Report on
Science & Technology
Indicators for Norway

2007

Human Resources

Research and Development

Technology

Innovation

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Preface

The Research Council of Norway is pleased to present the abridged English version of the original 2007 biennial Report on Science and Technology Indicators for Norway, published in Norwegian. The complete S&T Indicator Report has been prepared in collaboration between NIFU STEP (Norwegian Institute for Studies in Innovation, Research and Education), Statistics Norway (SSB) and the Research Council of Norway. The abridged version contains key figures and commentary/analysis relating to research, innovation and development and recruitment activity in science and technology fields in Norway.

The report is intended to serve as a basis for international comparison as well as to provide information to policymakers and others working with science policy issues.

One of the key objectives of Norwegian science and technology policy is to promote a balanced knowledge base and ensure that the national research and innovation system operates smoothly. In this respect the report also offers a framework for international contact and cooperation relating to policy questions as well as future research collaboration. We hope that it will provide useful insights to national and international partners, collaborators and other parties interested in learning about the current status of Norwegian research.

The 2007 English version consists of a series of summaries written by the authors of the complete Norwegian report, entitled Det norske forsknings- og innovasjonssystemet - statistikk og indikatorer 2007 (Ed.: Senior Advisor Kaja Wendt, NIFU STEP) published in Oslo, December 2007, (ISBN 978-82-12-02489-2).

The English version has been prepared by Senior Researcher Trude Røsdal with the assistance of Senior Advisor Kaja Wendt and Research Consultant Hebe Gunnes (all from NIFU STEP) .

Oslo, February 2008

Arvid Hallén
The Research Council of Norway
Director General

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Introduction

This report presents a selection of science and technology (S&T) indicators in Norway. The data presented in the report is annotated in English, and the presentation is designed to provide useful information and perspectives on a range of S&T issues. This English version caters especially to a foreign audience which is not necessarily familiar with the Norwegian S&T environment. It complements the full version which is found online in Norwegian.

The report is the latest addition in a series which goes back to 1997 but which has a much longer history. It continues the series' original pursuit of presenting a wide range of relevant statistics and indicators and of ensuring their continual development. Statistics on resources devoted to research and experimental development (R&D) in Norway, expenditure and personnel, have been compiled since 1963. Those relating to patents, bibliometric analyses and advanced technology have been included since the 1980s. Innovation studies were introduced in the 1990s.

The full-length Norwegian report presents a larger set of indicators and commentary on four basic themes: R&D expenditures, human resources devoted to S&T, collaboration patterns and output of R&D and innovation. It also includes a separate section with tables. The contributions of the authors of the original version has been revamped in this abridged version to include main points and expanded to present important features of the Norwegian research and innovation system. The highlights section as well as the tables on key figures are taken directly from the original version and may include topics not included in this abridged version.

The report is organized as follows: It opens with a brief presentation of the Norwegian system of education, research and innovation, following Highlights and Key Indicators. Chapter 1 then presents the main results from the 2005 R&D survey conducted among the three performing sectors in Norway: the Industrial sector, the Institute sector, and the Higher Education sector. The chapter also includes results from the 2004 Innovation survey conducted in the Industrial sector as well as time series and international comparisons. Chapter 2 draws on R&D and employment statistics and education statistics in order to look at the human resources of science and technology. Chapter 3 focuses on cooperation and collaboration in S&T by utilizing data on Norwegian participation in the EU Framework programme, R&D cooperation in the Industrial sector and collaboration in publications and patenting. The report rounds off with Chapter 4 which introduces output measures of R&D and innovation. The last chapter deals with indicators for Norwegian scientific publishing in international journals, patent applications, results from the research institutes and the Industrial sector, as well as trade in high, medium and low technology industries.

Some sections of the original report are not presented here. These include more detailed analyses on Government budget appropriations, as well as data on various industries, and others. The original Norwegian report also includes supplementary details on the Norwegian research and innovation system in more of the so-called “fact boxes” and in short, signed articles called “focus boxes”. While references do not feature in the abridged report, these are to be found in the report in Norwegian, which is available on Internet:
http://www.forskningsradet.no/

Currency rates

As of 2005 (year average):
1 Euro = 8.9 NOK (Norwegian kroner)
1 US$ = 6.4 NOK

As of January 2008:
1 Euro = 8.0 NOK
1 US$ = 5.4 NOK

Highlights

Resources for R&D and innovation

- Norwegian expenditure on research and experimental development (R&D) in nominal terms amounted to NOK 29.3 billion in 2005. Compared to 2003 this is a real increase of 3.3 percent.

- As a proportion of Gross Domestic Product (GDP) in 2005 R&D expenditures amounted to 1.5 percent. In 2004 the percentage of GDP was 1.6 percent and in 2003 it was 1.7 percent.

- In Sweden, R&D expenditures were 3.9 percent of GDP, in Finland 3.5 percent, in Iceland 2.8 percent and in Denmark it was 2.5 percent. The OECD average was 2.3 percent in 2005.

- Norway spent NOK 6 410 per capita on R&D in 2005. This is the lowest level in the Nordic area: Sweden spent NOK 10 890, Finland spent NOK 9 400, Iceland spent NOK 8 870 and Denmark spent NOK 7 280 per capita on R&D in 2005. The OECD average was NOK 5 770 this year.

- The Higher education sector accounted for NOK 9.1 billion in R&D in 2005. The equivalents for the Industrial sector and the Institute sector were NOK 13.6 billion and NOK 6.9 billion, respectively. The proportion of the Industrial sector of total R&D expenses has declined by 4 percentage points from 2003, to 46 percent. The Higher education sector has increased its share by 4 percentage points from 2005 and in 2005 it was 31 percent. The Institute sector's proportion of total R&D expenses in 2005 remained the same as in 2003 at 23 percent.

- In 2005, NOK 13.2 billion of Norwegian R&D expenditure was funded by Industry, NOK 12.9 billion by the Government and NOK 3.5 billion from other sources and abroad.

- R&D funded by the Government amounted in 2005 to 0.67 percent of GDP. Industry and other sources made up 0.86 percent.

- 26 percent of Norwegian industrial enterprises introduced new or considerably improved products or processes in the 2002-2004 period, and might thus be referred to as innovative. This proportion is somewhat lower than in the 1999-2001 period.

- Norwegian enterprises spent almost NOK 22.2 billion on innovation in 2004. This corresponds to 1.1 percent of total turnover, and represents a decline from 2001 when the innovation costs amounted to 1.5 percent of total turnover in the Industrial sector.

- The number of applications for tax deduction (SkatteFUNN) has declined since 2003 when 4 740 applications for tax deduction were filed. In 2006 the corresponding number was 2 600. In 2005, funding of R&D in the Industrial sector through SkatteFUNN was NOK 0.5 billion, while other Government funding of R&D was NOK 0.6 billion.

- For 2007, the Norwegian Government Budget Appropriation or outlays for R&D (GBAORD) was estimated at NOK 16.6 billion. In real terms the annual growth in expenditures during 2005-2007 was estimated to 4.6 percent.

Human resources

- In 2005, over 54 000 persons were involved in R&D in Norway. Of these 37 000 were defined as researchers or persons with five years or more of higher education.

- The overall percentage of female researchers in 2005 was 32 percent. In the Higher education sector the proportion was 39 percent, in the Institute sector it was 34 percent and in the Industrial sector 19 percent of the researchers were women. The overall increase from 2003 was 3 percentage points. The largest increase was in the Higher education sector.

- In 2005, total personnel accounted for 30 500 person-years, of which 21 700 were performed by researchers and 8 800 by technicians and support staff.

- The number of students in Norway has remained stable from 2002 at approximately 220 000. The number of students studying abroad has been declining.

- In 2005, the overall number of higher degree candidates at Norwegian higher education institutions was 8 400. This represents an increase of 9 percentage points from 2003.

- In total, Norwegian institutions have awarded 15 000 doctoral degrees over the years. This number is constantly increasing, and 900 new doctoral degrees were awarded in 2006. The increase is nevertheless lower than in the other Nordic countries. In Sweden the number of awarded doctoral degrees is twice as high as in Norway, adjusted for the number of inhabitants. Also Finland and Denmark have awarded considerably more doctoral degrees than Norway.
- Most of the doctors find work within the Government sector, mainly at universities and university colleges.
- The number of employees with a higher education, 5 years or more, increased in all industries. The largest proportion in 2006 was in oil and gas extraction, where 16 percent of a total of 38 000 employees had higher education.
- Unemployment among employees with higher education in 2007 was 0.7 percent.

Cooperation in R&D

- Overall a total of NOK 10.7 billion was transferred in 2005 in order to buy and finance R&D across the R&D performing sectors in Norway and abroad.
- Half of the Norwegian firms performing R&D reported cooperating with other firms in 2005. Contractors were the most important type of cooperation partner. As much as 93 percent of the cooperation partners in the Industrial sector were situated in Norway.
- In 2004, 33 percent of the innovative firms were involved in cooperation in innovation. 72 percent reported that cooperation with contractors was important or very important.
- Staff in the Higher education sector performs 87 person-years as adjunct professors in the Institute sector and the other way, staff from the Institute sector performs 46 person-years as adjunct professors in the Higher education sector. The use of adjunct professors is stable.
- More than half of all Norwegian articles in international scientific journals in 2006 were co-authored with foreigners. International collaboration has increased, primarily with the EU.
- At the start of 2007 Norway participated in 2 490 applications for the 6th European Framework programme on R&D, of which 30 percent were granted compared to an average of 20 percent for all countries in the Framework programme.
- The number of applications with Norwegian contribution to the European Patent Organization (EPO) increased from 205 in 1996 to 430 in 2005. In the 1996-2005 period most EPO applications with a Norwegian contribution were to be found within chemicals/ pharmaceuticals.

Results from R&D and Innovation

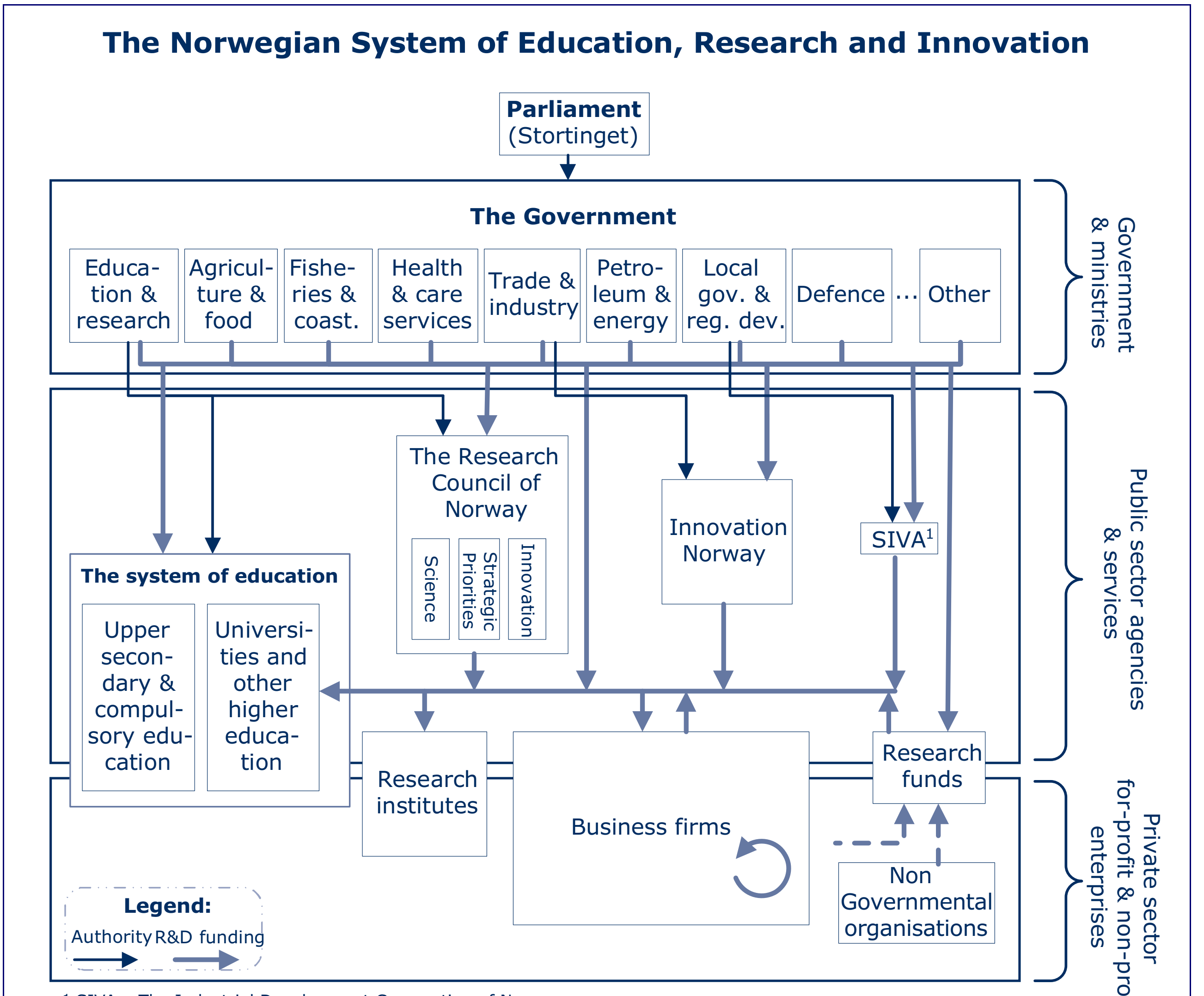
- In 2006, Norwegian researchers published nearly 7 200 articles, compared with 5 500 in 2004. Norway has strengthened its position within most of the scientific fields during the last decade.
- There is high activity in Norwegian research particularly within biology and geology, while the activity is relatively low within fields like physics, chemistry and technology.
- Norwegian articles are cited more often than before, and especially since the mid-1990s there has been a positive development. During the 2002-2006 period, Norwegian articles were cited 18 percent more often than the world average.
- For the research institutes, reports represented the dominating publication form in 2006, but the production of scientific articles is increasing. Most articles are written by researchers at the primary industry institutes.
- New or significantly improved products accounted for 5.9 percent of total turnover in the Industrial sector in 2004. This is a decline from 2001 when the proportion was 7.7 percent.
- Innovative firms that cooperate with other firms are more successful in the innovation activity than other firms. 70 percent of the cooperating innovators reported that the innovation activity was successful. In the group of "converted innovators" the majority experienced the innovation effort as medium or not successful.

The Norwegian system of education, research and innovation

The total population of Norway was 4.7 million in 2007. More than 1 000 000 Norwegians were studying in that year, including just above 210 000 at institutions of higher education. In 2005, 54 000 individuals were involved in research and experimental development activities in Norway, and 70 percent of these had qualifications corresponding to the Master's degree level or above.

The following figure introduces key parts of the Norwegian system of education, research and innovation. It distinguishes between institutions of the government (such as ministries), institutions in the public sector (agencies and service providers, such as The Norwegian Research Council, the Ministry of Education and Research, etc.), and organisations in the private sector (for profit and non-profit enterprises such as commercial firms, non-governmental organisations, etc.). The figure distinguishes between three levels: the governmental level, the institutional level, and the level of research and innovation where the activities take place. Some general characteristics of these are presented below to introduce the reader to the Norwegian environment.

The governmental level. The Norwegian Government and the Parliament - the Storting - set the overall policy agenda for the areas of education, research, and innovation. Governmental priorities are, in instrumental terms, expressed in the national budget proposal that the government forwards each year for approval by the Storting, cf. section 1.1.4. The government may appoint its own interministerial research committee, GRC, but policy priorities and relevant appropriations in Norway are made at the level of the ministries. Several higher level initiatives have been made over the



1 SIVA – The Industrial Development Corporation of Norway.

years to integrate policy areas to a greater degree across traditional ministerial mandates.

The Norwegian public sector plays a particularly central role in the country's education system. To emphasise this role, the education system is largely placed inside the system of public services in the figure. Public institutions also provide important support structures for research and innovation. A notable feature of the Norwegian landscape is the country's significant number of research institutions, which are formally independent of the higher education system. Originating in the public sector, many of these institutions have since become private foundations although most depend on public funding to some degree. In the figure, the research institutes are therefore shown to extend beyond the private sector. Similarly, since state ownership in industry is significant in Norway, the business sector is shown to extend beyond the private sector and into the system of public services.

While the system of education is fundamentally shaped by the *Storting* (Parliament) and by the Ministry of Education and Research, the governance of the research and innovation system is more complex. A number of ministries and government agencies initiate and support activities here. These public bodies are also involved in formulating overall priorities and strategies in the area. Public efforts are further complemented by significant contributions of the business system to the development of strategies and priorities.

The institutional support structure. Several public agencies help operationalize and coordinate research and innovation policies as formulated at the governmental level. The Research Council of Norway is the central support institution in the Norwegian research and innovation system. The Council is organised in three divisions, which allocate research resources to Basic science, to Large strategic initiatives and to Innovation. Innovation Norway, is the main policy channel for public support to research based innovation and business development. It replaced four organisations in 2004: The Norwegian Tourist Board, the Norwegian Trade Council, the Norwegian Industrial and Regional Development Fund and the Government Consultative Office for Inventors. Innovation Norway falls under the purview of the Ministry of Trade and Industry.

The state owned company SIVA (Industrial Development Corporation of Norway) is designed to build networks between regional, national and international R&D environments. This public corporation under the the Ministry of Local Government and Regional Development is a co-owner in more than 60 innovation centres in Norway.

A number of private research funds exist, but are often too small to play a significant role in the research system beyond specific niches. Interesting and important exceptions are found in medicine, and also in fisheries and agriculture where tax based funds provide resources for sector specific research and innovation.

Level of research and innovation. Research is carried out in the system of higher education, in the Institute sector, and in the Industrial sector. The strategic efforts of universities and of leading firms in a number of different industries, complement the strategic efforts of the Research Council of Norway and other agencies.

The Industrial sector. Less than one half of all Norwegian R&D expenditures are incurred by business firms. An important part of traditional industrial activities in Norway are related to the extraction of raw materials and natural resources (oil and gas, fish, wood), and to their industrial processing into bulk products and semi-finished goods. Such industries are less R&D intensive than industries such as pharmaceuticals and ICT, and there has been broad political agreement that efforts should be made to foster more R&D intensive, “knowledge based” industries. See also chapter 1.5.2 on R&D expenditures in different industries.

The Institute sector. The large number of research institutions outside the system of higher education is a characteristic feature of the Norwegian innovation system, and of the system of research. Historically, research institutes were established in the Post World War II period as a complement to the University of Oslo, the Norwegian Institute of technology in Trondheim, etc., and were intended to concentrate their efforts in specific knowledge areas that were deemed important for both policy and business reasons. Today, approximately one quarter of total R&D resources are spent in the Institute sector. In international terms the Institute sector is spilt into the Business Enterprise sector and the Governmental sector, see also box on performing sectors in chapter 1.

The system of higher education. Almost a third of all R&D in Norway takes place within the system of higher education, mainly within universities and specialised university institutions. There are also 24 state university colleges in the various regions of Norway. R&D is mainly funded over the institutions ordinary budgets, but supplementary financing is obtained for programmes and equipment, mainly from the Research Council, see chapter 1.2. As in many other countries, the Norwegian Higher education sector has during the last years underwent many changes. A Reform of the Quality of Higher Education has resulted in a new funding system for higher education institutions, a new marking system, new student programmes, more intense follow-up of students and new forms of evaluation. Contract research has been carried out for a while in the research system, first and foremost in the institute sector, but also in universities.

Key indicators

The following two tables present a set of key indicators. The intention is to introduce essential trends of Norwegian research and innovation in a concise form. The first table shows main trends in Norway.

The second table compares the status of Norway to that of the other Nordic countries, the EU, and the OECD. See also the indicators in the Table section of this report.

Key indicators for R&D and innovation in Norway in 1999, 2001, 2003 and 2005

	1999	2001	2003	2005
Resources for R&D and innovation				
R&D expenditure as a percentage of GDP	1.64	1.59	1.71	1.53
R&D expenditure per capita in constant 2005 prices (NOK)	5 480	6 010	6 280	6 410
R&D expenditure funded by government as a percentage of total R&D expenditure	42	40	42	44
R&D expenditure funded by industry as a percentage of total R&D expenditure	49	51	47	44
R&D expenditure in the Higher education sector as a percentage of total R&D expenditure	29	26	27	31
Innovation costs as a percentage of turnover in manufacturing and mining	2.7	2.1	..	2.3[1]
Human resources				
Percentage of the population with higher education	27	31	31	33
R&D full-time equivalent per 1 000 capita	5.7	6.0	6.4	6.6
R&D full-time equivalent per qualified researcher/ scientist per 1 000 capita	4.1	4.4	4.6	4.7
Percentage doctoral degree holders among qualified researchers/scientists	23	22	24	27
Percentage women among qualified researchers/ scientists	28	28	29	32
Cooperation in R&D and innovation				
Extramural R&D expenditure compared to intramural R&D expenditure in the Industrial sector (%)	40	33	26	30
Companies involved in cooperation on R&D as a percentage of all R&D companies	..	..	46	52
Companies involved in cooperation on innovation as a percentage of all innovative companies	..	41	..	37[1]
Articles in international scientific journals co-authored by Norwegian and foreign researchers as a percentage of all articles by Norwegian researchers	44	47	51	52
Results of R&D and innovation				
Percentage innovative companies in the Industrial sector	31	29	25	26[1]
Number of articles in international scientific journals per 100 000 capita	107	110	120	146
Number of patent applications to the European Patent Organization per million capita	128	133	117	..

Source: NIFU STEP, Statistics Norway

[1] 2004.

Key indicators for R&D and innovations in 2005 or last available year with comparable data in Norway, Sweden, Denmark, Finland, EU[1] and OECD

	Norway	Sweden	Denmark	Finland	EU	OECD
Resources for R&D and innovation						
R&D expenditure as a percentage of GDP	1.53	3.89	2.45	3.48	1.87	2.25
R&D expenditure per capita (NOK)	6 410	10 890	7 280	9 400	4 970	5 770
R&D expenditure funded by the government as a percentage of total R&D expenditure	44	24	28	26	34	29
R&D expenditure funded by the Business enterprise sector as a percentage of total R&D expenditure	46	65	60	67	55	63
R&D expenditure in the Higher education sector as a percentage of total R&D expenditure	31	21	25	19	22	18
Innovation costs as a percentage of turnover in manufacturing and mining[2]	1.8	6.5	5.6	..	..	..
Human resources						
Percentage of the population with higher education[3]	33	30	34	35	24	26
R&D full-time equivalent per 1 000 capita	6.6	8.6	8.0	11.0	5.0	..
R&D full-time equivalent per qualified researcher/ scientist per 1 000 capita	4.7	6.1	5.2	7.5	2.9	3.3
Cooperation in R&D and innovation						
Companies involved in cooperation on innovation as a percentage of all innovative companies[2]	33	43	43	44	..	..
Companies involved in cooperation on innovation as a percentage of innovative companies in manufacturing and mining[2]	37	48	42	47	..	..
Results of R&D and innovation						
Percentage innovative companies in the Business enterprise sector[2]	26	48	46	39	..	..
Percentage innovative companies in manufacturing and mining[2]	30	51	51	44	..	..
Number of articles in international scientific journals per 100 000 capita[4]	146	184	164	159	..	..
Number of patent applications to the European Patent Organization per million capita[5]	117	285	236	306	161	..

Source: NIFU STEP, Statistics Norway, OECD, Eurostat, national R&D statistics for Denmark and Sweden.

[1] EU 15.
[2] 2004.
[3] EU 19.
[4] 2006.
[5] 2003.

1 R&D and innovation resources

Growth, welfare and cultural development in a modern society presuppose a well functioning R&D system. This has been the premise for modern research policy since World War II. To make R&D an independent policy area and to make governments able to act with regard to the R&D system, it has been necessary to develop methods for mapping the system with the aim of obtaining reliable and periodic knowledge on political, relevant characteristics of national R&D activities.

Research policy is based on statistical information on a country's R&D resources and systems, and on the development of criteria to assess what the information tells us about the system's "health status": Are national R&D activities sufficient? Are R&D activities and resources adequately distributed across research areas, R&D institutions, objectives and type of research: (basic, applied and experimental development)? Is there a good balance, interaction and connection between the different elements in the system? What about cost versus benefit? On the basis of such criteria to assess selected, central parameters in the R&D system, statistical data in this area become indicators – of trends and changes, for the better or worse, and of the needs for political decisions to be taken in order to achieve development in the desired direction.

This chapter explores several dimensions of the resources dedicated to R&D as well as innovation activities in Norway. It presents data on the composition of R&D expenditure, including cross-country comparisons, on the performance of R&D and innovative activities in universities and university colleges in the Higher education sector, in the Institute sector and the Industrial sector.

1.1 R&D expenditure in Norway

1.1.1 Total figures for R&D performing sectors

Total R&D expenditure in Norway amounted to NOK 29.6 billion in 2005, or 1.5 percent of GDP, as shown in Table 1.1. The Industrial sector had 46 percent of the total R&D expenditure, while the Higher education sector and the Institute sector had 31 and 23 percent of the total R&D expenditure, respectively.

Table 1.1
Total R&D expenditure in Norway by performing sector and source of funds in 2005. Million NOK.

Performing sector	Total	Source of funds: Industry – Total	Industry – Of which: Oil companies	Government – Total	Government – Of which: The Research Council of Norway	Other national sources	Abroad – Total	Abroad – Of which: EU-commission
Industrial sector[1]	13 640	11 226	973	569	201	513	1 331	59
Institute sector	6 907	1 505	363	4 404	1 610	210	788	218
Of which: Research institutes								
serving enterprises[2]	*2 271*	*1 017*	*279*	*853*	*506*	*75*	*326*	*104*
Government sector	*4 636*	*488*	*85*	*3 551*	*1 104*	*135*	*462*	*114*
Higher education sector	9 096	431	139	7 964	1 655	428	274	166
Total	**29 643**	**13 163**	**1 476**	**12 973**	**3 466**	**1 151**	**2 393**	**443**
Share of GDP	1.53	0.68	0.08	0.67	0.18	0.06	0.12	0.02

[1] Private and public enterprises.
[2] Non-profit institutions.

R&D surveys

NIFU STEP and Statistics Norway carry out national statistical surveys on resources devoted to R&D in Norway. NIFU STEP is responsible for collecting, processing and dissemination of statistics and indicators regarding the Institute and Higher education sectors, while Statistics Norway is responsible for the Industrial sector. NIFU STEP is also responsible for compiling the data into the official R&D statistics for Norway. Annual statistical surveys are carried out for the Industrial and Institute sectors. For the Higher education sector, the survey is carried out every second year. Main figures are produced every year for all three sectors. The statistics are produced using guidelines by the OECD (2002), "Frascati manual".

Current expenditure on R&D amounted to NOK 27.6 billion in 2005: 64 percent was spent on salaries, the rest on other current costs. This is the same distribution as in 2003. A little more than NOK 2 billion was spent on investments on R&D: 1.5 billion on instruments and equipment, the rest on land and buildings. There was a marked decline in capital investments from 2003 to 2005. The reduction amounted to NOK 360 million, distributed evenly between scientific equipment and land and buildings. The decline in expenditure on instruments and equipment was caused by a considerably lower level of investments in the Industrial sector. The Institute sector had an increase in R&D expenditure on instruments and equipment of 33 percent nominally, and the corresponding growth in the Higher education sector was 17 percent.

Total expenditure on R&D in Norway increased by NOK 2.3 billion from 2003 to 2005. In fixed prices this corresponds to a 1.7 percent annual growth. By comparison, the same growth was 2.7 percent per year from 2001 to 2003 and as high as 6.0 percent per year from 1999 to 2001.

The Industrial sector's R&D expenditure decreased by 1.8 percent annually from 2003 to 2005. The decline in capital investments is an important cause of this reduction in the two year period, but expenditure on salaries also showed a small decrease.

Total R&D expenditure in the Institute sector experienced a real annual growth of 1.7 percent from 2003 to 2005, with a small increase in current expenditure and declining capital investments. In the Higher education sector, however, R&D expenditure was much higher in 2005 than in 2003. Part of the increase can be explained by changes in the data basis at the university hospitals, but most of the growth is real. Adjusted for the university hospitals, real annual growth in this sector was 6.0 percent from 2003 to 2005.

Total R&D expenditure's share of GDP of 1.5 percent represents a decrease from 2003, when this share was 1.7 percent and compared with 2004 as well, when the R&D share of GDP was 1.6 percent. In the same period there has been a strong increase in GDP.

Looking at Norway's R&D expenditure in a longer time perspective, the three R&D performing sectors show different developments, as shown in Figure 1.1. In 1970 there were only small differences in total R&D between the sectors. 35 years later – in 2005 – R&D in the Industrial sector was twice as high as the Institute sector, and the Higher education sector had a considerably higher level of R&D expenditure than the Institute sector. However, the figure shows that there has been a stagnation in the Industrial sector in recent years, compared with the other two sectors. Estimates for 2006 show continued

OECD's definition of research and experimental development (R&D)

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

The term R&D covers three activities:

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

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

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

The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty, according to the Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development, OECD, 2002.

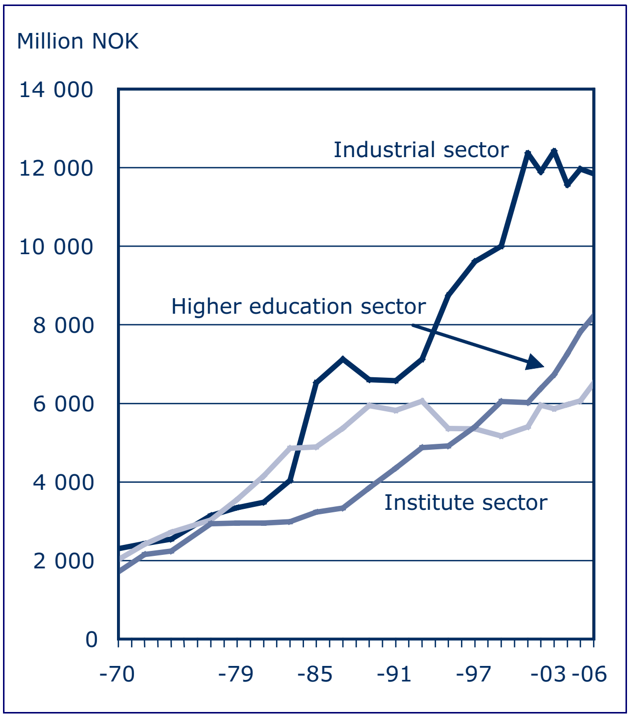
Performing sectors for R&D

In Norway, national R&D statistics are categorised according to three basic sectors:

- The Industrial sector: Firms, organisations and institutions whose primary activity is the commercial production of goods and services for sale to the general public at an economically significant price
- The Institute sector: Private non-profit institutes mainly serving industry (incl. in the Business enterprise sector in OECD's classification), research institutes and other R&D performing institutions (other than higher education) mainly controlled by and funded by the government (Government sector in OECD's classification), and non-market, private non-profit institutions serving the general public (Private non-profit sector in OECD's classification)
- The Higher education sector: Universities, governmental and private university institutions, national institutes of the arts and state university colleges

Based on these categories, the Business enterprise sector encompasses the private business sector and units that mainly serve that sector. The Government sector in Norway is understood here in the same way to encompass units in the Institute sector linked to government and other public and semi-public institutions and public mission-oriented institutes. Few Norwegian institutions can be classified in the private non-profit (PNP) sector. Thus, in reports to the OECD and other international statistics, PNP-institutions are included in the Government sector. R&D performed in international institutions is not covered by international R&D statistics. For this reason total figures in national statistics deviate somewhat from those in international statistics. National and international statistics are identical for the Higher education sector. See also the box on international comparisons in Chapter 1.7.

Figure 1.1
R&D expenditure in Norway in 1970–2006 by performing sector. Estimates for 2006. Constant 2000 prices.



Source: NIFU STEP, Statistics Norway/R&D statistics

growth for the Institute and Higher education sectors, while preliminary figures for Industrial sector show a small decrease in R&D.

1.1.2 The Government's R&D priorities

The Government's latest Report on R&D to the Storting indicates areas of particular importance with regard to R&D. These are areas where development of knowledge is regarded as having a major impact on society in general and where special efforts are required. These future priorities are classified into three groups:

Structural priorities (Internationalisation, Basic research, Research-based business development and innovation);

Thematic priorities (Energy and environment, Food, Sea, Health);

Technological priorities (Information and communication technology (ICT), Biotechnology, New materials).

In the R&D survey for 2005, questions on thematic and technological priorities were included for all three performing sectors, to enable monitoring of the Government's priorities over time. Energy and environment was the thematic area with most R&D resources in 2005; more than NOK 5 billion. NOK 4.5 billion was oriented towards health, and sea and food had R&D expenditure of NOK 2.0 and 1.4 billion, respectively.

NOK 10 billion, or 36 percent of total current expenditure on R&D, was spent on technological priorities. Information and communication technology, with NOK 6.4 billion, was by far the largest priority in this category. Compared with ICT, efforts within biotechnology with NOK 1.9 billion and new materials with NOK 1.4 billion seem rather small.

1.1.3 R&D funding

In 2005, NOK 13.2 billion or 44 percent of the total R&D expenditure was funded by industry. This is a relative decline compared with 2003, when the share was 47 percent. R&D funded from public sources increased from 42 percent in 2003 to 44 percent or NOK 12.9 billion in 2005, almost as much as funding from industry, see Figure 1.2. Sources from abroad amounted to NOK 2.4 billion. The effect of the tax deduction system for R&D (SkatteFUNN) in 2005 – slightly over NOK 500 million – is posted under "Other domestic sources".

Figure 1.3 illustrates the size of the contributions from each financing source in 2003 and 2005 in constant prices. Industry, without oil companies, had a real decline in financing R&D of almost 4 percent in the two-year period, while at the same time oil companies increased their funding of R&D by 10 percent in fixed prices. Funding from the Research Council of Norway increased by almost 7 percent, and other government sources had a 9 percent growth. Total funding from abroad had 12 percent real growth from 2003 to 2005, and sources outside the EU are responsible for this positive development. Financing from the European Com-

Sources of R&D funding

In Norway, the national R&D statistics are based on the following categories:

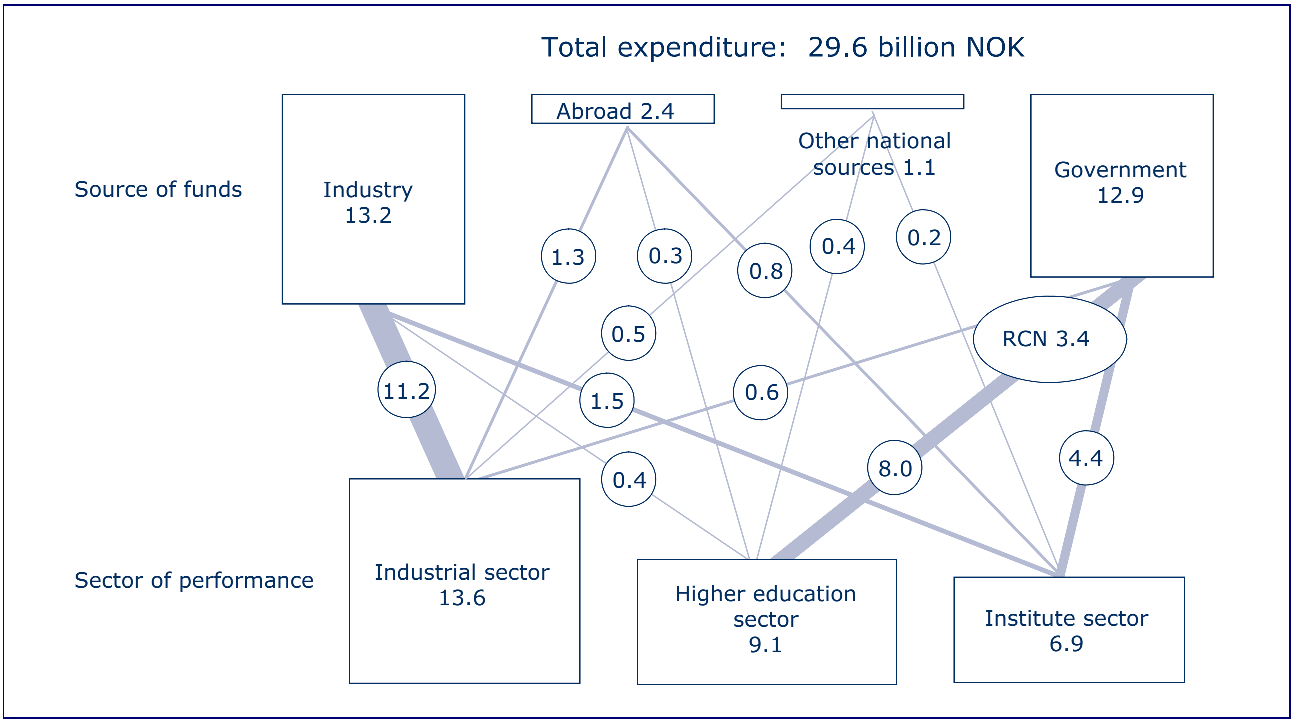
Industrial sources: Expenditure made by industrial enterprises or other industrial activity, in most cases for R&D activities in the enterprise itself.

Government sources: Expenditure made by the government, especially contributions by the Norwegian ministries directly to universities and other R&D institutions as well as contributions channelled through the Research Council of Norway. A small proportion also comes from county and municipal administrations.

