Tilastokeskus
Statistikcentralen
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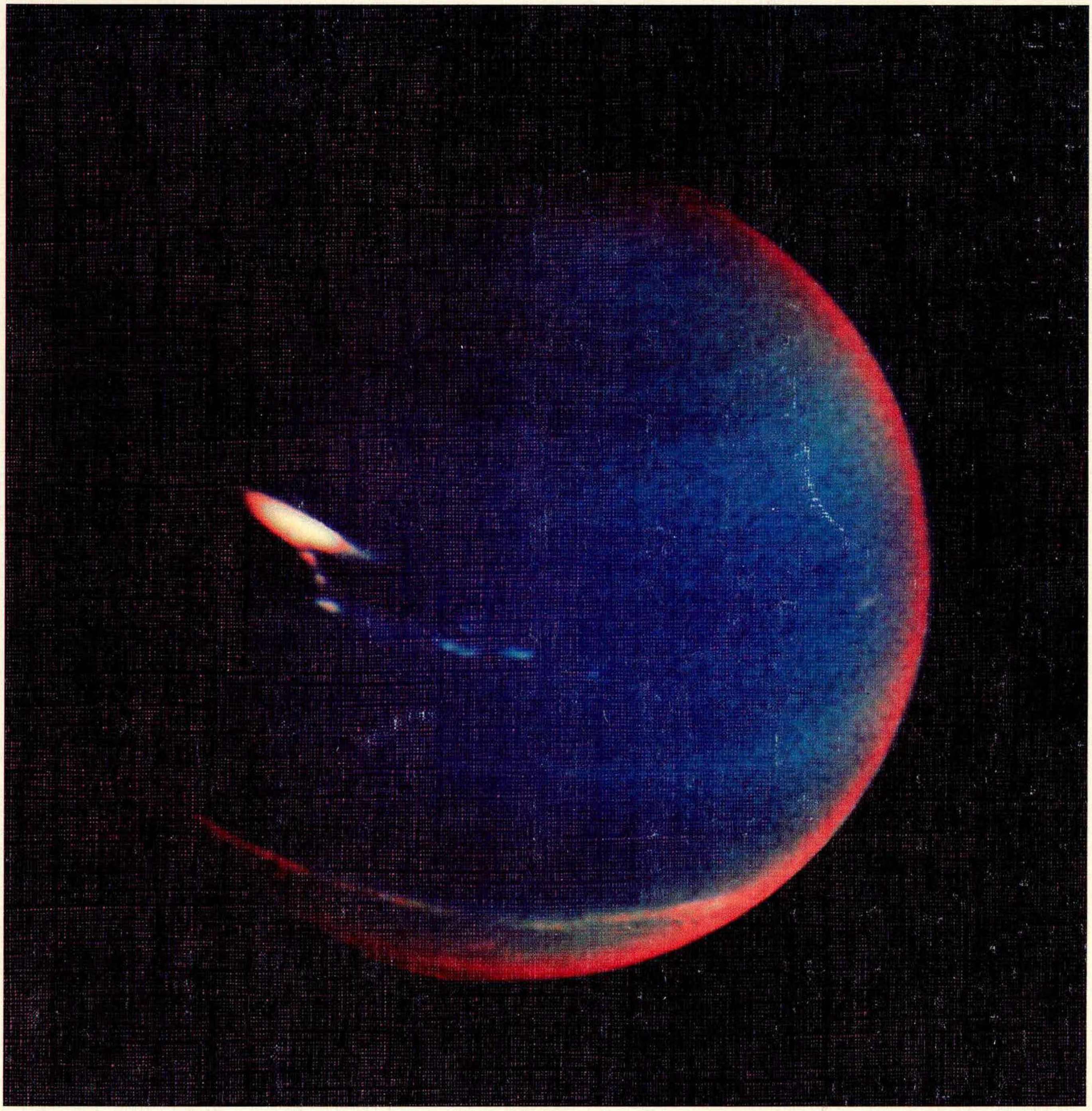
Koulutus ja tutkimus 1990:6
Utbildning och forskning
Education and research

# Science and technology in Finland 1989



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# Science and technology in Finland 1989

May 1990



Helsinki 1990

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A picture of NEPTUNE
as captured by Voyager II

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SVT *Suomen Virallinen Tilasto*
*Finlands Officiella Statistik*
*Official Statistics of Finland*

# Foreword

This publication contains information on research and development, their prerequisites, development, resources, and scope; furthermore, application and economic impact of science and technology are covered. This is a second report of the series. Additional information to the previous publication are bibliometric indicators and data on intangible investments. International comparison data are also more frequent than in the previous publication.

The report has been written by Planning Officer Markku Virtaharju (Chapters 5 and 6) and Senior Statistician Ari Leppälahti (Chapters 2.2, 2.3 and 3.). Chapter 4, Bibliometric indicators, has been compiled by Terttu Luukkonen, from the research staff of The Academy of Finland. Further contributions to this publication have been made by Senior Research Officer Mikael Åkerblom (Section 2.1) and Assistant Statistician Raili Kouvalainen. Eeva K. Varner has translated this publication from the original Finnish report, "Tiede ja teknologia".

Helsinki, the Central Statistical Office of Finland,
April 1990

Heikki Havén

# Contents

# Abstract

The number of population with a higher education degree (a graduate, post-graduate, or college engineering degree) was approximately 166 000 in 1987. During the first part of the 1980s, the average yearly growth was ca. 5 per cent. In 1985 - 1987, this growth rate slightly slowed down.

The population with a post-graduate degree numbered nearly 10 000 in 1987. Those with a post-graduate degree in natural sciences accounted for one fourth and those with a degree in social sciences and medical sciences one fifth each of this total stock. The number of post-graduate degrees attained has increased heavily since 1986.

The number of Master's level degrees has also clearly started to increase since 1986. However, growth in the number of graduate level engineering degrees has been sluggish and the number of graduate college level engineers has even slightly decreased.

Information services rendered by the scientific libraries and especially external data base search services have accelerated considerably in 1985 - 1987. In contrast, library loan activities showed fairly modest increase. A hindrance to acquisition of scientific journals is their heavy price fluctuation.

Generally speaking, research salaries have increased somewhat slower than the general salary indices in the 1980s. Research salaries for The Academy of Finland research staff and for assistants in institutions of higher education experienced the smallest increase.

In the 1980s, the growth rate in R&D expenditure in Finland has been among the highest in the OECD countries. In 1983 - 1987, it was approximately 10 per cent per year. After 1987, the growth rate is expected to slow down both in Finland and in other industrial countries. The Business Enterprise Sector has continued to increase its share in R&D expenditure, and in 1989 its share is estimated to amount to ca. 61 per cent.

In 1987, the R&D expenditure was 1.7 per cent of the GDP in Finland. The 1989 share is estimated to be approximately 1.8 per cent. Measured by gross domestic product, Finland places in the middle among the OECD countries. Large industrial countries, such as the United States, Japan, the Federal Republic of Germany, and Sweden, a Nordic country, have considerably bigger investments in R&D. But, for instance, Denmark, Austria, Italy, and Canada have a lower GDP share than Finland.

The regional focus of R&D activities is around the Helsinki metropolitan area, accounting for ca. 45 per cent of all R&D expenditure.

R&D expenditure in the Business Enterprise Sector was approximately 4 billion FIM in 1987. Industry accounted for approximately 3.3 billion of this expenditure.

Growth in R&D expenditure in the Public Sector has been slower than in the Business Enterprise Sector or in the institutions of higher education.

The estimated share of the Public Sector in R&D expenditure is expected to have been approximately 19 per cent for 1989 when it still in 1983 amounted to ca. 21 per cent.

The share of the General University Funds for R&D in institutions of higher education has decreased in 1983 - 1987. In contrast, enterprises and income surplus from research activities at institutions of higher education have increased their share in R&D funding.

In the 1980s, Government budget appropriations for R&D have increased 5 - 7 per cent each year. Most Government funding for research came from the Ministry of Trade and Industry and the Ministry of Education, totalling approximately three fourths of the R&D appropriations in 1989. By objective, the most important areas are: advancement of general sciences (mainly institutions of higher education and The Academy of Finland), accounting for approximately 37 per cent and industry, accounting for approximately 28 per cent.

Bibliometric indicators measure scientific productivity and impact of research on the forefront of international research within the respective field. Finnish researchers are publishing proportionally more than before in international journals, with quantities now exceeding those of Norwegian researchers. But, measured by international references, impact of research papers by Finnish researchers has the lowest rating of all Nordic countries. Proportionally, publications by Finnish researchers in the fields of physics and biology are most frequently referred to and rate above the international median within their respective fields.

Since 1986, the number of domestic patent applications filed in Finland has again taken an upward turn. This is due to patent applications filed by companies. The number of domestic patent applications filed by private persons has somewhat decreased. The regional focus of patent applications filed by the Business Enterprise Sector has been in southern Finland. More than 40 per cent of inventors of patent applications filed by the Business Enterprise Sector come from the Province of Uusimaa.

The number of foreign patent applications filed in Finland has continued to rise more than that of domestic applications. Most foreign patent applications still originated from the United States and the Federal Republic of Germany.

The number of patent applications filed abroad originating from Finland has grown steadily in the 1980s, except for a decrease in 1986. The share of patents granted to Finnish applicants in all patents granted in the United States has increased slightly from 1985, totalling 0.70 per cent in 1987. In proportion to population, Finland's share in pat-

ents granted in the United States is equal to that of the Great Britain and Austria. This publication also contains indicators on references to patents granted to Finns in the patent applications filed in the United States. That citation level is quite low. Only the citation level of Other Transport Equipment product group surpasses the reference level of total patents granted in the United States in 1986.

Industrial machinery and equipment investments have increased heavily, especially in 1987. Also, the share of machinery and equipment investments in total tangible investments has slightly increased, accounting for 76.7 per cent in 1987; hence, measured by this indicator, the share of technology in industrial investments has increased. Intangible industrial investments amounted to approximately 7.2 billion FIM in 1987. Intangible investments accounted for approximately 30 per cent of total industrial investments.

The number of robots has continued to increase heavily. In 1988, 545 robots were in operation. Arch welding applications accounted for 41 per cent of all applications against Sweden's 30 per cent and the Federal Republic of Germany's 18 per cent.

The growth in the production value of high technology goods has been faster than that of total industrial production, amounting to approximately 14.1 billion FIM in 1987. Various branches of high technology in Finland accounted for a total of 6.6 per cent of all industrial production in 1986, against the OECD aggregate output of approximately 16 per cent.

Export of high technology products manufactured in Finland has continued to increase more rapidly than import. Their share was 8.6 per cent in total export and 16.2 per cent in total import in 1987. Compared with the other Nordic countries, Finland's import of high technology products almost equalled to that of Sweden (16.3 per cent) and was slightly higher than that of Norway and Denmark. But, the share of high technology export in total export was considerably smaller than that of Sweden and Denmark but higher than that of Norway.

The largest single product group of high technology goods exported was telecommunications equipment, amounting to ca. 1.8 billion FIM in 1987. Computers were the biggest product group imported, with import amounting to 2.9 billion FIM.

**The development in R&D activities in Finland has been favorable in the 1980s. The growth rate of R&D expenditure has reached international top levels. In proportion to gross domestic product, Finland's investment in R&D today equals to the average investment level in the OECD countries.**

**There are certain risk factors for the continuing rapid growth, especially in the Business Enterprise Sector. The growth rate of personnel with higher education engaged in R&D work in the Business Enterprise Sector is double to total stock of people with higher education. Hence, this trend of continuous growth in R&D activities calls for educating more people with a third level degree or transfer of personnel with higher education employed elsewhere to work in R&D, for instance. An additional factor affecting the availability of competent research personnel is their salary development which seems to have been somewhat slower than the general salary development in recent years.**

**In all the countries included in this comparison study, with regard to application of technology and its economic impact, the importance of technology has increased. Measured by patents and foreign trade in high technology, import of technology exceeds their export in Finland. The gap has slightly widened in recent years. However, compared with other small and mid-size OECD countries, the trend in Finland has been similar; hence, Finland's international standing has remained unchanged.**

# 1. Introduction

## Initial Approach

The increasing importance of science and technology for the Finnish industry to compete internationally and for the well-being of the Finnish society presents intensified demands for the science and technology information systems.

Since 1971, the Central Statistical Office has provided statistics on R&D, consisting of data on research man years, expenditure, and funding.

Many countries, especially the United States, Canada, and the Netherlands, have information systems which depict prerequisites for science and technology, resources for these, and economic and social impact of science and technology in more detail than conventional research statistics. These countries regularly publish versatile reports on the standing of science and technology.

Development of new information systems has been stimulated among others by the OECD work for expansion of research statistics into science and technology indicators. Within the last ten years, the OECD has arranged several meetings dealing with various indicators on output of researh activities and presenting results of international research work in respective fields.

The OECD data base has been expanded to include indicators on output of R&D activities (e.g. patents, foreign trade of high technology products, and balance of payments in technology).

The initial approach in the design of the Finnish science and technolgy indicator system was based on research work connected to this field of study and on results of experiences in international development activities. The science and technology indicator system follows foreign models with some modifications. The aim has been to give a versatile representation of the standing, development, and future trends of science and technology in Finland.

## Some Concepts

Usually, science is taken to mean, on one hand, a systematic entity of, or results of scientific research on, data pertaining to nature, man, and society; on the other hand, meaningful and systematic pursue for such data, or a scientific research process. Technology can simply be defined as a stock of knowledge that makes it feasible to generate new products or processes.

Science and technology indicators are indicators on the development of science and technology compiled from various statistics and other information sources.

Special features of science and technology indicators are:

- they don't generally directly measure a phenomen but only indicate its scope and progress

- several indicators must be studied simultaneously so that sufficiently reliable conclusions on the standing and trend of science and technology can be drawn.

A science and technology indicator system is a compilation of indicators on the standing and trends of science and technology applicable to statistical process, together with information sources needed to generate them.

# On Use of Indicators

Science and technology indicators can be used for:

- acquiring information on internal dependence within science and technology
- acquiring information on impact of science and technology on competitiveness, productivity, and employment, among others
- identifying trends that require science and technology policy measures
- science and technology policy planning and reporting
- background information for appropriation of resources for R&D activities and for other measures advancing science and technology
- discussion on science and technology

# Structure of Report

Science and technology indicators are presented in this report as follows:

- indicators of general prerequisites for science and technology
- indicators of resources for R&D (conventional research statistics)
- bibliometric indicators
- indicators of application of technology
- indicators of economic impact of science and technology and on transfer of technology

At the beginning of each chapter, indicators used and information sources to generate them from are presented. Furthermore, their features as a reflection of the standing of science and technology are given.

International comparison is also applied to the Finnish indicators as often as possible. Most comparisons are based on statistics by the OECD. Some tables not published elsewhere are included as appendices to this report.

Data contents of this report are being continuously monitored for improvement based on feedback from the users and on research work done in the respective research field.

# 2. General Prerequisites for Science and Technology

General prerequisites for science and technology are presented in the form of statistical indicators in the following fields of study: 1) population with higher education, 2) scientific library and information services, and 3) research salaries.

## 2.1 Population with Higher Education

Knowledge and know-how have become increasingly important factors of production and they are crucial for economic growth. The basic prerequisite for advancement of science and technology is sufficient intellectual capital. Without population with higher education, generation of new knowledge and its application to produce new innovations are impossible.

These prerequisites are presented below by certain figures on the stock of personnel with higher education. The data are compiled mainly from the educational statistics and the Register of Completed Education and Degrees at the Central Statistical Office and from population cencuses. Nordic comparison data are based on official statistics obtained from respective countries.

*Population with higher education is taken here to mean those with research education (doctors and licentiates) or with a Master's or an engineering college degree.*

The definition corresponds with the internationally used term "Scientists and engineers".

Educational categories are derived from the educational classification used by the Central Statistical Office (Central Statistical Office, Handbook No. 1, Helsinki 1988). The classification by field of science is based on the UNESCO recommendations.

As the purpose is to present potential manpower for advancement of science and technology, those aged 65 or older have been excepted from this study.

### Growth in Population with Higher Education Slightly Down

Population with higher education totalled approximately 166 000 at the end of 1987. At the end of 1980, the figure was 118 000. Table 2.1 shows that the number of those with a graduate degree or a college engineering degree grew slightly slower in 1985 - 1987 compared with the growth during the first half of the decade. However, the number of population with research education seems to have increased a little faster.

Annex Table 1 gives a more detailed presentation of figures on population with higher education by field of science.

**Table 2.1 Population with higher education degree in 1980, 1985 and 1987. (excl. those aged 65 and over and population with military education)**

| | 1980 | 1985 | Annual Growth Rate 1980–85 % | 1987 | Annual Growth Rate 1985–87 % |
|---|---|---|---|---|---|
| Postgraduate degree | 7 294 | 9 066 | 4.4 | 9 971 | 4.9 |
| - of which: in engineering | 1 118 | 1 513 | 6.3 | 1 719 | 6.5 |
| Graduate degree | 81 344 | 104 234 | 5.1 | 114 769 | 5.0 |
| - of which: in engineering | 16 572 | 21 127 | 5.0 | 22 875 | 4.0 |
| College engineering degree | 29 726 | 38 454 | 5.3 | 41 497 | 3.9 |
| **Total** | **118 364** | **151 754** | **5.1** | **166 237** | **4.7** |
| - of which in engineering | 47 416 | 61 094 | 5.2 | 66 091 | 4.0 |

## Proportionally Most Research Education in Natural Sciences and Medicine

Figures 2.1 and 2.2 show that one quarter of population with research education are natural scientists while they number only one to ten within those with a basic degree. The share of research education degrees in medicine is 20 per cent, compared with 14 per cent of basic degrees.

**Figure 2.1 Population with research education by field of science, 1987**

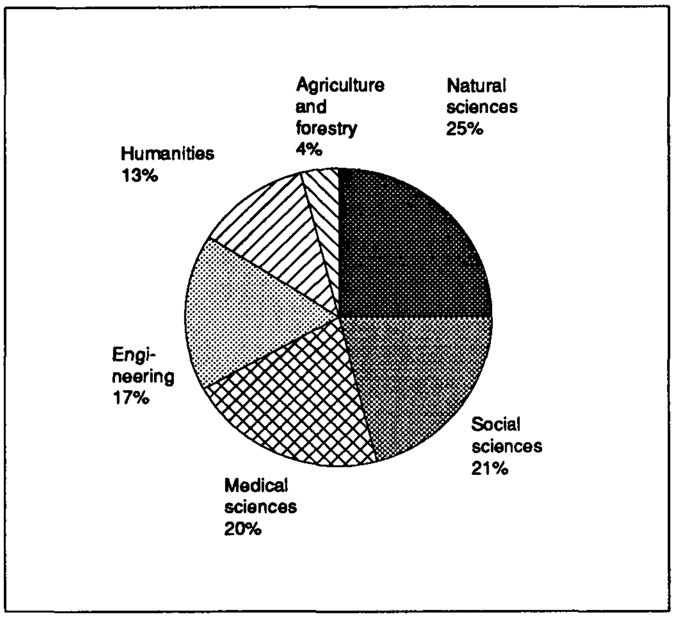
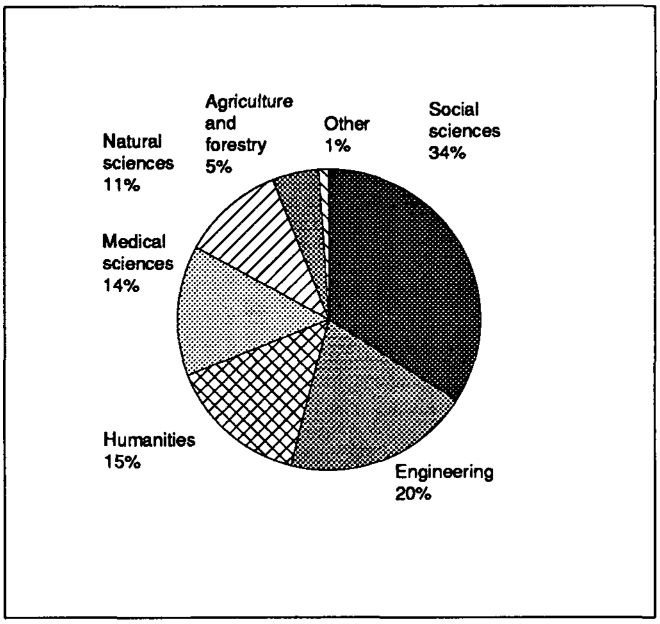



**Figure 2.2 Population with graduate degree by field of science, 1987**




## Finland Slightly Behind Sweden in Proportion of Population with Research Education

0.30 per cent of Finland's population aged 15 - 64 had a research education degree, compared with Swedens 0.41 per cent. The corresponding figure in Norway was considerably lower, ca. 0.14 per cent. However, women's share in those with a research education degree was highest in Finland, ca. 21 per cent against Sweden's 18 per cent and Norway's 12 per cent. Similar comparisons are not feasible among those with a graduate degree.

## Industry and Business Services Employ Increasing Numbers of Personnel with Research Education

Table 2.2 shows that the share of those with higher education in population gainfully employed has increased from 3 per cent in 1970 to approximately 6 per cent in 1985. Industry and business services employ proportionally increasing numbers of personnel with higher education.

**Table 2.2 Population with higher educatione and their share in gainfully employed population, 1970, 1980 and 1985**

| Standard Industrial Classification (SIC) Year | Post-graduate degree | Graduate degree | College engineers | Total | Gainfully Employed Population[1] (1970=100) | Share in gainfully employed population % |
|---|---|---|---|---|---|---|
| **Industry (3)** | | | | | | |
| 1970 | 224 | 5 493 | 5 211 | 10 928 | 100 | 2.1 |
| 1980 | 412 | 8 968 | 10 644 [2] | 20 024 | 105 | 3.6 |
| 1985 | 612 | 12 071 | 12 162 | 24 845 | 99 | 4.8 |
| **Business service (8)** | | | | | | |
| 1970 | 149 | 4 308 | 1 381 | 5 838 | 100 | 8.1 |
| 1980 | 294 | 7 979 | 3 945 | 12 218 | 165 | 10.3 |
| 1985 | 416 | 12 492 | 6 712 | 19 620 | 215 | 12.7 |
| **Public services (9)** | | | | | | |
| 1970 | 3 211 | 28 502 | 1 965 | 33 678 | 100 | 8.8 |
| 1980 | 5 800 | 47 027 | 4 449 | 57 276 | 143 | 10.4 |
| 1985 | 7 379 | 60 595 | 5 000 | 72 974 | 169 | 11.2 |
| **Other** | | | | | | |
| 1970 | 152 | 5 422 | 3 983 | 9 557 | 100 | 0.8 |
| 1980 | 301 | 8 329 | 7 780 [2] | 16 410 | 88 | 1.6 |
| 1985 | 356 | 10 766 | 11 109 | 22 231 | 84 | 2.3 |
| **Total** | | | | | | |
| **1970** | **3 736** | **43 725** | **12 540** | **60 001** | **100** | **2.8** |
| **1980** | **6 807** | **72 303** | **26 818** | **10 5928** | **105** | **4.8** |
| **1985** | **8 763** | **95 924** | **34 983** | **13 9670** | **107** | **6.1** |

[1] From 1985 gainfully employed
[2] Industry: SICs 2.3 and 4

## Growth Rate of Degrees Accelerated Since 1986

Figure 2.3 shows that the number of population with a postgraduate degree has increased heavily since 1986. Growth from 1987 to 1988 was 20 per cent for licentiaces and nearly 10 per cent for doctoral dissertations approved. Study of the whole decade of the 1980s reveals that growth has been especially heavy for licentiates in humanities and technology and for doctors in medical sciences and technology.

**Figure 2.3 Number of post-graduate degrees, 1980–1988**

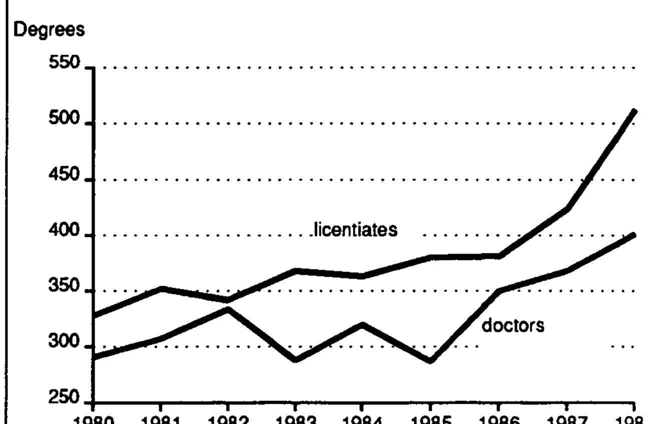
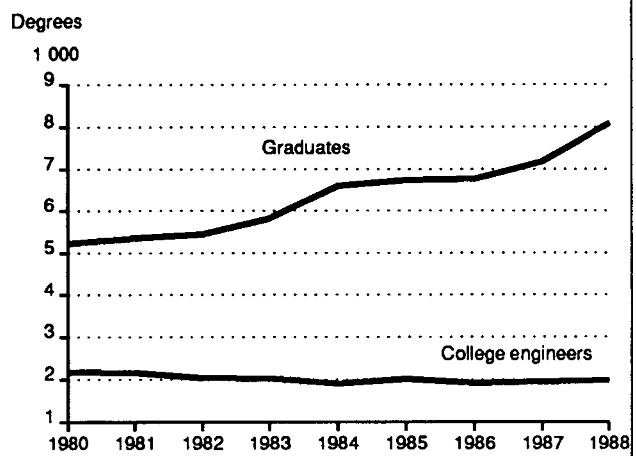


Figure 2.4 shows increased growth also for those with a graduate degree, focusing mainly in the social sciences and humanities in the 1980s. Growth in the number of graduate engineering degrees was slightly less than the average (e.g. no growth in 1983 - 1985). The number of licentiate degrees attained in medical sciences has decreased in the 1980s.

