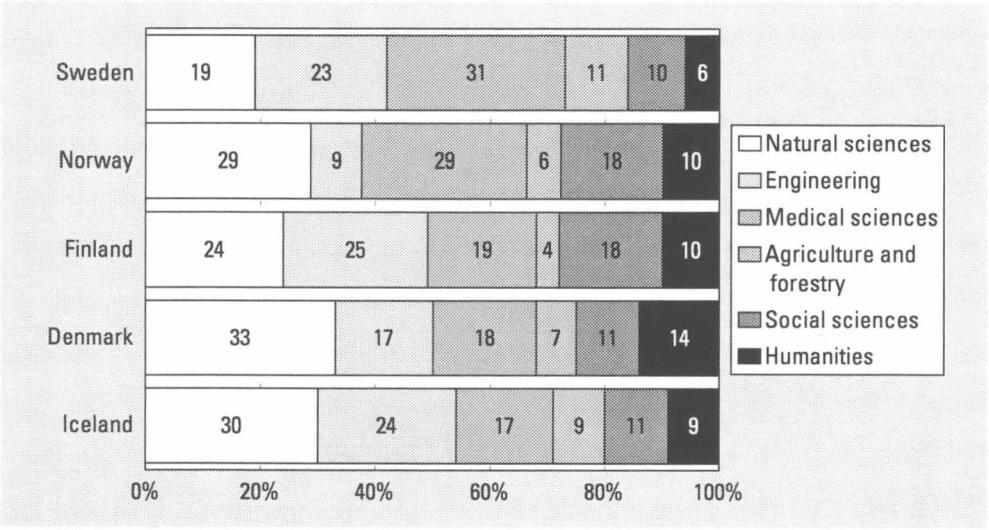


3.15
Research person-years and R&D expenditure of the universities 1981–93 (in 1990 prices)

* No statistical data on research person-years



3.16
R&D expenditure of the universities by field of science 1987 and 1993



3.17
R&D expenditure of the universities in the Nordic countries by field of science 1991

Source: *Nordic Industrial Fund*

Share of Engineering in Research Increased

Over one-fourth of the expenditure on university research was allocated to *engineering* and slightly less then one-fourth to the *natural sciences*. The shares of the various fields of science remained relatively constant from 1987[2] onwards. Engineering increased its proportion to the greatest degree, by about 3 percentage points. The share of the medical sciences decreased the most, by about 4 percentage points.

In a Nordic comparison, the proportion of the university research expenditure allocated to engineering was largest in Finland. In Sweden and Norway the expenditure proportion was largest for medicine, and in Denmark and Iceland for the natural sciences. The combined share of the social sciences and the humanities in the total university research expenditure was highest in Norway and lowest in Sweden.

2 No reference data for 1989 are available regarding the allocation by field of science.

Importance of Extramural Funding Increased

More than one-half of research in the universities is funded with the university appropriations of the Government Budget. The proportion of the appropriations in 1993 was 59 per cent of the research expenditure of the universities. The proportion of extramural funding in the research expenditure of the universities increased by 5 percentage points from 1989.

As to the public funding organizations, the importance of the Academy of Finland and the Technology Development Centre (TEKES) in extramural funding of research in universities has in particular increased in the 1990s. From 1989 to 1993, the share of the Academy of Finland in the research funding of the universities increased by 4 percentage points and that of the Technology Development Centre by 3 percentage points. It is estimated that the proportion of extramural funding has increased even after 1993, since the budgetary funds of the universities themselves have been reduced during 1993–95.

In 1991, only in Sweden among the Nordic countries was the share of direct budgetary funding in the research expenditure of the universities lower, 54 per cent, than in Finland. Among the OECD countries, the share of budgetary funding in the research expenditure of the universities was highest in the Netherlands, 88 per cent.

Extramural Funding Most Extensive in Engineering

The importance of extramural funding varies according to the field of science. In 1993, 74 per cent of research in engineering was funded with extramural funds. In medical, social science and humanities research the share of budgetary funding was greater than that of extramural funding. In these fields, also, the share of extramural funding increased.

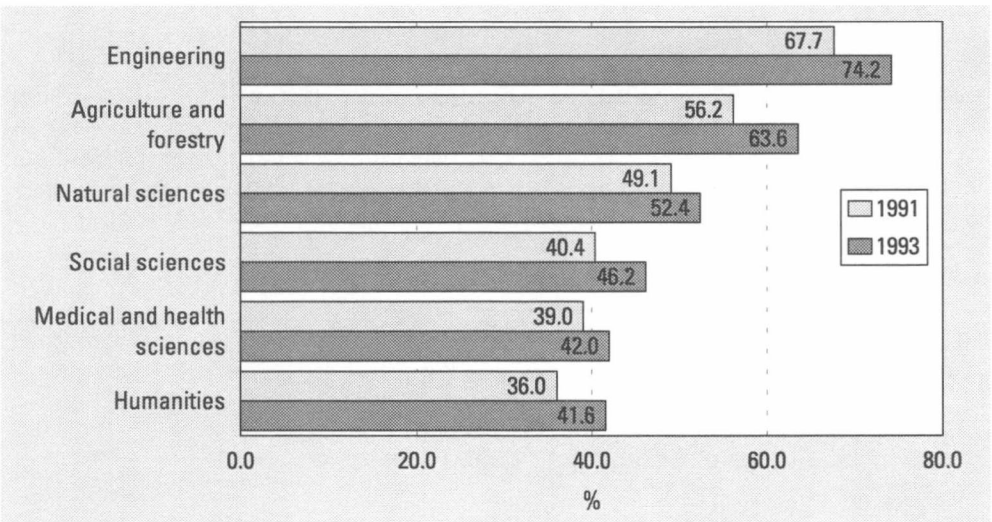
Number of Personnel with doctorates Education Increased

Among the research personnel of the universities in 1993, doctorate or licentiate degrees were held by

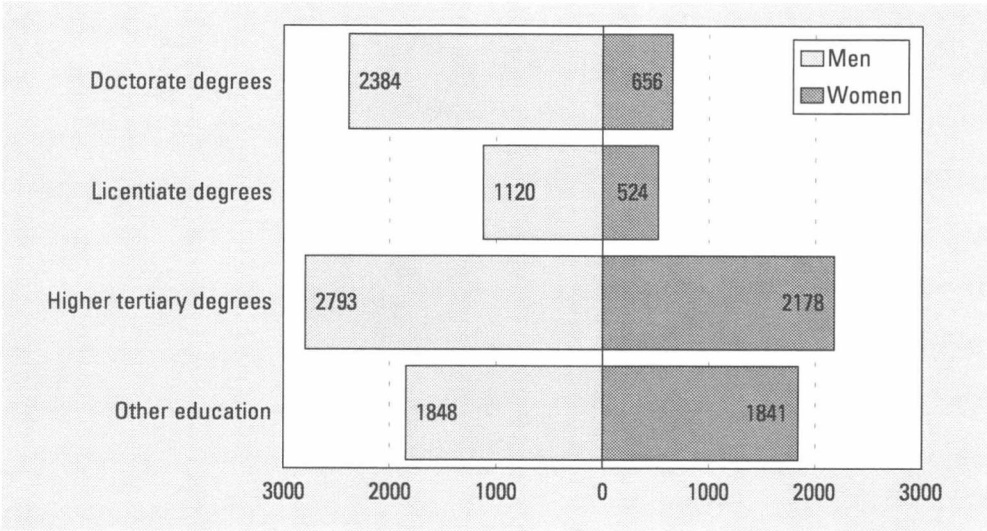
3.18
Research expenditure of the universities by source of funding 1989, 1991, and 1993

Source of funding	1989		1991		1993	
	FIM million	%	FIM million	%	FIM million	%
University appropriations2	1 095	63.5	1 532	68.1	1 291	59.1
Academy of Finland	190	11.0	298	13.3	305	14.0
Technology Development Centre	70	4.1	78	3.5	124	5.7
Other Government administration	113	6.5	118	5.3	158	7.2
Domestic business enterprises	83	4.8	80	3.6	100	4.6
Other extramural domestic funding[3]	159	9.2	118	5.1	163	7.4
Foreign funding	16	0.9	24	1.1	44	2.0
Total	**1 726**	**100.0**	**2 248**	**100.0**	**2 185**	**100.0**

1 Change in the statistical bases of university research expenditure (+ FIM 170 million)
2 Includes budgetary appropriations and capital expenditure on construction
3 Other public funding, municipalities, Finnish funds, and intramural university assets



3.19
Extramural funding in proportion to research person-years of universities by field of science 1991 and 1993



3.20
Research personnel of universities by education level and by sex 1993

35 per cent, which was 6 percentage points more than in 1989. During the same period, the proportion of women in the research personnel with doctorates education increased from 21 per cent to 25 per cent. Personnel in research assistance amounted to slightly less than one-third, of whom more than one-half were women.

3.6 Government R&D Funding

The Academy of Finland has since 1975 prepared annual surveys on the development of Government R&D funding. Alongside the official R&D statistics, the budget analysis produced by the Academy of Finland provides the most up-to-date information regarding the quantitative resources of public R&D funding and the allocation of the resources to the various administrative sectors and fields of research.

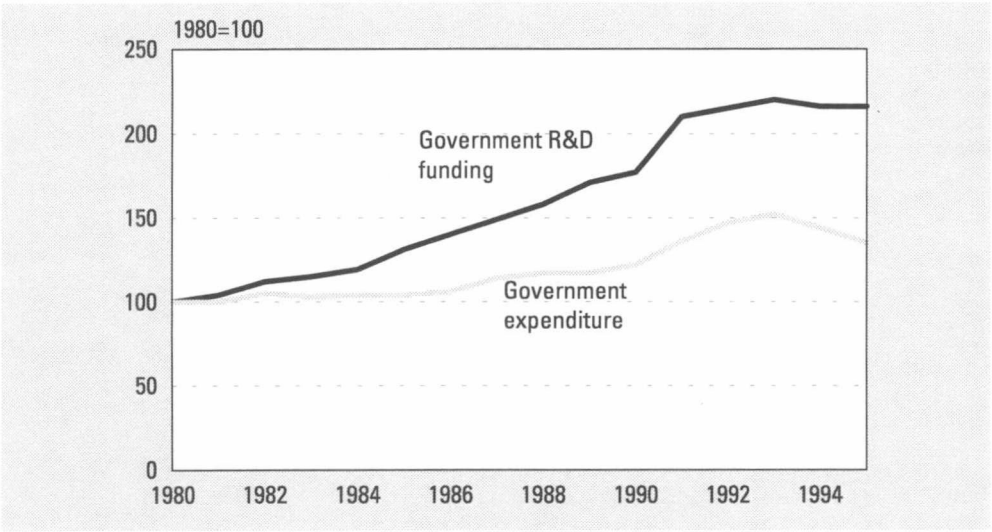
The primary purpose of the budget analysis is to assess the objectives of the Government and the various ministries in their support of R&D. The estimates of Government R&D funding are based on the appropriations granted in the Government Budget Proposal. In addition to the Budget Proposal, the financial and operational plans of the various ministries and research-funding organizations are used in the calculation of R&D funding. The R&D expenditures of universities and research institutes are estimated by using data from the research statistics of Statistics Finland, on the basis of which the share used for research is determined.

Owing to the methodological differences between the budget analysis of the Academy of Finland and the research statistics of Statistics Finland, the 1993 research expenditure according to the budget analysis was about FIM 640 million higher than the public sector R&D funding according to the research statistics, based on performance. The data presented below regarding Government R&D funding are based on the analyses made at the Academy of Finland. The latest analysis[3] concerns the year 1995.

R&D about 3.1 per cent of Total Government Expenditure

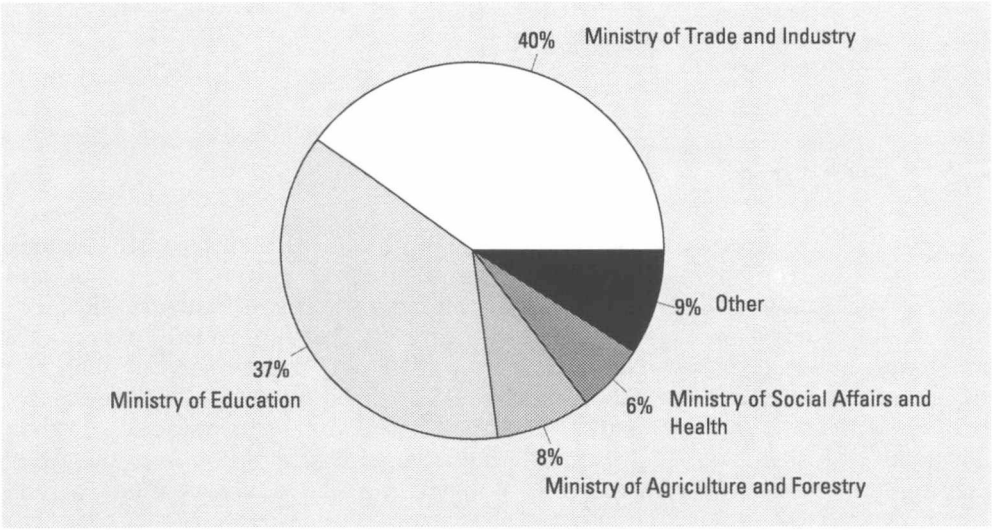
In its 1995 Budget, the Finnish Government allocated an estimated FIM 5600 million to R&D, which is 3.1 per cent of total Government expenditure, excluding the costs of the National Debt. In fifteen years, Government R&D funding has more than doubled in real terms.

3 Pirjo Niskanen, Tutkimus ja kehittämismäärärahat valtion talousarviossa vuonna 1995 (Research and Development Appropriations in the Government Budget in 1995). Academy of Finland publications 2/95. Painatuskeskus, Helsinki.



3.21
Real development of Government R&D funding (gross volume) and of total Government expenditure 1980–95 (1980=100)

Source: *Academy of Finland 1995*



3.22
Breakdown of Government R&D funding by administrative field 1995

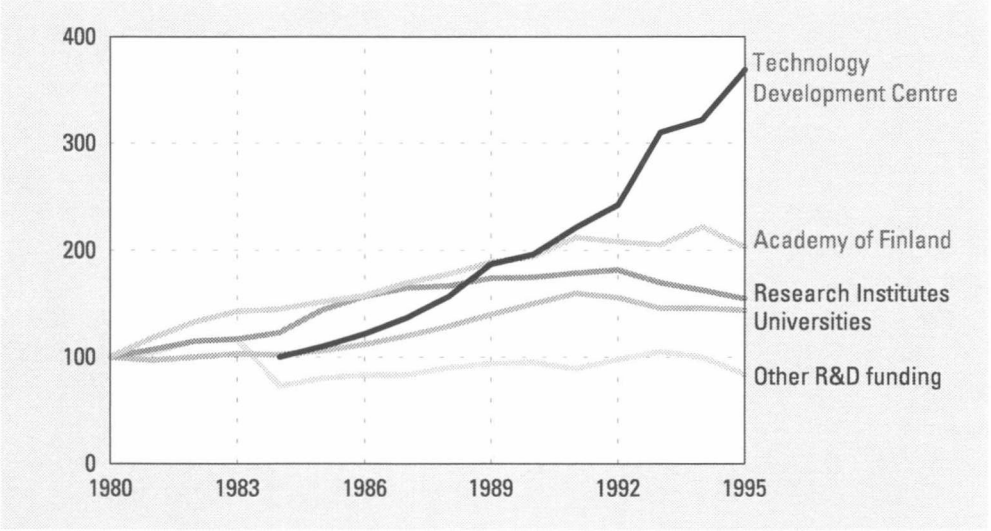
Source: *Academy of Finland 1995*

The growth of Government R&D funding has clearly slowed in the 1990s. The real total growth of R&D funding during 1989–95 was on average 3 per cent a year, whereas during 1980–89 it was about 6 per cent a year. As for total Government expenditure, the annual rate of growth was on average 2 per cent both during 1980–89 and during 1989–95 (cf. Appendix Table 3.8).

Increase in R&D Funding Share of Ministry of Trade and Industry

Over four-fifths of Government R&D funding is channelled via three administrative fields: the Ministry of Trade and Industry, the Ministry of Education, and the Ministry of Agriculture and Forestry. As compared with 1989, the Ministry of Trade and Industry, the Ministry of Defence, the Ministry of Transport and Communications, the Ministry of Social Affairs and Health, and the Ministry of the Environment have increased their respective shares.

The *Technology Development Centre* (TEKES) under the administration of the Ministry of Trade and Industry accounts for the largest share, about 30 per cent, of the funds allocated by the Government for research. The R&D share in the budgetary funds of the *universities* is 26 per cent, that of *State research institutes* 22 per cent, and that of the *Academy of Finland* 8 per cent. The share of *other R&D funding* is 14 per cent, which includes the R&D funds of the ministries and the national boards subordinated to them, as well as certain contribution shares for international co-operation and membership dues.



3.23
Real development of Government R&D funding (from 1991 onwards net volume) by research organization 1980–95 (1980=100)

Note: A portion of the noncommitted R&D funds for engineering were transferred in 1994 from the category 'other R&D funding' to the Technology Development Centre (TEKES). Another important transfer of resources concerns the year 1995, in which the Ministry of Trade and Industry transferred to the Technology Development Centre certain energy research funds previously included in the category 'other R&D funds.'

Source: *Academy of Finland 1995*

The resources of the Technology Development Centre, mainly promoting industrial R&D activities, have been increased on average by 13 per cent a year during 1989–95. During the same period the annual real growth of the R&D funds of the universities, funding basic research, was about 1 per cent and that of the Academy of Finland about 5 per cent. The budgetary funds of the State research institutes decreased from 1989 to 1995 on average by 1 per cent a year. Other Government R&D funding has in real terms remained at the level of 1989. In the above growth percentages, both the transfers of resources made within the Government Budget after 1989 and the changes in the bases of calculation have been taken into consideration.

Advancement of Industry Given Priority in Appropriation Increases

When classified according to the objective of research, the share of the *general advancement of science* in R&D funding was largest, about 36 per cent. This includes the research appropriations of the universities and the Academy of Finland in their entirety. Almost equally much, about 33 per cent, was allocated to the *promotion of industry*. The share of *agriculture and forestry* was about 7 per cent and that of *energy* 4 per cent.

The appropriation increases in the 1990s have focussed on R&D activity for the promotion of industry. Since 1989 the share of this objective in Government R&D funding increased by 7 percentage points. The share of general advancement of science respectively decreased by one percentage point.

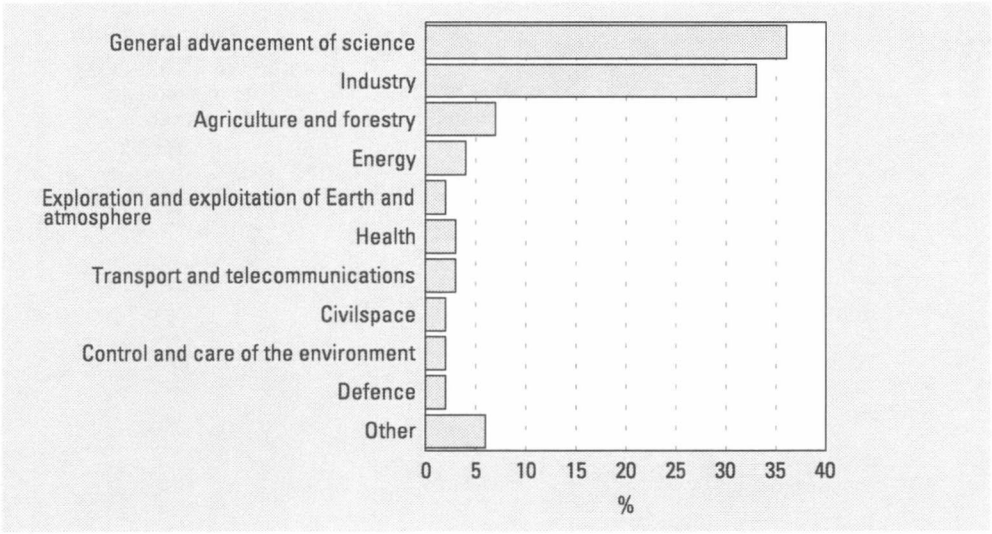
As for the other categories of objectives, the shares of *agriculture and forestry* and *exploration and exploitation of Earth and atmosphere* decreased the most. The decrease in the R&D expenditure on agriculture and forestry is in part accounted for by the linking of certain small research institutes under the Ministry of Agriculture and Forestry to larger research institutes. *Health research* and *transport and telecommunications research* have increased their shares most in the 1990s. The increase in the share of health research is mainly due to the fact that the expenditures of research institutes in the field of health have been cut relatively less than all research expenditure on average.

From 1990 onwards the share of *environmental research* funded by various ministries and research institutes increased steadily until 1993, but it has subsequently decreased.

Appendix Tables 3.9–3.11 show more detailed data on Government R&D funding by field of administration, research organization, and research objective in 1989, 1994, and 1995.

Funding of International Research Co-operation

The Government allocated in 1995 about FIM 150 million to the funding shares and membership dues of international R&D co-operation. When the other appropriations allocated in the Government Budget for international research co-operation are added to this, the expenditure on international R&D co-operation is about FIM 282 million, which is about 5 per cent of total Government R&D funding.



3.24
Breakdown of Government R&D funding by objective 1995

Source: *Academy of Finland 1995*

However, it is estimated that the costs incurred by the Government from international R&D cooperation are higher than those presented above, since the data are not all-inclusive. For example, the figures do not include the costs of participation in EU research programmes, which are paid for in the membership dues of Finland. The figures also do not include the expenditure on international R&D co-operation of the universities.

4 International Co-operation in Science and Technology

Determined efforts have been made in Finland since the mid-1980s to increase international co-operation in science and technology. A larger proportion than previously of Government R&D funding is being used for international R&D co-operation. In business enterprises, also, the internationalisation of R&D activities has become almost as important as the internationalisation of marketing and production.

A number of problems are involved in the follow-up of the internationalisation process. Comprehensive statistical data on international co-operation in science and technology are scanty. Furthermore, a large proportion of international activity takes place as informal and unofficial cooperation the extent of which is in practice impossible to estimate.

The internationalisation of science and technology may have both positive and negative impacts on individual national innovation systems. The positive impacts may include financial benefits gained through the sharing of costs and risks of R&D activity. Very often co-operation also provides the participants opportunities to supplement their own knowledge and skills. Successful co-operation generates results which would not be produced without a combination of the knowledge and skills of the participants. International co-operation is especially important for a small country such as Finland, since a small country does not have sufficient resources to maintain expertise covering all fields. Internationalisation may be detrimental if the focus of research transfers to nationally less important fields.

An assessment of the impacts of international co-operation would require a wide mapping of the extent and development of the international R&D co-operation of Finnish researchers. The present chapter focusses mainly on those forms of international science and technology co-operation which have become important in the 1990s.

Conscious efforts have been made since the end of the 1980s to increase both national and international mobility of researchers. The first sub-chapter describes the *international mobility of Finnish researchers and promotion of this mobility* on the basis of the researcher exchanges of the Academy of Finland and the Centre for International Mobility.

The European integration process has created a new role for science and technology co-operation in regions close to Finland. Sub-Chapter 4.2 deals with *co-operation in science and technology with the Nordic countries and with Russia and Eastern Europe*. Co-operation with Russia and Eastern Europe is examined, for example, on the basis of funding by the Academy of Finland.