Other domestic sources: Private trusts, gifts, loans, grants from voluntary organisations and own funds in the Higher education and Institute sectors and SkatteFUNN (Tax deduction system for R&D, see separate box) in the Industrial sector.

Sources from abroad: Contributions made by foreign enterprises, institutions and foreign trusts as well as those from the EU, Nordic and other international organisations.

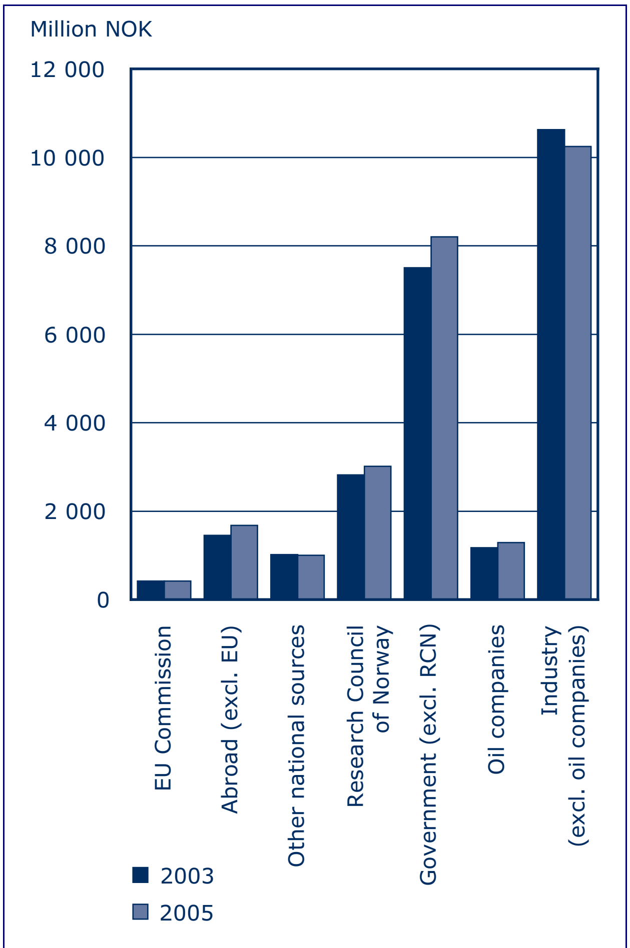
Figure 1.2
R&D expenditure in Norway in 2005 by source of funds and performing sector.



[1] Other national sources include private funds, gifts, own income/profit and tax deduction in the Industrial sector (SkatteFUNN).

Source: NIFU STEP, Statistics Norway/R&D statistics

Figure 1.3
R&D expenditure in 2003 and 2005 by source of funds. Constant 2000 prices.



Source: NIFU STEP, Statistics Norway/R&D statistics

mission declined by about one percent in the period, mostly caused by a reduction in the number of EU projects in the Industrial sector.

1.1.4 Government budget appropriations for R&D

Analyses of the state budget or the government budget appropriations or outlays for R&D (GBAORD) have been conducted yearly by NIFU STEP since 1970. The analyses are based on budget documents and other information and describe the government's intentions with R&D allocations, in contrast to the R&D surveys, which describe the actual expenditure on R&D.

There are some differences between the two methods of quantifying R&D funding that lead to varying results. The figures estimated in the budget analysis contain R&D grants for sources abroad, while the R&D statistics only include research conducted in Norway. Resources from counties and municipalities are not included in the budget analysis, but are registered as government sources in the R&D statistics.

The estimated appropriations for R&D in the 2007 budget amount to NOK 16.6 billion, which represents an increase of more than NOK 900 million or 5.9 percent nominally from 2006. From 2005 to 2006 the budget increased by 10 percent. In constant prices annual growth was 4.6 percent from 2005 to 2007. In the 2007 budget the increase was in international R&D collaboration in particular, whereas a large part of the marked growth in the 2006 budget was allocations aimed at basic research and industrial oriented research.

In 2007, NOK 8.5 billion or 51 percent of government appropriations for R&D was channelled through the Ministry of Education and Research. There was a large gap to the next ministries with regard to the size of R&D allocations. The Ministry of Health and Care Services and the Ministry of Trade and Industry had 10 and 9 percent of the appropriations for R&D, respectively.

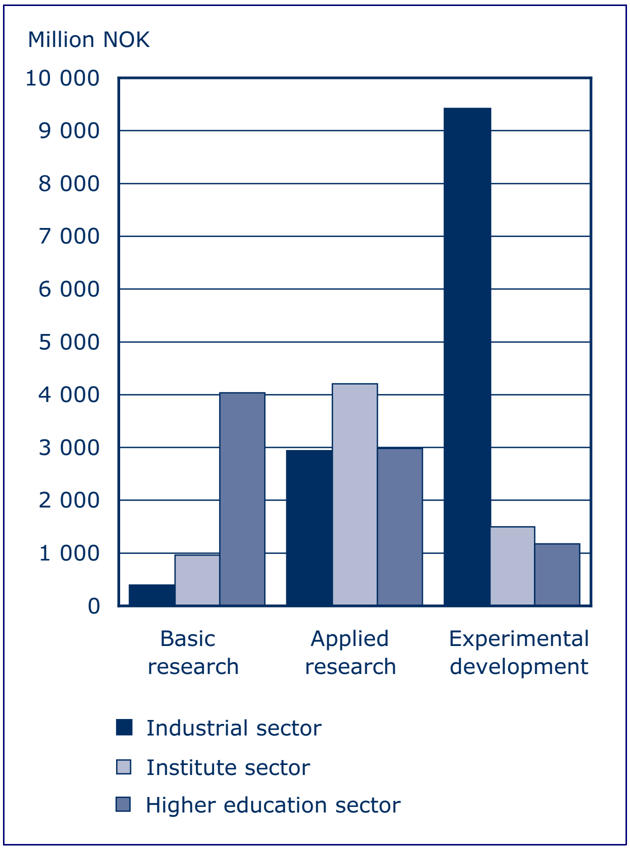
R&D constitutes 2.33 percent of the state budget in 2007. This is approximately the same share as in 2006, but higher than in 2005 with 2.18 percent. R&D grants as a share of GDP is estimated to 0.78 percent in 2007, and this represents only a small increase from 2005.

In 2007, 41 percent of the appropriations were channelled to higher education institutions, and 29 percent was allocated to the Research Council of Norway. The remaining categories of recipients – other research institutions, abroad and project grants – were of about the same size: 10 percent each. There has been a considerable increase in allocations for higher education institutions in the period from 1995 to 2007, an increase of 3.7 percent per year in constant prices. In the same period allocations to the Research Council of Norway experienced an even greater increase: 4 percent yearly in real terms.

1.1.5 Type of R&D activity

In 2005 almost 20 percent of current expenditure on R&D was spent on basic research, close to 37 percent on applied research and 44 percent on experimental development. The corresponding figures in 2003 were 18 percent on basic research, 34 percent on applied research and 48 percent on experimental development. Figure 1.4 shows that the three R&D performing sectors have very different profiles regarding type of R&D activity.

Figure 1.4
Current expenditure on R&D in 2005 by type of R&D activity and performing sector.



Source: NIFU STEP, Statistics Norway/R&D statistics

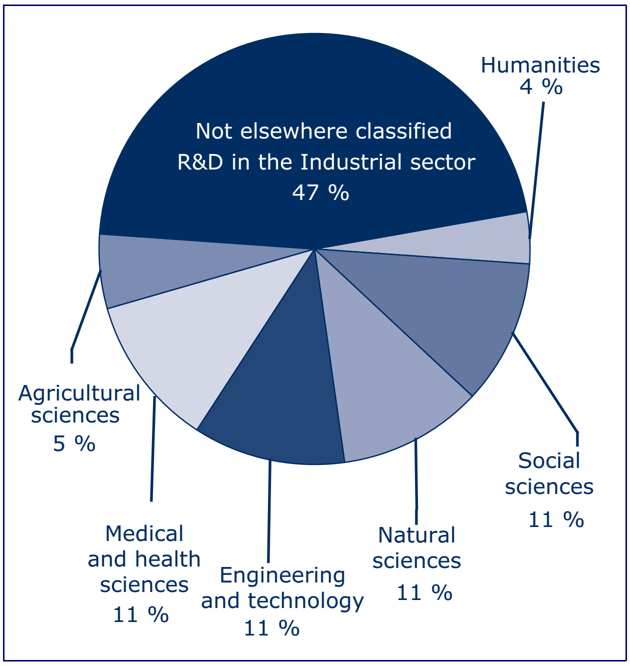
In all three sectors there has been an increase in basic research in 2005 compared with 2003. In total, current expenditure on R&D in basic research increased by 16 percent in fixed prices between 2003 and 2005. Applied research also experienced a real growth of 12 percent, while experimental development had a 3 percent real decline.

Seen in a longer time perspective, it is particularly in the Industrial and Institute sectors the R&D profile has changed, in the Industrial sector in the direction of a higher share of total basic research – from less than one percent in 1970 to 7 percent in 2005. The Institute sector has developed in the opposite direction and was responsible for 24 percent of current expenditure on R&D in 1970, compared with 18 percent in 2005. The Higher education sector had 75 percent of basic research both years.

1.1.6 Fields of science and technology

R&D activity in the Industrial sector is not distributed by fields of science and technology, but is mostly oriented towards technological development

Figure 1.5
Current expenditure on R&D in 2005 by fields of science and technology.



Source: NIFU STEP, Statistics Norway/R&D statistics

– "unspecified" in Figure 1.5. If we exclude current expenditure on R&D in the Industrial sector (which amounted to 47 percent in 2005), the humanities and agricultural sciences were the smallest fields of science, with 4 and 5 percent of current expenditure on R&D in 2005, respectively. Social sciences, natural sciences, engineering and technology and medical and health sciences were all about the same size, with 11 percent of current R&D expenditure each.

1.2 R&D in the Higher education sector

The Higher education sector is an important part of the Norwegian R&D system, amounting to 31 percent of the total Norwegian R&D effort in 2005.

The Higher education sector in Norway underwent some major changes between 2003 and 2005. The Agricultural University of Norway (now: Norwegian University of Life Sciences) and Stavanger State University College (now: University of Stavanger) were both granted university status from 2005. In addition the implementation of the Reform of the Quality of Higher Education has resulted in some important changes, including a new funding system for higher education institutions, a new marking system, new student programmes, more intense follow-up of students and new forms of evaluation.[1]

1.2.1 Main results

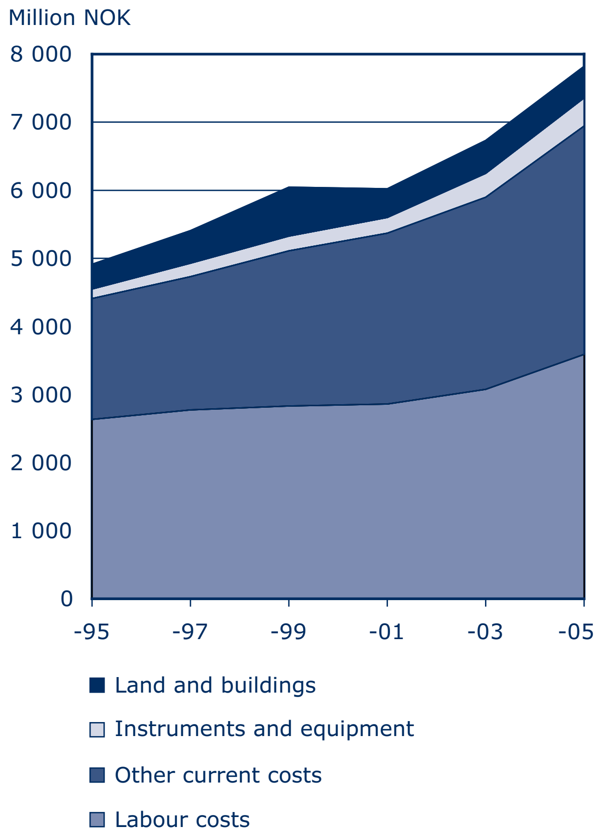
Total expenditures on R&D in the Norwegian Higher education sector amounted to NOK 9.1 billion in 2005. This represents a real growth of 11 percent since 2003, adjusted in relation to the change and expansion of the statistical basis for the university hospitals. This increase was considerable higher than for the other sectors. The Institute sector saw growth of 3.4 percent from 2003 to 2005, while the Industrial sector experienced a recession of 3.6 percent. The current expenditures amounted to 90 percent of the R&D expenditures in the Higher education sector, of which salaries amounted to 56 percent.

In 2005, 9 420 R&D person-years were performed in the Higher education sector. This corresponds to 31 percent of the total R&D person-years performed in Norway, and represents an increase of 19 percent since 2003. Compared with the other sectors, the highest growth in R&D person-years was in the Higher education sector. The total increase in R&D person-years for all sectors was 5 percent.

The R&D statistics for 2005 include 45 different higher education institutions; from the largest universities to the smallest private universities colleges. The universities together with the university hospitals represented the main part of the R&D expenses in the sector in 2005: 83 percent. The state university colleges together with the private university colleges represented 11 and 6 percent, respectively. This distribution of the R&D expenses has not changed much from 2003. However, looking at the development in a wider time perspective, e.g. from 1995 to 2005, the share of the state university colleges has increased considerably.

The trend is that R&D activity in state university colleges is still increasing. All in all both the current and the capital expenses on R&D increased, but for the state university colleges, capital expenses decreased by 20 percent from 2003 to 2005 (constant prices). R&D expenditure on land and buildings vary considerably from year to year, depending on whether building operations have been put into effect, see Figure 1.6. According to the OECD guidelines for R&D statistics, the whole investment is supposed to be accounted for the current year.

Figure 1.6
R&D expenditure in the Higher education sector in 1995–2005 by type of expenditure. Constant 2000 prices.



Source: NIFU STEP/R&D statistics

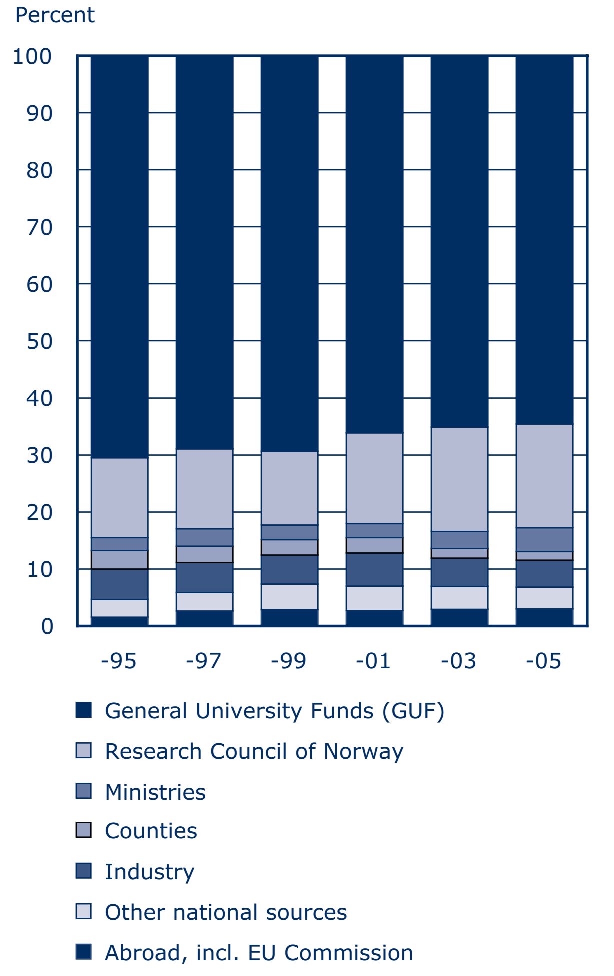
1.2.2 R&D funding

R&D activities in the Higher education sector are largely funded by public sources. A basic distinction can be drawn between general university funds (GUF) and external funding. GUF is a form of basic funding that includes institutional funding from the Ministry of Education and Research and the Ministry of Health and Care Services. External funding includes all other sources, such as funding from the Research Council of Norway.

Figure 1.7 illustrates that the share of general university funds has declined from 70 to 65 percent during the period from 1995–2005. Funding from the Research Council and funding from other governmental external sources has increased. Thus the total share of public funding from national sources only declined from 90 percent in 1995 to

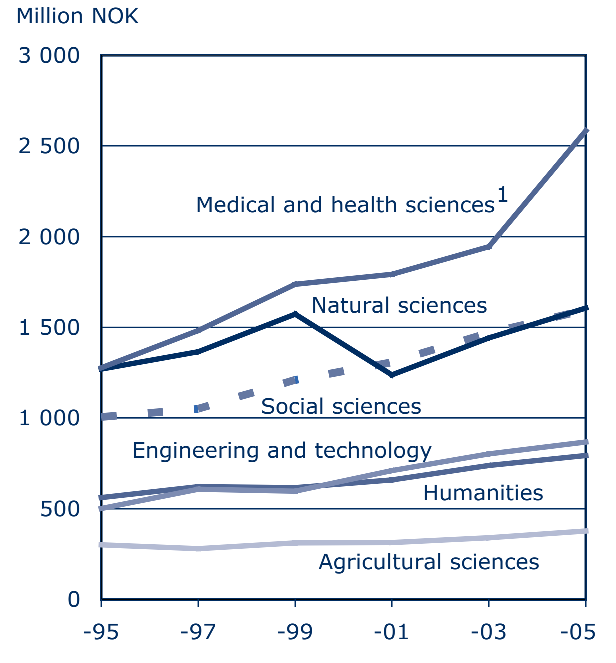
[1] Report no. 27 to the Storting (2000–2001): Do your duty – Demand your rights, Ministry of Education and Research. Michelsen, Svein, Håkon Høst and Jens Petter Gitlesen (2006): Evaluation of the Quality Reform in Higher Education. The Quality Reform between education and research, part report 10/2006 in the series *Evaluation of the Quality Reform*.

Figure 1.7
R&D expenditure in the Higher education sector in 1995–2005 by source of funds.



Source: NIFU STEP/R&D statistics

Figure 1.8
R&D expenditure in the Higher education sector in 1995–2005 by field of science. Constant 2000 prices.



[1] Some of the growth within medical and health sciences from 2003–2005 is caused by changes and extension of the statistical population at the University hospitals.

Source: NIFU STEP/R&D statistics

88 percent in 2005. During the same time span, R&D expenditure in the sector has increased from NOK 4.1 billion to NOK 9.1 billion in current prices.

A closer look at external R&D sources shows that the Norwegian Research Council was clearly the largest source of funding in the Higher education sector in 2005. Funding from the Research Council constituted well over 50 percent of the external funding, close to NOK 1.7 billion in 2005.

Public external funding experienced a real growth of 66 percent from 2003 to 2005. These funds include funding from the Ministries – without GUF – and from directorates and other governmental institutions. It is mainly within the fields of medical and health sciences and social sciences that these resources have been used. The Ministry of Health and Care Services and the Ministry of Education and Research were the main contributors to R&D within medicine and social sciences, respectively.

R&D funding from the European Commission was NOK 166 million in 2005. In 2003 the corresponding amount was NOK 148 million. Most of the funding from the European Commission went to R&D within natural sciences and medicine and healthcare sciences.

The Industrial sector's funding of R&D in the Higher education sector amounted to NOK 430 million in 2005, but this is a relatively small share. In 2001 funding from industrial sources constituted 6 percent of the total R&D expenditure in the Higher education sector, but in 2005 this share had declined to less than 5 percent.

1.2.3 Fields of science and technology

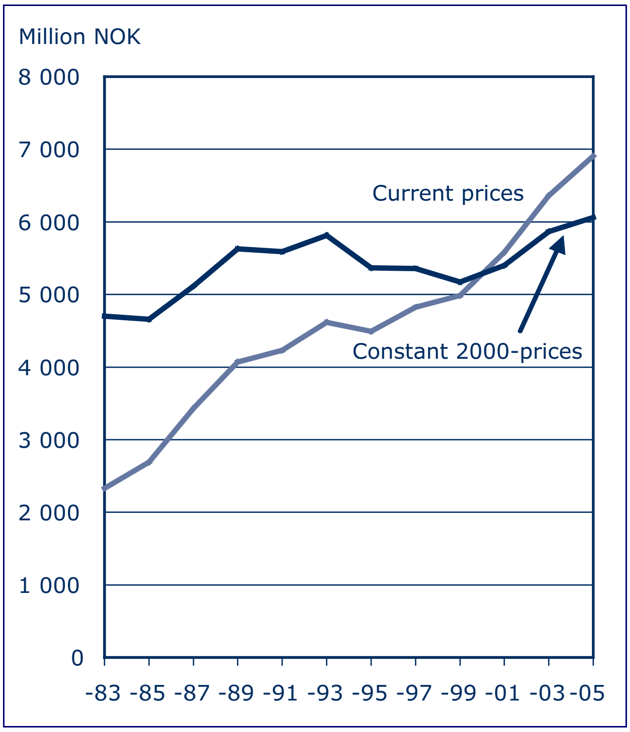
Medical and health sciences was the largest field of science in the Norwegian Higher education sector in 2005, representing one third of the R&D expenditures. Together with engineering and technology, medical and health sciences is also the field of science that has experienced the largest increase in

R&D expenditure between 1995 and 2005. This is illustrated in Figure 1.8. The other fields of science together experienced smaller growth than this sector. Part of the impressive growth within medical and healthcare sciences can be attributed to changes and extension of the statistical population.

1.3 R&D in the Institute sector

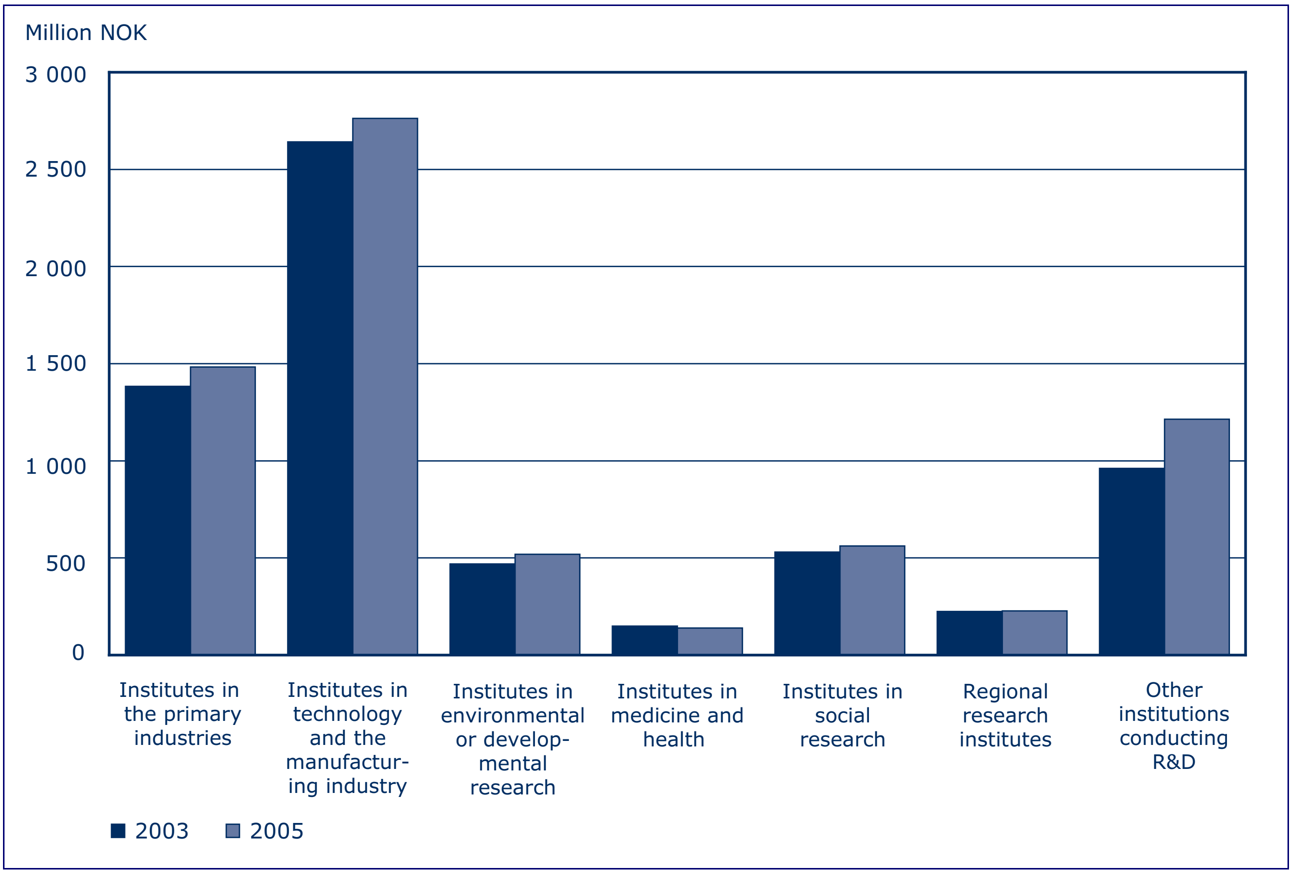
During the last 50 years Norway has built up an extensive Institute sector. In 2005, the sector accounted for 23 percent of the total Norwegian R&D budget – the same share as in 2003. The sector includes quite dissimilar institutions. Most of the R&D is performed in units that have R&D as their main activity, i.e. research institutes. The remaining units have other main objectives, with R&D only making up a minor share of their total activities. Examples of such units include administrative agencies, industry associations, and museums. Non-teaching hospitals are also classified in the Institute sector.

Figure 1.9
R&D expenditure in the Institute sector in 1983–2005. Current and constant 2000 prices.



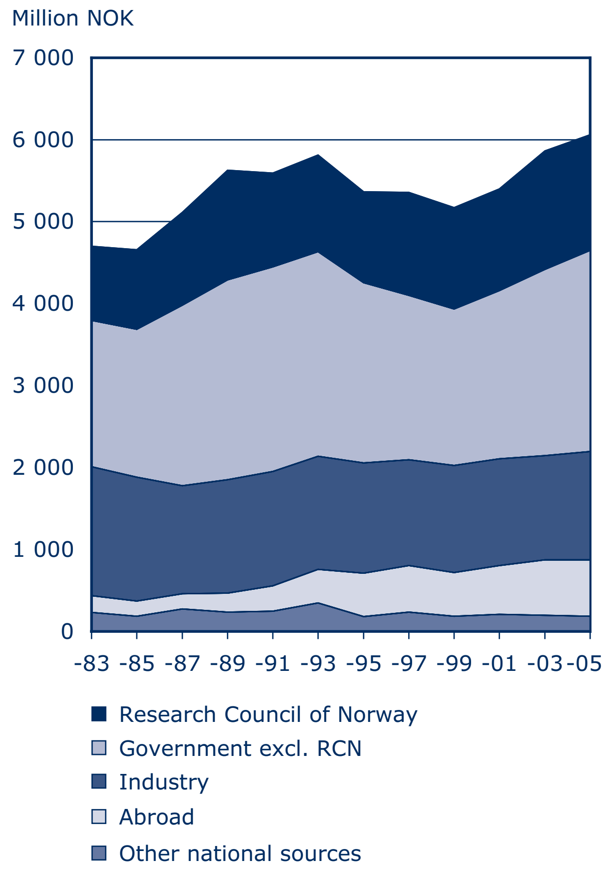
Source: NIFU STEP/R&D statistics

Figure 1.10
R&D expenditure in the Institute sector in 2003 and 2005 by type of institutes. Current prices.



Source: NIFU STEP/R&D statistics

Figure 1.11
R&D expenditure in the Institue sector in 1983–2005 by source of funds. Constant 2000 prices.



Source: NIFU STEP/R&D statistics

In international R&D statistical terms, the Institute sector includes units from the government and private non-profit sectors, and also non-profit institutions performing R&D within the Industrial sector.

Thus, the Institute sector is heterogeneous regarding extension of R&D activity, research topics and size of institutes. A formal division can be drawn between research institutions and other institutions conducting R&D. However, for the sake of simplicity all units that belong to the Institute sector will be referred to as institutes.

Total R&D expenditure in this sector amounted to NOK 6.9 billion in 2005, which was NOK 550 million more than in 2003. This corresponds to an annual growth of 4.3 percent or a real growth of 1.7 percent, correcting for wage and price inflation. R&D expenditure in 2005 reached an all-time high. As illustrated in Figure 1.9, the development in R&D expenditure has been far more positive in recent years than in the second half of the 1990s, when there was a slight decrease in R&D expenditure in real terms.

R&D was carried out by more than 100 institutes in 2005. In addition there are numerous museums and health institutions, in which R&D only constitutes a marginal element. There were 62 research institutes that reported key figures according to the "Guidelines for public funding of research institutes." Total R&D expenditures by the research institutes amounted to NOK 5.7 billion in 2005, which corresponds to 82 percent of the total expenditure in the sector. As shown in Figure 1.10 technological-industrial research institutes accounted for most of the expenditure with NOK 2.8 billion, followed by primary sector research institutes with NOK 1.5 billion. NOK 1.2 billion (18 percent of the R&D expenditure) was spent at institutions with other main objectives than conducting R&D in 2005.

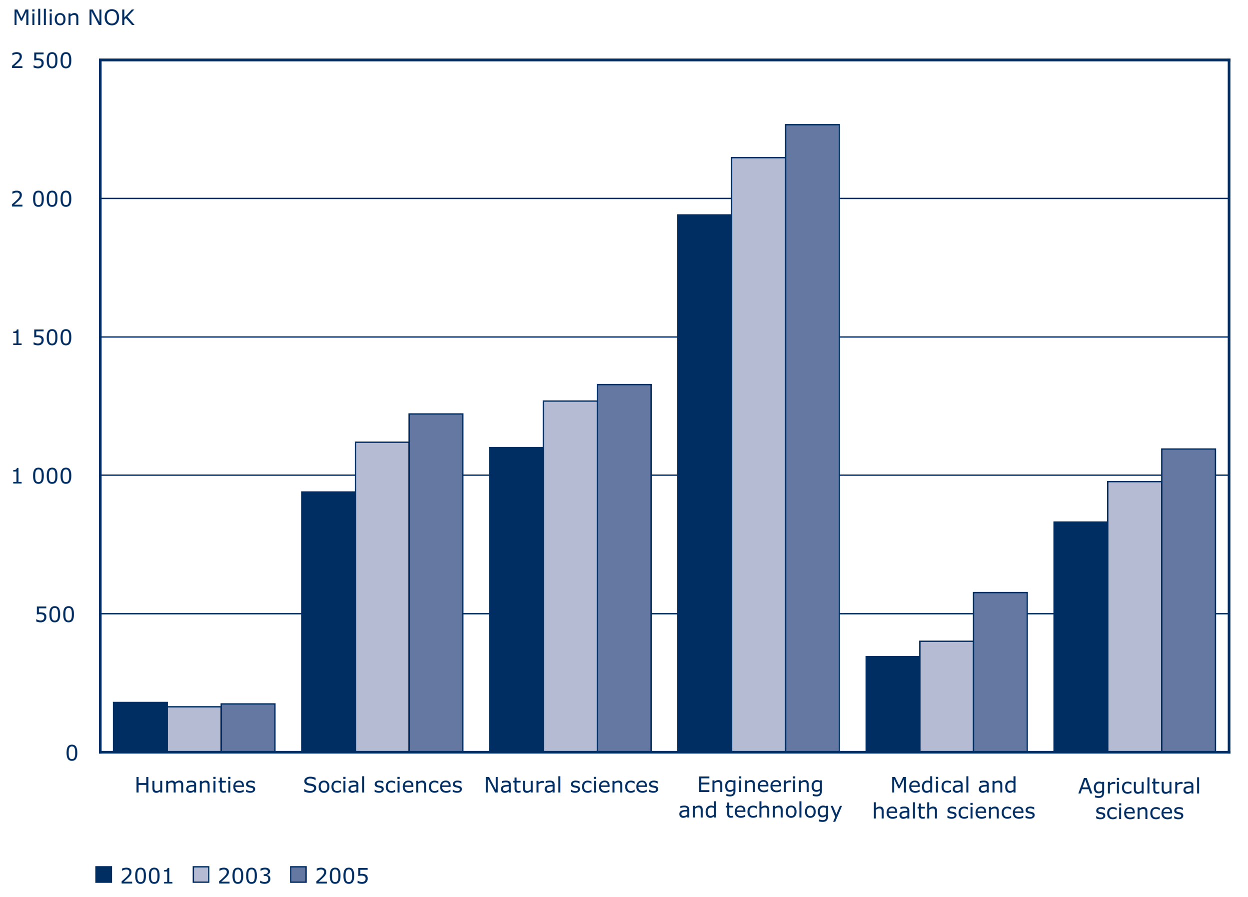
67 percent of the total R&D expenditure was spent by public oriented institutes and 33 percent was spent in institutes serving enterprises. Annual growth in real terms from 2003 was 3 percent in public oriented institutes, whereas there was a 1 percent decrease in institutes serving enterprises. In a longer perspective, there is a tendency for an increasing amount of R&D in the Institute sector to be carried out by public oriented institutes. In the mid-1980s, public and industrial sector oriented institutes were roughly equal regarding R&D volume.

The institutes also vary in size. A huge share of the R&D activity was carried out by a handful of the largest institutes. The R&D expenditure in the five largest institutes accounted for nearly NOK 2.5 billion in 2005, i.e. more than one third of the total expenditure.

64 percent of the expenditure devoted to R&D in 2005 was funded by public sources, 22 percent of the funding came from industrial sources, and 11 percent was funded from abroad. From 2003 to 2005 funding from both government and industrial sources increased by 2 percent annually in real terms, while the increase in R&D funding from abroad was 1 percent. The real growth from government sources was due to increased funding from the ministries (4 percent), whereas there was a decline of approximately 1 percent in funding from the Norwegian Research Council.

Figure 1.11 shows developments in funding in the Institute sector since 1983 in constant prices. Since the mid-1980s, government funding has amounted to more than 60 percent of the total expenditure in the Institute sector, reaching a peak of 67 percent in 1989. During the 1990s the public share fell to about 60

Figure 1.12
Current R&D expenditure in the Institute sector in 2001–2005 by subject field. Current prices.



Source: NIFU STEP/R&D statistics

percent, before increasing again in 2003. Industrial sources funded one third of the R&D expenditure in the early 1980s, but the share decreased considerably later that decade. During the 1990s, the share funded by industrial sources remained quite stable at around 25 percent, until it declined again in 2003. In a longer view, funding from abroad has increased the most. In the early 1990s it amounted to only 5 percent of total funding; since then the share has more than doubled.

The funding shows that the institutes serve a wide range of clients, including the civil service and the Industrial sector. The variety of customers also reflects the variety of subject areas in the sector. Technology is the dominating area with more than one third of the total R&D in 2005. The second largest subject area was the natural sciences with 20 percent. Social and agricultural sciences had 18 and 16 percent respectively; medical and health sciences and humanities were the smallest with 9 and 3 percent. As illustrated in Figure 1.12, all subject areas except the humanities have had an increase during the last years.

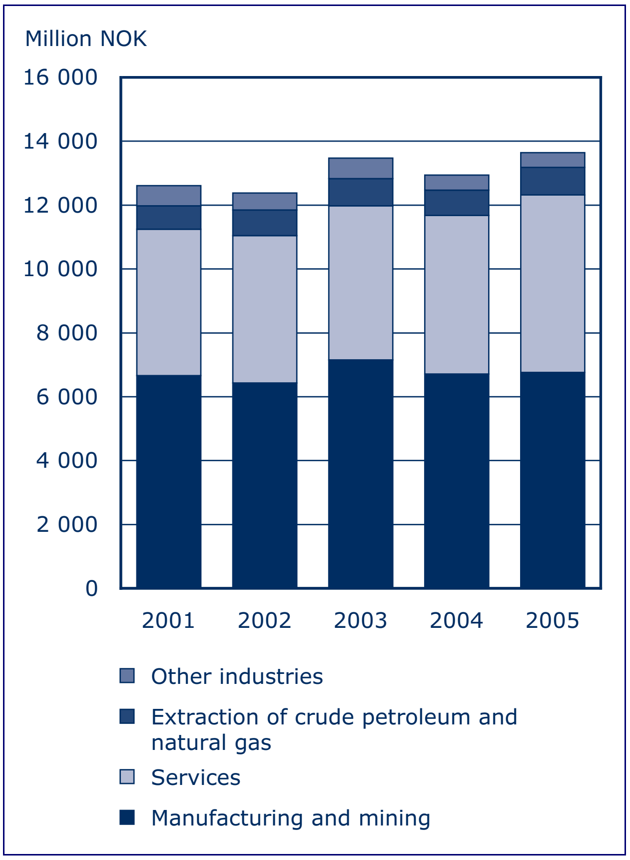
1.4 R&D in the Industrial sector

About half of the R&D in Norway is carried out in the Industrial sector. Although the sector's share of the total R&D has increased over the last 20 years, there have been signs in the last few years that this share is decreasing. Adjusted for price and wage growth, the Industrial sector's share of the total R&D has decreased 1.9 percent from 2003 to 2005. In comparison, the real growth in the Higher education sector was 11 percent.

1.4.1 Main results

R&D expenditures by Norwegian enterprises amounted to NOK 13.6 billion in 2005. Compared with 2003, this is a decrease of just under 1 percent. By type of cost, wages increased by 2.4 percent from 2004 to 2005, while other current costs increased by 16 percent from 2004 to 2005. However, other current costs decreased from 2003 to 2004 by 9 percent. Other current costs accounts for 28 percent of total

Figure 1.13
Intramural R&D expenditure in 2001–2005 by performing industry. Current prices.



Source: Statistics Norway/R&D statistics

R&D expenditure in 2005, compared with 27 percent in 2003.