The number of college engineering degrees attained has also decreased in the 1980s and, due to a prolonged study program, it is still expected to go further down in the next years to come.

Annex Table 2 gives more detailed information on the numbers of graduate, postgraduate, and engineering degrees.

**Figure 2.4 Graduate degrees and college engineering degrees, 1980–1988**




### Number of Postgraduate Degrees Also up in Other Nordic Countries in Recent Years

Since 1986, especially the number of postgraduate degrees has increased heavily in all the Nordic countries. In 1988, the yearly growth rate of doctoral or licentiate degrees was 40 per cent in Denmark, 17 per cent in Norway, and 10 per cent in Sweden. The growth rate in Finland was ca. 15 per cent.

## 2.2 Scientific Library and Information Services

A prerequisite for advancement in science and technology is acquisition and transfer of information. Data on scientific library and information service activities can be used as an indicator on availability and usage of information. The Council for Scientific Information and Research Libraries (TINFO) in Finland has the responsibility of compiling these statistics.

Although the figures presented below depict scientific libraries, it is to be recognized that the importance of public libraries as mediator of scientific information has increased in recent years. Information transfer through data service systems in the big companies also plays an important role in mediating information.

Scientific libraries can be divided into university libraries and special libraries (mainly in public administrative offices and research institutes). The statistic is compiled from approximately 570 library units, with approximately 500 of these located in institutions of higher education.

### Use of Scientific Libraries on Rise

Table 2.3 presents some basic information on the activities of scientific libraries in 1987, with comparable figures from 1985.

Scientific libraries contained ca. 15.5 million publications in 1987. Operating expenses amounted to nearly 190 FIM million, with approximately 1 300 man years worked. In 1987, scientific libraries loaned out ca. 2.8 million books (2.7 million in 1985) and carried out approximately 55 000 information service orders. Of these, approximately 33 000 orders handled information search through external data bases. This figure is double the work load of 1985, thereby indicating the impact of increasing use of computers on information transfer.

### Price of Scientific Journals Fluctuates

One of the problems in the availability of of scientific and technical information is increase in the price of scientific journals. Strongest price increases took place in the middle of the 1980s; for instance, in 1983 - 1984 the price of foreign periodicals procured for institutions of higher education went up 22 per cent on the average. From 1986 to 1987, the price increase was only approximately 2.5 per cent. This price development has been partly dictated by fluctuation in exchange rates. Thus, this decrease in the price growth rate may well be only temporary. The development in book prices has been more constant.

**Table 2.3 Scientific libraries, 1985 and 1987**

| | | Man years | Expenditure: Total operating expenses | Of which payroll expenses | Procurement of literature | Stock (Accumulation): Shelf length (meters) | Volumes | Book accumulation | Services: Loans | Data retrieval orders: Total | Of which external data base search |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mill. FIM | mill. FIM | mill. FIM | 1000 | 1000 | 1000 | Mill. | 1000 | 1000 |
| University Libraries | 1985 | 974 | 123.3 | 64.2 | 49.8 | 357 | 12 416 | 359 | 2.5 | 32.7 | 7.6 |
| | 1987 | 1 060 | 153.5 | 78.4 | 63.0 | 383 | 13 301 | 379 | 2.5 | 33.4 | 17.7 |
| Special libraries | 1985 | 231 | 30.2 | 17.4 | 7.0 | 53 | 2 129 | 58 | 0.2 | 16.1 | 9.7 |
| | 1987 | 232 | 36.4 | 21.4 | 8.6 | 56 | 2 261 | 50 | 0.3 | 22.1 | 15.4 |
| **Total** | **1985** | **1 205** | **153.5** | **81.6** | **56.8** | **410** | **14 545** | **417** | **2.7** | **48.8** | **17.3** |
| | **1987** | **1 292** | **189.9** | **99.8** | **71.6** | **439** | **15 562** | **429** | **2.8** | **55.5** | **33.1** |

# 2.3 Research Salaries

One factor in the availability of competent research personnel is the development in the income level of personnel engaged in R&D. The following represents the development in earnings of research personnel in industry, in the Public Sector, and in institutions of higher education compared to other respective groups. The data are derived from the income statistics prepared by the Central Statistical Office.

## Earnings by Research Personnel Up Less Than Average

Industrial research salaries went up ca. 8 per cent slower than the average income level of industrial administrative employees in 1980–1987.

**Table 2.4 Salary indices for research personnel in industry**

| 1980=100 | Actual research work | Research assistance | Administrative industrial employees, average |
|---|---|---|---|
| 1980 | 100 | 100 | 100 |
| 1981 | 110 | 112 | 112 |
| 1982 | 121 | 123 | 124 |
| 1983 | 133 | 135 | 138 |
| 1984 | 146 | 148 | 151 |
| 1985 | 157 | 159 | 163 |
| 1986 | 165 | 168 | 173 |
| 1987 | 176 | 177 | 184 |

Table 2.5 shows that the difference in the salary development of state research personnel compared with the general salary development of Government employees varies in concert with the research objective. General research salaries, mainly in The Academy of Finland, have experienced the slowest income development. Income development for personnel in health care research facilities or for those engaged in research work for industrial or commercial purposes has even exceeded the general growth rate.

## Salaries of University Teachers Lag Behind

Income development for university teachers trails behind the general income development of Government employees. Especially income development for assistants has been slow; however, the fact that the share of unqualified assistants has increased is partially to blame for this. Professorial salaries as well did not reach the general salary growth rate of Government employees in 1985 - 1987.

**Table 2.5 Salary indices for research personnel in the public sector, 1980–1987**

| 1980=100 | General research | Health care research | Agricultural and forestry research | Business services research | Goverment employees, average |
|---|---|---|---|---|---|
| 1980 | 100 | 100 | 100 | 100 | 100 |
| 1981 | 101 | 108 | 106 | 108 | 108 |
| 1982 | 117 | 120 | 122 | 123 | 123 |
| 1983 | 125 | 136 | 131 | 136 | 135 |
| 1984 | 129 | 144 | 135 | 140 | 140 |
| 1985 | 139 | 157 | 147 | 154 | 152 |
| 1986 | 147 | 167 | 156 | 165 | 162 |
| 1987 | 156 | 181 | 168 | 180 | 177 |

**Table 2.6 Salary indices for university teachers, 1980–1987**

| 1980=100 | Professors | Assistant professor | Lecturers | Assistants | Goverment employees, average |
|---|---|---|---|---|---|
| 1980 | 100 | 100 | 100 | 100 | 100 |
| 1981 | 105 | 105 | 106 | 109 | 108 |
| 1982 | 120 | 123 | 122 | 125 | 123 |
| 1983 | 132 | 135 | 131 | 132 | 135 |
| 1984 | 138 | 140 | 136 | 134 | 140 |
| 1985 | 154 | 154 | 146 | 142 | 152 |
| 1986 | 162 | 166 | 159 | 150 | 162 |
| 1987 | 172 | 174 | 170 | 161 | 177 |

# 3. Resources for R&D

With advancement of technology, the success of an enterprise is based more than before on know-how and adaptability. Several studies prove that developing production technology and products profits an enterprise more than mere extension in the use of inputs.

Research and development in the Public Sector produce knowledge serving both the state administration and the Business Enterprise Sector. Institutions of higher education, on the other hand, play a crucial role both in advancement of general sciences and in basic research not actually directed towards techno-economical applications.

The Central Statistical Office has compiled biennial statistical data on research and development since 1971. The statistics are based on replies to questionnaires by the Business Enterprise Sector, the Public Sector, and institutions of higher education.

*Research and development (research and development activities, R&D) is taken to mean a systematic process of increasing the stock of knowledge and using that knowledge to find new applications.*

Research and development include basic research, applied research, and experimental development.

The statistics are compiled in accordance with the OECD recommendations published in a handbook (OECD: The Measurement of Scientific and Technical Activities, Paris 1981). Corresponding statistics are compiled in all the OECD countries in compliance with the same recommendations.

The OECD gathers biannually detailed information on research and development activities of its member countries. This is published both in the form of summary statistics and in various analytical reports. The international R&D data in this publication are based on the OECD data.

One of the problems in the statistics on resouce for R&D is differing interpretation of the definition for R&D activities in the units providing information. The instructions to respondents which are based on international recommendations make it possible to give only general guidelines on outlining R&D activities. But in practice, the actual application of the definition is up to the respondent.

As the definition of R&D is open to interpretation and as only a few companies or institutes keep track of their research expenditure, acquisition of exact figures is further hampered. Especially data submitted by small companies may be rather haphazardly estimated.

Data on research work in institutions of higher education are derived both from replies to questionnaires by the Central Statistical Office and from estimates based on other data pertinent to institutions of higher education, such as questionnaires on usage of time by personnel, questionnaires directed to individual departments, and various administrative data sources.

Below, general presentation of data on R&D is given, followed by a study of advancement in research activities in the Business Enterprise Sector, in the Public Sector, and in institutions of higher education, respectively.

Data on R&D are based on information compiled by the Central Statistical Office. Detailed statistics have been published in the Central Statistical Office Series, Education and research. Data on Government R&D appropriations are based on the calculations by The Academy of Finland.

The statistics on resources for R&D activities indicate the scope and trend of research activities and distribution of R&D expenditure and financial sources. But, they don't reveal anything about the results of research activities or impact of research. These are examined in Chapters 4 to 6 of this report in more detail.

# 3.1 General Development in Resources

## Share of R&D 1.7 Per Cent in GDP in 1987

The most widely used indicator of research input in an economy is the share of R&D expenditure in GDP. This figure is referred to as well in discussions on technology policy as in comparisons between various countries.

R&D expediture has increased faster than the GDP at least since 1971, the year the R&D statistics were introduced. The share of R&D in GDP was ca. 0.9 per cent in 1971 and 1.7 per cent in 1987. It is expected to account for 1.8 per cent in 1989.

Growth in 1983 - 1987 was rather rapid while the share of R&D in the GDP went up ca. 0.1 percentage unit per year. This growth rate is estimated to have slowed down in the following two years.

**Figure 3.1 Share of R&D expenditure in GDP, 1983–1989**

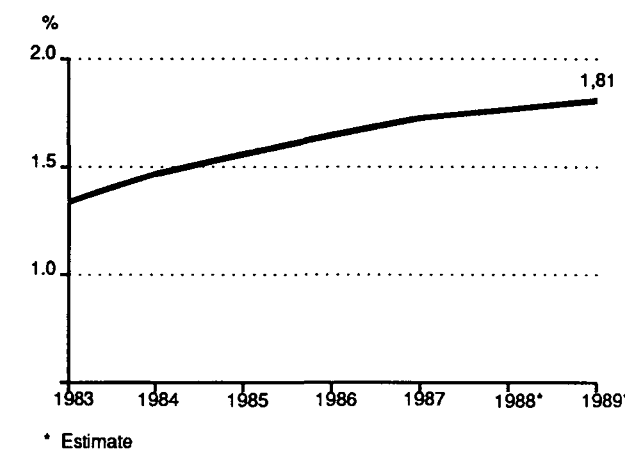



**Table 3.1 R&D in 1983–1989**

| Year | Enterprises | | Public sector 1) | | Institutions of higher education | | **Total** | | Share in GDP |
|---|---|---|---|---|---|---|---|---|---|
| | FIM mill. | % | FIM mill. | % | FIM mill. | % | **FIM mill.** | % | % |
| 1983 | 2 060 | 55.7 | 791 | 21.4 | 845 | 22.9 | **3 696** | **100.0** | 1.34 |
| 1984 | 2 638 | 58.0 | 936 | 20.6 | 976 | 21.4 | **4 550** | **100.0** | 1.47 |
| 1985 | 3 082 | 58.7 | 1 069 | 20.4 | 1097 | 20.9 | **5 248** | **100.0** | 1.56 |
| 1986 | 3 512 | 58.9 | 1 215 | 20.4 | 1234 | 20.7 | **5 961** | **100.0** | 1.65 |
| 1987 | 4 002 | 58.9 | 1 389 | 20.5 | 1401 | 20.6 | **6 792** | **100.0** | 1.73 |
| 1988 2) | 4 642 | 59.8 | 1 520 | 19.6 | 1602 | 20.6 | **7 764** | **100.0** | 1.77 |
| 1989 2) | 5 431 | 60.9 | 1 654 | 18.6 | 1 829 | 20.5 | **8 914** | **100.0** | 1.81 |

1) Goverment administrative sectors, other public institutions, private non-profit sector
2) 1988 and 1989 figures based on estimates

## Real Growth in Research Expenditure About 10 Per Cent Per Year

From 1983 to 1987, average real growth in R&D expenditure was 10 per cent a year. Approximately 6.8 billion FIM was spent on research and product development in 1987. Research expenditure for 1989 is estimated to amount to nearly 9 billion FIM.

The real growth rate puts Finland among the top OECD countries. In 1983 - 1987 among the leading industrial countries, the United States had an average growth rate in expenditure of ca. 5 per cent, Japan 7 per cent, and the Federal Republic of Germany 4 per cent. The growth rate in Sweden was 7 per cent and in Norway 8 per cent.

## Share of Business Enterprise Sector in R&D Up Fastest

The Business Enterprise Sector accounted already for 59 per cent of R&D expediture in 1987. The share of institutions of higher education was 21 per cent and that of other Public Sector accounted for 20 per cent. The trend is expected to continue along these lines and in 1989, the Business Enterprise Sector's share is estimated to have been approximately 61 per cent.

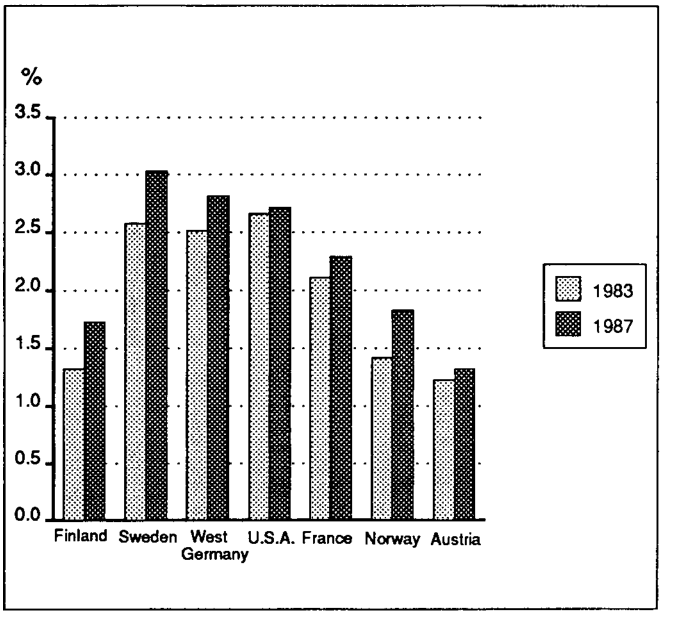
## Share of Research Expenditure in GDP Less in Finland Than in Leading OECD Countries But Close To General Median Level

In 1985, the aggregate share of R&D expenditure in the aggregate GDP of the OECD countries was ca. 2.3 per cent. The weights of the larger countries with extensive research activities have greatly influenced this figure. The median value of R&D expenditure in the GDP of the OECD member countries was approximately 1.4 per cent in 1987.

Comparison between the Nordic countries reveals that Finland (1.7 per cent) clearly lags behind Sweden (3.0 per cent) but Norway's share of R&D expenditure in the GDP (1.8 per cent) in 1987 was close to Finland's level. Austria (1.3 per cent), Italy (1.3 per cent), and Canada (1.4 per cent) had a lesser share of R&D expenditure in the GDP than Finland. But, France (2.3 per cent), England (2.4 per cent), the United States (2.7 per cent), the Federal Republic of Germany (2.8 per cent), Japan (2.9 per cent), and Switzerland (2.9 per cent) were clearly ahead of Finland.

Military research with high demand for resources has an effect on the share of research expenditure in the GDP. For instance, if military research costs for the United States figures are exempted, its share is estimated to have been 1.9 per cent in 1985. Military research does not really have much importance for the small OECD countries and Japan in this respect.

**Figure 3.2 Share of R&D in GDP in some OECD countries, 1983 and 1987**




## Big OECD Countries as Leaders

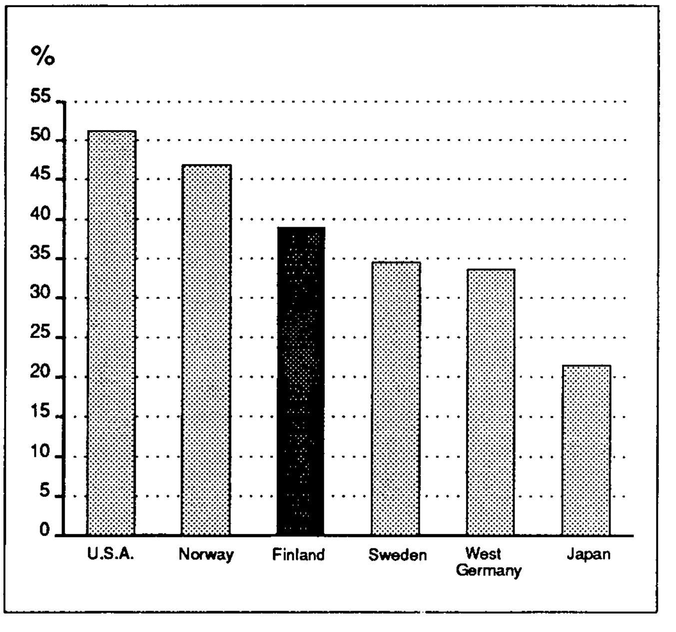
The share of the United states in the aggregate R&D expenditure of the OECD countries was approximately 48 per cent, with Japan's 16 per cent, and EC's ca. 28 per cent (standing in 1985). The aggregate share of the Nordic countries was approximately 2.4 per cent.

## Share of Public Sector in Research Funding Varies Between Countries

Besides the study of actual R&D expenditure, origin of financial sources for costs incurred may also be surveyed.

The Public Sector financed approximately 39 per cent of research work done in Finland in 1987, which accounts for more than in Sweden, but less than in Norway. Approximately one half of the funds for research work in the United States comes from the Public Sector; in contrast, Japan's Public Sector finances only a little more than one fifth of her research activities.

**Figure 3.3 Share of goverment R&D funding in total R&D funding in some OECD countries, 1987**



## R&D Concentrated Around Helsinki Metropolitan Area

In 1987, approximately 45 per cent of R&D expenditure was spent in the Helsinki metropolitan area. About 40 per cent of the R&D expenditure in the Business Enterprise Sector incurred in the Helsinki metropolitan area and also approximately two thirds of the Public Sector's R&D expenditure focused in the area. As to research expenditure by institutions of higher education, regional distribution is evened out especially by the large share of the Province of Oulu.

Concentration of R&D activities is evening out: the share of the Province of Uusimaa in R&D expenditure was approximately 56 per cent in 1983, but in 1987 it was approximately 51 per cent.

**Table 3.2 Research expenditure by province and sector, 1987**

| Province | Business enterprises sector | Public sector | Higher education sector | **Total** |
|---|---|---|---|---|
| | % | % | % | % |
| Uusimaa | 50.8 | 67.0 | 42.6 | **52.4** |
| - of which *) | 39.5 | 65.4 | 42.5 | **45.4** |
| Turku – Porin | 17.1 | 2.3 | 14.8 | **13.6** |
| Aland | 0.0 | 0.2 | - | **0.0** |
| Häme | 11.8 | 13.7 | 11.5 | **12.2** |
| Kymi | 3.9 | 0.4 | 2.4 | **2.9** |
| Mikkeli | 0.9 | 0.6 | 0.4 | **0.7** |
| Northern Karelia | 0.7 | 1.6 | 2.7 | **1.3** |
| Kuopio | 1.6 | 1.9 | 4.5 | **2.3** |
| Central Finland | 3.4 | 2.5 | 6.1 | **3.7** |
| Vaasa | 4.4 | 1.1 | 1.1 | **3.0** |
| Oulu | 4.1 | 4.6 | 12.8 | **6.0** |
| Lapland | 1.0 | 3.0 | 1.1 | **1.5** |
| Unspecified | 0.3 | 1.1 | 0.0 | **0.4** |
| Expenditure (FIM mill.) | 4 002 | 1 389 | 1 401 | **6 792** |
| Share (%) | 59 | 20 | 21 | **100** |

*) Helsinki Metropolitan Area (Helsinki, Espoo, Vantaa)

## More Than 36 000 Employees in R&D Work

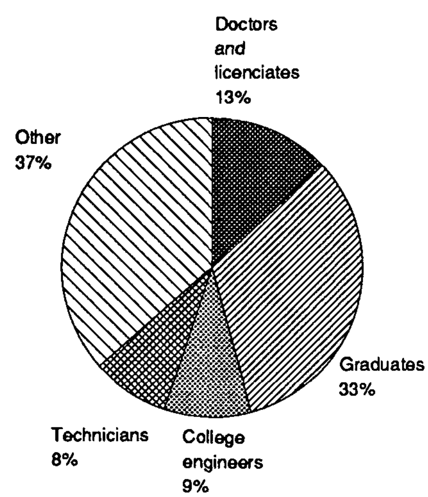
In 1987, ca. 26 200 research man years were worked; hence, this figure is up from 1983 an approximate average of 7 per cent a year.

Approximately 36 6000 employees were engaged in R&D work in 1987, which is ca. 22 per cent more than in 1983. Women accounted for 32 per cent of all employees in R&D, or nearly 12 000.

About one half of the population aged under 65 with a doctoral or a licentiate degree were engaged in R&D work in 1987. Of those engaged in R&D work, approximately 46 per cent had at least a graduate degree.

Ca. 20 per cent of doctors and licentiates engaged in R&D work were women (women accounted for approximately 21 per cent of population with a research degree); 27 per cent of all research personnel with a graduate degree were women. Among personnel with a lower educational background, i.e., mainly among research assistants, more than half were women. Male dominance in technological research is shown in the fact, among others, that only approximately 7 per cent of college engineers and technicians engaged in R&D work were women.

**Figure 3.4 Total stock of research personnel by educational level, 1987**



# 3.2 Research and Product Development in the Business Enterprise Sector

## Research Expenditure in Business Enterprise Sector 4 FIM billion

Companies spent 4 002 FIM million for their own research and product development in 1987. Industry (including minerals industry, electric, gas, and water maintenance) accounted for 3 331 FIM million of the total amount.

External R&D orders by companies amounted to 229 FIM million.

External R&D funding in the Business Enterprise Sector accounted for approximately 8.6 per cent in 1987 (excluding R&D loans with a clause).

## Electrical Products Biggest Product Group

Approximately 28 per cent of research expenditure in the Business Enterprise Sector was spent on R&D in electrical industry, followed by machinery and equipment with 16 per cent, and chemical products with 17 per cent.

R&D intensity in producing various goods can be measured by the share of R&D expenditure in the value added of the products.

The share of R&D expenditure in the industrial value added has been on the increase throughout the 1980s. In 1987, it was approximately 3.8 per cent (including minerals industry and electric, gas, and water maintenance). Variations by product groups are great. Pharmaceutical products were the biggest product group with 29.3 per cent, followed by instrumentation with 16.7 per cent, and computers and office machinery with 16.6 per cent.

The respective shares of textile industry, mechanical wood processing industry, and graphic industry was below 1 per cent.

Comparison among Nordic countries reveals that the share of industrial research expenditure in value added in Finland is clearly lower than that in Sweden, close to that of Norway, and more than that of Denmark.

## Approximately 13 500 Research Man Years in Business Enterprise Sector in 1987

R&D man years increased with a yearly rate of 9 per cent from 1983 to 1987.

In 1987, the number of companies engaged in R&D activities was approximately 950, an addition of ca. 100 from 1985.

