Report on Science & Technology Indicators for Norway

2015

Human Resources

Research and Development

Technology

Innovation

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The latest available figures and analyses of the Norwegian research and innovation system are presented in this abridged English version of the Report on Science and Technology indicators for Norway for 2015. The report also includes reflections and assessments of methodological challenges related to how the information is collected and used. Data in themselves are not sufficient for understanding - they must be put into context to make sense. In this respect the S&T indicator report is a valuable entry point. The full-length annual Norwegian version presents a larger set of indicators and analyses. The contributions from that report have been adapted and abridged to make up this biennial English version.

The content is organized in such a way that it can be easily accessible and function as a reference work. Great efforts have been put into ensuring comparability over time. Processes of developing new knowledge are time-consuming, which also applies to adoption and use of new knowledge. The report and its figures and graphs are available online at http://www.forskningsradet.no/prognett-indikatorrapporten/Home_page/1224698172612 where the information is updated continuously as new data become available.

Even with the high quality of the data, collection procedures and analyses there are still needs for improvements both for this report on S&T and the statistics on S&T in general. Actual use of the data for analytical purposes is the best approach to succeed in this. Therefore researchers are given access to the microdata to perform better and more detailed analysis of causality and data predictive power.

The report is produced in collaboration between NIFU, Statistics Norway (SSB) and The Research Council of Norway. In addition other experts are invited to contribute to the work where relevant. The editorial board for the report includes members from Innovation Norway, SIVA and the University of Oslo.

I want to thank the editors and all other contributors for their efforts. I hope the resulting book and online information will be of use for foreign and national readers!

Arvid Hallén
Director General
Research Council of Norway

Norwegian main report

This document presents a selection of science and technology (S&T) indicators for Norway. This abridged English report is published biannually based on the more comprehensive Norwegian text. The report is designed to provide useful information and perspectives on a range of S&T issues. It aims to provide relevant and useful information for foreign audiences, who may not be familiar with the Norwegian S&T environment. It complements the full version, which is published annually and can be found online (in Norwegian).

R&D and innovation statistics

This report is the latest of a regular series, which goes back to 1997, although it also draws on certain measurements and indicators with a much longer history. It continues the series' original aim of presenting a wide range of relevant statistics and indicators and of ensuring their ongoing development. Statistics on the resources devoted to research and experimental development (R&D) in Norway, in terms of expenditure and personnel, have been compiled since 1963. The Norwegian R&D statistics are based on the guidelines of the OECD Frascati Manual, which were revised in 2015. The classifications are updated to be in line with the latest edition.

Indicators relating to patents, bibliometric analyses and advanced technology have been included since the 1980s. Innovation studies were first introduced in the 1990s and the range of innovation indicators has been considerably extended following the revision of the Oslo Manual in 2005. A revision of the Oslo Manual is in progress.

The full-length Norwegian report presents a larger set of indicators and commentary, divided into international, national and regional sections, and sections on results, effects and cooperation on research and innovation. It also includes a separate section with detailed tables. The executive summary and tables on key indicators are taken from the original version of the report.

Structure of the report

This English version of the report's structure should make it easy to find information across the wide range of topics covered. The report opens with an executive summary, and a short text on the Norwegian system of education, research and innovation followed by an overview of the Key Indicators presented. Chapter 1 presents the main international trends with results from R&D surveys; this chapter also includes results from the 2012 Innovation survey, and presents comparisons over time and between countries, for statistics on scientific publications and citations, educational level, and doctoral degrees. Chapter 2 draws on national R&D statistics for the three research-performing sectors in Norway: the industrial sector, the institute sector and the higher education sector. Data for health trusts are also presented separately. Chapter 3 includes available data on knowledge sharing and cooperation, including indicators of the Norwegian participation in the European research programme/ Horizon 2020, cooperation on scientific publishing and on innovation. Chapter 4 presents the results and effects of research and innovation activities. Chapter 5 entails regional indicators for R&D and innovation.

The original Norwegian report includes more supplementary details on the Norwegian research and innovation system in a number of «fact boxes» and more short comment pieces from experts in «focus boxes». Similarly, this abridged report does not feature full references, but these can be found in the Norwegian report, together with a complete set of updated tables available on the Internet: http://www.forskningsradet.no/indikatorrapporten

Currency rates

As of 2013 (year average):
1 Euro = 7.8 NOK (Norwegian kroner)
1 US$ = 5.9 NOK

As of October 2015:
1 Euro = 9.3 NOK
1 US$ = 8.3 NOK

Knowledge investments follow economic cycles

Global investments in research and experimental development (R&D) remain unevenly spread and reflect general economic differences between countries. Hence, the major share of world R&D have traditionally been dominated by the US, Japan and major Western European countries. However, during the last ten to fifteen years, there is a clear tendency towards increased investments in R&D and education in emerging economies, while several «established» knowledge nations seem to stagnate. China is already the country with the highest number of researchers in the world. If current growth trends continue, China will soon surpass the US also in terms R&D expenditure. Economic prospects are however very uncertain, also for the emerging economies. The question that arises is therefore whether countries are able to invest in R&D and innovation if economic growth levels off.

From stimulus packages to austerity

Public R&D investments often follow a countercyclical pattern and function as a buffer in times of declining business investments. This was also the case during the financial crisis, when many countries increased public allocations to R&D as part of so-called crisis stimulus packages. In recent years, however, it appears that the stimulus packages are phased out, while fiscal consolidation has reduced the room for maintaining increases in public R&D. Norway is one of the exceptions in this respect. After a few years of stagnation, public R&D-budgets in Norway have shown annual real growth rates of 4-5 per cent for the last four consecutive years.

A mixed picture of Norway

International comparisons of R&D and innovation provide a rather mixed picture of Norway. Total R&D expenditure is relatively low and amounts to 1.65 per cent of GDP in 2013. This level has been rather stable for the past 20 years. Norway is thus significantly behind the average for the Nordic countries as well as the EU and OECD average. This modest position is largely due to the fact that Norway has one of the highest levels of GDP per capita in the world and relatively little R&D in the business sector. In terms of public R&D spending, Norway is in the upper echelon of countries. Furthermore, Norway stands out among the leading nations when it comes to human resources. The share of the population with higher education is higher than average in both OECD, EU and Nordic countries. Norway has a high and rising density of researchers in the working population.