Traditionally, the manufacturing sector has been the largest sector, and it accounted for just under 50 percent of total R&D in 2005. This is only a slight nominal increase compared with 2004. The service industry had much larger growth, increasing its share of the total R&D from 38 percent in 2004 to 41 percent in 2005.

The largest enterprises, with more than 500 employees, were the largest contributors to the increase in the total R&D for 2005. This share has increased during the last few years, after a decline from 2001 to 2003. In 2005, the share of R&D performed by the largest enterprises amounted to 39 percent, compared with 37 percent in 2004 and 35 percent in 2003. Enterprises with 100–499 employees also increased their share of total R&D from 2004 to 2005, while the smallest companies, with less than 100 employees, have experienced a decrease in intramural R&D of 2 percent from 2004 to 2005. This decline came in spite of the SkatteFUNN tax deduction scheme, specifically targeted at smaller companies. However, mergers, demergers and other reorganisations affect the distribution of intramural R&D by size of enterprise, because enterprises may move to a different size group from one year to the next.

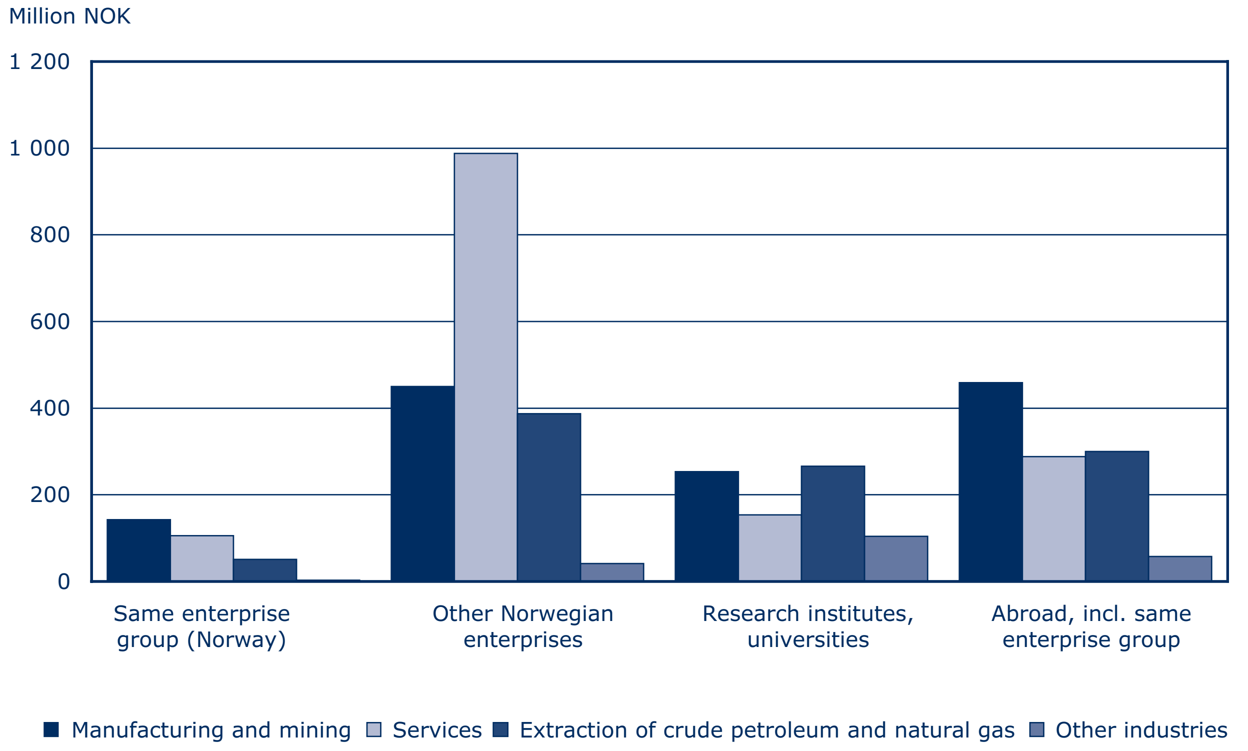
Norwegian enterprises also purchase R&D services from others. In 2005, Norwegian enterprises spent NOK 4 050 million on extramural R&D services. This is a growth of 11 percent from 2003 to 2004, and a growth of almost 3 percent from 2004 to 2005. By comparison, purchased R&D decreased by 17 percent from 2001 to 2003. The service industry increased purchases of R&D by 13 percent, while the manufacturing industry experienced a decrease of 9 percent from 2004 to 2005. For the entire Industrial sector, enterprises spend over three times as much on intramural R&D as on purchased R&D services.

Acquisition from other Norwegian enterprises is the most common source of extramural R&D services, and accounts for 46 percent of total extramural R&D in 2005, a slight increase from 2003. The figures for acquisitions from abroad were greatly affected by a change in one company's expenditure. If we exclude this company, there has been an increase in extramural R&D from abroad of over 20 percent from 2003 to 2005, but if this company is included, there is a decrease of 13 percent. Acquisitions of R&D services from research institutes, universities and colleges have remained stable at between 19 and 21 percent for the last 10 years.

As previously, only a small percentage of R&D expenditure in the Industrial sector is spent on basic research activities. Only 3 percent of the R&D expenditures were classified as basic research in 2005, while 23 percent were applied research. Thus the remaining 74 percent was spent on development activities. Production of new products or services accounted for 45 percent of total R&D expenditure in 2005, while improvement of existing products or services constituted 31 percent of the total R&D expenditure. Product-oriented R&D amounted to 76 percent of the total R&D in 2005, compared with 74 percent in 2003. Process-oriented R&D made up the remaining 24 percent of the total R&D expenditure in the Industrial sector in 2005.

The amount spent on product and process oriented R&D varies in different industries. This reflects the importance of the production process in relation to the final product in the industry's activities. However, there is only a slight difference between manufacturing companies and service oriented companies. An important exception is *extraction of oil and gas*, where only 19 percent of R&D activity was product oriented. For the entire Industrial sector,

Figure 1.14
Extramural R&D in the Industrial sector in 2005 by performing industry.



Source: Statistics Norway/R&D statistics

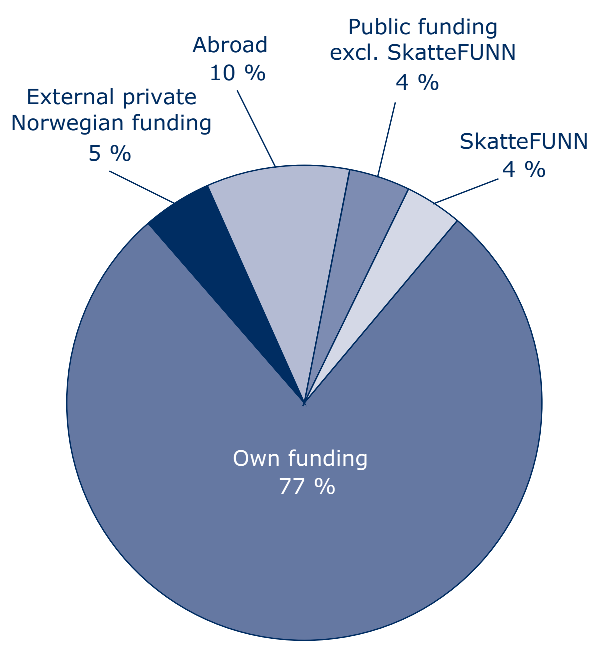
product-oriented R&D accounted for 58 percent of total R&D expenditure in 2005.

In 2005, 41 percent of R&D was conducted in relation to information and communication technology (ICT), compared with 34 percent in 2003. 69 percent of enterprises in the service industry report R&D on ICT. For enterprises in the manufacturing industry, R&D expenditures on ICT accounted for 24 percent of total expenditure – an increase of 5 percent compared with 2003. In the 2005 survey there were additional questions on nanotechnology and biotechnology. Nanotechnology constituted 1 percent of total R&D expenditure, and biotechnology accounted for 8 percent of total R&D expenditures in 2005.

1.4.2 R&D funding

Most R&D costs in Norwegian enterprises are financed internally, as shown in Figure 1.15. In 2005, internal funding accounted for 77 percent of R&D expenditure. Foreign capital, external financing from other private Norwegian enterprises and public financing constituted the remaining share. Contributions from units in the same corporate group accounted for a large part of external private and for-

Figure 1.15
Intramural R&D expenditure in the Industrial sector in 2005 by source of funds.

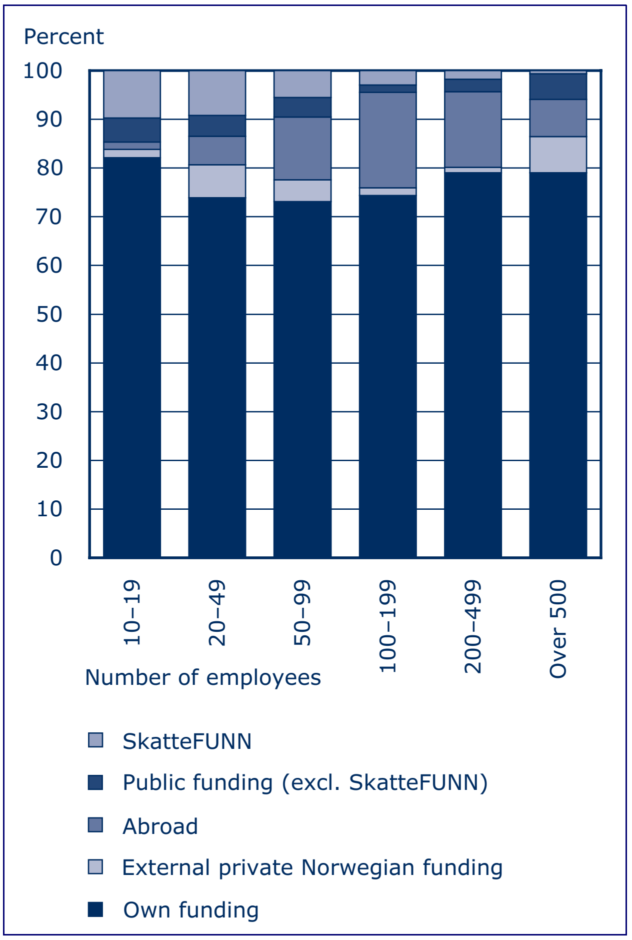


Source: Statistics Norway/R&D statistics

SkatteFUNN

Tax deductions for R&D expenditure in the Industrial sector were introduced for small and medium-sized enterprises from 2002, and all companies from 2003. The aim is to stimulate R&D activity in the Industrial sector. Enterprises with less than 250 employees may claim a 20 percent tax deduction based on R&D costs, while larger enterprises can claim 18 percent. The maximum amount of R&D expenditure as basis for deduction is NOK 4 million. This amount can be extended by an additional NOK 4 million in joint projects with an approved R&D institution. Also companies not currently liable for taxation are eligible under the scheme, and will be paid an amount corresponding to the tax deduction directly from the tax authorities. The maximum amount has not been changed since 2002, and in real 2006 prices this is just under NOK 3.5 million.

Figure 1.16
R&D expenditure in the Industrial sector in 2005 by source of funds and size group.



Source: Statistics Norway/R&D statistics

eign funding. Funding from EU institutions constitutes only a small contribution, at 0.4 percent of the total R&D expenditures.

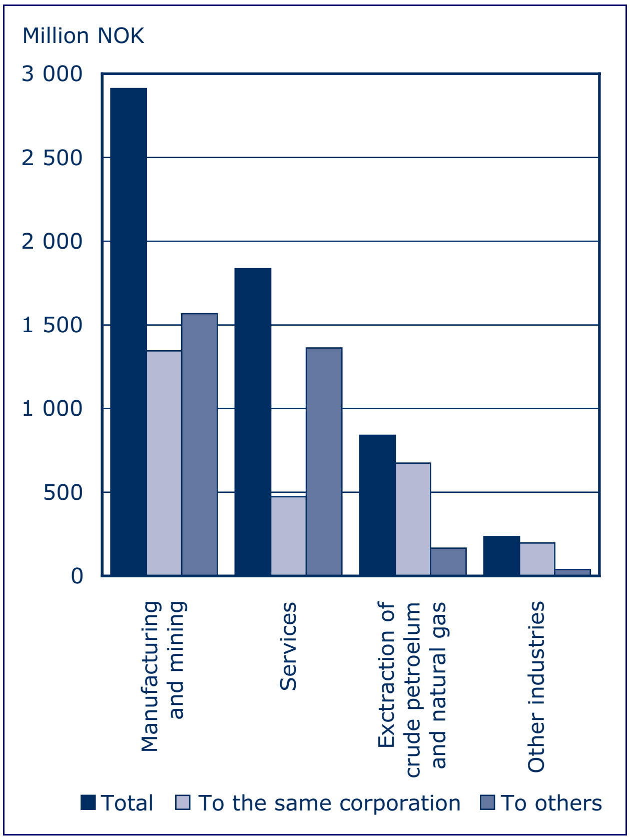
Funding from the SkatteFUNN tax deduction scheme made up almost as much as other public funding of R&D in 2005. The SkatteFUNN scheme accounted for NOK 500 million, while other public funding was reported at NOK 600 million. Public funding decreased from NOK 1.3 billion in 2003 to NOK 1.1 billion in 2005. Funding from abroad is more important for enterprises in the service industry than for the manufacturing industry, but for both industries the share of funding from abroad has increased.

Figure 1.16 illustrates how internal funding also varies between different enterprise size groups. The smallest companies, with 10–19 employees, reported internal funding of 82 percent of their R&D costs in 2005, while the largest companies, with more than 200 employees, reported 79 percent internal funding of R&D. SkatteFUNN is much more important for the smallest enterprises, and about 10 percent of the total funding comes from the tax deduction scheme. For the largest companies, only 0.5 percent of the funding comes from SkatteFUNN. Enterprises in the service industry have significantly lower shares of funding from SkatteFUNN than enterprises in the manufacturing industry and other industries.

The SkatteFUNN scheme was very popular when it was introduced in 2002, and the number of applications peaked in 2003. Since then, there has been a steady decline in the number of applications, down from 4 740 in 2003 to 2 600 in 2006. About 70 percent of the applications are approved each year. For 2006, the budgeted R&D expenditure was NOK 8.3 billion for approved projects, including both new projects for 2006 and ongoing projects from previous years. This is a decrease from NOK 9.1 billion in 2005 and NOK 9.9 billion in 2004. The decrease is similar between new and previously approved projects.

According to information from the tax authorities, not all R&D projects are carried out as planned. Of about 4 000 projects for 2005, only 2 911 enterprises have reported finished projects to the authorities, and been granted a tax refund. Thus, the original costs of NOK 9.1 billion were reduced to NOK 6.8 billion for 2005. The share of enterprises finishing their projects decreased from 2002 to 2005, and was at 75 percent in 2005. It is mainly the smallest companies, with fewer than five employees, that do not carry out their projects as planned. One reason for this may be that the smallest companies are more vulnerable to adjustments in the market.

Figure 1.17
Sale of R&D services in 2005 by performing industry and purchaser.



Source: Statistics Norway/R&D statistics

In total, the tax deduction for 2005 amounted to NOK 1.1 billion. Of this, NOK 813 million was refunded to enterprises not liable for taxation. It is mainly the largest companies that are liable for taxation.

Another source of funding for enterprises is selling R&D services to other enterprises or to other units in the same corporate group, see Figure 1.17. Only 2 percent of companies reported selling R&D services in 2005. However, selling of R&D services amounted to NOK 2.9 billion in 2005, or 21 percent of total intramural R&D. Most of the enterprises that sell R&D are in the service industry, and a few large companies in this sector are especially large sellers of R&D services.

More and more of the R&D activity is concentrated in a few large companies. In 2003, 10 percent of the largest companies accounted for 68 percent of total R&D. For 2005, this share has increased to 72 percent. However, there are some differences between industries. For the manufacturing industry, the 10 percent largest companies accounted for 72 percent of total R&D, while for the service industry, the 10 percent largest companies accounted for 69 percent of the total R&D activity in 2005. The figures are comparable to the figures for 2003.

1.5 Innovation in the Industrial sector

This chapter examines the results of the 2004 Innovation Survey of the Norwegian Industrial sector. Indicators such as the share of innovative enterprises, innovation expenditures, information sources, and hampering factors are examined. Co-operation on innovation projects is presented in

OECD's definition of innovation

The terms innovation, innovative and innovation activity are used about product or process innovations (PP innovation) that includes the introduction of new or considerably improved products or processes. The innovation survey of 2004 also mapped organisational and marketing innovation. However, unless otherwise stated, innovation in this context refers to PP innovation. The definitions of the different terms used in the innovation survey are:

Product innovation is a product or a service that is either new or significantly improved with regard to its characteristics, technical specifications, built-in software or other immaterial components or its user-friendliness. The innovation must be new to the enterprise, but not necessarily new to the market.

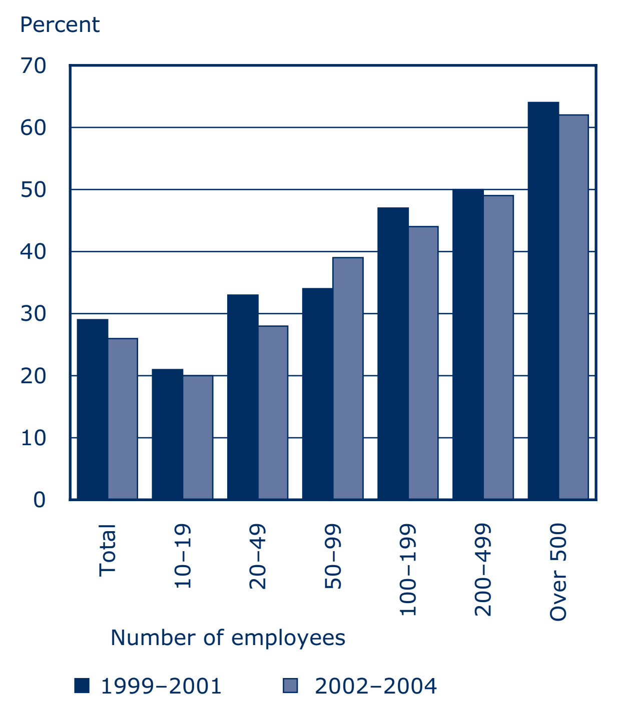
Process innovation includes new or significantly improved production technology/methods and new or significantly improved methods for delivery of goods and services. The innovation should be new to the enterprise, but the enterprise does not necessarily have to be the first to introduce this process.

Organisational innovation is the implementation of a new or significantly changed structure in the enterprise or new or significantly changed managerial strategies in order to increase the enterprise's use of knowledge, the quality of goods and services or the efficiency of working processes.

Marketing processes means introduction of a new or significantly changed design, in addition to the introduction of new or significantly changed sales methods in order to make the products of the enterprise more attractive or to open up new markets.

See the OECD, 2005: Oslo Manual: guidelines for collecting and interpreting innovation data/a joint publication of OECD and Eurostat. 3rd ed., for further descriptions of the terms.

Figure 1.18
Share of innovative enterprises in the periods 1999–2001 and 2002–2004 by size group.



Source: Statistics Norway/Innovation Survey

chapter 3.2, and results from innovation are discussed in chapter 4.4.

1.5.1 Innovative enterprises

The 2004 Innovation survey showed that 26 percent of all Norwegian enterprises had introduced new or significantly improved products or processes in the period 2002–2004 and may thus be defined as innovative. The reported innovation activity for the period was a little lower than for the previous comprehensive innovation survey for the period 1999–2001. Manufacturing and service enterprises are for the most part stable in their innovation activity. Within other industries, including extraction of oil and natural gas, electricity and water supply and construction, there is a decline.

The innovation activity in Norwegian enterprises tends to vary with the size of the enterprise, as shown in Figure 1.18. The largest enterprises are by far more innovative than smaller enterprises. Within the Industrial sector as a whole, 62 percent of the enterprises with more than 500 employees introduced new or significantly improved products or processes in the period 2002–2004. Only 20 percent of the enterprises with between 10 and 19 employees did the same. This may be for various reasons. Larger enterprises often have more resources to be used for innovation purposes, both financial and human. Furthermore, large enterprises also tend to have a wider range of products and more processes than smaller enterprises, and thus have greater opportunities for innovation in at least one area.

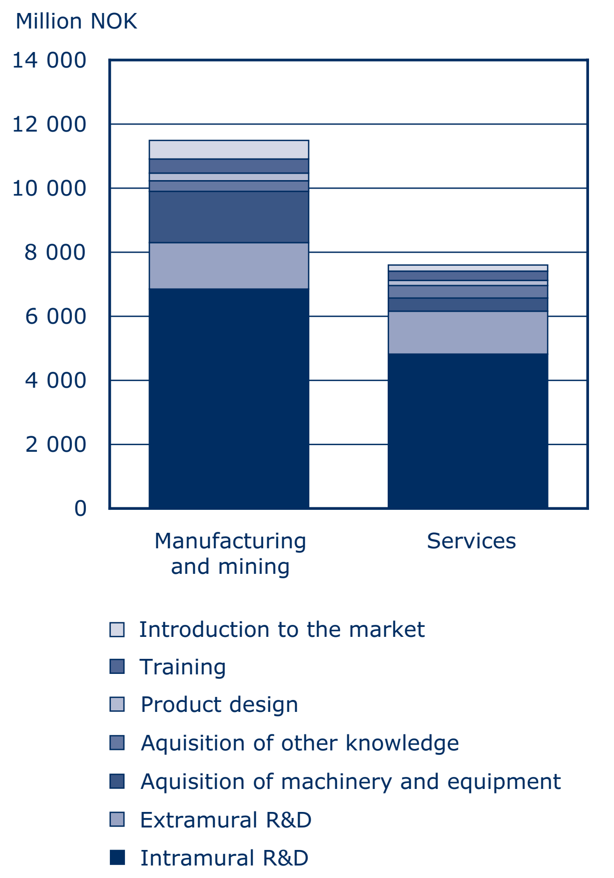
The difference between large and small enterprises is more pronounced within manufacturing than service industries. As much as 77 percent of the largest manufacturers were innovators, while only 26 percent of the smallest enterprises stated the same. Within the service industries, 50 percent of the largest enterprises introduced new or improved products or processes, while 24 percent of the smallest enterprises created the same results.

The majority of the innovative enterprises have introduced products that were new to the enterprise – 21 percent report this. Far fewer, only 11 percent, have introduced products that are new also to the market. A 16 percent share of the enterprises can be called process innovators as they have introduced new or significantly improved production technology, or methods of production or delivery. The tendency is, however, that the same enterprises are both product and process innovators.

The majority of the innovative enterprises state that they mostly develop their own innovations. Product innovators were particularly self-reliant in innovation activities – 71 percent declared that the enterprise developed innovations independently. While 22 percent of the product innovators developed their innovation in cooperation with others, only 8 percent let other parties develop the products. Among the process innovators the differences are less pronounced, but also here the self-reliant enterprises make up the majority – 51 percent developed the processes within the enterprise.

Manufacturing enterprises are more innovative than service enterprises, as was also found in previous surveys. While 37 percent of manufacturing enterprises have introduced new or improved products or processes, only 28 percent of service enterprises can say the same. Some industries stand out as particularly innovative, and these are industries that have been above average in past surveys as well. The single most innovation-intensive industry is the *manufacturing of radio, television and communication equipment and apparatus*, in which 73 percent of the enterprises were innovative. There was also a high share of innovators in *manufacturing of chemicals and chemical products* (63 percent), *manufacturing of basic metals* (58 percent) and *manufacturing of medical, precision and optical instruments* (58 percent). Among service enterprises, *computers and*

Figure 1.19
Innovation expenditure in 2004 by type within mining and manufacturing and service industries.



Source: Statistics Norway/Innovation Survey

related activities and *telecommunications* stand out, with a share of innovative enterprises of 61 and 51 percent, respectively.

1.5.2 Innovation expenditure

The Industrial sector's innovation expenditures totalled almost NOK 22.2 billion in 2004. This equals 1.1 percent of the total turnover, and represents a decline from the 2001 survey (1.5 percent) and 1997 (1.7 percent). The Industrial sector has seen a slight nominal decline in innovation expenditures. The relative decline, however, is larger, as the sector has significantly increased its turnover in the same period.

Over half of all innovation expenditures can be attributed to intramural R&D. Figure 1.19 shows the distribution of innovation expenditures on manufacturing and mining and service industry. In addition there are expenses connected to extramural R&D, acquisition of machinery used in innovation processes and market introduction of innovations.

The enterprises often have difficulties reporting their innovation expenses and separating them from other costs of production. These are figures that are not readily available in the enterprises' accounts. Expenditure excluding R&D expenses seem particularly difficult to report. Hence, these figures are uncertain.

1.5.3 Information sources

The enterprises gather information needed for successful innovation from various sources. Internal sources are the most important – 51 percent state they gather the necessary information from sources within the enterprise. Clients and customers provide information to 35 percent of the enterprises. Suppliers, which are most frequently reported as co-operation partners, are only used as a source of information by 22 percent.

Competitors, consultants and commercial laboratories/R&D enterprises are used to a lesser extent as information sources, only by 9, 4 and 3 percent of the enterprises, respectively. Nor are universities and higher education institutes (3 percent) or research institutions (4 percent) common sources of information.

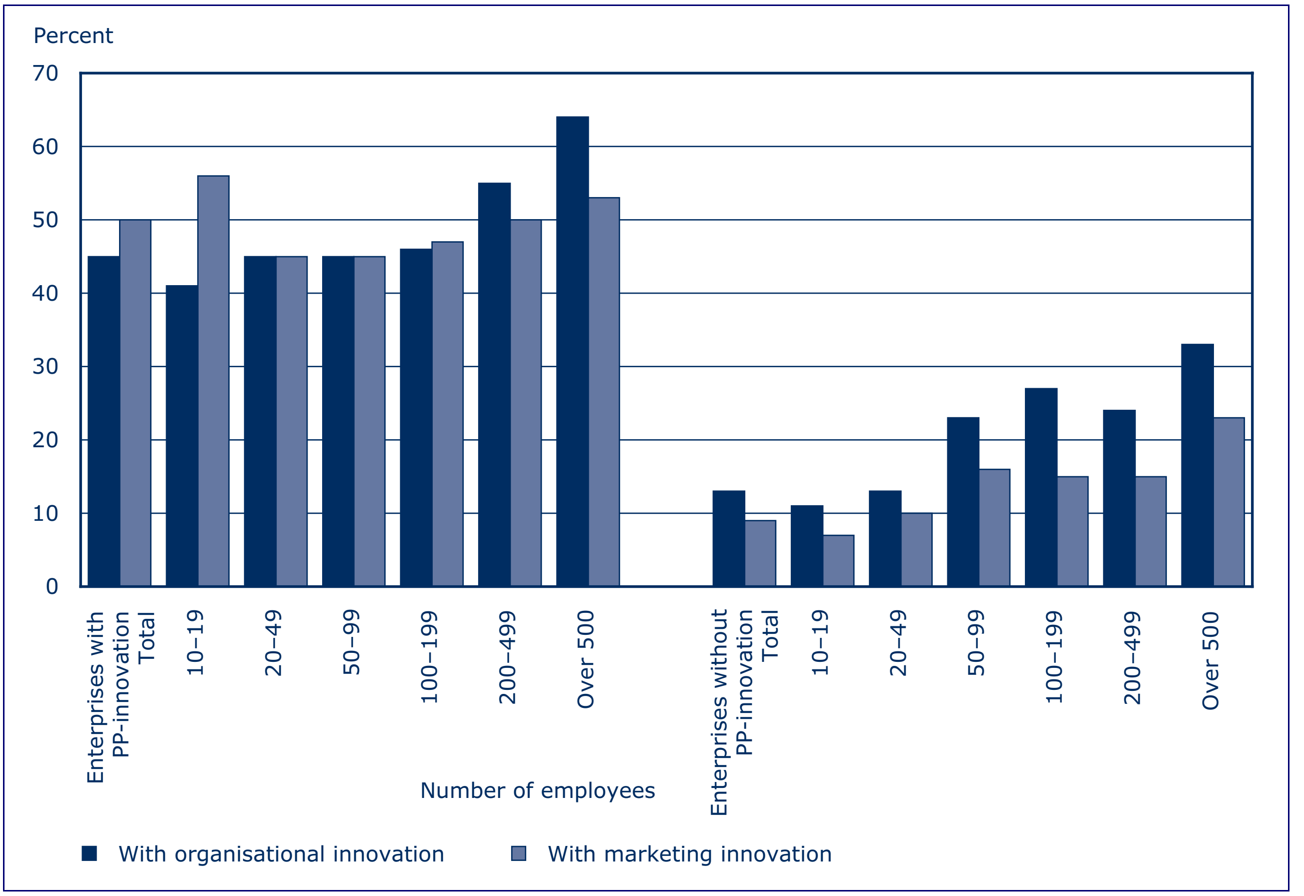
1.5.4 Obstacles to innovation

A considerable number of enterprises reported that their innovation activities were limited or obstructed during 2002–2004. Primarily, financial factors are reported: 17 percent of the innovative enterprises report that high innovation costs hampered their innovation activities. Lack of external or internal funding is cited as an important factor by 12 and 13 percent, respectively. Relatively few enterprises consider internal factors such as lack of qualified personnel or lack of information about technology or the market as substantial obstacles. Nor is there a widespread view that uncertainties concerning demand or the dominance of other enterprises significantly hamper innovation.

1.5.5 Organisational and marketing innovations

The 2004 Innovation Survey contains more information about organisational and marketing innovation than has been the case in past surveys. Of all enterprises, 22 percent have carried out organisational alterations of a kind that can be called organisational

Figure 1.20
Organisational and marketing innovation in the period 2002–2004 by size group. Share of enterprises with and without product and process innovation.



Source: Statistics Norway/Innovation Survey

innovation. Among these enterprises, 73 percent have altered the management structure or organisational structure, while 52 percent have introduced new knowledge management systems to improve use or exchange of information.

Of all enterprises, 20 percent have implemented marketing innovations during the period 2002–2004. Among these, 74 percent have found new client bases or market segments, while 46 percent have significantly altered the design or packaging of a product or service.

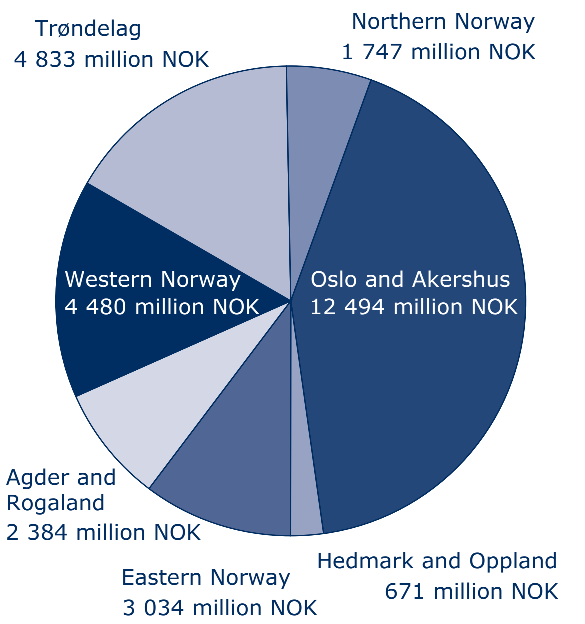
The survey shows that organisational and marketing innovations are primarily introduced by enterprises engaged in product or process innovation. Moreover, large enterprises are generally more often engaged in these types of innovation as well, than smaller enterprises, as shown in Figure 1.20.

1.6 The geographic distribution of R&D activity

In international R&D statistics there is a strong focus on regional distribution of indicators describing R&D and innovation. Figure 1.21 shows Norway's total R&D expenditure by geographic region in 2005. Naturally, the capital area Oslo and Akershus is the dominating region with regard to R&D activity. NOK 12.5 billion, corresponding to 42 percent of total R&D, was related to this region. At the other end of the scale are Hedmark and Oppland with only 2 percent of R&D expenditure in 2005. Northern Norway, with 6 percent of R&D resources in 2005, also includes Svalbard.

In addition to Oslo and Akershus, Sør-Trøndelag and Hordaland are R&D intensive regions, with 16

Figure 1.21
Total R&D expenditure by region[1] in 2005. Million NOK.



[1] Svalbard is included in Northern Norway.

Source: NIFU STEP, Statistics Norway/R&D statistics

and 12 percent of total R&D expenditure in 2005, respectively. Sør-Trøndelag – with NOK 16 600 on R&D per capita – is not far below Oslo with NOK 17 050. The average for Norway was NOK 6 500 per capita. In addition to the two most R&D intensive counties – Oslo and Sør-Trøndelag – in terms of R&D expenditure per capita, Hordaland, Troms and Akershus were all above average in 2005.

1.7 International comparisons of R&D and innovation

In this chapter Norwegian R&D expenditure is put into an international context by comparing figures with central OECD members and the other Nordic countries. We look at the sectorial R&D profiles, funding and growth of R&D.

1.7.1 Total R&D expenditure

The OECD countries together spent NOK 6 700 billion on R&D in 2005. The United States is still the leading nation for R&D investments and represented 42 percent of total R&D efforts in the OECD area. In an international context Norway is a small nation when it comes to R&D. The Norwegian R&D expenditures of almost NOK 30 billion corre-

International comparisons

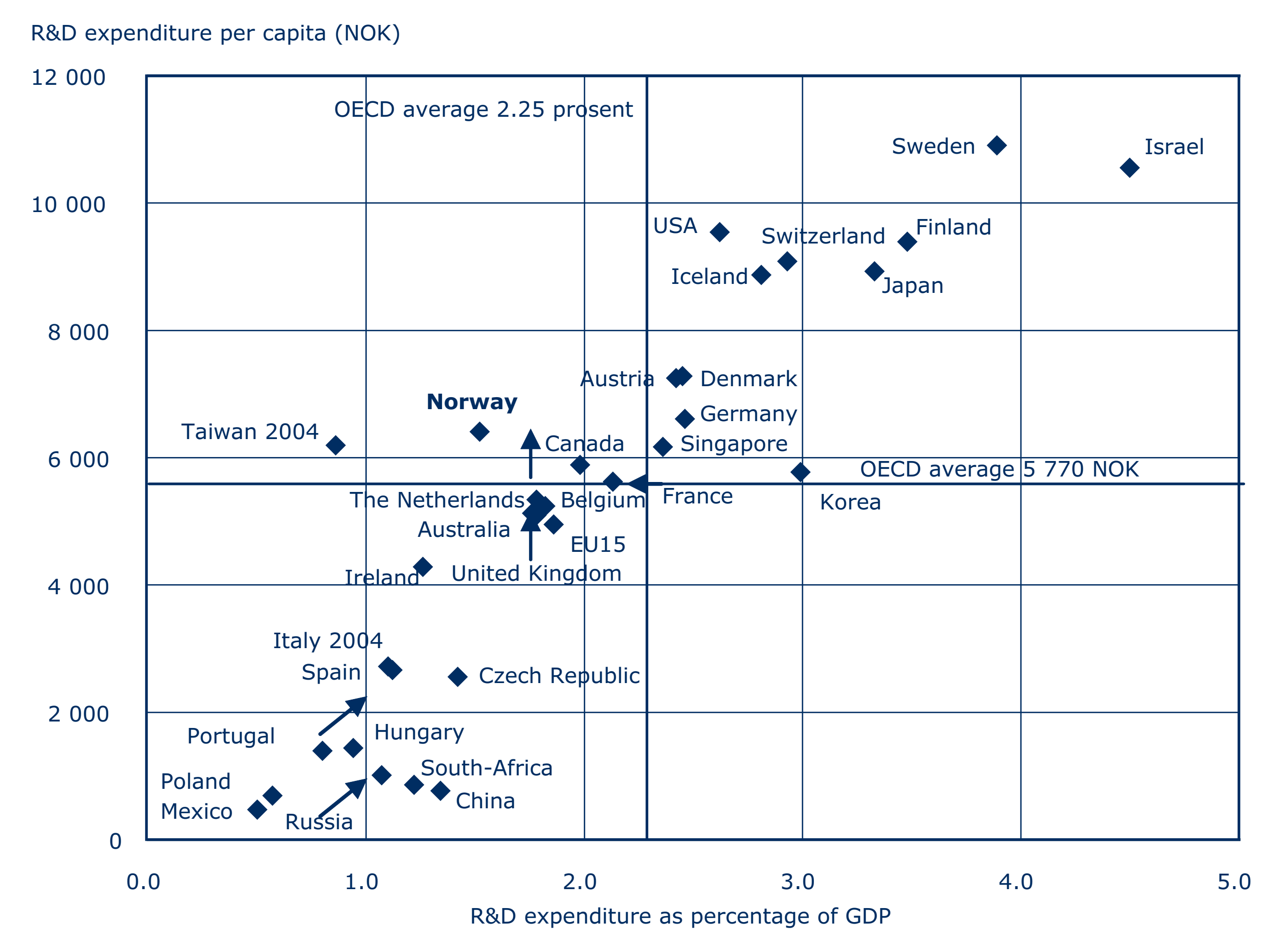
The international comparisons are based on the R&D surveys that each country conducts, standardised through the OECDs “Frascati manual”. This manual contains definitions, classifications and guidelines on how to treat data in order to measure R&D activity.