**Figure 3.5 Distribution of R&D expenditure by product group, 1987**

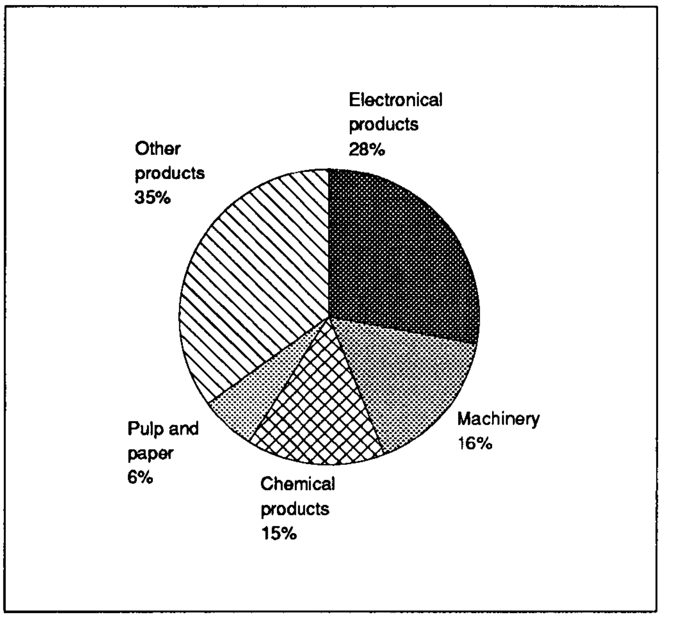
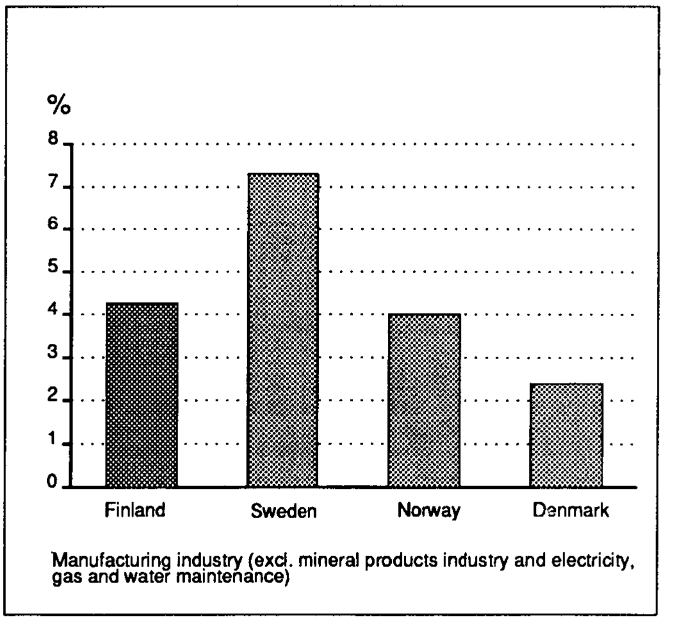



**Figure 3.6 Share of R&D expenditure in value added in four Nordic countries, 1987**



# 3.3 Public Sector R&D

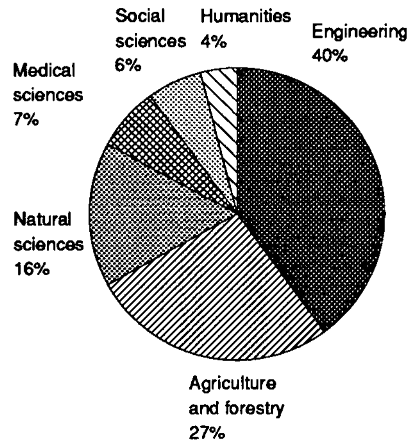
In 1987, research and development expenditure in the Public Sector (including state administration, public institutions, the Private Non-Profit Sector) was 1 389 FIM million, or approximately 20 per cent of the total R&D expenditure.

The yearly real growth rate of R&D expenditure from 1983 to 1987 averaged 9 per cent, or two percentage units less than that of the Business Enterprise Sector during the same time period.

Most of the Public Sector R&D (i.e., 93 per cent) was done in the Government administrative sector. The remaining 7 per cent includes research and development in other public institutions and in the Private Non-profit Sector.

The administration of the Ministry of Trade and Industry spent most in R&D, 640 FIM million, followed by the Ministry of Agriculture and Forestry with 341 FIM million, the Ministry for Social Services and Health with 120 FIM million, and other public institutions with 76 FIM million.

**Figure 3.7 Public sector research man years by field of science, 1987**




## Research Man Years in Public Sector Up Slower Than in Other Sectors

In 1987, 6 015 research man years were worked in the Public Sector. The average annual growth rate was ca. 4 per cent from 1983 to 1987.

The most research man years by field of science were worked in technological sciences, with approximately 40 per cent of the man years, followed by agriculture and forestry with 27 per cent and natural sciences with 16 per cent.

# 3.4 Research in the Higher Education Sector

## Share of External Funding Up

University research expenditure surpassed that of the other Public Sector entities, amounting to 1 401 FIM million. Approximately 6 700 research man years were worked, with an average annual growth rate of ca. 5 per cent from 1983 to 1987.

University research expenditure is funded mainly by the General University Funds (GUF), with an annual share of ca. 52 per cent in 1987. However, the share of external funding aside from the General University Funds has clearly increased: in 1983 the share of General University Funds was nearly 58 per cent.

The Academy of Finland and the Technology Development Center are two of the most important single sources of funds in the Public Sector.

The Business Enterprise Sector increased its share proportionally most from 1983 to 1987 but the share still remained relatively modest, 4 per cent, or the average OECD level.

**Table 3.3 Research expenditure in the higher education sector, by source of funds, 1983 and 1987**

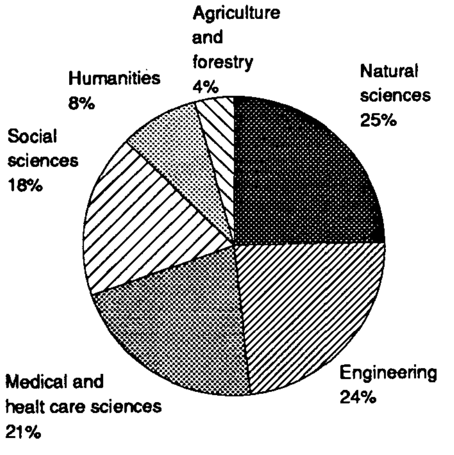
| Source of funds | 1983 | | 1987 | |
|---|---|---|---|---|
| | FIM mill. | % | FIM mill. | % |
| **General university funds** | 486.0 | 57.5 | 733.1 | 52.3 |
| **Public sector** | 254.2 | 30.1 | 425.4 | 30.4 |
| -of which | | | | |
| Academy of Finland | 94.2 | 11.1 | 160.2 | 11.4 |
| Techn. Devel. Center | - | - | 45.8 | 3.3 |
| **Other funds** | 44.0 | 5.2 | 148.9 | 10.6 |
| - of which: | | | | |
| Enterprises | 22.1 | 2.6 | 53.8 | 3.8 |
| Income surplus | 5.1 | 0.6 | 22.3 | 1.6 |
| **Unspecified** | 61.1 | 7.2 | 94.0 | 6.7 |
| **Total** | **845.3** | **100.0** | **1 401.4** | **100.0** |

## Share of R&D in Natural Sciences Slightly Down

By field of science, most research expenditure, approximately one fourth, in the Higher Education Sector incurred in natural sciences. Also, the shares of both technology and medical sciences were more than 20 per cent.

Compared to 1983, the share of natural sciences is down by approximately 2 percentage units. Most increase is in the fields of technology and agriculture and forestry. Also, the share of social sciences research in research expenditure is slightly up and that of medical sciences and humanities slightly down.

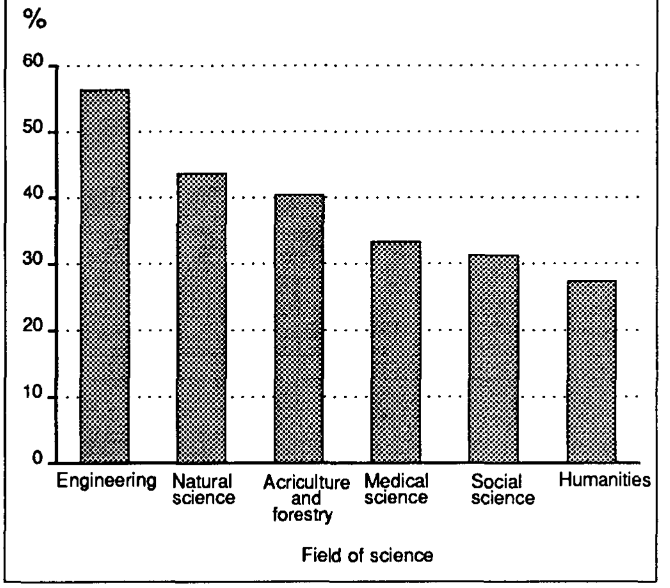
**Figure 3.8 Research expenditure in higher education sector by field of science, 1987**




## Distinct Variations by Field of Science in External Funding

External funding for technological research in Higher Education Sector accounted for approximately 56 per cent of the expenditure. External funding for medical research was one third of the expenditure and for research in humanities approximately 27 per cent of the expenditure.

**Figure 3.9 Share of external funding in research expenditure by field of science, 1987**




# 3.5 Government R&D Appropriations

Information on Government research funding is based on the budget analyses by The Academy of Finland (Academy of Finland: Analysis of Proposed 1989 Government R&D Appropriations, Helsinki 1988). This analysis contains assessment of R&D budget appropriations for various sectors of the budget. The total R&D expenditure arrived at by these calculations is higher than in the statistics of R&D expenditure based on R&D performance.

## Share of Research Expenditure in Government Budget 3.2 Per Cent

Research appropriations in the 1989 Government budget amounted to 3 570 FIM million, or a real growth rate of 6.8 per cent from 1988, compared with the real growth rate of 4.0 per cent in total Government expenditure.

## Most Research Funding through Ministry of Trade and Industry and Ministry of Education

Most of the Public Sector research funding is circulated through the Ministry of Trade and Industry and the Ministry of Education. Circa three fourths of appropriations directed toward public research activities originate from these administrative fields.

Most research funding (ca. 590 FIM million) appropriated through the Ministry of Trade and Industry consists of appropriations to the Technology Development Center (Tekes). The Technology Development Center mainly focuses on promoting technological competitiveness in industry, for instance, in the form of loans and grants for product development. Research appropriations for the Technology Development Center were clearly the fastest growing sector of government research funding throughout the 1980s.

Within the fields governed by the Ministry of Education, the share of institutions of higher education in research funding is approximately 975 FIM million. Research funding at the institutions of higher education went up slower than the average Government research expenditure during the first half of the 1980s. However, the situation changed during the second half the decade and in the 1989 budget proposal, the growth rate of research appropriations for institutions of higher education exceeds by more than 2 percentage units the average growth rate of Government research funding.

In the 1980s, The Academy of Finland appropriations have almost kept an even pace with the growth rate of the average Government research funding.

## Focus on Promoting General Sciences

Research by objective classification, promoting general sciences covers approximately 37 per cent of Government research funding. This group includes for instance all appropriations to institutions of higher education and to The Academy of Finland. Compared with the 1988 budget proposal, promoting general sciences and industry have slightly inreased their share; classification groups by objective, Agriculture and Energy have slightly decreased their share.

Annex tables 3 and 4 include detailed information on development and distribution by field of adminstration of Government research funding.

## Special Research Project Appropriations in the Government Budget Close to 900 FIM million

The Central Statistical Office gathered data for 1987 on special appropriations directed by the Government towards R&D activities.

The 1987 Government budget directed ca. 894 FIM million as special appropriations for R&D, with 36 per cent going to the Business Enterprise Sector, 27 per cent to institutions of higher education, and 23 per cent to the Public Sector. The balance went to the Private Nonprofit Sector, individual researchers, and international cooperation.

**Figure 3.10 Government research funding by field of administration, 1989**

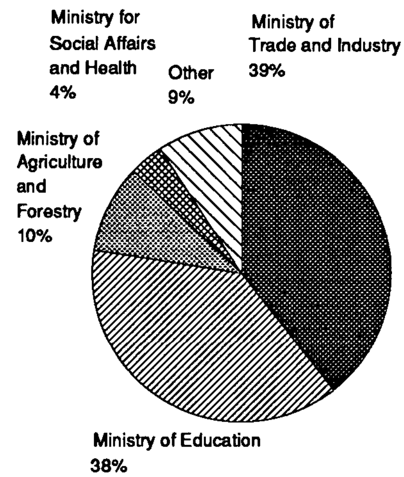
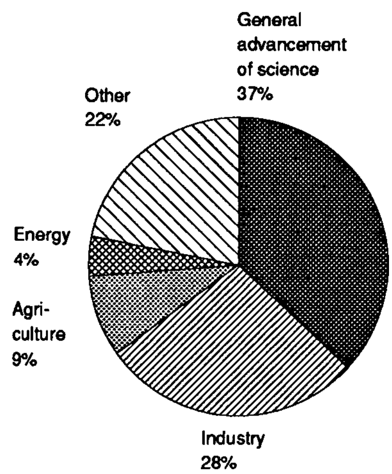



**Figure 3.11 Government research funding by objective, 1989**



# 4. Bibliometric Indicators

by Terttu Luukkonen, The Academy of Finland

## 4.1 Description of Indicators

Bibliometrics is taken to mean quantitative studies of publishing activities. Bibliometric indicators are used for many purposes but increasingly for measuring scientific research output. Some of the most common bibliometric indicators used for assessing research output are the number of scientific publications and models and indicators based on references in scientific literature. In addition, international coauthorship is becoming an object of interest for science policy makers.

The use of bibliometric indicators in assessing scientific output is based on the importance of written communication to research work. Publications are the most common channel used for disseminating results of scientific research. Publishing research results in scientific publications is characteristic especially of research done in institutions of higher education and of basic research; hence, the bibliometric indicators are best suited for measuring the output of basic research and research activities in institutions of higher education.

### Number of Publications

The number of publications measures scientific productivity; it is a simple and easily calculable figure. However, the number of publications in itself does not tell much about the quality of the work. In counting publication figures, the weights of various types of publications must be determined as they differ much in importance and in work invested in them. Books are normally weighed higher than articles in scientific journals. However, there do not exist commonly accepted weights for assessing the relative importance of books vs. articles.

In international article data bases, most publications listed are articles in journals; therefore, weighting different publications do not present a problem. If such data are used in counting output, a qualitative dimension is also attained: in order to be published, a scientific article has to pass an evaluation process.

Journals are not the most important channel in all fields of science. For instance, in the fields of technological sciences, humanities, and social sciences books and reports are an important form of literature output. Hence, data based mainly on articles do not suffice for the description of output in these fields of science. In addition, publishing in international series is relatively scant in many fields of science. In every field of science, however, international data bases describe the development of international publishing activities.

### Citations

Citations issued in scientific publications serve as the basis for compilation of citation indices. The use of citations as an output indicator of scientific research is based on the assumption that citations portray the real importance of the cited publications to other research and the recognition of the material referred to. Hence, citations measure a qualitative dimensions although they cannot unequivocally be considered as indicators of the quality of work. The reason for this is that many other factors than the quality of work affect the accumulation of citations.

The language, type, and country of publication contribute to the size of the scientific audience and thereby to the accumulation of citations. Important prerequisites for high citation counts are: publishing in the English language; publishing in general or review journals with a large audience; or publishing in recognized Anglo-American journals. Frequent publication in periodicals in small countries, even though in English, accumulates relatively few citations.

Likewise, the average citation levels in different fields of science vary because of different publication channels and different citation habits. For the same reason, basic and applied research have different citation levels even within the same field of science.

Due to the reasons stated above, only a part of the value of citation indicators can be interpreted to give a measure of the quality or importance of the publications referred to. In order to control the effect of differing publication and citation habits on the results of an analysis, citation counts should not be compared across fields directly with each other; instead, they should be related to the average of their own field or to some other proportional factor. The units being compared should also be similar in relation to orientation and environment of research. Citation indices contain technical errors (misspelling of names, incorrect bibliographic information, homonyms, etc.) In order to reduce error factors, the units compared should be relatively large. If small units are studied, every single reference should be checked. Citation indicators are incomplete indicators of the quality of research work. Hence, they should be used together with other indicators and qualitative information.

## Data Bases

Along with the expansion of computer based information services and above all with the the creation of the Science Citation Index (SCI) in 1963 and its development, the use of bibliometric indicators has become more common. Besides the SCI, there are other international data bases to be used to gather bibliographic data on publications: e.g., Medline or Excerpta Medica for medical sciences, Biological Abstracts for biological sciences, and Physics Abstracts for physics. These data bases include more Finnish publications than the SCI which included only seven Finnish source journals in 1987.

The Institute for Scientific Information data bases, of which the SCI is a part of, are the only data bases collecting citations systematically. The Institute for Scientific Information maintains four data bases: the Science Citation Index; the Social Sciences Citation Index; the Arts and Humanities Citation Index; and the Computer & Mathematics Search. The data in the SCI on publications and citations are compiled from more than 3 000 source publications (3 167 in 1987). Most source publications are scientific journals. In designing this data base, scientific journals were assumed to be a central channel of scientific communication. This is not true in every field of science; hence, for instance in such fields of science as humanities, social sciences, or technological sciences books and reports are important means of communication. Therefore, the use of the SCI, or the data bases in the field of the social sciences and humanities, the Social Sciences Citation Index, and the Arts and Humanities Citation Index, cannot be recommended without taking into consideration this fact, and the data should be complemented with information from other sources.

The Computer Horizons Inc (CHI) data base contains the SCI publication and citation data processed by field of science and by country. The fields of science have been defined by the science classification of journals. The data base is based on the 1973 set of source journals used by the SCI (a total of 2 300 journals) and covers 1973 through 1984. The set of journals has remained unchanged to allow a generation of comparable time series. If narrow fields of research are surveyed, this field of science classification based on journals may prove problematic. Cancer research, for instance, includes only 15 journals. Nevertheless, articles on cancer research are also published in multidisciplinary and general medical journals, in basic biomedical journals, and in other specialized journals. Hence, according to Medline, in 1978 - 1982 only 12 per cent of cancer research carried out in Finland was published in the cancer journals used by the CHI data base. However, the CHI data base is the only one to include pre-classified data by field of science; and, its use can be justified for producing a general picture of the volume of publications and citations by field of science.

# 4.2 Development in International Publishing Activities

Figure 4.1 presents a time series of the share of papers by Nordic (excl. Iceland) researchers in the SCI (Annex Table 5 gives the absolute numbers). Each Nordic country has a slightly upward trend. This cannot be explained by additions to the assortment of source journals used by the SCI, as, for instance, the share of articles originating from Finland is increasing despite the SCI's cutbacks on Finnish journals included in their data base in the 1980s.

**Figure 4.1 Share of publications by Nordic researchers in SCI, 1974–1988**

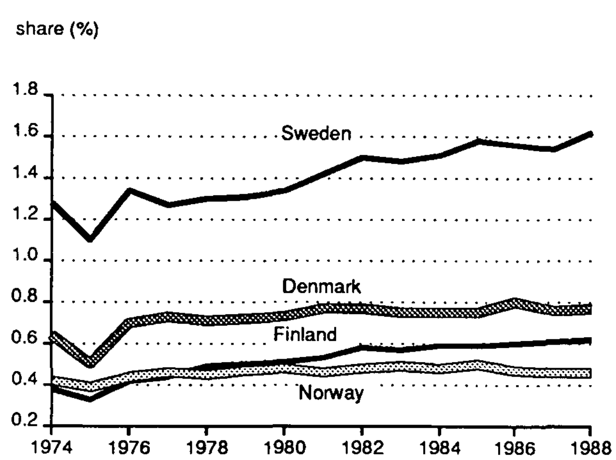
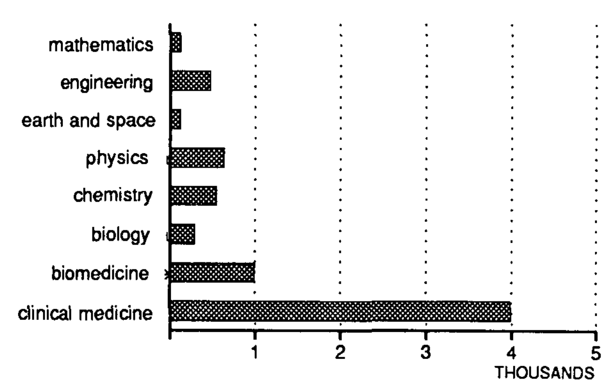



**Figure 4.2 Papers by Finnish researchers, 1981–1984**




Source: Computer Horizons Inc./ SPRU, University of Sussex

Figure 4.2 includes the numbers of papers by field of science, using the CHI data base, by Finnish researchers in 1981 through 1984. Medical research generates the most papers published in the assortment of journals covered by the CHI data base. The result reflects above all the fact that Finland's medical research is internationally orientated. It is also a fact that medical research publishes numerous articles.

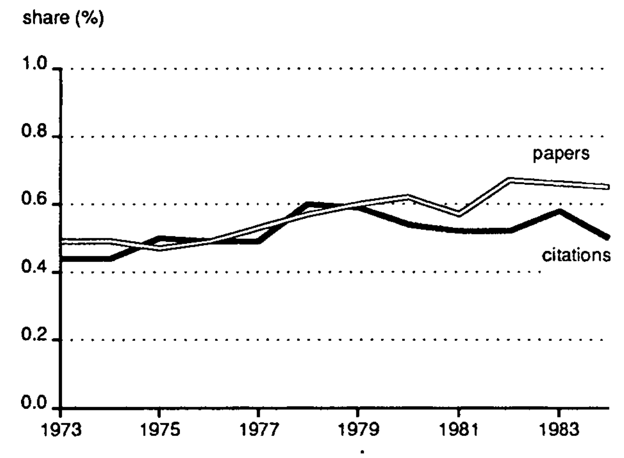
Based on data in Figure 4.2, it cannot be directly concluded that medical research as such is more productive than other fields of scientific research. To draw such a conclusion, also data on the extent of domestic publishing activities should be considered and publication data should be related to data on funding and stock of researchers. Comparable data on domestic publishing by field of science is not available. A crucial factor for the lack of this information is that as the manner of publishing varies between different fields of science, weighing publications is problematic. And, there is not enough accurate information on funding or stock of researchers by field of science.

# 4.3 Citation Level of Finnish Research

Figure 4.3 includes the development in the share of papers and citations accumulated by Finnish researchers in the CHI data base in 1973 through 1984. Both have a slightly upward trend, but during the last few years, the share of citations remains somewhat lower than the share of papers. However, the difference is in the magnitude of tenths of a percent.

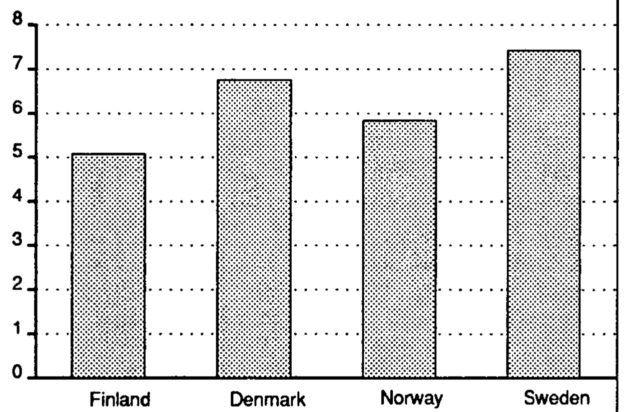
According to the CHI data base, the average number of the citations accumulated by Finnish papers was smaller than that of the other Nordic countries in 1973 through 1984 (Figure 4.4). The citation counts of especially Danish and Swedish papers were larger than those of Finland. However, the trend in the share of citation counts of Finnish papers in the data base is - if anything - increasing (Figure 4.5) (when citation counts are calculated by the year of publication of the cited work) while it is slightly decreasing for the other Nordic countries. The differences, however, are minimal and it is hard to say whether they reflect changes in publishing structure of Finnish research: for instance that Finnish researchers publish more than before in prominent and esteemed journals.

**Figure 4.3 Share of papers by Finnish researchers and respective citations, 1973–1984**



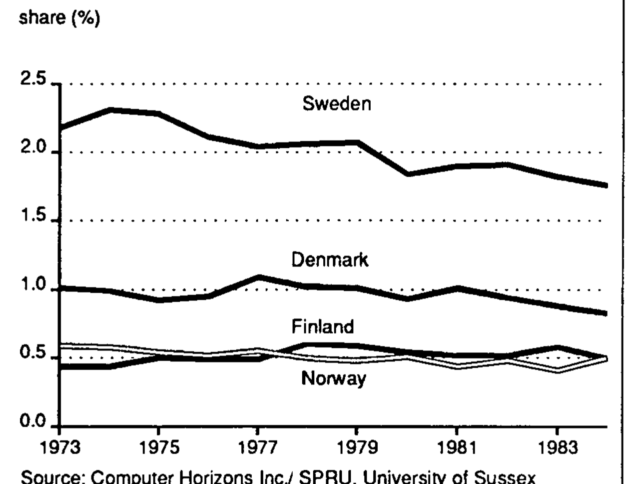

Source: Computer Horizons Inc./ SPRU, University of Sussex

**Figure 4.4 Average number of citations accumulated by Nordic papers, 1973–1984**




Source: Computer Horizons Inc./SPRU, University of Sussex

**Figure 4.5 Share of Citations*) obtained by Nordic researchers in CHI data base, shares in 1973–1984**




Source: Computer Horizons Inc./ SPRU, University of Sussex

*) Accumulation of citations calculated according to the year of publication of the cited work

Figure 4.6 reflects the citation level of Finnish papers by field of science, related to the international average of respective fields of science. The Index value 1 on y-axis corresponds to the international average. Only scientific research in the fields of physics and biology in Finland exceeds the international average; even citations to medical research remained below it. The result for other Nordic countries is quite different (Figures 4.6 - 4.9). Every field of science in Sweden surpassed the international average as do most fields of science in Denmark. Three fields of science in Norway well surpassed the international average.

The above described averages by field of science conceal significant variations within fields of science. And so, for instance, Finnish cancer research rated among the top research in 1973 through 1984 calculated according to the CHI data base information (Table 4.1).