The majority of Norwegian doctorates awarded to women

The year 2014 marks an historic turning point, as for the first time more women (50.4 per cent) than men earned their doctoral degree in Norway. The number of doctoral degrees has shown a strong and steady increase over time, but now seems to stabilize at about 1,500 annually. During the last decade, the increase in Norwegian doctorates has primarily been driven by women and foreign scholars. Among Norwegian men, there is actually a decline in the number of doctorates. Women also represent the majority among Norwegian PhD students, and has long been outnumbering men in the total student population. Except for science and technology, there is now a fairly good gender balance among doctorates within most academic disciplines. However, further up the career ladder, the gender balance is less developed, as men still hold 75 per cent of all academic top positions in Norway.

Norwegian research cited more

Recent bibliometric data show a continuous growth in the global scientific production. The by far strongest growth is in China, where the number of articles has increased by almost 200 per cent since 2006. Norway is also among the countries with high growth in the same period. Furthermore, Norwegian articles are increasingly cited. Admittedly, countries such as Switzerland, the Netherlands and Denmark have higher total citation rates, but Norway is among the countries with the highest growth in this respect. Only Austria and Finland have experienced a stronger growth in citations per article in recent years.

Half of Norwegian enterprises are innovative

The most recent innovation survey (CIS 2014 for Norway) shows that around half of all Norwegian firms had innovation activities during the three-year period 2012–2014. Since Norway began to collect innovation data through a separate survey, there has been a noticeable increase in the share of innovative enterprises in the Norwegian economy. Separate surveys is also the most common practice elsewhere in Europe and will therefore be used in future innovation surveys in Norway. Thus, there is reason to expect that Norway will climb a few positions in international rankings of innovation. For instance, unofficial calculations indicate that Norway will be ranked 13th instead of 16th in the Innovation Union Scoreboard if Norwegian data is based on the new separate innovation survey methodology.

Big gap between innovative and non-innovative enterprises

In Norway, innovation activities are most common among large industrial companies, but overall innovation is as prevalent in the manufacturing and service industries. However, it seems that there are far more innovative enterprises among those operating in international competition compared with those who are spared/protected from such competition. In manufacturing industry only 20 per cent of enterprises in local/regional markets are innovative, while almost 70 per cent of those operating in international markets are innovative. We see that enterprises without innovation activity identify, to some extent, specific obstacles to innovation. The main reason why enterprises are not innovative appears to be that they see no need for it.

Public procurement drives little innovation

In Norway, it is estimated that total public procurement account for 14 per cent of GDP. Hence, if public contracts open for or require innovative solutions, public procurement can be a powerful tool for stimulating innovation and renewal. The most recent innovation surveys have introduced questions which aim to identify whether firms have had contracts for public entities, and whether these contracts have contributed to innovation. Responses indicate that this potential remains unexploited. Among Norwegian companies that have supplied goods or services to the public sector, only 10 per cent report that the contract required some form of innovation. International CIS-data shows that this share is about the same or even lower in other most other European countries.

Strong growth in petroleum-related R&D

Health and care is by far the largest thematic R&D area in Norway. In 2013, health and care research accounted for 12 billion NOK – nearly 25 per cent of total R&D expenditure in Norway. Most of this research activity was performed in the higher education sector, including university hospitals. The second most important thematic area is R&D related to the petroleum industry. In total 5.7 billion NOK was spent on petroleum research, thus accounting for about 12 per cent of total R&D expenditure. Oil and gas related R&D is primarily performed in the industrial sector, but research institutes also have a considerable share of petroleum-related research in their portfolio. In recent years, there has been a strong growth in R&D related to the petroleum industry, with a real growth of 17 per cent from 2011 to 2013. A substantial part of oil and gas related R&D is performed within the petroleum industry, but this industry also purchases research from research institutes and other industries, including ICT services. A key question is therefore how the recent fall in oil prices and the consequent reduction in oil and gas activities will affect R&D related to this sector.

Small steps towards «greener R&D»

The Parliament Climate Agreement in 2008 marked a noticeable boost for R&D efforts targeted at environmental and climate issues and renewable energy. In recent years, however, the picture is more mixed. Climate research is steadily increasing, while R&D directed towards renewable energy has declined in real terms. The decline is particularly noticeable in the industrial sector, where R&D related to renewable energy was almost halved from 2009 to 2013. Other types of «green R&D» also appear to be levelling off. At the same time, data on scientific publishing as well as success and return rates in the EU framework programmes indicate that environmental and energy related research is an area where Norwegian research groups have a strong specialization and high international impact.

Strong competition for EU funds

EU framework programmes represent the world's largest collaborative arena for R&D and innovation. The new program Horizon 2020 has a total budget of nearly €80 billion over the next seven years. Norway's annual contribution to the budget amounts to nearly 2 billion NOK, which represents a substantial share of Norway's public allocations to R&D. Given this investment, the Government puts a strong emphasis on encouraging Norwegian researchers to participate and compete for EU funds. But the competition is strong, partly also because researchers across Europe increasingly seek EU-funding because of tight budgets and limited access to national funds. The first round of applications to Horizon 2020 received nearly 36,000 applications. The overall success rate of eligible full proposals under the first round of is around 14 per cent, compared with around 20 per cent for the seventh framework programme. Like most other countries, Norway has experienced a lower success rate so far in Horizon 2020. On the other hand, the economic return has increased, largely thanks to successful applications for a few very large projects. It is therefore uncertain whether Norway will be able to maintain and strengthen the return rate in the years ahead.