According to the OECD guidelines, the performing sectors are supposed to form the basis of the mapping of R&D effort. There are four performing sectors:

Business Enterprise Sector
Government Sector
Private Non Profit Sector (PNP Sector)
Higher Education Sector

In addition to the Industry, the Business Enterprise Sector in Norway also covers some units in the Institute sector. These units mainly serve the Business enterprise sector and include special branch institutes and task oriented industry institutes. The Government sector includes units in the Institute sector that are subject to Departments or institutions directly connected to Departments, in addition to other public or semipublic institutions and Government directed task oriented institutes. Institutions within the PNP Sector are small and few in Norway. In reports to the OECD and other international statistics, these institutions will therefore be included in the Government Sector. R&D conducted at international institutions is not supposed to be reported in international statistics. The numbers for the national statistics for Norway will therefore differ from the numbers reported internationally, because the national statistics include R&D conducted at Nordic institutions. The Higher education sector is therefore the only performing sector that is identical for both national and international statistics. See also the box on performing sectors in Chapter 1.1.

Figure 1.22
R&D expenditure in selected countries in 2005 or latest year for available data.



Source: OECD – Main Science and Technology Indicators 2007-1

sponds to 0.4 percent of the total R&D effort in the OECD area.

During the last few years, the OECD has also collected data from some non-member countries.[2] The sum of R&D expenditures in member and non-member countries is NOK 7 700 billion. China is the fastest growing country when it comes to R&D efforts.

R&D as a proportion of gross domestic product (GDP) is a common indicator for evaluating a country's R&D effort in international comparisons. Figure 1.22 shows R&D expenditures as a proportion of GDP and per capita expenditure in selected countries. The Norwegian proportion of 1.53 percent is below OECD average of 2.25 percent and below the other Nordic countries. Sweden and Finland are among the world leaders in this regard, with an R&D proportion of GDP in 2005 of 3.9 and 3.5 percent respectively.

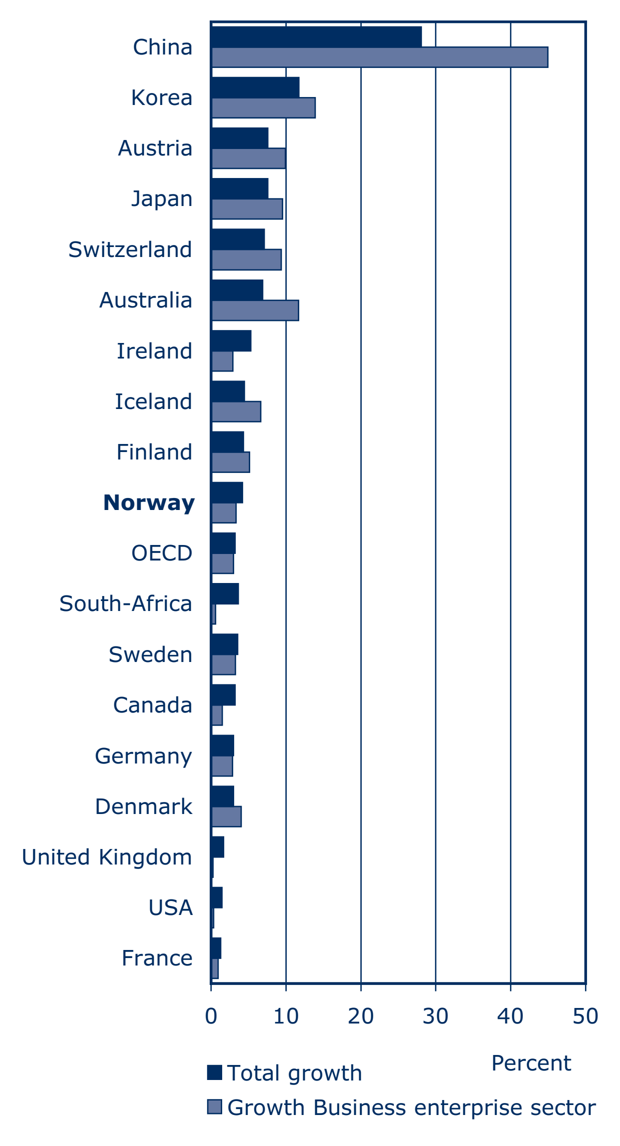
However, Norwegian R&D expenditures are higher than the OECD average relative to population. In 2005, Norway spent NOK 6 400 per capita on research, while the OECD average was almost NOK 5 800. Nevertheless, the Norwegian amount was far below the rest of the Nordic countries on this indicator. Sweden spent NOK 10 900 per capita in 2005 while the corresponding amount for Finland was NOK 9 400, Iceland NOK 8 900 and Denmark NOK 7 300.

Figure 1.23 presents the growth in R&D expenditures from 1999 to 2005. Among the countries in the figure, China and Korea had the largest growth. Norwegian R&D expenditure had an annual growth of 4.2 percent, which is just over the OECD average of 3.2 percent.

Among the countries with the highest growth: China, Korea, Austria, Japan, Switzerland and Australia, the figure shows that the Business enterprise sector contributed strongly to this growth. Also for Iceland, Finland and Denmark the Business enter-

2 Argentina, China, Israel, Romania, Russia, Singapore, Slovenia, South-Africa and Taiwan.

Figure 1.23
Annual real growth in R&D expenditure total and Business enterprise sector in the 1999–2005 period or latest year for available data.



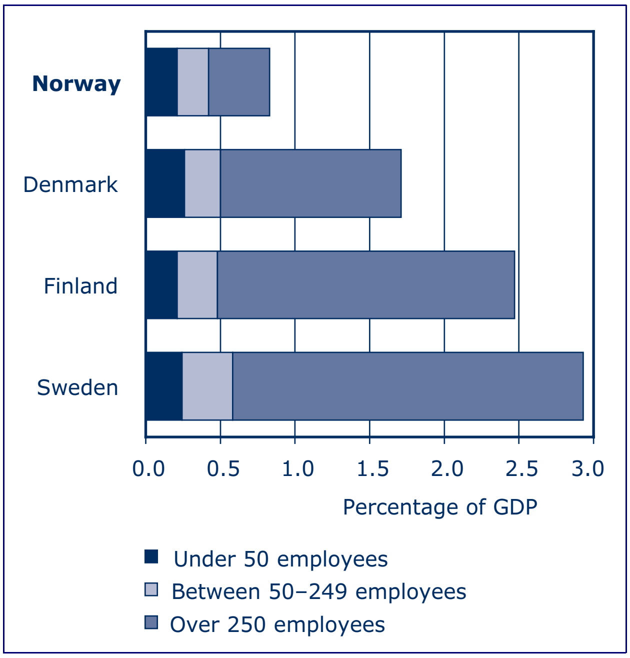
Source: OECD – Main Science and Technology Indicators 2007-1

prise sector showed a higher growth than total growth, while in Sweden and Norway the Business enterprise sector had a smaller growth than total R&D expenditures.

The figure also reveals that several of the large European research nations (Germany, Great Britain and France) and the USA had a lower growth than the OECD average. Over time this will influence the geographical distribution of research performance in the world.

In the OECD the largest share of R&D efforts are conducted by the Business enterprise sector; in 2005 the average was 68 percent.[3] In Norway the Business enterprise sector's share has decreased from 60 per-

Figure 1.24
R&D expenditure as share of GDP in 2005 by size group.



Source: OECD – Main Science and Technology Indicators 2007-1

cent in 2001 to less than 54 percent in 2005. This share is similar to that in Iceland, the Netherlands, Spain and Canada. The highest share of R&D expenditures in the Business enterprise sector in 2005 was in Japan with 76 percent. Also USA, Finland, Germany, China and Denmark had a high share of R&D activity in this sector, at about 70 percent.

When we look at branches where R&D is conducted we find a different composition in Norway than in the other Nordic countries. In Denmark, Finland and Sweden most of the R&D is performed in high-technology and medium-high-technology branches. As a share of GDP the R&D performed in these sectors amounted to 2.4 percent in Sweden, 1.8 percent in Finland, 0.9 percent in Denmark and in Norway 0.3 percent.

Figure 1.24 shows another characteristic of the Norwegian R&D performed in the Business enterprise sector: the high share of small and medium-sized businesses. While Denmark, Finland and Sweden had most of their R&D conducted in large businesses with more than 250 employees, in Norway small and medium-sized businesses had about the same performance of R&D as large businesses.

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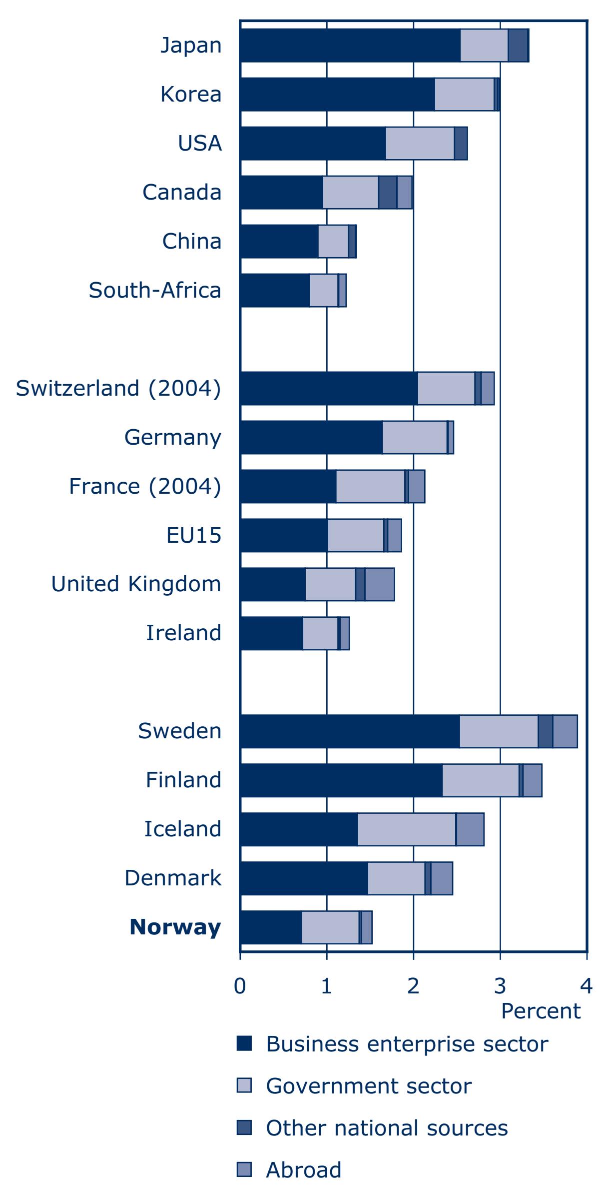
3 In Norway the Business enterprise sector consists of the Industrial sector and research institutes serving the Industrial sector.

Figure 1.25
R&D expenditure as a share of GDP by source of funds in selected countries in 2005 or latest year for available data.



Source: OECD – Main Science and Technology Indicators 2007-1

Figure 1.25 shows funding sources of R&D as a share of GDP. We see that the Business enterprise sector is the dominating sector when it comes to *funding* R&D, as we have seen it is regarding *performance* of R&D. The Business enterprise sector performed 68 percent of R&D in the OECD in 2005, while it funded 62 percent of R&D in OECD countries. In Norway the Business enterprise sector funded 46 percent of R&D, in Iceland the share was 48 percent, while Denmark, Finland and Sweden had a much higher share with 60 percent, 67 percent and 65 percent respectively.

Other national sources funded less than 2 percent of total R&D in Norway. Among the countries in the figure, total R&D funded by this source was 10 percent in Canada and about 6 percent in Great Britain and the USA.

Funding from abroad amounted to 8 percent in Norway in 2005, which is about the same level as in the other Nordic countries. In Great Britain 19 percent of R&D activities were funded by this source, while the share was less than 1 percent in China, Korea and Japan. The average in the EU15 countries increased from 7 percent in 1995 to almost 9 percent funded by sources from abroad in 2005.

Internationally the share of government funding of R&D is decreasing. Among the OECD countries there has been a decline from 42 percent in 1985 to 34 percent in 1995 and less than 30 percent in 2005. The Norwegian share has been higher and has not had such a strong decline. In 2005 the government share was 44 percent in Norway.

As a share of GDP, government funding of R&D in 2005 was 0.67 percent in Norway. This is the same as the OECD average, but less than the other Nordic countries. For Norway this means a small decrease from 2003 when the share in Norway was 0.73 percent and the OECD average was 0.68 percent.

The size of the Higher education sector differs among the OECD countries. As an average this sector amounted to almost 18 percent of R&D in 2005. In Norway the share amounted to 31 percent. Other countries with a large share of R&D performed in the Higher education sector were Canada with 36 percent, Spain with 29 percent and the Netherlands with 28 percent. Among the other Nordic countries, Denmark had the second largest share after Norway, with 24 percent of R&D performed in this sector.

1.7.2 R&D intensities at the industrial level

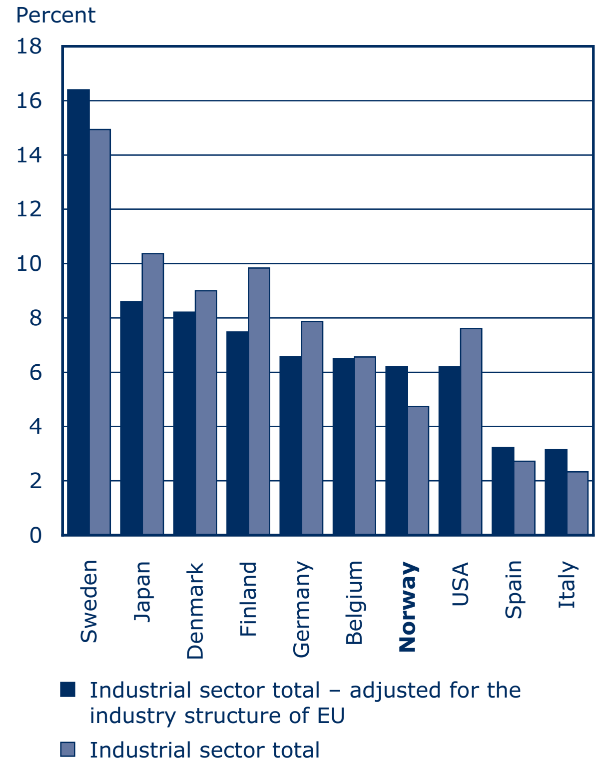
R&D intensity, as defined by the ratio of R&D costs to production value, show considerable variation from industry to industry. When comparing whole economies, the composition of industries in each country is significant for the aggregated performance on this indicator. In many international comparisons this problem is overlooked, although there are several ways of taking the problem into consideration. In this chapter two alternative methods are used. Firstly we compare industry by industry to assess each industry's performance in relation to the more or less similar activities in other countries. Secondly we calculate national R&D intensities on the basis of observed intensities in each industry, under the condition that all countries have the same industrial structure. The benchmark structure used is that of the original EU15. Due to constraints in data availability, the comparisons only include manufacturing industries. Data sources are the OECD ANBERD database for R&D, comparable Norwegian R&D and production data, and production data for EU15 from the EU KLEMS database.[4]

Correcting for industrial structures is not unproblematic. Problems include access to internationally comparable data broken down to the relevant level of industrial aggregation. This generally takes time and is especially problematic for service industries. A related problem is that there are no precise guidelines as to what is the most adequate level of aggregation. Ideally the breakdown should allow comparisons of identical, or competing, activities, but this is not feasible from a practical point of view, and the opportunistic solution is to choose a level that can be handled in practice. It is also important to remember that firms compete across the somewhat arbitrary classifications of industries, for instance producers of fish competing with producers of meat. Lastly, an indicator adjusted for structure becomes a synthetic measure whereas practical policy has to take the existing structure as its starting point. We must also be aware that the choice of benchmark (EU15, OECD total, G7) affects the result. The adjusted measure nevertheless allows a decomposition of the observed R&D intensity into a structure-driven component and a component driven by the level of R&D in each industry, allowing a more targeted policy.

The results for 2004 reveal a considerable change in Norwegian R&D intensity after correction for industrial structure, from a value of 4.7 percent uncorrected to 6.2 percent after correction, see Figure 1.26. However, the relative position among the 10 countries included is less affected, moving Norway from 8th to 7th position. Also Sweden, Italy and Spain obtain higher R&D intensities after correction, whereas the remaining countries all have their R&D intensities reduced. Sweden is in a position of its own with R&D intensity at around 15 percent both before and after correction. Seven countries have corrected R&D intensities of relatively equal magnitude, ranging from 6.2 percent (Norway and USA) to 8.2 percent (Japan). At the bottom of the ranking we find Spain and Italy with R&D intensities of around 3 percent.

[4] For more information on production value from KLEMS: http://www.euklems.net.

Figure 1.26
R&D expenditure in the Business enterprise sector as a share of the gross product of the sector within the manufacturing industry in selected OECD countries in 2004[1]. Total and adjusted for the industry structure of the EU.



[1] The figures for Sweden, Japan and USA are from 2003.

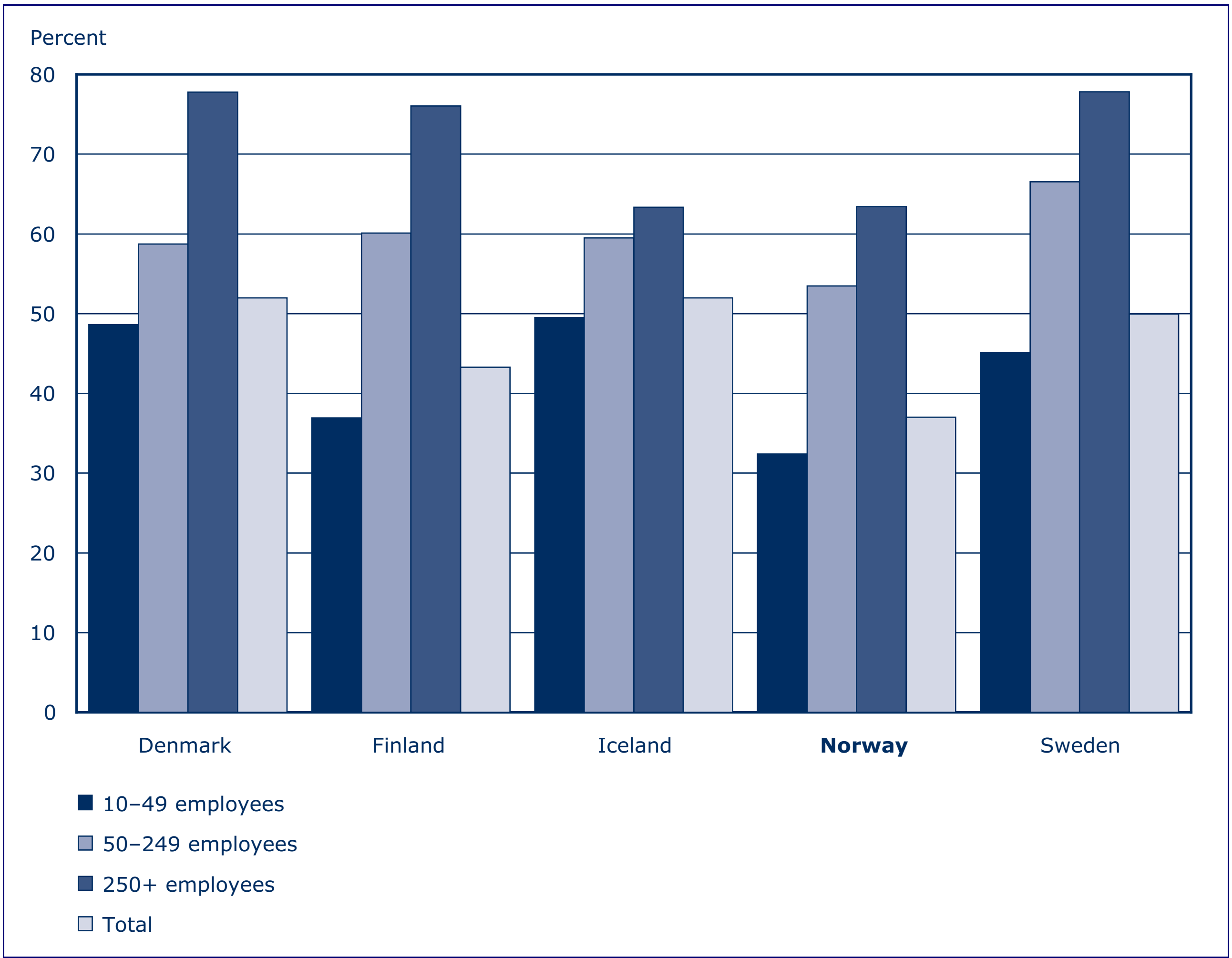
Source: The OECD's ANBERD database 2005

Looking at the comparative performance of the different industries reveals that only very few perform as low as rank 8. Among these we find *chemical products* and *machinery and equipment*. By contrast, we also find a number of industries performing among the best. These include *textiles and wearing apparel*, *wood products*, *metals*, and *metal products*. The industries that have the best performance in the comparison generally turn out to have low R&D levels and/or small shares of overall production. This is the reason why the overall performance of Norwegian manufacturing ends up with a weaker relative performance than we find for the majority of industries.

1.7.3 International comparisons of innovation resources

The harmonisation of the European countries' innovation surveys through Eurostat facilitates comparisons between Norwegian and other countries' inno-

Figure 1.27
Enterprises with innovation activities in the Nordic countries in the period 2002–2004, by size group.



Source: Statistics Norway/Innovation Survey

vation data. Comparisons are important as it is impossible *a priori* to know what goals to set for the level of innovation and for the innovation projects' results. Innovation is part of the enterprises' market adjustment; thus, reasonable levels are determined by what the competition is doing. Since large parts of the Norwegian Business enterprise sector are internationally competitive, the innovation activities of other countries are of consequence. It must be mentioned, however, that comparisons across countries are not straightforward. Even countries often used for comparison may have very different business structures, and this can affect the total figures for innovation intensity.

The Norwegian Business enterprise sector's innovation activities are similar to those of the other Nordic countries. Typically, large companies are innovative. There are also similarities across Nordic borders in terms of the extent to which the enterprises develop their own innovation or co-operate with others. However, the total share of innovative enterprises is lower in Norway than in the other Nordic countries. In Denmark and Iceland, 52 percent of all enterprises had innovation activities in 2002–2004, whereas the corresponding numbers were 50 and 43 percent in Sweden and Finland, respectively. The Norwegian share was 37 percent.

2 Human resources

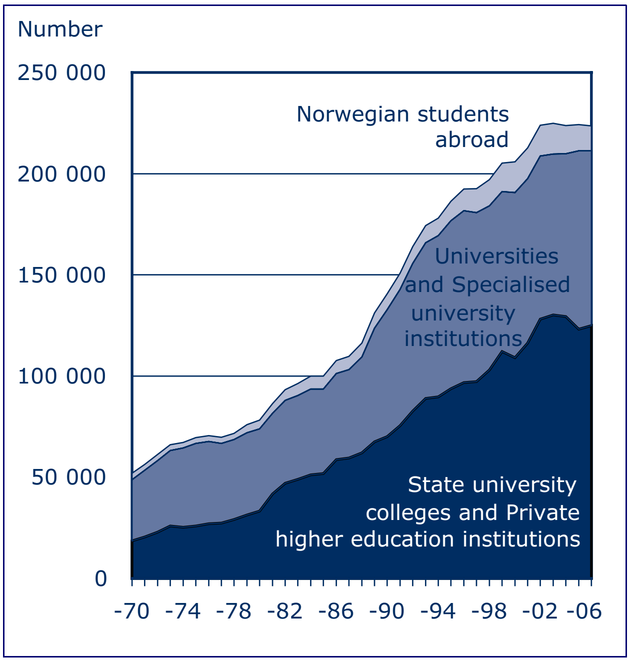
Research and experimental development (R&D) is founded on human knowledge and competency. Access to people with adequate education and experience is thus a basic condition and the most important resource in order to be able to perform R&D and innovation. Competency is a decisive factor when it comes to using and exploiting existing technology in new ways to develop new technology. A high competency level is therefore important to be able to maintain competitiveness and a high national standard of living.

In Norway there was considerable growth in the number of students from the 1980s to the mid-1990s, and Norway is among the OECD countries with the highest educational level. There has been considerable growth in the number of employees with higher education in both the public and private sectors. Although the number of students has stopped rising, the education level of the population will continue to increase for a long time.

The focus on women in research and science has been intensified in many countries. Even though Norway is in the forefront in many areas when it comes to gender equality, the situation for Norwegian women in science and research is characterised by uneven representation; while there are more female students than male students, there are relatively few women who occupy professorships or senior researcher positions.

This chapter will present statistics and indicators related to graduates, R&D personnel, the labour market for people with higher education, and some international comparisons on higher education.

Figure 2.1
Total number of students in 1970–2006 by sector of education.



Source: Statistics Norway, Norwegian State Educational Loan Fund

2.1 Higher education

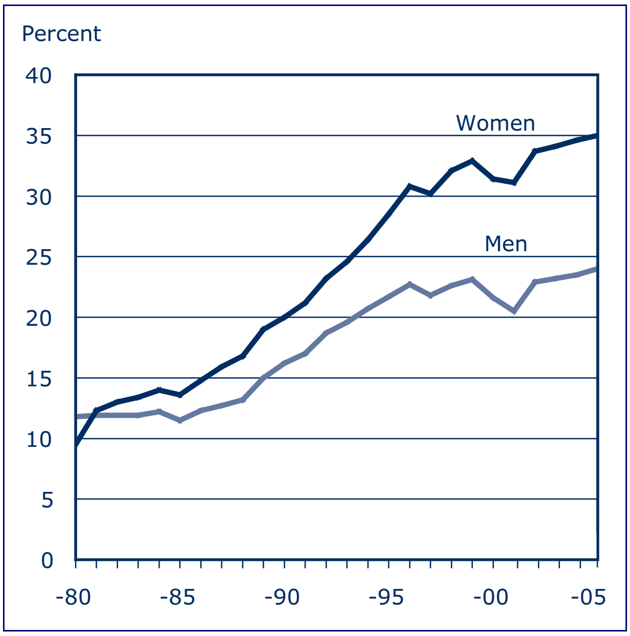
2.1.1 Graduates

After over 30 years with continuous growth in the number of students, it appears the growth has finally stopped, see Figure 2.1. Since 2002 the number of students, including foreign students, has remained more or less constant at about 220 000. The number of Norwegian students abroad has declined during recent years, but the number of students in Norway has remained at approximately the same level.

In 2005, the total number of registered students in the Higher education sector in Norway was 211 200. This represented an increase of 1 300 compared with 2004. Preliminary figures for 2006 indicate a further increase of 400 students compared with 2005.

There is a difference between female and male students in relation to the increase in the number of students. The numbers for 2006 show an increase of 1 200 female students in higher education compared with 2005. The trend during the last 20 years has been that there has been a majority of women in higher education. In 2006 women represented 60 percent of the total number of students. Figure 2.2 shows how the proportion of women and men in higher education among the total population aged 19–24 years has developed during the period from 1980 to 2004. At the beginning of this period, only about 10 percent of this age group was to be found in higher education. The proportion among the male population was slightly larger than among the female population. Since the mid-1980s the proportions have increased considerably for both sexes. The increase has nevertheless been much larger among women than among men. Towards the end of this

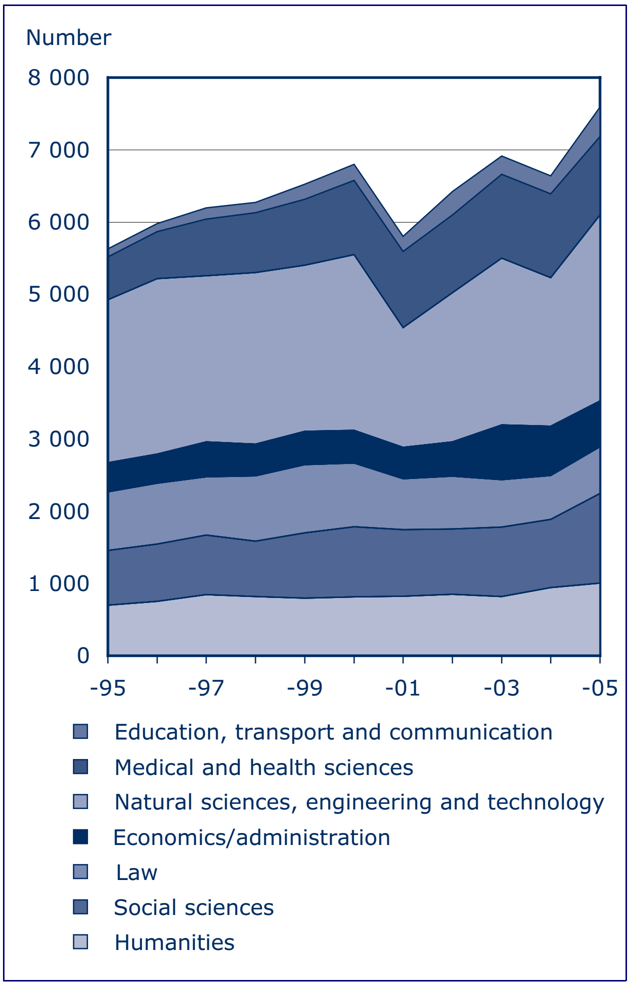
Figure 2.2
Men and women aged 19–24 in higher education as a share of total number of persons in the same age group in 1980–2004.[1]



[1] Persons enlisted in PhD programmes are not included in these numbers.

Source: Statistics Norway

Figure 2.3
Graduates with a higher degree from universities and specialised university colleges etc. in 1995–2005 by field of study.



Source: NIFU STEP/Graduate register

period, 35 percent of the women in this age group and 24 percent of the men were in higher education.

The Reform of the Quality of Higher Education was implemented during the autumn of 2003. This is the most extensive reform ever implemented in Norwegian higher education (Michelsen & Aamodt, 2007). One of the main reasons for implementing this reform was the obvious indications that students were taking too long to graduate and too many students were dropping out (Hovdhaugen & Aamodt, 2006).

Implementation and evaluation of the reform started simultaneously. The evaluation was conducted by NIFU STEP and Rokkansenteret in Bergen (www.rokkansenteret.uib.no). They completed the evaluation in January 2007. One of the most interesting findings was considerable changes in forms of teaching and evaluation. The students are followed up more intensely than before the reform, and the productivity in the Higher education sector has improved.

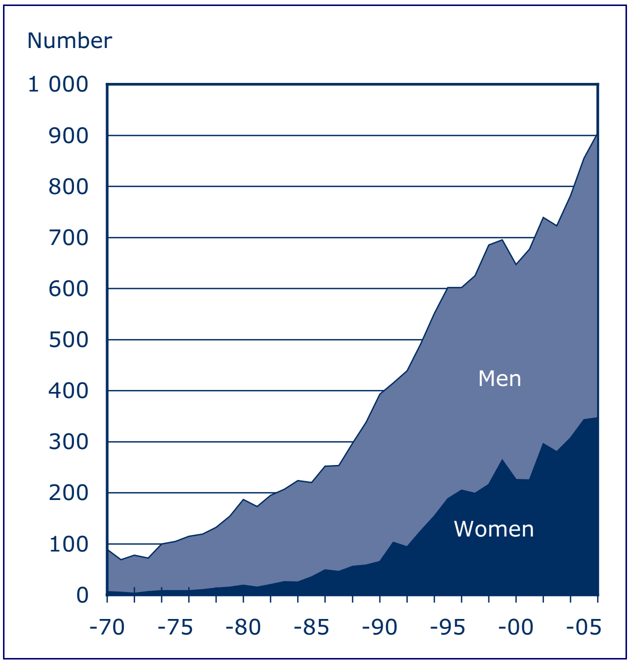
2.1.2 Graduates with a higher degree

In 2005, the total number of graduates with a higher degree from universities, university colleges, state colleges and other colleges was 8 420. 90 percent of the graduates came from universities, university colleges and other colleges, and 10 percent came from state colleges. During the last decade the number of graduates with a higher degree has increased by 37 percent and since 2003 by 9 percent.

The highest number of higher degree graduates was in the field of natural sciences and technology, with nearly 2 300 graduates. This field of study had the smallest increase during the decade 1995–2005, with 14 percent. Humanities and social sciences had a strong, steady increase in the production of graduates in the same period, with 44 and 63 percent respectively. This is illustrated in Figure 2.3.

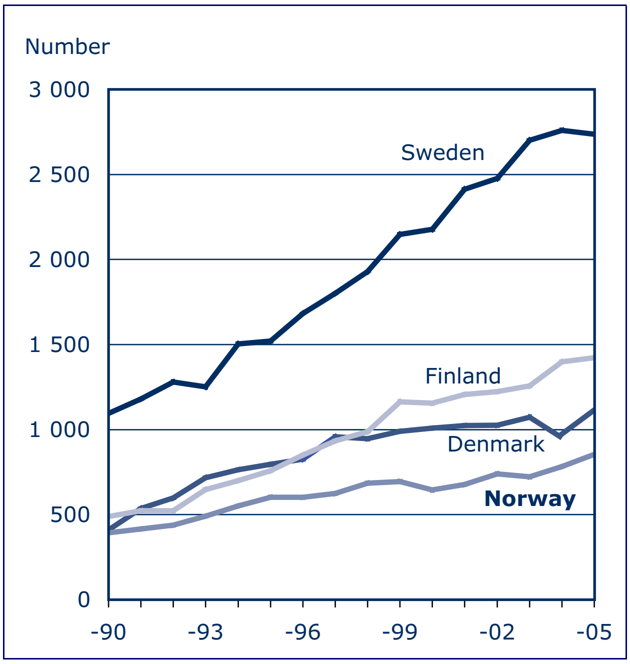
The number of higher degree graduates at state colleges has increased strongly, by 62 percent, from 1995 to 2005. The increase is mostly due to the fact that more and more state colleges are offering courses resulting in a higher degree. In 2005 there were 17 state colleges that offered such courses.

Figure 2.4
Awarded doctoral degrees in Norway in 1970–2006 by gender.



Source: NIFU STEP/Doctoral Degree Register

Figure 2.5
Doctoral degrees in four Nordic countries in 1990–2006.



Source: NIFU STEP/NORBAL

The proportion of women in higher education increased from 39 percent in 1991 to 51 percent in 2005. It has increased in all fields of study, with the smallest increase in education and communication, (from 70 to 73 percent) and natural science and technology (from 29 to 34 percent) and the highest increase in medicine and health subjects (from 51 to 65 percent).

2.1.3 Doctoral degrees in Norway and the Nordic countries

Almost 11 000 doctoral degrees have been awarded at Norwegian institutions during the 1990–2006 period. This constitutes more than two-thirds of all doctorates ever awarded in Norway. The number of annual awards has doubled in the last 15 years. The increase was particularly strong in the early 1990s, see Figure 2.4. Since then, developments have been more variable, with occasional drops in some years around the turn of the century.

The share of female doctors has increased over time in Norway. In 1990, 17 percent of the doctoral degrees were earned by women. This percentage doubled over the next six years. By the end of the 1990s the trend was more moderate, and in the 2002–2006 period the proportion of women has remained stable at about 38–40 percent. In the first half of 2007, however, the women's share jumped to 47 percent.

However, the increase in the number of doctorates awarded in Norway has been slower than in the other Nordic countries, as shown in Figure 2.5. In real terms, Sweden has always had a higher number of doctoral awards than its neighbouring countries as a natural consequence of its population size. In 1990, Norway, Denmark and Finland awarded about the same number of doctorates. A few years later, the situation changed considerably. Whereas the total number had doubled in Norway between 1990 and 2005, it had tripled in Finland over the same period. In Denmark, the number of doctorate awards also increased more than in Norway. In recent years, however, the growth rate has been almost the same in these two countries. Nevertheless, the overall growth in the number of trained research personnel has been less in Norway than in its neighbouring countries during the last fifteen years. The proportion of females with a doctoral degree in 2005 was 49 percent in Finland, 45 percent in Sweden, 41 percent in Denmark and 40 percent in Norway.

In Norway 37 percent of the doctoral degrees awarded in 2006 were in the natural sciences and engineering – about the same percentage as in the other Nordic countries. This represents a decrease from 1990, when the natural sciences and engineering accounted for more than the half of all doctoral awards in Norway. In 2006 the medical and health sciences accounted for 24 percent of doctorates, the

Table 2.1
All doctoral degrees in Norway 1817–2006, by awarding institution.

Institution (year of first award)	Number
University of Oslo (1817)	6 437
University of Bergen (1949)	2 707
Norwegian University of Science and Technology (NTNU) (1924)	3 964
University of Tromsø (1974)	956
Norwegian University of Life Sciences (UMB) (1927)	815
University of Stavanger (2000)	28
University of Agder (2006)	4
Norwegian School of Veterinary Science (1959)	346
Norwegian School of Economics and Business Administration (1957)	217
Norwegian School of Sport Sciences (1990)	59
The Oslo School of Architecture and Design (1985)	35
Norwegian Academy of Music (2002)	6
Bodø University College (2003)	8
Molde University College (2006)	3
Oslo University College (no awards by the end of 2006)	0
Norwegian School of Theology (1991)	36
Norwegian School of Management (BI) (2000)	33
School of Mission and Theology (2006)	3
Total	15 657

Source: NIFU STEP/Doctoral Degree Register

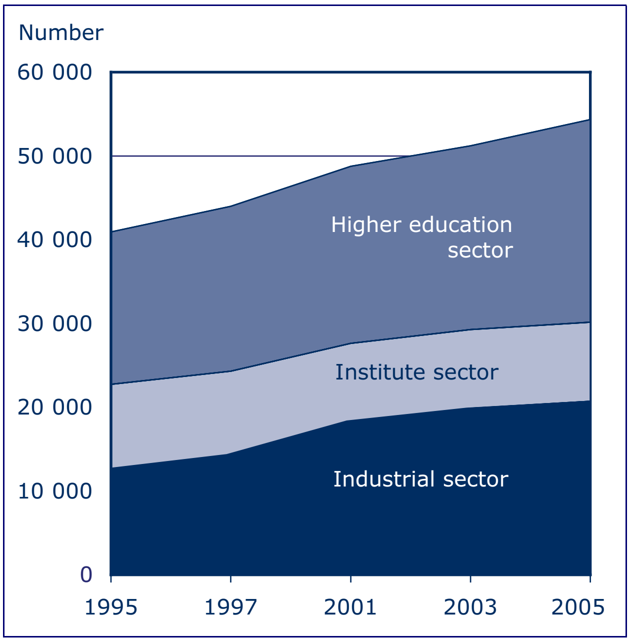
social sciences 20 percent, the humanities 12 percent, and the agricultural sciences including veterinary medicine 7 percent.