**Table 4.1 Citations from Finnish cancer research papers *), related to international average, 1973–1984**

| | Relative citation rate |
|---|---|
| **Finland** | 1.35 |
| Norway | 0.92 |
| Denmark | 0.76 |
| Sweden | 1.62 |
| Netherlands | 0.87 |
| Great Britain | 1.11 |
| Italy | 0.49 |
| France | 0.80 |
| Federal Republic of Germany | 0.72 |
| United States of America | 1.16 |
| **International Average** | **1.00** |

Source: Computer Horizons Inc./SPRU, University of Sussex

*) Relative citation rate, calculated according to the publication year of the articles

**Relative citation levels of scientific fields in the Nordic countries, average of 1973–1984**

**Figure 4.6**

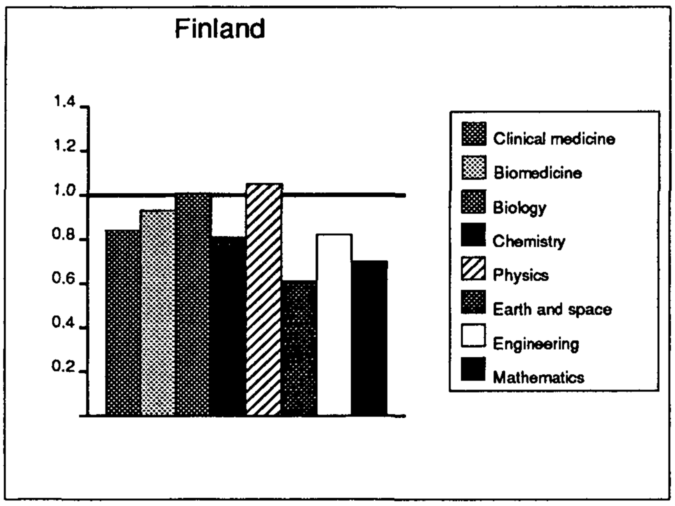



**Figure 4.7**

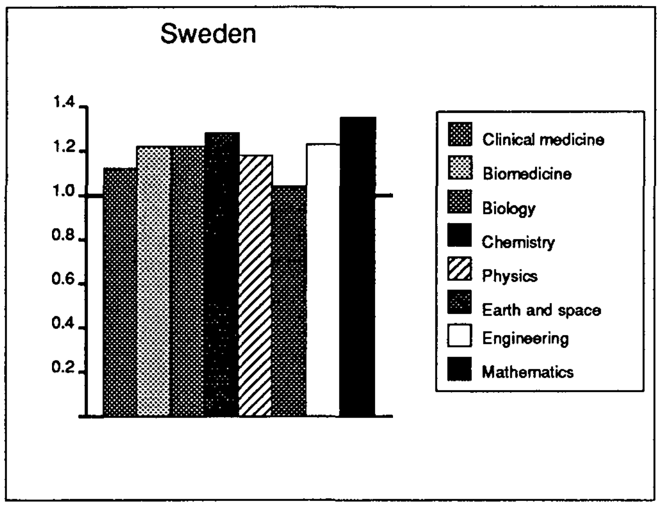



**Figure 4.8**

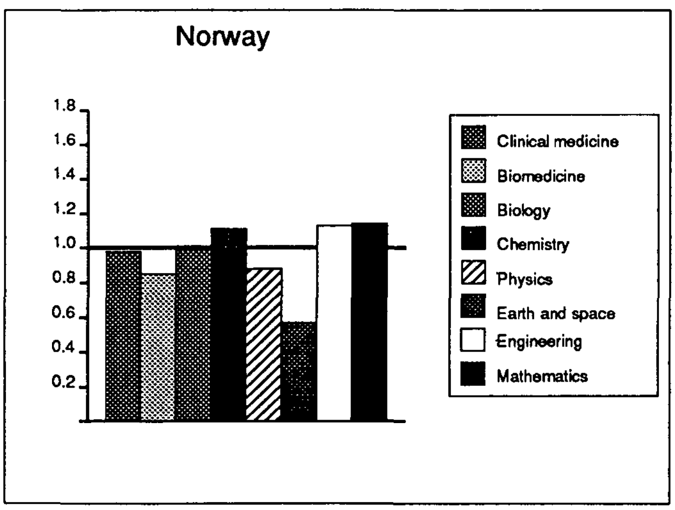
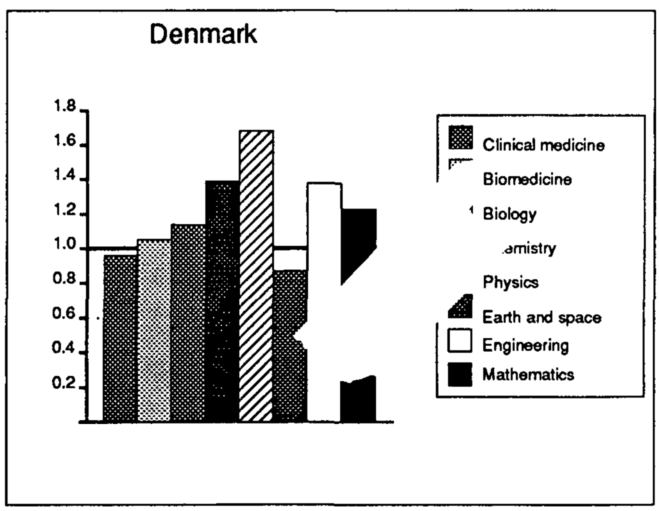



**Figure 4.9**




*)Source: Computer Horizons Inc./SPRU, University of Sussex

# 5. Application of Technology

## 5.1 Patents

*A patent is an exclusive right of a specific duration granted by the state to an inventor or a patentee to utilize the invention.*

The invention to be patented has to be new, useful, applicable to industry, and sufficiently inventive. Types of inventions protected by the patent right vary greatly by country, e.g., in Finland, medical and food substances cannot be patented, only their production method.

A patent is a formal record of the fact that new and useful technical information has been obtained. Increase in the number of patents indicates growth in technological knowledge. Hence, patent statistics can be used as science and technology indicators.

Patenting is considered to increase the willingness of companies to invest in R&D activities because the patent system protects inventions from competitors. Furthermore, as the inventor, in exchange for the exclusive right, makes the invention, its background, purpose, and applicability public, new, industrially adaptable information is introduced fast and effectively into common knowledge. Although the patent system gives a temporary technological monopoly, it is considered, however, to accelerate more than slow down technological progress.

Although novelty and adaptability are prerequisites for a patent grant, this does not guarantee that the invention has technological or economic market value. All patents are not industrially exploited, either, for instance, because of the technology not being applicable to big-scale production or because of difficulties in marketing.

Benefits and deficiencies of patent statistics as technology indicators are:

### Benefits:

- Patent information is amply recorded in time series for a long period of time
- International comparison figures on patents and patent statistics are available
- Possibilities to process the material are manifold: a study of diverse characteristics of the invention and of the inventor/patentee gives information on the nature of technological progress.

The most commonly studied characteristics are: the homeland of the inventor and patent applicant/patentee; type of applicant/patentee (private persons, companies, the Public Sector); particular data on companies applying for patents (industrial sector, R&D expenditure, turnover, profit, manpower information, etc.); features of the invention patented (type of process/product, technical properties); and fields of activity benefitting from the invention as users or producers.

Patent data in various countries reveals information on transfer of science and technology between the countries. Patenting by multinational businesses is of special interest. Comparison is complicated by different criteria for granting patents in various countries.

### Deficiencies:

The deficiencies of patent statistics can be summed up into two factors: difficulties in identification and evaluation of patents.

#### Identification:

Patent statistics reveal only a partial or incomplete picture of inventions in general:

- All inventions cannot be patented
- Patents are not applied for all patentable inventions
- Variations in patenting fees, patent protection, and patent processing make international comparison difficult.

Patent statistics do not include those inventions which, according to the existing legislation, cannot be patented or are not inventive enough. Also, they do not include inventions for which no patent is applied for but which are protected in some other way.

#### Evaluation:

Problems in evaluating patents deal with the following factors:

- Patented products or methods may be radical inventions or only minor improvements to the already existing ones
- Patents may only have protective purpose in business patents or they are directly connected with products being marketed
- Economic importance of patents varies.

Time delay is a factor to be considered in examining patent statistics. If, instead of patent applications, patents granted are studied, different durations of application processing have an effect on the number of patents for different time periods. Processing times vary by country and by field. According to the National Patent and Register Board, an average processing time in Finland was 4.2 years in 1988. Processing time for domestic applications was 2.5 years and 5.1 years for foreign applications. Time lapse between the patent application and its financial utilization also varies. This has to be taken into consideration in studying economic impact of patenting.

### Data Sources and Definitions:

Information on patents applied for and granted in Finland is based on the data acquired from the data base maintained by the National Patent and Register Board of Finland.

The patent data base does not include those foreign applications mediated by international patent agreements (the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC)). This information has been derived from the the World Intellectual Property Organization (WIPO).

The definitions of direct patent applications and direct patents granted denote direct patent applications to the patent authority and direct patent grants by the patent authority in the respective country.

### International Patent Agreements (EPC and PCT):

Patents based on the European Patent Convention (EPC) are applied for in the European Patent Office (EPO) or through an official authorized by the EPO. A patent can be applied for in all member countries or only in some of them at the same time. A patent granted by the EPO has the same rights as a patent granted as a result of direct application.

A patent application based on the PCT patent agreement is of different nature than a direct patent application. In a sense, the applicant names the invention he actually applies for at a later date. Applications made through the PCT do not lead into any international patent but only mean to facilitate such patent applications. The patent is granted by the patent official in the respective member country. Patents granted through this arrangement are considerably fewer than those based on direct applications.

Patent data by product group are based on the correspondence tables between the International Patent Classification (IPC) and the Central Statistical Office's new Standard Industrial Classification (SIC, 1988), developed by the Central Statistical Office in cooperation with the National Patent and Register Board of Finland. Due to the transition period from the old classification into the new industrial classification, data by product group do not fully correlate with the respective data in the previous Science and Technology report (1987).

## 5.1.1 Development in Patenting in Finland

The number of domestic patent applications has started to increase; also, the number of foreign applications has increased. Domestic applications accounted for 32.6 per cent of all applications filed in 1988. The number of patent applications based on international patent cooperation agreements continues to increase. In 1987, 19.7 per cent of foreign patent applications were based on the international patent agreements.

The number of patent applications filed by domestic companies increased approximately 12 per cent in 1988; the number of applications filed by private persons remained unchanged and their proportion decreased. One reason for the increase in the number of business patent applications filed may be heavy investments by businesses on R&D in 1983 - 1985. Companies engaged in R&D activity filed 779 patent applications in 1987.

The number of patent applications filed by private inventors has slightly decreased but remains still high in Finland. They accounted for 37.5 per cent in 1988. However, the figures on private applications filed also includes patent applications filed by researchers in institutions of higher education; therefore, these figures do not give an entirely truthful picture of the number of applications filed by independent inventors.

The average yearly growth rate of direct foreign patent applications filed in Finland and of those through the PCT naming process between 1983 and 1987 was ca. 10.5 per cent.

The number of foreign patent applications also increased in the other OECD countries in 1987; the growth rate in Sweden was ca. 7 per cent and in West Germany ca. 5 per cent. This is an indication of increasing technological diffusion via patenting activities.

**Table 5.1 Domestic patent applications filed in Finland, 1980–1988**

| Year of application | Applicant | | |
|---|---|---|---|
| | Private | Company | Total |
| 1980 | 626 | 728 | 1 354 |
| 1981 | 627 | 792 | 1 419 |
| 1982 | 701 | 932 | 1 633 |
| 1983 | 770 | 943 | 1 713 |
| 1984 | 700 | 1 069 | 1 769 |
| 1985 | 681 | 1 038 | 1 719 |
| 1986 | 716 | 1 035 | 1 751 |
| 1987 | 747 | 1 104 | 1 851 |
| 1988 | 742 | 1 235 | 1 977 |

**Table 5.2 Foreign patent applications filed in Finland, 1980–1988**

| Year of application | Direct applications | Total of direct and pct-applications |
|---|---|---|
| 1980 | 2 738 | 2 862 |
| 1981 | 2 818 | 3 676 |
| 1982 | 2 909 | 4 013 |
| 1983 | 3 184 | 4 348 |
| 1984 | 3 414 | 4 808 |
| 1985 | 3 480 | 5 271 |
| 1986 | 3 630 | 5 741 |
| 1987 | 3 949 | 6 481 |
| 1988 | 4 091 | – |

## About 450 Companies Filed Patent Applications in 1987

The top ten companies for patent applications filed accounted for nearly a third of all patent applications filed by companies.

Machinery accounted for approximately 36 per cent of patent applications filed by domestic companies. Its share decreased from 1985 about 2 percentage units; the share of instrumentation patents of all patent applications decreased by the same percentage. The share of metal products remained nearly the same. Annex table 6 shows the figures by product group.

In 1988, 576 patents were granted to domestic companies in Finland; or, an increase of ca. 6 per cent from the previous year. Patents granted to companies accounted for 75 per cent of all patents granted. Machinery product group accounted for 36 per cent of the patents granted to companies.

### Patent Statistics Show over Half of Inventions by Companies in the Provinces of Uusimaa and Turku and Pori

Table 5.3 shows the regional distribution of patenting by companies as indicated by the provincial address of the inventor(s) on the application. Data on the inventors are chosen for the basis as they give better information on the place of invention than the data on the applicant.

If the regional distribution of the inventors is compared with the regional distribution of R&D in the Business Enterprise Sector in 1987, the Provinces of Uusimaa and Turku and Pori accounted for ca. 68 per cent of research expenditure and 56 per cent of patenting. In contrast, the share of researchers in the Province of Häme (18 per cent) was larger than its share of research expenditure (ca. 12 per cent).

### Finland Averaged Approximately 35 Inventors Employed by Companies per 100 000 Citizens

The proportion in the Province of Uusimaa was 60 employed inventors, 46 in the Province of Häme, 9 in the Province of Northern Karelia, and 5 in the Province of Lapland.

**Figure 5.1 Patent applications by domestic companies in Finland by product group, 1988**

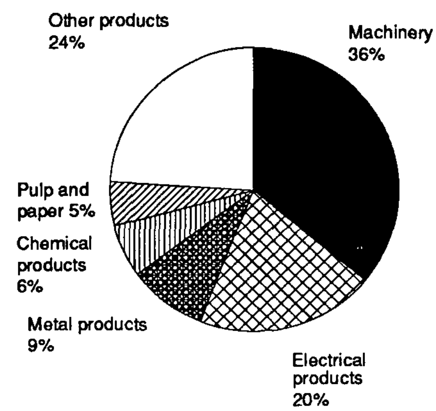



**Table 5.3 Inventors employed by domestic companies filing for patent application, by province, in Finland 1985 and 1988**

| Province | 1985 | | 1988 | |
|---|---|---|---|---|
| | Number | % | Number | % |
| Uusimaa | 589 | 38.1 | 741 | 40.4 |
| Turku-Pori | 226 | 14.6 | 243 | 13.2 |
| Aland | - | - | 1 | 0.1 |
| Häme | 301 | 19.5 | 349 | 19.0 |
| Kymi | 85 | 5.5 | 114 | 6.2 |
| Mikkeli | 32 | 2.1 | 38 | 2.1 |
| Northern Karelia | 26 | 1.7 | 17 | 0.9 |
| Kuopio | 44 | 2.8 | 34 | 1.8 |
| Central Finland | 106 | 6.8 | 145 | 7.9 |
| Vaasa | 76 | 4.9 | 61 | 3.3 |
| Oulu | 53 | 3.4 | 79 | 4.3 |
| Lapland | 9 | 0.6 | 14 | 0.8 |
| **Total*)** | **1 547** | **100.0** | **1 836** | **100.0** |

*) More inventors than patent applications as one application may include more than one inventor

See Annex Tables 7 - 9 on foreign patenting.

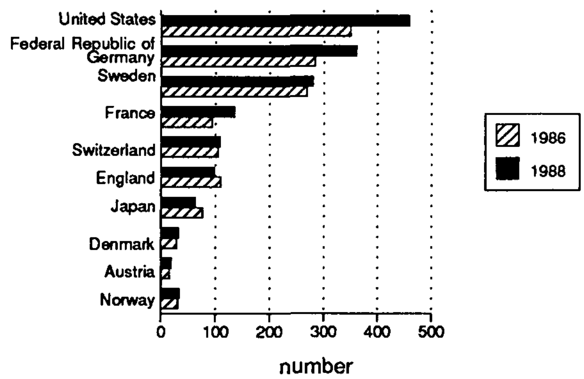
In 1988, most direct foreign patent applications filed came from the United States, i.e., 1098 applications, or approximately 27 per cent of all foreign patent applications filed. Compared with the previous year, the figure remained nearly unchanged.

The Federal Republic of Germany was next with 828 applications, an increase of ca. 11 per cent from the previous year. The number of patent applications from Sweden went down from 1987 by approximately 7.5 per cent, totalling 340 in 1988.

Patent applications from Japan have continued to grow in numbers. In 1988, 215 applications were filed, or a 13 per cent increase from the previous year.

The biggest product group of foreign patent applications filed was pharmaceuticals, ca. 22 per cent; its share remained nearly unchanged compared with the previous years. Also electronics (18.6 per cent) and machinery (16.1 per cent) were large product groups.

**Figure 5.2 Patents granted in Finland to applicants from some OECD countries, 1986 and 1988**




## In 1988, 1869 Patents Granted to Foreign Applicants in Finland

Patent applicants from the United States accounted for a little less than one fourth, followed by the Federal Republic of Germany with 21.8 per cent and Sweden with 15.1 per cent.

The share of patents granted to the United States and the Federal Republic of Germany has increased by approximately one percentage unit from the previous year. Sweden and England, for their part, have reduced their share by the same percentage unit.

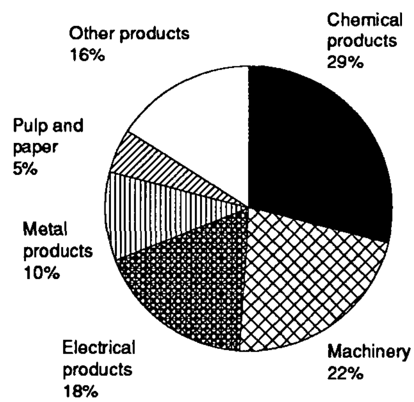
The distribution by product group of those 1869 patents granted to foreign applicants is as follows (Figure 5.3):

- 538 patents were granted for pharmaceutical and chemical products, of which pharmaceutical products accounted for 57 per cent, or the same figure as in the previous year.

- A total of 414 patents were granted to machinery, a slightly higher number than in the previous year.

- And, 122 patents were granted to telecommunications equipment, against 80 in the previous year.

**Figure 5.3 Direct patents granted to foreign applicants by product group, 1988**



## 5.1.2 International Comparison of Patenting

*The following data include both direct applications and applications filed through patent agreements. Foreign patent applications from Finland may be filed under the auspices of the Patent Cooperation Treaty (PCT) or the European Patent Convention (EPC). The figures are gross data, i.e. a patent application may have been filed or a patent granted for the same invention in many countries. See in Annex Tables 10 - 11 for details.*

### In 1987, 3 968 Foreign Patent Applications Originated from Finland

The number of patent applications filed has been reduced by 8.4 per cent compared with 1985. Fewer patent applications have been filed especially in Sweden, France, and the Federal Republic of Germany. This exceptional decrease in foreign patent applications filed by Finns may be partially due to the fact that an unusually large number of applications were filed in 1985.

In 1987, 578 (14.6 per cent) patent applications were filed by the Finns in the United States, 349 (8.8 per cent) in Sweden, and 289 (7.3 per cent) in the Federal Republic of Germany.

A total of 1 581 foreign patents were granted to the applicants from Finland in 1987, or almost the same number of patents as in the previous year (1 578).

In 1987, of the foreign patents granted to applicants from Finland, 275 (17.4 per cent) were in the United States, 182 (11.5 per cent) in Sweden, and 122 (7.7 per cent) in England.

### Other OECD Countries Increased Their Patenting Abroad

The number of foreign patent applications from all the countries studied increased, with the exception of Switzerland and Finland. England and France experience a strong increase in patent applications filed abroad.

If plain figures are studied, the United States increased their share the most, with an increase of approximately 13 000 patent applications filed compared with the previous year. In contrast, the number of Japanese patent applications has remained unchanged.

**Figure 5.4 Patents granted to Finnish applicants in some OECD countries, 1985 and 1987**

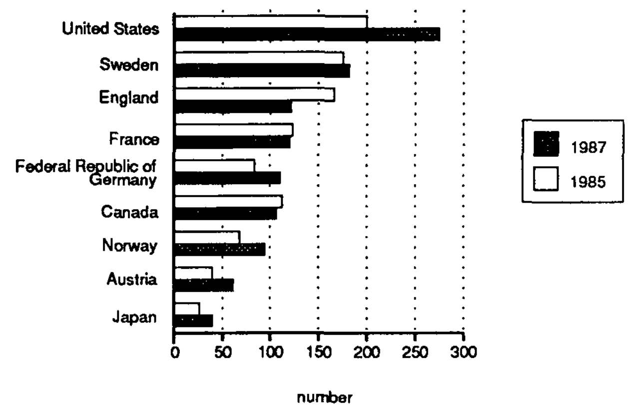



**Table 5.4 External patent applications filed in some OECD countries, 1986**

| Country | Patent applications filed | Change from 1985 % |
|---|---|---|
| Sweden | 16 207 | 6.5 |
| Norway | 2 544 | 12.0 |
| Austria | 6 614 | 7.1 |
| Switzerland | 23 752 | -4.2 |
| France | 40 587 | 10.4 |
| Federal Republic of Germany | 101 515 | 8.0 |
| England | 42 677 | 13.6 |
| Japan | 74 415 | 0.1 |
| United States | 162 666 | 8.7 |

*Source: OECD*

## Number of Patent Applications by Finns in the United States Continue to Rise

*A study of patenting activities in some large market area reveals information on the international standing of the country in question. The U.S. market data are the most commonly used basis for international comparison.*

Of the total of 89 489 patents granted in the United States in the 1987, 39 434 patents were granted to foreign applicants, an increase of ca. 20 per cent from the previous year.

The share of patents granted to Finns in the United States has somewhat increased in the 1980s (Table 5.5), as is that of Norway; in contrast, Sweden and Denmark have somewhat decreased their share.

The share of Japanese patents has gone up by approximately 2 percentage units. Another big patent country, the Federal Republic of Germany, has slightly reduced its share.

In proportion to inhabitants, Switzerland still is the biggest foreign country in patenting in the United States (Table 5.5). This is largely due to multinational companies based in Switzerland. Patenting by Finns, proportioned to inhabitants, has slightly increased. Compared with the other OECD countries, Finland's position in patenting has remained unchanged.

**Table 5.5 Share in foreign patents granted in the United States of some OECD countries, 1985**

| Country | 1985 | 1986 | 1987 |
|---|---|---|---|
| | % | % | % |
| Japan | 39.70 | 40.35 | 41.99 |
| Federal Republic of Germany | 20.76 | 20.78 | 19.83 |
| France | 7.48 | 7.24 | 7.29 |
| Great Britain | 7.77 | 7.36 | 7.05 |
| Swizerland | 3.84 | 3.70 | 3.48 |
| Sweden | 2.67 | 2.70 | 2.40 |
| Austria | 0.99 | 1.09 | 0.87 |
| Finland | 0.62 | 0.64 | 0.70 |
| Denmark | 0.58 | 0.56 | 0.52 |
| Norway | 0.28 | 0.25 | 0.34 |
| **Total of patents granted** | **32 107** | **32 736** | **39 434** |

## 5.1.3 Citation rate of U.S. Patents

Patented inventions vary in importance. In the indicators based on the number of patents each patented invention has an equal weight. One way to measure the importance of a patented invention, i.e., how important it is to others, is to study how many times it has been cited in new patent applications. A proportioned citation rate is not affected by the size of the country as much as the indicators based on the number of inventions.

Table 5.6 shows patent citation rates and the most important product groups for various countries. Only patents from the United States and from Japan have their general patent citation rates above the average international citation level.

The general patent citation rate in Finland is close to the level of other small countries, with Sweden having the highest citation rate among the Nordic countries which is somewhat higher than that of Finland.

The average general citation level of patents granted in the United States is surpassed only by the product group, Other Transportation Equipment among the most referenced product groups in Finland. Each of the five most important Swedish patent product groups surpasses the average citation level.