World-wide co-operation in science and technology has expanded rapidly in the 1990s. European and other multilateral international co-operation in science and technology has opened many new opportunities and challenges for Finnish business enterprises, research institutes, and universities. Sub-Chapter 4.3 describes *multilateral co-operation in science and technology* on the basis of, for example, participation in EU, COST, EUREKA, and ESA research programmes and projects. The data concerning multilateral R&D co-operation are based on surveys of the programmes and on data obtained from the organizations responsible for the programmes.

4.1 International Mobility of Researchers

One of the objectives of Finnish science and technology policy in the 1990s has been to promote the transfer of Finnish researchers abroad and their seeking foreign places for doctorates studies. The traditional countries for doctorates education for Finns have been the United States and the other Nordic countries. Along with European integration, increasing numbers of Finnish researchers are finding their way also to universities and research institutes in Great Britain, Germany, and France.

Data are presented below concerning the international mobility of Finnish researchers and the arrival of foreign researchers to Finland. The data of the University Information System (KOTA) describe the transfer of university personnel to foreign countries and the numbers of researchers arriving at Finnish universities. The data from the Academy of Finland and the Centre for International Mobility (CIMO), on the other hand, describe the funding of researcher mobility, i.e. grants awarded for researcher exchange. A significant proportion of these grants are allocated to researcher exchanges of universities.

In addition to the above, international mobility of researchers is also promoted by research institutes, the Technology Development Centre in connection with technology projects, and a number of private funds and foundations. Statistical data on the subsidy by these organizations or by business enterprises for the promotion of the mobility of researchers were not available at the time of preparation of the present report.

Researcher Exchange of Universities

Nearly 1000 persons of the personnel of the universities worked or studied for at least one month in foreign universities during 1994. The regular holders of posts and positions and the temporary holders of vacancies, from professors to laboratory engineers, are counted as university personnel. Also included are researchers funded by the Academy of Finland and researchers hired for at least six months with other extramural funding.

About 1300 researchers from abroad came to Finnish universities during 1994. From 1990, the number of persons in the exchange of researchers from Finland to abroad increased by one-fourth and from abroad to Finland by slightly less than one-third.

Periods of researcher visits have also increased; the numbers of months of stay increased at an even higher rate than the numbers of persons. During 1990–94, the number of months of stay from Finland to abroad increased by about one-half and from abroad to Finland it almost doubled.

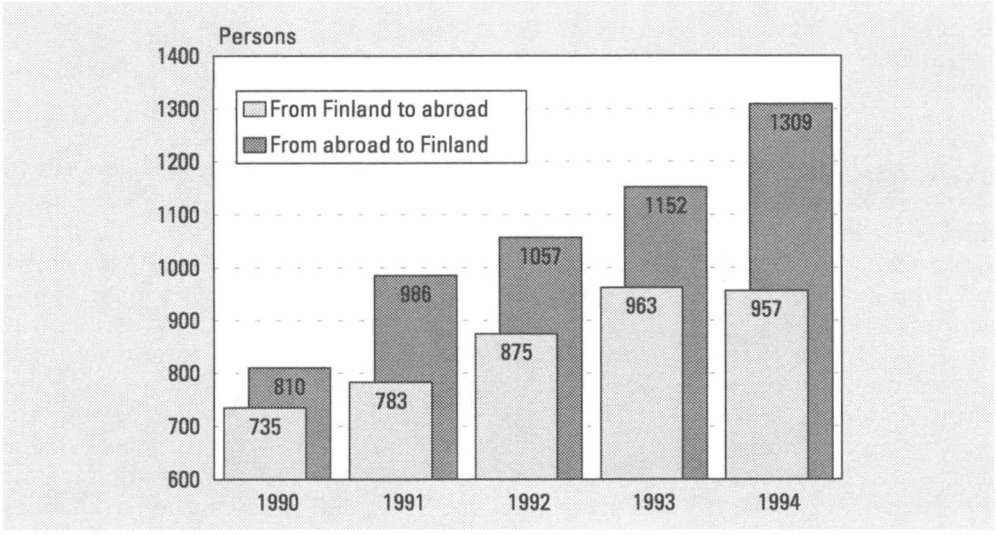
Examined according to the number of persons, the University of Helsinki had the most extensive researcher exchange, 34 per cent of all researcher exchange of the universities. The second was Helsinki University of Technology, the share of which in the researcher exchange of universities was 12 per cent. As compared with 1990, the number of researcher exchanges increased most at the University of Helsinki and second most at the University of Turku. Appendix Table 4.1 shows detailed data on the researcher exchange of universities by university in 1994.

Grants and Exchange Grants of Academy of Finland

The Academy of Finland subsidises the international mobility of researchers in two ways: the research councils may award a grant for doctorates study or work abroad, or a researcher may be awarded an exchange grant through researcher exchange based on a bilateral agreement. Regular grants are used for long-term study or work abroad, whereas exchange grants are used primarily for the funding of trips of researchers.

The research councils of the Academy of Finland in 1994 awarded a total of 420 grants to 298 Finnish researchers for purposes of doctorates study or work abroad. The grants awarded totalled FIM 22 million, for a total of 1971 months.

40 per cent of the grants were for exchange targeted on the United States. The next most popular targets were Great Britain (18 %), Canada (7 %), and Germany (6 %). About one-half of all grants were targeted on countries of the European Union. The share of the social sciences in the grants was the highest, 29 per cent. The share of the natural sciences was 26 per cent, of the medical sciences 14 per cent, of engineering and the humanities each 11 per cent, and of agriculture and forestry 7 per cent. Appendix Table 4.2 shows the Academy grants for the international mobility of researchers by country and by field of science in 1994.



4.1
Number of participants in international researcher exchange of universities 1990–94

Source: *Ministry of Education*

In addition to regular grants, the Academy awarded in 1994 a total of 360 exchange grants based on bilateral agreements. The total funding through exchange grants amounted to FIM 3.3 million.

The share of exchange with Russia amounted to 29 per cent of the exchange grants. The next largest numbers of exchange grants were awarded for exchange with Poland, Estonia and Hungary. About one-half of the exchange grants were allocated to the natural sciences. The shares of the social sciences and the humanities were 15 per cent each. More details regarding the exchange grants of the Academy of Finland are shown in Appendix Table 4.3.

Grants of the Centre for International Mobility

The Centre for International Mobility (CIMO) operating under the Ministry of Education subsidises the international mobility of researchers through the following grant programmes: 1) programmes based on cultural exchange and other bilateral agreements signed by Finland; 2) a programme intended for foreign doctorates students and young researchers; and 3) a programme of the Nordic Council of Ministers for the Baltic States and Northwestern Russia. Through these programmes, a total of 673 grants were awarded in 1994 both for longer-term doctorates studies and for short visits by researchers. The total sum of the grants amounted to slightly over FIM 12 million.

More than one-half of the grants awarded by CIMO were allocated to researcher exchange with Central and Eastern European countries. The share of the EU countries was slightly less than one-third, and that of countries outside Europe about one-sixth. As for exchange with individual countries, the largest number of grants were awarded for exchange between Finland and Estonia, a total of 104, i.e. about 15 per cent.

A total of 211 grants were awarded for exchange from Finland to abroad. Hungary, France and Germany were the most popular target countries.

Of countries outside Europe, exchange with China was most extensive. A total of 43 grants were awarded for exchange between Finland and China; this is one-half more than the number of grants for exchange with Japan, which came second.

The share of the humanities and the social sciences in all the grants awarded was 52 per cent. The share of the natural sciences and biosciences was 27 per cent, of engineering 11 per cent, and of the medical sciences 10 per cent.

Appendix Table 4.4 shows the grants awarded by CIMO for doctorates studies and visits of researchers by country and by field of science in 1994.

4.2 Co-operation with Regions Close to Finland and with Eastern European Countries

4.2.1 Nordic Co-operation

Finland has traditionally had good co-operation relations with the science organizations of the other Nordic countries. The research councils have a number of Nordic co-operation organs which award grants for the preparation, research and publications of inter-Nordic research projects and for meetings and seminars. The co-operation organs are:

- Nordiska samarbetsnämnden för humanistisk forskning, NOS-H;
- Nordiska samarbetsnämnden för naturvetenskaplig forskning, NOS-N;
- Nordiska samarbetsnämnden för medicinsk forskning, NOS-M;
- Nordisk kontaktorgan för jordbruksforskning, NKJ;
- Nordiska samarbetsnämnden för samhällsforskning, NOS-S.

Nordisk forskerutdanningsakademi (NorFa) operating under the Nordic Council of Ministers subsidises researcher courses and seminars organized in the Nordic countries. Annually about 6000 researchers and persons in researcher training from the various Nordic countries attend these courses. The funding by NorFa in 1994 amounted to about NOK 35 million.

The Nordic Industrial Fund (NI), promoting industrial R&D co-operation, funded R&D in 1994 with about NOK 260 million. The projects funded by the Nordic Industrial Fund were participated in by a total of 1200 business enterprises and research organizations from on average 3–4 Nordic countries per project. The contribution of the Nordic Industrial Fund to the funding of project costs was on average 28 percent, the contribution of the business enterprises 49 per cent, and the contribution of national sources of funding 23 per cent. The priorities in R&D subsidy granted by NI were the paper industry, the forest industry, the food industry, and the development of materials and construction technology.

4.2.2 Co-operation with Russia and other Eastern European Countries

Co-operation in science and technology with Russia and other Eastern European countries has in recent years obtained new forms and dimensions. Alongside informal expansion of co-operation, also official forms of co-operation have been reinforced. An objective is to make Finland known as a country having extensive, high-standard and internationally interesting knowledge and know-how regarding Russia.

Co-operation with Russia and Eastern European countries has so far been based primarily on bilateral agreements. Such individual agreements have been signed, for example, by universities, research institutes, and the Academy of Finland. R&D co-operation with Russia and the regions close to Finland have also been supported by the Centre for International Mobility (CIMO) and the Science and Technology Commission of the Ministry of Foreign Affairs. The strong fields in the co-operation of Finland with Russia and Eastern Europe have been the natural sciences and linguistics. At present also the social sciences and space sciences play important roles in co-operation with the regions close to Finland.

Data are presented below on the co-operation funded by the Academy of Finland and CIMO with Russia and Eastern European countries. Corresponding data regarding the agreements of universities or research institutes were not available at the time of the preparation of the present report.

The participation of Finnish researchers in cooperation of the EU countries with Russia and Eastern European countries is discussed in the sub-chapter (4.3.1) dealing with EU research co-operation.

R&D Co-operation Funded by Academy of Finland with Russia and Eastern Europe

The Academy of Finland is funding co-operation with Russia and Eastern European countries by granting research appropriations to researchers and researcher teams and by awarding exchange grants for trips of researchers. In addition, the Academy of Finland has since April 1995 attended to the science exchange of the Science and Technology Commission of the Ministry of Foreign Affairs, its funding amounting to about FIM 2 million a year.

In 1994 the research councils of the Academy of Finland used about FIM 20 million to fund 3- to 5-year research projects involving co-operation with Russia.

Furthermore, towards the end of 1994 an extensive research programme on Russia and Eastern Europe was started; within this programme, a total of about FIM 21 million will be used to fund 19 research projects. The primary aim of this research programme is to reinforce in Finland social science and humanities research targeted at Russia and Eastern Europe.

The bilateral researcher exchange of the Academy of Finland is based on a co-operation agreement signed in 1972 with the Russian Academy of Science. During the 23 years the agreement has been in force, there have been in progress about sixty fixed-term research projects of 3–5 years. Almost 40 of the projects have already ended. Within these projects the Academy of Finland has primarily supported the exchange of researchers.

In 1994 the Academy of Finland awarded a total of 105 exchange grants for the exchange of researchers between Finland and Russia. The total funding through the grants was about FIM 600 000, of which two-thirds were awarded for exchange from Russia to Finland. The share of the natural sciences in the exchange grants was 61 per cent. The share of Russia in 1994 was about one-third of the total bilateral exchange under the Academy of Finland. The exchange grants awarded by the Academy of Finland for researcher exchange with Russia and Eastern European countries are shown in Appendix Table 4.3.

Subsidy by Centre for International Mobility for Co-operation with Russia

The Centre for International Mobility (CIMO) subsidises co-operation with Russia and Eastern European countries by awarding grants to young foreign doctorates students and young foreign researchers for 3–6 months of doctorates studies and research in Finnish universities. A proportion of these grants have been earmarked for Russian citizens. In addition, CIMO has its own grant programme for doctorates students of the University of St. Petersburg, subsidizing the studies of postgraduate students of the University of St. Petersburg at their own university. CIMO grants for research co-operation with Russia and Eastern Europe are discussed in Sub-Chapter 4.1.

4.3 Multilateral International Co-operation

The rapid expansion of international co-operation in science and technology has been advanced in Finland in particular by closer and more extensive participation than previously by Finnish researchers in European co-operation projects and in European Union (EU) research activities. In addition to the EU co-operation, other European science and technology co-operation organizations and research institutes include:

- European Co-operation in the Field of Scientific and Technical Research, COST
- EUREKA
- European Space Agency, ESA
- European Organization for Nuclear Research, CERN
- European Molecular Biology Laboratory, EMBL
- European Molecular Biological Conference, EMBC

Within worldwide science and technology co-operation Finland has participated in, for example, the following projects: the construction of a new fusion energy research facility (ITER), Global Change, and the application of intelligent manufacturing systems (IMS).

4.3.1 European Union Research Co-operation

Research Programmes

Finns have been able to participate in R&D projects subsidized by the European Union (EU) since 1987. Before the coming into force of the EES and before Finland became a member of the EU, the costs of the Finnish participants were funded with national funds. At present the contribution of Finland towards the R&D expenditure of the EU is included in the EU membership dues of Finland regardless of the activeness of Finnish researchers in participation.

The EU R&D expenditure has been about 4 per cent of the EU Budget, which means about ECU 3000 million, or about FIM 17 000 million, annually. The Finnish contribution to the budget of the EU research programmes in 1994 amounted to 1.2 per cent. It is estimated that the share of R&D activity in the membership dues of Finland will amount to about FIM 250 million annually in the next few years.

The most significant funder of EU research projects in Finland is the Technology Development Centre (TEKES), which has used about FIM 50 million a year to fund the domestic costs of EU

4.2
Finnish participation in research projects under the EU Third Framework Programme

Programme	Acronym	Number of projects	Number of participants
Agriculture and agricultural industry, incl. fisheries	AIR	54	57
Measurement and testing	BCR	69	81
Biomedicine and health research	BIOMED	78	112
Biotechnology	BIOTECH	9	10
Industrial and materials technologies	BRITE/EURAM 2	15	20
Environment	ENV C	24	28
Information technology	ESPRIT 3	43	76
Human resources and mobility	HCM	67	68
Non-nuclear energy	JOULE 2	22	30
Marine research and marine engineering	MAST	3	3
Telecommunications engineering	RACE 2	24	37
Developing-country biosciences and technologies	STD3	4	5
Generally interesting telematic systems	TELMASYS	28	50
Total		**440**	**577**

projects. It is estimated that the subsidy given by the Academy of Finland for EU co-operation in 1996 will amount to about FIM 26 million.

A total of about 600 Finnish researchers participated in the EU Third Framework Programme for Research which ended in 1994. Finns were involved in about 400 of its projects. The largest numbers of Finns were involved in the BCR and BIOMED programmes. Financially the largest programmes were ESPRIT 3, BRITE/EURAM 2, and RACE 2. Appendix Table 4.2 shows the objects of research of the programmes and the numbers of Finnish participants.

Nearly one-half of the Finnish organizations participating in EU programmes were research institutes. About 20 per cent were business enterprises, which corresponds to the European average. The share of universities among the participants was 30 per cent.

In terms of participation in proportion to the population, Finland was the 14th most active country in European research programmes. Denmark, Spain, Italy and Austria were behind Finland.

Source:
Finnish EU R&D Secretariat

INTAS

The International Association for the Promotion of Co-operation with the Independent States of Former Soviet Union (INTAS) was founded in 1993 for purposes of co-operation between the countries of the EU and the Commonwealth of Independent States (CIS). This organization funds basic research co-operation between the EU and the CIS countries. It is a particular objective of INTAS to support the work of researchers of the area of the former Soviet Union in their own home countries, in co-operation with Western European researchers. INTAS is a fixed-term organization; its term will expire at the end of 1995. After the expiration of the term of INTAS, the co-operation between the EU and the CIS countries will probably be incorporated into the Fourth EU Framework Programme, its second operational entity, funding research co-operation with countries outside the EU.

Finland was a member of INTAS even before joining the European Union. Finns have participated in a total of 34 projects funded by INTAS. A total of 40 Finnish researchers have been involved in INTAS projects, 14 of them as project coordinators. The funding received by Finnish research projects from INTAS has amounted to ECU 1.6 million (about FIM 10 million). The University of Helsinki has had the largest number, 12, of INTAS projects. Next are the Universities of Jyväskylä and Oulu, each with 4 projects.

Source:
Academy of Finland

4.3.2 Other Multilateral Co-operation

CERN

The European centre for nuclear research, CERN, is the leading research centre in its field, located in Geneva, Switzerland. CERN was established in 1954 by eight European countries. Subsequently the number of its member States has increased to nineteen. The member countries are Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Great Britain, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, and Switzerland. Finland has been a member of CERN since 1991.

CERN has a regular personnel of 3000, and annually about 6000 visiting researchers. The annual budget of CERN amounts to about FIM 3700 million. Most of the activity of CERN is funded with the membership dues of the member States. Finland's membership share was gradated from the year of accession so that the full membership dues were paid for the first time in 1995. In 1995 Finland's membership dues amounted to FIM 34.9 million, which is about 1 per cent of all membership dues of CERN.

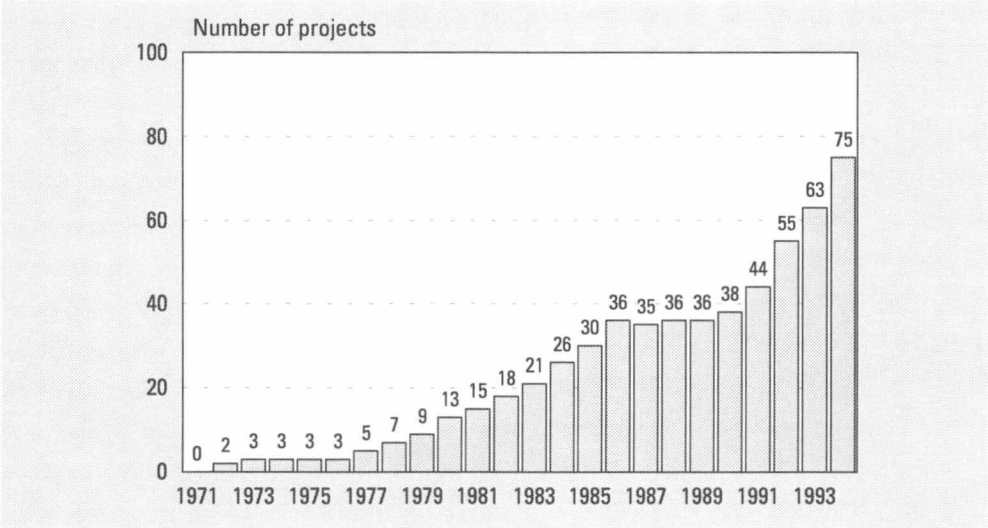
Source:
University and Science Department of the Ministry of Education

COST

European co-operation in research and technology actually started after the founding of COST (European Co-operation in the Field of Scientific and Technical Research) in 1971. COST was established to promote R&D co-operation among European countries. Its objective is to advance co-operation in basic and applied research among business enterprises, universities and national research institutes. The aim is to increase the exploitability of research projects and to spur co-operation among researchers from different countries. At present all the EU countries, as well as Norway, Iceland, Switzerland, Hungary, Poland, Turkey, Slovenia, Slovakia, and the Czech Republic, are participating in COST.

Finland has been involved in COST activities since the very beginning. By the end of 1994 Finland had taken part in 131 projects. Finland has participated most actively in projects in telecommunications, transport engineering, and materials technology. Participation increased clearly at the beginning of the 1990s, as shown in Figure 4.3.

About 40 per cent of the Finnish organizations which have participated in COST have been research institutes. Universities and other Government agencies and institutes among the participants amounted to about 25 per cent and business enterprises to 10 per cent.



4.3
Finnish participation in COST projects 1971–93

Source: *Ministry of Trade and Industry*

In a comparison of the COST countries, Finland and Sweden in 1994 shared the sixth place in terms of activity in participation in COST, after Great Britain, France, Germany, Switzerland, and Spain.

Source:
Ministry of Trade and Industry, Pia Miettinen: Suomen osallistuminen COST yhteistyöhön (Participation of Finland in COST)

EMBL and EMBC

The European Molecular Biology Laboratory, EMBL, is a molecular biology research facility located in Heidelberg, Germany, and maintained by its member countries. The laboratory has been in operation since 1973. Finland joined as a member in 1985. The other member countries are Austria, Belgium, Denmark, France, Germany, Great Britain, Greece, Iceland, Ireland, Israel, Italy, the Netherlands, Norway, Spain, Sweden, and Switzerland.

The activity of the EMBL is supported by the European Molecular Biology Organization (EMBO), which funds the work and doctorates training of researchers in the field and organizes courses and workshops for researchers in the field.

There are about 800 persons working at the EMBL. The researchers receive their funding directly from the EMBL, as grants from the EMBO, or from national funders. The membership dues of Finland to the EMBL in 1995 amount to FIM 1.3 million.

In 1969, twelve European countries set up the European Molecular Biology Conference (EMBC), the function of which is to support the work and doctorates studies of researchers in the field. Finland's dues to the EMBC amount to FIM 0.7 million in 1995.

Source:
Academy of Finland

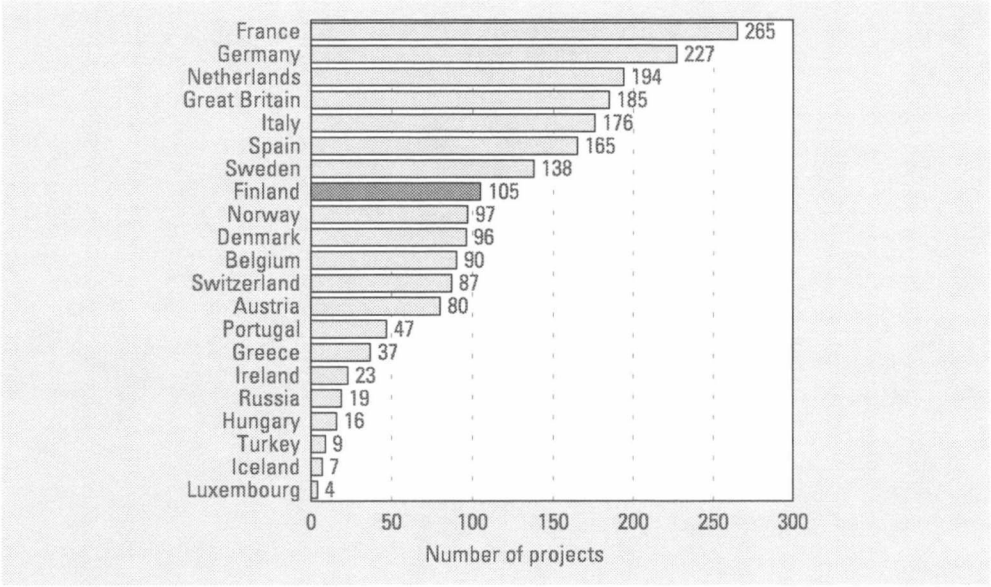
EUREKA

Eureka was established in 1985 as a joint high technology development project of the European countries. Its objective was to raise the standard of European high technology and thereby its competitiveness against the technological superiority of the United States and Japan. In the Ministerial Meeting of the Eureka countries held in Switzerland in June 1995 the number of member countries increased to 24, when the Czech Republic and Poland were accepted as new members. The other members are all of the EU countries, as well as Iceland, Norway, Switzerland, Hungary, Russia, Slovenia, and Turkey.