There has been an increasing share of non-Norwegian citizens among the doctoral graduates, from 10 percent in the early 1990s to about 20 percent in the recent years.

In connection with the Reform of the Quality of Higher Education in Norway, which took effect in 2003, the number of doctoral titles – previously 14 – has been reduced to just two. Research courses now lead to a PhD, corresponding to the Anglo-American degree system. In addition the Dr.philos. degree has been retained for people who wish to pursue their own working plans, independently of their tutor, contract, and time schedule. At present 18 institutions are authorised to award doctoral degrees, including all seven universities, eight specialised university institutions (public and private), and three state university colleges.

The first Norwegian doctoral degree was awarded at the University of Oslo in 1817. By the end of 2006 the total number of awards had amounted to more than 15 600, see Table 2.1.

Figure 2.6
R&D personnel in Norway in 1995–2005 by performing sector.



Source: NIFU STEP, Statistics Norway/R&D statistics

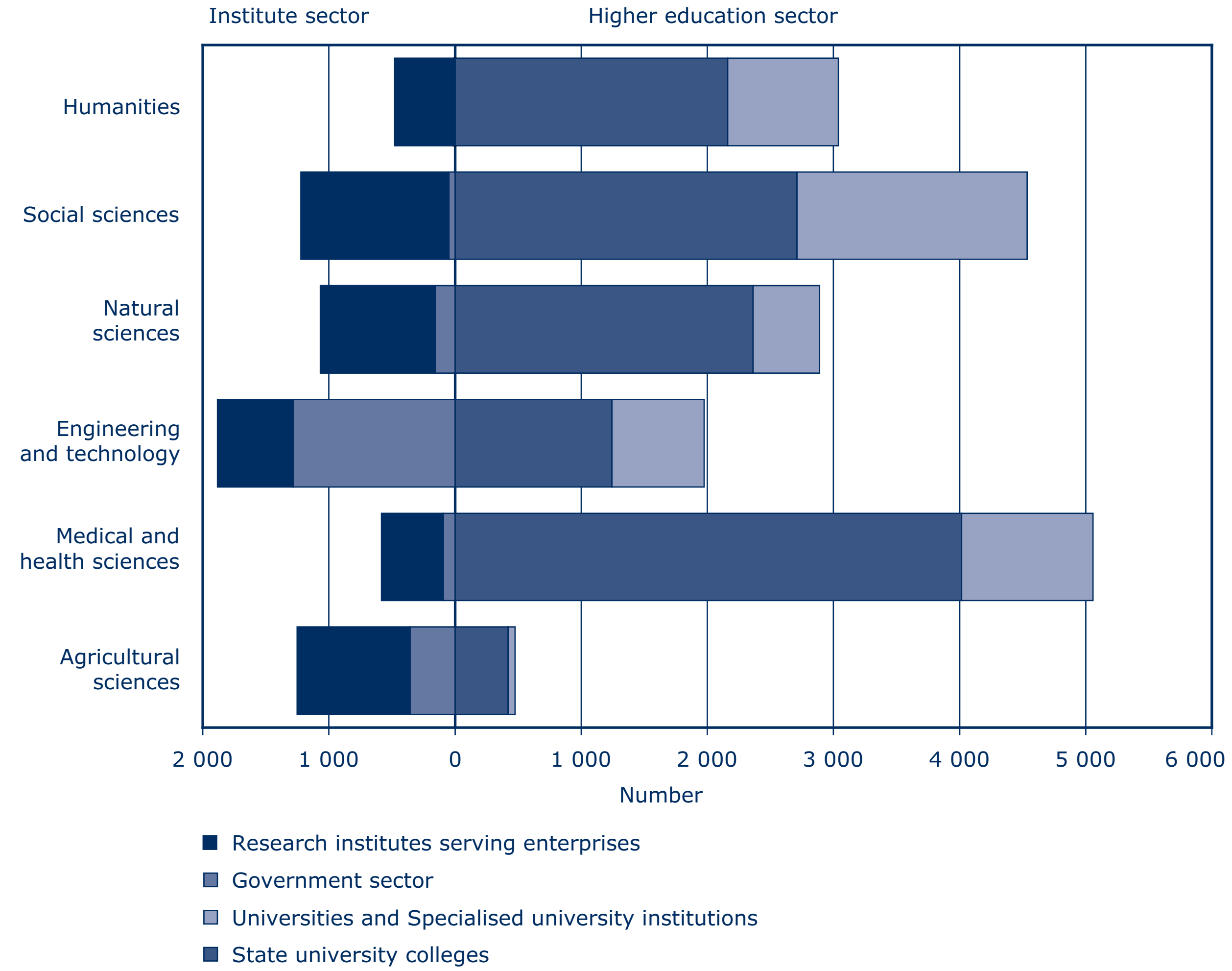
2.2 R&D personnel

2.2.1 R&D personnel in Norwegian R&D performing sectors

In 2005, 54 000 individuals were involved in R&D activities in Norway. Of these 24 000 were employed in the Higher education sector, nearly 21 000 in the Industrial sector, and well above 9 000 in the Institute sector. These numbers include all personnel that contributed to R&D, including technical personnel and personnel that in other ways assisted in carrying out R&D. The development is illustrated in Figure 2.6. From 2003–2005 the largest growth was to be found in the Higher education sector, where the number of R&D personnel increased by 2 200 persons or 10 percent. During the 1995–2005 period, R&D personnel in the Industrial sector increased by 60 percent, and was thus more than doubled during this period. However, the Industrial sector has experienced a serious decline in the number of researchers in the last few years. In the Higher education sector the increase was about 30 percent, while the number of R&D personnel in the Institute sector remained approximately the same throughout the whole period.

In Norway, 10 000 of a total of 37 000 researchers involved in R&D in 2005 held a doctoral degree, or 27 percent of those with qualifications corresponding to a Masters degree or above. In the Higher education

Figure 2.7
Researchers in 2005 by field of science and technology and performing sector.



Source: NIFU STEP/Register of Research Personnel

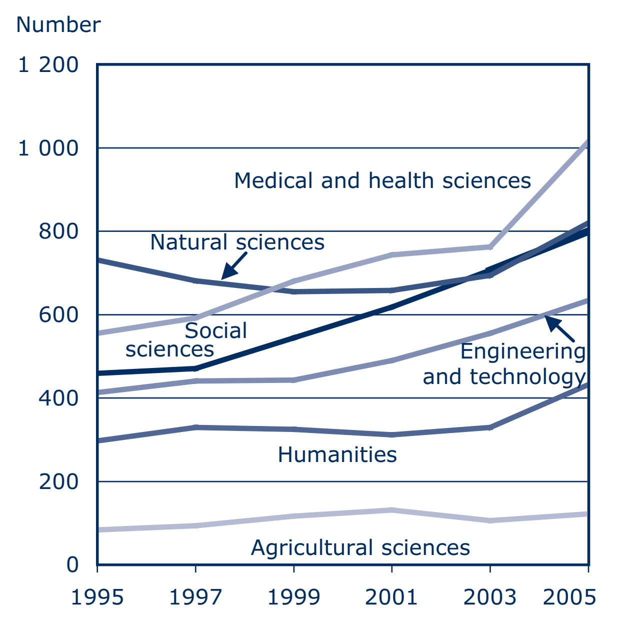
sector the proportion of total academic staff holding a doctoral degree was 37 percent; in the Institute sector, 35 percent, and in the Industrial sector, 10 percent. Thus, the proportion of researchers holding a doctoral degree has increased for all three sectors from 2003. In the Higher education sector and the Institute sector the increase was 3 percentage points, while in the Industrial sector the increase was 2 percentage points in the same period.

Figure 2.7 shows distribution by subject fields in the Higher education sector and the Institute sector. In 2005, 5 700 researchers or academic staff worked in the social sciences, the largest field. Three-quarters of these were employed at universities and state university colleges. A further 5 600 were employed within medical and health sciences, mainly at universities or university hospitals. More than 3 900 persons were engaged in the natural sciences: 73 percent of these were in the Higher education sector and 27 percent in the Institute sector. The area of engineering and technology was evenly distributed across both sectors and was the largest subject field in the Institute sector. The numbers of researchers within this subject field was 3 800. Humanities employed just over 3 500 researchers, while 1 700 were employed within agricultural sciences.

Compared with 2003 all fields of science have experienced an increase in the number of researchers. For both the sectors the increase has been 9 percent. The largest increase has been within medical and health sciences, where the increase in R&D personnel has been 20 percent. One third of this growth is due to the extension and change of the statistical population.

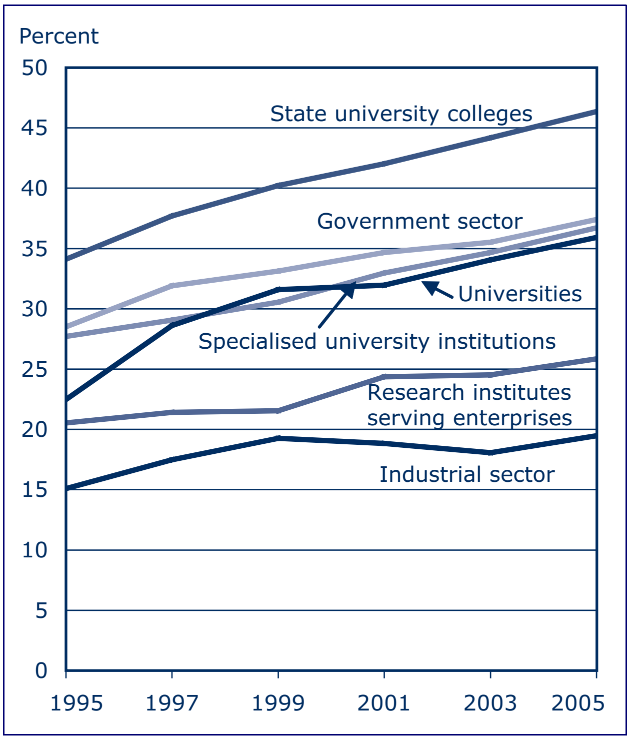
The figure also breaks down researchers in the Higher education sector. Here it distinguishes between personnel at universities/specialised university colleges and at state university colleges, which

Figure 2.8
PhD students in the Higher education sector in 1995–2005 by field of science and technology.



Source: NIFU STEP/Register of Research Personnel

Figure 2.9
Women's proportion of the total number of researchers in Norway in 1995–2005 by performing sector and type of institution.



Source: NIFU STEP, Statistics Norway/R&D statistics

covers professional teaching establishments for teacher education, nursing and technicians. For the Institute sector the figure shows the distribution between research institutes serving enterprises i.e. non-profit institutions (NPIs) and the Government sector. In international R&D statistics NPIs and the Industrial sector are included in the Business enterprise sector, see the OECD Frascati Manual 2002.

The number of PhD students in the Higher education sector amounted to more than 3 800 in 2005. This represents an increase of 800 persons compared with 2003. As a proportion of the total R&D personnel in the Higher education sector, PhD students constituted 21 percent, an increase of 2 percentage points from 2003. The number of research fellows has increased relatively more than the rest of the R&D personnel. The increase is mainly due to an increase in PhD students financed directly through the general university fund.

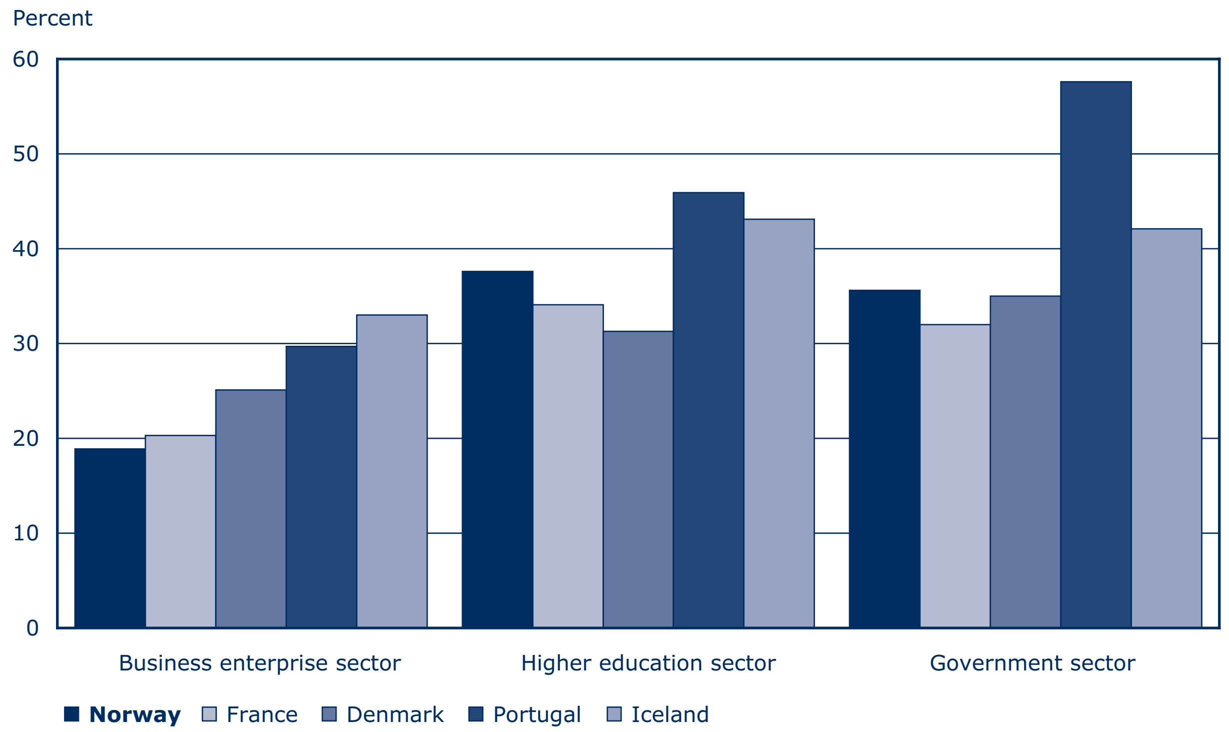
Figure 2.8 illustrates the development in the number of PhD students during a ten year period from 1995 to 2005. In particular it is the social sciences, medical and health sciences and the area of engineering and technology that have experienced a steady growth. The number of PhD students within natural sciences declined in the middle of this period, but then rose again in 2005. The number of research fellows within the humanities and agricultural sciences has also varied, but the humanities experienced a considerable growth in 2005.

2.2.2 Women in science

In 2005, 11 750 women with higher education were involved in R&D in Norway. This amounts to 32 percent of the total number of R&D personnel in Norway and represents an increase from 24 percent in 1995. The Higher education sector had the highest share of women, 39 percent, followed by the Institute sector with 34 percent. In the Industrial sector, only 19 percent of the researchers were women in 2005. Figure 2.9 shows that there has been an increase in the proportion of women in all sectors from 1995 to 2005. State university colleges had the highest share of women in the period 1995–2005, followed by the Government sector. The Business enterprise sector, which consists of the Industrial sector and research institutes serving enterprises, had the lowest proportion of women during the entire period.

The proportion of women varies with the level of position. Among full professors in the Higher education sector, 17 percent were women in 2005, which was the same percentage as two years earlier. 31 percent of the associate professors were female. Lecturers had the highest share of women in 2005, 57 percent, and among the lecturers in medical and health sciences at the state university colleges, as many as

Figure 2.10
Women's proportion of the total number of researchers in selected OECD countries in 2003 by performing sector.



Source: OECD – Main Science and Technology Indicators 2007-1

77 percent were women. Research fellows came closest to achieving gender equality with 48 percent women. Among the post doctors, the share of women dropped from 50 percent in 2003 to 43 percent in 2005. Of 620 post doctorates starting between 2003 and 2005, only 34 percent were women. Social sciences and agricultural sciences were the only fields that recruited more women than men into post doctorates during this period. Natural sciences had the highest growth in the number of post doctors from 2003 to 2005. Of the doctorates granted in natural sciences in 2000–2004 in Norway, 34 percent were granted to women, which mean that there were fewer female doctorates to recruit post doctors from.

At the university hospitals, 31 percent of the physicians participating in R&D were women. Women's proportion was 18 percent for chief physicians, 26 percent for physicians and 45 percent for junior physicians. The university hospitals were thus the type of institution in the Higher education sector with the lowest participation rate of women. The data show that the higher the position, the smaller the proportion of women.

Approximately half of the research candidates in Higher education in the OECD countries are women, but among R&D researchers, only 25–30 percent are women. The gender gap is largest in Austria, Japan, Korea and Switzerland, while Greece, New Zealand, Portugal and Slovakia have a higher proportion of female researchers. Women participating in R&D are often found within biology, health, agricultural sciences and pharmacy, while there are fewer female researchers in physics, informatics and communication technology and engineering.

The proportion of women participating in R&D varies by performing sector, as shown in Figure 2.10. The share of women in the Norwegian Business enterprise sector, 19 percent, was among the lowest in the OECD countries that reported the share of women in 2003. In Denmark, 25 percent of the researchers in the Business enterprise sector were female, while in Portugal this share was 30 percent. Iceland had the highest proportion of women in the Business enterprise sector, with 33 percent. Several OECD countries, including Germany, Hungary, the Netherlands, Norway and Spain, experienced a decrease in the proportion of female researchers in the Business enterprise sector from 2001 to 2003. The decrease was biggest in the countries where the number of researchers in the sector did not rise in the period, namely Germany, the Netherlands and Norway.

The Government sector in Norway consisted of 34 percent female researchers in 2003. This was far below Portugal, where 58 percent of the personnel involved in R&D in the Government sector were women. The other OECD countries that reported the share of women for this sector all had between 30 and 40 percent female researchers.

2.3 Person-years on R&D

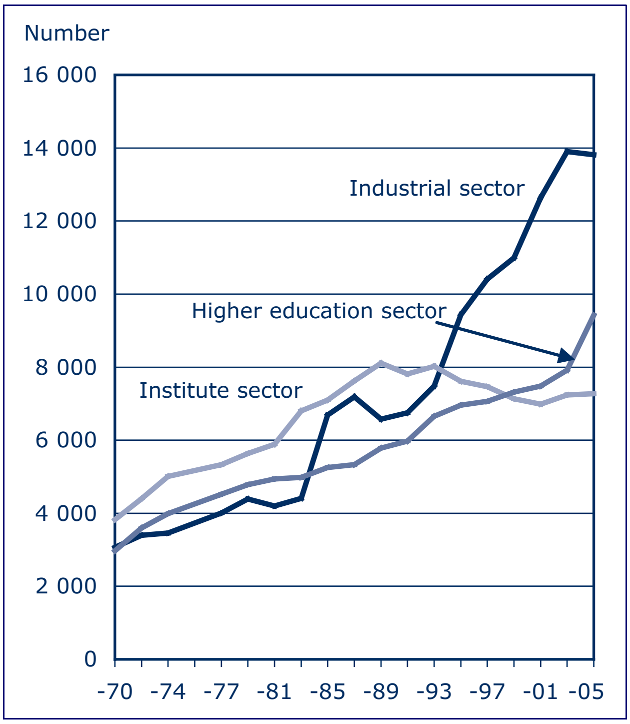
This section complements data regarding head counts of people involved in R&D in Norway with a series of data based on full-time equivalents (FTE). This is important since research and development is often a secondary function in the work of an individual, for example in the case of university scientists whose work also involves a significant amount of teaching. Full-time equivalent R&D personnel is a measure of the volume of R&D. It takes into account the R&D share of a person's working time including administration of R&D, and is also referred to as R&D person-years. According to the Frascati Manual, no single individual can represent more than one full-time equivalent in any year, and hence cannot perform more than one full-time equivalent on R&D.

2.3.1 Person-years on R&D in the Norwegian R&D performing sectors

In Norway, 30 500 R&D person-years were conducted in 2005. This breaks down into about 13 800 person-years in the Industrial sector, close to 7 300 in the Institute sector, and 9 400 R&D person-years in the Higher education sector.

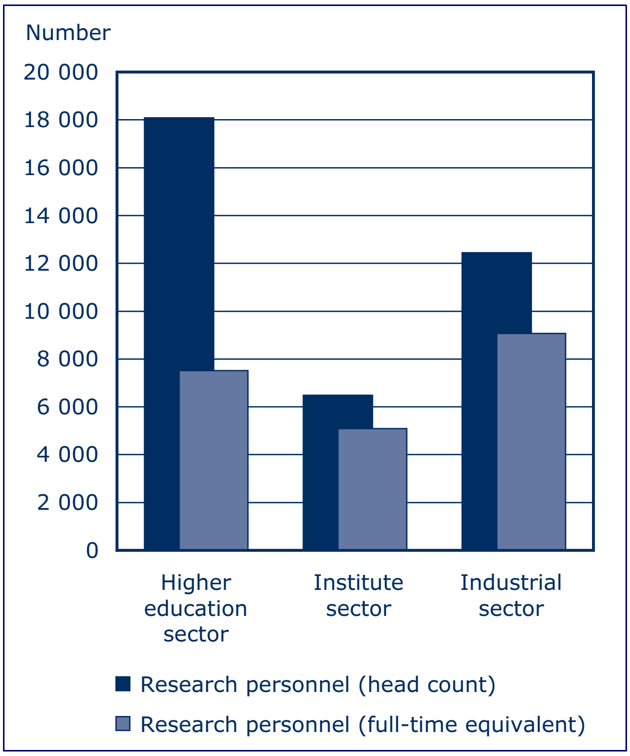
The greatest increase in R&D person-years during the whole period from 1970 to 2005 has been in the Industrial sector. However, with regard to the Industrial sector it must be pointed out that the figures have been affected by an extension in the survey procedure between 1993 and 1995. In the Institute sector more R&D person-years were performed in the late 1980s, than in 2005. In the Higher education sector the increase in person-years has been steady throughout the whole period, as shown in Figure 2.11. However, in the Industrial sector the total number FTE performed in 2005 represented a decline of 0.6 percent compared with 2003. For the Institute sector there was an increase of 0.5 percent, while the Higher education sector saw an increase in the total number of R&D person-years performed of as much as 19 percent from 2003 to 2005.

Figure 2.11
Total person-years on R&D in 1970–2005 by performing sector.



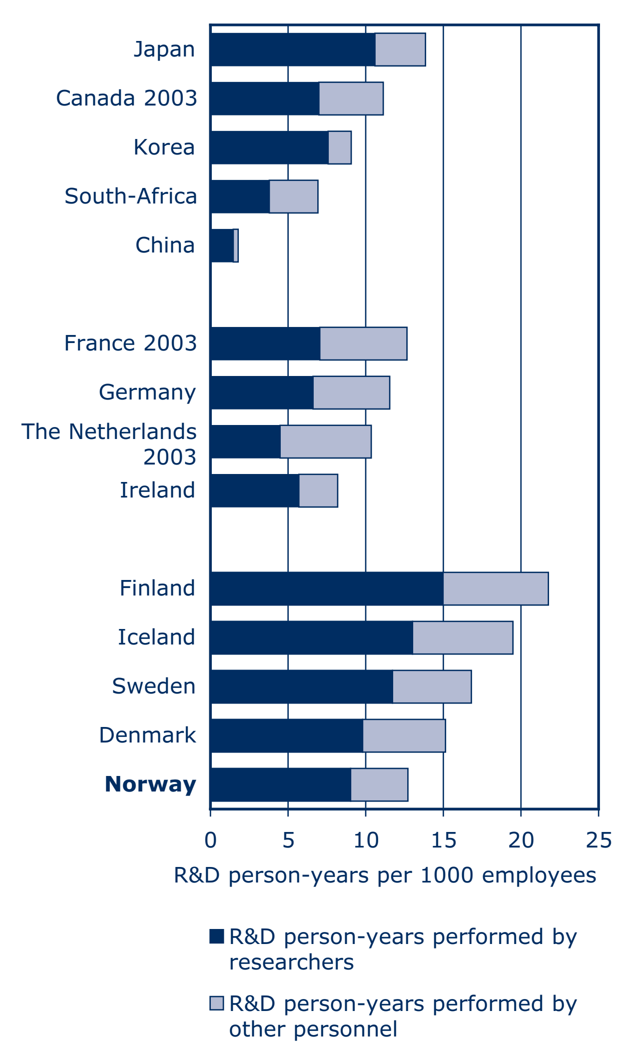
Source: NIFU STEP, Statistics Norway/R&D statistics

Figure 2.12
Total number of researchers in head counts and person-years on R&D in 2005 by performing sector.



Source: NIFU STEP, Statistics Norway/R&D statistics

Figure 2.13
R&D person-years performed in selected OECD countries by researchers and technicians per 1 000 employees in 2005 or latest year for available data.



Source: OECD – Main Science and Technology Indicators 2007-1

Based on full-time equivalents on R&D, researchers represent a high percentage of total R&D personnel. In 2005, about 21 700 FTE were performed by researchers or persons with a master's degree or higher, and 8 800 by technicians or equivalent staff. During the 1993–2005 period the number of R&D person-years performed by researchers or persons with a master's degree or higher has increased more rapidly than the person-years performed by technicians or equivalent staff.

Compared with the number of R&D personnel, the number of R&D person-years gives a somewhat different picture if we look at the three different sectors. Figure 2.12 illustrates how the Industrial sector is the largest when it comes to R&D person-years. Counting heads, the Higher education sector is by far the largest. In the Institute sector, 6 500 R&D personnel performed 5 100 person-years. This means that the relative research intensity was highest in this sector, closely followed by the Industrial sector.

2.3.2 International comparison of R&D person-years

Figure 2.13 compares R&D person-years in total and R&D person-years performed by researchers/university graduates per 1 000 employees in 2005. Norway is ranked relatively high among the countries when it comes to total number of R&D person-years performed per number of employees, but nevertheless last among the Nordic countries. When it comes to R&D person-years performed by researchers, Norway, with a proportion of 71 percent is ranked before all the other groups besides the Asian countries. In China, Korea and Japan this proportion is 82, 84 and 77 percent, respectively.

2.4 The highly educated in the Norwegian labour market

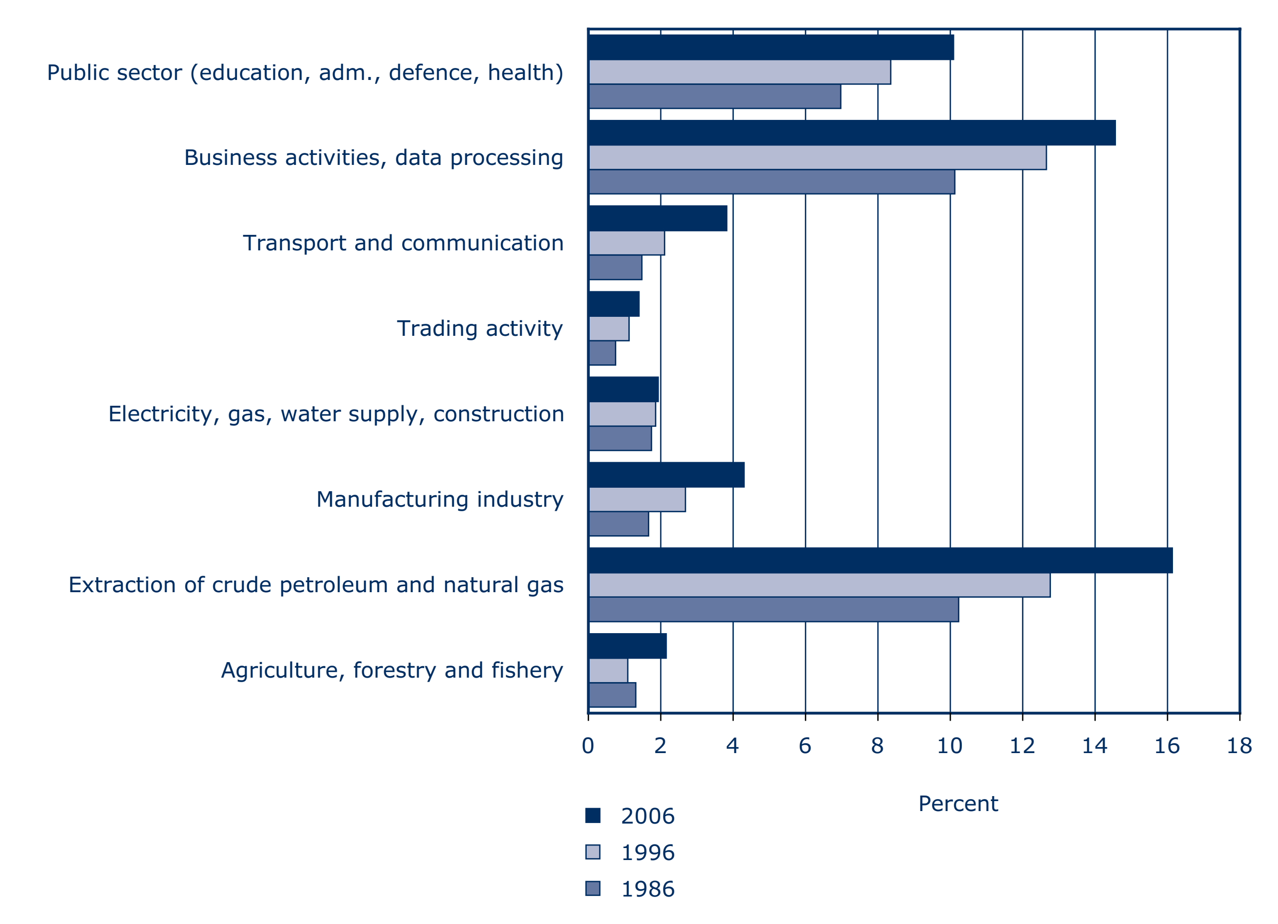
2.4.1 Educational level of the labour force

Real competency is an important condition for the development of innovation and competitiveness. It is difficult to make good indicators on level and types of competency in the labour market. In this context we choose to use formal education as an indicator. We have data on education and employment from 1986 to 2006 at our disposal.

Figure 2.14 breaks down the proportion of employees with at least 5 years of higher education by industry in 1986, 1996 and 2006. The largest proportion of highly educated people in 2006 was in *oil and gas extraction, mining* with 16 percent of the industry's total workforce of 38 000. The oil industry was followed by *business activities, data processing* in which 15 percent of the 265 000 employees had at least five years of higher education. *Public sector* was the third industry on this list, where 10 percent of a total workforce of 900 000 had higher education. This is thus the largest single-sector employment, mainly due to the fact that skill-intensive functions such as education, hospitals and public administration are found here.

Agriculture, forestry, fishing, electricity, gas, water supply, construction and *trading activity* have a low proportion of highly educated workers. In each of these three major industrial divisions the propor-

Figure 2.14
Proportion of the employees with higher education[1] in 1986, 1996 and 2006 by industry.



[1] University or college education, 5 years or more.

Source: NIFU STEP, Statistics Norway

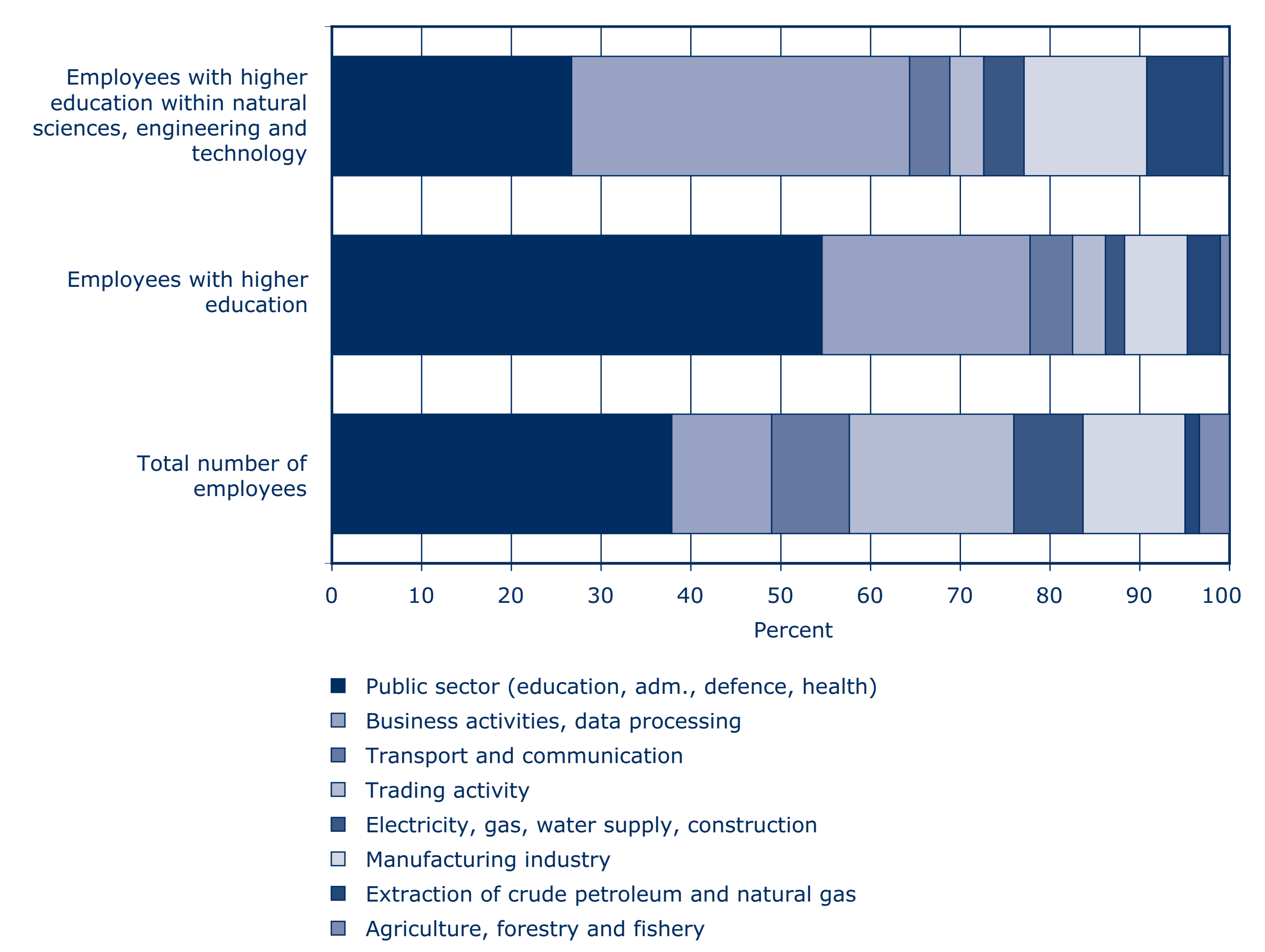
tion of workers with higher education was below two percent. *Trading activity*, which is the largest industry after public sector, by number of employees, had the lowest proportion of highly educated workers of all the industries.

The figure also shows how this measure of knowledge intensity has changed over time by looking at the development from 1986 to 2006. The proportion of highly educated workers has increased in all industries. During the period it increased significantly in *manufacturing* and in *transport and communication*. The increase in the *public sector* and within *business activities, data processing* was weaker. Nevertheless it has to be said that the proportion of highly educated employees in the *manufacturing industry* is still considerably lower than in, for instance, the *public sector*.

Figure 2.15 illustrates how employees with different kinds of higher education are divided between the eight industries in 2006.

The horizontal bars show the distribution of employees with higher education within natural science and technical engineering, everyone with higher education (including those with education within natural science and technical engineering), and the total number of employees in every industry, with every level of education, respectively. The figure shows that *public sector* had the largest number of employees, and therefore included a large share of highly educated people in Norway. *Business activities, data processing* was the industry with most employees with a higher education within natural science and technical subjects in 2006. A third of all employees with this kind of education were employed in this industry, a quarter in the *public sector* and a sixth in the *manufacturing industry*. There are a high proportion of employees with higher education within natural science and technical subjects in *business activities, data processing*. In this industry we will find consultancy firms within technical subjects, consultative engineers etc.

Figure 2.15
Proportion of employees with higher education[1] in 2006 by industry.



[1] University or college education, 5 years or more.

Source: NIFU STEP, Statistics Norway

2.4.2 Mobility among employees

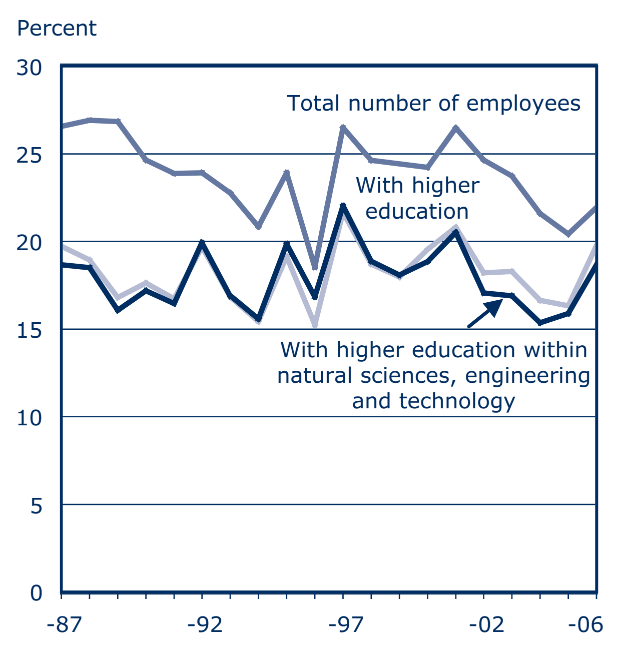
Every time an employee changes employer, he or she brings with them their formal competency and more specific knowledge acquired during their everyday working life. Mobility among employees is therefore an important mechanism for transfer of knowledge and competency across companies and industries. This is not to say that mobility should be as high as possible. Mobility also entails a loss of competency, in particular when indispensable employees leave a company. These employees often possess a lot of tacit knowledge, which they take with them when they move on and which it will take others time to gain.