**Figure 5.5 Patents granted to applicants from some countries in the United States, per million inhabitants; 1981–1984 and 1985–1987 (excl. patents based on patent agreements)**

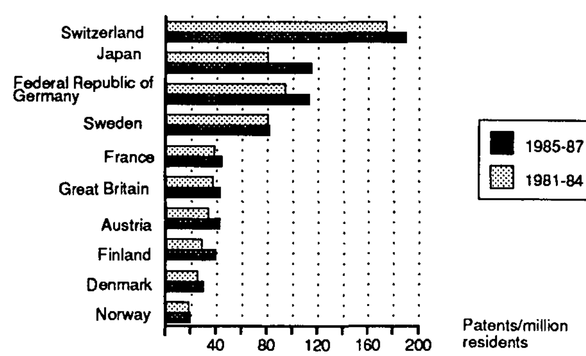


**Table 5.6 Citation rate of patents granted in the United States by country and product group, 1986**

| | Total patent citation rate, five most cited product groups (see abbreviations below) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Finland | 0.58 | OTR | 1.78 | IN | 0.96 | CH | 0.9 | RP | 0.87 | NFM | 0.83 |
| Sweden | 0.63 | AE | 1.66 | PE | 1.58 | DR | 1.45 | CH | 1.34 | TC | 1.34 |
| Norway | 0.52 | CH | 1.46 | SH | 1.17 | MANEC | 0.85 | OTMAN | 0.80 | RP | 0.76 |
| Denmark | 0.54 | FDT | 1.21 | CH | 1.03 | DR | 0.96 | RP | 0.77 | IN | 0.67 |
| Austria | 0.55 | DR | 1.11 | FM | 1.06 | MV | 1.02 | AE | 0.92 | CH | 0.82 |
| Swezerland | 0.67 | OTR | 2.48 | FM | 1.20 | AE | 1.16 | NFM | 1.01 | OTMAN | 0.96 |
| Federal Republic of Germany | 0.72 | AE | 2.97 | MV | 0.95 | FM | 0.91 | FMP | 0.85 | OTMAN | 0.85 |
| France | 0.75 | AE | 2.81 | SH | 1.44 | OC | 0.98 | MV | 0.94 | FDT | 0.90 |
| England | 0.91 | AE | 1.93 | FDT | 1.38 | CH | 1.29 | FM | 1.15 | DR | 1.13 |
| Japan | 1.35 | AE | 2.97 | MV | 1.82 | OTMAN | 1.48 | RP | 1.30 | FMP | 1.24 |
| U.S.A. (Enterprises) | 1.22 | AE | 3.70 | SH | 1.51 | NFM | 1.27 | OTMAN | 1.25 | EE | 1.22 |
| U.S.A. (Other) | 1.05 | AE | 2.90 | NFM | 1.27 | OTMAN | 1.25 | TC | 1.14 | SH | 1.13 |

Product group abbreviations used in Table 5.6:

AE: Space and Aeronautics
CH: Chemicals
DR: Drugs
EE: Electronics Equipment and Components
FM: Ferrous Metals
FDT: Food
IN: Instrumentation

NFM: Non-Ferrous Metals
MANEC Machinery Not Elsewhere Classified
MV: Motor Vehicles
OTMAN: Other Goods Manufactured
OTR: Other Transport Equipment
PE: Petroleum Refineries
PP: Paper and Printed Matter
SCG: Stone, Clay, and Glass
SH: Ships
RP: Rubber and Plastics

Source Evaluating the production and international diffussion of Tecnology by means of 'Patents indicators and the Technology Balance of Payements' – TBP OECD, Group of National Experts on Science and Tecnology, DSTI/ IP/ 89.31, Paris 1989.

## 5.1.4 Other Patent Indicators

In addition to indicators based on the number of ordinary patent applications filed and patents granted, development in patenting activities is also represented by ratios calculated using this data.

**Abbreviations:**

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

### DA/NA Ratio, or Indicator of Independence of Patented Technology

DA/NA ratio, or the share of domestic patent applications in all patent applications. The indicator represents technological independence in patenting process. It also describes the relative level of inventing within respective countries. The higher the value of the indicator (max. = 1), the more technologically independent the country is, measured by patenting activities.

Table 5.7 reveals low values for the Nordic countries, indicating dependence on foreign patented technology. Furthermore, Finland's DA/NA ratio has slightly decreased from 1980; hence, measured by this ratio, it indicates increased dependence on foreign technology.

Measured by this ratio, the high indicator values of the large industrial countries, such as the United States, the Federal Republic of Germany, and especially Japan indicate technological self sufficiency.

Low ratios in small countries, such as Switzerland and Austria, may be partly due to patent applications filed by multinational companies and may also be explained by the fact that they also otherwise have an open market system.

**Table 5.7 Ratio of domestic patent applications and total patent applications in some OECD countries, 1980–1986**

| Country | 1980 | 1982 | 1984 | 1986 |
|---|---|---|---|---|
| Finland | 0.32 | 0.29 | 0.27 | 0.23 |
| Sweden | 0.19 | 0.17 | 0.14 | 0.12 |
| Norway | 0.15 | 0.12 | 0.14 | 0.13 |
| Denmark | 0.15 | 0.15 | 0.12 | 0.11 |
| Austria | 0.15 | 0.13 | 0.11 | 0.09 |
| Swizerland | 0.20 | 0.18 | 0.14 | 0.12 |
| France | 0.25 | 0.23 | 0.22 | 0.21 |
| Federal Republic of Germany | 0.46 | 0.44 | 0.43 | 0.42 |
| England | 0.33 | 0.33 | 0.29 | 0.29 |
| Japan | 0.86 | 0.88 | 0.89 | 0.90 |
| U.S.A. | 0.58 | 0.56 | 0.54 | 0.53 |

## FA/DA Ratio, or Indicator of Technological Diffusion

FA/DA ratio is an indicator of diffusion of foreign patented technology. The higher the indicator value, the more open the country is to foreign technology. Small countries have considerably higher values than large countries. This indicator is complementary to the above calculated DA/NA ratio.

Increase in the FA/DA ratio for Finland (Table 5.8) implies that diffusion of foreign technology to Finnish market is increasing; in other words, Finland is technologically more open. Similar increase in the ratio is detectable also in other countries, excepting Japan. Increase in large countries, however, has been less than in small countries like Finland.

Japan's very low ratio is due to a different system of patenting, which generates a large number of domestic patents; in turn, the indicator value is underestimated.

**Table 5.8** **Ratio of foreign patent applications and domestic patent applications in some OECD countries, 1980–1986**

| Country | 1980 | 1982 | 1984 | 1986 |
|---|---|---|---|---|
| Finland | 2.11 | 2.45 | 2.71 | 3.27 |
| Sweden | 4.17 | 4.87 | 6.03 | 7.42 |
| Norway | 5.62 | 7.27 | 6.26 | 6.58 |
| Denmark | 5.84 | 5.57 | 7.28 | 8.22 |
| Austria | 5.69 | 6.93 | 8.28 | 10.01 |
| Switzerland | 3.89 | 4.52 | 5.94 | 7.23 |
| France | 3.07 | 3.39 | 3.65 | 3.67 |
| Federal Republic of Germany | 1.18 | 1.29 | 1.30 | 1.36 |
| England | 2.03 | 2.04 | 2.43 | 2.47 |
| Japan | 0.17 | 0.13 | 0.12 | 0.11 |
| U.S.A. | 0.71 | 0.77 | 0.85 | 0.87 |

## EA/FA Ratio, or Indicator of Balance of Patent Applications

EA/FA ratio is an indicator of the balance of patents. The indicator is the ratio of external patent applications to foreign patent applications. EA/FA ratio represents the balance of patent applications, or how many patents are filed abroad compared with foreign patents filed in the country. Indicator values close to one (1) indicate a balanced situation and the higher the value the bigger the surplus in the balance of patents. A better balance of patents may indicate, for instance, increased efforts by the country to export its technological knowledge or for one reason or other diminished willingness of foreign countries to file patents in the country.

Finland's balance of patents (Table 5.9) shows a deficit which has remained almost unchanged for the whole of 1980s. The other Nordic countries also had a balance of patents with a deficit.

Only the balance of patents in the United States, the Federal Republic of Germany, and Japan had a notable surpluss. France and England have their patents almost in balance.

**Table 5.9** **Ratio of external patent applications and foreign patent applications in some OECD countries, 1980–1986**

| Country | 1980 | 1982 | 1984 | 1986 |
|---|---|---|---|---|
| Finland | 0.74 | 0.76 | 0.75 | 0.71 |
| Sweden | 0.66 | 0.65 | 0.60 | 0.58 |
| Norway | 0.32 | 0.33 | 0.29 | 0.43 |
| Denmark | 0.51 | 0.60 | 0.54 | 0.62 |
| Austria | 0.34 | 0.27 | 0.26 | 0.29 |
| Switzerland | 1.36 | 1.11 | 1.05 | 0.90 |
| France | 0.97 | 0.95 | 0.87 | 0.90 |
| Federal Republic of Germany | 2.28 | 1.98 | 2.15 | 2.27 |
| Englanti | 0.70 | 0.79 | 0.76 | 0.85 |
| Japan | 1.62 | 2.02 | 2.07 | 2.30 |
| U.S.A. | 2.64 | 2.52 | 2.81 | 2.86 |

### $EA_t/DA_{t-1}$ Ratio, or Indicator of Dissemination of Technology

EAt/DAt-1 ratio is an indicator of dissemination of technology. It is the ratio of external patent applications to domestic patent applications filed during the previous year. The ratio indicates the proportion of domestic inventions applying for patent protection also abroad. The indicator represents diffusion of domestic technology abroad.

The ratios for all the other countries but Japan are relatively high (Table 5.10). Dissemination of Finnish technology has sligthly increased in the 1980s. But, it still remains below dissemination of technology from Sweden, for instance.

The low value for Japan is due to an exceptionally large number of domestic patent applications; hence, this indicator does not give an entirely truthful picture about the extension of Japanese technology.

**Table 5.10 Ratio of external patent applications and domestic patent applications in previous year in some OECD countires, 1980-1986**

| Country | 1980 | 1982 | 1984 | 1986 |
|---|---|---|---|---|
| Finland | 1.53 | 2.15 | 2.10 | 2.37 |
| Sweden | 2.76 | 3.22 | 3.37 | 4.17 |
| Norway | 1.62 | 2.31 | 2.11 | 2.76 |
| Denmark | 3.22 | 3.39 | 3.23 | 5.72 |
| Austria | 1.85 | 1.73 | 2.18 | 2.81 |
| Switzerland | 4.94 | 5.22 | 5.65 | 6.51 |
| France | 2.90 | 3.14 | 3.24 | 3.34 |
| Federal Republic of Germany | 2.66 | 2.63 | 2.83 | 3.10 |
| England | 1.44 | 1.59 | 1.78 | 2.16 |
| Japan | 0.30 | 0.29 | 0.28 | 0.27 |
| U.S.A. | 1.92 | 1.97 | 2.49 | 2.55 |

# 5.2 Investments

## 5.2.1 Tangible Investments

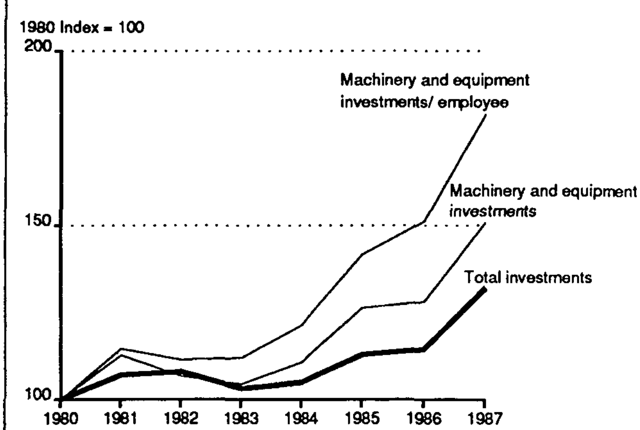
Most machinery and equipment investments entail new technology. The quantity of new technology varies and is mostly difficult to measure. Data on investments at least indirectly indicate introduction of new technology; hence, they can be used as science and technology indicators.

### Share of Machinery and Equipment Investments in Tangible Investments Still Increasing

Figure 5.6 shows that the total industrial investments (SIC 3) have gone up by ca. 32 per cent in the 1980s. During the same time period, machinery and equipment investments have increased by 50 per cent.

Industrial machinery and equipment investments were ca. 37 500 FIM per employee in 1987. Compared with 1985, the total industrial growth rate was approximately 28.7 per cent. A study by industrial sectors indicates the biggest increase in investments per employee for metals manufacturing, paper industry, and chemical industry.

**Figure 5.6 Development in tangible industrial investments, 1980–1987**



## 5.2.2 Intangible Investments

Intangible investments include costs of R&D, long-term marketing, education and training, and other activities aimed at the development of the enterprise.

Intangible industrial investments for 1987 are estimated to have been approximately 7.2 FIM billion, accounting for ca. 3 per cent of industrial turnover.

Approximately 39 per cent of intangible investments went to R&D expenditure, ca. 22 per cent to marketing, ca. 14 per cent to education and training, and ca. 25 per cent to other business promotion. Marketing and education and training investments include some fixed asset acquisitions connected with these activities.

Other promotional expenditure includes computer software acquisition expenditure worth approximately 407 FIM million. Other promotional expenditure also includes orientation training and other personnel training and education expenditure.

Intangible investments focused on large companies (more than 500 employees), accounting for approximately 72 per cent of all intangible industrial investments, with approximately 45 per cent going towards R&D. Intangible investments by small companies (less than 100 employees) were mainly expenditure on marketing and other promotional activities.

Tangible industrial investments are estimated to have grown faster than intangible investments from 1985 to 1987.

Tangible industrial investments and intangible industrial investments total ca. 24 FIM billion in 1987. Intangible investments accounted for ca. 30 per cent of all investmens, a somewhat lesser share than in 1985.

**Figure 5.7 Intangible industrial investments, 1987**

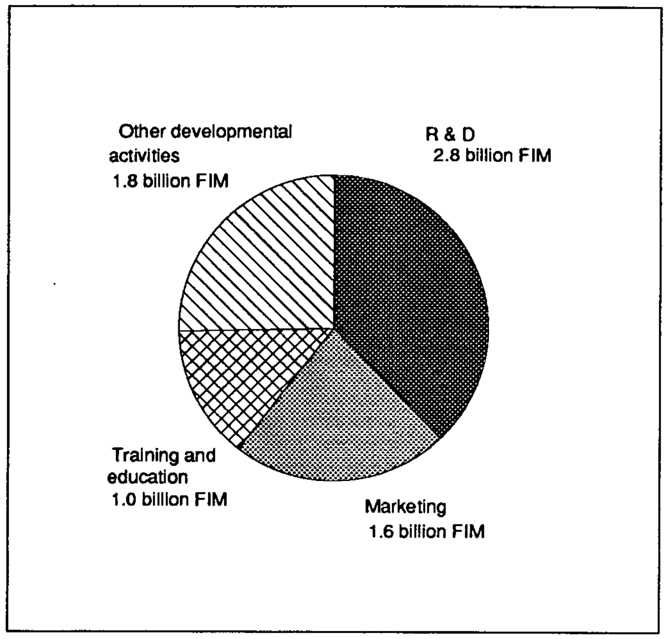
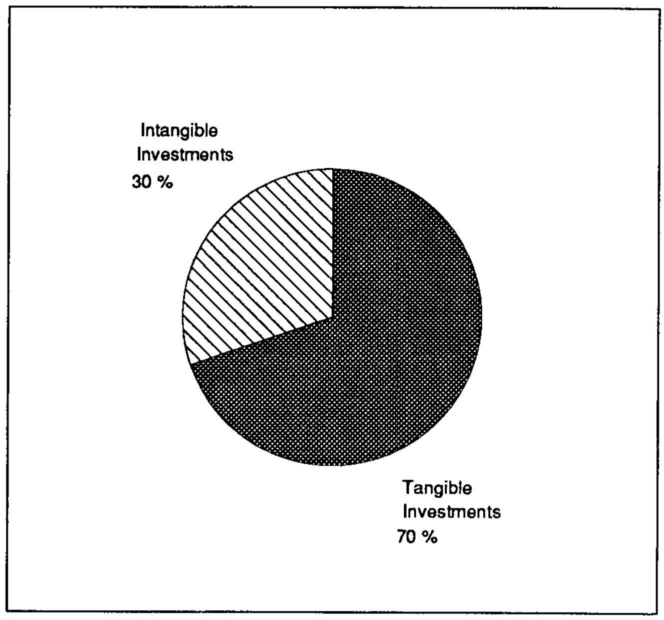



**Figure 5.8 Total industrial investments, 1987**



# 5.3 Robots

*The totals on robots in industries with robots in operation give indication on the technological level of production machinery. Indicators of robotics are based on data derived from the Robotics Society in Finland and the Finnish Association of Technical Traders.*

### Number of Robots Continues to Increase Heavily

A total of 121 new industrial robots were delivered in 1988, compared with 82 in the previous year, an increase of nearly 29 per cent. Similar increase took place also in other countries, e.g. approximately 15 per cent in West Germany.

Welding is the biggest application field in robotics in Finland. A total of 222 welding applications were in operation, or ca. 41 per cent of total robotics, compared with ca. 18 per cent in West Germany and 30 per cent in Sweden.

However, Finland exploits robots still less than its competitor countries. Comparison of total robot applications proportioned to total industrial personnel reveals that Finland lags behind its competitors in welding automation. Finland has ca. 3.4 and Sweden 6.5 applications per 10 000 employees.

Metal products industry is still the main industrial sector exploiting robotics. Over a half of the total applications 1988 were procured for metal products and machinery industries. Approximately one fifth of the robots went to the fields of education and training and research.

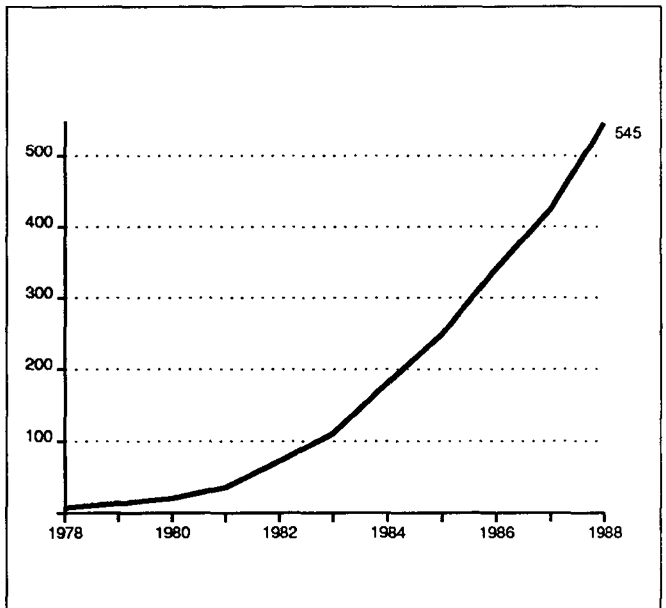
### Domestic Trade in Robotics Slightly Down

Companies trading in robots numbered 16 in 1988. This figure has remained relatively stable.

Domestic trade in products associated with robotics totalled ca. 46.4 FIM million in 1988, a decrease of 6.6 per cent from the previous year. Robots accounted for 25.8 FIM million of the total trade, a decrease of 11 per cent from the previous year. Turnover in robotics, including export, was 185.7 FIM million.

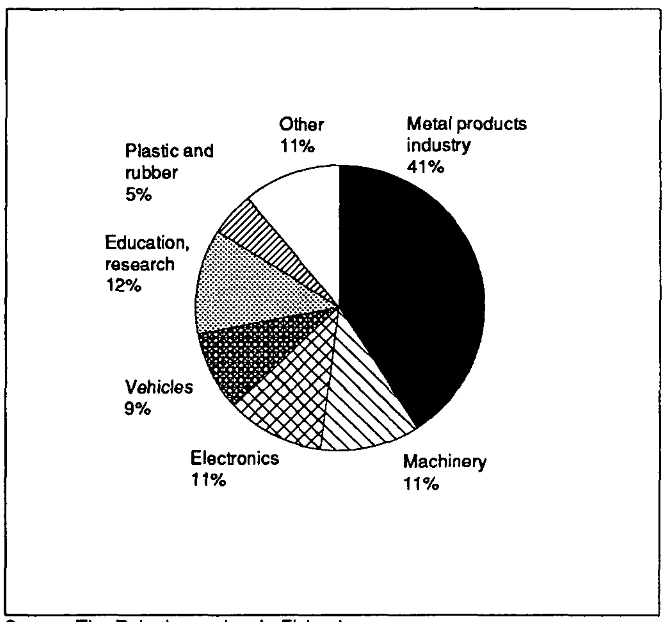
Import of robotics totalled 19.1 FIM million, a decrease of 7 per cent from the previous year.

**Figure 5.9 Total of robots in Finland, 1978–1988**




Source: The Robotics Society in Finland

**Figure 5.10 Use of robots by industrial sector, 1988**




Source: The Robotics society in Finland

# 6. Economic Impact of Science and Technology and Transfer of Technology

New technology generated by R&D activities also reflects upon production and foreign trade. Economic impact of science and technology is represented by indicators of high technology products and foreign trade.

### Definition of High Technology Products:

This report uses the OECD definition of high technology products (List of Commodities in Annex 1).

According to the OECD, high technology products have the following characteristics:

- strongly dependent upon R&D activities
- strategically important to Governments
- quick out-dating of products and processes
- large capital investments subject to risk
- strong international cooperation and competition

The OECD has operationally defined high technology products, starting with industrial sectors where the share of R&D expenditure in turnover is relatively high. First, the research intensity, or the share of R&D expenditure in turnover, has been calculated for each country and industrial sector during the period 1970 - 1980. The industrial sectors have been divided into high, medium, and low research intensity groups as follows:

- high intensity: share of research expenditure in turnover over 4 per cent
- medium intensity: share more than 1 per cent but less than 4 per cent
- low intensity: share 1 per cent or less.

Then the intensities per industrial sector for all the OECD countries have been calculated weighing the research intensity of each country and industrial sector with a parameter that represents the share of the industrial sector of the respective country in the total production within the industry. Then, specialists have chosen the products to be included within each industrial sector. The calculations include eleven of the leading OECD countries.

The OECD classification of high technology products based only on research intensity is not quite satisfactory, especially in case of small countries, because of the following reasons, among others:

- calculation of research intensity has been done rather roughly at the industrial classification level. Although the share of research expenditure in turnover is not very large, the industrial sector may include products or parts of products, the development of which require high technological knowledge.
- technological diffusion is not taken into account. Technological progress within certain industrial sectors is not based on own R&D activities but on purchase of technology (patents, licenses, investments associated with production machinery).

The data on foreign trade have been worked out from the statistics on foreign trade by the National Board of Customs and the production data have been derived from the industrial statistics maintained by the Central Statistical Office. The production data have been converted into international foreign trade classification (SITC Rev. 2), using the code by The Research Institute of the Finnish Economy (ETLA) which makes it possible to convert the classification of high technology products based on SITC Rev. 1 to comply with the SITC Rev. 2 used in the statistics on foreign trade.

For international comparability, the production data have also been calculated based on the OECD classification of high technology sectros. This classification method gives a rougher picture of production activity than the classification based on precise product groups.

The following industrial sectors are included herewith:

- medicinal and pharmaceutical products (SIC 3522)
- computers and office machinery (SIC 3825)
- electronics (SIC 383, excl. 3832)
- radios, televisions, telecommunications equipment (SIC 3832)
- airplanes (SIC 3845)
- scientific instrumentation (SIC 385)

Although the statistics on foreign trade and production examine identical flow of commodities with the same classifications, some discrepancies and inconsistencies due to time differences, methods, and definitions occur.

The data on value of production and on value of foreign trade are not quite comparable. The value of production is calculated from ex factory -price, the value of export from f.o.b. price, and the value of import from c.i.f. price. The difference in values consists mainly of relatively small transportation expenses. The time difference biases the statistics. Production statistics consist of data on finished products at the factory but export and import data are compiled after customs clearance. Time series study is not affected by this as much as the process repeats itself every year, thereby evening itself out. Various producers of statistics may differ in classifying goods under different headings.

# 6.1 Output of High Technology Products

*As industrial statistics started to use the shipment of goods as basis for statistical data in 1986, earlier time series data are not quite comparable.*

## Production Value of High Technology Products up Faster than Value of Total Industrial Production

The gross production value of manufacturing industry increased by 7.1 per cent and the gross production value of high technology products increased by 18.8 per cent in 1987.

The share of high technology products in the gross value of industrial production went up to 5.8 per cent in 1987, an increase of one percentage unit from 1985. The largest single product group continued to be chemicals, with an approximate share of 23 per cent. The product groups of electric machinery and telecommunications equipment had almost as large a share, each accounting for ca. 22 per cent.

Compared with 1985, the relative shares of the product groups have remained rather stable. The share of telecommunications equipment is up by almost 3 percentage units. In comparison, the shares of non-electronic machinery and scientific instrumentation are slightly down.

Figure 6.1 depicts the share of value added of high-technology industrial sector in the total value added of manufacturing industry (SIC 3). The share has increased by 3.7 percentage units since the beginning of the 1980s.

**Figure 6.1 Share of value added of high technology in total value added of industry in Finland, 1980–1987**

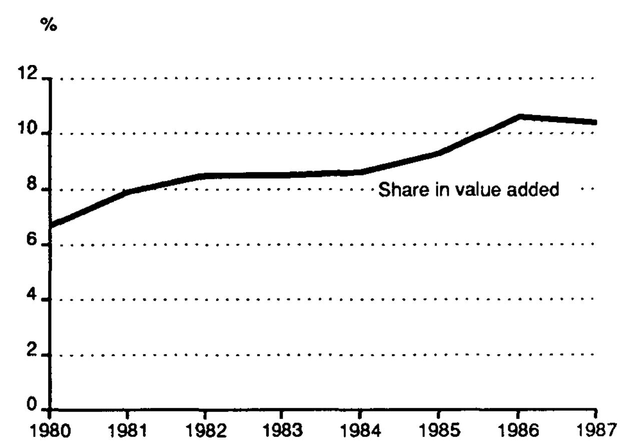



**Table 6.1 Output of high technology product in Finland by product group, 1980–1987**

| Product group | Million FIM (current prices) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| Space and aeronautics | 10.8 | 7.1 | 7.0 | 5.0 | 5.3 | 8.2 | 14.5 | 13.0 |
| Computers and peripheral units | 421.8 | 532.9 | 748.6 | 928.0 | 1 352.4 | 1 738.4 | 1 714.9 | 2 280.2 |
| Electronical devices | 174.2 | 95.7 | 112.3 | 138.7 | 216.8 | 257.2 | 377.0 | 454.6 |
| Telecommunications equipments | 731.0 | 827.0 | 1 085.7 | 1 413.0 | 1 574.7 | 2 077.1 | 2 539.0 | 3 010.5 |
| Drugs and related products | 48.3 | 27.6 | 13.5 | 16.0 | 27.3 | 25.6 | 32.5 | 40.9 |
| Scientific instrumentation | 395.4 | 490.1 | 645.6 | 763.0 | 839.6 | 1 068.7 | 954.2 | 981.2 |
| Electrical machines | 1 504.5 | 1 699.4 | 1 715.7 | 1 887.2 | 2 098.6 | 2 369.8 | 2 746.5 | 3 043.4 |
| Non-electrical machines | 433.0 | 517.2 | 734.1 | 849.9 | 940.7 | 1 068.6 | 856.1 | 1 094.1 |
| Chemicals | 2 010.6 | 1 950.9 | 1 957.3 | 2 325.8 | 2 587.5 | 2 567.0 | 2 644.9 | 3 196.3 |
| **Total** | **5 729.6** | **6 147.9** | **7 019.8** | **8 326.6** | **9 642.9** | **11 180.6** | **11 879.6** | **14 114.2** |

## Compared with Other Countries, Share of High Technology Products in Finland Still Low

*The data on Finland has been retrieved from the industrial statistics maintained by the Central Statistical Office. The data on the other countries have been compiled from the OECD data base on industrial statistics. The data are presented by industrial sector and differ somewhat from the data on high technology by product group. The OECD data may also include inaccuracies due to estimation.*

In the total industrial output of Sweden, production of high technology industrial sectors accounted for 10.0 per cent against Finland's 6.6 per cent. Finland's high technology production value was one third of that in Sweden which was 40.9 FIM billion in 1986.