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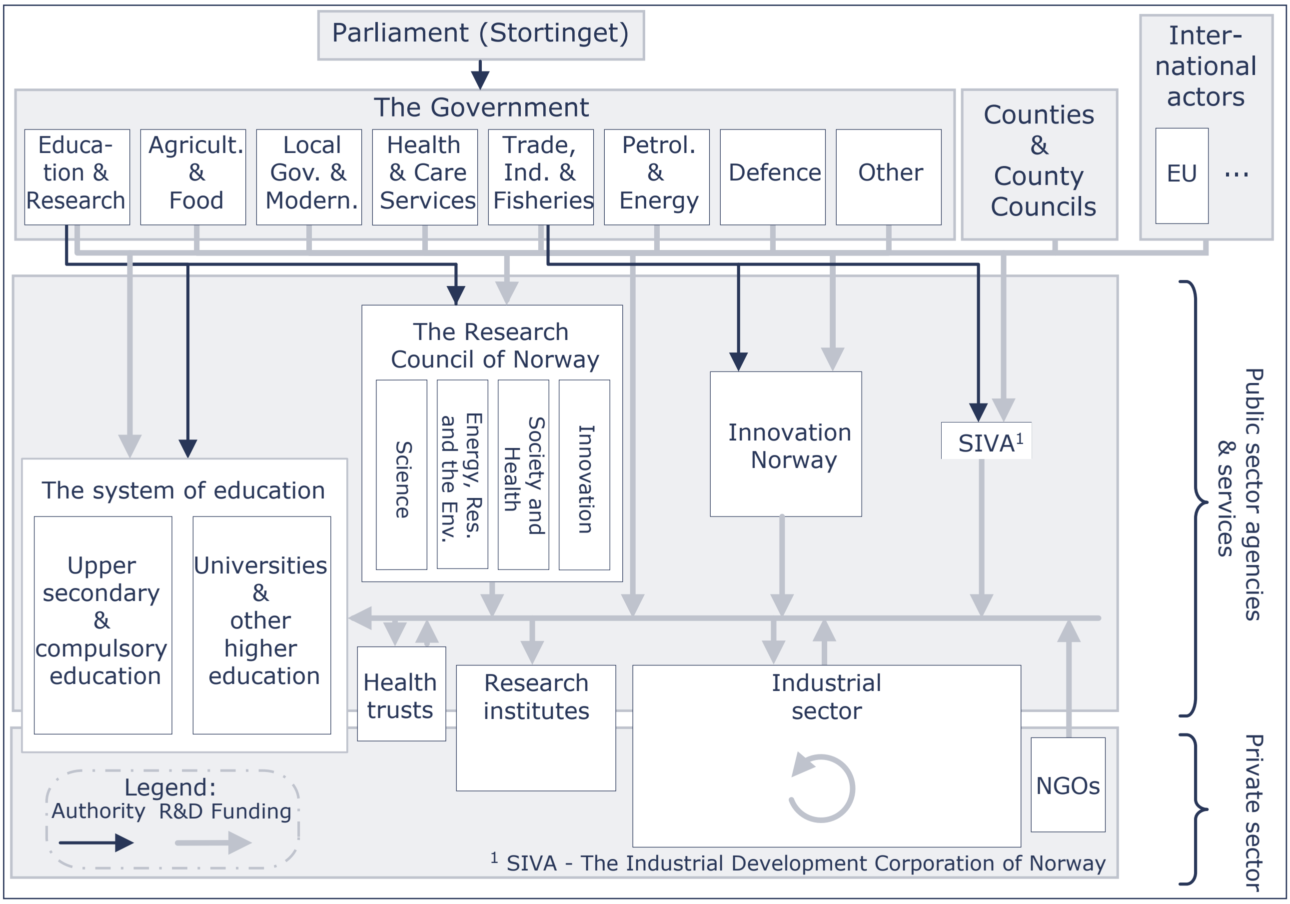
The Norwegian system of education, research and innovation



The Norwegian research and innovation system includes a large number of institutions with different roles. It is common to distinguish between three levels: the political, the strategic and the performing level. The increasing internationalization of Norwegian research also means that the international dimension should be taken into consideration. Foreign actors are important to all parts of the Norwegian R&D system.

The figure above provides a simplified picture of the organization and division of labor in the R&D and innovations system. The description is limited to those actors which are involved in research and research-based innovation. The system can be characterized by a large degree of pluralism at the political level. According to the «sector principle» all 18 ministries are responsible for financing both short term and long term research within their respective sectors. Hence, public research funding and science policy involves extensive coordination.

At the same time R&D budgets are fairly concentrated, as five ministries stand for 85 per cent of all R&D funding, with the Ministry of Education and Research allocating approximately half of all funding and coordinating of R&D policy. The main funding streams consist of 1) the R&D component integrated in the basic funding to universities and university colleges and 2) funds allocated via the Research Council of Norway.

At the strategic level, Norway has fewer actors and stronger coordination. The establishment of one unified Research Council in the early 1990s is unique in an international context. Furthermore, the innovation agency «Innovation Norway» fulfils functions which in many other countries are divided among several actors.

On the performing level, there is a broad variety of actors, including 8 universities, 25 state university colleges and a number of private higher education institutions. At the same time, research activity is rather concentrated, as universities (including university hospitals) carry out more than 80 per cent of the higher education sector's total R&D expenditure in 2013. Compared to other countries, a relatively high share of Norwegian R&D is performed by research institutes, a sector which is also rather heterogenuos, both in terms of the size, profile and legal status of the institutes. The sector includes both public sector oriented and industry oriented institutes, where the latter group plays an important role in carrying out contract research for Norwegian and foreign companies. Even though the industrial sector accounts for nearly half of all R&D expenditure in Norway, there is little research performed in this sector compared with other countries. Given the resource-based structure of the Norwegian economy, there are relatively few large R&D-intensive companies in Norway.

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 compare the status of Norway to that of the other Nordic countries, the EU, and the OECD. See also the indicators in the appendix of this report.

Key indicators for R&D and innovation in Norway in 2007, 2009, 2011, 2012 and 2013.