In a manner deviating from the other European science and technology projects (EU research programmes and COST), Eureka focusses on market-oriented research and on technology development close to the market. In Eureka, research initiatives come according to the so-called bottom-up principle from the participating organizations themselves. In addition to business enterprises, there are also research institutes and universities participating in Eureka projects, but their number is small as compared with that of business enterprises.

So far, a total of 1061 Eureka projects have been approved; some of them have already been completed and some have had to be discontinued. By the end of June 1995, a total of 720 Eureka projects were in progress. At a ministerial meeting held in June 1995, 147 new Eureka projects were approved. The costs budgeted for Eureka projects amount to about FIM 80 000 million. The annual budget of Eureka's Finnish funder, the Technology Development Centre, for Eureka projects has been about FIM 50–80 million.

Figure 4.4 shows that France, Germany and the Netherlands have had the largest numbers of Eureka projects. Of the Nordic countries, Sweden



4.4
Number of EUREKA projects in progress at the beginning of 1994 by member country

Source: *Technical Research Centre of Finland, 1995*

has been the first and Finland the second. However, differences among Finland, Denmark and Norway are small. At the beginning of 1994, Finnish business enterprises and research institutes were involved in 105 projects. Of the organizations participating from Finland, about 80 per cent have been industrial business enterprises. Among the participants from all countries the share of industrial business enterprises is 65 per cent. Among the Finnish industrial business enterprises the share of small and medium-sized business enterprises is about 37 per cent, which is somewhat larger than the average of the Eureka countries (32 %). Most of the Finnish projects are in the fields of environmental and information technology and medicine and biotechnology.

Source:
Technology Development Centre (TEKES) and Tarmo Lemola & Kirsi LaPointe, Suomi Eurekassa – Eureka Suomessa (Finland in Eureka – Eureka in Finland, publications of the Technical Research Centre of Finland 807, Espoo 1995.

ESA

The European Space Agency (ESA) is a European organization with an objective to promote and co-ordinate peaceful space research and development of its applications by European countries. The operations of ESA include the development of satellites and space laboratories associated with space research and with its applications, their launching into orbit, and the use of space systems.

The members of ESA are 14 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, and Switzerland. In addition, ESA has a co-operation agreement with Canada.

Finland has been involved in the activities of ESA since 1987, and has been a full member since the beginning of 1995. Finland participates in scientific research activities and in programmes of remote mapping of the Earth and telecommunications by satellite.

The total expenditure of the Finnish public sector on space research and technology projects and on the development and exploitation of applications of space technology in 1994 amounted to FIM 146 million, in which the share of expenditure on ESA co-operation was FIM 91 million, i.e. 62 per cent. The share of Finnish projects in the ESA expenditure was FIM 18 million.

Of the national funders, the share of the Technology Development Centre was FIM 74 million, i.e. 81 per cent. Funding of ESA co-operation by the Academy of Finland amounted to FIM 4.5 million and the total combined funding by the research institutes and universities to FIM 4.5 million.

A total of 170 Finnish researchers have participated in ESA co-operation. Finns have had 36 co-operation projects, of which one-half have been projects commissioned by ESA from Finland and one-half projects funded with domestic funds.

Source:
Technology Development Centre (TEKES)

5 Output and Economic Impacts of Science and Technology

The preconditions and resources for science and technology have been described in the foregoing. For the advancement of science and technology it is also important to know what impacts the financial inputs into research have had. Interest in input indicators of science and technology arose in particular in the 1980s. In recent years, various indicators of the output and impacts of science and technology have been developed in most western and international organizations. This indicator development work has produced new knowledge and created preconditions for the assessment of the output and impacts of science and technology.

The present chapter deals with the output and economic impacts of science and technology. The article written by Terttu Luukkonen describes the level and international visibility of Finnish scientific research on the basis of *scientific publishing*. Sub-Chapter 5.2 describes *technology output* on the basis of patent data. Sub-Chapter 5.3 deals with the *economic impacts of science and technology, and technology transfer*, which are described using indicators concerning the output of and foreign trade in high technology products.

5.1 Scientific Publishing

– International Visibility of Finnish Research as Measured by Bibliometrics

(Terttu Luukkonen, Senior Researcher, Docent, Group for Technology Studies, Technical Research Centre of Finland)

5.1.1 Introduction

Scientific publishing can be surveyed with the help of bibliometric indicators. Bibliometrics means simply a quantitative study of written communication. Bibliometrics has, both in Finland and elsewhere, become subject to keen interest as one tool for the assessment of research.

The uses of bibliometrics are manifold, depending on which bibliometric indicators are used. The most common bibliometric indicators are publication and citation counts. These are used for measuring the productivity and impact of research. By using data obtained from international databases it is possible to measure, for example, the international *publishing activity* of Finnish science (number of publications) and its international *visibility and impact on other research activity in the field* (the frequency of citation of the publications).

The extent of scientific co-operation and the co-operation partners can be surveyed by analysing co-authorship. When a number of documents have cited a given pair of documents this is called co-citation. The development of new specialized fields and the forefront of science are examined using co-citation and co-word analysis. It is also possible to survey the extent to which individuals or institutions have participated in forefront research.

The latest application of bibliometrics is to analyze citations of patent applications and thereby the impact of patents on the development of technology. Through a survey of references in patent applications it is possible to survey how 'science-intensive' various fields of technology are, i.e. how closely the development of technology is associated with the development of scientific research in the field.

By the use of bibliometrics in the assessment of research is usually meant a numerical analysis of publication and citation frequencies. The use of bibliometric indicators in the evaluation of research results is based on the importance of written communication in the dissemination of research results. The publishing of research results in scientific literature is characteristic in particular of university research and basic research, therefore bibliometric indicators are best suited for measuring the output of basic research and university research.

There exists a large amount of literature concerning the problems involved in bibliometric indicators, especially those using citation data. There are significant differences among fields of science, and even among narrow specialized disciplines, in publishing and citation patterns, and therefore comparisons between different fields should not be made. Comparisons between units representing different fields of science and research can be made only in case the data being compared are related to the average or top performance in the respective fields, in which case the comparison will be relative. It should also be remembered that the use of bibliometric indicators alone does not constitute evaluation. The data provided by indicators have to be interpreted, and additional sources of information be used in support of conclusions. For example, on the basis of publication and citation data alone it is not possible to rank universities, university departments or institutes, and these data as such do not constitute a sufficient source of information for the allocation of resources or the making of decisions concerning projects. Comments by experts in the field are important in the interpretation of the results.

5.1.2 International Visibility of Finnish Research[4] as Measured by Bibliometrics

The present sub-chapter presents in a concise form the most important results from a Nordic report comparing the publications (mainly articles) produced in the Nordic countries and the citations to these publications in 1981–92 in the ISI (Institute for Scientific Information) database called National Science Indicators. It is based on the Science Citation Index database (SCI) maintained by ISI.

The ISI National Science Indicators database comprises papers included in SCI worldwide and the citations to these papers in 1981–92 in 17 fields of science. The field classification of papers is based on that of the journals. In total the database comprises 5 655 186 papers, which are in the main papers in scientific journals. On average two papers out of three have been cited in subsequent scientific literature. The database comprises a total of 40 516 820 citation data.

For this analysis, the 17 fields of science included in the database have been combined into 7 main categories, which are biology, biomedicine, physics, geosciences, chemistry, clinical medicine, and mathematics.

Biology includes agriculture and forestry. Engineering sciences and multidisciplinary fields have been excluded from the separate discussion, but when all fields are dealt with together, they are included in the data.

In the present sub-chapter, the data concerning Finland are compared with those concerning the Nordic countries and the largest OECD countries, that is, Great Britain, Germany, France, Italy, Spain, Belgium, the Netherlands, Switzerland, Austria, the USA, Canada, Australia, New Zealand, and Japan. These 19 OECD countries, including the Nordic countries, produced 80 per cent of the scientific papers in the database worldwide during 1981–92, and they accounted for more than 93 per cent of all citations during the same period.

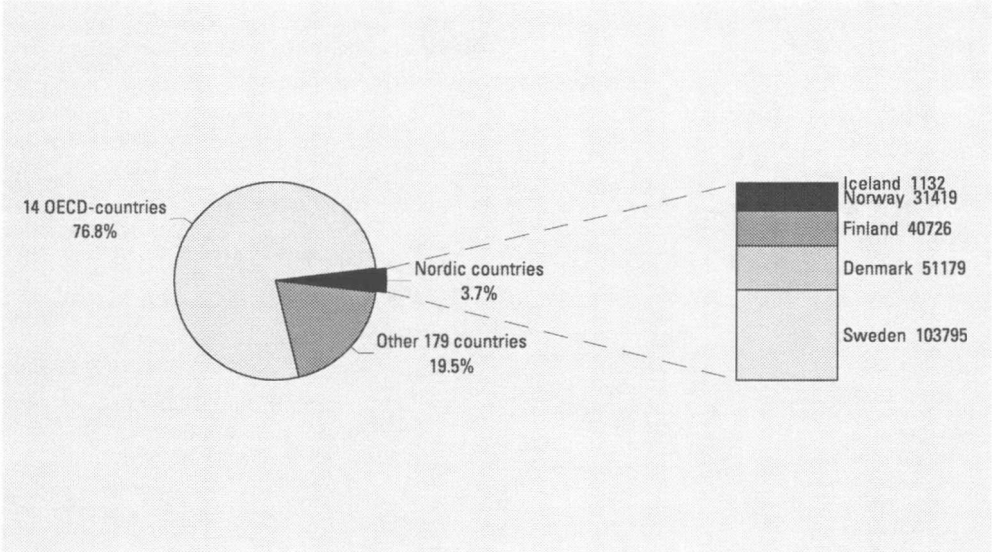
Technical Details

Publications with authors from multiple countries have been attributed to each of the author countries. Therefore the figures presented above may overlap somewhat in the examination by country. In the calculation of the coefficients describing the relative citation rates of individual countries, they have been weighted taking into consideration the mean citation rates of the respective fields of science and their shares in the scientific publishing of the respective countries.

All Fields of Science

The share of the Nordic countries in 1981–92 amounted to 4.6 per cent of the publications of the above 19 OECD countries and to 3.7 per cent of the publications worldwide. The share of Finland was at the average level of the Nordic countries.

[4] An Abridgement of the report Terje Bruen Olsen, Hanne Foss Hansen, Terttu Luukkonen, Olle Persson & Gunnar Sivertsen, Nordisk forskning i internasjonal sammenheng – en bibliometrisk beskrivelse av publisering og siteringer i naturvitenskapelig og medisinsk forskning, TemaNord 1994:618, Nordisk Council of Ministers, Copenhagen 1994. This sub-chapter also uses data from a project dealing with international research cooperation, the results of which are reported, for example, in Terttu Luukkonen, Olle Persson & Gunnar Sivertsen, Nordic Collaboration in Science – a bibliometric study. Nord 1991:28, Nordic Council of Ministers, Copenhagen 1991.



5.1
Scientific publishing in the natural sciences and medicine worldwide 1981–92

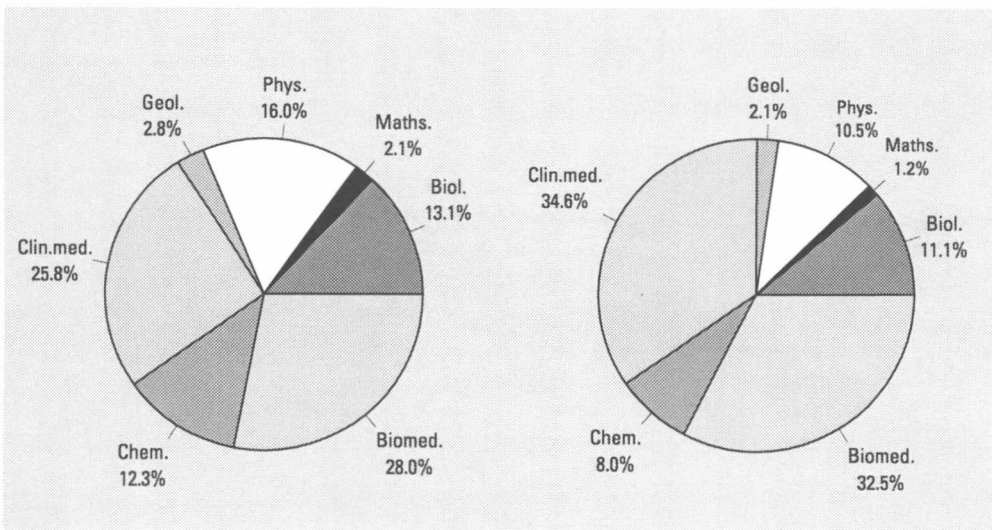
Source: *National Science Indicators*

The share of the USA in the publications is 41.4 per cent, of Great Britain 10.0 per cent, of Germany 9.2 per cent, of Japan 8.9 per cent, of France 6.5 per cent, and of Canada 5.4 per cent. The shares of the other countries are smaller than the total share of the Nordic countries.

Figure 5.3 shows the breakdown of the different fields of science in the OECD countries and the Nordic countries. The share of medicine was the largest in both, but in the Nordic countries even more clearly so than in the OECD countries in total.

5.2
Shares of the Nordic countries in the publications of 19 OECD countries in the ISI National Science Indicators database

Country	Percentage share
Finland	0.82
Denmark	1.03
Norway	0.63
Sweden	2.09
Iceland	0.02

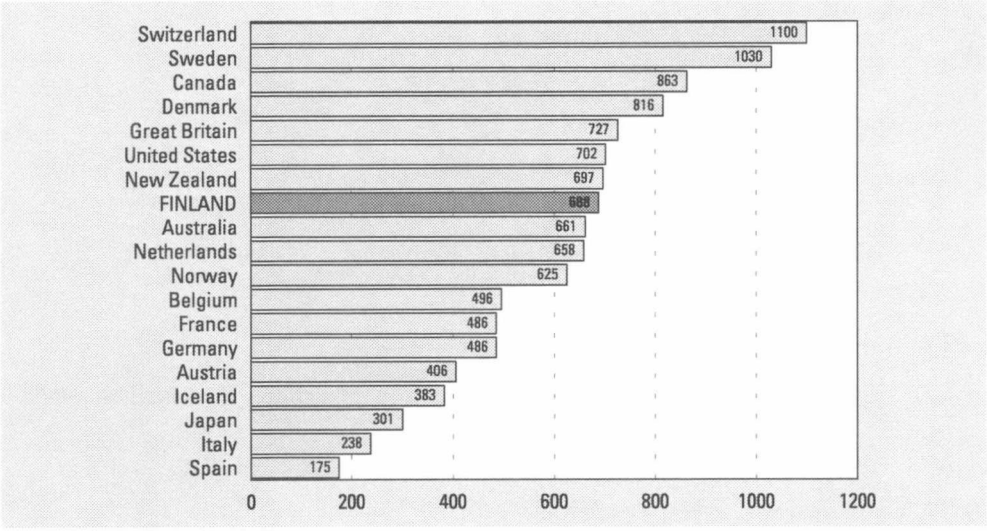


5.3
Shares of publications in the natural sciences and medicine 1981–92

Source: *National Science Indicators*

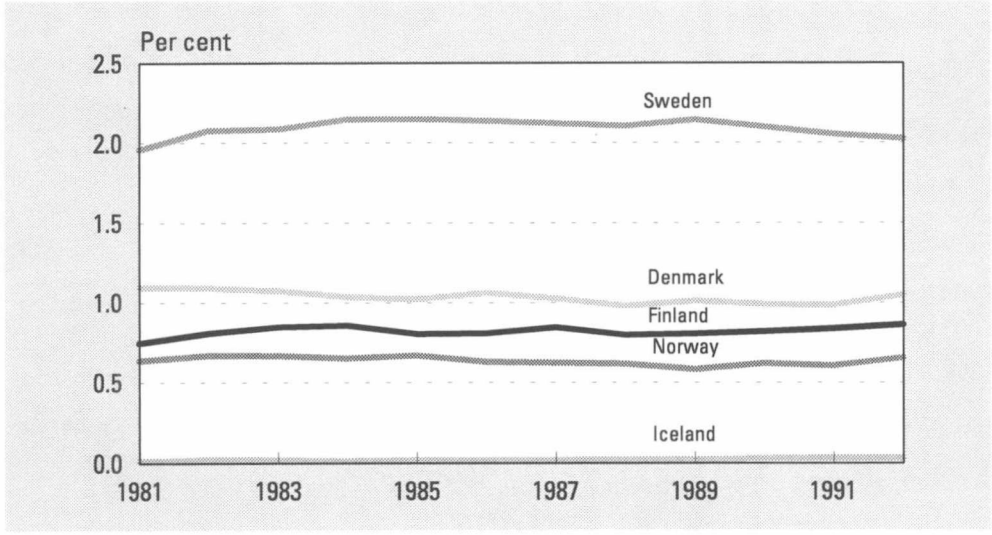
Figure 5.4 shows the international publishing activities of the OECD countries, related to the population and as an annual average during 1981–92. The figures concern all fields of science in total. Finland produced annually on average 688 papers, which is somewhat above the average of the OECD countries (598). In a Nordic comparison, however, Finland was clearly below Sweden and Denmark and somewhat above Norway.

Figure 5.5 shows the development of the publication activities of the Nordic countries during the period under discussion, as a percentage of the OECD country papers in the database. The percentages have changed very little, and the order of the countries with respect to publishing activity is the same as that related to the population.



5.4
Scientific publishing in the natural sciences, engineering and medicine. Papers per one million inhabitants 1981–92. Annual average

Source: *National Science Indicators*

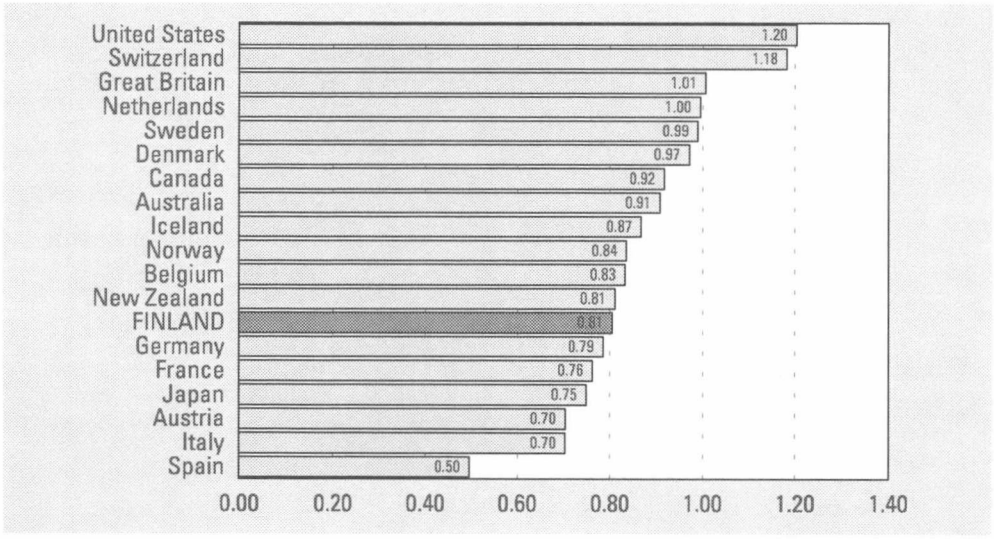


5.5
Scientific publishing in the natural sciences, engineering and medicine 1981–92. Nordic countries: share in papers of 19 OECD countries

Source: *National Science Indicators*

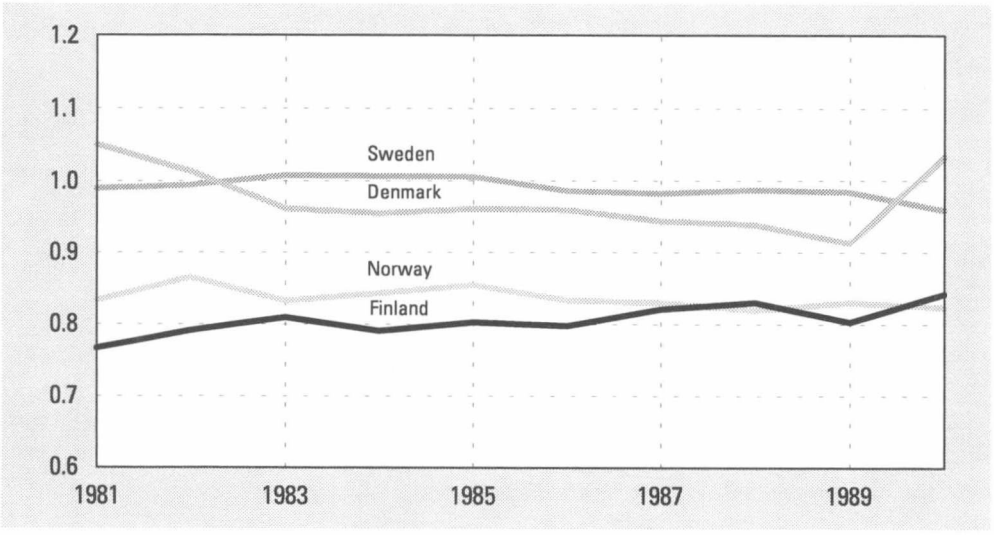
Figures 5.6 and 5.7 show the citations of the publications of 19 OECD countries and the Nordic countries in the source journals of the SCI database in 1981–90. In both, the numbers of citations are related to the average level of the said 19 OECD countries.

In terms of numbers of citations, Finland was clearly below the average of the OECD countries (Figure 5.6). The Nordic comparison shows that Finnish papers were cited in 1990 somewhat more than Norwegian papers, but clearly less than Danish or Swedish papers. However, the citation rate of Finnish papers has improved most among those of the Nordic countries during the ten-year period under discussion.