Electrical products, with 39 per cent, and radio, television, and data communications equipment, with 30 per cent, had the largest shares within the high technology industrial branches in Finland. Respective shares in Sweden were 28 per cent and 32 per cent in 1986.

Among the large industrial countries, approximately 42 per cent of Japan's output of high technology products were radio and data communications equipment in 1986. Japanese high technology output accounted for approximately one fifth of the total industrial output in Japan; compared with Finland, its output was more than 100-fold in 1986.

Finland accounted for ca. 0.3 per cent of the total OECD high technology output in 1986.

**Table 6.2 Share of high technology industrial branches in total industrial output in some OECD countries, 1984 and 1986**

| Country | 1984 % | 1986 % | Output in 1986 FIM mill. |
|---|---|---|---|
| Finland | 5.5 | 6.6 | 14.2 |
| Sweden | 9.8 | 10.0 | 40.9 |
| Norway | 5.9 | 6.1 | 9.4 |
| France | 12.6 | 12.6 | 274.3 |
| Federal Republic of Germany | 13.2 | 13.5 | 350.3 |
| England | 13.6 | 16.2 | 237.8 |
| Japan | 19.7 | 19.2 | 1 615.1 |
| U.S.A. | 17.0 | 17.2 | 2 081.0 |
| **Total of OECD countries** | 14.8 | **15.9** | **4 998.3** |

# 6.2 Foreign Trade in High Technology Products

Foreign trade in high technology products increased by 9.7 per cent and its deficit continued to decrease proportionally in 1987.

Trade in all commodities increased by 3.4 per cent, with a deficit of approximately 1.7 FIM billion.

Foreign trade in Finnish high technology products has been on the increase since 1980. Growth in export has been faster than growth in import. The average yearly growth rate of export was 18 per cent against import's 11 per cent from 1985 to 1987.

The share of high technology products import in the total products import has grown faster than the share of high technology products export in the total products export.

Import accounted for 13.1 per cent and export for 6.2 per cent in 1985; hence, the share of import in all import is up by 3.1 percentage units and the share of export in all export by 2.2 percentage units from 1985 to 1987.

**Figure 6.2 Share of high technology products in foreign trade of commodities, 1980–1987**

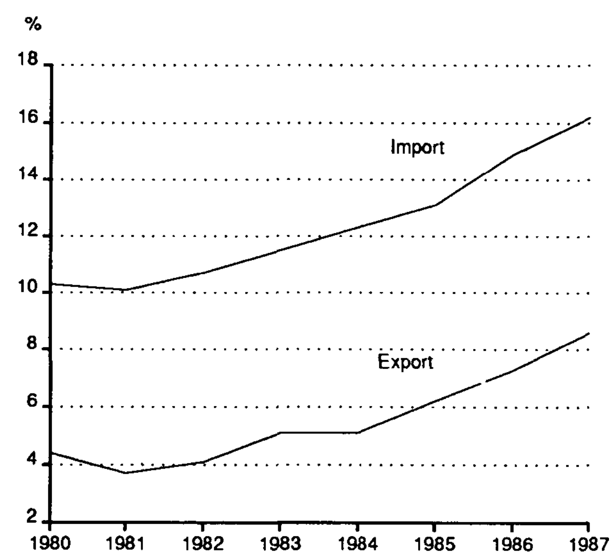


**Table 6.3 Foreign trade in high technology products, 1980–1987**

| Year | FIM mill. (current prices) | | | | Share in foreign trade | |
|---|---|---|---|---|---|---|
| | **Total trade** | Import | Export | Trade balance | Import | Export |
| 1980 | **8 273.4** | 5 974.6 | 2 298.8 | -3 675.8 | 72.2 | 27.8 |
| 1981 | **8 485.5** | 6 158.6 | 2 326.9 | -3 831.7 | 72.6 | 27.4 |
| 1982 | **9 813.4** | 6 940.4 | 2 873.0 | -4 067.4 | 70.7 | 29.3 |
| 1983 | **11 834.9** | 8 246.3 | 3 588.6 | -4 657.7 | 69.7 | 30.3 |
| 1984 | **13 640.5** | 9 475.2 | 4 165.3 | -5 309.9 | 69.5 | 30.5 |
| 1985 | **15 909.5** | 10 715.3 | 5 194.2 | -5 521.1 | 67.4 | 32.6 |
| 1986 | **17 567.8** | 11 580.0 | 5 987.8 | -5 592.2 | 65.9 | 34.1 |
| 1987 | **20 526.5** | 13 304.5 | 7 222.0 | -6 082.5 | 64.8 | 35.2 |

## Telecommunications Equipment Emerged as Largest Product Group Exported

The share of the product group previously largest, electronic machinery, is down by 1.9 percentage units from 1985. The share of chemicals in export is also down. Furthermore, it can be assessed that not all the products belonging to the chemicals product group here in Finland represent very high technology.

Only export of a single product group of telecommunications equipment has surpassed import in 1987. The 90 FIM million deficit in foreign trade in 1985 has turned into a surplus of 400 FIM million. Among the other product groups, pharmaceuticals and non-electric machinery reduced their deficit in the balance of trade from 1985.

In addition, export of telecommunications equipment and scientific instrumentation has increased.

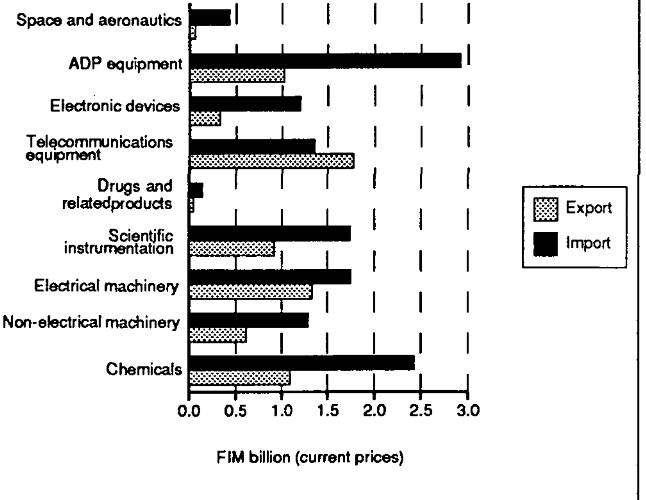
**Table 6.4 Export and import distribution of high technology products by product group, 1987**

| Product group | Shares % | | |
|---|---|---|---|
| | Export | Import | Export/ import |
| Space and aeronautics | 0.9 | 3.2 | 0.16 |
| Computers and peripheral units | 14.2 | 21.9 | 0.35 |
| Electrical devices | 4.5 | 9.1 | 0.27 |
| Telecommunications equipments | 24.6 | 10.3 | 1.30 |
| Drugs and related products | 0.7 | 1.1 | 0.33 |
| Scientific instrumentation | 12.8 | 13.1 | 0.53 |
| Electrical machines | 18.6 | 13.2 | 0.77 |
| Non-electrical machines | 8.6 | 9.8 | 0.48 |
| Chemicals | 15.1 | 18.3 | 0.45 |
| **Total** | **100.0** | **100.0** | **0.54** |

## Computers Largest Product Group Imported

Trade in computers and their peripheral units increased proportionally most in the 1980s. Import of computers increased nearly three fold and export nearly seven fold. Computers accounted for 21.9 per cent of total high technology import in 1987.

**Figure 6.3 Foreign trade in Finnish high technology products by product group, 1987**



## Focus of Foreign Trade in High Technology on EC Countries

Import from the EC countries increased nominally by 27 per cent from 1985 to 1987, against approximately 5 per cent from the EFTA countries.

The EC countries accounted for 46.2 per cent of import in 1987, or 1 percentage unit more than in 1985, against the reduction of 3 percentage units of the EFTA countries, down to 18.4 per cent.

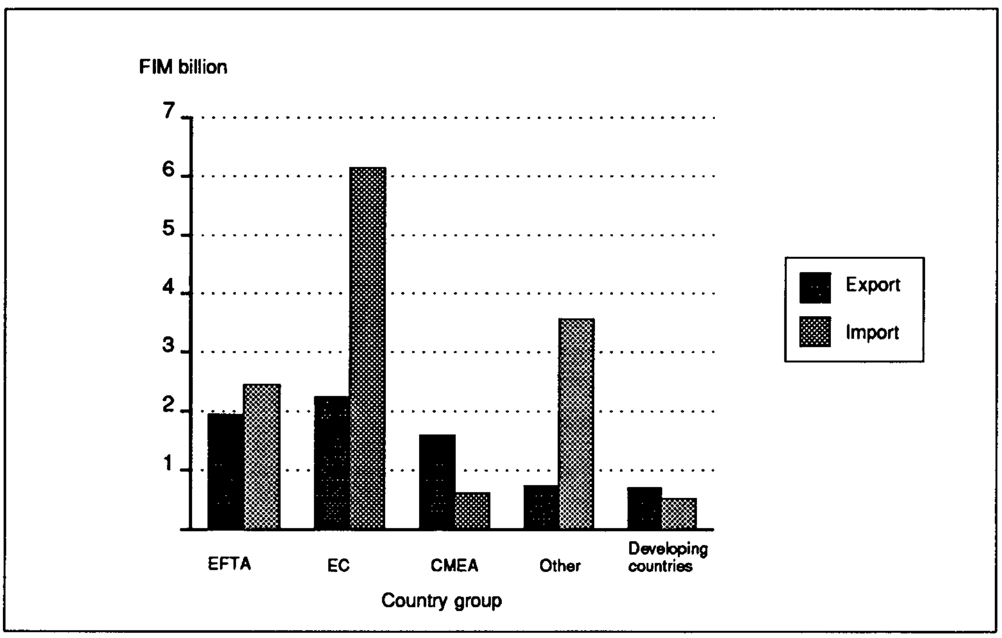
Finland exports the most high technology products to the Soviet Union with export value of ca. 1.5 FIM billion in 1987, a 21.1 per cent share of the total high technology products export. Nominally, export was up by ca. 60 per cent from 1985. The surplus of Soviet trade balance was 1.1 FIM billion in 1987, or approximately 67 per cent more than in 1985.

Another significant export country was Sweden, with export value of ca. 1.3 FIM billion in 1987, an increase of 10 per cent from 1985.

The most high technology products were imported from the Federal Republic of Germany in 1987, valued at ca. 2.9 FIM billion, or approximately 22 per cent of import. Other noteworthy countries importing to Finland were the United States and Sweden. The countries mentioned above accounted for about one half of the high technology import. Import from Japan is also increasing heavily. Compared with 1985, there was an increase of approximately 36 per cent.

The biggest trade deficit was with the Federal Republic of Germany, ca. 2.4 FIM billion. Trade deficit with the United States and Japan was approximately 1.5 FIM billion.

**Figure 6.4 Foreign trade in Finnish high technology products by country group, 1987**



## Foreign Trade in High Technology in Other OECD Countries

Every OECD country has increased its share of high technology in foreign trade in the 1980s.

Compared with the other Nordic countries, Finland experienced the biggest increase in the share of high technology products import in the total products import in the 1980s. But, the initial levels in Sweden and Denmark were higher than in Finland.

Export of high technology products from Japan and the United States experienced a strong increase. Of the total export from these countries, about one fourth consisted of high technology products in 1987.

Among the countries studied (Table 6.6), the share of high technology import in all import increased most in the United States, by 6.6 percentage units. Finland was second with a share increase of 6.1 percentage units.

Export of high technology exceeded import only in Japan and the Federal Republic of Germany in 1987.

Comparison with trade volume reveals that the export value of Finnish high technology products is 2.9 per cent of that of Japan and 2.7 per cent of that of the United States; hence, export from Finland is only a small fraction of the OECD trade in high technology products.

**Table 6.5 Value of foreign trade in high technology products in some OECD countries**

| Country | Import FIM bill. | Export FIM bill. | Export/ import |
|---|---|---|---|
| Finland | 13.3 | 7.2 | 0.54 |
| Sweden | 29.1 | 27.5 | 0.95 |
| Norway | 13.4 | 5.6 | 0.42 |
| Denmark | 15.3 | 10.8. | 0.70 |
| Austria | 18.8 | 16.5 | 0.88 |
| Federal Republic of Germany | 143.3 | 207.0 | 1.44 |
| England | 116.1 | 109.4 | 0.94 |
| France | 109.3 | 102.3 | 0.93 |
| Japan | 52.9 | 247.2 | 4.67 |
| U.S.A. | 292.8 | 270.9 | 0.93 |

**Table 6.6 Share of high technology products in foreign trade in some OECD countries, 1981–1987**

| Country | 1981 | | 1983 | | 1985 | | 1987 | |
|---|---|---|---|---|---|---|---|---|
| | Import % | Export % | Import % | Export % | Import % | Export % | Import % | Export % |
| Finland | 10.1 | 3.7 | 11.5 | 5.1 | 13.1 | 6.2 | 16.2 | 8.6 |
| Sweden | 11.5 | 12.0 | 14.4 | 13.0 | 14.4 | 13.0 | 16.3 | 14.1 |
| Norway | 10.1 | 4.4 | 11.2 | 4.1 | 13.1 | 4.1 | 13.5 | 6.0 |
| Denmark | 10.0 | 8.2 | 11.1 | 8.0 | 12.1 | 10.0 | 13.8 | 10.0 |
| Austria | 9.6 | 8.3 | 10.6 | 10.9 | 11.9 | 12.1 | 13.1 | 13.9 |
| Federal Republic of Germany | 10.0 | 13.8 | 11.0 | 14.9 | 12.7 | 15.3 | 14.3 | 16.0 |
| England | 12.7 | 16.6 | 14.8 | 17.2 | 16.4 | 19.2 | 17.1 | 19.0 |
| France | 11.3 | 12.3 | 12.4 | 13.5 | 13.5 | 15.1 | 15.8 | 16.2 |
| Japan | 4.3 | 16.1 | 5.6 | 18.9 | 6.5 | 20.3 | 8.1 | 24.5 |
| U.S.A. | 9.1 | 17.4 | 12.1 | 22.5 | 13.6 | 24.5 | 15.7 | 25.1 |

# APPENDICES

# Appendix 1. Nomenclature of high technoloty products and SITC, Rev. 2 codes according to the OECD definition

## 1. Space and aeronautics

-7131 = 'Engines for aircraft and parts thereof'
-7144 = 'Injection turbo, and other reaction engines'
-71481 = 'Turbopropellers, gas turbines'
-71491 = 'Parts, n.e.s. of the engines and motors of group 714 engines
-79281,
-79282 = 'Other aircraft, auxililiary equipment'
-7929 = 'Parts of aircraft'

## 2. Automatic data processing equipment

-7512 = 'Calculating machines, accounting machines, and similar machines'
-752 = 'Automatic data processing equipment'
-7599 = 'Parts of automatic data processing equipment'

## 3. Electronic equipment

-7741 = 'Electro-mecical apparatus and equipment'
-7742 = 'X-ray apparatus'
-776 = 'Picture tubes, diodes, transistors, etc.'

## 4. Telecommunications equipment

-7641 = 'Electrical line telephonic and telegraphic apparatus'
-7642 = 'Microphones, ludspeakers, audiofrequence electric amplifiers'
-7643 = 'Radio-broadcasting and television transmitters'
-76491,
-76492,
-76493 = 'Parts of the apparatus and equipment falling within division 76'
-76481,
-76483 = 'Other data dommunications apparatus and equipment'

## 5. Drugs

-5411 = 'Provitamins and vitamins'
-54131,
-54139 = 'Antibiotics'
-5414 = 'Vegetable alkaloids and their derivatives'
-5415 = 'Homones, natural or reproduced by synthesis'
-5416 = 'Glycosides, glands, antisera, and similar products'

## 6. Scientific instrumentation

-7782 = 'Electric lamps'
-77885 = 'Other electrical appliances and apparatus'
-75182,
-75181,
-75188 = 'Other office machines'
-8710 = 'Optical instruments and apparatus'
-87201,
-87202 = 'Medical instruments and apparatus (non-electro-medical)'
-8731 = 'Gas, liquid and electricity meters'
-8741 = 'Geodetic, meteorological, and similar apparatus'
-8748 = 'Electrical or electronic instruments and apparatus for measuring and similar activities'
-8811 = 'Photographic cameras and flashlight apparatus'
-8812 = 'Cinematographic and projecting apparatus and equipment'
-88131 = 'Other apparatus and equipment connected with photography and cinematography'
-885 = 'Watches and clocks'

## 7. Electrical machinery

-716 = 'Electric generators and motors'
-7641 = 'Electrical line telephonic and telegraphic apparatus'
-7642 = 'Microphones, ludspeakers, audiofrequence electric amplifiers'
-7643 = 'Radio-broadcasting and television transmitters'
-7648 = 'Other data dommunications apparatus and equipment'
-7649 = 'Parts of the apparatus and equipment falling within division 76'
-77881,
-77882 = 'Electric traffic control equipment'
-77883 = 'Electric sound or visual signalling apparatus'
-771 = 'Transformers, static converters, rectifiers'
-772 = 'Electrical apparatus for electrical circuit work, eg., making connections'

## 8. Non-electrical machinery

-712 = 'Steam turbines'
-7132,
-7133,
-7138,
-7139 = 'Internal combustion engines, and parts thereof'
-7187 = 'Nuclear reactors, and parts thereof'
-71488,
-71499 = 'Gas turbines, and part thereof'
-71882,
-71889 = 'Water turbines'

## 9. Chemicals

-524 = 'Radioactive and associated materials'
-531 = 'Synthetic organic dyestuffs'
-591 = 'Pesticides'
-583 = 'Products of polymerization and similar plastics'
-89391,
-89392 = 'Other articles of artificial plastic materials'

**Appendix Table1. Degrees granted (graduate and post-graduate degrees and college engineering degrees) by field of science, 1980, 1983, 1985 and 1988**

| Degree/field of science *) | 1980 | | 1983 | | 1985 | | 1988 | |
|---|---|---|---|---|---|---|---|---|
| | Total | Of which women | Total | Of which women | Total | Of which women | Total | Of which women |
| **Doctors** | **291** | **58** | **288** | **60** | **287** | **79** | **401** | **113** |
| - Natural sciences | 75 | 24 | 80 | 21 | 71 | 16 | 88 | 19 |
| - Engineering | 38 | - | 37 | 2 | 44 | 3 | 56 | 4 |
| - Medical sciences | 99 | 22 | 104 | 26 | 100 | 34 | 150 | 46 |
| - Agriculture and forestry | 9 | 1 | 8 | 1 | 17 | 4 | 15 | 7 |
| - Social sciences | 42 | 6 | 40 | 8 | 28 | 9 | 54 | 17 |
| - Humanities | 28 | 5 | 19 | 2 | 27 | 13 | 38 | 20 |
| **Licentiates** | **328** | **77** | **368** | **107** | **380** | **116** | **512** | **173** |
| - Natural sciences | 99 | 21 | 106 | 35 | 113 | 32 | 145 | 50 |
| - Engineering | 70 | 5 | 91 | 10 | 96 | 13 | 113 | 13 |
| - Medical sciences | 2 | 2 | 8 | 4 | 3 | 2 | 2 | - |
| - Agriculture and forestry | 8 | 2 | 10 | 5 | 17 | 5 | 27 | 10 |
| - Social sciences | 99 | 29 | 94 | 31 | 104 | 40 | 131 | 56 |
| - Humanities | 49 | 18 | 57 | 22 | 47 | 24 | 91 | 42 |
| - Fine Arts | 1 | - | 2 | - | - | - | 3 | 2 |
| **Total post-graduate degrees** | **619** | **135** | **656** | **167** | **667** | **195** | **913** | **286** |
| **Graduate Degrees** | 5 238 | 2 352 | 5 838 | 2 714 | 6 728 | 3 358 | 8 099 | 4 229 |
| - Natural sciences | 716 | 293 | 676 | 301 | 725 | 349 | 1 076 | 524 |
| - Engineering | 1 115 | 206 | 1 222 | 208 | 1 227 | 207 | 1 355 | 209 |
| - Medical sciences | 838 | 468 | 760 | 445 | 870 | 553 | 775 | 513 |
| - Agriculture and forestry | 221 | 89 | 253 | 105 | 279 | 133 | 323 | 140 |
| - Social sciences | 1 607 | 807 | 2 138 | 1 148 | 2 742 | 1 520 | 3 154 | 1 797 |
| - Humanities | 678 | 450 | 654 | 436 | 768 | 527 | 1 215 | 918 |
| - Fine Arts | 63 | 39 | 135 | 71 | 117 | 69 | 201 | 128 |
| **College engineers** | **2 186** | **239** | **2 027** | **182** | **2 010** | **186** | **1 977** | **195** |

*) Field of science -classification derived from field of education classification. Veterinary medicine is included in medical sciences.

**Appendix Table 2. Population with graduate, post-graduate, or college engineering degree in 1971, 1980, 1985, and 1987 (excl. those aged 65 or over)**

| Degree/Field of science | 1971 | 1980 | 1985 | 1987 |
|---|---|---|---|---|
| **Post-graduate degree** | **4 089** | **7 294** | **9 066** | **9 971** |
| Natural science | 1 017 | 1 885 | 2 334 | 2 540 |
| Engineering | 471 | 1 118 | 1 513 | 1 719 |
| Medical science | 670 | 1 357 | 1 806 | 2 026 |
| Agriculture and forestry | 215 | 303 | 336 | 360 |
| Social sciences | 929 | 1 569 | 1 918 | 2 069 |
| Humanities | 779 | 1 055 | 1 154 | 1 253 |
| Unspecified | 8 | 7 | 5 | 4 |
| **Graduate degree** | **49 568** | **81 344** | **104 234** | **114 769** |
| Natural science | 4 885 | 8 905 | 11 454 | 12 519 |
| Engineering | 10 033 | 16 572 | 21 127 | 22 875 |
| Medical science | 7 857 | 12 239 | 15 240 | 16 223 |
| Agriculture and forestry | 4 112 | 4 694 | 5 108 | 5 290 |
| Social sciences (incl. teachers) | 12 460 | 24 156 | 33 299 | 38 511 |
| Humanities | 9 579 | 13 697 | 16 386 | 17 539 |
| Fine arts | 588 | 1 012 | 1 557 | 1 747 |
| Unspecified | 54 | 69 | 63 | 65 |
| College engineers | 14 612 | 29 726 | 38 454 | 41 497 |
| **Total** | **68 269** | **118 364** | **151 754** | **166 237** |

**Appendix Table 3. Development in Government R&D funding in the 1980s**

| Receiver of funding | Average real change per year | | | |
|---|---|---|---|---|
| | 1981–1986<br>% | 1986–1987<br>% | 1987–1988<br>% | 1988–1989<br>% |
| Institutions of higher education | 4.6 | 8.6 | 7.1 | 9.0 |
| Academy of Finland | 7.8 | 8.1 | 5.5 | 8.4 |
| Technology Development Center | 11.1 | 13.2 | 10.6 | 11.8 |
| Government research facilities | 7.4 | 5.8 | 1.7 | 3.6 |
| Other research | 8.0 | 1.6 | 4.2 | 3.7 |
| **Total** | **7.3** | **7.0** | **5.2** | **6.8** |

Source: The Academy of Finland: Analysis of Proposed 1989 Government R&D Appropriations (Helsinki 1988)

**Appendix Table 4. Distribution of Government R&D funding by field of administration, 1988 and 1989**

| Field of Administration | FIM million (Current prices) | | Real Change (%) |
|---|---|---|---|
| | 1988 | 1989 | 1988–1989 |
| Ministry for Trade and Industry | 1 264.4 | 1 405.7 | 6.0 |
| - institutions | 612.7 | 651.8 | 1.4 |
| - Technology Development Center | 503.5 | 590.6 | 11.8 |
| - other | 148.2 | 163.3 | 5.0 |
| Ministry of Education | 1 197.2 | 1 360.6 | 8.3 |
| - institutions of higher education | 852.8 | 974.9 | 9.0 |
| - Academy of Finland | 271.1 | 308.3 | 8.4 |
| - institutions | 34.4 | 37.2 | 3.1 |
| - other | 38.9 | 40.2 | -1.5 |
| Ministry of Agriculture and Forestry | 309.0 | 343.6 | 6.0 |
| - institutions | 262.6 | 297.6 | 8.0 |
| - other | 46.4 | 46.0 | -5.5 |
| Ministry for Social Affairs and Health | 123.5 | 133.8 | 3.3 |
| Ministry for Foreign Affairs | 84.1 | 82.6 | -6.4 |
| Ministry for the Environment | 64.4 | 64.2 | -5.0 |
| Ministry of Defence | 51.0 | 59.0 | 10.3 |
| Ministry of Communications | 37.3 | 42.3 | 8.1 |
| Ministry of Finance | 35.6 | 54.4 | 45.6 |
| Ministry for Internal Affairs | 9.1 | 9.7 | 1.6 |
| Ministry of Labour | 6.3 | 7.7 | 16.5 |
| Ministry of Justice | 5.4 | 6.6 | 16.5 |
| **Total** | **3 187.3** | **3 570.2** | **6.8** |

Source:The Academy of Finland: Analysis of Proposed 1989 Government R&D Appropriations (Helsinki 1988)

**Appendix Table 5. Publications by Nordic researchers in SCI data base, 1974–1988**

| Country*) | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|
| Finland | 1642 | 1419 | 1874 | 2362 | 2619 | 2783 | 2959 | 3162 |
| Denmark | 2 733 | 2 131 | 3 135 | 3 903 | 3 840 | 4 019 | 4 220 | 4 627 |
| Norway | 1 807 | 1 690 | 1 989 | 2 473 | 2 427 | 2 603 | 2 761 | 2 771 |
| Sweden | 5 478 | 4 538 | 6 005 | 6 779 | 7 019 | 7 278 | 7 681 | 8 492 |
| **Total** | **425 920** | **427 825** | **449 458** | **532 208** | **537 342** | **555 543** | **575 024** | **598 903** |

| Country *) | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|---|
| Finland | 3 595 | 3 811 | 4 026 | 4 098 | 4 210 | 4 370 | 4 301 |
| Denmark | 4 785 | 5 019 | 5 106 | 5 216 | 5 625 | 5 457 | 5 342 |
| Norway | 2 952 | 3 279 | 3 270 | 3 442 | 3 274 | 3 308 | 3 238 |
| Sweden | 9 321 | 9 856 | 10 248 | 10 991 | 10 968 | 11 069 | 11 219 |
| **Total** | **621 395** | **665 592** | **676 480** | **694 036** | **703 984** | **716 585** | **691 759** |

*) At least one of the authors has a permanent residence in respective Nordic country.