	2007	2009	2011	2012	2013
Resources for R&D and innovation					
R&D expenditure as a percentage of GDP	1.57	1.72	1.63	1.62	1.65
R&D expenditure per capita in constant 2010-prices (NOK)	8,875	9,000	8,798	8,842	8,863
R&D expenditure funded by government as a percentage of total R&D expenditure	45	46	46	..	45
R&D expenditure funded by industry as a percentage of total R&D expenditure	43	42	43	..	41
R&D expenditure in the higher education sector as a percentage of total R&D expenditure	32	32	31	31	32
Human resources					
Percentage of the population with higher education	34	37	38	39	40
R&D full-time equivalents per 1,000 capita	7.1	7.5	7.5	7.5	7.6
R&D full-time equivalents per qualified researcher/scientist per 1,000 capita	5.2	5.4	5.5	5.5	5.6
Percentage doctoral degree holders among qualified researchers/scientists	27	30	32	33	34
Percentage women among qualified researchers/scientists	34	35	36	40	36
Cooperation in R&D and innovation					
Extramural R&D expenditure compared to intramural R&D expenditure in the industrial sector (%)	28	31	27	28	27
Companies involved in cooperation on R&D as a percentage of all R&D companies	39	39	34	..	33
Companies involved in cooperation on innovation as a percentage of all innovative companies	39[1]	37[2]	38[3]	34	43[4]
Articles in international scientific journals co-authored by Norwegian and foreign researchers as a percentage of all articles by Norwegian researchers	54	56	57	58	60
Results of R&D and innovation					
Percentage innovative companies in the business enterprise sector	31[1]	27[2]	23[3]	21	36[4]
Percentage of turnover of new or substancially altered products in the industrial sector	5.9[1]	4.5[2]	5.2[3]	4.9	5.9[4]
Number of articles in international scientific journals per 100,000 capita	172	198	224	230	238
Number of patent applications to the European Patent Organization per million capita[5]	102	122	106	109	..

[1] 2006.
[2] 2008.
[3] 2010.
[4] 2014. Break i series.
[5] By inventor address and by application date, European applications only (EP-A).

Sources: NIFU, Statistics Norway, OECD, Eurostat

Key indicators for R&D and innovation in last available year with comparable data in Norway, Sweden, Denmark, Finland, EU and OECD.

	Year	Norway	Sweden	Denmark	Finland	OECD	EU 28
Resources for R&D and innovation							
R&D expenditure as a percentage of GDP	2013	1.65	3.30	3.06	3.31	2.36	1.91
R&D expenditure per capita (NOK)	2013	9,990	13,567	12,320	12,142	8,237	6,198
R&D expenditure funded by the government as a percentage of total R&D expenditure	2013	46	28	29	26	28	33[1]
R&D expenditure funded by the business enterprise sector as a percentage of total R&D expenditure	2013	43	61	60	61	61	55[1]
R&D expenditure in the higher education sector as a percentage of total R&D expenditure	2013	32	27	32	22	18	24
Human resources							
Percentage of the population with higher education	2013	40	37	35	41	33	30[2]
R&D full-time equivalents per 1,000 capita	2013	7.6	8.4	10.4	9.7	..	5.3
R&D full-time equivalents per qualified researcher/scientist per 1,000 capita	2013	5.6	6.5	7.3	7.2	3.51	3.4
Cooperation in R&D and innovation							
Companies involved in cooperation on innovation as a percentage of all innovative companies	2012	28	30	42	36	..	31
Companies involved in cooperation on innovation as a percentage of innovative companies in manufacturing and mining	2012	31	31	44	42	..	29[3]
Results of R&D and innovation							
Percentage of innovative companies in the business enterprise sector	2012	31	45	38	45	..	36
Percentage of innovative companies in manufacturing and mining	2012	35	49	42	52	..	47[3]
Percentage of turnover of new or substantially altered products in the business enterprise sector	2012	5.2	6.1	13.9	11.1	..	13.5
Percentage of turnover of new or substantially altered products in Manufacturing or Mining	2012	12.0	7.4	20.1	19.2	..	20.1
Number of articles in international scientific journals per 100,000 capita	2014	247	272	310	237	78	103[4]
Number of patent applications to the European Patent Organization per million capita[4]	2012	109	299	227	271	..	112

1 2012.

2 EU 21.

3 EU 15.

4 By inventor address and by application date, European applications only (EP-A).

Sources: NIFU, Statistics Norway, OECD, Eurostat, DG Enterprise

1 Norwegian R&D and innovation in an international context

Dag W. Aksnes, Frank Foyn, Mark Knell, Espen Solberg, Kaja Wendt, Lars Wilhelmsen

Norway and the main international trends

- The global shift in R&D resources continues. USA's and Europe's share of world R&D are dwindling, while Asia's, and especially China's, share increases. If this development continues, China will be the largest R&D nation within a few years.

- The highest growth in R&D expenditure is found in countries that have not previously had much R&D, including several Asian and East European countries.

- Over time, we see that R&D expenditure varies with the trend in GDP. This is particularly true for R&D expenditure in the business enterprise sector, while public R&D expenditure has had a more even development.

- In recent years, the buffering effect of public research decreases. It is in the business enterprise sector we find the strongest growth in R&D expenditure in 2013.

- For the total of the OECD countries, R&D expenditure as a percentage of GDP amounted to 2.36 per cent. Norway's R&D ratio, at 1.65 per cent of GDP, was well below this level, and below the level in the other Nordic countries. Meanwhile, Norwegian growth in R&D expenditure is slightly stronger than in the other Nordic countries.

- The world production of scientific articles has grown significantly in recent years. The USA is the largest research nation with 400,000 articles, or 20 per cent of the world's scientific knowledge production in 2014.

- In China, we find the strongest growth in production of scientific articles between 2006 and 2014, followed by South Korea, Australia, Denmark and then Norway.

- Norwegian researchers produced 12,500 articles in 2014. This corresponds to 2.57 articles per thousand inhabitants; the corresponding figures in Denmark and Sweden were respectively 3.10 and 2.72 articles.

- Norwegian scientific articles were cited about as frequently as Swedish and Finnish articles, but slightly less than the Danish scientific production.

Innovation measurements

- Norway ranks higher on broad measures of political or economic conditions. When it comes to innovation rankings, the picture is more mixed.