There are different ways of measuring mobility among employees. In Figure 2.16 we look at persons that have changed workplace from one year to another. Most will also change employer, but the numbers also include people who change workplace within the same company.

As Figure 2.16 illustrates, there are no great differences between people with higher education of five years or more and those with higher education within natural science and technical engineering. The yearly rates of mobility follow each other closely. If we look at the mobility for all employees, it is about 6 to 7 percentage points higher. This is mainly due to the fact that the youngest employees are far more mobile, because of part-time working, few jobs – and a more active search for new jobs.

There are no obvious reasons for the variations in the mobility from year to year. The economic situation, i.e. the level of unemployment and the number of new businesses, do have an effect on yearly mobility, but not in an unambiguous way. The rates are also strongly influenced by statistical routines. The great changes we see in the 1994–1997 period are due to changes and reorganisation in relation to the implementation of a new register (The Central Coordinating Register for Legal Entities), and to the very

Figure 2.16
Proportion of mobility among employees in 1986–2006 by type of education.



Source: NIFU STEP, Statistics Norway

special economic situation in some parts of the labour market in relation to the dotcom-bubble.

2.4.3 The professional career of doctoral degree holders

Most doctoral degree holders who earned their degree at a Norwegian institution are employed in the public sector, and most of them at universities and colleges, according to a recent study (Olsen, 2007). The study confirms the common understanding that most persons holding qualifications at doctoral level aspire to a career in academic or other research institutions.

However, for a long time a large minority of the doctoral degree holders have filled positions in other business and enterprises, both in the private and the public sector. The share of employed doctoral degree holders working in the private sector has been increasing over time.

Even if the majority of the doctoral degree holders are still employed in the public sector, this applies to a decreasing share of doctoral degree holders. About 80 percent of the people awarded a doctoral degree in the 1970s were employed in the public sector 2003. The corresponding percentage of the 1990 cohorts was only 60 percent.

Figure 2.17 shows the sectorial and subsectorial affiliation in 2003 of the economically active doctoral degree holders. More than 60 percent were working in the public sector. Two thirds of the doctors in the public sector were attached to subsector *Education*. One in four doctorate holders in the public sector worked in *Health and social services* and one in ten were in *Public administration* or *Other public activities*.

The distribution among subsectors has remained relatively stable over time. However, a larger percentage of the 1970 cohorts than the succeeding cohorts are employed within *Education*.

In 2003 about 3 600 doctoral degree holders were classified in the *Education* sub sector. Almost all of them were affiliated with universities and university colleges. The women's share of the doctoral degree holders in *Education* was 28 percent.

Most of the 1 400 doctoral degree holders in *Health and social services* worked at *somatic hospitals*. Not surprisingly, 93 percent of them hold a doctoral degree in medical and health sciences. Only one in five doctoral degree holders working in a hospital were women. In social services, by contrast, there was a majority of women among the doctoral degree holders.

The 400-odd doctoral degree holders working in *Public administration etc.* were distributed along several activity categories, among which *Defence* employed a lot.

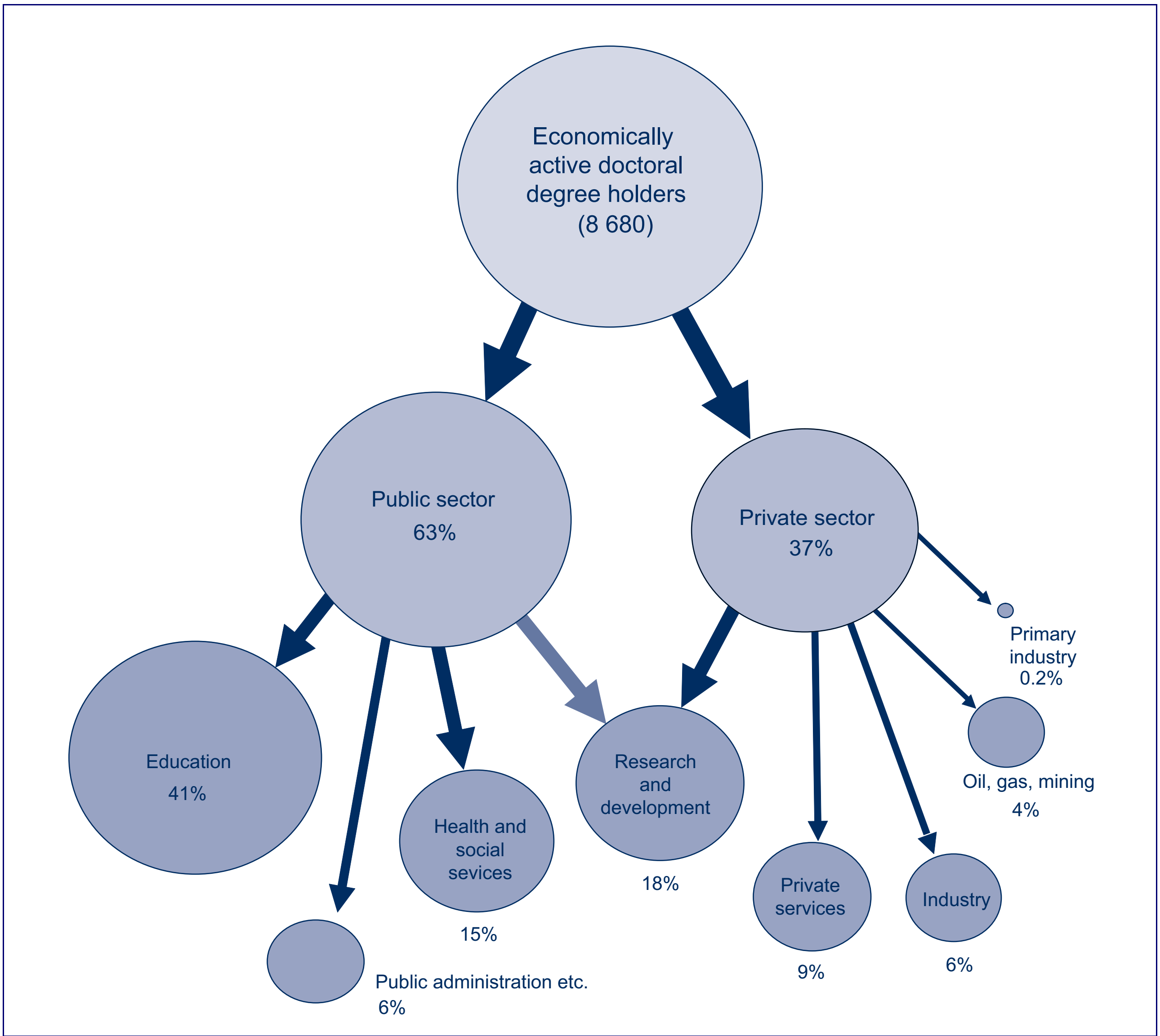
In 2003, the private sector included slightly below 40 percent of all employed doctoral degree holders. Half of them were working at research institutions or enterprises (NACE code 73 *Research and development*) with R&D as a main objective. It should be noted that even though, in this context, units classified as NACE code 73 are considered private, many of them are in fact non-academic research institutions primarily funded by the government. It should also be noticed that code 73, despite its name, only covers a smaller share of the total R&D activities, and does not include the Higher education sector or R&D at enterprises with a main objective other than R&D.

One quarter of the doctoral degree holders in the private sector worked in the subsector *Services* and smaller shares in manufacturing *Industry* and *Oil, gas, mining*. There are almost no doctoral degree holders in *Primary industry.*

About every fifth doctoral degree holder in the private sector was a woman.

In 2003 all employees in Norway amounted to 2.26 million people. The number of employees holding a Norwegian doctoral degree earned during the 1970–2002 period, was 8 680, which is 0.4 percent of all employees. In 2007 the percentage will probably increase to above 0.5 percent. However, persons

Figure 2.17
Sectorial and subsectorial affiliation of economically active doctoral degree holders in 2003 having earned a Norwegian doctoral degree in the 1970–2002 period.



Source: NIFU STEP/Doctoral Degree Register and Statistics Norway/System for personnel data

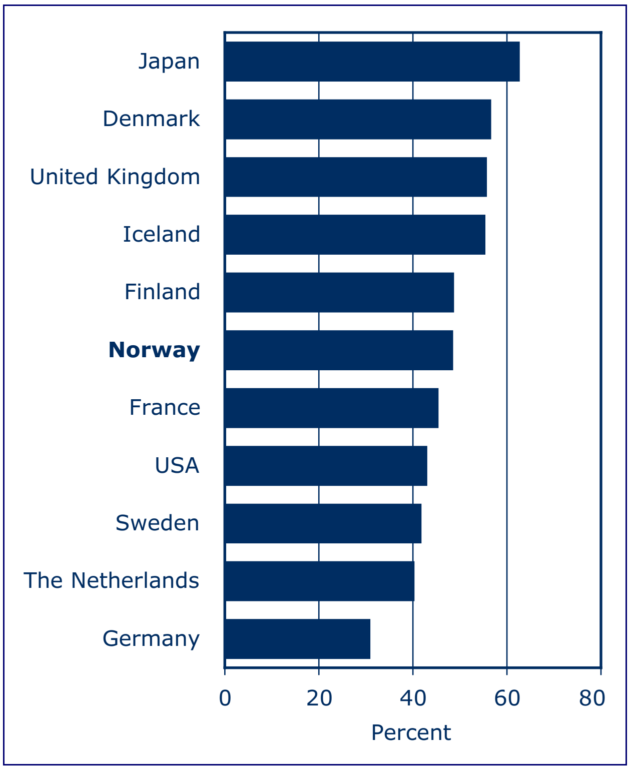
holding formal research qualifications still constitute only a very small part of the total Norwegian labour force.

2.5 International comparison of higher education

International reports show an increasing demand for workers with higher education. Since the mid-1980s it has also been observed how the economic return of higher education has increased. However, the data from the OECD database Education at a Glance does not indicate that this is the case for Norway.

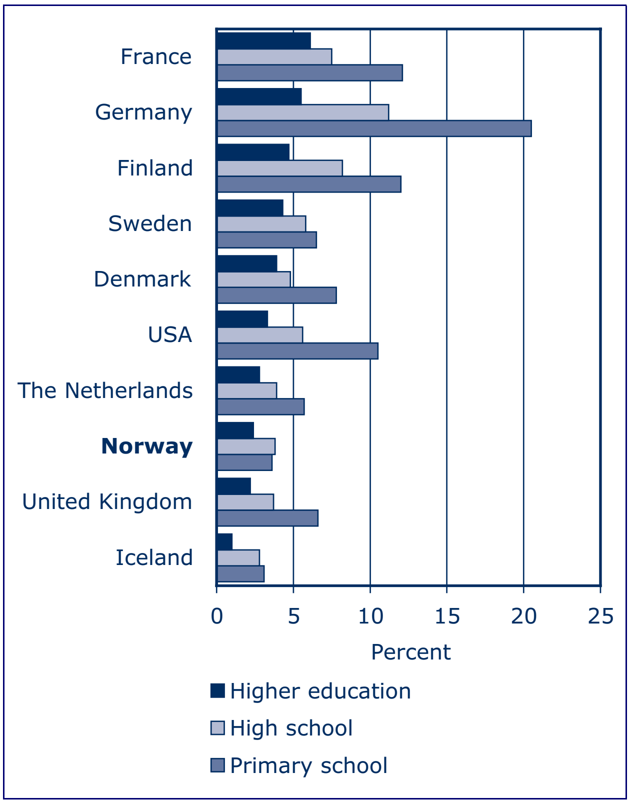
Today Norway is one of the countries in the world with the highest educational level. The tendency towards getting higher education has not only increased in Norway the last 10–20 years, but also in many other countries. Because of this, we cannot take it for granted that Norway will keep its position as one of the countries in the world with the highest educational levels. Figure 2.18 shows the share of the youth population that will complete higher education. According to this indicator, countries like Denmark, Great Britain and Iceland, which today have a lower educational level than Norway, are experiencing a stronger tendency among young people towards getting a higher education. Over time these countries may attain a higher educational level than Norway.

Figure 2.18
Calculated proportion of age cohort (the typical age of graduation) which completes higher education in selected OECD countries in 2004.



Source: OECD – Education at a Glance 2006

Figure 2.19
Unemployment rate in selected OECD countries in 2004 by educational level.



Source: OECD – Education at a Glance 2006

Comparing the share of the youth population in Norway that starts on a course of higher education within the highest level of education – ISCED 5A/6[1] – with the corresponding share in selected OECD countries, gives a picture that is more advantageous for Norway. In this context Norway is number four on the list, just behind Sweden, Iceland and Finland.

The recent period of strong economic growth in Norway has led to a very low unemployment rate, especially for employees with higher education. In 2007 only 0.9 percent of the employees with a lower degree and 0.7 percent of employees with a higher degree, were unemployed.

Figure 2.19 shows the unemployment rate by educational level in selected OECD countries in 2004, which is the last year for which comparable data are available.

In spite of the high educational level in the Norwegian workforce, Figure 2.19 shows that the unemployment rate among workers with higher education still is much lower in Norway than in other countries. Only 2.4 percent of the workforce with higher education was unemployed in 2004. But the figure also shows that unemployment was generally lower in Norway than most other countries. The probability of unemployment for workers with higher education relative to the probability for workers without higher education was higher in Norway than in the other countries, with the exception of Sweden. This can indicate that the high educational level in Norway has led to higher unemployment among workers with higher education. Also, over time, the difference in the unemployment rate between those with and those without higher education has diminished.

The wage premium for workers with higher education is much lower in Norway than in most other countries. This is a traditional part of the Norwegian welfare model with high emphasis on income equity, and cannot be explained by the high educational level. National studies have found that the wage premium has increased also in Norway. Nevertheless, the benefits of investing in higher education will not be as obvious in Norway, as in other countries.

[1] ISCED (International Standard Classification of Education) 6 corresponds to education at PhD level. ISCED 5A is education at a high theoretical level that gives access to PhD education, while ISCED 5B mainly is vocationally oriented education lasting 2 years or more.

3 Cooperation in R&D and Innovation

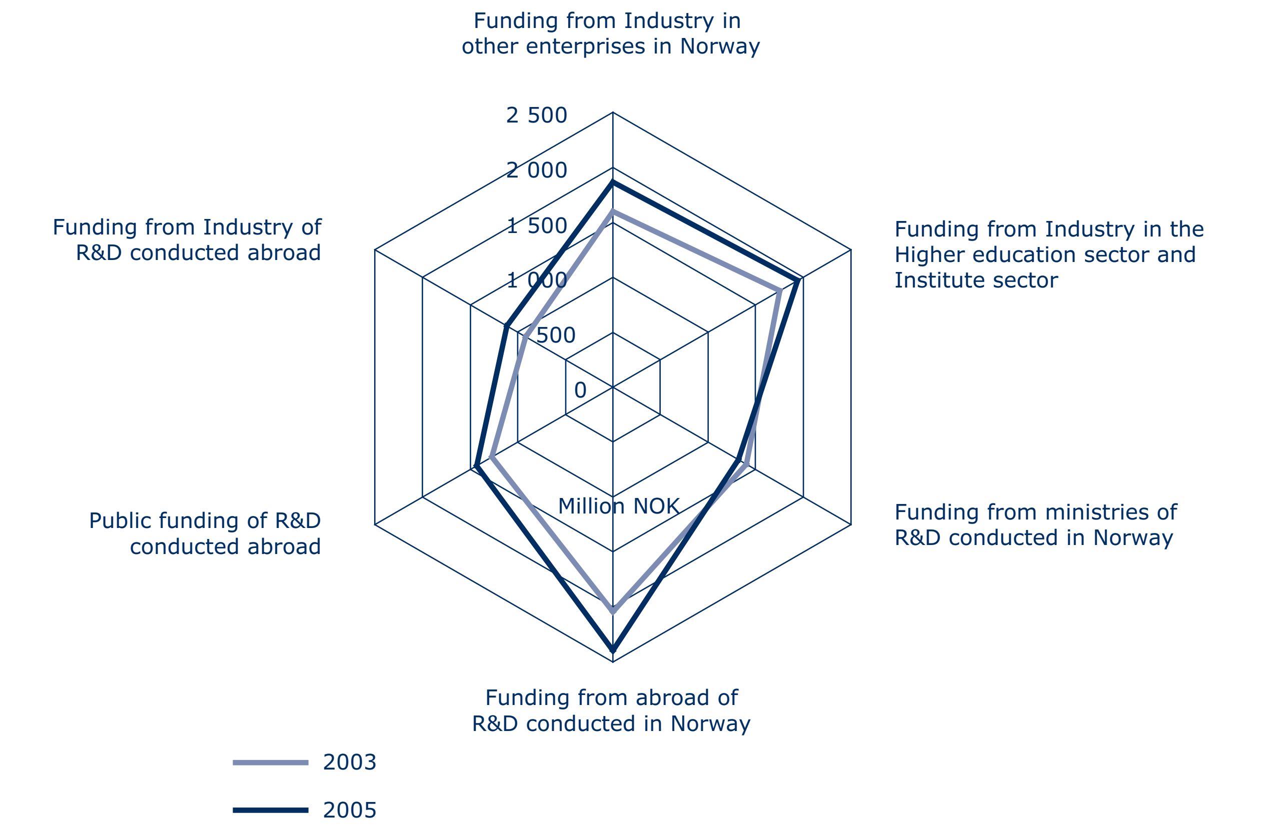
Research, development and innovation are not isolated activities that take place apart from the rest of the world. Rather there is an extensive interaction with the surrounding environment, but in different ways and with different intensities. These are the relations that contribute to the establishment of what we refer to as the research and innovation *system*. While the rest of this report describes activities and resources in the different parts of this system, chapter 3 addresses indicators that say something about the interaction and cooperation between the different parts of the research and innovation system.

Interactions and relations are important for many reasons. For instance, they influence the likelihood of innovation processes succeeding by supplementing other elements of contribution. Thus the analysis of the relationship between input and output will be incomplete if interaction and cooperation are not taken into consideration. Also, major parts of public politics focus on strengthening relations and knowledge transfer between different actors in order to get the most out of investments in competency. To be able to evaluate the policy, it is therefore necessary to have an understanding of and good indicators for innovation.

3.1 Cooperation in R&D and Innovation

Cooperation in R&D and innovation is mainly based on formalised cooperation between different participants, but informal contact and networking between the industry, universities and university colleges and research institutes, together with exchange or loan of personnel, is also of great importance in this context. In the Oslo Manual (OECD 2005) different forms of interaction and cooperation are described. Included here are open information sources without any substantial costs, buying technology, consultancy services, contract research and cooperation relations where both parties actively contribute.

Figure 3.1
Resources used on R&D cooperation in 2003 and 2005 by funding source.



Source: NIFU STEP, Statistics Norway/R&D statistics

On the basis of the R&D statistics, in this chapter we have calculated the transfer of resources in relation to R&D activities.

Altogether NOK 10.7 billion were transferred in 2005, intended for purchasing and funding of R&D across the three sectors and abroad. Funding of R&D cooperation conducted in Norway amounted to NOK 8.2 billion, while Norwegian funding of R&D conducted abroad amounted to NOK 2.5 billion in 2005. The last part covers foreign aid projects and membership fees for international organisations like the Framework Programmes of the European Commission, CERN and ESA. This funding is in addition to the total amount of NOK 29.6 billion spent on R&D in Norway in 2005.

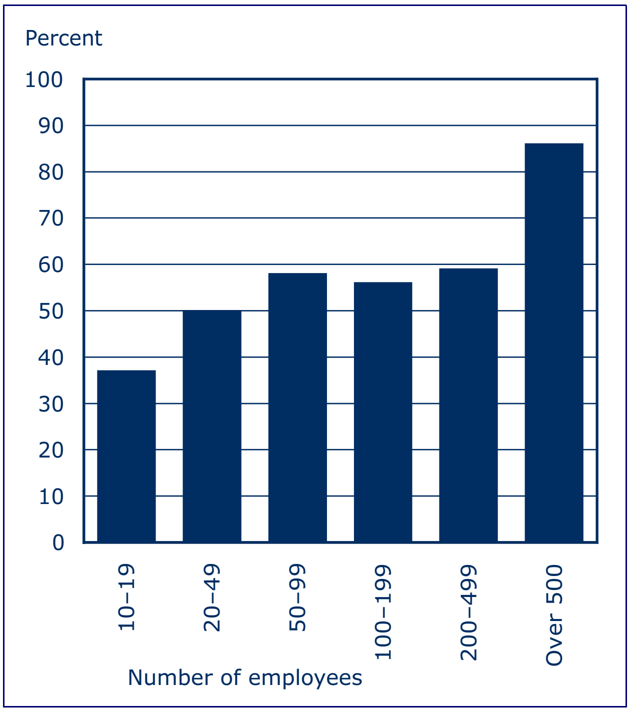
The Industrial sector spent NOK 3.8 billion buying R&D from other Norwegian companies, funding R&D projects in the Higher education sector and in the Institute sector. Funding of R&D cooperation from public sources and foreign sources amounted to NOK 2.0 billion and NOK 2.4 billion respectively in 2005.

From 2003 to 2005 the total amount spent on R&D conducted in Norway and abroad with Norwegian funding increased by more than NOK 1 billion or 12 percent. In this period the funding of R&D from abroad and the Industrial sector's purchase of R&D from Norwegian companies both increased by 17 percent. It was, however, the Industrial sector's purchase of R&D from abroad that increased the most: by 22 percent. Funding of R&D conducted in Norway by the European Commission decreased from 2003 to 2005, and constituted less than 20 percent of the total foreign funding of R&D in Norway in 2005. Public funding of R&D conducted in the Industrial sector also decreased from 2003 to 2005.

3.2 Cooperation in R&D and innovation in the Industrial sector

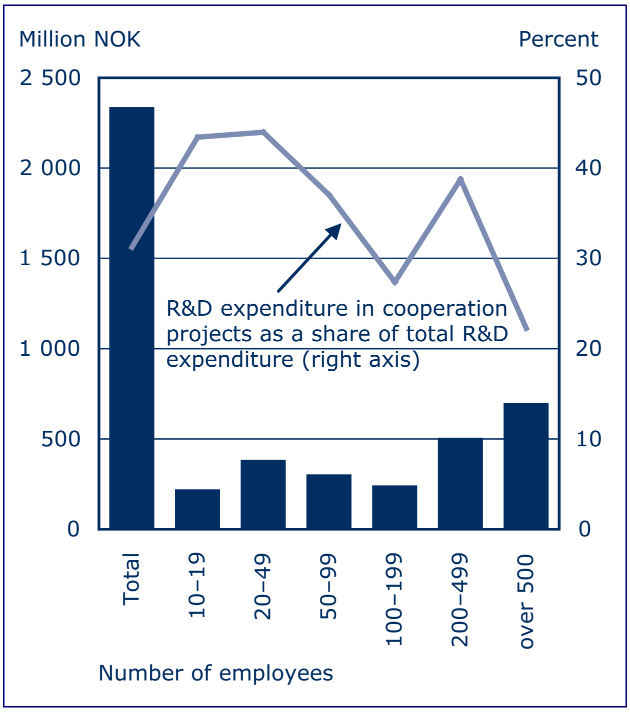
Chapter 3.2.1 is about cooperation on R&D in the Industrial sector, based on the 2005 R&D Survey. In chapter 3.2.2 results from the 2004 R&D and Innovation Survey are examined, where the cooperation is on innovation projects. Hence, results for the two years are not comparable.

Figure 3.2
Share of enterprises with R&D cooperation in 2005 by size group.



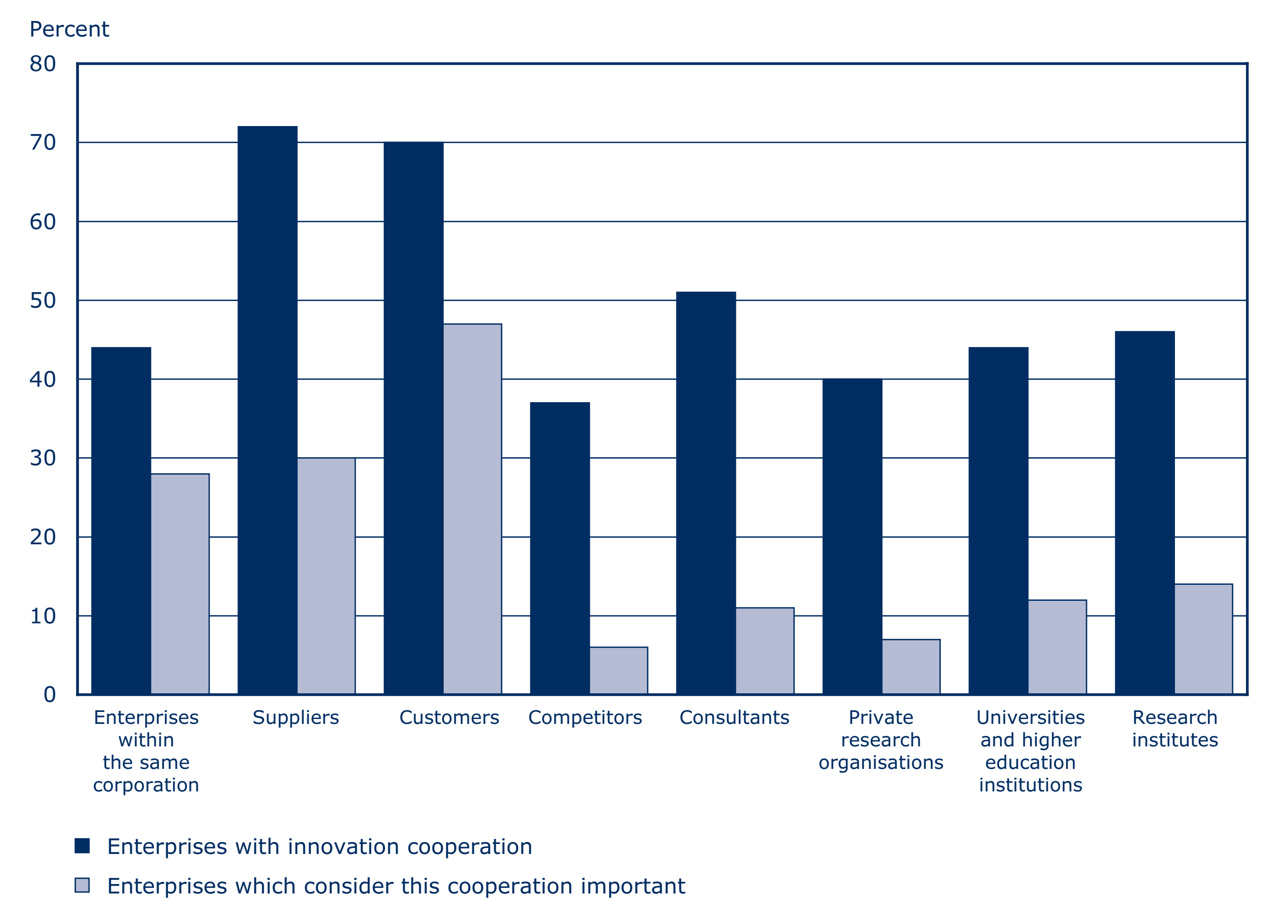
Source: Statistics Norway/R&D statistics

Figure 3.3
R&D expenditure in cooperation projects in 2005 by size group (left axis). R&D expenditure in cooperation projects as a share of total R&D expenditure in 2005 (right axis).



Source: Statistics Norway/R&D statistics

Figure 3.4
Cooperation partner and important cooperation partner in 2002–2004. Percent of enterprises with innovation cooperation.



Source: Statistics Norway/Innovation Survey

3.2.1 Cooperation in R&D in the Industrial sector

Half of all R&D enterprises cooperate with others, according to the 2005 R&D Survey. In mining and manufacturing, 52 percent of all enterprises with R&D reported having cooperated on R&D projects in 2005, while the corresponding figure for the service industries was 26 percent. In some industries practically all enterprises cooperated with others on R&D. Large companies report having cooperated on R&D more frequently than smaller companies, see figure 3.2.

R&D cooperation means active participation in joint R&D with other organisations – either other enterprises or non-commercial institutions. It does not necessarily imply that both partners derive immediate commercial benefit from the venture. Pure contracting out of work, where there is no active collaboration, is not regarded as cooperation.

Suppliers were the most frequently cited cooperation partner: 64 percent of all enterprises with R&D cooperation reported this. 62 percent reported customers and clients as a partner, while 47 percent cooperated research institutions.

As much as 93 percent reported having cooperation partners in Norway. Many companies also found their partners elsewhere; partners in the Nordic countries and the EU were reported by 39 and 40 percent, respectively. A share of 19 percent had partners in the USA, and 19 percent cooperated with partners from other countries.

In the 2005 survey, the respondents were asked about the share of their total R&D expenses spent on cooperation projects. Although half of all R&D enterprises reported having such projects, only 17 percent of the Industrial sector's total R&D expenditure – just over NOK 2.3 billion – were spent on cooperation projects. This in turn means that each R&D cooperating firm spent 31 percent of their R&D expenditure in cooperation with others.

3.2.2 Cooperation in innovation activities in the Industrial sector

The 2004 Innovation Survey addressed innovation cooperation in the Industrial sector. The survey shows that this kind of cooperation is quite common. A successful innovation project often requires the enterprise to cooperate with other parties, and 33 percent of the innovative enterprises had such cooperation agreements.

Suppliers are most frequently cited as partners. A 72 percent share of all enterprises cooperating with others report they have this form of cooperation agreement, while 29 percent assess that cooperating with suppliers is vital to their innovation project. Customers are almost as frequently used as partners in such agreements – 70 percent report this – and cooperation with customers is the form of agreement most frequently reported as vital to the project (42 percent state this).

Consultants are cited as partners by 51 percent, while government and private research organisations are reported by 48 percent and universities and higher education institutes are reported by 44 percent. Shares of 11, 14 and 12 percent, respectively, assess these cooperation arrangements as vital to the enterprise's innovation project. This is illustrated in figure 3.4.

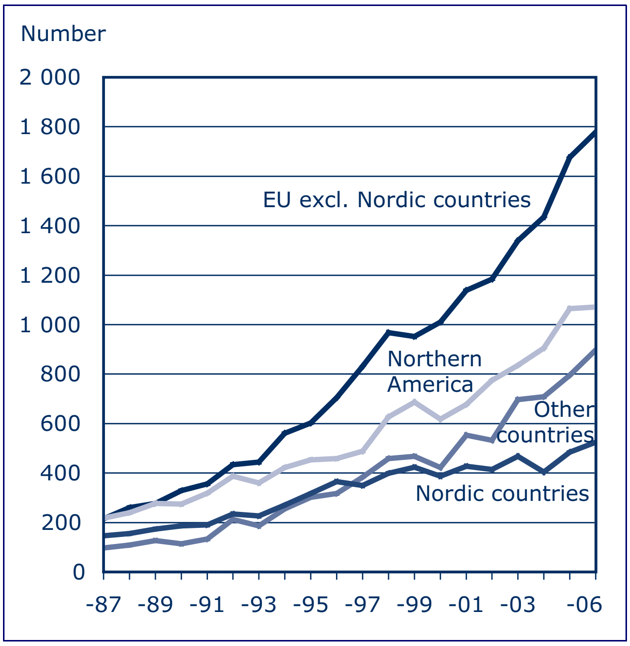
There are, however, some differences between enterprises of different sizes, when it comes to choosing partners for cooperation agreements. While consultants are reported as partners by roughly half of all enterprises regardless of size, research organisations and universities and higher education institutes are much more frequently used by the larger enterprises. Among enterprises with more than 500 employees, 73 percent cite the former as a partner, while 70 percent cooperate with universities and higher education institutes.

3.3 International collaboration in publications

International collaboration in R&D can be observed in scientific journals that have co-authors in different countries. The authors have to state their address in the journals, and this information is then registered in the bibliometric databases at Institute for Scientific Information (ISI).

Through ISI, NIFU STEP has obtained data about 85 208 scientific articles that were registered at ISI during the twenty years from 1987 to 2006, and that

Figure 3.5
Number of articles with international collaboration by geopolitical region in 1987–2006.



Source: Science Citation Index

have at least one author address registered in Norway. This is the majority of all the articles published by Norwegian researchers in international scientific journals during this period.

An increasing share of these articles also has author addresses in other countries. In 1985 there was international co-authorship in 23 percent of the articles. Ten years later this share had risen to 40 percent, and in 2005 52 percent of the articles had combinations of Norway and other countries in the addresses. The strongest increase was during the 1990s. In recent years the share has remained stable at just above 50 percent. There has also been a strong increase in the number of Norwegian articles in this period: from 2 700 in 1987 to 6 600 in 2006.

In spite of this increase, Norway's proportion of all scientific articles indexed at ISI has remained relatively stable at 5–6 per thousand during the whole period. Norwegian co-authored articles also belong to other countries. In addition world production has also increased, and this is to a great extent due to an increasing co-authorship in every country's articles. The proportion of such articles is higher in small countries than in large countries, but it has increased in every country. The tendency of international integration in the research publication is in itself international.

As in every other Western country, the USA is the largest collaborator for Norway. This should be seen in relation to the fact that USA is the world's largest research nation measured in the number of ISI articles. Our Nordic neighbours have higher proportions of Norway's co-authored articles, than they have of the world production of ISI articles. The Nordic countries are thus close collaborators for Norway. China and Japan are examples of the opposite.

Twenty years ago five countries dominated the Norwegian collaboration articles: USA, Sweden, Great Britain, Germany and Denmark. These are still the most important collaboration countries, but the collaboration profile of Norway has broadened in recent decades and now includes co-authorship with scientists in most countries that are active in research.

Figure 3.5 shows the number of Norwegian collaboration articles divided into four geopolitical regions. If the collaboration is only with Denmark, Finland or Sweden, the articles are counted in the Nordic countries category, which also includes Iceland. USA and Canada are included in the North-America category. The figure illustrates that EU is now more important than North America in the international collaboration related to Norwegian research. This change is particularly notable from 1994 and can be related to the Norwegian participation in the EU Framework Programmes from the mid-1990s. The strong historical tradition of internal Nordic collaboration has lost much of its weight within a broader collaboration profile.

In recent years there has also been a considerable increase in collaboration with countries outside the three main geographical areas. At the same time the relative importance of the three main areas has changed.

3.4 Norway's participation in the EU Framework Programme

This section focuses on Norwegian participation in projects supported by the EU Framework Programme on Research and Technological development. This is the world's largest research cooperation. The 7th Framework Programme amounts to 50.5 billion Euros.

As a member of the European Economic Area agreement (EEA), Norway has participated in this cooperation since the 4th Framework Programme in 1994. The contingent for participation among the EEA countries is related to GDP. The Norwegian financial contribution for the 6th Framework Programme was about NOK 660 million per annum. For the 7th Framework Programme it will cost about NOK 8.9 billion or NOK 1.28 billion per annum on average.

The results of the Norwegian participation in the Framework Programme have been very good. This is shown in several evaluations. The 6th Framework Programme has been a far-reaching programme consisting of seven thematic priorities and nine horizontal activities.

As of April 2007 Norwegians had participated in 2 490 applications, 1 724 of which came under the thematic priorities and 766 under the horizontal activities. Of these 749 were recommended for grant. This gives a Norwegian success rate of 30 percent; this is 10 percent higher than EU average.[1] There were especially many Norwegian applications within Information Society Technologies, while Sustainable Transport Systems had the highest success rate.