5.6
Citations in the natural sciences, engineering and medicine. Relative citation index 1981–90

Source: *National Science Indicators*



5.7
Citations in the natural sciences, engineering and medicine 1981–92
Nordic countries: relative citation index

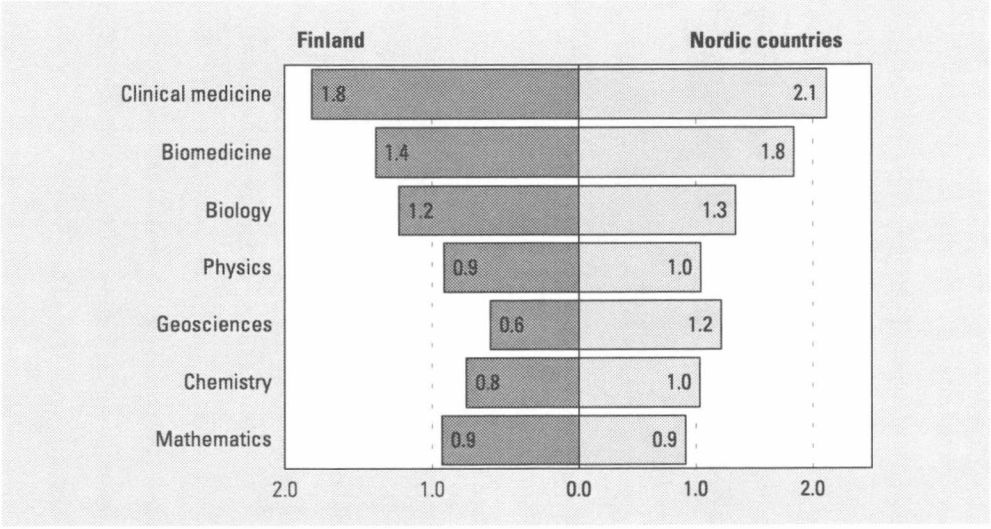
Source: *National Science Indicators*

Examination by Field of Science

Figures 5.8 and 5.9 show the publication and citation profiles of Finnish research by field of science in comparison with the Nordic averages. In each figure, the numbers of publications and citations are related to the average of the OECD countries, which equals one. Finland was in nearly all fields below the Nordic average both in publishing activity and in the number of citations. The only exception with respect to the number of publications is mathematics, in which Finns published approximately as much as the Nordic countries on average. In mathematics, however, the numbers of citations of Finnish papers were below the average of the Nordic countries. Finland published – as did the Nordic countries in general – more than the average of the OECD countries in clinical and biomedicine and in biology. The citations of Finnish publications were at the average level of the OECD countries only in mathematics. In all other fields the citation level was clearly below the average of the OECD countries.

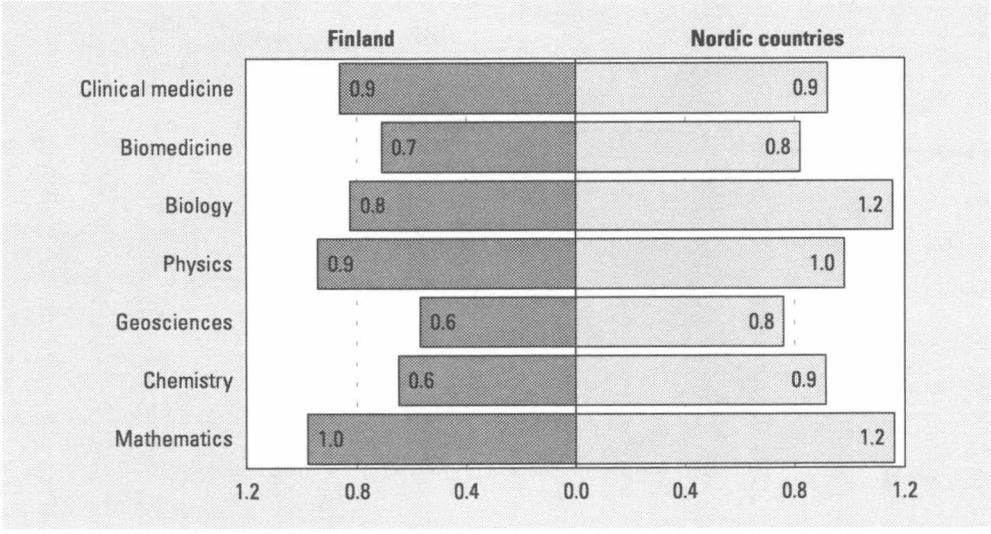
Internationality of Finnish Science

From the above data it can be concluded that Finnish research is slowly going international. It is less internationally oriented than, for example, Swedish or Danish research. This conclusion is corroborated by the propensity of Finnish researchers to engage in international co-operation.



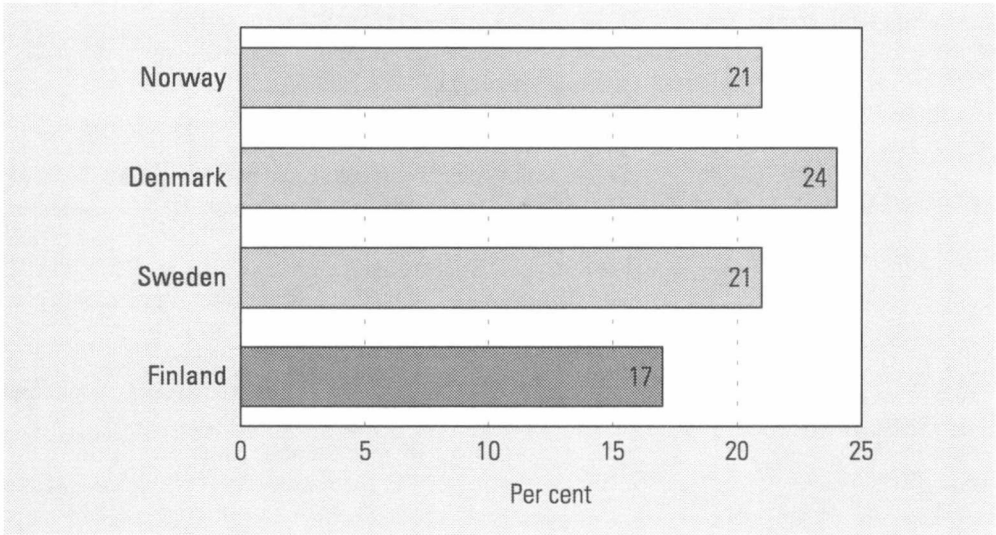
5.8
Finland - publication profile. Papers per inhabitant 1981–92

Source: *National Science Indicators*



5.9
Finland - citation profile. Relative citation index 1981–90

Source: *National Science Indicators*



5.10
Shares of internationally co-authored papers in the Nordic countries 1981–86

Source: *Computer Horizons/National Science Foundation Science Literature Indicators Database*

International co-operation is measured by the proportion of publications in the SCI which have authors from more than one country. The data available concern the years 1981–86. A Nordic comparison based on these data shows that Finns have the smallest proportion of internationally co-authored publications (Figure 5.10).

5.2 Patenting

Patent Statistics as Technology Indicators

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

A patent is a formal record of the fact that new and useful technical knowledge has been obtained. With respect to business enterprises it is one of the indicators of the fruitfulness of their R&D activities. However, all patents are not exploited economically, for example for the reason that the technology cannot be applied to industrial output or that the marketing of the product is too difficult.

The use of patent statistics as a technology indicator is justified by the fact that a large quantity of internationally comparable data on patents are available in time series over a long period. The possibilities for processing the material are manifold. However, comparisons are complicated by the fact that the bases for the granting of patents and the regulations concerning patents are different in different countries.

Patent statistics in general provide only a partial or incomplete picture of new technology, since all inventions are not patentable, and all patentable inventions are not patented. The economic significance of patents varies.

Patented products or methods may be considerable inventions or only minor improvements on already existing products or processes.

If patents granted are examined instead of patent applications, the different processing periods of patent applications will affect the numbers of patents in various periods. The processing periods vary by country and field.

Material and Definitions

The data concerning patent applications and patents granted are based on data in international patent databases, received from the Finnish National Board of Patents and Registration. The tables concerning patenting abroad by Finnish applicants include patent applications/patents granted which have become public directly in the country concerned or through the European Patent Office.

Patents based on the European Patent Convention (EPC) are applied for through the European Patent Office (EPO) or a public agency authorised by it. A patent application can be filed at the same time in all or in only some of the member States. An invention regarding which a patent application has been filed through this system becomes automatically public 18 months after the first registration of the application. A patent can be granted after this. A patent granted by the EPO provides the invention the same protection as a patent applied for directly from a national patent authority.

The product-group-specific patenting data are based on a key between the International Patent Classification (IPC) and the Standard Industrial Classification (SIC 1988), developed by Statistics Finland and the National Board for Patents and Registration.

Upturn in Total Number of Patent Applications Filed in Finland

In 1994, a total of 6 206 patent applications were filed in Finland; 62 per cent of them were foreign applications. The number of foreign applications had also increased from the previous year after a drop in the preceding years. The number of domestic applications increased at a somewhat higher rate, and their proportion thus somewhat increased from the previous year. The number of applications filed by business enterprises increased somewhat more than did the number of private applications. The proportion of applications filed by private persons was 40 per cent of all domestic applications.

In 1994, the largest proportions of foreign patent applications filed in Finland were from the United States (31 %), the next largest from Germany (18 %) and Sweden (10 %).

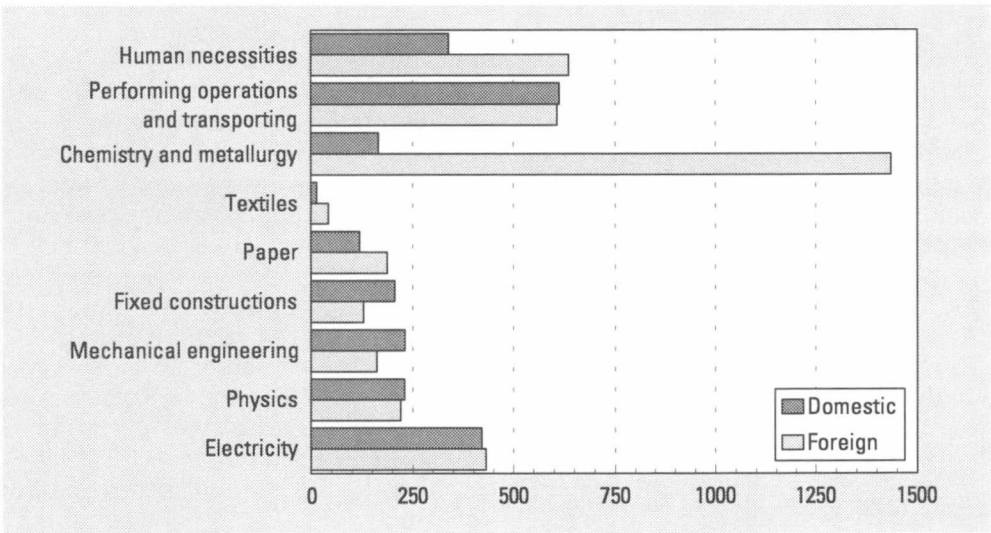
The number of patents granted in Finland in 1994 totalled 2559. The share of foreign applicants was 64 per cent of all patents granted. The number of patents granted to foreign applicants decreased as a result of a decrease in patent applications in the preceding years. Of domestic patents (930), the share of patents granted to business enterprises and other corporate bodies was 80 per cent.

Examined according to the International Patent Classification, slightly more than one-fourth of the domestic patent applications filed in Finland in 1994 were in the section of performing operations and transporting. The next largest group was in the section of electricity, 18 per cent of the applications.

The largest group among foreign applications filed in Finland was in the section of chemistry and metallurgy, 37 per cent of the applications. The share of applications in the section of electricity was 11 per cent.

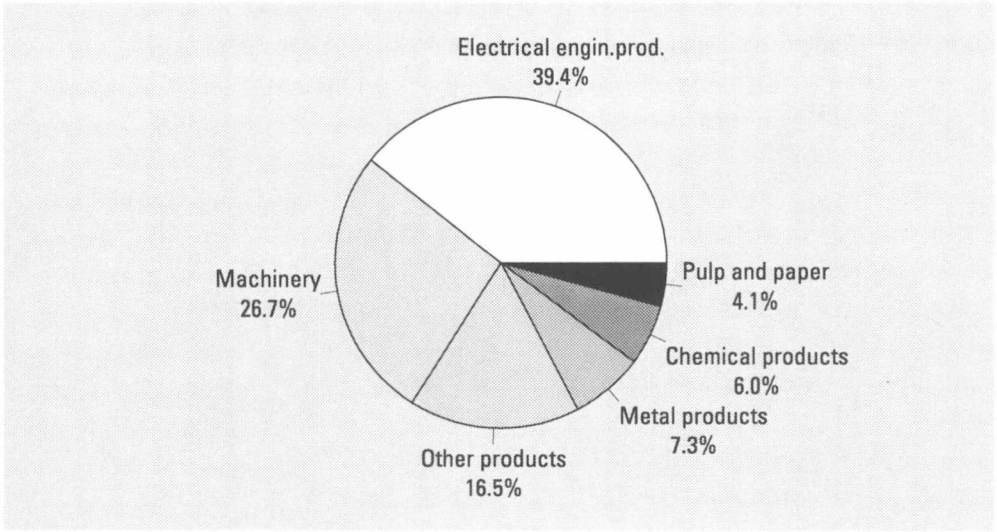
5.11
Domestic patent applications filed in Finland 1985–94

Year	Domestic applicants		Domestic total	Foreign applicants	Applications total
	Private persons	Corporate bodies			
1985	681	1 038	1 719	3 480	5 199
1986	718	1 035	1 753	3 630	5 383
1987	747	1 104	1 851	3 949	5 800
1988	742	1 235	1 977	4 091	6 968
1989	682	1 262	1 944	4 415	6 359
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	3 864	6 206



5.12
Patent applications filed in Finland by IPC section* 1994

* International Patent Classification



5.13
Domestic patent applications filed by business enterprises by product group 1994

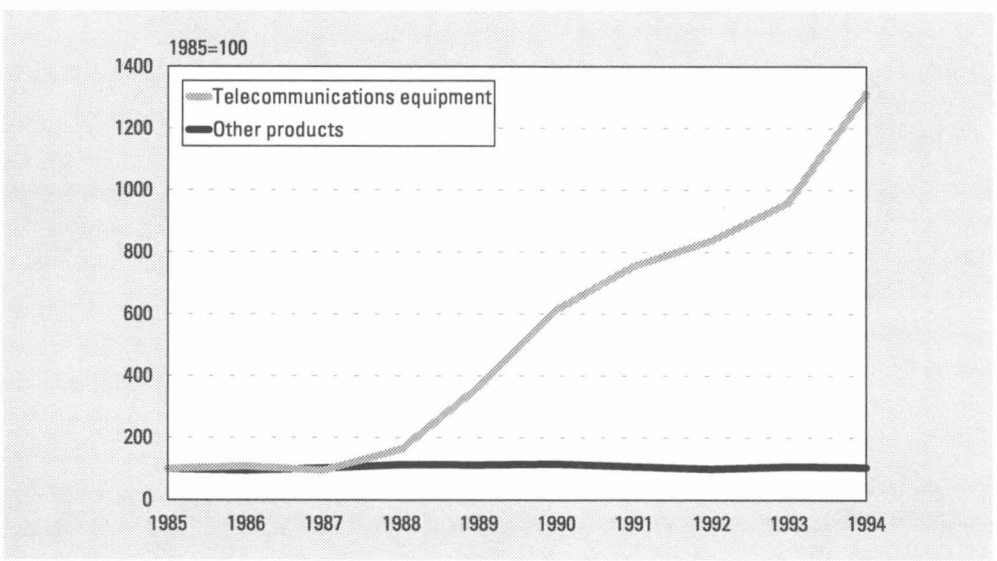
Appendix Table 5.1 shows patent applications filed in Finland by more detailed technology classification (source of classification: E.C. Engelsman and A.F.J. van Raan, The Netherlands in modern technology: a patent-based assessment, 1991). According to this classification, the Finnish patent applications are mainly concentrated in construction technology and telecommunications engineering. Foreign applications for their part are mostly related to chemical engineering and genetic engineering.

About 490 Finnish Business Enterprises Filed Domestic Patent Applications in 1994

Patenting is rather strongly concentrated. In all patent applications filed by business enterprises and corporate bodies, the share of the ten business enterprises which had filed the largest numbers of patent applications was slightly over 40 per cent.

Clearly the largest product group in patent applications filed by business enterprises was electrical engineering products, which in 1994 constituted slightly less than 40 per cent. The next largest product group was machinery.

In the product group of telecommunications equipment, patenting increased very strongly (Figure 5.14). In 1985 business enterprises filed 22 patent applications in this product group, and in 1994 the number had increased to 289. In other product groups the numbers of applications increased only slightly during the same period.



5.14
Patenting by business enterprises 1985–94

5.15
Inventors named in patent applications filed by domestic business enterprises by province 1991 and 1994

Province	1991		1994	
	Number	%	Number	%
Uusimaa	544	35.7	718	42.1
Turku and Pori	255	16.8	240	14.1
Häme	247	16.2	234	13.7
Kymi	74	4.9	54	3.2
Mikkeli	44	2.9	29	1.7
Northern Karelia	14	0.9	4	0.2
Kuopio	28	1.8	47	2.8
Central Finland	125	8.2	117	6.9
Vaasa	56	3.7	69	4.0
Oulu	126	8.3	182	10.7
Lapland	9	0.6	13	0.8
Aaland	–	–	–	–
Total	**1 522**	**100.0**	**1 707**	**100.0**

Table 5.15 shows the inventors named in patent applications filed by business enterprises by province. The table describes primarily the annual 'inventor personnel' of business enterprises by province. The same inventor may be included in different years, and one invention may have several inventors from different provinces. The data are slightly imprecise owing to deficient address data of inventors.

In an examination according to the address province of the inventor named in a patent application, Uusimaa increased its share in the filing of patent applications by business enterprises. The growth was slightly over 6 percentage points from 1991. The Province of Oulu also clearly increased its share of inventors. The shares of the Province of Turku and Pori and the Province of Häme respectively decreased.

Table 5.16 depicts the extent of filing of domestic patent applications by business enterprises in the sense that all the inventors named in the different applications are included. Not equally many inventors were named in all applications, and therefore different applications are weighted somewhat differently. The total share of Uusimaa was 44 per cent, of which slightly more than 30 per cent was in the section of electricity. More than two-thirds of the inventors in the Province of Oulu belonged to this section. In the Province of Turku and Pori and the Province of Häme the inventors were concentrated in the section of performing operations and transporting.

In 1994, in the section of chemistry, two-thirds of the inventors named in the applications filed by business enterprises, in the section of physics, more than one-half (58 %), and in the section of electricity, nearly one-half (48 %) were from the Province of Uusimaa (Table 5.16). The share of the Province of Oulu in the section of electricity was 29 per cent. The shares of the Province of Häme (29 %) and the Province of Turku and Pori (22 %) were the largest in the sub-section of building.

5.16
Patenting* by domestic business enterprises by IPC section and by province 1994

Province	Total	IPC section**							
		A	B	C	D	E	F	G	H
Uusimaa	44.2	48.3	38.9	67.0	27.4	19.0	27.2	58.6	48.3
Turku and Pori	12.3	20.3	15.9	8.0	8.1	21.6	12.8	5.2	10.1
Häme	12.9	10.6	18.6	10.3	4.9	29.3	16.9	11.5	9.0
Kymi	3.3	.	4.9	1.3	9.9	1.7	8.7	2.9	0.6
Mikkeli	1.6	1.4	2.7	0.3	3.6	2.6	2.1	1.7	0.3
Northern Karelia	0.2	0.5	0.2	0.3	–	0.9	–	–	–
Kuopio	2.4	2.9	3.9	3.3	0.9	5.2	5.6	0.6	0.3
Central Finland	7.0	2.4	5.1	2.0	40.4	4.3	13.8	1.7	1.2
Vaasa	3.7	4.8	4.6	1.7	3.6	6.0	10.3	2.3	1.6
Oulu	11.8	7.2	4.9	5.3	0.4	4.3	2.6	14.4	28.8
Lapland	0.6	1.4	0.2	0.3	0.9	5.2	–	1.1	–
Aaland	–	–	–	–	–	–	–	–	–
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

* Named inventors, gross (same person may be named in several applications)
** A: Agriculture, B: Performing operations, C: Chemistry and metallurgy, D: Textiles and paper, E: Fixed constructions, F: Mechanical engineering, G: Physics, H: Electricity

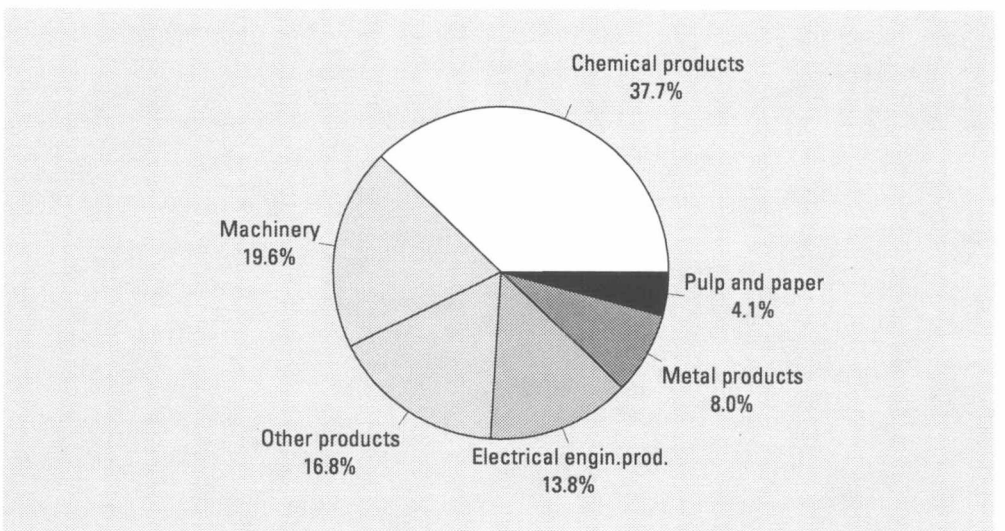
Drop in Number of Patents Granted to Foreigners

The largest single product group in patents granted to foreign applicants in Finland (5.17 and 5.18) was pharmaceutical products, for which 385 patents were granted in 1994. The applications relating to pharmaceuticals originated in the United States (32 %), Germany (17 %), and Japan (13 %).

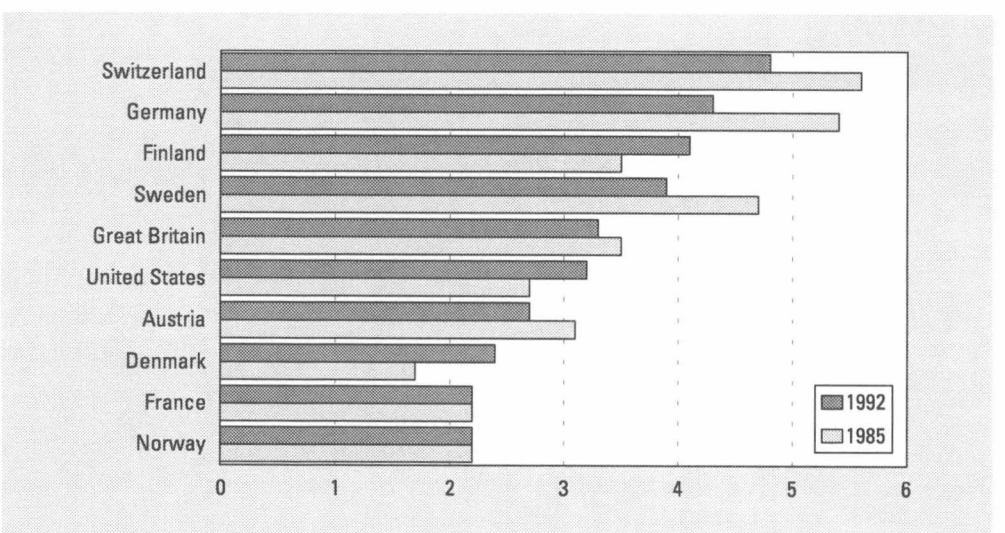
Of the patents granted to applicants from the United States, 45 per cent were in the group of chemical products. The largest product groups in patents granted to Germans in 1994 were drugs (22 %), industrial general-purpose machinery (12 %), and metal products (10 %). The patents of Swedish applicants were also concentrated in industrial machinery (20 %) and metal products (16 %). Of the patents granted to Japanese applicants, 58 per cent related to chemical products and 8 per cent to instruments.