- On the EU's Innovation Union Scoreboard (IUS) 2015, Norway is regarded as a moderate innovator. With the results from the alternative innovation survey by Statistics Norway, Norway would move up three places to 13th position.

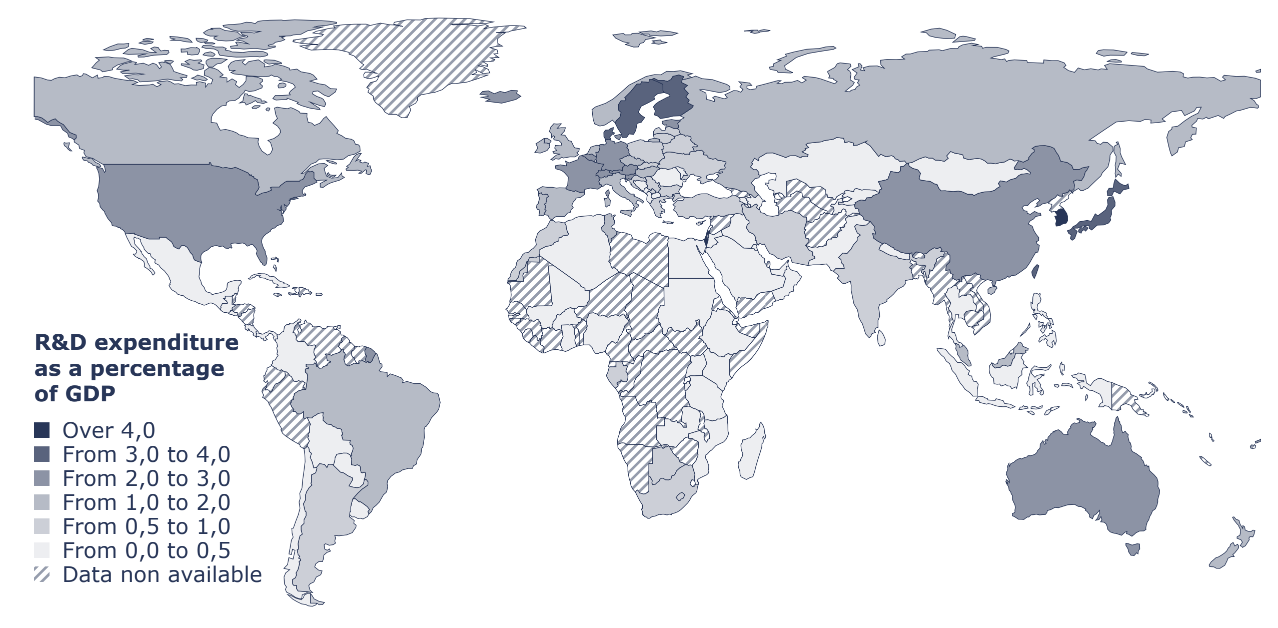
Human resources

- In OECD countries, the proportion of the population with completed secondary or higher education is increasing, while the proportion of the population without such education goes down.

- In 2013, China had most scientists in the world with 1.5 million R&D FTEs. The Nordic countries have most researchers in relation to the number of inhabitants.

- Regarding doctoral candidates, there is gender balance in many European countries. However, further up the job hierarchy men are still in the majority.

Figure 1.1
Total R&D expenditure as a percentage of GDP in the world: 2013 or latest available year.



Source: UNESCO, OECD - MSTI 2015:1

Research and innovation requires significant resources and long-term planning: there is also a clear correlation between economic development and investment in this field. In addition, investment in research and innovation often contributes to economic growth. The Figure above shows how much different countries in the world are investing in research and experimental development (R&D) as a share of gross domestic product (GDP). There is still a clear tendency for rich Western countries to spend most resources on R&D. The dark spots on the map indicate the countries that spend most on R&D, while the light areas are countries with relatively low investment.

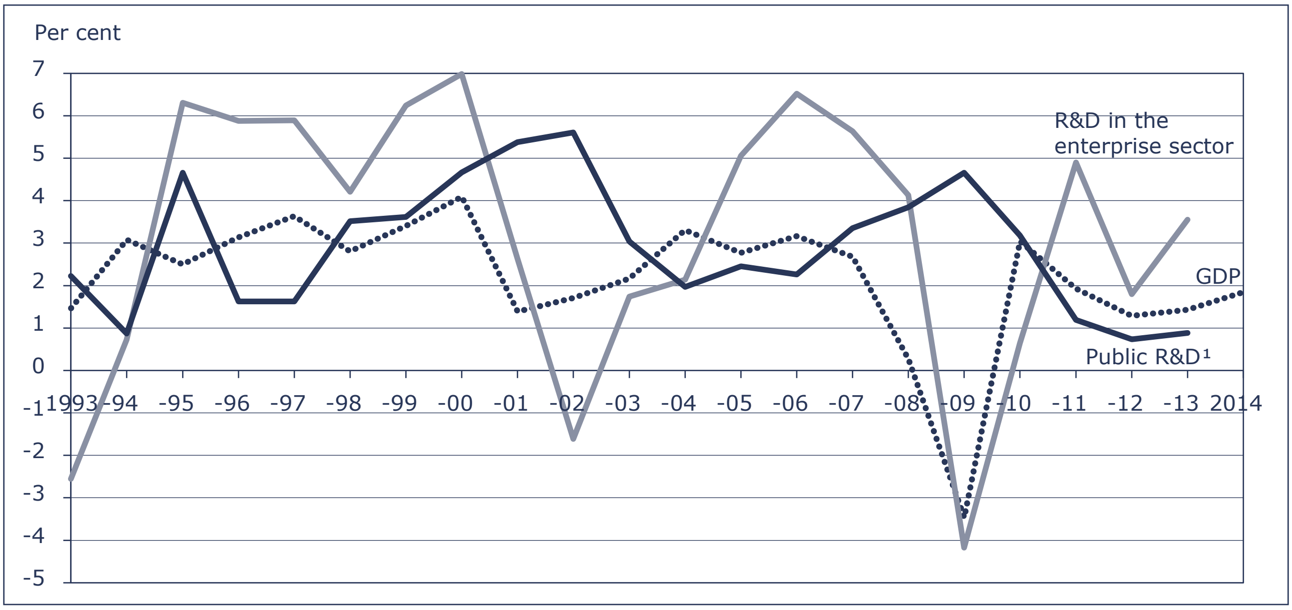
This chapter looks at Norwegian R&D and innovation in an international context, beginning with a closer look at the global distribution of R&D. Although the main picture is stable, the traditional relation of strength is changing. This is partly reflected in the so-called emerging economies also becoming research nations. This goes for both financial and human resources, and patterns of scientific publication and citation.