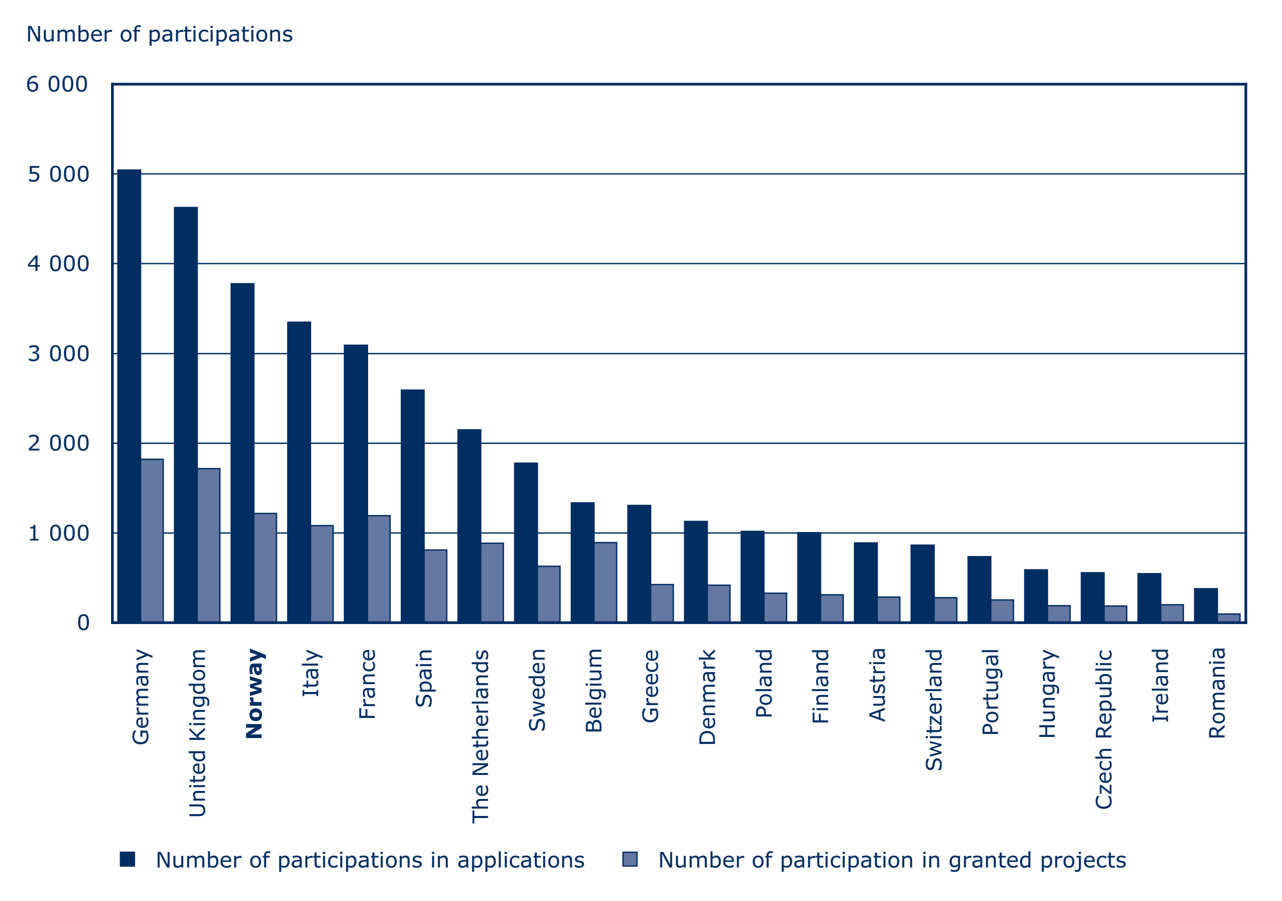
The international dimension of the programme is considerable. Norway's participation entails cooperation with 105 countries. Cooperation is primarily with the 15 old EU countries, then with the 10 new plus Switzerland, and a relatively smaller share with other European countries. Cooperation with non-European countries is sparse and of smaller volume.

Figure 3.6 shows the 20 most frequent countries of cooperation with Norway according to number of applications and granted projects. The number of granted projects compared with applications is especially high for projects with Belgium, but also for the Netherlands, France, Denmark and Great Britain. Germany is the most frequent cooperation partner both when it comes to applications and granted projects. This has both historical reasons and is related to the country's size. Relative to population numbers, the results are different. Cooperation with other Norwegian partners is naturally the most frequent, followed by cooperation with researchers in Denmark, Sweden, Finland, Ireland, the Netherlands, Belgium and Greece.

When it comes to a sectorial division of the Norwegian participation in granted projects, the Institute sector has the highest share with 35 percent of the participations, followed by the Industrial sector with 29 percent, the Higher education sector with 25 percent and 11 percent other participations. The last category includes participations by public services and different organisations. Relative to the number of applications, it is also the Institute sector that has the

1 These figures do not include the Marie Curie activities and EURATOM projects.

Figure 3.6
Norway's 20 most important countries[1] of cooperation in EU's 6th Framework Programme.



[1] Based on number of applications by April 2007.

Source: The Norwegian Research Council/The EU Commission

highest share of granted applications followed by others, the Industrial sector and the Higher education sector.

3.5 Norwegian co-patenting in Europe

Economic agents rarely innovate on their own. Innovation tends to involve cooperative efforts that bring together different types of knowledge from different places. Co-patenting, in which different agents participate in the same patent application, provides potential insight into this increasingly prevalent form of collaboration. This section presents two types – or levels – of this kind of patent-oriented cooperation.

(i.) Type 1: the relationship between multiple agents who are co-applicants in a patent application. Cooperation between applicants indicates cooperative effort in the development and/or utilisation of the invention

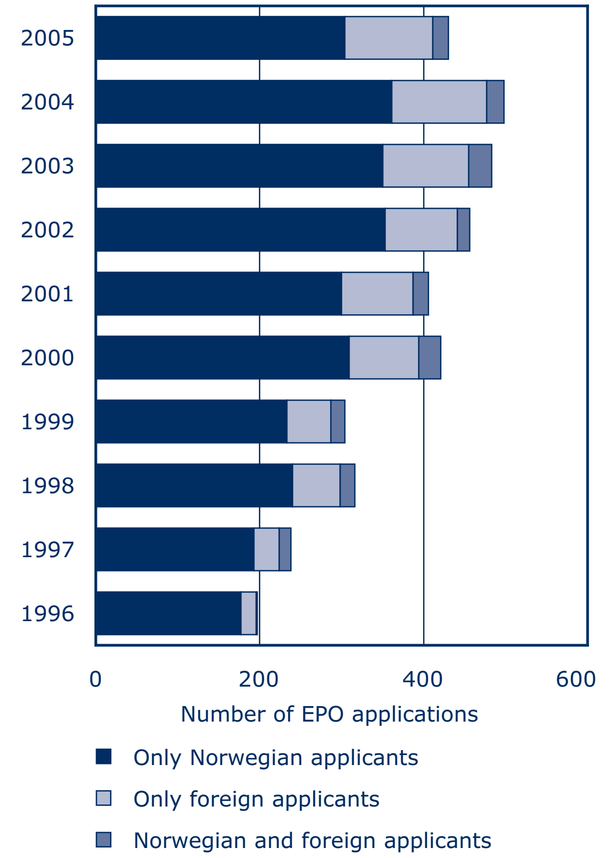
(ii.) Type 2: the relationship between applicant(s) and inventor(s). The relationship implies cooperation or transfer of knowledge between inventors and the applicant(s).

The focus here is on Norwegian applications filed with the European Patent Organization (EPO). The publication date at the EPO lays the basis for the ten year period, 1996–2005.[2] The presentation is based on European patent applications (EP-A) involving Norwegian actors; i.e., applications with at least one applicant and/or inventor with a Norwegian address.

EPO applications involving Norwegian actors increased from 205 in 1996 to 430 filings in 2005, with a peak of nearly 500 in 2004. Co-patenting

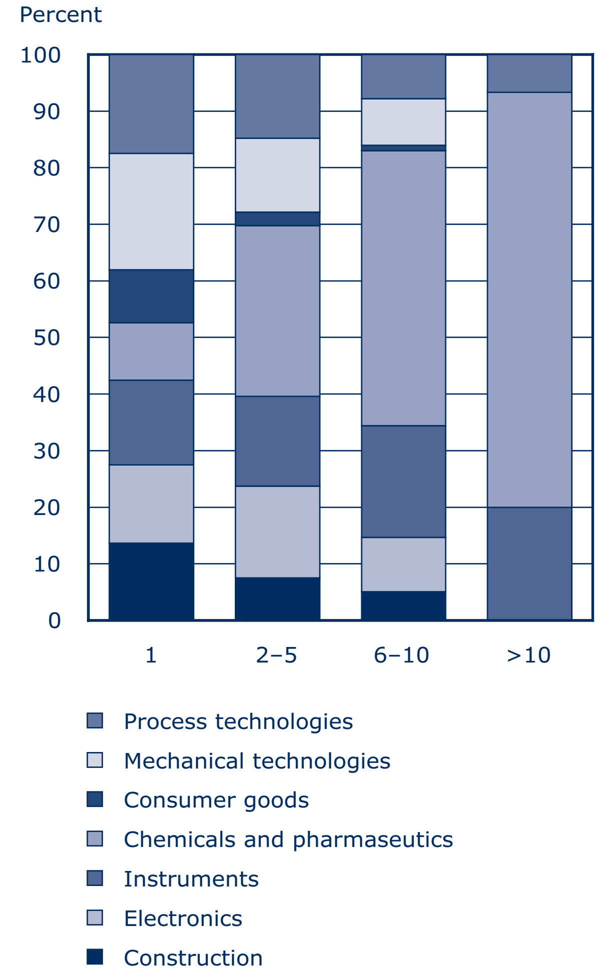
[2] Norway formally becomes part of the EPO system in January 2008. Applications filed with the EPO before then will generally reflect earlier, typically first-filings in Norway with priority dates which are significantly earlier.

Figure 3.7
European filings involving Norwegian actors in 1996–2005 by category of applicant(s).



Source: Data from Questel (February 2006) compiled by NIFU STEP.

Figure 3.8
Norwegian EPO filings in 1996–2005 by technological area and number of inventors per application.[1]



[1] Four applications lack inventor data.

Source: Data from Questel (February 2006) compiled by NIFU STEP.

involving co-assignees (Type 1) is found in a minority of these filings. The rate of co-patenting of this type remains stable at about 20 percent throughout the period. Those involving two applicants and those involving three or more applicants make up 9 and 1 percent of the total, respectively.

These 'Norwegian' filings at the EPO fall into three categories as presented in Figure 3.7:

Applications involving only Norwegian applicant(s); applications involving only foreign applicant(s) but with at least one Norwegian inventor; and applications with at least one of each.

Figure 3.7 indicates that Norwegian filings at the EPO generally involve Norwegian applicants. During the period, 76 percent involved one or more Norwegian applicants, while five percent involved a mix of domestic and foreign applicants. The remaining 19 percent feature a combination of foreign-only applicants but at least one Norwegian inventor. Norwegian private individuals (no affiliation provided) are most prevalent among co-assignees, followed by Norwegian firms, foreign firms (often an international corporation), and foreign private individuals. A small minority explicitly involves both domestic and foreign actors at public research organisations.

From this angle, the form of co-patenting that grew fastest in the period was the combination of foreign applicants and at least one Norwegian inventor. Co-patenting in chemicals and pharmaceuticals, particularly, exhibits a number of interesting features. This area makes up the largest group of filings at the EPO with Norwegian involvement (N=856), it involves the greatest number of applicants per application (1.2 per application) in the population, it is the fastest growing, and with 63 percent it has the lowest level of Norwegian involvement on the applicant side.

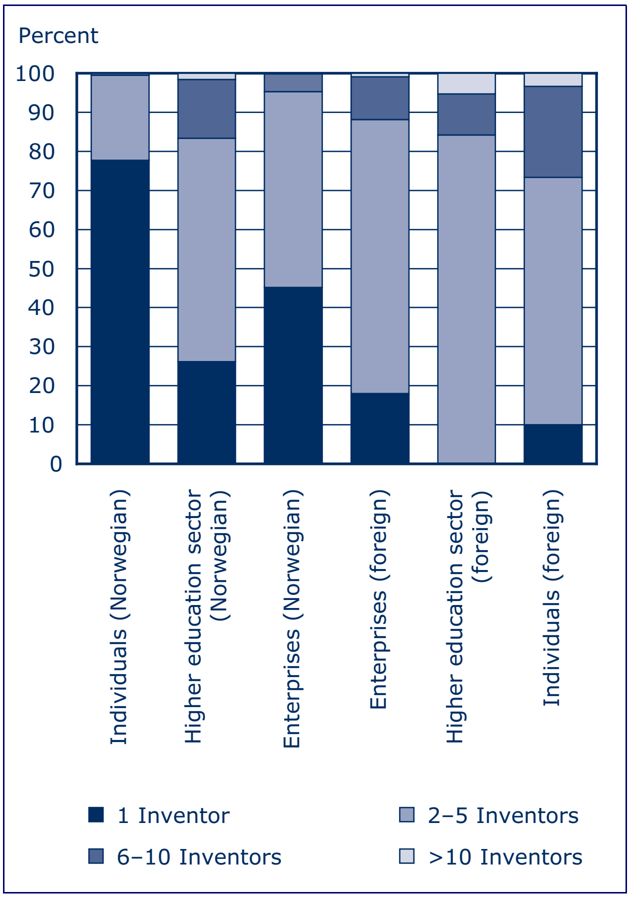
The more general tendency is that the number of inventors per application grows rapidly through the period, especially from 1999 onwards. The increase is again technology specific, with the average number of inventors increasing most in process technologies as well as in chemicals and pharmaceuticals. Figure 3.8 shows that three technological areas are more inventor-intensive, namely chemicals and pharmaceuticals, instruments, and electronics. The remaining areas are dominated by single-inventor applications.

The most inventor-intensive applications are again found in the chemical and pharmaceuticals area, with as many as 20 inventors on the same application. This type of collaboration (Type 2) involving multiple inventors per application is also relatively common in instruments and process technologies. Figure 3.9 illustrates that applications with multiple inventors also vary according to who the primary applicant is. It distinguishes between six categories of primary applicant as correlated by the number of inventors.

The figure shows that the majority of applications with a single inventor also have a single applicant. These make up a large proportion of the applications filed by private individuals.

More than half of the filings with a Norwegian firm as the primary applicant involve multiple inventors. The proportion is higher for public research organisations, which are more likely to be in the chemicals and pharmaceutical area. Overall, the increase in co-patenting in Norwegian filings at the EPO tends to be down to Type 2 collaborations involving foreign applicants and one or more Norwegian inventors.

Figure 3.9
Link between primary applicants and number of inventors in 1996–2005.[1]



[1] Four applications lack inventor data.

Source: Data from Questel (February 2006) compiled by NIFU STEP.

4 Results from R&D and Innovation

Documentation of the usefulness and results of research and innovation activities is given a great deal of attention both in national and international institutions and in public and private budget processes. In Norway different types of result indicators have been of great importance both in connection with the new incentive-based financing in the Higher education sector, and in the discussion of a new financing system in the Institute sector. In the EU, with contributions from the OECD, some major projects are underway to monitor and coordinate the development of research and innovation policy at both national and regional level. The goal is to encourage EU members to develop national research and innovation political strategies that are in accordance with the policy of the European Commission. The purpose is increased quality of life, welfare, employment, solidarity, economic and sustainable development and competitiveness.

Norway too has seen an extensive effort in the last few years to establish different arrangements specifically in order to raise the quality of Norwegian research. Some of the arrangements that merit mention in this context are for instance the 21 Centres of Excellence (13 established in 2002, eight in 2006), 14 Centres for Research-based Innovation (established in 2006), and six clusters within the Norwegian Centres of Expertise programme (established in 2006).

This chapter presents established results indicators for knowledge production and innovation.

4.1 Publications and citations

This section presents various bibliometric indicators on the performance of Norwegian science. The indicators measure two basic parameters: 1) the extent of publishing in international scientific journals, and 2) the extent to which these papers have been referred to or cited in subsequent scientific literature. In turn, these indicators represent indirect measures of knowledge production and of scientific impact and international visibility. Through a bibliometric survey information is thereby provided on the structure and output of the nation's research system. The indicators are based on data provided by Thomson Scientific (formerly Institute for Scientific Information, ISI), the producer of the most important database for bibliometric purposes.

Table 4.1
Scientific publishing in 2006 in selected countries.

Country	Proportion of world production[1]	Number of articles per 1000 capita	Relative citation index[2]
Switzerland	1.5	2.26	145
Sweden	1.5	1.84	123
Denmark	0.8	1.64	135
Iceland	0.0	1.60	135
Finland	0.7	1.59	120
Israel	0.9	1.51	111
Norway	**0.6**	**1.46**	118
Netherlands	2.1	1.44	132
Canada	3.9	1.37	116
Australia	2.4	1.35	108
New Zealand	0.5	1.30	99
UK	6.8	1.28	125
Belgium	1.1	1.22	122
Ireland	0.4	1.03	104
Austria	0.7	1.02	117
USA	25.8	0.99	135
Germany	6.4	0.88	119
France	4.5	0.83	110
Taiwan	1.5	0.73	74
Greece	0.7	0.73	83
Spain	2.7	0.71	101
Italy	3.5	0.68	107
Czech Republic	0.5	0.58	81
Japan	6.3	0.56	91
Portugal	0.5	0.55	90
Korea	2.1	0.48	80
Hungary	0.4	0.45	94
Poland	1.2	0.34	74
Turkey	1.2	0.19	49
Russia	1.8	0.14	57
Brazil	1.5	0.09	67
Mexico	0.6	0.06	67
China	6.1	0.05	73
India	2.3	0.02	60

1 Number of articles 2006 divided by the sum of all countries' article production

2 Based on the publications from the period 2002–2006 and the citations to these publications. The index for each country has been weighted according to the countries' relative field distribution of articles.

Source: National Science Indicators Thomson Scientific/ NIFU STEP

4.1.1 Scientific publishing and citations – overall figures

The USA is the world's largest scientific nation and accounted for 26 percent of the global production of publications in 2006 measured as the sum of all countries' production, cf. Table 4.1. Then follow four countries with proportions above 5 percent: UK, Germany, Japan, and China. It is worth noting that China has doubled its number of publications in no more than five years and will probably soon take over as the world's second largest scientific nation.

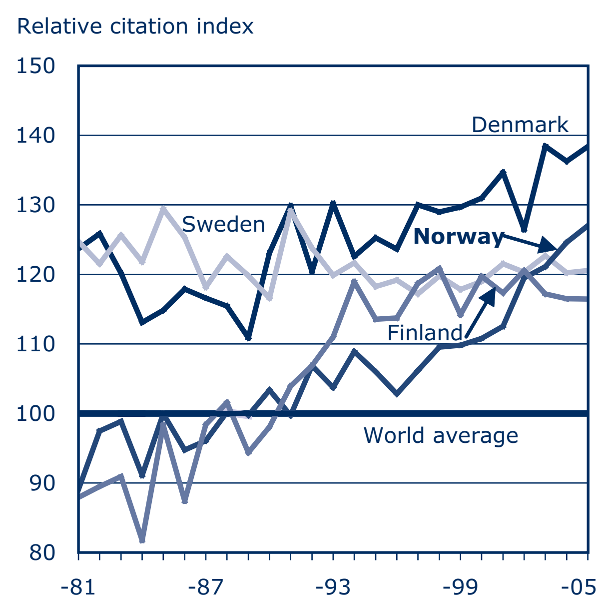
Norwegian researchers published 7 200 scientific articles in 2006, representing approximately 0.6 percent of the world production of scientific publications. This percentage has remained fairly stable in recent decades. Measured as number of articles per 1 000 capita, Norwegian scientists produced 1.46 articles this year. Norway thus ranks as number 7 among the nations shown in Table 4.1. Among the Nordic countries, however, Norway has the lowest per capita production. Here, Sweden is by far the largest scientific nation with a total number of articles that is almost twice as large as that of the next ranking country, Denmark.

Table 4.1 also shows an overall citation indicator for the countries. In absolute numbers the countries with the largest number of articles also receive the highest numbers of citations. It is however common to use a size-independent measure to assess whether a country's articles have been highly or poorly cited. One such indicator is the relative citation index showing whether a country's scientific publications have been cited above or below the world average (=100). Because there are large differences in the citation rates among different scientific disciplines a country's overall citation rate will depend upon the relative distribution of its papers within different scientific disciplines. A relatively large number of papers within highly cited fields would significantly increase a country's overall level of citations. In order to account for such differences the relative citation rates are weighted according to a worldwide (average) field distribution of articles. This then gives an indicator that allows direct international comparisons.

In terms of citations Norway ranks 11th of the countries in Table 4.1, with a relative citation index of 118. This means that the Norwegian publications were cited 18 percent above average. For a long time Norwegian publications have been cited below the world average. This is evident from Figure 4.1, which shows the annual relative citation index for four Nordic countries for the period 1981–2006. It

Figure 4.1

Relative citation index for four Nordic countries in 1981–2005.[1]



[1] Based on annual publication windows and accumulated citations to these publications. The index for each country has been weighted according to the countries' relative field distribution of articles. The index for 2005 is more uncertain than for the other years due to a short citation period.

Source: National Science Indicators Thomson Scientific/ NIFU STEP

was not until the middle of the 1990s that Norway passed the world average. Switzerland is the nation that has the highest scientific impact measured by citations. Swiss articles were cited 45 percent above the world-average for the period 2002–2006. Then follow three countries with a citation index of 135: USA, Denmark and Iceland.

The general tendency is that the differences in citation rates between the countries have been reduced over the period. At the beginning of the 1980s there was a gap between Sweden and Denmark on the one hand, and Finland and Norway on the other. Norway has been improving, particularly since the mid-1990s. Just as striking is the rapid increase in the citation rates of Finnish articles during the 1990s. The scientific production of Sweden and Denmark has been highly cited during the entire period, although there has been a moderate decline in Sweden. The reason for Norway's improved position at the end of the 1990s has not been analysed in detail. Apparently, clinical medical science in particular has contributed to the positive trend for Norway. Also we find a considerable increase in the share of international co-authorship during the period and these articles are generally more highly cited than the articles authored by Norwegian scientists alone. Thus, the increase in international collaboration seems to have contributed to improving the impact of the research.

4.1.2 Fields of science

Norway has a distinct scientific profile. This is reflected in the so-called "specialisation index". This index states whether a country has a higher or lower proportion of its publications in a particular subfield than the average for all countries. A strong specialisation in a particular field does not necessarily imply a high citation rate, or vice versa. Generally, Norway has a relative high publication activity in the geosciences and biology. In contrast, there is a de-specialisation in the "hard" sciences physics, chemistry and engineering. This scientific profile has its roots in historical traditions and has been described as a "bio-environmental model", that is, the pattern most typical for developing and more 'natural' countries (e.g. Australia or South Africa) with biology and earth and space sciences being the main focus.

In biology Norway has a particularly strong specialisation in aquatic sciences, ecology/environment and animal science. In biomedicine and clinical medicine the picture is heterogeneous. We find a positive specialisation in clinical medicine and particularly in dentistry, while in biomedicine the overall publication proportion is slightly lower than "expected". In chemistry, physics and engineering the Norwegian proportion of the world production is very low, a characteristic that has remained a part of the Norwegian scientific profile for a long time.

The citation rates also show large variations among the different disciplines. Analysing citation frequencies of articles published in the period 2002–2006, we find a particularly strong performance with a citation rate of 30 percent or more above the corresponding world average in the following disciplines: environment/ecology, clinical medicine, mathematics, engineering, and computer sciences.

4.2 Patent indicators

This section presents a general snapshot of the level of Norwegian patent activity at the European Patent Office (EPO). Norway formally joins as a full-member of EPO in 2008[1] as essentially the last European country to do so (see also blue box). The brief presentation complements a detailed presentation[2] that documents Norwegian patenting on the eve of its transition to the regional patent regime. An additional presentation of current patterns of cooperation of Norwegian actors in EPO patenting is found elsewhere in this report (3.5). As a result, the next round of the report will provide a more complete presentation of Norwegian patenting.

Patent statistics have long been used as an indicator of the level and orientation of technological innovation. Patents indicate inventive activity with a presumed potential for commercial application. There are several dimensions to the indicator. The most common distinction runs between the patent applications, where the claim of inventiveness remains unverified by the patent authority. In this case, there is greater uncertainty about the innovative content of the indicator, but the indicator is more current. The inverse case is that of the patent grant, where the claim to novelty has been tested. The trade-off is that the granting process entails a considerable time-lag (typically 3–5 years). This lag detracts from the currency and thus the value of the indicator, particularly in fast-moving fields.

Patent applications and grants are traditionally seen as an output indicator of innovative activity.

The Norwegian transfer to the European Patent Convention

The main purpose of the European Patent Convention (EPC) is to make it possible for one patent applicant with one application to gain patent in those countries that are members of the Convention. The negotiation of the EPC was finished in 1973 and came into force in 1977. Norway participated in the negotiation of the Convention and signed on October 5th 1973, but has still not ratified it.

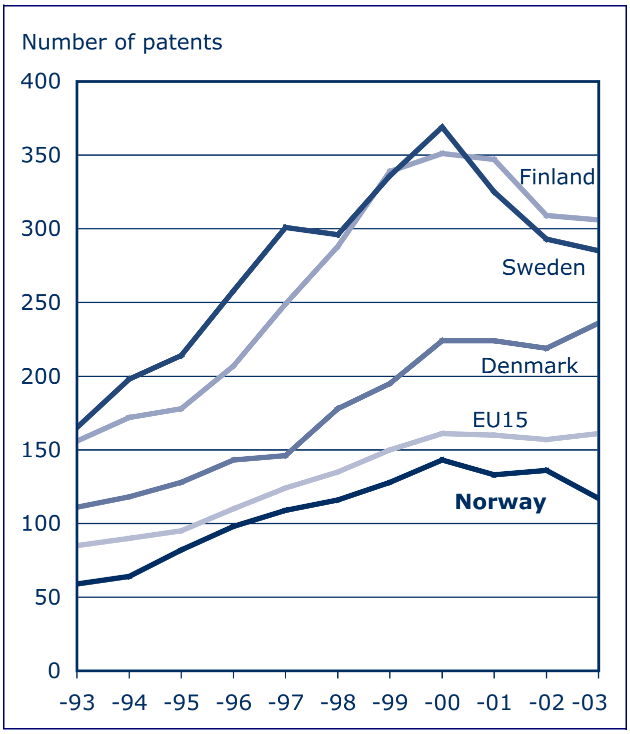
The Ministry of Trade and Industry has now initiated a Norwegian approval to the EPC. It is supposed to be put into effect in January 2008, more than thirty years after the issue was raised for the first time. There have been several reports and hearings during these years.

The patent directive of the EU was included in the European Economic Area agreement (EEA) in 2003 and then carried out in the Norwegian court. The material patent legislation was completely harmonised with the EPC. Norway is obliged to have the same rules for patenting as the EPC.

1 That is a signatory of the European Patent Convention (EPC).

2 Delrapport 1/2007 of the original Norwegain report.

Figure 4.2
Number of patents applied for at the European Patent Office (EPO) in 1993–2003 per one million capita in the four Nordic countries and the EU15.



Source: Eurostat

However, patenting can also be regarded as representing an input factor, especially in cases where innovation processes are cumulative and involve multiple technologies. In addition, patent statistics are constrained by a series of other interpretation factors, such as the variation of the value of patenting, the variation in the propensity to patent across technologies. One of the most salient features of the patent-based indicators is the ability to track developments between countries and in technologies over time.

Figure 4.2 presents a general picture of patents applied for at the EPO for selected countries. It illustrates that patent intensity in Europe increased in the eleven year period ending in 2003.

The number of applications involving Norwegian applicants doubled in the period to 117 applications per million Norwegians in 2003. The average for the European-15 countries was by way of comparison 161 applications per million. The most patent-intensive countries by population in the group were Switzerland, Germany and the other Nordic countries. Norway, which was still not a member of the EPO in the period, is consistently among the least patent-intensive countries in the overall comparison. The general trend over time is a break in the strong growth of European patenting in 2000, followed by a relative stabilisation. The trend is different for different countries. The downturn in Sweden and Finland is consistent with the observation that the downturn in the first years of the millennium first and foremost affected information and communication technology. The Danish patent intensity continued to increase.

4.3 Results from Norwegian research institutes

Norwegian research institutes published over 2 000 scientific articles in 2006. Nearly 8 000 reports were published, 230 books and 1 830 chapters and articles in books were written. 44 patents were applied for, and 26 were granted. NOK 5 million was entered as licence income and nine new companies were established based on the activity of research institutes. In the last ten years, research institutes have published nearly 17 000 scientific articles, nearly 2 000 books and 86 000 reports.

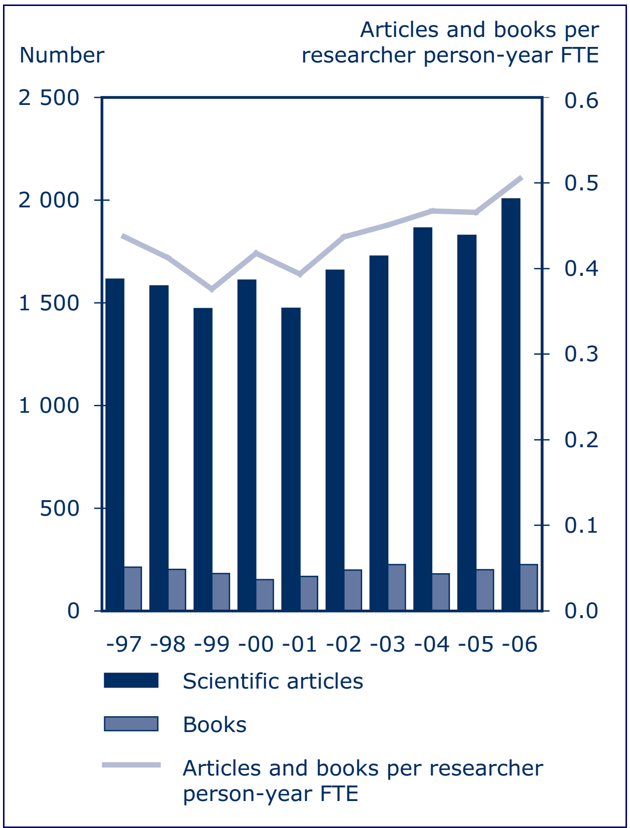
Norwegian research institutes and laboratories are a heterogenous group in terms of their mission, disciplinary focus, organisation and size. For a description of these insitutions, see Chapter 1.3.

The contribution of research institutes and laboratories to the academic community comes in different forms. Their primary contribution takes the form of the production of articles in scientific journals, books, and conference papers, and by providing students with the opportunity to take part in research while studying.

The number of articles published in refereed journals is shown in Figure 4.3. On average for the 1997–2006 period nearly 1 700 articles and 200 books were published annually. This includes specialised books, textbooks and other independent publications, and on average this corresponds to just over 0.4 articles and books per researcher person-year. The number of scientific articles has increased in recent years, but the number of published books has been stable. The same is also true for the number of publications per researcher person-year. Even though there are some variations from one year to the next, the main tendency is that nearly one article or book is published for every second researcher person-year during the whole period.

The production of scientific articles in refereed journals varies between the different groups of institutes. Most articles are written by the researchers at institutes in the primary industries. This group pub-

Figure 4.3
Articles and peer review journals and books authored by employees at Norwegian research institutes and laboratories in 1997–2006. Number of articles and books authored by researcher person-year FTE.



Source: NIFU STEP

lished 0.7 articles per researcher person-year. The corresponding number for the researchers at institutes in environmental or developmental research was 0.6, for institutes in social research it was 0.4, and 0.2 for researchers at institutes in technology and manufacturing industry. The average article production for the 1997–2001 and 2002–2006 periods shows that the biggest increase in the production of articles per researcher person-year was at the institutes in social sciences, and at the institutes in the primary industries. The two other groups did increase their production, but not by much.

The most usual result from a research assignment is some form of a report. These vary from extensive publications like books to relatively informal duplicated or online publications. Even though the total number of reports dropped from 9 500 to 8 000 from 1997 to 2006, reports are still the dominating type of publications at institutes. In relation to the number of researcher person-years, approximately 1.8 reports are produced per researcher person-year, while the corresponding number for scientific articles in refereed journals is 0.4. Most reports per researcher person-year are produced at institutes in technology and the manufacturing industry: 2.2 reports in 2006. In their own periodicals, research institutes published a total of 2 500 reports in 2006. Over 600 reports were published in other institutes' periodicals.

One last category of reports is those returned to the employer without being published in any formal way. In 2006 over 4 800 such reports were produced, of which 80 percent were made at institutes in technology and the manufacturing industry.

In the 1997–2006 period the research institutes applied for over 780 patents. More than 90 percent of these applications came from institutes in technology and the manufacturing industry, while the remaining 10 percent came from institutes in primary industries. The number of announced patents has remained stable since 1997. During the 1997–2006 period, Norwegian institutes have been granted 233 patents in total, which means approximately every third application is granted.

Research institutes also sell licenses for products as a result of R&D activities at the institute. From 1997 to 2006, 1 070 licenses have been sold, most of which from institutes in technology and manufacturing.

4.4 Results from the Industrial sector's innovation activities

Innovation is in itself a result of research and development, as enterprises introduce new and improved products and processes, and implement organisational and marketing related changes. Innovation also creates results for the enterprises. This chapter examines the effects of the enterprises' innovation activities, as they were reported in Statistics Norway's 2004 Innovation Survey.

4.4.1 Turnover from new products

New or significantly improved products generated 5.9 percent of the entire turnover in the Industrial sector in 2004. This represents a decline from 2001, when the corresponding figure was 7.7 percent.

The share was highest in mining and manufacturing, where new and improved products generated 9.7 percent of the total turnover. However, the mining and manufacturing industries saw the largest decline since the last survey – in 2001, 13.4 percent of the total turnover came from innovated products.

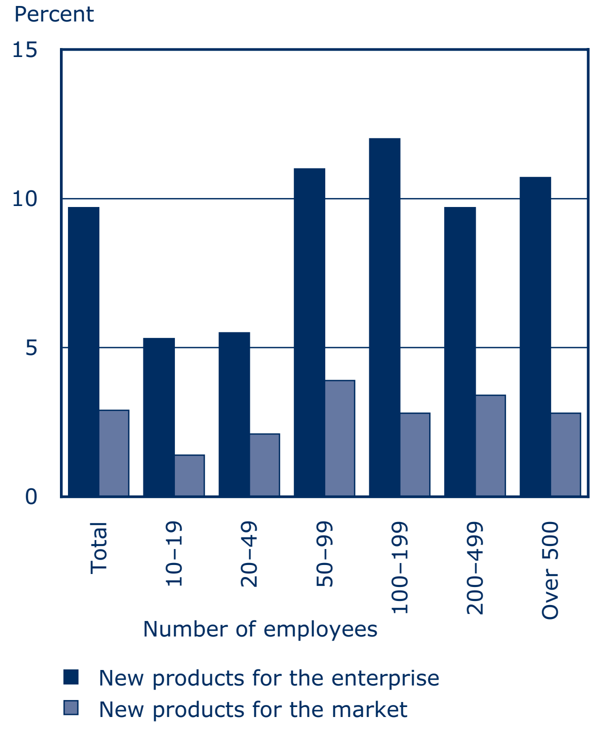
In the services industries, the share has increased by over two percentage points over three years, to 7.3 percent in 2004. This was not enough, however, to stop the decline for the Industrial sector as a whole.

There are several possible explanations for the decline in turnover shares from innovated products. One is that the share of innovators declined somewhat in the period. Another is the sharp increase in overall turnover.

Total turnover increasing significantly more than the turnover from new products can seem paradoxical. One possible explanation is that the enterprises have problems reporting the correct figures. Innovation and corresponding terms can seem vague and be difficult to report or find in the enterprises' accounts.

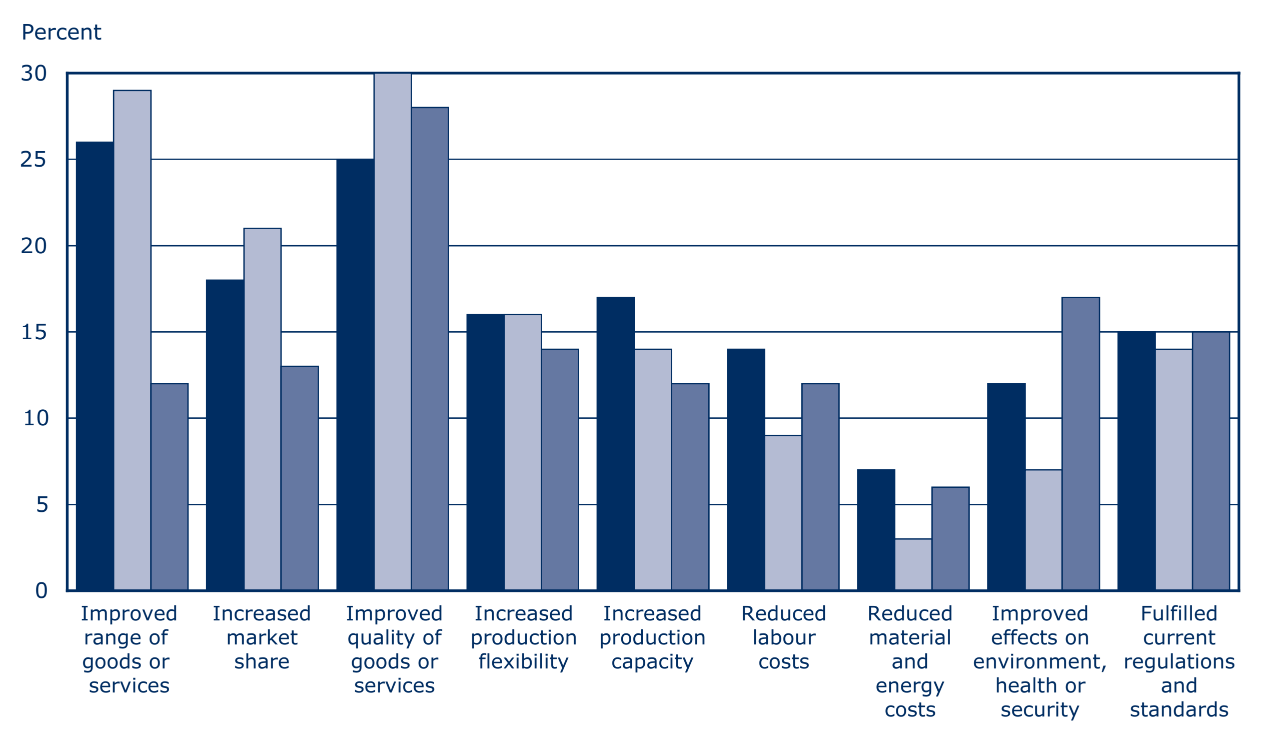
Furthermore, the time horizon may be a factor. It is difficult to make generalisations about the life span of an innovation – the time before it is replaced by a new product. How long it takes from its introduction until it generates turnover also varies across industries and size groups. Goods and services introduced in previous periods are not counted as innovations. If enterprises generate large shares of their income from products that were innovated, say, in the previous period, the innovation survey draws a somewhat skewed picture of the impact of innovations on total turnover.