5.17
Patents granted in Finland to foreign applicants by country 1993–94

	1993	1994
United States	479	450
Germany	353	291
Sweden	176	154
Japan	102	119
Switzerland	127	109
France	137	99
Great Britain	98	96
Netherlands	74	53
Denmark	54	50
Italy	46	46
Austria	28	26
Norway	24	26
Other countries	88	112
Total	**1 786**	**1 631**



5.18
Patents granted in Finland to foreign applicants by product group 1994



5.19
Number of domestic patent applications / 10 000 population in certain OECD countries 1985 and 1992

Source: *OECD, MSTI indicators 1995-1*

Invention in different countries is compared in Figure 5.19. The numbers of applications prorated to the population were highest in Switzerland and in Germany. In Finland this rate has increased continually, and in 1994 about 1 patent application more per 10 000 population was filed than in 1985. Among the countries in the comparison, only in the United States in addition to Finland did the rate increase during 1985–92.

International Comparison of Patenting

In 1994 Finnish applicants filed the largest numbers of applications in Sweden, France, and Germany (Table 5.20). The number of patent applications filed abroad increased in all of the most important patenting countries.

The number of patents granted to Finnish applicants also increased in 1994. The numbers of patents granted to Finnish applicants were largest in the United States and Germany.

European Patenting on Vigorous Increase

The European patent system was established in 1978, and after a slower development in the 1980s it has become an increasingly important channel for patenting. At present it is a uniform patenting system which is not based on the system of any specific country, and therefore no country has a 'home advantage' in this respect, although a European orientation of some degree will probably remain. The annual number of applications is about 55 000, slightly less than one-half of them being from European countries.

The share of Finland quadrupled from 1981 to 1993. Finnish applicants filed about 450 applications. Among the other Nordic countries, the share of Sweden dropped from 2.3 per cent to one and a half per cent during the same period.

5.20
Patent applications* filed by Finnish applicants and patents granted to Finnish applicants in certain OECD countries 1990–93

	1991		1992		1993		1994	
	Applications	Granted	Applications	Granted	Applications	Granted	Applications	Granted
Sweden	442	271	424	119	459	227	494	276
Norway	123	104	126	75	120	54	136	51
Denmark	200	51	250	63	226	86	248	112
Germany	374	181	365	159	409	222	530	278
France	396	150	383	159	436	198	480	275
Great Britain	351	184	340	177	391	200	450	222
Switzerland	253	96	238	93	231	123	267	160
Austria	308	129	284	115	249	158	288	196
Japan	116	39	117	44	98	63	319	51
Canada	253	111	221	137	111	115	–	–
United States	331	331	360	360	293	293	312	312

* Applications which have become public

5.21
European patent applications by country group 1981–93

	1981	1883	1985	1987	1989	1991	1993
	Percentage shares						
EU	52.8	48.9	45.9	46.5	46	41.9	42.6
EFTA	8.7	8.1	7.9	7.4	6.7	6.6	6.5
– Finland	0.2	0.4	0.3	0.4	0.5	0.6	0.8
Former socialist countries of Eastern Europe	0.3	0.5	0.5	0.5	0.7	0.5	0.3
NAFTA	27.3	27.4	28.4	28.1	26.1	27.3	29.4
Other American countries	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Japan	9.4	13.4	15.5	15.4	19	21.9	19.1
DAE[1]	0.1	0.1	0.1	0.2	0.2	0.4	0.6
ASEAN countries[2]	0	0	0	0	0	0	0
Other Asian countries	0	0	0	0.1	0.1	0.1	0.1
Oceania3	0.8	1.1	1.1	1.2	0.6	0.6	0.6
Number	**22 332**	**28 964**	**36 238**	**43 137**	**51 110**	**58 021**	**55 354**

1 DAE: Developing Asian Economies; Hong Kong, Korea, Singapore, Taiwan
2 Indonesia, Malaysia, the Philippines, Thailand
3 Australia, New Zealand

Source: European Commission, The European Report on Science and Technology 1994

5.22
Shares of certain OECD countries in patents granted to foreign applicants in the United States 1990–94

	1990	1991	1992	1993	1994
	%	%	%	%	%
Finland	0.7	0.7	0.8	0.6	0.7
Sweden	1.8	1.6	1.4	1.4	1.5
Norway	0.3	0.2	0.2	0.3	0.3
Denmark	0.4	0.5	0.4	0.4	0.5
Germany	17.7	16.9	16.2	15.3	14.8
France	6.7	6.7	6.7	6.4	6.1
Great Britain	6.5	6.2	5.4	5.1	4.9
Switzerland	3.0	2.9	2.6	2.5	2.6
Austria	0.9	0.8	0.8	0.7	0.6
Japan	45.4	46.4	48.5	49.4	49.1
Canada	4.3	4.5	4.3	4.3	..
Patents granted total	**42 971**	**45 331**	**45 190**	**45 111**	**45 484**

The country with the largest share, 28.4 per cent, in patent applications filed through the EPO in 1993 was the United States. Next largest numbers of patent applications were filed by Germany and Japan, the share of each being about five per cent of all applications. In general, the shares of applicants from European countries have decreased and those of the United States and Asian countries have increased.

Slight Increase in Foreign Patenting in United States

The United States patenting system differs from, for example, the patenting system of Finland in that information on only the patents granted are made public (Table 5.20).

In 1994, foreign applicants were granted in the United States a total of 45 484 patents, of which slightly fewer than one-half were to Japanese applicants. In the early 1990s the share of Finnish applicants, 0.7 per cent, of the patents granted has remained relatively constant.

Of the patents granted in the United States to Finnish applicants, the largest proportion were patents in the field of telecommunications (18 %). Other large groups were process technology (9 %) and sensors (9 %).

Table 5.23 shows the average development of patents granted in the United States by country group. The table is based on a key between the United States patent classification and the Standard Industrial Classification. The percentages of change have been calculated from the increase/decrease in the shares.

5.23
Average annual changes in patenting in the United States by industrial classification and by country group 1981–93

	Aircraft	Electronics	Drugs	Machinery	Land transport equipment	Chemicals	Other
	%	%	%	%	%	%	%
EU	0.54	–4.73	–1.59	–1.72	–1.32	–1.17	– 2.21
EFTA	–5.42	–4.10	–35.52	–2.80	–5.41	–2.59	–3.29
Former socialist countries of Eastern Europe		–16.15	–7.95	–15.23	–14.55	–12.35	–15.97
NAFTA	–0.81	–0.45	0.51	–0.54	–0.97	–0.42	–0.19
Other American countries		3.72	–7.80	2.59	–5.65	10.17	4.19
Japan	17.78	3.37	2.08	4.27	3.38	3.87	3.65
DAE[1]		25.22	22.04	23.16	17.57	16.08	18.50
ASEAN countries[2]		15.75	–1.86	4.74		13.67	0.93
Other Asian countries		19.72	14.27	20.42		14.40	12.88
Oceania[3]	2.58	–3.99	3.23	–1.91	–0.30	–3.48	–2.20
Israel/South Africa		2.43	4.16	–0.50	–0.22	–0.46	0.18
Applications							
1983	180	12 446	3 472	13 895	1 824	5 719	12 092
1993	270	29 115	6 686	20 322	2 959	8 136	18 603

1 DAE: Developing Asian Economies; Hong Kong, Korea, Singapore, Taiwan
2 Indonesia, Malaysia, the Philippines, Thailand
3 Australia, New Zealand

Source: European Commission, The European Report on Science and Technology 1994

The shares of the EU countries during 1983–93 on average decreased in all industries except aircraft. The decrease in the share was especially strong in electronics. The shares of the EFTA countries (including Finland) also decreased. The share has decreased in particular in drugs.

Respectively, the shares of Asian countries increased. Japan increased its share in particular in aircraft. The developing economies of Asia (Hong Kong, Singapore, Korea, and Taiwan) and the ASEAN countries (Indonesia, Malaysia, the Philippines, and Thailand) increased their shares in patenting in electronics, and other Asian countries (China, Pakistan, and India) in machinery.

Other Patent Indicators

The development of patenting in different countries is compared using indicators based on the numbers of patent applications. The tables depicting patent indicators in various OECD countries are derived from the OECD publication 'Main Science and Technology Indicators 1, 1995.'

Acronyms Used:

NA = Total of patent applications filed
DA = Domestic patent applications
FA = Foreign patent applications
EA = External patent applications
(Patent applications filed abroad)

The DA/NA ratio (ratio of domestic to all patent applications) describes technological independence in terms of patenting. The closer to one the ratio, the less dependent the country is on foreign technology.

According to this indicator, the dependence of Finland on foreign technology increased somewhat in the early 1990s, after patent applications by foreign business enterprises took an upturn after a period of slight decline.

Increasing internationalisation can also be seen as increased patent activity in nearly all countries; in particular, applications filed on the basis of international patent treaties increased. Patent applications are filed in all countries of the potential market area. Only in Japan has the share of domestic applications remained considerably higher than in other countries.

Surplus in Finnish Balance of Patents

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

In 1992 the surplus of the Finnish balance of patents was 2 per cent. Including international patent applications, Finnish applicants filed 12 991 applications abroad, which is 241 applications fewer than in 1991. Foreign applications filed in Finland also decreased slightly during the same period.

The patent balances of the other Nordic countries continued to show a deficit. The patent balances of the leading industrial countries (United States, Japan, Germany) clearly showed a surplus.

5.24
Ratio of domestic to all patent applications in certain OECD countries 1988–91

	1988	1989	1990	1991	1992
Finland	**0.21**	**0.18**	**0.16**	**0.16**	**0.14**
Sweden	0.09	0.08	0.07	0.07	0.07
Norway	0.10	0.10	0.08	0.07	0.07
Denmark	0.11	0.10	0.04	0.03	0.03
Germany	0.38	0.36	0.32	0.35	0.35
France	0.19	0.18	0.16	0.17	0.16
Austria	0.07	0.06	0.05	0.05	0.05
Switzerland	0.10	0.09	0.08	0.07	0.07
Great Britain	0.26	0.24	0.21	0.22	0.21
Japan	0.89	0.89	0.88	0.88	0.88
United States	0.51	0.51	0.52	0.50	0.50
OECD total	**0.46**	**0.44**	**0.41**	**0.41**	**0.37**

5.25
Ratio of external to foreign patent applications in certain OECD countries 1982–92

	1982	1984	1986	1988	1990	1992
Finland	**0.76**	**0.75**	**0.71**	**0.90**	**0.94**	**1.02**
Sweden	0.65	0.60	0.58	0.61	0.60	0.74
Norway	0.33	0.29	0.30	0.35	0.48	0.63
Denmark	0.60	0.54	0.62	0.77	0.30	0.40
Germany	1.98	2.12	2.27	2.43	2.45	2.54
France	0.95	0.87	0.90	0.99	1.01	1.06
Austria	0.27	0.26	0.29	0.26	0.23	0.28
Switzerland	1.11	1.05	0.90	0.86	0.79	0.84
Great Britain	0.79	0.76	0.85	0.91	1.12	1.38
Japan	2.02	2.07	2.30	2.77	2.98	2.79
United States	2.52	2.81	2.86	2.79	3.49	4.43
OECD total	**1.09**	**1.11**	**1.13**	**1.17**	**1.21**	**1.26**

Considerable Increase in Dissemination of Technology Developed in Finland

The EA_t / DA_{t-1} ratio is an indicator of the dissemination of technology. It depicts the proportion of inventions for which patents are applied also 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. Domestic applications also include the patent applications filed by private persons, which in turn are proportionately fewer among the applications filed abroad. Indicator values based on patent applications filed only by business enterprises would be higher than those presented.

The dissemination of Finnish technology abroad nearly tripled within ten years (Table 5.26). The growth was especially strong in the early 1990s. Increasingly often also a foreign application is filed regarding an invention. The trend is similar in the other Nordic countries. Economic integration has led to a situation in which patent applications are filed at the same time in a plurality of countries. It should be noted, however, that all patents applied for or named through various patent treaties do not lead to actual patent applications, to speak nothing of patents granted.

5.26
Ratio of external patent applications to domestic patent applications of previous year in certain OECD countries 1982–92

	1982	1984	1986	1988	1990	1992
Finland	**2.2**	**2.1**	**2.4**	**3.6**	**5.0**	**6.1**
Sweden	3.2	3.4	4.2	5.9	8.0	10.1
Norway	2.3	2.1	1.9	3.4	5.2	8.9
Denmark	3.4	3.2	5.7	7.6	9.1	14.2
Germany	2.6	2.8	3.1	3.9	4.9	5.0
France	3.1	3.2	3.3	4.1	5.3	5.5
Austria	1.7	2.2	2.8	3.3	4.2	5.5
Switzerland	5.2	5.6	6.5	7.5	8.8	11.8
Great Britain	1.6	1.8	2.2	2.7	4.0	5.1
Japan	0.3	0.3	0.3	0.3	0.4	0.4
United States	2.0	2.5	2.6	2.9	3.6	4.7
OECD total	**1.2**	**1.2**	**1.2**	**1.4**	**1.8**	**2.2**

5.3 Economic Impacts of Science and Technology, and Technology Transfer

The new technology produced by innovation is also visible in industrial output and foreign trade. The present sub-chapter describes the economic impacts of science and technology by using indicators describing capital expenditure by industry, and the output of and foreign trade in high technology products.

5.3.1 Capital Expenditure

Capital Expenditure as Technology Indicator

Capital expenditure on machinery and equipment is in general always associated with the exploitation of new technology. Data on capital expenditure thus indirectly describe the adoption of new technology. The data published here originate in the system of national accounts of Statistics Finland.

Development of Capital Expenditure on Machinery and Equipment

In 1994 the capital expenditure by the manufacturing industries on machinery and equipment amounted to FIM 10 900 million, which was 80 per cent of the total fixed capital expenditure. Owing to the economic depression, capital expenditure dropped to the level preceding the 1980s (Figure 5.27), but again took an upturn in 1994. The total capital expenditure increased most in the manufacture of electrical engineering products and instruments, in which it increased by more than 70 per cent from the level of the peak year 1989. In the manufacture of vehicles the total capital expenditure of 1994 also exceeded the 1989 level. The other manufacturing industries remained below the 1989 level.

5.3.2 Output of and Foreign Trade in High Technology Products

Concept and Definition of High Technology

The characteristics of high technology products and processes are deemed to include a strong input into R&D, rapid outdating of the products and processes, high and risky outlays of capital, strategic importance, and strong international co-operation and competition. These characteristics are implicitly associated most often with computers and electronics, space research, new drugs, advanced weapons systems, equipment required for the production of nuclear power, and the like.

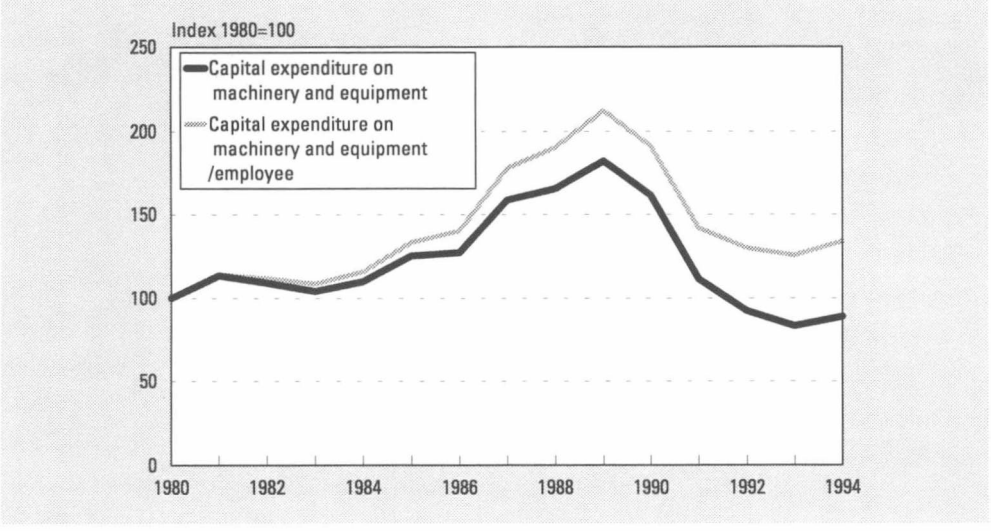
In defining high technology there are in principle two different approaches:

1. industry-specific approach
2. product-specific approach.

1. High Technology Industries

Conventionally the definition of high technology has been based on industries in which the proportion of R&D expenditure to turnover is relatively high. The industries have also been classified into categories of high, medium and low R&D intensity, as follows:

- high intensity: share of R&D expenditure over 4 per cent of turnover
- medium intensity: R&D share over 1 per cent and less than 4 per cent
- low intensity: R&D share 1 per cent or less.



5.27
Capital expenditure of the manufacturing industries on machinery and equipment 1980–94

According to this method, aircraft manufacture and the manufacture of computers, drugs, electronics products, and electrical appliances and apparatus have been defined as high technology industries. This definition by the OECD has been applied in preparing the statistics on Finnish high technology output.

This definition is deficient in that it is probably outdated and that it does not include technology embodied to the intermediate products used or the machinery and equipment required by an industry, i.e. the indirect technology. The definition was drawn up at the beginning of the 1980s, after which there have presumably occurred changes in the structures of the R&D activities of different countries, and these changes should be taken into account. Taking indirect technology into account provides a more detailed picture of the technology level of those industries whose own R&D activities are not so extensive and which mainly exploit technology developed in other industries.

For this reason, the OECD has drawn up a new industrial classification based on estimated total technology intensity. The classification is based on the data of those ten OECD countries (United States, Japan, Germany, France, Great Britain, Canada, Italy, the Netherlands, Australia and Denmark regarding which there were available uniform R&D expenditure and input-output data necessary for the calculation of indirect technology. The assessment of the total technology of the Finnish manufacturing industries and the development of the technology intensities of various industries have been described in Statistics Finland report 'Technology intensity of Finnish manufacturing industries' (Science and Technology 1993:3).

In the new definition, the medium technology category has been further divided into categories of high-medium technology and low-medium technology. The manufacture of electric appliances and equipment has been transferred from the category of high technology to that of high-medium technology. This definition and the industrial codes according to TOL88, the industrial classification of Statistics Finland, are shown in Appendix 5.1.

2. High Technology Products

Product-specific definition has the advantage of higher precision. It is also possible to include high technology products of industries classified into the category of low technology and respectively to exclude those products of high technology industries which cannot be counted as high technology products.

High technology products can further be selected in two ways.

1. assessment by experts
2. quantitative methods

In assessment by experts, the products manufactured are reviewed and a decision is made regarding each one as to whether it is a high technology product or not. In quantitative definition, a method based on product-group-specific R&D intensity is generally used.

In the present publication, Statistics Finland definition of high technology products is used; this definition follows the previous OECD product-specific definition. Methodologically it is a combination of the two approaches described above. The definition is presented in Appendix 5.2.

Differing and excessively aggregated classifications in R&D statistics and other statistics constitute a general problem in the definition of high technology products. In other words, it is not known precisely at which products R&D activity is targeted, and it is not possible to pick out these products from output and foreign trade statistics. For example, in the statistics on the R&D of Finnish business enterprises the use of R&D expenditure is allocated to 56 product groups; the Standard International Trade Classification (SITC) at its most precise level comprises 3118 items; and the even more detailed Harmonised System for the Description and Coding of Goods (HS) comprises about 6200 items.

The data on the values of output and foreign trade are not fully comparable. The value of output is calculated from the ex works price, the value of exports from the FOB price, and the value of imports from the CIF price. The differences among these values consist mainly of relatively small transportation costs. Time differences cause bias in the statistics. Output is included in the statistics after the product is completed at the works, exports and imports for their part after customs clearance has been performed. In a time series examination, this will not cause much harm, since the same procedure is repeated annually, the system thus being self-correcting. Different producers of statistics may have differences in their placement of goods under the various headings.

Output of High Technology Products

Table 5.28 shows manufacturing industry enterprises classified by technology level according to the principal industry of the enterprise. The data are derived from the business enterprise register of Statistics Finland.

From 1989 to 1993 the number of manufacturing industry enterprises decreased by about 3000. The total personnel of the manufacturing industry enterprises decreased within the same period by about one-fourth.

Among the manufacturing industry enterprises, the share of business enterprises operating in high technology industries increased from 1989 to 1993 by slightly less than half a percentage point. In 1993, high technology enterprises in Finland numbered 499. High-medium technology enterprises increased their share by two percentage points, and respectively the share of low technology enterprises decreased.

In 1993 about 7 per cent of all personnel were in high technology enterprises. The share had increased by two and a half percentage points from 1989. On the other hand, the personnel share of high-medium technology enterprises, which include the manufacturers of electrical engineering products, had remained almost unchanged.

Assessed on the basis of share in turnover the change in the share of high technology industries was even greater. In 1993 the high technology and high-medium technology industries accounted for a total of about 38 per cent of the total turnover of manufacturing industry enterprises.

The value of high technology products manufactured in 1993 totalled about FIM 24 000 million (Table 5.29). The output increased by 38 per cent from the previous year. The output of other products increased considerably less, by 7 per cent.

The share of telecommunications equipment in the output of high technology products continued to increase. The share of these products was about 38 per cent, the growth being about 8 percentage points from the previous year. Other large product groups were electronic data processing equipment (17 %) and chemicals (8 %).

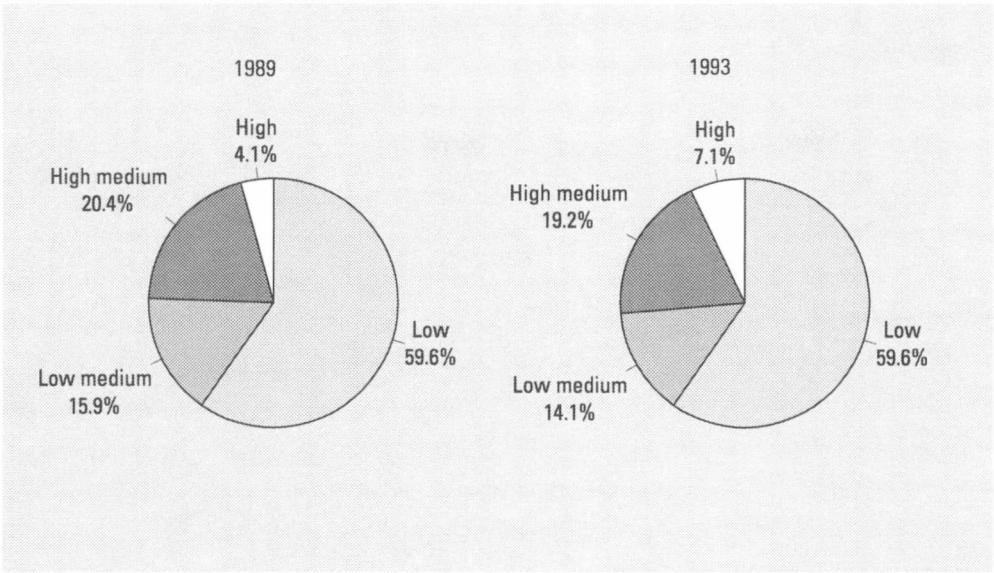
5.28
Manufacturing industry enterprises by technology level 1989–93

Technology level	1989			1991			1993		
	number %	personnel %	turnover %	number %	personnel %	turnover %	number %	personnel %	turnover %
High	2.0	4.2	3.5	2.2	5.9	4.7	2.4	6.8	6.5
High medium	14.9	21.5	27.0	15.2	22.3	30.9	17.0	21.9	31.2
Low medium	30.1	18.3	13.9	30.8	19.7	13.6	30.1	18.8	13.0
Low	53.0	56.0	55.6	51.9	52.1	50.9	50.4	52.5	49.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Business enterprises, number	23 373			23 963			20 393		
Personnel		504 978			445 385			374 683	
Turnover, FIM 1000			305 558 263			293 072 689			321 685 256

Source: Business Enterprise Register of Statistics Finland.