Furthermore, we look at trends in public and private R&D expenditure in the years before and after the financial crisis. There are large differences between individual countries, but also a clear tendency that demands for public cost savings make it difficult to strengthen R&D budgets.

The chapter also examines recent numbers for comparing innovation between countries. Countries that invest heavily in research also tend to score high on indicators measuring innovation. We also show that measurement of innovation is problematic, and that methodology can have a major impact when comparing countries, not least for Norway.

Finally, we look at the gender balance in research. In most countries, women are now in the majority among students. In Norway and some other countries, women are also in the majority in terms of doctorates. Further up the job hierarchy, on boards and in management, men remain in the majority.

Figure 1.2
Total GDP and R&D expenditure by main sector of performance in the OECD countries: 1993–2013/2014. Constant PPP$-prices.



[1] Incl. higher education sector.
Source: OECD MSTI 2015:1 and World Bank

To a large degree, trends in R&D expenditure follow trends in economic developments. The financial crisis hit sharply and immediately the economy measured by GDP growth. Since then growth has largely recovered and varied at around 2 per cent in recent years. R&D expenditure in the business enterprise sector largely followed the same trend both in the period before and after the financial crisis. It reflects the fact that most R&D in the OECD area is carried out by private enterprise. The impact on overall R&D is still more moderate, as public R&D helps to curb development.

The buffer effect of public R&D decreases

Public R&D investment has had a more even development than private R&D investment. Public R&D also had a noticeable buffer effect on total R&D during recessions, as shown in Figure 1.2. Both when the dotcom bubble burst in the early 2000s and after the financial crisis of 2008, there was real growth in public R&D, while the business enterprise sector in both periods had a real decrease in R&D expenditure. Directly after the financial crisis, there was a quite strong growth in public sector R&D, mainly as a result of the various stimulus packages introduced in many countries. In recent years, however, R&D growth in the public sector has been reduced and languished at just under 1 per cent annual real growth. In the OECD area business enterprise sector R&D increased more than R&D in the public sector.

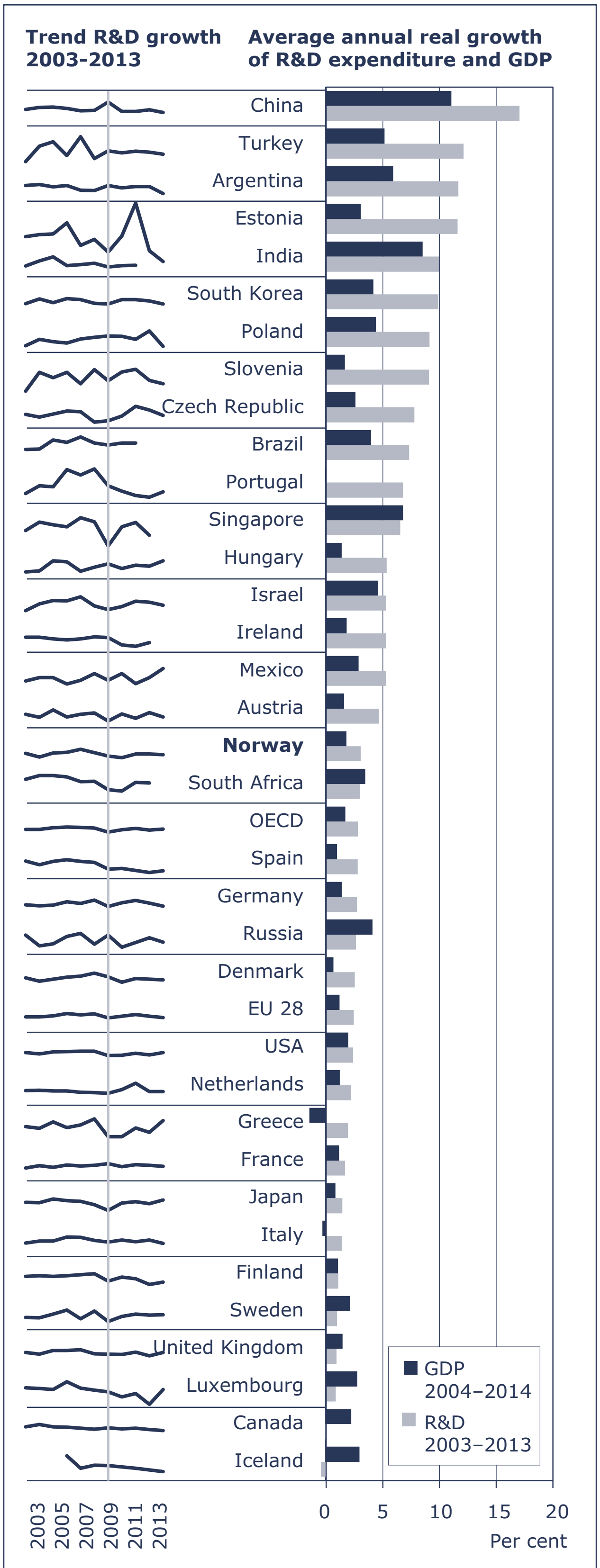
Mixed international economic trends

Continued GDP growth is expected in the OECD area. Among Norway's main trading partners growth recovered towards the end of 2014 (SSB Økonomisk utsyn 1/2015). While growth in the euro area in 2013 was 1 per cent, it rose to 2.5 per cent for the USA, Sweden and the UK. After the upswing in autumn 2014, economic growth slowed globally in the first quarter of 2015. Indeed, growth has increased in the euro area, but declined markedly in the UK and Sweden, and turned to decline in the US. For the 2015–2017 period, GDP is expected to grow by just over 1 per cent annually in the euro area and then pick up to 1.7 per cent in 2018. Several euro countries are expected to remain in recession until the end of 2018.