**Appendix Table 6. Domestic patent applications by Finnish companies by product group, 1980–1988**

| Product group | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| Food, beverage, tobacco | 8 | 9 | 12 | 9 | 7 | 14 | 12 | 24 | 21 |
| Textile | 3 | 2 | 2 | 1 | 3 | 4 | 6 | 3 | 3 |
| Clothing, leather, footwear | 4 | 3 | 3 | 6 | 7 | 9 | 6 | 7 | 11 |
| Timber, wood manufactures | 7 | 9 | 11 | 9 | 9 | 9 | 8 | 13 | 12 |
| Pulp, paper, paper products | 47 | 41 | 50 | 53 | 46 | 52 | 59 | 56 | 57 |
| Publishing, printing | 4 | 2 | 3 | 3 | 4 | 2 | 2 | 1 | 2 |
| Furniture | 12 | 15 | 8 | 8 | 11 | 8 | 4 | 9 | 14 |
| Chemicals, chemical products | 12 | 22 | 21 | 28 | 34 | 29 | 29 | 39 | 33 |
| Drugs | 18 | 26 | 21 | 15 | 18 | 14 | 19 | 16 | 24 |
| Other chemical products | 5 | 4 | 4 | 6 | 9 | 7 | 6 | 7 | 6 |
| Crude oil and coal, nuclear fuel | 1 | 1 | 5 | 5 | 4 | 7 | 3 | 2 | . |
| Rubber products | 1 | . | 2 | 1 | 3 | 2 | 6 | 6 | 6 |
| Plastic products | 6 | 6 | 9 | 10 | 12 | 8 | 7 | 9 | 6 |
| Clay, glass, and stone | 31 | 35 | 38 | 39 | 63 | 42 | 49 | 60 | 47 |
| Iron, steel, and ferroalloys | 4 | 1 | 4 | 4 | 2 | 1 | 1 | 1 | 3 |
| Other metals | 17 | 11 | 7 | 6 | 5 | 3 | 4 | 2 | 4 |
| Metals, unspecified | 3 | 3 | 1 | 1 | 4 | 5 | 4 | . | 2 |
| Metal products | 92 | 94 | 110 | 94 | 116 | 92 | 94 | 109 | 111 |
| Machinery, unspecified | 171 | 207 | 208 | 199 | 261 | 258 | 251 | 228 | 278 |
| Stationary engines and turbines | 7 | 12 | 18 | 7 | 13 | 23 | 14 | 18 | 18 |
| Agricultural and forestry machinery | 14 | 17 | 22 | 26 | 21 | 27 | 18 | 26 | 23 |
| Building and stone processing machinery | 12 | 18 | 41 | 33 | 27 | 31 | 35 | 33 | 36 |
| Pulp and paper machinery and equipment | 32 | 34 | 52 | 39 | 43 | 62 | 44 | 76 | 91 |
| Electornics, unspecified | . | . | 1 | . | 1 | 1 | 2 | . | 1 |
| Computers and office machinery | 4 | 5 | 4 | 11 | 8 | 9 | 7 | 4 | 12 |
| Entertainment electronics and data communications equipment | 13 | 16 | 19 | 29 | 28 | 20 | 23 | 20 | 34 |
| Electric apparatus and equipment, home appliance | 33 | 46 | 47 | 57 | 46 | 41 | 75 | 55 | 66 |
| Instrumentation and precision mechanics | 76 | 72 | 92 | 118 | 126 | 111 | 113 | 116 | 137 |
| Total other transport equipment | 39 | 26 | 37 | 35 | 58 | 44 | 50 | 44 | 61 |
| Ships and boats | 5 | 6 | 11 | 15 | 14 | 25 | 18 | 21 | 8 |
| Airplanes | 2 | . | . | 1 | 2 | . | 3 | 6 | 6 |
| Total other industrial manufactures | 23 | 26 | 44 | 36 | 40 | 42 | 36 | 38 | 53 |
| Electricity, gas, water | 3 | 5 | 3 | 2 | 3 | 5 | 3 | 10 | 8 |
| Construction | 19 | 18 | 22 | 37 | 21 | 31 | 24 | 45 | 41 |
| **Total** | **728** | **792** | **932** | **943** | **1 069** | **1 038** | **1 035** | **1 104** | **1 235** |

**Appendix Table 7. Foreign patent applications in Finland by country, 1980–1988**

| Country | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| Argentina | . | 1 | . | . | . | . | . | . | . |
| Australia | 9 | 11 | 14 | 19 | 19 | 28 | 38 | 34 | 26 |
| Austria | 24 | 34 | 31 | 50 | 35 | 55 | 54 | 51 | 47 |
| Bahama Islands | 5 | 2 | 3 | . | 1 | 1 | . | . | . |
| Belgium | 19 | 32 | 21 | 25 | 28 | 30 | 30 | 22 | 31 |
| Brasil | 5 | . | 3 | . | . | 1 | 2 | 1 | 1 |
| Bulgaria | 5 | 5 | 6 | 1 | 3 | 7 | 3 | 9 | 1 |
| Czechoslovakia | 4 | 4 | 7 | 7 | 8 | 5 | 2 | 6 | 6 |
| Danada | 42 | 50 | 37 | 40 | 34 | 57 | 42 | 46 | 49 |
| Denmark | 58 | 33 | 64 | 75 | 61 | 61 | 81 | 83 | 79 |
| Federal Republic of Germany | 570 | 558 | 568 | 511 | 609 | 652 | 661 | 748 | 828 |
| France | 156 | 141 | 196 | 177 | 188 | 209 | 214 | 271 | 280 |
| German Democratic Republic | 10 | 9 | 12 | 11 | 16 | 22 | 14 | 8 | 9 |
| Great Britain | 176 | 187 | 231 | 249 | 226 | 247 | 259 | 277 | 277 |
| Greece | . | 1 | . | . | . | 1 | . | . | . |
| Hungary | 43 | 60 | 70 | 59 | 67 | 67 | 58 | 47 | 49 |
| India | . | . | . | . | 1 | 1 | . | . | . |
| Ireland | . | 3 | 4 | 2 | 1 | . | 1 | 2 | 4 |
| Israel | 2 | . | 2 | 6 | 4 | 6 | 9 | 4 | 3 |
| Italy | 59 | 51 | 63 | 66 | 66 | 70 | 87 | 92 | 103 |
| Japan | 93 | 92 | 96 | 96 | 118 | 139 | 163 | 190 | 215 |
| Jugoslavia | 1 | 3 | 5 | 2 | 1 | . | 4 | 1 | 2 |
| Liechtenstein | 17 | 10 | 10 | 13 | 9 | 16 | 15 | 9 | 11 |
| Luxemburg | 8 | 6 | 7 | 10 | 10 | 5 | 7 | 8 | 2 |
| Mexico | 1 | . | 1 | . | . | . | . | . | . |
| Netherlands | 75 | 87 | 82 | 111 | 110 | 93 | 111 | 113 | 156 |
| New Zeeland | 4 | . | 2 | 2 | 3 | . | 1 | 3 | 2 |
| Norway | 56 | 37 | 51 | 42 | 63 | 57 | 68 | 71 | 62 |
| Panama | 8 | 3 | 6 | 16 | 14 | 15 | 7 | 4 | 1 |
| Poland | 7 | 1 | 3 | 5 | 1 | 1 | . | . | 3 |
| Portugali | 1 | . | . | . | . | 1 | 1 | 1 | . |
| Republic of South Africa | 3 | 3 | 8 | 8 | 12 | 10 | 6 | 12 | 3 |
| Romania | . | . | . | . | 1 | . | . | . | . |
| Soviet Union | 47 | 81 | 38 | 55 | 55 | 64 | 91 | 101 | 109 |
| Spain | 8 | 9 | 6 | 7 | 9 | 12 | 18 | 12 | 19 |
| Sweden | 366 | 417 | 403 | 420 | 462 | 410 | 325 | 369 | 340 |
| Switzerland | 206 | 178 | 203 | 204 | 204 | 229 | 239 | 249 | 256 |
| United States | 631 | 670 | 641 | 875 | 954 | 898 | 1 010 | 1 086 | 1 098 |
| Others | 19 | 39 | 15 | 20 | 21 | 10 | 9 | 19 | 19 |
| **Total** | **2 738** | **2 818** | **2 909** | **3 184** | **3 414** | **3 480** | **3 630** | **3 949** | **4 091** |

**Appendix Table 8. Foreign patents granted in Finland by country, 1980–1988**

| Country | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| Australia | 12 | 3 | 8 | 7 | 7 | 8 | 12 | 5 | 5 |
| Austria | 2 | 23 | 12 | 17 | 18 | 13 | 15 | 29 | 19 |
| Bahama Islands | 2 | . | 2 | 1 | 1 | . | . | 1 | 1 |
| Belgium | 23 | 11 | 23 | 20 | 19 | 14 | 13 | 18 | 13 |
| Brasil | 1 | . | . | 4 | . | 3 | . | . | 1 |
| Bulgaria | . | 5 | 4 | 2 | 2 | . | 5 | 2 | . |
| Canada | 24 | 27 | 24 | 17 | 31 | 29 | 39 | 33 | 23 |
| Czechoslovakia | 1 | 12 | . | 1 | 3 | 1 | 2 | 5 | 5 |
| Denmark | 30 | 25 | . | 25 | 35 | 26 | 29 | 28 | 32 |
| Federal Republic of Germany | 293 | 283 | 275 | 272 | 230 | 304 | 283 | 345 | 360 |
| France | 86 | 96 | 89 | 99 | 96 | 93 | 95 | 116 | 136 |
| German Democratic Republic | 4 | . | . | . | 10 | 6 | 5 | 2 | 4 |
| Great Britain | 102 | 91 | 78 | 119 | 87 | 83 | 110 | 108 | 98 |
| Greece | 2 | . | . | . | . | . | . | . | . |
| Hungary | 17 | 13 | 25 | 14 | 40 | 31 | 34 | 33 | 36 |
| India | . | . | . | . | . | . | . | . | . |
| Irleland | 1 | 1 | 1 | . | 2 | . | 1 | . | . |
| Israel | . | . | 1 | 2 | 1 | 1 | . | 1 | 1 |
| Italy | 24 | 26 | 28 | 26 | 24 | 21 | 28 | 34 | 44 |
| Japan | 64 | 67 | 44 | 52 | 45 | 58 | 76 | 79 | 63 |
| Jugoslavia | . | . | . | 1 | 1 | . | . | . | 1 |
| Liechtenstein | 8 | 14 | 16 | 13 | 13 | 16 | 4 | 8 | 8 |
| Luxemburg | 2 | 3 | 4 | 2 | 4 | 3 | 4 | 7 | 7 |
| Mexico | . | 1 | 2 | 1 | . | . | . | . | . |
| Netherlands | 46 | 51 | 55 | 47 | 39 | 65 | 59 | 73 | 63 |
| New Zeeland | 1 | . | . | . | 1 | . | . | 1 | 1 |
| Norway | 35 | 41 | 38 | 46 | 41 | 29 | 31 | 28 | 33 |
| Panama | 1 | . | 5 | 9 | 3 | . | 3 | 4 | 3 |
| Poland | 1 | 1 | 2 | . | 5 | 3 | 3 | 2 | . |
| Portugal | . | . | . | . | . | . | . | . | . |
| Republic of South Africa | 3 | 2 | 6 | 2 | 4 | 2 | 5 | 1 | 7 |
| Romania | . | 1 | . | . | 1 | . | . | . | . |
| Soviet Union | 27 | 33 | 39 | 45 | 43 | 49 | 35 | 61 | 40 |
| Spain | . | 4 | 1 | 3 | 4 | 3 | . | 3 | 3 |
| Sweden | 280 | 311 | 315 | 274 | 239 | 233 | 269 | 278 | 279 |
| Swizerland | 107 | 85 | 96 | 111 | 129 | 96 | 106 | 116 | 109 |
| United States | 268 | 325 | 295 | 348 | 373 | 326 | 349 | 414 | 458 |
| Others | . | 4 | 7 | 5 | 6 | 1 | 5 | 2 | 16 |
| **Total** | **1 467** | **1 559** | **1 495** | **1 585** | **1 557** | **1 517** | **1 620** | **1 837** | **1869** |

**Appendix Table 9. Foreign patent applications in Finland by product group, 1980–1988**

| Product group | Year of application | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| Food, beverage, tobacco | 58 | 71 | 88 | 99 | 87 | 100 | 92 | 117 | 122 |
| Textile | 18 | 17 | 16 | 16 | 33 | 17 | 23 | 43 | 34 |
| Clothing, leather, footwear | 16 | 8 | 18 | 18 | 13 | 15 | 13 | 14 | 21 |
| Timber, wood manufactures | 15 | 16 | 10 | 9 | 12 | 8 | 8 | 10 | 7 |
| Pulp, paper, paper products | 129 | 150 | 108 | 128 | 130 | 134 | 125 | 118 | 152 |
| Publishing, printing | 8 | 9 | 12 | 19 | 18 | 18 | 21 | 25 | 24 |
| Furniture | 14 | 12 | 8 | 11 | 14 | 17 | 16 | 15 | 12 |
| Chemicals, chemical products | 285 | 252 | 281 | 323 | 363 | 370 | 416 | 460 | 520 |
| Drugs | 536 | 562 | 583 | 649 | 713 | 720 | 801 | 845 | 886 |
| Other chemical products | 66 | 60 | 63 | 79 | 78 | 75 | 94 | 98 | 110 |
| Crude oil and coal, nuclear fuel | 28 | 20 | 21 | 23 | 31 | 30 | 42 | 39 | 35 |
| Rubber products | 10 | 11 | 9 | 9 | 7 | 3 | 6 | 3 | 7 |
| Plastic products | 20 | 17 | 24 | 29 | 28 | 25 | 31 | 33 | 33 |
| Clay, glass, and stone | 75 | 94 | 106 | 97 | 111 | 135 | 100 | 156 | 129 |
| Iron, steel, and ferroalloys | 8 | 13 | 14 | 19 | 19 | 15 | 11 | 10 | 18 |
| Other metals | 25 | 39 | 35 | 36 | 31 | 35 | 34 | 35 | 30 |
| Metals, unspecified | 11 | 9 | 19 | 20 | 8 | 23 | 14 | 12 | 6 |
| Metal products | 218 | 244 | 249 | 229 | 221 | 238 | 228 | 265 | 247 |
| Machinery, unspecified | 414 | 465 | 446 | 478 | 494 | 477 | 515 | 560 | 562 |
| Stationary engines and turbines | 26 | 25 | 21 | 39 | 34 | 41 | 32 | 45 | 43 |
| Agricultural and forestry machinery | 18 | 23 | 23 | 29 | 22 | 28 | 33 | 17 | 25 |
| Building and stone processing machinery | 28 | 34 | 31 | 45 | 44 | 49 | 44 | 38 | 32 |
| Pulp and paper machinery and equipment | 37 | 48 | 46 | 44 | 48 | 57 | 38 | 54 | 65 |
| Electornics, unspecified | 3 | 3 | 3 | 4 | 7 | 7 | 2 | 6 | 8 |
| Computers and office machinery | 29 | 29 | 18 | 38 | 51 | 33 | 30 | 48 | 46 |
| Entertainment electronics and data communications equipment | 98 | 90 | 96 | 93 | 102 | 110 | 145 | 127 | 169 |
| Electric apparatus and equipment, home appliance | 156 | 135 | 131 | 160 | 153 | 175 | 159 | 168 | 184 |
| Instrumentation and precision mechanics | 188 | 165 | 206 | 209 | 272 | 268 | 294 | 320 | 353 |
| Total other transport equipment | 52 | 39 | 66 | 63 | 54 | 60 | 64 | 67 | 44 |
| Ships and boats | 30 | 22 | 28 | 24 | 50 | 39 | 27 | 35 | 24 |
| Airplanes | 3 | 1 | . | 6 | 13 | 4 | 5 | 8 | 3 |
| Total other industrial manufactures | 77 | 94 | 84 | 96 | 114 | 113 | 125 | 121 | 111 |
| Electricity, gas, water | 7 | 4 | 5 | 5 | 3 | 7 | 3 | 7 | 3 |
| Construction | 32 | 37 | 41 | 38 | 36 | 33 | 39 | 30 | 26 |
| **Total** | **2 738** | **2 818** | **2 909** | **3 184** | **3 414** | **3 480** | **3 630** | **3 949** | **4 091** |

**Appendix Table 10. Patent applications by Finnish applicants by country, 1975–1987 (starting 1985, incl. all applications, earlier only direct applications)**

| Country | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| Algeria | . | . | 1 | 9 | . | . | . | 1 | 1 | 5 | 2 | 1 | 1 |
| Argentina | . | 6 | 14 | 7 | 6 | 12 | 3 | 12 | 8 | 4 | . | . | . |
| Australia | 30 | 24 | 29 | 24 | 28 | 26 | 31 | 50 | 41 | 40 | 80 | 91 | 99 |
| Austria | 27 | 43 | 69 | 48 | 43 | 34 | 24 | 40 | 46 | 44 | 187 | 87 | 122 |
| Barbados | . | . | . | . | . | . | . | . | . | . | 3 | 8 | 8 |
| Belgium | . | 19 | 21 | 27 | 25 | 20 | 31 | 20 | 18 | 25 | 152 | 61 | 81 |
| Brasil | . | . | 72 | . | 46 | 48 | 29 | 41 | 29 | 23 | 28 | 58 | 55 |
| Bulgaria | 3 | 1 | 3 | . | . | 3 | 7 | 3 | 1 | 1 | 15 | 13 | 22 |
| Canada | 101 | 109 | 134 | 127 | 114 | 122 | 142 | 175 | 173 | 188 | 196 | 188 | 228 |
| Chile | 1 | . | 2 | 2 | . | . | 10 | 4 | 11 | 6 | 2 | 11 | 2 |
| China | . | . | . | . | . | . | . | . | . | . | 22 | 25 | 33 |
| Columbia | 1 | . | . | . | 1 | . | . | . | . | . | 1 | 3 | 1 |
| Costa Rica | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| Cuba | 1 | 1 | 1 | . | 1 | 1 | 1 | 1 | . | . | . | . | . |
| Czechoslovakia | 16 | 15 | 17 | 6 | 5 | 15 | 17 | 10 | 10 | 10 | 15 | 2 | 13 |
| Denmark | 48 | 59 | 58 | 58 | 74 | 73 | 74 | 78 | 95 | 87 | 201 | 190 | 158 |
| Ecuador | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| Egypt | . | 1 | 1 | 1 | 2 | 1 | 3 | 3 | . | 2 | 1 | 2 | 4 |
| England | 93 | 111 | 137 | 145 | 164 | 122 | 92 | 120 | 138 | 98 | 313 | 186 | 223 |
| Federal Republic of Germany | 155 | 160 | 212 | 159 | 201 | 165 | .. | 219 | 187 | 186 | 370 | 252 | 289 |
| France | 87 | 97 | 108 | 99 | 111 | 104 | 78 | 97 | 112 | 103 | 254 | 123 | 162 |
| German Democratic Republic | 16 | 21 | 17 | 17 | 13 | 13 | 20 | 22 | 20 | 13 | 19 | 11 | 16 |
| Greece | 5 | . | 12 | 20 | 3 | 9 | 9 | 7 | 3 | 7 | 5 | 14 | 43 |
| Guatemala | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| Hong Kong | . | 1 | . | . | 1 | 1 | . | 1 | 2 | 6 | 1 | . | 6 |
| Hungary | 10 | 7 | 8 | 4 | 6 | 10 | 11 | 17 | 7 | 8 | 24 | 28 | 45 |
| Iceland | 1 | 1 | 1 | . | . | 1 | 3 | 2 | . | 5 | . | 1 | 5 |
| India | 5 | 10 | . | . | 5 | 8 | 9 | . | . | 6 | 13 | 6 | 17 |
| Indonesia | . | . | . | 1 | 2 | 1 | . | . | . | 1 | 4 | 3 | 2 |
| Iran | 2 | 5 | 4 | 7 | 1 | 1 | . | 2 | . | 3 | 4 | . | 7 |
| Iraq | . | 2 | . | . | 1 | 2 | . | 1 | . | . | . | 1 | 6 |
| Ireland | 7 | 9 | 9 | 6 | 4 | 12 | 6 | 17 | 17 | 11 | 13 | 9 | 18 |
| Israel | 1 | . | . | 2 | 2 | 1 | 5 | 8 | . | 3 | 1 | 1 | 5 |
| Italy | . | . | . | . | . | 45 | . | . | . | . | 119 | 59 | 75 |
| Japan | 66 | 80 | 100 | 89 | 108 | 100 | 100 | 123 | 141 | 106 | 211 | 203 | 258 |
| Jugoslavia | 7 | 5 | 10 | 8 | 5 | 11 | 10 | 14 | 10 | 9 | 13 | 5 | 17 |
| Luxemburg | 1 | 4 | 1 | 3 | 1 | . | 2 | . | . | 7 | 94 | 39 | 59 |
| Madagaskar | . | . | . | . | . | . | . | . | . | . | 5 | 9 | 7 |
| Malawi | . | . | . | . | . | . | . | . | . | . | 5 | 8 | 7 |
| Malesia | . | . | . | . | . | . | . | . | . | . | 11 | . | . |
| Malta | . | . | . | . | . | 1 | . | . | . | . | . | . | 1 |
| Mexico | . | . | . | . | 15 | 14 | 25 | 22 | 15 | 11 | 5 | 3 | 8 |
| Monaco | . | . | . | . | . | . | . | . | . | . | 8 | 11 | 17 |
| Morocco | . | 1 | . | 1 | 2 | . | 3 | . | 1 | 1 | 1 | 2 | 1 |
| Netherlands | 31 | 35 | 39 | 44 | 32 | 34 | 23 | 32 | 22 | 26 | 194 | 94 | 118 |
| New Zeeland | 2 | 6 | 7 | 3 | 4 | 8 | 5 | 16 | 4 | 15 | 14 | 9 | 16 |
| Nigeria | . | . | . | 4 | . | . | . | . | . | . | . | . | . |
| North-Korea | . | . | . | . | . | . | . | . | . | . | 12 | 11 | 11 |
| Norway | 76 | 94 | 124 | 103 | 105 | 105 | 98 | 133 | 145 | 145 | 212 | 190 | 280 |
| Oapi | . | . | . | . | . | . | . | . | 1 | 5 | . | . | . |