5.29
Output of high technology products 1991–93

	1991		1992		1993	
	FIM million	Percentage share	FIM million	Percentage share	FIM million	Percentage share
Space and aviation	24.4	0.0	30.2	0.0	169.5	0.1
Electronic data processing equipment	1913	0.8	3 221.5	1.3	4 134.5	1.5
Printed circuits and components	445.4	0.2	611.1	0.2	746.0	0.3
Telecommunications equipment	3 411.1	1.4	4901	2.0	9 092.1	3.4
Pharmaceuticals	254.8	0.1	433.3	0.2	396.2	0.1
Instruments	1 557.8	0.6	1 649.3	0.7	1 971.8	0.7
Electrical appliances	3 007.3	1.2	3 214.8	1.3	3 674.1	1.4
Power engines and equipment	1 091.4	0.4	1 238.3	0.5	1 676.7	0.6
Automated machine tools	135.6	0.1	124.2	0.1	128.2	0.0
Chemicals	1 777.9	0.7	1 850.2	0.8	1 924.6	0.7
High technology products total	**13 618.7**	**5.5**	**17 273.9**	**7.2**	**23 913.7**	**8.9**
Other products	230 593.4	94.5	228 967.4	92.8	245 267.9	91.1
Output total	244 212.2	100.0	246 241.2	100	269 181.5	100.0



5.30
Manufacturing industry output by technology level 1989 and 1993

Foreign Trade in High Technology Products

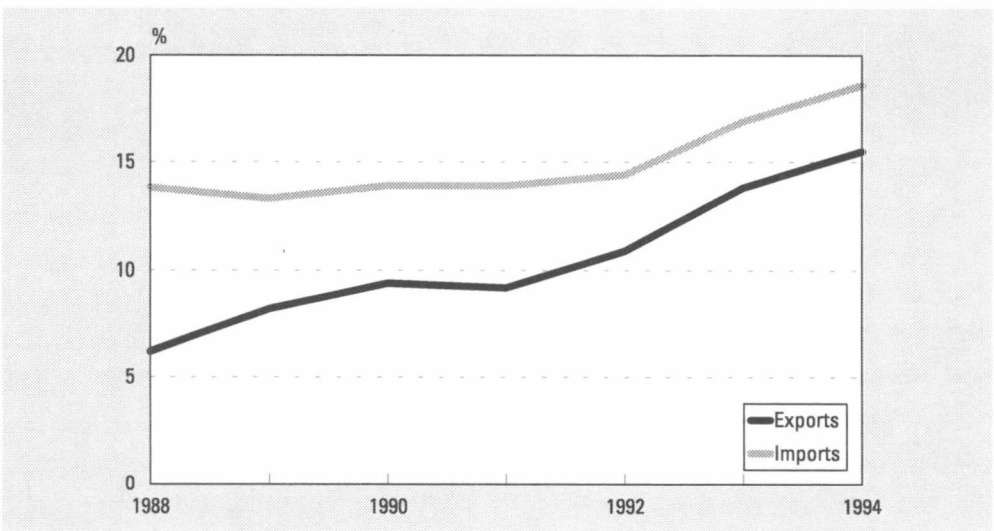
Exports of High Technology Products FIM 24 000 million

The growth in Finnish exports of high technology products has been very strong, especially in recent years (Table 5.32). The value of high technology exports more than quadrupled from 1988 to 1994. In 1994 the share of high technology exports in the total exports of goods was 15.5 per cent (Figure 5.32). The value of high technology imports in 1994 was about FIM 22 000 million. The share of high technology imports in total imports of goods was slightly less than 19 per cent.

The leading countries for Finnish high technology exports in 1994 were Sweden and Great Britain, each with a share of about 12 per cent. The share of the EFTA countries was about 16 per cent and that of the EU countries 40 per cent. The share of each country group decreased somewhat from the previous year. The share of the EFTA countries in high technology imports to Finland was 11 per cent (Sweden 6 %) and of the EU countries 35 per cent (Germany 14 %). The leading countries for Finnish high technology imports in 1994 were the United States (20 %) and Japan (17 %).

Surplus in Balance of Trade of High Technology Products

In 1993 the Finnish balance of trade in high technology products for the first time showed a surplus, about FIM 1000 million. The surplus increased further in 1994, when the exports were about FIM 1600 million more than the imports. The surplus is in part due to the drastic weakening of the domestic demand for imported commodities because of the economic depression. In the total foreign trade the surplus in 1994 was slightly less than FIM 34 000 million.



5.31
Shares of high technology imports and exports in total Finnish imports and exports 1988–94

5.32
Finnish foreign trade in high technology products 1988–94

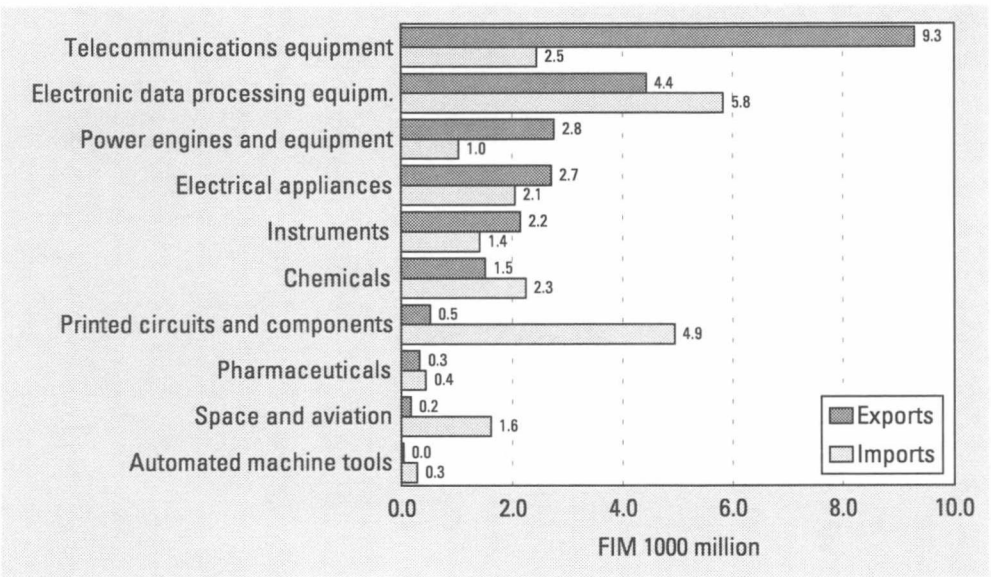
Year	FIM million (in current prices)				% of trade	
	Total trade	Imports	Exports	Trade balance	Imports	Exports
1988	17 705.7	12 135.9	5 569.8	–6 566.1	68.5	31.5
1989	22 179.2	14 038.4	8 140.8	–5 897.6	63.4	36.6
1990	23 831.5	14 270.3	9 561.2	–4 709.1	67.0	33.0
1991	20 722.6	12 185.9	8 536.7	–3 649.2	58.8	41.2
1992	25 378.2	13 677.5	11 700.7	–1 976.8	52.7	47.3
1993	35 863.9	17 422.2	18 441.7	+1 019.5	48.6	51.4
1994	46 236.6	22 313.5	23 923.1	+1 609.5	48.3	51.7

Exports Increasingly Concentrated in Telecommunications Equipment

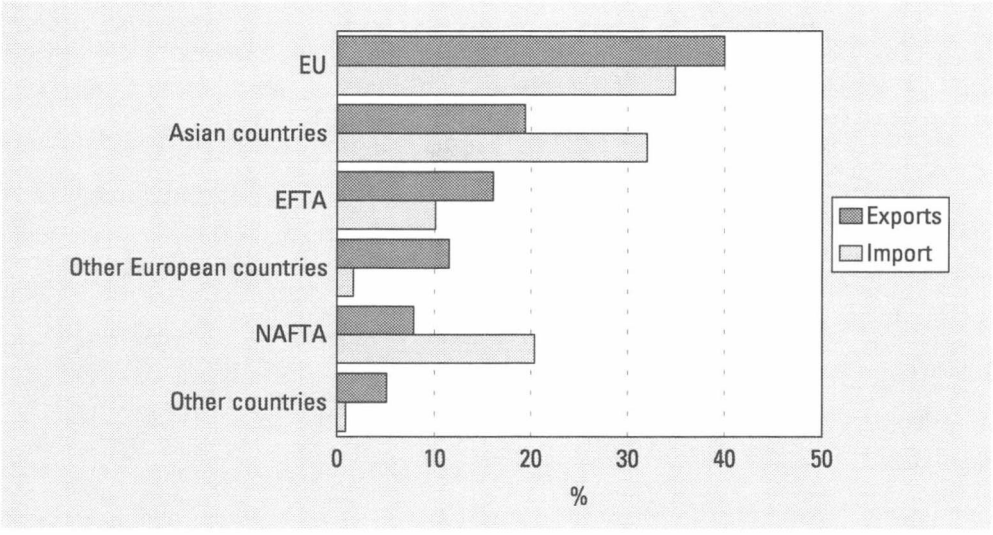
Telecommunications equipment continued to increase its share as the largest product group (Table 5.33). Its share in 1994 was nearly 40 per cent of the exports of high technology products, the increase being more than 5 percentage points from the previous year. Other major product groups were electronic data processing equipment, and power engines and equipment. Of the telecommunications equipment, 16 per cent were exported to EFTA countries (Sweden 14 %), 40 per cent to EU countries (Great Britain 14 %), and about 17 per cent to other European countries (Russia 4 %). Most of the electronic data processing equipment was exported to EFTA countries (21 %) and EU countries (54 %).

5.33
Finnish exports and imports of high technology products by product group 1994

	Exports	Imports	
	%	%	Exports/imports
Space and aviation	0.7	7.2	0.11
Electronic data processing equipment	18.5	26.1	0.76
Printed circuits and components	2.2	22.2	0.11
Telecommunications equipment	38.8	10.9	3.79
Pharmaceuticals	1.4	2.0	0.75
Scientific instruments	9.0	9.0	1.52
Electrical appliances and apparatus	11.4	9.2	1.32
Power engines and equipment	11.6	4.6	2.68
Automated machine tools	0.2	1.3	0.07
Chemicals	6.3	6.3	0.67
Total	**100.0**	**100.0**	**1.07**
Value (FIM 1000 million)	23.9	22.3	



5.34
Finnish foreign trade in high technology products by product group 1994



5.35
Finnish foreign trade in high technology products by country group 1994

More than 60 per cent of the power engines were exported to countries outside Europe. Of the exports to the United States (FIM 1700 million), the largest proportion in 1994 consisted of electronic data processing equipment (32 %) and instruments (25 %). Of the electronic data processing equipment, the largest proportions were imported from the EU countries (27 %) and the United States (26 %). Of the printed circuits and components, the largest proportions were imported from Japan (33 %) and from the United States (20 %).

Among the product groups, the largest surplus in 1994 was in telecommunications equipment, in which the exports were nearly four times greater than the imports. On the other hand, the largest deficit was in automated machine tools, the imports of which were 14-fold the exports.

Foreign Trade in High Technology Products in Other OECD Countries

In a comparison with certain other OECD countries, the share of high technology products in exports during 1989–93 grew most in Finland (Table 5.36). The share increased by 5.6 percentage points. In 1993 the share of Finland was already slightly higher than the respective share of Sweden. The shares of the United States, Japan and Great Britain continued to be clearly highest. In 1993, the shares of imports of high technology products were equal in Sweden and Finland. The share was smallest in the imports of Japan, 12 per cent.

5.36
Shares of imports and exports of high technology products in the total imports and exports of certain OECD countries 1989 and 1993

Country	1989		1993	
	Imports	Exports	Imports	Exports
	%	%	%	%
Finland	13.3	8.2	16.9	13.8
Sweden	15.1	12.6	16.9	13.5
Norway	11.3	4.2	13.3	4.5
Denmark	13.0	8.9	12.8	8.9
Austria	12.3	9.5	12.8	10.4
Switzerland	13.0	17.0	14.4	17.2
Germany	15.3	14.5	15.5	14.9
France	14.1	15.0	16.2	18.0
Great Britain	16.1	22.0	20.4	24.9
Japan	9.5	24.4	12.1	26.1
United States	15.5	27.0	18.8	28.8

Expressed in FIM (Table 5.37) the high technology exports in 1993 were highest in value in the United States, over FIM 700 000 million. The balance of trade surplus of Japan was clearly the largest; the exports were over three times greater than the imports. In all of the major exporting countries, and in Finland, the balance of trade showed a surplus.

5.37
Foreign trade in high technology products in certain OECD countries 1989 and 1993

Country	1989			1993		
	Imports	Exports	Exports/imports	Imports	Exports	Exports/imports
	FIM 1000 million			FIM 1000 million		
Finland	**14.3**	**8.1**	**0.57**	**17.4**	**18.4**	**1.06**
Sweden	31.6	27.9	0.88	44.9	41.8	0.93
Norway	11.5	5.2	0.45	18.3	8.5	0.46
Denmark	14.7	10.3	0.70	22.4	19.0	0.85
Austria	20.5	13.3	0.65	33.8	24.8	0.73
Switzerland	32.4	37.4	1.15	50.8	63.4	1.25
Germany	176.4	212.6	1.21	303.1	332.4	1.10
France	115.2	110.8	0.96	194.3	222.7	1.15
Great Britain	138.9	144.0	1.04	247.2	247.4	1.00
Japan	84.3	287.5	3.41	165.5	537.7	3.25
United States	327.0	401.9	1.23	647.7	709.0	1.09

Appendix 5.1

Industrial Classification by Total Technology

1. High technology industries

- pharmaceuticals
- computers and office appliances
- telecommunications equipment
- instruments
- aircraft

2. High-medium technology industries

- chemical products
- rubber and plastics products
- machinery and equipment
- electrical equipment for industry
- electrical engineering products
- transport equipment

3. Low-medium technology industries

- glass, clay and stone products
- non-ferrous metals
- metal products
- ships and boats
- other transport equipment
- other manufacture

4. Low technology industries

- foodstuffs
- textiles
- clothing, leather products, footwear
- timber, wood products
- pulp and paper
- publishing, printing
- petroleum products
- metals

Appendix 5.2

High-Technology Product Groups and SITC-rev.3 Codes

1. Space and aviation

7131 = Internal combustion piston engines for aircraft
714 = Engines and motors, non-electric
792 = Aircraft and associated equipment excl. 79281, 79282

2. Electronic data processing equipment

75124 = Cash registers incorporating a calculating device
7513 = Photo-copying apparatus
752 = Automatic data processing machines and units thereof
75995 = parts of the electronic calculating machines of sub-group 7512
75997 = parts of the machines of group 752

3. Printed circuits and components

776 = Thermionic, cold cathode or photo-cathode valves and tubes, diodes, transistors, etc.
7722 = Printed circuits

4. Telecommunications equipment

764 = Telephone, telegraph, radio and television equipment excl. 7642, 76492, 76499
77318 = Optical fibre cables

5. Pharmaceuticals

541 = Medicinal and pharmaceutical products

6. Scientific instruments

774 = Electro-diagnostic and radiological apparatus
871 = Optical instruments and apparatus
8731 = Gas, liquid or electricity supply or production meters
874 = Measuring, checking, analysing and controlling instruments and apparatus excl. 8742, 8743

7. Electrical appliances and apparatus

771 = Transformers, converters
7723 = Electrical resistors, other than heating resistors; and parts thereof
7726 = Boards, panels (including numerical control panels)
7786 = Electrical capacitors
7787 = Particle accelerators
7788 = Electrical safety equipment

8. Power engines and equipment

716 = Rotating electric plant and parts thereof, n.e.s.
718 = Hydraulic turbines, nuclear reactors, etc.

9. Automated machine tools

7311 = Machine-tools for working any material by removal of material, by laser or other light or photon beam, ultra-sonic, electro-discharge, electro-chemical, electron beam, ionic-beam or plasma jet processes
7312 = Machining centres, unit construction machines
73131 = Horizontal lathes, numerically controlled
73135 = Other lathes, numerically controlled
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
73161 = Flat-surface grinding machines, numerically controlled
73163 = Other grinding machines, numerically controlled
73165 = Sharpening (tool or cutter grinding) machines, numerically controlled
73312 = Bending, folding, straightening or flattening machines (including presses), numerically controlled
73314 = Shearing machines (including presses), numerically controlled
73733 = Machines and apparatus for resistance welding of metal, fully or partly automatic
73735 = Machines and apparatus for arc, including plasma arc welding of metal, fully or partly automatic

10. Chemicals

5311,
5312 Synthetic organic coloring matter
5146 = Oxygen-function amino-compounds
516 = Other organic chemicals (excl. 5161)
525 = Radio-active and associated materials
575 = Other plastics, in primary forms
591 = Pesticides

Appendix Tables

Appendix Table 2.1
Population with tertiary education (15–64 years of age) by education level, by field of science and by sex 1975, 1980, 1985 and 1993 (excl. military education)

Education level (ISCED) / Field of science	1975 Total	1975 out of which women	1980 Total	1980 out of which women	1985 Total	1985 out of which women	1990 Total	1990 out of which women	1993 Total	1993 out of which women
Total	**195 353**	**92 854**	**245 330**	**119 034**	**290 965**	**144 148**	**352 493**	**176 937**	**413 222**	**214 329**
Doctorate										
(7) All	**5 379**	**841**	**7 230**	**1 276**	**9 066**	**1 838**	**12 719**	**3 122**	**16 276**	**4 710**
Natural sciences	1 394	195	1 925	336	2 389	480	3 044	728	3 524	916
Engineering	746	24	1 118	50	1 513	97	2 117	168	2 644	252
Medical and health sciences	942	167	1 332	249	1 791	369	3 349	992	5 097	1 909
Agriculture and forestry	287	71	313	79	335	98	401	130	462	160
Social sciences	1 148	166	1 526	276	1 857	414	2 307	582	2 777	808
Humanities	856	216	1 009	283	1 176	377	1 490	515	1 741	644
Fine arts	–	–	–	–	–	–	9	6	29	20
Unspecified	6	2	7	3	5	3	2	1	2	1
Higher tertiary										
(6) All	**135 075**	**54 142**	**175 761**	**72 918**	**208 845**	**87 529**	**248 385**	**106 698**	**273 982**	**120 279**
Natural sciences	11 373	4 671	15 126	6 373	17 971	7 863	20 179	8 996	21 812	9 855
Engineering	33 476	1 618	46 300	3 176	59 587	4 829	72 398	6 565	81 154	7 877
Medical and health sciences	13 475	6 497	16 204	8 260	17 741	9 600	19 593	11 544	20 305	12 545
Agriculture and forestry	4 697	1 275	5 112	1 523	5 650	1 920	9 053	2 563	9 953	2 935
Social sciences	45 621	22 026	60 937	31 529	71 203	37 924	87 501	49 377	98 160	57 359
Humanities	22 947	16 740	28 087	20 592	32 205	23 672	34 564	25 566	36 652	27 224
Fine arts	1 369	813	1 733	1 038	2 240	1 326	2 880	1 732	3 423	2 081
Unspecified	2 117	502	2 262	427	2 248	395	2 217	355	2 523	403
Lower tertiary										
(5) All	**54 899**	**37 871**	**62 339**	**44 840**	**73 054**	**54 781**	**91 389**	**67 117**	**122 964**	**89 340**
Engineering and natural sciences	536	89	871	261	1 580	595	8 503	1 758	17 258	3 161
Unspecified	54 363	37 782	61 468	44 579	71 474	54 186	82 886	65 359	105 706	86 179

Appendix Table 2.2
Tertiary degrees awarded by education level, by field of science and by sex 1985 and 1990–1993

Education level (ISCED) / Field of science	1985 Total	1985 out of which women	1990 Total	1990 out of which women	1991 Total	1991 out of which women	1992 Total	1992 out of which women	1993 Total	1993 out of which women
Total	**106 062**	**8 663**	**23 434**	**12 360**	**25 743**	**14 777**	**27 892**	**16 454**	**30 070**	**17 875**
Doctorate										
(7) All	**667**	**196**	**1 488**	**531**	**1 702**	**666**	**1 661**	**628**	**1 883**	**763**
Natural sciences	196	55	272	85	259	87	271	85	299	108
Engineering	141	16	199	24	246	38	268	36	275	46
Medical and health sciences	101	36	629	274	768	359	649	314	750	375
Agriculture and forestry	28	6	39	19	42	17	49	15	50	20
Social sciences	124	45	206	65	225	88	262	108	313	130
Humanities	77	38	137	60	156	71	158	68	183	75
Fine arts	–	–	6	4	6	6	4	2	13	9
Higher tertiary										
(6) All	**11 646**	**5 395**	**12 802**	**6 348**	**12 601**	**6 281**	**13 200**	**6 571**	**14 237**	**6 991**
Natural sciences	1 220	596	904	425	884	415	903	438	1 121	534
Engineering	3 370	437	3 547	469	3 602	485	3 897	545	4 283	549
Medical and health sciences	1 079	738	930	674	1 003	719	1 086	790	1 169	845
Agriculture and forestry	325	164	581	181	494	170	500	177	454	172
Social sciences	3 891	2 296	5 173	3 366	4 797	3 243	5 065	3 434	5 283	3 591
Humanities	1 543	1 052	1 448	1 106	1 447	1 078	1 389	1 028	1 484	1 112
Fine arts	147	90	182	125	247	157	232	140	234	152
Unspecified	71	22	37	2	127	14	128	19	209	36
Lower tertiary										
(5) All	**3 749**	**3 072**	**9 144**	**5 481**	**11 440**	**7 830**	**13 031**	**9 255**	**13 950**	**10 121**
Engineering and natural sciences	268	111	3 364	520	2 981	478	2 986	463	3 088	519
Unspecified	3 481	2 961	5 780	4 961	8 459	7 352	10 045	8 792	10 862	9 602

Appendix Table 3.1
Share of R&D expenditure in GDP and share of public funding in R&D expenditure in certain OECD countries 1981–1993, per cent

Country	1981		1987		1989		1991		1993	
	GDP share	Public funding	GDP share	Public funding	GDP share	Public funding	GDP share	Public funding	GDP share	Public funding
	%									
Netherlands	1.85	47	2.28	44	2.12	42	1.92	45	1,87	47
Ireland	0.70	57	0.86	42	0.84	34	1.02	28	1,06	26
Iceland	0.65	86	0.77	66	1.02	66	1.20	70	1,33	71
Great Britain	2.37	48	2.22	39	2.20	36	2.13	36	2,19	37
Italy	0.87	47	1.19	54	1.24	50	1.38	52	1,30	46
Austria	1.17	47	1.32	49	1.37	43	1.51	47	1,58	47
Japan	2.32	25	2.63	20	2.80	17	2.86	16	2,72	20
Canada	1.23	50	1.42	45	1.37	44	1.51	43	1,50	42
Norway	1.29	57	1.82	47	1.86	51	1.84	50	1,94	49
France	1.97	53	2.27	52	2.33	48	2.41	49	2,41	44
Sweden	2.29	42	2.98	37	2.94	38	2.86	35	3,12	..
Germany	2.43	41	2.88	35	2.87	34	2.63	36	2.48	37
FINLAND	1.20	43	1.76	38	1.83	35	2.07	41	2.23	43
Switzerland	2.29	25	..	..	2.86	23	2.68	28	2.68[1]	31
Denmark	1.10	54	1.42	46	1.55	46	1.70	40	..	..
United States	2.43	49	2.84	49	2.76	48	2.86	41	2.72	41
OECD countries	2.00	47	2.34	45	2.34	41	2.32	39	2.24	39
EU countries	1.72	48	1.97	44	1.99	42	1.98	42	1.96	..
Nordic countries	1.61	48	2.14	42	2.19	43	2.23	42	2.36	..