For the emerging economies the picture is more mixed. Development is particularly weak among large commodity producers such as Brazil and Russia, with partly negative growth rates. In the first quarter of 2015, growth in China was the weakest since 2009, while India's growth continues.

An oil price decline usually stimulates the world economy, but low oil prices turn out differently for oil-exporting and oil-importing countries. China and other emerging economies in Asia are among the largest oil importers, but Europe, Japan and the US also import much oil. Based on new production technology in the US, the country has built up a significant oil-producing sector, but for the economy as a whole a decline in oil prices is expected to be positive.

Figure 1.3
Annual real growth in R&D expenditure 2003–2013 and GDP 2004–2014 for selected countries and R&D trend 2003–2013. Fixed PPP$-prices.



Source: OECD – MSTI 2015:1

Most countries with updated figures experienced a decline in R&D expenditure in connection with the financial crisis. However, there are major differences between individual countries. In Figure 1.3, we look closer at the average annual real growth in R&D expenditure in individual countries for the decade 2003–2013 and for GDP in the period 2004–2014. To reveal the annual changes in the period we have also included trend figures for R&D for each country. For most countries, 2009 saw the weakest growth in R&D expenditure (marked line in the Figure), and for the majority growth was weaker after 2009 than before. The majority of countries in the Figure focused more strongly on R&D than the economic developments in the decade might imply. In particular, China, Turkey, several East European countries, crisis-hit countries such as Portugal, Ireland and Greece, as well as South Korea, Austria and Denmark, all invested a great deal in R&D.

China's R&D growth is in a class of its own

We find the highest R&D growth in the last decade outside Europe. China has by far the highest growth, followed by Argentina and Turkey. Following them, we find countries like India, South Korea, and Brazil.

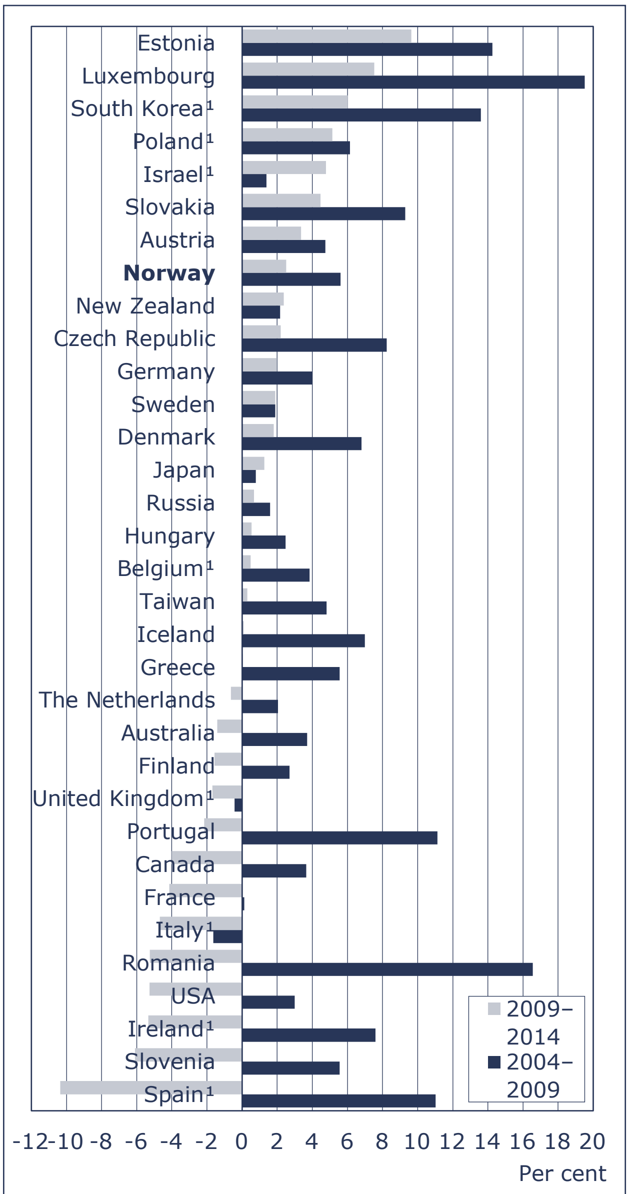
Outside Europe, Canada had the lowest growth in from 2003 to 2013. The US and Japan also have lower growth in R&D expenditure than the OECD average and contribute greatly to reducing the average figure.

In the US there was a real decrease in R&D expenditure of one per cent in 2009; after that the growth in R&D expenditure varied and in 2013 was over three per cent. Since the financial crisis Japan has had some growth, most in 2013 at nearly 6 per cent. Countries where R&D investments were hit particularly hard by the financial crisis in 2009 were Singapore, Japan, and South Africa.

Norway has the strongest growth in the Nordic region

In Europe, the East European countries had the strongest growth in R&D expenditure in the period 2003–2013. The weak trend of traditionally strong research nations like France and Britain contributes to reduce the average for EU 28 countries. In the last two years with updated figures, growth in the EU 28 declined, amounting in 2013 to only 0.7 per cent. Among the countries with weak growth in the decade, we find Sweden and Finland. Iceland has the weakest growth; methodological issues regarding the change of statistical producer might play a role. Norway is slightly above the average for OECD countries.

Figure 1.4
Average annual real growth in government budget allocations for R&D (GBARD) in selected countries: 2004–2009 and 2009–2014 or last available year.



[1] 2009–2013.
Source: OECD – MSTI 2015:1

Figures on government budget allocations for R&D (GBARD) provide a more updated picture of developments in public R&D efforts than figures from the R&D statistics. Government budget figures provide information on the intention of the funds, while R&D statistics show the actual use of funds. R&D statistics are therefore a more reliable source for measuring the research actually performed, while budget analysis is more up to date and provides a better picture of the government's intentions.