Figure 4.4
Turnover from new and improved products in mining and manufacturing in 2004 by size group. Percent of total turnover.



Source: Statistics Norway/Innovation Survey

Figure 4.5
Effects from the innovation activities in the 2002–2004 period, by main industry. Share of innovative enterprises reporting the effect in question to be of great importance.



Source: Statistics Norway/Innovation Survey

Furthermore, the innovation survey is still a relatively new survey and is still under development. Comparisons over time should thus be made with some caution.

4.4.2 Positive effects from innovation activities

The result of innovation activities may cause other positive effects for the enterprise. Improved quality of goods and services and an increased range of goods and services are the effects that most enterprises report as important, 28 and 26 percent, respectively, as shown in Figure 4.5. A 16 percent share reported an increased market share as the result of their innovation activities.

Different enterprises report to a greater extent than in previous surveys the same effects of innovation activities. The various effects are present with relatively small variations, regardless of size or industry.

The enterprises experience different effects from the organisational and marketing innovations. Among the effects from organisational innovations, increased capacity stands out – 29 percent report this effect. 27 percent state their enterprise has increased its profitability, and 26 percent have had quality improvements in the enterprise's goods and services. A 21 percent share experienced reduced rates of employee turnover or improved employee satisfaction as a result of organisational innovations.

Enterprises engaged in marketing innovation experience positive effects as well. Of all marketing innovators, 68 percent report increased sales, and 48 percent have also increased their profitability as a result of the marketing innovations.

4.5 International trade in industries with different R&D intensity

Nations' industry-specific trade patterns, and in particular success on export markets, is a widely used criterion of success in international benchmarking. According to the established definitions and indicators of technological and economic success[3], the Norwegian economy is in a paradoxical situation. On the one hand Norway scores low on most of the input indicators, which say something about the basis for economic results. The typical measures are research and innovation. On the other hand Norway scores high on output indicators, which say something about economic growth, welfare, productivity and quality of life. This section highlights this paradox by looking at industry-specific export performance.

The prevailing indicators reflect existing regimes of measurement and available statistics, which are by and large based on registered research and development effort. R&D effort as an indicator, which in this case is used to classify industries with different R&D intensity, captures only parts of the knowledge that feeds into innovation and positive economic results in industries and firms. In existing statistics and benchmarking, industries with high R&D effort have been incorporated as normative when assessing economic success. Indicators need to be developed that capture the internal variation in industries and that capture the fact that firms and industries generate knowledge and develop, innovate, in many different ways.

In its latest Science and Technology Scoreboard (2005) the OECD focuses on the positive development of industries with high and medium-high R&D effort after the crisis in 2000–2001. The countries concerned can however refer to structural differences when it comes to export, a point we will return to in the comments on the figure below.

The OECD is cautious in its normative reflections in its latest publications[4]. But even if the OECD took a nuanced approach in early presentations of the classification[5] of industrial branches on basis of their average R&D effort[6], the classification was from the outset interpreted normatively in benchmarking of technology and innovation policy. Export shares in

3 The main reference is Science and Engineering Indicators (SEI) http://www.nsf.gov/statistics/seind06/, which presents the indicators that benchmark nations' technological and economic success.

4 Science and Technology Scoreboard 2005 and Economic Surveys Norway 2007.

5 The OECD classifies industries according to R&D expenditure as a proportion of turnover. Four groups are identified: high technology in which R&D expenditure amounts to 4 percent or more of turnover; medium-high technology in which the R&D expenditure amounts to between 2.5 percent and 4 percent of turnover; medium-low technology in which the R&D expenditure amounts to between 1 and 2.5 percent; and low technology in which the R&D expenditure amounts to less than 1 percent of turnover. The groups are based on the mean values for the industries across all OECD countries in such a way that the same industries are found in the same group in all countries.

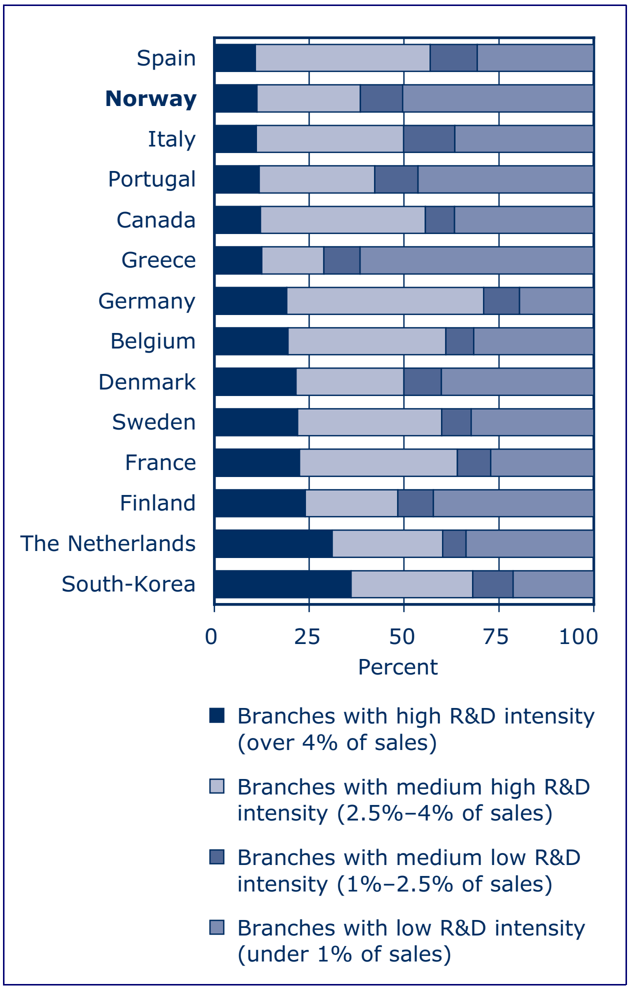
6 See OECD, OECD Science and Technology Indicators, No 2: R&D, Invention and Competitiveness, (OECD, Paris), pp.58–61, or for example OECD, 1996, The knowledge based economy, OECD, Paris.

combination with the OECD classification have thus led to a normative interpretation of export activity. Because high R&D effort is considered an indisputable strength for industrial branches, exports from industrial branches with high R&D effort have also been considered an undisputable indicator of success. Competitiveness is measured by export activity, but only industrial branches with a high average R&D effort are taken into account.

It is considered good to be in industrial branches with high R&D intensity, while industrial branches with low R&D intensity are not positive in the long run. They are considered to be "sun-set" industrial branches. This normative understanding of the significance of certain industrial branches has had uniform consequences in the EU, in the USA (and in the OECD), and in the rest of the world. The countries are working hard to support industrial activities with high R&D intensity. The Norwegian paradox consists in Norway's high welfare and good economic results in elucidation of the normative assessment of high R&D as economic policy salvation in nations. This necessitates closer scrutiny of the regime of interpretation of branch-specific result indicators.

Export from different industrial branches gives an indication of a country's most competitive industrial branches on international markets, in relative terms. In previous versions of this report we have shed light on trade in industrial branches by means of the mentioned OECD definition. Figure 4.6 compares exports from the different types of industrial branches in Norway with a selection of OECD countries. Industrial branches with low R&D intensity dominate the total Norwegian export activity. Of the countries in the figure, only Spain has a lower share than Norway of export from industrial branches with high R&D intensity. If we include industrial branches with medium-high R&D intensity, Norway is exceeded by Spain and ends up as the last but one, exceeding only Greece. At the other end of the scale we find South Korea and Germany, where exports from industrial branches with high R&D intensity dominate. In this comparison, Germany has the lowest export share from industrial branches with low R&D intensity.

Figure 4.6
Total industrial export in selected OECD countries in 2003 by industries with different R&D intensity.



Source: OECD, STAN database 2005

We have interpreted this export indicator in elucidation of the countries' different industrial structures. Generally, export shares from industrial branches are strongly related to industrial structure, as for example an overview of industrial branches' contribution to production value added reveals. Hence, industrial branches with low R&D intensity dominate Norway's total production.

Tables and figures

Figures

Tables

Appendix Tables

Tables

Table 1
Total R&D expenditure in Norway by sector of performance and source of funds. 2005. Million NOK.

Sector of performance	Total	Industry		Government		Other national sources[1]	Abroad	
		Total	Of which: Oil companies	Total	Of which: Research Council of Norway		Total	Of which: EU-commission
Business enterprise sector	15 911.1	12 243.7	1 251.8	1 422.3	707.3	587.9	1 657.2	163.6
Of which Industrial sector[2]	13 640.3	11 226.4	973.3	569.4	201.4	513.2	1 331.3	59.3
Institutions serving enterprises[3]	2 270.8	1 017.3	278.5	852.9	505.9	74.7	325.9	104.3
Government sector	4 636.0	487.9	84.5	3 551.3	1 103.9	135.2	461.6	113.5
Of which Institutions serving government	4 620.5	487.5	84.5	3 549.1	1 103.9	135.2	448.7	113.5
International organisations	15.5	0.4	-	2.2	-	-	12.9	-
Higher education sector	9 096.3	431.0	139.3	7 963.8	1 655.1	427.3	274.2	166.2
Of which Universities and Specialiced university institutions	8 112.8	415.6	139.3	7 030.2	1 573.9	410.6	256.4	149.7
State university colleges	983.5	15.4	-	933.6	81.2	16.7	17.8	39 584.0
Totalt	**29 643.4**	**13 162.5**	**1 475.6**	**12 937.3**	**3 466.3**	**1 150.6**	**2 393.0**	**443.4**

Source: NIFU STEP, Statistics Norway/R&D statistics

1 Includes private funding, gifts and SkatteFUNN in the Industrial sector.
2 Private and public enterprises.
3 Non-profit institutions (NPI).

Table 2
Current expenditure on R&D by sector of performance and field of science. 2005. Million NOK.

Field of science	Total	Industrial sector[1]	Institute sector[2]	Higher education sector
Humanities	1 042.4	..	174.3	868.1
Social scienes	2 991.6	..	1 221.5	1 770.1
Natural sciences	3 002.4	..	1 327.8	1 674.6
Engineering and technology	3 169.9	..	2 265.5	904.4
Medical and health sciences	3 144.5	..	576.3	2 568.2
Agricultural sciences	1 500.5	..	1 095.5	405.0
Not elsewhere classified	12 719.9	12 719.9	-	-
Total	**27 571.2**	**12 719.9**	**6 660.9**	**8 190.4**

Source: NIFU STEP, Statistics Norway/R&D statistics

1 Private and public enterprises.
2 Includes government sector, private non-profit sector and non-profit institutions (NPI) mainly serving enterprises.

Table 3
Current expenditure on R&D by type of R&D and sector of performance. 2005. Million NOK and percent.

Sector of performance		Total	Basic research	Applied research	Experimental development
Industrial sector[1]	Million NOK	12 719.9	386.3	2 926.6	9 407.0
	Percent	100	3	23	74
Institute sector[2]	Million NOK	6 660.9	958.9	4 204.8	1 497.2
	Percent	100	14	63	23
Higher education sector	Million NOK	8 190.4	4 034.0	2 979.8	1 176.6
	Percent	100	49	37	14
Total	**Million NOK**	**27 571.2**	**5 379.2**	**10 111.2**	**12 080.8**
	Percent	**100**	**19**	**37**	**44**

Source: NIFU STEP, Statistics Norway/R&D statistics

1 Private and public enterprises.
2 Includes government sector, private non-profit sector and non-profit institutions (NPI) mainly serving enterprises.

Table 4
R&D expenditure in Norway by sector of performance and type of cost. 1970–2005. Million NOK. Current prices.

	Total			Industrial sector[1]			Institute sector[2]			Higher education sector		
Year	Total	Current expenditure	Investments	Total	Current expenditure	Investments	Total	Current expenditure	Investments	Total	Current expenditure	Investments
1970	891.0	774.1	116.9	275.6	255.5	20.1	329.3	295.3	34.0	286.1	223.3	62.8
1972	1 236.0	1 094.5	141.5	355.4	335.3	20.1	459.3	417.3	42.0	421.3	341.9	79.4
1974	1 633.1	1 467.3	165.8	478.6	434.4	44.2	629.5	578.8	50.7	525.0	454.1	70.9
1977	2 716.2	2 356.1	360.1	850.0	747.4	102.6	958.8	859.6	99.2	907.4	749.1	158.3
1979	3 265.2	2 951.9	313.3	1 026.5	941.6	84.9	1 229.9	1 134.6	95.3	1008.8	875.7	133.1
1981	4 267.7	3 865.2	402.5	1 334.4	1 209.8	124.6	1 713.3	1 569.5	143.0	1 220.0	1 085.9	134.1
1983	5 764.6	5 207.2	557.4	1 886.4	1 737.6	148.8	2 404.6	2 142.1	262.5	1 473.6	1 327.5	146.1
1985	8 202.9	7 361.7	841.2	3 574.0	3 248.7	325.3	2 826.4	2 493.8	332.6	1 802.5	1 619.2	183.3
1987	10 319.4	9 216.1	1 103.3	4 548.5	4 036.7	511.8	3 605.1	3 232.2	372.9	2 165.8	1 947.2	218.6
1989	11 662.2	10 313.7	1 348.5	4 590.3	4 056.6	533.7	4 300.5	3 839.3	461.2	2 771.4	2 417.8	353.6
1991	12 744.0	11 285.2	1 458.8	4 979.8	4 463.2	516.6	4 405.2	4 024.3	380.9	3 359.0	2 797.7	561.3
1993	14 335.6	12 667.5	1 668.1	5 631.2	4 906.8	724.4	4 810.7	4 338.2	472.5	3 893.7	3 422.5	471.2
1995[3]	15 970.4	14 389.2	1 581.2	7 340.6	6 437.6	903.0	4 490.7	4 271.5	219.2	4 139.1	3 680.1	459.0
1997	18 243.9	16 485.2	1 758.7	8 571.5	7 742.0	829.5	4 826.6	4 518.6	308.0	4 845.8	4 224.6	621.2
1999	20 346.5	18 441.4	1 905.1	9 540.0	8 772.3	767.7	4 987.1	4 752.8	234.3	5 819.4	4 916.3	903.1
2001	24 469.4	22 305.3	2 164.1	12 613.7	11 348.5	1 265.2	5 581.5	5 337.4	244.1	6 274.2	5 619.4	654.8
2003	27 332.2	24 899.7	2 432.5	13 477.1	12 163.5	1 313.6	6 360.0	6 075.3	284.7	7 495.1	6 660.9	834.2
2005	29 643.4	27 571.2	2 072.2	13 640.3	12 719.9	920.4	6 906.8	6 660.9	245.9	9 096.3	8 190.4	905.9

Source: NIFU STEP, Statistics Norway/R&D statistics

1 Private and public enterprises.
2 Includes government sector, private non-profit sector and non-profit institutions (NPI) mainly serving enterprises.
3 1995 is not directly comparable with the previous years due to an extension in the data coverage in the Industrial sector, as well as the transfer of state commercial enterprises from the institute sector to the Industrial sector.

Table 5
R&D personnel (head count) in Norway by sector of performance and gender. 1974–2005.

	Total			Industrial sector			Institute sector			Higher education sector		
	Total	Researchers[1]		Total	Researchers[1]		Total	Researchers[1]		Total	Researchers[1]	
Year		Total	Women		Total	Women		Total	Women		Total	Women
1974	21 820	9 756	..	5 152	1 419	..	7 599	3 286	306	9 069	5 051	606
1977	23 952	10 818	..	5 851	1 688	..	8 108	3 517	334	9 993	5 613	775
1979	25 154	11 851	..	6 402	2 017	..	8 605	3 982	375	10 147	5 852	841
1981	26 297	12 939	..	6 473	2 316	..	9 138	4 376	511	10 686	6 247	955
1983	27 930	14 002	..	7 254	2 909	..	9 793	4 663	504	10 883	6 430	1 032
1985	30 979	15 923	..	10 041	4 475	..	9 818	4 792	638	11 120	6 656	1 178
1987	31 898	18 128	..	10 332	5 897	..	10 077	5 343	843	11 489	6 888	1 336
1989	32 871	19 515	3 599	9 734	5 861	741	10 639	5 882	1 131	12 498	7 772	1 727
1991	31 473	20 118	4 020	8 634	5 671	780	10 094	5 909	1 204	12 745	8 538	2 036
1993	33 979	21 879	4 837	9 402	6 192	966	10 514	6 339	1 500	14 063	9 348	2 371
1995[2]	40 915	26 712	6 454	12 631	8 012	1 209	10 092	6 048	1 551	18 192	12 652	3 694
1997	43 972	30 280	7 907	14 326	10 377	1 815	9 998	6 118	1 730	19 648	13 785	4 362
1999	43 893	30 994	8 629	14 545	10 710	2 063	9 279	5 920	1 727	20 069	14 364	4 839
2001	48 752	34 907	9 904	18 353	13 666	2 574	9 285	6 077	1 912	21 114	15 164	5 418
2003	51 228	35 740	10 529	19 856	13 174	2 381	9 411	6 350	2 049	21 961	16 216	6 099
2005	54 360	37 013	11 750	20 730	12 442	2 422	9 425	6 484	2 207	24 205	18 087	7 121

Source: NIFU STEP, Statistics Norway/R&D statistics

[1] Personnel with a higher education degree (ISCED-level 5A and 6). Only academic staff is included in the Higher education sector.
[2] 1995 is not directly comparable with the previous years due to an extension in the data coverage in the Industrial sector, as well as the transfer of state commercial enterprises from the Institute sector to the Industrial sector.

Table 6
R&D personnel (FTE) in Norway by sector of performance. 1970–2005.

	Total			Industrial sector			Institute sector			Hiher education sector		
Year	Total	Researchers[1]	Others	Total	Researchers[1]	Others	Total	Researchers[1]	Others	Total	Researchers[1]	Others
1970	9 857	4 317	5 540	3 067	867	2 200	3 820	1 663	2 157	2 970	1 787	1 183
1972	11 395	5 115	6 280	3 395	976	2 419	4 400	1 992	2 408	3 600	2 147	1 453
1974	12 459	5 630	6 829	3 460	1 011	2 449	5 007	2 309	2 698	3 992	2 310	1 682
1977	13 860	6 358	7 502	4 003	1 202	2 801	5 333	2 556	2 777	4 524	2 600	1 924
1979	14 810	7 112	7 698	4 390	1 390	3 000	5 638	2 906	2 732	4 782	2 816	1 966
1981	15 025	7 548	7 477	4 201	1 524	2 677	5 885	3 125	2 760	4 939	2 899	2 040
1983	16 188	8 350	7 838	4 409	1 821	2 588	6 801	3 544	3 257	4 978	2 985	1 993
1985	19 036	9 767	9 269	6 687	2 995	3 692	7 095	3 605	3 490	5 254	3 167	2 087
1987	20 140	11 557	8 583	7 187	4 102	3 085	7 619	4 181	3 438	5 334	3 274	2 060
1989	20 471	12 256	8 215	6 579	3 862	2 717	8 108	4 725	3 383	5 784	3 669	2 115
1991	20 530	13 570	6 960	6 747	4 599	2 148	7 810	4 817	2 993	5 973	4 154	1 819
1993	22 166	14 803	7 363	7 482	5 021	2 461	8 026	5 045	2 981	6 658	4 737	1 921
1995[2]	24 003	15 964	8 039	9 437	6 169	3 268	7 611	4 802	2 809	6 955	4 993	1 962
1997	24 935	17 520	7 415	10 410	7 662	2 748	7 463	4 767	2 696	7 062	5 091	1 971
1999	25 444	18 319	7 125	10 995	8 080	2 915	7 136	4 718	2 418	7 313	5 521	1 792
2001	27 108	20 077	7 031	12 636	9 684	2 952	6 988	4 723	2 265	7 484	5 670	1 814
2003	29 057	21 023	8 034	13 901	9 810	4 091	7 238	4 962	2 276	7 918	6 251	1 667
2005	30 511	21 669	8 842	13 815	9 070	4 745	7 276	5 088	2 188	9 420	7 511	1 909

Source: NIFU STEP, Statistics Norway/R&D statistics

1 Personnel with a higher education degree (ISCED-level 5A and 6). Only academic staff is included in the Higher education sector.
2 1995 is not directly comparable with the previous years due to an extension in the data coverage in the Industrial sector, as well as the transfer of state commercial enterprises from the Institute sector to the Industrial sector.

Table 7
EU indicators for science, technology and innovation. Structural indicators in selected countries in 2005 or latest year for available data.

	Indicators	EU 25	EU15	Austria	Belgium	Denmark	Finland	France	Germany	Hungary	Iceland	Ireland	Italy	Japan	Netherlands	**Norway**	Portugal	Spain	Sweden	Switzerland	United Kingdom	USA
1	**Human resources**																					
1.1	Public spending on R&D as a percentage of GDP	5.1	..	5.5	6.0	8.5	6.4	5.8	4.6	5.4	7.6	4.8	4.6	3.7	5.2	**7.6**	5.3	4.3	7.4	6.0	5.3	5.1
2	**R&D expenditure**																					
2.1	Gross domestic expenditure on R&D as a percentage of GDP	1.85	1.91	2.36	1.82	2.44	3.48	2.13	2.51	0.94	..	1.25	..	..	..	**1.51**	0.81	1.12	3.86	2.93	..	..
2.2	Gross domestic expenditure on R&D financed by industry as a percentage of GDP	54.5	54.8	45.7	60.3	59.9	69.3	51.7	66.8	39.4	43.9	58.7	..	74.5	51.1	**49.2**	31.7	48.0	65.0	69.7	44.2	61.4
2.3	Gross domestic expenditure on R&D financed by government as a percentage of GDP	34.7	34.4	36.4	23.5	27.1	26.3	37.6	30.4	49.4	40.1	32.9	..	17.7	36.2	**41.9**	60.1	41.0	23.5	22.7	32.8	30.4
2.4	Gross domestic expenditure on R&D financed by abroad as a percentage of GDP	8.5	8.5	17.6	12.9	10.3	3.2	8.8	2.5	10.7	14.5	6.6	..	0.3	11.3	**7.4**	5.0	6.2	7.3	5.2	17.2	..
3	**Internet access**																					
3.1	Level of internett access - percentage of all households	48.0	53.0	47.0	50.0	75.0	54.0	34.0	62.0	22.0	84.0	47.0	39.0	57.0	78.0	**64.0**	31.0	36.0	73.0	..	60.0	55.0
4	**Science and technology graduates**																					
4.1	Total tertiary graduates in S&T, age 20–29 years per 1 000 capita	13.4	..	9.8	10.9	14.7	17.7	22.5	9.7	5.1	10.1	24.5	11.6	13.7	8.6	**9.0**	12.0	11.8	14.4	14.6	18.4	10.6
4.2	Female tertiary graduates in S&T, age 20–29 years per 1 000 capita	8.4	..	4.6	6.0	10.1	10.8	12.9	4.8	3.1	7.6	15.0	8.7	4.1	3.5	**4.7**	9.7	7.2	9.9	4.7	11.4	6.8
4.3	Male tertiary graduates in S&T, age 20–29 years per 1 000 capita	18.3	..	14.8	15.7	19.3	24.3	32.0	14.5	7.0	12.5	33.8	14.3	23.0	13.6	**13.1**	14.3	16.2	18.7	24.6	25.3	14.2
5	**Patents**																					
5.1	Number of patents applications to EPO per mio. capita	136.1	160.7	195.1	144.5	235.8	305.6	149.1	311.7	18.9	153.6	77.3	87.3	219.1	244.3	**117.1**	7.5	30.6	284.9	3.3	121.4	167.6
5.2	Number of patents applications granted by USPTO per mio. capita	23.6	28.1	40.2	27.0	26.4	50.6	23.0	58.5	1.9	26.9	21.3	14.9	276.0	32.7	**13.1**	0.8	4.0	48.7	0.0	22.7	274.7
6	**Venture capital investments**																					
6.1	Venture capital investments, early stage, as a percentage of GDP	..	0.022	0.012	0.021	0.051	0.044	0.027	0.014	0.004	..	0.022	0.002	..	0.002	**0.028**	0.039	0.013	0.052	0.021	0.047	0.035
6.2	Venture capital investments, expansion & replacement, as a percentage of GDP	..	0.115	0.039	0.019	0.351	0.052	0.071	0.043	0.048	..	0.043	0.045	3.400	0.157	**0.108**	0.103	0.075	0.248	0.022	0.315	0.147
7	**ICT expenditure**																					
7.1	Expenditure on information technology as a percentage of GDP	3.0	3.1	3.0	2.9	3.4	3.7	3.4	3.1	2.4	..	2.0	1.9	4.2	3.9	**3.1**	2.2	1.7	4.4	4.2	4.2	4.0
7.2	Expenditure on telecommunication technology as a as a percentage of GDP	3.4	3.3	3.3	3.4	3.1	3.3	2.6	3.1	5.7	..	3.2	3.4	..	3.7	**2.1**	5.2	3.8	4.2	3.4	3.8	2.7

	Indicators	EU 25	EU15	Austria	Belgium	Denmark	Finland	France	Germany	Hungary	Iceland	Ireland	Italy	Japan	Netherlands	**Norway**	Portugal	Spain	Sweden	Switzerland	United Kingdom	USA
8	**E-commerce**																					
8.1	Share of turnover sold via the internet by enterprises among business enterprises	2.7	2.8	1.0	2.2	4.4	1.1	..	3.1	1.1	0.5	10.1	0.7	..	..	**3.9**	1.3	0.6	..	..	4.1	..
9	**Youth education attainment level**																					
9.1	Proportion of population, age 20–24 years, with completed at least upper secondary education	77.5	74.6	85.9	81.8	77.1	83.4	82.6	71.5	83.4	50.8	85.8	73.6	..	75.6	**96.2**	49.0	61.8	87.5	82.9	78.2	..
9.2	Proportion of females, age 20–24 years, with completed at least upper secondary education	80.3	77.7	87.3	85.3	80.5	85.7	85.0	72.5	84.9	57.7	88.9	78.1	..	79.9	**97.5**	57.5	68.5	88.7	85.6	78.9	..
9.3	Proportion of males, age 20–24 years, with completed at least secondary education	74.7	71.5	84.6	78.4	73.8	81.0	80.1	70.4	81.9	44.5	82.6	69.2	..	71.4	**94.9**	40.8	55.4	86.4	80.4	77.4	..
10	**E-government on-line availability**																					
10.1	Online availability of 20 basic public services	41.0	49.0	72.0	35.0	58.0	67.0	50.0	47.0	15.0	50.0	50.0	53.0	..	32.0	**56.0**	40.0	55.0	74.0	6.0	59.0	..
11	**E-government usage by individuals**																					
11.1	Percentage of population, aged 16 to 74 who have used the internet, in the last 3 months, for interaction with public authorities	23.0	26.0	29.0	18.0	44.0	47.0	:	33.0	18.0	55.0	18.0	14.0	18.0	46.0	**52.0**	14.0	..	52.0	..	24.0	23.0
11.2	Percentage of females, aged 16 to 74 who have used the internet, in the last 3 months, for interaction with public authorities	20.0	23.0	25.0	16.0	39.0	47.0	:	30.0	18.0	50.0	17.0	12.0	..	38.0	**46.0**	12.0	..	47.0	..	22.0	..
11.3	Percentage of males, aged 16 to 74 who have used the internet, in the last 3 months, for interaction with public authorities	26.0	29.0	33.0	20.0	49.0	47.0	:	37.0	17.0	61.0	18.0	17.0	..	53.0	**58.0**	16.0	..	56.0	..	27.0	..
12	**Use of public internett servies among business enterprises**																					
12.1	Percentage of enterprises which use the internet for internacion with public authorities	57.0	56.0	75.0	61.0	87.0	91.0	:	44.0	67.0	97.0	76.0	73.0	..	57.0	**84.0**	58.0	55.0	80.0	..	39.0	..
13	**Broadband**																					
13.1	Number of broadband lines subscribed in percentage of the population	10.6	12.0	11.6	17.4	22.0	18.7	13.9	10.2	4.5	..	4.4	9.5	..	22.4	**..**	10.1	10.0	17.1	..	13.5	..
14	**Export of high technological products**																					
14.1	Export of high technology products as a share of total exports	18.0	17.7	15.0	7.0	13.0	18.0	20.0	15.0	22.0	2.0	29.0	7.0	22.0	19.0	**4.0**	8.0	6.0	14.0	21.1	23.0	27.0

Source: Eurostat

Table 8
EU indicators for science, technology and innovation. Indicators for benchmarking in selected countries in 2005 or latest year for available data.

	Indicators	EU 25	EU 15	Austria	Belgium	Denmark	Estonia	Finland	France	Germany	Hungary	Iceland	Ireland	Italy	Japan	Nether-lands	**Norway**	Portugal	Spain	Sweden	Switzer-land	United Kingdom	USA
	Human resources																						
1.1	New PhDs within S&T, proportion of persons aged 20–29 (‰)	12.7	13.6	8.7	11.2	13.8	8.9	17.4	22.0	9.0	5.1	10.8	23.1	10.1	13.4	7.9	**9.0**	11.0	12.5	15.9	14.6	18.1	10.2
1.2	Proportion of population with tertiary education, aged 25–64 (%)	22.8	24.0	17.8	31.0	33.5	33.3	34.6	24.9	24.6	17.1	30.6	29.1	12.2	37.4	30.1	**32.6**	12.8	28.2	29.2	28.8	29.6	38.4
1.3	Participation in life-long learning, proportion of persons aged 25–64 (%)	11.0	12.1	13.8	10.0	27.6	5.9	24.8	7.6	8.2	4.2	26.6	8.0	6.2	..	16.6	**19.4**	4.6	12.1	34.7	26.9	29.1	..
1.4	Employment in medium-high and high-tech manufacturing as proportion of total workforce (%)	6.7	6.7	6.5	6.5	6.3	4.8	6.8	6.3	10.4	8.2	2.1	6.0	7.4	7.3	3.3	**3.9**	3.3	4.7	6.5	7.3	5.6	3.8
1.5	Employment in high-tech services as proportion of total workforce (%)	3.4	3.5	2.7	3.7	4.7	2.8	4.5	3.9	3.4	3.0	5.0	3.6	2.9	..	4.1	**4.0**	1.8	2.8	5.1	3.8	4.3	..
1.6	Proportion of persons aged 20–24 with upper secondary education (%)	76.9	74.1	85.9	80.3	76.0	80.9	84.8	82.8	71.0	83.3	53.0	86.1	72.9	..	74.6	**96.3**	48.4	61.3	87.8	82.5	77.1	..
2	**Knowledge creation**																						
2.1	Public R&D expenditures as a percentage of GDP	0.7	0.7	0.7	0.6	0.8	0.5	1.0	0.8	0.8	0.5	1.2	0.4	0.6	0.7	0.8	**0.7**	0.4	0.5	0.9	0.7	0.6	0.7
2.2	Business R&D expenditures as a percentage of GDP	1.2	1.2	1.5	1.3	1.7	0.4	2.5	1.3	1.8	0.4	1.6	0.8	0.6	2.4	1.0	**0.8**	0.3	0.6	2.9	2.2	1.2	1.9
2.3.1	EPO high-tech patents applications per mio. capita	136.7	161.4	195.1	144.5	235.8	15.5	305.6	153.7	311.7	18.9	153.6	77.3	87.3	174.2	244.3	**117.1**	7.5	30.6	284.9	425.6	121.4	142.6
2.3.2	USPTO high-tech patents applications per mio. capita	50.9	60.2	74.7	52.4	72.9	1.2	104.6	56.8	123.0	5.3	57.4	37.4	31.2	304.6	78.3	**34.9**	1.9	7.7	109.7	168.4	44.6	277.1
2.3.3	Number of patent applications to EPO, USPTO and JPO per mio. capita	32.7	38.9	33.7	32.0	32.4	-	101.7	36.5	85.2	1.9	28.5	14.8	11.6	102.1	59.6	**24.8**	0.6	2.7	66.3	108.9	33.0	47.9
2.4	Number of new trademark registrations in the EU per mio.capita	100.7	115.7	187.0	92.2	159.8	31.7	106.8	76.0	140.5	18.8	79.1	143.0	92.7	11.7	141.0	**29.2**	73.8	140.9	136.7	225.2	125.2	33.8
2.5	Number of new design regnistrations in the EU per mio. Capita	110.9	127.6	195.8	124.6	243.2	9.2	95.5	88.1	186.5	15.2	29.6	49.0	176.3	13.2	132.8	**37.7**	49.8	106.2	136.9	210.0	76.1	17.5
3	**Transmission and application of knowledge**																						
3.1	SMEs innovating in-house as a percentage of all SMEs in manufacturing and mining	..	..	42.5	38.3	16.1	29.8	37.6	29.2	46.2	17.0	46.5	47.2	31.0	15.3	34.2	**28.8**	36.2	24.3	35.2	34.4	22.4	..
3.2	SMEs involved in cooperation on innovation as a percentage of all SMEs in manufacturing and mining	..	..	7.7	16.6	20.8	16.0	17.3	11.5	8.6	6.6	14.0	15.6	4.3	6.9	12.3	**11.3**	7.0	5.7	20.0	12.1	12.6	..
3.3	Proportion of SME with organisational innovation (% of all SME in industry)	..	..	48.1	38.1	57.1	39.2	47.0	35.9	53.2	19.1	54.0	49.6	32.2	..	26.2	**23.2**	40.7	27.6	44.0	63.0	..	..
3.4	Innovation expenditures as a percentage of total turnover in manufacturing and mining	..	..	..	2.0	2.4	1.6	2.5	2.2	2.9	1.3	1.7	1.7	1.8	..	1.3	**1.0**	2.6	0.9	3.5	1.4	1.6	..
4	**Innovation finance, output and markets**																						
4.1	High-tech venture capital investments as a percentage of total venture capital investments	..	89.2	83.0	79.5	84.7	62.0	86.4	86.8	92.3	87.8	..	85.0	87.8	86.7	87.9	**69.7**	61.1	77.0	92.7	92.0	91.7	89.9

Indicators		EU 25	EU 15	Austria	Belgium	Denmark	Estonia	Finland	France	Germany	Hungary	Iceland	Ireland	Italy	Japan	Netherlands	**Norway**	Portugal	Spain	Sweden	Switzerland	United Kingdom	USA
4.2	Venture capital investment, early phase, as a percentage of GDP	..	0.023	0.009	0.019	0.068	..	0.036	0.026	0.015	0.002	0.048	0.021	0.002	..	0.005	**0.022**	0.033	0.011	0.067	0.024	0.048	0.072
4.3.1	Sales of "new to market" products as a percentage of all sales by industrial enterprises	..	..	5.2	4.8	5.2	4.4	9.7	6.2	7.5	4.2	4.9	5.6	6.3	..	4.0	**2.1**	10.8	3.8	8.3	4.9	6.4	..
4.3.2	Sales of "new to firm but not new to market" products as a percentage of total turnover by industrial enterprises	..	..	5.4	8.2	5.8	7.6	5.1	5.6	10.0	2.5	7.8	4.5	5.6	..	4.3	**5.1**	15.1	10.0	5.1	5.8	7.6	..
4.4	Internett access by households and enterprises (composed indicator)	10.6	12.0	11.6	17.4	22.0	11.1	18.7	13.9	10.2	4.5	22.5	4.4	9.5	16.3	22.4	**18.4**	10.1	10.0	17.1	20.3	13.5	14.9
4.5	ICT expenditures as a percentage of GDP	6.4	6.4	6.3	6.3	6.5	9.8	7.0	6.0	6.2	8.1	..	5.2	5.3	7.6	7.6	**5.2**	7.4	5.5	8.6	7.7	8.0	6.7
4.6	Proportion of enterprises receiving public funding for innovation (%)	..	..	17.8	11.7	7.8	0.3	15.2	6.6	9.2	5.7	4.8	27.8	14.0	..	12.9	**16.1**	13.7	9.0	9.1	4.7	3.8	..
4.7	Export of high tenchnology products, as proportion of total export (%)	18.4	17.7	14.7	7.1	13.3	10.1	17.8	20.1	15.4	21.7	2.4	29.1	7.1	22.4	19.1	**3.5**	7.5	5.7	14.1	22.3	22.8	26.8

Source: DG Enterprise

Acronyms

ANBERD	Analytical Business Enterprise Research and Development database
BE	Business Enterprise
CIS	Community Innovation Survey (of the European Union)
EC	European Commission
EEA	European Economic Area
EPC	European Patent Convention
EPO	European Patent Organization
EU	European Union
EURATOM	Euratom Supply Agency
EUROSTAT	Statistical Office of the European Communities
FTE	Full Time Equivalent
GBAORD	Government Budget Appropriations or Outlays for R&D
GDP	Gross Domestic Product
GUF	General University Funds
HE	Higher Education
ICT	Information and Communication Technology
ISCED	International Standard Classification of Education (of UNESCO)
ISI	Institute of Scientific Information
NIFU STEP	Norwegian Institute for Studies in Innovation, Research and Education
NOK	Norwegian Kroner (the Norwegian currency)
NPI	Non-profit institutions
NSI	National Science Indicators
OECD	Organisation for Economic Co-operation and Development
PhD	Doctor of Philosophy
PNP	Private Non-Profit
R&D	Research and Experimental Development
RCN	Research Council of Norway
RTD	Research and Technological Development
S&T	Science and Technology
SCI	Science Citation Index
STAN	Structural Analytic Database