1 1992

Appendix Table 3.2
R&D expenditure by performer sector and by source of funding 1989 and 1993

Performer	Source of funding (FIM million)									
	Business enterprises		Public sector (incl. universities)		Funds		Foreign countries		Total	
	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993
Business enterprises	5 137	5 533	323	604	1	4	38	93	5 499	6 234
Public sector	183	190	1 437	1 992	50	21	31	55	1 701	2 258
Universities	83	100	1 580	2 004	47	37	16	44	1 726	2 185
Total	5 403	5 823	3 340	4 600	98	62	85	192	8 926	10 677
Share in R&D funding	61 %	55 %	37 %	43 %	1 %	1 %	1 %	2 %	100 %	100 %

Appendix Table 3.3
R&D expenditure by performer sector 1971–93

Year	Business enterprises		Public sector (+ private non-profit sector)		Universities		Total
	FIM million	R&D share %	FIM million	R&D share %	FIM million	R&D share %	FIM million
1971	238	55	107	24	91	21	436
1973	332	53	153	25	139	22	624
1975	497	52	253	27	204	21	954
1977	674	52	353	27	272	21	1 299
1979	958	55	470	27	320	18	1 748
1981	1 418	55	600	23	577	22	2 595
1983	2 060	56	791	21	845	23	3 696
1985	3 082	59	1 069	20	1 097	21	5 248
1987	4 002	59	1 389	20	1 401	21	6 792
1989	5 499	62	1 701	19	1 726	19	8 926
1991	5 798	57	2 126	21	2 248	22	10 172
1992	5 896	57	2 209	21	2 283	22	10 388
1993	6 234	58	2 258	21	2 185	21	10 677
1994	7 431	62	2 330	19	2 333	19	11 941

Appendix Table 3.4
Breakdown of R&D expenditure by province and by performer sector 1993, and change from 1989

Province	Business enterprise sector		Public sector		Universities		Total	
	Share %	Change 1989–93 percentage points	Share %	Change 1989–93 percentage points	Share %	Change 1989–93 percentage points	Share %	Change 1989–93 percentage points
Uusimaa	50.2	–0.5	61.7	–4.5	40.7	–2.0	50.8	–4.4
– of which the Metropolitan Helsinki area	39.1	3.5	59.0	–5.7	40.7	–1.9	43.7	4.7
Turku and Pori	15.1	1.1	2.8	0.5	15.2	0.4	12.6	1.8
Häme	10.2	–1.1	13.8	1.9	12.1	0.3	11.3	0.9
Kymi	4.1	–1.9	0.4	–0.2	2.5	0.3	3.0	–0.9
Mikkeli	1.5	0.1	1.0	0.2	0.4	0.0	1.2	0.2
Northern Karelia	0.7	0.1	1.6	0.3	3.8	0.6	1.5	0.4
Kuopio	1.2	–0.6	2.9	0.4	4.7	0.6	2.3	0.2
Central Finland	3.3	0.0	3.3	–0.7	6.5	–0.4	4.0	0.3
Vaasa	5.3	0.7	1.0	–0.2	1.7	0.7	3.7	0.7
Oulu	7.2	1.9	6.8	1.6	11.2	–0.8	7.9	2.0
Lapland	1.0	0.0	3.9	0.3	1.2	0.3	1.6	–1.1
Aaland	0.1	0.1	0.2	0.0	–	–	0.0	0.0
Unspecified	0.1	0.1	0.6	0.3	–	–	0.1	–0.1
Expenditure (FIM million)	6 234	735	2 258	557	2 185	507	10 677	1 799
R&D share (%)	58.4	–3.6	21.1	2.1	20.5	1.5	100.0	–

Appendix Table 3.5
R&D personnel by education, by sex and by performer sector 1993

Education	Business enterprise sector		Public sector		Universities		All	
	Total	of which women	Total	of which women	Total	of which women	Total	of which women
Doctorates	442	70	881	203	3 040	656	4 363	929
Licentiate	473	62	562	150	1 644	524	2 679	736
Other upper tertiary degrees	5 990	1 223	3 386	1 224	4 971	2 178	14 347	4 625
College engineers	3 919	309	354	35	122	23	4 395	367
Technicians	2 749	195	287	36	262	103	3 298	334
Other	6 105	2 536	3 619	2 326	3 305	1 715	13 029	6 577
Grand total	**19 678**	**4 395**	**9 089**	**3 974**	**13 344**	**5 199**	**42 111**	**13 568**
Share in R&D personnel	47 %		22 %		32 %		100 %	
Share of women in R&D personnel in the sector		22 %		44 %		39 %		32 %

Appendix Table 3.6
GDP share of R&D expenditure by performer sector in OECD countries 1992

Country	Business enterprises	Public Sector	Universities
	per cent		
Netherlands	0.97	0.37	0.48
Australia	0.80	0.44	0.35
Belgium	1.11	0.10	0.44
Spain	0.46	0.18	0.26
Ireland	0.66	0.14	0.24
Iceland	0.29	0.58	0.41
Great Britain	1.43	0.31	0.36
Italy	0.77	0.27	0.27
Austria	0.69	0.10	0.44
Japan	2.06	0.25	0.36
Canada	0.81	0.27	0.40
Greece	0.12	0.19	0.16
Norway	1.04	0.37	0.53
Portugal	0.15	0.16	0.31
France	1.51	0.49	0.37
Sweden	2.15	0.13	0.83
Germany	1.70	0.37	0.41
FINLAND	1.24	0.45	0.48
Switzerland	1.88	0.10	0.33
Denmark	1.02	0.30	0.38
Turkey	0.12	0.04	0.33
New Zealand	0.29	0.37	0.17
United States	2.04	0.27	0.40
Median of OECD countries	1.57	0.28	0.37

Appendix Table 3.7
Expenditure of business enterprises on commissioned research 1993

Performance site	Domestic		Foreign		Subsidies, etc.	Total	
	FIM million	%	FIM million	%	FIM million	FIM million	%
Unit of same corporation	285	43	305	72	–	590	50
Other business enterprise	160	24	65	15	–	225	19
Research institute	131	20	34	8	–	165	14
University	64	9	11	3	–	75	6
Other	30	4	6	2	90	126	11
Total	**670**	**100**	**421**	**100**	**90**	**1 181**	**100**

Appendix Table 3.8
R&D appropriations in Government Budgets, and their share in Government expenditure 1980–95

Year	Government expenditure	R&D funding	Share of R&D expenditure in Government expenditure	Real change		Cost index
	(in current prices)	(in current prices)		Government expenditure	R&D funding	1990=100
	FIM million	FIM million	%	%	%	
1980	49 441	1 063	2.2	–2.6	8.2	44.3
1981	55 744	1 238	2.2	0.3	3.6	49.8
1982	64 329	1 472	2.3	4.5	7.6	55.0
1983	69 329	1 665	2.4	–2.2	2.7	60.6
1984	76 524	1 896	2.5	1.0	4.2	66.2
1985	83 848	2 273	2.7	0.6	10.1	72.1
1986	90 409	2 558	2.8	2.2	6.6	76.1
1987	102 001	2 862	2.8	7.2	6.3	80.1
1988	111 884	3 240	2.9	2.9	6.2	85.4
1989	120 227	3 772	3.1	–0.1	8.2	91.9
1990	136 014	4 239	3.1	4.0	3.3	100.0
1991[1]	161 978	4 755	2.9	11.6	6.5	106.7
1992	178 780	4 993	2.8	8.3	3.1	108.7
1993	187 115	5 240	2.8	3.3	3.6	110.1
1994	178 137	5 275	3.0	–5.7	–0.2	111.1
1995[2]	171 139	5 545	3.1	–6.0	–1.1	113.6

1 From 1991 onwards, R&D funding has been calculated according to the net principle. In calculation according to the net principle, the estimated income from paid services is deducted from appropriations granted to State institutions and agencies. In addition, the comparability with previous years of figures regarding R&D funding is also reduced by the inclusion of pension contributions in R&D expenditure from 1991 onwards and by certain adjustments made after 1991 in the R&D shares. The real change in R&D funding from 1990 to 1991 has been calculated according to the gross principle. The gross expenditure on R&D funding in 1991 amounted to about FIM 4727 million.

2 Rebudgeting of the expenditure of Government real estate administration caused a computational addition of about FIM 211 million in the R&D expenditure. Data for 1995 without the Supplementary Budget.
From 1995 rents of Government buildings have been included. Share of R&D expenditure in Government expenditure and real change of R&D funding has been calculated without these rents.

Appendix Table 3.9
Government R&D appropriations by administrative field 1989, 1994 and 1995

Administrative field	FIM million			Per cent		
	1989	1994	1995[1]	1989	1994	1995
Ministry of Trade and Industry	1 449	2 077	2 227	38.4	39.4	40.2
Ministry of Education	1 477	1 898	2 029	39.2	36.0	36.6
Ministry of Agriculture and Forestry	342	449	445	9.1	8.5	8.0
Ministry of Social Affairs and Health	134	305	326	3.5	5.8	5.9
Ministry of Transport and Communications	50	165	165	1.3	3.1	3.0
Ministry of the Environment	64	136	124	1.7	2.6	2.2
Ministry of Defence	59	111	115	1.6	2.1	2.1
Ministry of Foreign Affairs	110	80	61	2.9	1.5	1.1
Ministry of Finance	56	27	27	1.5	0.5	0.5
Ministry of Labour	7	9	11	0.2	0.2	0.2
Ministry of the Interior	17	12	9	0.4	0.2	0.1
Ministry of Justice	7	5	5	0.2	0.1	0.1
Prime Minister's Office	0	2	1	0.0	0.0	0.0
Total	**3 772**	**5 275**	**5 545**	**100.0**	**100.0**	**100.0**

1 Rebudgeting of the expenditure of Government real estate administration caused a computational addition of about FIM 211 million in the R&D expenditure. Data for 1995 without the Supplementary Budget.

Appendix Table 3.10
Government R&D appropriations by research organization 1989, 1994 and 1995

Research organization	FIM million			Per cent		
	1989	1994	1995	1989	1994	1995
Universities	1 006	1 278	1 436	26.7	24.2	25.9
Academy of Finland	311	491	457	8.2	9.3	8.2
Technology Development Centre	672	1 410	1 654	17.8	26.8	29.8
State research institutes	1 170	1 182	1 212	31.0	22.4	21.9
Other R&D funding	613	914	786	16.3	17.3	14.2
Total	**3 772**	**5 275**	**5 545**	**100.0**	**100.0**	**100.0**

Appendix Table 3.11
Government R&D appropriations by objective 1989, 1994 and 1995

Objective	FIM million			Per cent		
	1989	1994	1995	1989	1994	1995
Agriculture, forestry and fisheries	313	378	389	8.3	7.2	7.0
Promotion of industry	1 042	1 735	1 847	27.6	32.9	33.3
Energy	160	184	198	4.2	3.4	3.6
Defence	59	111	115	1.6	2.1	2.1
Soil, water and atmosphere	197	109	92	5.2	2.1	1.6
Social policy and services	533	813	803	14.2	15.4	14.5
Transport and telecommunications	74	146	148	2.0	2.8	2.7
Housing and communities	18	27	26	0.5	0.5	0.5
Environmental protection	63	126	121	1.7	2.4	2.2
Work and working environment	52	81	83	1.4	1.5	1.5
Health care	75	164	183	2.0	3.1	3.3
Social security	14	77	79	0.4	1.5	1.4
Education	9	11	11	0.2	0.2	0.2
Culture	31	44	43	0.8	0.8	0.8
International relations	96	47	36	2.5	0.9	0.6
Other social functions	101	90	74	2.7	1.7	1.3
General advancement of science	1 352	1 846	1 979	35.8	35.0	35.7
Universities	1 006	1 278	1 436	26.7	24.2	25.9
Other general advancement of science	346	568	543	9.1	10.8	9.8
Space	116	99	122	3.1	1.9	2.2
Total	**3 772**	**5 275**	**5 545**	**100.0**	**100.0**	**100.0**

Appendix Table 4.1
International researcher exchange of universities by university 1994, and change from 1990

University	Researcher exchange 1994				Change from 1990	
	Abroad from Finland[1]	From abroad to Finland[2]	Total		Abroad from Finland	From abroad to Finland
	number	number	number	%	number	number
University of Helsinki	328	387	604	33	+114	+111
University of Jyväskylä	75	89	108	6	+41	+56
University of Oulu	83	83	142	8	+5	+24
University of Joensuu	26	37	36	2	–1	+27
University of Kuopio	63	44	109	6	+13	–2
University of Turku	88	145	153	8	+24	+80
University of Tampere	62	44	103	6	+25	+3
Åbo Akademi University	43	65	68	4	+8	+40
University of Vaasa	10	10	13	1	+6	+7
University of Lapland	10	14	12	1	+5	+12
College of Veterinary Science	4	6	7	0	–9	+3
Helsinki University of Technology	71	158	209	12	–36	+20
Tampere University of Technology	38	66	102	6	+7	+2
Lappeenranta University of Technology	11	25	26	1	+1	+10
Helsinki School of Economics and Business Administration	19	85	29	1	+7	+75
Swedish School of Economics and Business Administration	11	2	13	1	+4	+2
Turku School of Economics and Business Administration	10	8	13	1	+5	+5
University of Industrial Arts	4	3	10	1	+3	–3
Sibelius Academy	–	32	32	2	–1	+26
Theatre Academy	1	3	6	0	+1	–2
Academy of Fine Arts	–	3	0	0	0	+3
Total	**957**	**1 309**	**1 795**	**100**	**+222**	**+499**

1 Work or postgraduate studies in foreign universities for more than one month by university personnel

Appendix Table 4.2
Academy of Finland grants for researchers' doctorates studies and work abroad by country and by field of science 1994

Country	Natural Sciences	Engineering	Medical sciences	Agriculture and forestry	Social sciences	Humanities	Total	
							number	%
United States	40	23	42	16	30	14	165	39.3
Great Britain	11	5	7	–	59	20	102	24.3
Canada	14	2	2	5	3	–	26	6.2
Germany	11	5	4	–	–	2	22	5.2
Netherlands	7	3	–	2	5	–	17	4.0
Sweden	6	2	1	3	4	1	17	4.0
France	7	4	–	1	4	–	16	3.8
Italy	2	–	1	–	9	3	15	3.6
Switzerland	4	1	–	–	3	1	9	2.1
Australia	4	–	2	–	–	1	7	1.7
Israel	–	–	–	–	–	5	5	1.2
Denmark	–	1	–	–	2	1	4	1.0
Norway	–	2	–	1	–	1	4	1.0
Belgium	2	–	–	–	1	–	3	0.7
Austria	1	–	–	–	1	–	2	0.5
Ecuador	–	–	–	2	–	–	2	0.5
Greece	–	–	–	1	–	1	2	0.5
Bolivia	–	–	–	–	1	–	1	0.2
Costa Rica	–	–	–	–	1	–	1	0.2
Total	**109**	**48**	**59**	**31**	**123**	**50**	**420**	**100.0**
Share in grants	26.0 %	11.4 %	14.0 %	7.4 %	29.3 %	11.9 %	100.0 %	

Appendix Table 4.3
Academy of Finland researcher exchange grants based on bilateral agreements by country and by field of science 1994

Country	Natural sciences	Engineering	Medical sciences	Agri-cultureand forestry	Social sciences	Humanities	Total	
							number	%
Russia	64	12	2	4	9	14	105	29.2
Poland	27	5	10	4	8	13	67	18.6
Estonia	21	10	1	–	10	5	47	13.0
Hungary	25	3	2	–	6	11	47	13.0
Czech Republic	7	3	2	–	–	5	17	4.7
China	4	–	1	2	5	1	13	3.6
Lithuania	5	–	2	–	6	–	13	3.6
Slovakia	5	2	1	1	1	1	11	3.1
Japan	2	5	1	2	–	–	10	2.8
Bulgaria	7	–	2	–	–	–	9	2.5
Rumania	5	–	1	–	–	1	7	1.9
Great Britain	3	–	–	–	–	3	6	1.7
Latvia	–	–	–	–	4	–	4	1.1
Austria	2	–	–	–	–	–	2	0.6
White Russia	–	1	–	–	–	–	1	0.3
Unknown	1	–	–	–	–	–	1	0.3
Total	**178**	**41**	**25**	**13**	**49**	**54**	**360**	**100.0**
Share in grants	49.5 %	11.4 %	6.9 %	3.6%	13.6 %	15.0 %	100.0 %	

Appendix Table 4.4
Centre for International Mobility grants for doctorates studies and researcher visits by country and by field of science 1994

Country	Humanities and social sciences		Natural sciences, biosciences		Engineering		Medical sciences		All		
	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	From Finland	To Finland	Total
Australia	–	1	–	1	1	–	–	–	1	2	3
Austria	2	–	3	2	–	–	–	–	5	2	7
Belgium	7	8	2	2	2	1	–	–	11	11	22
Bulgaria	1	1	–	3	–	1	–	1	1	6	7
Canada	–	2	–	1	–	–	–	–	0	3	3
China	7	5	–	16	–	9	–	6	7	36	43
Cuba	–	–	–	1	–	1	–	–	0	2	2
Czech Republic	7	5	1	2	–	1	–	1	8	9	17
Denmark	3	–	–	–	–	–	–	–	3	0	3
Egypt	1	–	–	–	–	–	–	2	1	2	3
Estonia	3	19	1	42	1	10	6	22	11	93	104
Ethiopia	–	1	–	–	–	–	–	–	0	1	1
France	9	3	5	5	2	3	2	5	18	16	34
Germany	10	8	4	5	1	2	–	2	15	17	32
Great Britain	–	4	–	2	–	2	–	–	0	8	8
Greece	5	1	–	–	–	1	–	–	5	2	7
Hungary	28	22	–	16	–	6	–	1	28	45	73
Iceland	–	3	–	4	–	–	–	–	0	7	7
India	2	–	–	2	–	–	–	1	2	3	5
Ireland	10	11	1	–	–	1	–	–	11	12	23
Israel	5	1	2	2	–	–	–	–	7	3	10
Italy	5	6	3	3	–	5	–	–	8	14	22
Japan	7	6	1	1	–	3	1	3	9	13	22
Latvia	1	6	–	9	–	2	1	1	2	18	20
Lithuania	2	4	–	4	–	2	–	4	2	14	16
Mexico	3	2	–	–	–	1	–	1	3	4	7
Netherlands	7	6	1	1	1	–	1	–	10	7	17
New Zealand	–	–	–	1	–	–	–	–	0	1	1
Norway	1	–	–	–	1	1	–	–	2	1	3
Poland	9	10	–	5	–	2	–	2	9	19	28
Portugal	2	1	1	–	–	1	–	–	3	2	5
Republic of Korea	–	–	–	–	–	–	–	–	0	0	0
Rumania	3	5	–	1	–	2	–	–	3	8	11
Russia	–	25	–	19	–	5	–	3	0	52	52
Slovakia	4	3	–	1	–	–	–	–	4	4	8
Spain	9	3	2	2	–	1	1	–	12	6	18
Sweden	1	–	–	1	1	–	–	–	2	1	3
Switzerland	–	–	1	1	–	–	–	–	1	1	2
Turkey	5	–	2	1	–	2	–	1	7	4	11
Turkmenistan	–	–	–	–	–	–	–	1	0	1	1
Unites States	–	7	–	2	–	1	–	1	0	11	11
White Russia	–	1	–	–	–	–	–	–	0	1	1
Total	**159**	**180**	**30**	**158**	**10**	**66**	**12**	**58**	**211**	**462**	**673**
Share in all researchers going abroad from Finland	75 %		14 %		5 %		6 %		100 %		
Share in all researchers coming to Finland		39 %		34 %		14 %		13 %		100 %	

Appendix Table 5.1
Patent applications filed in Finland by field of technology 1991–94

Field of technology	1991		1992		1993		1994	
	Number	Percentage share	Number	Percentage share	Number	Percentage share	Number	Percentage share
Mining, civil engineering, building materials, air-conditioning, waste treatment	784	12.7	675	11.2	638	10.7	583	9.4
Paper-making, printing	383	6.2	372	6.2	365	6.1	349	5.6
Textiles, clothing, amusement, textile machinery	170	2.7	132	2.2	147	2.5	136	2.2
Biomedicine	189	3.1	238	4.0	216	3.6	269	4.3
Agriculture, foods, beverages, tobacco	327	5.3	263	4.4	248	4.2	280	4.5
Biotechnology, genetic engineering, drug manufacture	519	8.4	577	9.6	534	8.9	601	9.7
Organic chemistry, petroleum chemistry	651	10.5	752	12.5	717	12.0	677	10.9
Polymeric materials (polymer chemistry)	230	3.7	204	3.4	206	3.5	194	3.1
Polymers manufacture and application	193	3.1	175	2.9	183	3.1	168	2.7
Inorganic chemistry	122	2.0	112	1.9	112	1.9	115	1.9
Coating, crystal growth	39	0.6	41	0.7	36	0.6	40	0.6
Process technology, separating and mixing of materials	274	4.4	244	4.1	257	4.3	291	4.7
Mechanical technology, machine construction, weapons	203	3.3	186	3.1	184	3.1	169	2.7
Material processing machine tools	280	4.5	242	4.0	251	4.2	266	4.3
Materials handling, conveying equipment, robots	330	5.3	310	5.2	336	5.6	338	5.4
Transporting, traffic	227	3.7	242	4.0	215	3.6	267	4.3
Engines, turbines, pumps	114	1.8	94	1.6	85	1.4	107	1.7
Electric power, nuclear technology	77	1.2	93	1.5	97	1.6	112	1.8
Electrical appliances	173	2.8	155	2.6	136	2.3	181	2.9
Lasers	2	0.0	3	0.0	1	0.0	2	0.0
Optical equipment	57	0.9	54	0.9	44	0.7	23	0.4
Instruments, control devices	114	1.8	99	1.6	124	2.1	131	2.1
Metrology, sensors	253	4.1	246	4.1	262	4.4	223	3.6
Data processing	29	0.5	41	0.7	52	0.9	51	0.8
Information recording	17	0.3	22	0.4	11	0.2	7	0.1
Telecommunications	311	5.0	351	5.8	416	7.0	539	8.7
Image transfer	89	1.4	60	1.0	53	0.9	40	0.6
Electronics, electronics components	37	0.6	22	0.4	42	0.7	54	0.9
Total	**6 194**	**100.0**	**6 005**	**100.0**	**5 968**	**100.0**	**6 213**	**100.0**