**Appendix Table 10. cont.**

| Country | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| Pakistan | . | . | . | . | 1 | . | . | . | . | . | . | . | . |
| Peru | 2 | . | . | 3 | . | 3 | 10 | 4 | 7 | . | . | . | 1 |
| Philippines | 3 | 1 | 2 | 2 | 5 | 4 | 5 | 5 | 4 | 3 | 3 | . | . |
| Poland | 22 | 17 | 23 | 12 | 9 | 22 | 15 | 8 | 6 | 9 | 12 | 4 | 6 |
| Portugal | 2 | 6 | 9 | 8 | 8 | 4 | 9 | 6 | 5 | 10 | 5 | 9 | 12 |
| Romania | 7 | 3 | 6 | . | 2 | 5 | 9 | 2 | 5 | 4 | 25 | 14 | 24 |
| Sambia | 2 | . | 3 | 3 | 1 | 1 | 6 | 2 | 3 | . | . | . | . |
| Singapore | . | . | . | . | . | 1 | . | 1 | 1 | 4 | 1 | . | . |
| South Africa | 19 | 9 | 6 | 19 | 19 | 21 | 22 | 43 | 30 | 41 | 26 | 16 | 17 |
| South Corea | . | . | . | . | 2 | 5 | 4 | 13 | 12 | 13 | 29 | 31 | 59 |
| Sovjet Union | 54 | 60 | 87 | 65 | 60 | 67 | 67 | 109 | 115 | 111 | 207 | 151 | 142 |
| Spain | 11 | 24 | 20 | 20 | 34 | 27 | 33 | 47 | 23 | 28 | 37 | 41 | 96 |
| Sri Lanka | . | . | . | . | . | . | . | 1 | . | . | 4 | 9 | 7 |
| Sudan | . | . | . | . | . | . | . | . | . | . | 4 | 8 | 8 |
| Sweden | 227 | 205 | 291 | 223 | 240 | 221 | 180 | 228 | 263 | 265 | 468 | 323 | 349 |
| Swizerland | 22 | 44 | 38 | 31 | 26 | 25 | 12 | 26 | 14 | 18 | 180 | 80 | 107 |
| Tanzania | . | . | 4 | . | . | . | . | . | . | . | . | . | . |
| Thailand | . | . | . | . | . | 1 | . | 1 | 3 | . | 3 | . | 1 |
| Tunis | . | . | . | . | . | . | . | . | . | . | . | 2 | . |
| Turkey | 1 | . | 1 | . | . | 3 | 2 | 2 | . | . | 1 | 1 | 8 |
| United States | 173 | 184 | 203 | 228 | 231 | 258 | 275 | 300 | 346 | 363 | 489 | 350 | 578 |
| Venezuela | . | . | . | 3 | 1 | 4 | 3 | 5 | 4 | 105 | 2 | 5 | 4 |
| Zaire | . | . | 1 | 2 | . | . | 1 | 3 | 1 | . | . | . | . |
| Zimbabwe | . | . | . | . | 1 | 2 | 4 | . | 2 | . | 2 | . | . |
| **Total** | **1 338** | **1 480** | **1 905** | **1 643** | **1 771** | **1 797** | **1 528** | **2 097** | **2 102** | **2 184** | **4 328** | **3 062** | **3 968** |

**Appendix Table 11. Patents granted to Finnish applicants by country 1975–1978 (starting 1985, incl. all applications, earlier only direct applications)**

| Country | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| Algeria | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Argentina | . | 6 | 9 | 5 | 9 | 6 | 9 | 4 | 5 | 4 | . | 3 | 7 |
| Australia | 10 | 24 | 21 | 17 | 14 | 17 | 16 | 11 | 31 | 22 | 22 | 43 | 54 |
| Austria | 20 | 23 | 21 | 23 | 27 | 37 | 36 | 24 | 18 | 37 | 39 | 62 | 61 |
| Belgium | . | 19 | 21 | 27 | 25 | 20 | 31 | 20 | 18 | 25 | 34 | 47 | 33 |
| Brasil | 1 | 1 | . | . | 5 | . | . | 52 | 41 | 43 | 24 | 49 | 26 |
| Bulgaria | 1 | . | . | 1 | 2 | 1 | 2 | . | . | 2 | 2 | 2 | 3 |
| Canada | 53 | 76 | 54 | 78 | 91 | 125 | 99 | 114 | 85 | 110 | 113 | 132 | 107 |
| Chile | 2 | . | 1 | 1 | . | . | 8 | 5 | 10 | 8 | 2 | 4 | 2 |
| Cuba | . | . | . | . | . | 1 | 1 | . | . | . | 1 | . | . |
| Czechoslovakia | 7 | 6 | 3 | 12 | 16 | 14 | 6 | 15 | 9 | 6 | 11 | 5 | 8 |
| Denmark | 25 | 19 | 15 | 12 | 17 | 22 | 13 | 10 | 13 | 16 | 11 | 15 | 14 |
| Egypt | . | . | 1 | . | . | . | . | 1 | . | . | . | . | 1 |
| England | 89 | 93 | 84 | 96 | 68 | 55 | 59 | 107 | 145 | 90 | 166 | 158 | 122 |
| Federal Republic of Germany | 33 | 41 | 29 | 38 | 35 | 31 | .. | 40 | 67 | 44 | 83 | 121 | 111 |
| France | 22 | 50 | 55 | 56 | 53 | 61 | 61 | 67 | 79 | 87 | 123 | 150 | 120 |
| German Democratic Republic | 11 | 15 | 18 | 17 | 16 | 9 | 13 | 13 | 27 | 28 | 9 | 19 | 9 |
| Greece | 1 | 3 | 2 | 4 | 3 | 1 | 6 | 3 | 4 | 19 | 5 | 8 | 5 |
| Hong Kong | . | 1 | . | . | 1 | 1 | . | 2 | 1 | 5 | 1 | . | 5 |
| Hungary | 3 | 3 | 4 | 2 | 9 | 5 | 6 | 4 | 9 | 10 | 5 | 9 | 9 |
| India | . | 1 | . | . | 8 | 6 | 2 | . | . | 8 | 11 | 13 | 8 |
| Indonesia | . | . | . | . | . | . | . | . | 1 | . | . | . | . |
| Iran | 2 | 5 | 3 | 4 | 2 | 1 | . | 2 | 1 | 1 | 4 | . | 7 |
| Iraq | . | 2 | 1 | . | 1 | . | 1 | 1 | 1 | . | . | . | 3 |
| Ireland | 3 | 1 | 3 | 9 | 1 | 8 | 5 | 3 | 4 | 2 | 4 | 6 | 2 |
| Island | . | . | . | . | . | . | 1 | 2 | . | . | . | 1 | . |
| Israel | 151 | . | 2 | 1 | 1 | 1 | . | . | . | . | 1 | 1 | 2 |
| Italy | . | . | . | . | . | 14 | . | . | 6 | . | 16 | 16 | 23 |
| Japan | 18 | 12 | 19 | 14 | 17 | 20 | 30 | 24 | 25 | 37 | 26 | 33 | 39 |
| Jugoslavia | . | . | . | . | 2 | 1 | 3 | 1 | 3 | 2 | 1 | 3 | 7 |
| Luxemburg | . | 1 | 4 | 2 | 3 | . | 3 | . | . | 3 | 19 | 20 | 18 |
| Malesia | . | . | . | . | . | . | . | . | . | . | 9 | . | . |
| Malta | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| Mexico | . | . | . | . | . | 3 | 5 | 3 | 10 | 4 | 5 | 5 | 7 |
| Monaco | . | . | . | . | . | . | . | . | . | . | 1 | . | . |
| Morocco | . | . | . | . | 3 | . | 2 | 1 | 1 | 1 | 1 | 2 | . |
| Netherlands | 2 | 4 | 3 | 4 | . | 3 | 2 | 10 | 13 | 30 | 34 | 45 | 43 |
| New Zeeland | . | . | 2 | 4 | 4 | 5 | 4 | . | 10 | 4 | 8 | 5 | 11 |
| Nigeria | . | . | . | 4 | . | . | . | . | . | . | . | . | . |
| North Korea | . | . | . | . | . | . | . | . | . | . | . | 1 | 3 |
| Norway | 26 | 33 | 36 | 34 | 49 | 46 | 46 | 48 | 57 | 49 | 68 | 52 | 95 |
| Oapi | . | . | . | . | . | . | . | . | . | . | 1 | . | . |
| Peru | . | . | 1 | 1 | . | 7 | 3 | 7 | 5 | . | 4 | 6 | . |
| Philippines | . | . | 1 | . | . | 2 | 3 | 1 | 9 | . | 4 | . | . |
| Poland | 9 | 10 | 11 | 7 | 11 | 25 | 7 | 6 | 14 | 5 | 5 | 6 | 6 |
| Portugal | 2 | 4 | 3 | 9 | 6 | 14 | 3 | 6 | 6 | 2 | 3 | 16 | 5 |
| Romania | 1 | 1 | 3 | 1 | 1 | 3 | 5 | 4 | 3 | 5 | 5 | 5 | 7 |
| Sambia | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 5 | 1 | . | . | 2 | . |
| Singapore | . | . | . | . | . | . | . | 1 | 1 | . | . | . | . |

**Appendix Table 11. cont.**

| Country | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| South Africa | . | 9 | . | . | . | . | . | . | . | . | . | . | . |
| South-Korea | . | . | . | . | . | . | . | . | 2 | 1 | 1 | 3 | 2 |
| Soviet Union | 10 | 7 | 18 | 20 | 37 | 36 | 34 | 26 | 31 | 23 | 38 | 48 | 63 |
| Spain | 17 | 40 | 29 | 18 | 21 | 26 | 22 | 29 | 36 | 26 | 23 | 25 | 18 |
| Sri Lanka | . | . | . | . | . | . | . | 1 | . | . | . | . | . |
| Swaziland | . | 3 | . | . | . | . | . | . | . | . | . | . | . |
| Sweden | 110 | 97 | 99 | 81 | 87 | 80 | 73 | 99 | 88 | 130 | 176 | 175 | 182 |
| Swizerland | 31 | 20 | 43 | 2 | 21 | 18 | 13 | 27 | 19 | .. | 43 | 45 | 56 |
| Thailand | . | . | . | . | . | . | . | . | . | . | 31 | . | . |
| Tunisia | . | . | . | . | . | . | . | . | . | . | . | 4 | . |
| Turkey | . | 3 | 1 | . | . | 3 | . | 2 | . | 3 | . | . | . |
| United States | 95 | 109 | 105 | 122 | 76 | 123 | 140 | 125 | 116 | 167 | 200 | 210 | 275 |
| Uruguay | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| Venezuela | . | . | 1 | 1 | 2 | . | 1 | 3 | 3 | 3 | 1 | 1 | 2 |
| Zaire | . | . | 1 | 2 | . | . | 1 | 3 | 1 | . | . | . | . |
| Zimbabwe | . | . | . | . | 1 | 1 | 1 | 3 | 2 | 1 | . | 2 | . |
| **Total** | **761** | **741** | **729** | **732** | **747** | **854** | **778** | **935** | **1 031** | **1 063** | **1 394** | **1 578** | **1 581** |

**Appendix Table 12. Foreign Trade in high technology products by product group, 1980–1987 FIM mill.**

| Product group | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| Space and aeronautics | Export | 29.2 | 25.3 | 21.0 | 35.6 | 35.6 | 41.9 | 34.8 | 67.3 |
| | Import | 220.6 | 226.1 | 229.2 | 274.0 | 256.3 | 331.9 | 383.0 | 431.5 |
| | Trade Balance | -191.3 | -200.8 | -208.1 | -238.4 | -220.8 | -290.0 | -348.2 | -364.2 |
| Computers and peripheral units | Export | 152.9 | 116.4 | 186.2 | 296.7 | 357.7 | 769.2 | 744.0 | 1 022.2 |
| | Import | 805.5 | 963.4 | 1 161.7 | 1 610.1 | 2 055.7 | 2 380.9 | 2 414.4 | 2 917.3 |
| | Trade Balance | -652.6 | -847.0 | -975.5 | -1 313.4 | -1 698.1 | -1 611.7 | -1 670.4 | -1 895.0 |
| Electronical devices | Export | 108.3 | 96.6 | 105.3 | 121.3 | 201.0 | 208.9 | 263.0 | 327.9 |
| | Import | 427.7 | 393.7 | 443.3 | 613.1 | 907.2 | 1 002.5 | 1 023.7 | 1 208.5 |
| | Trade Balance | -319.4 | -297.2 | -338.0 | -491.8 | -706.2 | -793.6 | -760.7 | -880.6 |
| Telecommunications equipments | Export | 289.1 | 398.2 | 481.9 | 655.1 | 701.0 | 956.2 | 1 351.1 | 1 774.3 |
| | Import | 479.4 | 532.0 | 652.3 | 680.5 | 765.9 | 1 045.8 | 1 121.6 | 1 365.7 |
| | Trade Balance | -190.3 | -133.8 | -170.4 | -25.5 | -64.9 | -89.7 | 229.5 | 408.5 |
| Drugs and related products | Export | 78.4 | 58.5 | 45.1 | 41.2 | 47.1 | 36.5 | 41.5 | 49.5 |
| | Import | 98.8 | 76.1 | 103.0 | 112.9 | 120.1 | 155.1 | 163.7 | 148.4 |
| | Trade Balance | -20.4 | -17.6 | -57.9 | -71.7 | -73.0 | -118.6 | -122.2 | -98.9 |
| Scientific instrumentation | Export | 333.1 | 337.8 | 435.7 | 573.8 | 728.8 | 781.0 | 833.5 | 922.6 |
| | Import | 875.5 | 890.9 | 999.4 | 1 174.4 | 1 232.0 | 1 380.7 | 1 524.0 | 1 747.4 |
| | Trade Balance | -542.4 | -553.1 | -563.7 | -600.6 | -503.2 | -599.7 | -690.4 | -824.8 |
| Electrical machinery | Export | 497.6 | 545.3 | 708.3 | 775.3 | 875.1 | 1 065.6 | 1 167.9 | 1 343.1 |
| | Import | 928.0 | 941.2 | 1 072.8 | 1 110.3 | 1 171.7 | 1 308.4 | 1 449.7 | 1 754.0 |
| | Trade Balance | -430.4 | -395.9 | -364.5 | -335.0 | -296.6 | -242.8 | -281.8 | -410.9 |
| Non-electrical machinery | Export | 185.5 | 230.0 | 352.8 | 392.7 | 332.1 | 370.8 | 598.1 | 622.2 |
| | Import | 728.8 | 780.0 | 881.5 | 958.1 | 1 110.2 | 1 163.7 | 1 433.0 | 1 300.8 |
| | Trade Balance | -543.4 | -550.0 | -528.7 | -565.4 | -778.1 | -792.9 | -834.8 | -678.6 |
| Chemicals | Export | 624.6 | 518.9 | 536.7 | 697.0 | 886.8 | 964.2 | 953.8 | 1092.9 |
| | Import | 1 410.2 | 1 355.3 | 1 397.2 | 1 712.9 | 1 856.0 | 1 946.3 | 2 066.8 | 2 431.0 |
| | Trade Balance | -785.7 | -836.4 | -860.5 | -1 015.9 | -969.1 | -982.1 | -1 113.1 | -1 338.0 |
| **Total** | **Export** | **2 298.8** | **2 326.9** | **2 873.0** | **3 588.6** | **4 165.3** | **5 194.2** | **5 987.8** | **7 222.0** |
| | **Import** | **5 974.6** | **6 158.6** | **6 940.4** | **8 246.3** | **9 475.2** | **10 715.3** | **11 580.0** | **13 304.5** |
| | **Trade Blance** | **-3 675.8** | **-3 831.7** | **-4 067.5** | **-4 657.8** | **-5 310.0** | **-5 521.1** | **-5 592.2** | **-6 082.6** |

**Appendix Table 13. Foreign trade in high techonology Products by country group, 1980–1987 FIM mill.**

| Country group | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| **EFTA** | | | | | | | | | |
| Norway | Export | 133.3 | 114.8 | 155.4 | 167.5 | 203.9 | 264.2 | 293.5 | 378.7 |
| | Import | 146.4 | 168.4 | 174.8 | 229.4 | 244.7 | 284.5 | 270.3 | 301.7 |
| | Trade Balance | -13.1 | -53.5 | -19.4 | -61.9 | -40.8 | -20.3 | 23.2 | 77.0 |
| Sweden | Export | 739.3 | 627.3 | 710.9 | 901.4 | 1 035.3 | 1 200.9 | 1 274.5 | 1 320.5 |
| | Import | 1 014.2 | 1 036.6 | 1 201.9 | 1 247.9 | 1 552.3 | 1 601.2 | 1 760.9 | 1 616.4 |
| | Trade Balance | -274.9 | -409.3 | -491.0 | -346.5 | -517.1 | -400.3 | -486.4 | -295.9 |
| Others | Export | 62.4 | 48.1 | 60.7 | 68.9 | 94.3 | 129.6 | 165.9 | 242.2 |
| | Import | 283.2 | 291.5 | 314.4 | 360.9 | 376.8 | 431.9 | 479.9 | 524.9 |
| | Trade Balance | -220.8 | -243.4 | -253.8 | -291.9 | -282.5 | -302.3 | -314.0 | -282.8 |
| **Total** | **Export** | **935.0** | **790.2** | **926.9** | **1 137.9** | **1 333.4** | **1 594.8** | **1 733.9** | **1 941.4** |
| | **Import** | **1 443.8** | **1 496.4** | **1 691.2** | **1 838.2** | **2 173.7** | **2 317.7** | **2 511.2** | **2 443.0** |
| | **Trade Balance** | **-508.8** | **-706.2** | **-764.2** | **-700.3** | **-840.3** | **-722.9** | **-777.3** | **-501.6** |
| **EC** | | | | | | | | | |
| Federal Republic of Germany | Export | 185.1 | 170.2 | 173.8 | 227.2 | 270.4 | 301.3 | 394.2 | 490.3 |
| | Import | 1 323.2 | 1 276.9 | 1 488.4 | 1 718.8 | 1 881.6 | 2 168.5 | 2 426.4 | 2 867.6 |
| | Trade Balance | -1 138.1 | -1 106.7 | -1 314.6 | -1 491.6 | -1 611.2 | -1 867.2 | -2 032.2 | -2 377.3 |
| Denmark | Export | 109.8 | 114.2 | 115.7 | 181.9 | 198.6 | 227.7 | 276.6 | 322.8 |
| | Import | 127.2 | 139.1 | 163.5 | 184.4 | 199.2 | 234.5 | 274.4 | 318.6 |
| | Trade Balance | -17.4 | -24.9 | -47.8 | -2.5 | -0.6 | -6.8 | 2.2 | 4.2 |
| Great Britain | Export | 123.7 | 117.6 | 156.3 | 200.3 | 296.0 | 474.3 | 417.6 | 439.8 |
| | Import | 540.8 | 459.7 | 509.6 | 521.7 | 656.1 | 866.4 | 879.4 | 1 032.8 |
| | Trade Balance | -417.2 | -342.1 | -353.3 | -321.4 | -360.1 | -392.1 | -461.8 | -592.9 |
| Others | Export | 201.0 | 217.2 | 265.8 | 319.3 | 403.9 | 479.3 | 675.3 | 981.5 |
| | Import | 786.7 | 785.8 | 924.2 | 1 188.0 | 1 318.9 | 1 578.7 | 1 735.4 | 1 928.4 |
| | Trade Balance | -585.7 | -568.6 | -658.4 | -868.7 | -915.1 | -1 099.4 | -1 060.2 | -946.9 |
| **Total** | **Export** | **619.6** | **619.2** | **711.6** | **928.7** | **1 168.9** | **1 482.7** | **1 763.7** | **2 234.5** |
| | **Import** | **2 777.9** | **2 661.5** | **3 085.7** | **3 612.9** | **4 055.9** | **4 848.1** | **5 315.7** | **6 147.4** |
| | **Trade Balance** | **-2 158.4** | **-2 042.2** | **-2 374.0** | **-2 684.2** | **-2 887.0** | **-3 365.4** | **-3 551.9** | **-3 912.9** |
| **CMEA Europe** | | | | | | | | | |
| Soviet Union | Export | 352.9 | 479.2 | 579.3 | 762.6 | 723.7 | 957.4 | 1 183.6 | 1 522.5 |
| | Import | 214.6 | 228.6 | 194.1 | 318.9 | 254.6 | 312.4 | 425.2 | 446.9 |
| | Trade Balance | 138.3 | 250.6 | 385.3 | 443.7 | 469.1 | 644.9 | 758.4 | 1 075.7 |
| Others | Export | 42.3 | 17.7 | 32.3 | 56.1 | 48.6 | 31.2 | 60.5 | 73.1 |
| | Import | 74.2 | 97.6 | 102.4 | 112.0 | 141.1 | 111.3 | 127.8 | 174.3 |
| | Trade Balance | -31.9 | -79.8 | -70.1 | -55.9 | -92.5 | -80.1 | -67.3 | -101.2 |
| **Total** | **Export** | **395.1** | **496.9** | **611.6** | **818.7** | **772.3** | **988.6** | **1 244.1** | **1 595.7** |
| | **Import** | **288.7** | **326.2** | **296.4** | **430.9** | **395.7** | **423.7** | **553.0** | **621.2** |
| | **Trade Balance** | **106.4** | **170.7** | **315.2** | **387.8** | **376.6** | **564.8** | **691.1** | **974.5** |

**Appendix Table 13. cont.**

| Country group | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
| **OTHER COUNTRIES** | | | | | | | | | |
| Japan | Export | 12.4 | 10.6 | 19.6 | 21.4 | 30.1 | 35.8 | 89.4 | 70.0 |
| | Import | 407.9 | 446.8 | 562.3 | 826.8 | 950.6 | 1 145.7 | 1 245.8 | 1 553.0 |
| | Trade Balance | -395.5 | -436.2 | -542.7 | -805.4 | -920.5 | -1 109.9 | -1 156.4 | -1 483.0 |
| United States | Export | 54.7 | 76.7 | 95.4 | 134.1 | 258.4 | 393.5 | 368.6 | 381.6 |
| | Import | 920.2 | 1 086.3 | 1 155.8 | 1 320.6 | 1 594.7 | 1 662.0 | 1 569.1 | 1 921.1 |
| | Trade Balance | -865.5 | -1 009.6 | -1 060.4 | -1 186.6 | -1 336.3 | -1 268.5 | -1 200.4 | -1 539.4 |
| Others | Export | 52.9 | 70.6 | 77.8 | 93.5 | 168.3 | 183.1 | 246.3 | 293.7 |
| | Import | 43.0 | 56.0 | 41.5 | 72.0 | 59.2 | 76.7 | 81.3 | 94.6 |
| | Trade Balance | 9.9 | 14.6 | 36.4 | 21.5 | 109.1 | 106.4 | 165.0 | 199.1 |
| **Total** | **Export** | **120.1** | **157.9** | **192.8** | **248.9** | **456.7** | **612.4** | **704.3** | **745.4** |
| | **Import** | **1 371.2** | **1 589.1** | **1 759.5** | **2 219.4** | **2 604.5** | **2 884.4** | **2 896.2** | **3 568.6** |
| | **Trade Balance** | **-1 251.1** | **-1 431.2** | **-1 566.7** | **-1 970.5** | **-2 147.8** | **-2 272.0** | **-2 191.8** | **-2 823.3** |
| **DEVELOPING COUNTRIES** | | | | | | | | | |
| **Total** | Export | 229.0 | 262.6 | 430.0 | 454.3 | 433.9 | 515.9 | 541.7 | 705.1 |
| | Import | 92.9 | 85.4 | 107.6 | 144.9 | 245.4 | 241.5 | 304.0 | 524.3 |
| | Trade Balance | 136.1 | 177.1 | 322.3 | 309.4 | 188.5 | 274.4 | 237.7 | 180.8 |
| **TOTAL – ALL COUNTRIES** | | | | | | | | | |
| **Export** | | **2 298.8** | **2 326.9** | **2 873.0** | **3 588.6** | **4 165.3** | **5 194.2** | **5 987.8** | **222.0** |
| **Import** | | **5 974.6** | **6 158.6** | **6 940.4** | **8 246.3** | **9 475.2** | **10 715.3** | **11 580.0** | **13 304.5** |
| **Trade Balance** | | **-3 675.8** | **-3 831.7** | **-4 067.5** | **-4 657.8** | **-5 310.0** | **-5 521.1** | **-5 592.2** | **-6 082.6** |

# References

## Domestic

| | |
|---|---|
| Academy of Finland | - analyses of research appropriations in the Government budget |
| | - bibliometric indicators |
| Central Statistical Office | - statistics on R&D activities |
| | - statistics on educational structure and level of population |
| | - demographic statistics (censuses) |
| | - salary statistics |
| | - industrial statistics |
| | - national investment accounts |
| | - statistics on intangible investments |
| Finnish Council for Scientific Information and Research Libraries | - statistics on scientific libraries |
| | - miscellaneous reports |
| Ministry of Education | - KOTA data base |
| National Board of Customs | - Data files and statistics on foreign trade |
| National Patent and Register Board | - patent data base (PATH) |
| Robotics Society in Finland | - robot statistics |
| Technological Business Association of Finland | - sales figures on robotics |

## Foreign

| | |
|---|---|
| Nordic Industrial Fund | - R&D reports (short comparison summaries on development of R&D resources) |
| Nordic Ministerial Council | - Nordic comparison statistics on personnel with post-graduate education (Report on personnel with post-graduate education by the Central Statistical Office) |
| OECD | - science and technology indicator data base |
| WIPO (World Intellectual Property Organization) | - yearly statistics on patent applications filed and patents granted |

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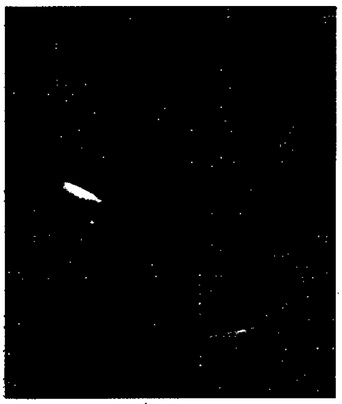

The publication describes the development of science and technology using a number of different indications:

- Population with higher education qualifications, scientific libary and information services, researches´ salaries
- Research and development in enterprises, in the public sector and in universities; government appropriations for research and development
- Bibliometric indicators
- Patents, investments in machinery and equipment, intangible investments, robots
- Production of and foreign trade in high-technology products

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