Appendix Table 5.2
Patent applications filed by domestic business enterprises by product group 1989–94

Product group	1989	1990	1991	1992	1993	1994
Foodstuffs	19	15	13	15	21	23
Textiles	9	8	6	8	8	9
Timber, wood products	8	11	10	6	6	6
Pulp, paper, paper products	55	64	78	66	63	56
Publishing, printing	4	3	2	4	2	5
Furniture	11	5	16	8	10	10
Industrial chemicals	52	48	49	67	39	53
Drugs	18	20	20	18	24	19
Other chemical products	7	10	9	13	17	13
Petroleum refining	–	1	–	2	2	4
Petroleum and coal products	–	–	2	1	–	–
Rubber products	8	5	2	–	–	–
Plastics products	8	11	8	7	5	4
Glass, glass products	52	74	57	45	60	39
Iron and steel	3	15	3	3	5	4
Other metals	8	11	2	13	11	3
Metal products	94	100	110	89	90	99
Stationary engines	20	14	14	8	17	20
Other general-purpose machinery	204	196	169	167	193	192
Agricultural machinery	14	23	20	12	8	10
Machine tools	37	30	35	25	31	41
Machinery for mining and construction	34	31	31	21	24	21
Paper-making machinery	85	77	59	57	65	63
Other specialized industrial machinery	54	39	32	37	29	15
Machinery total	**448**	**410**	**360**	**327**	**367**	**362**
Computers	4	12	20	15	16	19
Electronic circuits	80	135	166	184	211	289
Electrical appliances	63	69	75	49	73	93
Household appliances	11	8	8	6	6	13
Instruments	128	140	105	137	152	120
Ships	63	59	72	52	49	57
Other products	41	38	36	36	45	34
Manufacturing industry total	**1 194**	**1 272**	**1 229**	**1 171**	**1 282**	**1 334**
Energy and water supply	9	7	6	3	2	5
Construction	27	30	27	27	22	17
Total	**1 230**	**1 309**	**1 262**	**1 201**	**1 306**	**1 356**

Appendix Table 5.3
Foreign patent applications filed in Finland by country 1989–94

Country	1989	1990	1991	1992	1993	1994
Argentina	–	–	1	1	1	2
Australia	15	31	18	27	19	27
Austria	75	75	61	53	48	59
Belgium	37	29	19	26	47	50
Brazil	3	3	5	4	3	–
Bulgaria	5	–	6	1	4	–
Canada	56	44	34	50	51	57
Chile	–	–	2	1	3	1
Cyprus	–	2	1	2	–	–
Denmark	61	65	74	98	96	89
former Czechoslovakia	16	7	2	–	–	–
France	332	395	294	277	225	289
Germany	803	728	719	719	722	679
Gibraltar	–	3	2	–	7	1
Great Britain	345	308	286	280	247	232
Greece	–	1	1	3	2	1
Hong Kong	1	–	1	1	1	–
Hungary	33	28	32	17	6	14
Iceland	1	–	2	2	–	2
India	1	–	–	–	1	–
Ireland	5	2	1	–	–	5
Israel	6	8	5	7	8	2
Italy	112	91	101	77	89	93
Japan	256	240	216	210	157	211
Liechtenstein	4	9	10	26	8	11
Luxembourg	8	5	9	8	2	11
Mexico	1	–	–	2	–	2
Monaco	1	2	3	3	–	4
Netherlands	150	173	182	168	145	126
New Zealand	4	3	2	2	4	4
Norway	35	47	67	67	46	57
Poland	1	–	1	2	1	–
Portugal	–	1	–	–	1	–
Republic of Korea	1	8	2	4	5	6
Republic of South Africa	11	3	9	1	4	6
Russia	7	1	–	6	8	8
Singapore	–	2	–	–	1	–
Spain	13	13	21	19	22	17
Sweden	351	316	312	273	290	372
Switzerland	240	246	231	232	215	197
Taiwan	6	4	1	1	3	3
United States	1 250	1 362	1 238	1 252	1 265	12 15
Other countries	169	159	42	26	13	11
Total	**4 415**	**4 414**	**4 013**	**3 948**	**3 770**	**3 864**

Appendix Table 5.4
Finnish foreign trade in high technology products by product group 1988–94

Product group		1988	1989	1990	1991	1992	1993	1994
		(FIM million)						
Space and aviation	Exports	86.6	167.8	135.1	54.8	71.4	83.5	171.3
	Imports	1 232.7	954.9	1 601.4	1 151.2	736.4	1 162.0	1 610.8
	Trade balance	–1 146.1	–787.1	–1 466.3	–1 096.4	–665.0	–1 078.5	–1 439.5
Electronic data processing equipment	Exports	840.9	1 119.6	1 257.5	1 373.5	2 461.7	3 586.0	4 429.6
	Imports	3 663.0	4 402.2	3 940.6	3 242.9	3 665.3	4 518.4	5 828.4
	Trade balance	–2 822.1	–3 282.6	–2 683.1	–1 869.4	–1 203.6	–932.4	–1 398.8
Printed circuits and components	Exports	104.4	148.6	255.9	229.6	246.0	389.5	521.8
	Imports	1 051.2	1 224.1	1 266.9	1 131.1	1 947.6	3 456.5	4 946.2
	Trade balance	–946.8	–1 075.5	–1 011.0	–901.5	–1 701.6	–3 066.9	–4 424.3
Telecommunications equipment	Exports	1 814.1	2 775.4	3 264.7	2 245.2	3 422.5	6 073.7	9 283.8
	Imports	1 306.3	1 785.0	1 742.9	1 706.0	1 581.8	1 743.4	2 451.4
	Trade balance	507.8	990.4	1 521.8	539.2	1 840.7	4 330.3	6 832.3
Pharmaceuticals	Exports	80.2	123.2	165.3	206.5	284.5	351.9	331.2
	Imports	265.8	285.7	292.5	310.2	359.7	433.8	443.5
	Trade balance	–185.6	–162.5	–127.2	–103.7	–75.2	–82.0	–112.3
Instruments	Exports	952.5	1 172.8	1 296.9	1 367.1	1 560.0	1 890.5	2 153.9
	Imports	1 153.1	1 341.7	1 327.1	1 246.1	1 323.2	1 298.4	1 413.3
	Trade balance	–200.6	–168.9	–30.2	121.0	236.8	592.1	740.6
Electrical appliances and apparatus	Exports	832.4	1 127.9	1 322.8	1 344.2	1 487.9	2 261.3	2 716.2
	Imports	946.5	994.8	1 062.7	886.2	1 145.6	1 587.3	2 053.8
	Trade balance	–114.1	133.1	260.1	458.0	342.3	674.0	662.4
Power engines and motors	Exports	442.3	540.1	743.7	761.0	1 161.1	2 585.8	2 764.0
	Imports	827.2	1 054.0	923.8	791.5	1 029.9	927.7	1 032.6
	Trade balance	–384.9	–513.9	–180.1	–30.5	131.2	1 658.1	1 731.5
Automated machine tools	Exports	38.7	37.9	53.0	33.3	36.2	38.1	37.4
	Imports	262.9	362.1	435.1	212.1	122.7	151.3	282.4
	Trade balance	–224.2	–324.2	–382.1	–178.8	–86.5	–113.1	–245.0
Chemicals	Exports	455.3	906.5	1 036.7	910.1	960.7	1 174.9	1 513.7
	Imports	1 405.5	1 613.1	1 650.2	1 492.0	1 745.9	2 111.7	2 251.2
	Trade balance	–950.2	–706.6	–613.5	–581.9	–785.2	–936.8	–737.4
Total	**Exports**	**5 647.4**	**8 119.8**	**9 531.6**	**8 525.3**	**11 692.0**	**18 435.3**	**23 923.1**
	Imports	**12 114.2**	**14 017.6**	**14 243.2**	**12 169.3**	**13 658.1**	**17 390.5**	**22 313.5**
	Trade balance	**–6 466.8**	**–5 897.8**	**–4 711.6**	**–3 644.0**	**–1 966.1**	**1 044.8**	**1 609.5**

Appendix Table 5.5
Finnish foreign trade in high technology products by country group 1988–94

Country group/Country		1988	1989	1990	1991	1992	1993	1994
		(FIM million)						
EFTA								
Austria	Exports	54.2	86.8	97.7	103.8	111.5	129.8	167.5
	Imports	86.8	79.3	103.0	59.8	80.6	129.4	267.8
Switzerland	Exports	100.2	118.7	140.6	181.3	229.5	311.2	334.9
	Imports	262.0	249.1	277.0	257.7	234.4	368.1	357.0
Iceland	Exports	5.7	7.8	6.2	9.5	13.5	9.4	7.4
	Imports	0.2	1.3	0.0	0.0	0.2	0.3	0.4
Norway	Exports	175.0	231.1	226.2	299.9	294.2	432.0	57.4
	Imports	140.7	169.1	176.4	164.0	186.8	197.0	334.7
Sweden	Exports	1 105.7	1 447.8	1 536.1	1 482.2	1 752.9	2 231.6	3 277.2
	Imports	1301.7	1 644.0	1 429.0	1 326.3	1 339.7	1 202.6	1 405.4
Total	**Exports**	**1 440.8**	**1 892.3**	**2 006.8**	**2 076.7**	**2 401.5**	**3 114.0**	**3 844.4**
	Imports	**1 791.3**	**2 142.8**	**1 985.4**	**1 807.9**	**1 841.8**	**1 897.3**	**2 365.2**
European Union								
Germany	Exports	399.6	572.2	802.4	1 122.6	1 622.0	1 755.8	2 511.9
	Imports	2 170.6	2 513.5	2 478.7	2 108.8	2 293.6	2 449.1	3012.3
Denmark	Exports	144.7	232.9	204.9	251.2	320.4	393.2	526.3
	Imports	250.7	323.6	344.0	237.0	244.3	325.5	334.7
France	Exports	296.5	492.9	608.3	463.3	493.2	653.1	909.1
	Imports	673.6	790.0	755.1	609.3	754.3	772.3	781.0
Great Britain	Exports	439.4	636.5	715.6	640.3	1 432.4	2 235.3	2 775.1
	Imports	1 039.0	1 185.9	1 224.8	1 003.5	1 097.0	1 508.1	1 985.9
Ireland	Exports	14.5	23.4	29.4	20.9	30.8	47.6	478.5
	Imports	102.9	105.1	110.8	139.6	168.2	224.5	245.4
Italy	Exports	152.6	236.3	274.3	282.8	447.2	751.1	885.2
	Imports	399.9	496.1	538.7	457.1	518.3	529.7	647.1
Netherlands	Exports	153.1	200.7	290.6	285.0	474.9	805.1	837.3
	Imports	242.2	252.5	221.9	208.0	271.9	380.4	401.6
Other countries	Exports	226.4	429.0	628.7	656.5	809.1	943.3	1 100.5
	Imports	188.4	225.6	221.6	237.8	271.4	274.7	379.3
Total	**Exports**	**1 826.9**	**2 823.7**	**3 554.2**	**3 722.5**	**5 629.9**	**7 584.4**	**9 569.2**
	Imports	**5 067.4**	**5 892.1**	**5 895.6**	**5 001.0**	**5 619.0**	**6 464.4**	**7 787.4**
Other European countries								
Estonia	Exports	.	.	.	12.8	87.9	227.6	502.4
	Imports	.	.	.	0.6	4.9	8.1	145.9
Hungary	Exports	5.4	16.6	18.4	26.3	64.6	128.5	334.9
	Imports	12.0	10.5	13.9	14.6	11.2	15.3	30.3
Russia	Exports	.	.	.	.	223.7	713.4	789.5
	Imports	.	.	.	.	138.5	104.5	111.0
Other countries	Exports	1 117.1	1 674.4	1 915.6	619.6	290.4	599.2	1 124.4
	Imports	410.1	426.0	435.3	207.3	45.6	53.4	99.3
Total	**Exports**	**1 122.5**	**1 691.0**	**1 934.0**	**658.7**	**666.6**	**1 668.7**	**2 751.2**
	Imports	**422.1**	**436.5**	**449.2**	**222.5**	**200.2**	**181.3**	**386.4**

Appendix Table 5.5
(cont.)

Country group/Country		1988	1989	1990	1991	1992	1993	1994
		(FIM million)						
Asian countries								
China	Exports	44.2	58.4	18.5	64.6	216.4	380.8	622.0
	Imports	13.9	17.3	25.3	26.2	38.2	69.7	124.3
Hong Kong	Exports	18.4	76.6	59.9	57.2	112.6	184.6	502.4
	Imports	77.7	97.0	99.7	89.8	166.3	248.6	432.0
Japan	Exports	97.3	161.9	115.8	136.0	153.1	229.5	478.5
	Imports	1 556.6	1 943.5	1 780.1	1 544.1	1 997.9	2 778.8	3 838.3
Republic of Korea	Exports	21.7	48.2	65.0	48.4	147.4	331.5	478.5
	Imports	101.5	121.1	135.0	140.6	196.0	355.4	523.9
Malaysia	Exports	18.6	39.9	43.9	43.8	80.2	188.8	263.2
	Imports	42.8	40.6	47.3	66.8	203.7	452.7	637.0
Singapore	Exports	22.3	51.3	67.6	85.8	62.2	219.9	358.8
	Imports	83.6	107.4	139.1	153.6	343.6	423.2	514.9
Taiwan	Exports	9.6	42.5	49.0	31.8	65.6	170.5	119.6
	Imports	265.8	355.6	307.8	295.7	398.6	596.1	676.3
Other countries	Exports	356.2	270.8	574.7	606.6	692.6	1 996.7	1 818.2
	Imports	43.0	62.9	46.4	37.0	70.3	199.2	395.0
Total	**Exports**	**588.3**	**749.6**	**994.4**	**1 074.2**	**1 530.1**	**3 702.3**	**4 641.1**
	Imports	**2 184.9**	**2 745.4**	**2 580.7**	**2 353.8**	**3 414.6**	**5 123.7**	**7 141.6**
NAFTA								
Canada	Exports	80.6	108.4	127.4	85.3	82.0	91.3	136.4
	Imports	50.4	58.3	105.3	67.2	80.9	83.3	139.6
Mexico	Exports	1.1	3.7	23.6	8.3	16.2	48.1	52.6
	Imports	3.6	7.2	8.1	7.4	9.0	18.1	27.6
United States	Exports	421.0	469.5	504.8	521.6	818.0	1 390.3	1 710.5
	Imports	2 600.7	2 732.2	3 214.7	2 702.1	2 485.0	3 577.7	4 414.4
Total	**Exports**	**502.7**	**581.6**	**655.9**	**615.1**	**916.2**	**1 529.8**	**1 899.5**
	Imports	**2 654.7**	**2 797.6**	**3 328.2**	**2 776.7**	**2 574.8**	**3 679.1**	**4 581.6**
Other countries	Exports	188.7	402.7	416.0	389.5	562.8	838.5	1 217.6
	Imports	15.1	24.0	31.2	23.9	27.1	44.7	51.3
All countries total	**Exports**	**5 669.9**	**8 140.9**	**9 561.3**	**8 536.7**	**11 707.1**	**18 437.7**	**23 923.1**
	Imports	**12 135.5**	**14 038.4**	**14 270.3**	**12 185.8**	**13 677.5**	**17 390.5**	**22 313.5**

Appendix Table 5.6
Foreign trade in high technology products in certain OECD countries 1988–93

Country		1988	1989	1990	1991	1992	1993
		(USD million)					
Finland	Exports	1 350.1	1 892.3	2 231.7	2 108.1	2 610.4	3 222.4
	Imports	2 896.1	3 266.7	3 725.7	3 009.2	3 049.4	3 039.8
Sweden	Exports	6 120.0	6 491.7	7 456.6	7 259.7	7 359.0	7 303.3
	Imports	6 621.0	7 354.4	8 357.2	7 695.3	7 839.8	7 856.3
Norway	Exports	1 239.7	1 203.8	1 514.3	1 432.7	1 585.4	1 490.1
	Imports	2 604.6	2 688.8	3 458.5	3 082.8	3 544.8	3 200.8
Denmark	Exports	2 263.9	2 393.8	3 248.2	3 292.3	3 660.4	3 322.6
	Imports	3 138.7	3 416.1	4 091.4	4 480.1	4 182.8	3 910.2
Netherlands	Exports	14 547.3	15 840.9	20 066.2	1 9640.2	20 968.3	24 311.0
	Imports	13 896.0	15 830.2	18 984.2	1 9729.8	21 384.3	20 358.7
Austria	Exports	3 254.8	3 086.8	4 202.9	4 289.3	4 415.5	4 332.3
	Imports	4 370.1	4 771.1	6 121.3	6 269.2	6 419.4	5 916.4
Switzerland	Exports	9 173.1	8 721.0	10 765.3	10 483.3	11 578.6	11 088.7
	Imports	7 773.6	7 550.3	8 996.6	9 370.0	9 328.0	8 878.2
Germany	Exports	45 256.3	49 537.1	57 315.0	62 058.9	64 659.0	58 098.9
	Imports	35 547.4	41 120.9	50 902.3	59 761.7	61 599.8	52 981.2
France	Exports	23 951.6	25 830.6	32 978.9	37 947.2	40 495.5	38 935.3
	Imports	25 641.4	26 855.8	34 114.6	36 337.7	37 373.7	33 969.6
Great Britain	Exports	31 638.1	33 552.1	38 973.0	43 970.9	45 025.4	43 236.7
	Imports	30 557.1	32 369.7	38 955.3	39 807.0	42 100.3	43 206.8
Japan	Exports	62 674.3	66 998.2	69 214.9	77 810.8	84 771.6	93 978.6
	Imports	17 192.0	19 642.5	23 920.2	25 336.7	25 714.6	28 922.7
United States	Exports	..	93 652.5	106 941.9	117 074.6	122 818.3	123 925.1
	Imports	..	76 214.8	81 523.3	89 120.9	100 408.8	113 208.4

Appendix Table 5.7
Foreign trade in high technology products in certain OECD countries by product group 1993

Product group	Finland	Sweden	Norway	Denmark	Netherlands	Austria	Switzerland	Germany	France	Great Britain	Japan	United States
	(%)											
EXPORTS												
Space and aviation	0.5	9.5	14.4	4.5	15.0	2.2	5.6	17.5	34.7	24.9	1.2	31.8
Electronic data processing equipment	19.5	10.2	15.9	17.5	32.8	11.8	5.2	13.4	14.6	25.1	31.5	21.0
Printed circuits and components	2.1	3.2	1.5	4.0	11.7	14.4	3.3	8.3	8.2	12.0	24.2	12.7
Telecommunications equipment	32.9	41.5	19.6	12.7	5.8	8.0	4.5	8.5	7.2	7.4	15.1	8.6
Pharmaceuticals	1.9	1.9	9.1	9.7	3.2	12.6	18.9	5.3	4.1	3.0	1.1	3.0
Instruments	10.3	11.3	15.5	13.9	9.8	9.3	13.2	12.2	6.2	8.3	6.7	9.5
Electric appliances and apparatus	12.3	7.0	10.0	9.1	5.4	18.5	8.7	10.2	5.5	5.6	10.4	4.7
Power engines	13.9	6.5	3.0	9.3	1.6	8.9	5.9	5.8	4.4	2.9	3.5	2.4
Automated machine tools	0.2	2.5	0.1	0.7	0.3	4.4	7.3	3.0	0.5	0.6	2.6	0.6
Chemicals	6.4	6.3	10.9	18.7	14.4	9.9	27.2	15.8	14.6	10.0	3.6	5.7
Total	**100.0**	**100 .0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Value of exports (USD million)	3 222.4	7 303.3	1 490.1	3 322.6	2 4311	4 332.3	11 088.7	58 098.9	38 935.3	43 236.7	93 978.6	123 925.1
IMPORTS												
Space and aviation	6.7	11.4	13.3	4.6	13.2	3.2	8.8	22.4	20.8	18.8	15.1	10.7
Electronic data processing equipment	26.0	29.0	31.0	38.7	43.3	27.3	29.7	28.1	25.7	35.3	23.2	36.1
Printed circuits and components	19.9	10.6	4.9	5.6	9.5	11.6	5.5	10.2	11.4	13.4	18.7	19.6
Telecommunications equipment	10.0	12.0	15.2	11.1	6.7	10.3	7.4	7.9	5.8	8.0	6.6	11.0
Pharmaceuticals	2.5	3.2	2.5	6.1	2.8	7.7	8.8	3.2	4.9	2.5	7.2	2.0
Instruments	7.5	10.1	9.8	7.1	7.5	10.1	8.6	6.5	7.6	7.3	8.1	5.7
Electric appliances and apparatus	9.1	8.2	10.3	7.1	4.8	11.3	8.4	8.3	6.2	6.4	7.1	6.7
Power engines	5.3	5.8	5.0	4.4	2.2	5.5	5.5	3.3	3.7	2.0	2.7	2.6
Automated machine tools	0.9	1.0	0.8	0.9	0.5	2.6	1.6	1.0	1.1	0.7	0.7	1.4
Chemicals	12.1	8.6	7.3	14.6	9.4	10.3	15.7	9.1	12.8	5.6	10.7	4.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Value of imports (USD million)	3 039.8	7 856.3	3 200.8	3 910.2	20 358.7	5 916.4	8 878.2	52 981.2	33 969.6	43 206.8	28 922.7	113 208.4

References

Domestic Statistics and Databases

ORGANIZATION	STATISTICS, DATABASE OR OTHER SOURCE	TOPIC
Statistics Finland	statistics on research and development activities	resources for research and development (R&D)
	statistics on educational structure and education level of population	human resources for science and technology (S&T)
	demographic statistics (censuses)	-"-
	employment statistics	-"-
	salary statistics	-"-
	industrial statistics	-"-
	national capital expenditure accounts	output and impacts of S&T
		-"-
Academy of Finland	data system on R&D funding (TUTTI)	mobility of researchers, international cooperation
	Government research funding database	resources for R&D
Ministry of Education	KOTA database	mobility of researchers
Centre for International Mobility (CIMO)	researcher exchange database	-"-
Technology Development Centre (TEKES)	database on participation in EU research programmes	international cooperation
National Board of Patents and Registration	patent database (PATH)	output of S&T
	patent statistics of various countries	-"-
National Board of Customs	foreign trade database (ULTIKA)	economic impacts of S&T

International Statistics and Databases

ORGANIZATION	SOURCE OF INFORMATION	TOPIC
OECD	science and technology indicator database	resources for R&D
	statistics on education	human resources for S&T
	database on industries	output and impact of S&T
	database on foreign trade (TRADIKA)	-"-
Nordic Industrial Fund	Nordic R&D statistics 1991 and Government budget analysis 1993	resources for R&D
WIPO (World Intellectual Property Organization)	annual statistics on patent applications and patents granted	output and impacts of S&T
European Commission	The European Report on Science and Technology Indicators 1994	-"-
ISI (Institute for Scientific Information)	Science Citation Index (SCI): National Science Indicators database	output of science; bibliometric indicators

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