Stagnation and cuts in research budgets after the financial crisis

A relevant question is whether the authorities in the various countries have increased or decreased research funding following the financial crisis. Comparing the period prior to the financial crisis (2009) with the period after, there is a clear tendency to decline, or slower growth, in the last period. As shown in Figure 1.4, only two countries (Italy and the United Kingdom) had a decline in R&D budgets during the five-year period prior to 2009. In the period after 2009, almost half of the OECD countries had a decline. Of all OECD countries with available figures, only Israel had stronger growth in R&D budgets in the period after 2009 compared with five years before. This indicates that the research boost that came in the years immediately after the financial crisis is seldom maintained.

From crisis packages to public savings

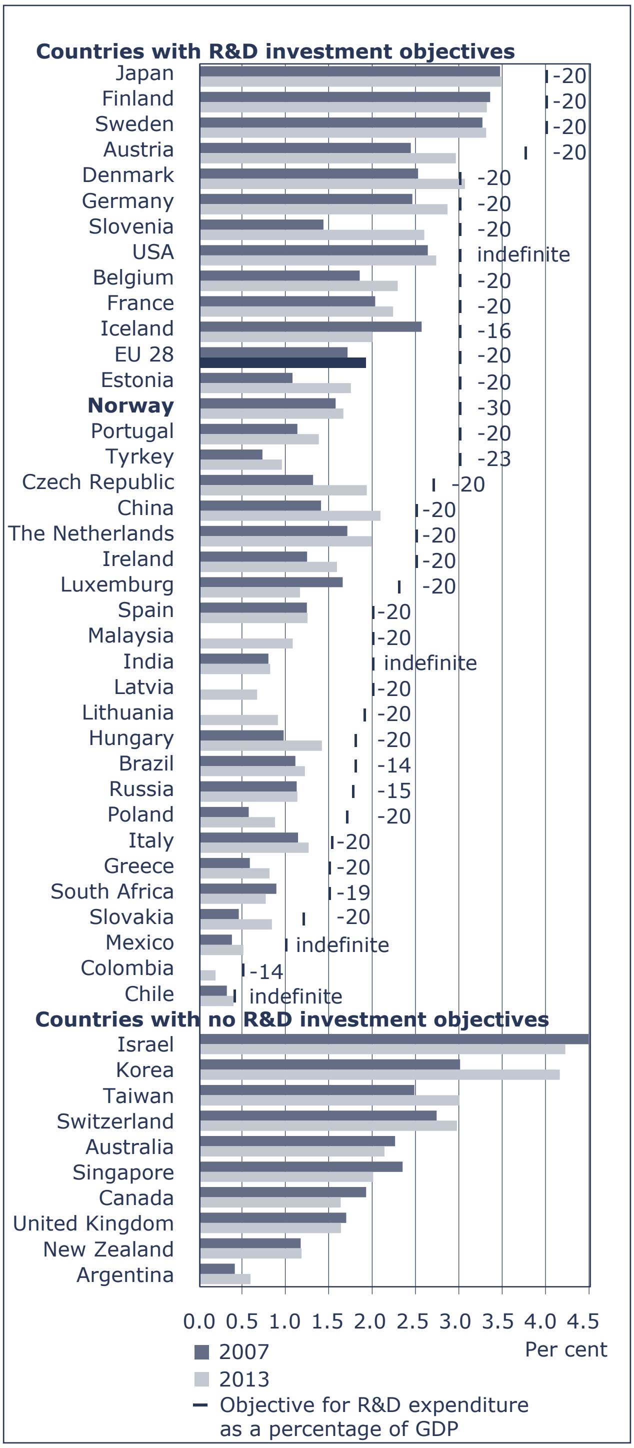
A consistent pattern seems to be that after the financial crisis the development of R&D has gone in two phases: the first phase was characterised by an upsurge through the so-called crisis packages, where several countries adopted a powerful boost in R&D budgets against crisis. In 2009, for example, 10 OECD countries had a real growth in public R&D funding of over 10 per cent. These include major players such as the United States, Australia, Russia and South Korea. Norway also had a sharp upswing in 2009, with real growth of more than 8 per cent. We find, however, substantial fluctuations from year to year and between individual countries. In Greece, the financial crisis resulted in sharp cuts in the years after 2009, but from 2012 the appropriations in Greece have increased.

Norway has the strongest increase among the Nordic countries

The Nordic region shows that R&D budgets develop differently also when comparing relatively homogenous countries. While all countries had real growth up to 2009, the picture is mixed for the past five years. In Denmark, growth levelled off, while Finland continues to cut R&D budgets. In Sweden and Norway, research budgets increased. Growth is now strongest in Norway, both last year and over the last five years. Iceland has an overall zero growth from 2009 to 2014.

Figure 1.5

R&D expenditure as a percentage of GDP in selected countries: 2007 and 2013 or last available year. National targets for R&D investments.



Kilde: OECD STI Outlook 2014, MSTI 2015:1, Eurostat

A widely-used indicator for international comparison of R&D resources is to measure the resources against gross domestic product (GDP). This measure is independent of exchange rates, but affected by fluctuations in GDP level. For example, R&D as a share of GDP increases if GDP levels go down.[1] In Figure 1.5, we have sorted countries by target for R&D expenditure as a percentage of GDP and by real R&D efforts.

Widespread EU R&D target at 3 per cent

Since 2001, the European Commission target for R&D expenditure in the member states is three per cent of GDP. At first, the goal was to be reached by 2010; then the deadline was postponed until 2020. When the target was introduced, R&D expenditure in the EU 28 member states was 1.7 per cent of GDP. In 2013, this had risen to 1.92 per cent of GDP. Many countries, adopted the three per cent target as a national target. Among others, Finland, Sweden and Austria set themselves higher targets than the EU, while Britain has not quantified a growth target.

Does the target lead to higher investments?

From Figure 1.5 we see that in 2013 Israel, South Korea, Japan, Finland, Sweden and Denmark had the highest R&D expenditure as a percentage of GDP: all over three per cent. At the other end of the spectrum, Argentina, Mexico, Greece, India and Turkey, all spend less than one per cent of GDP on R&D.

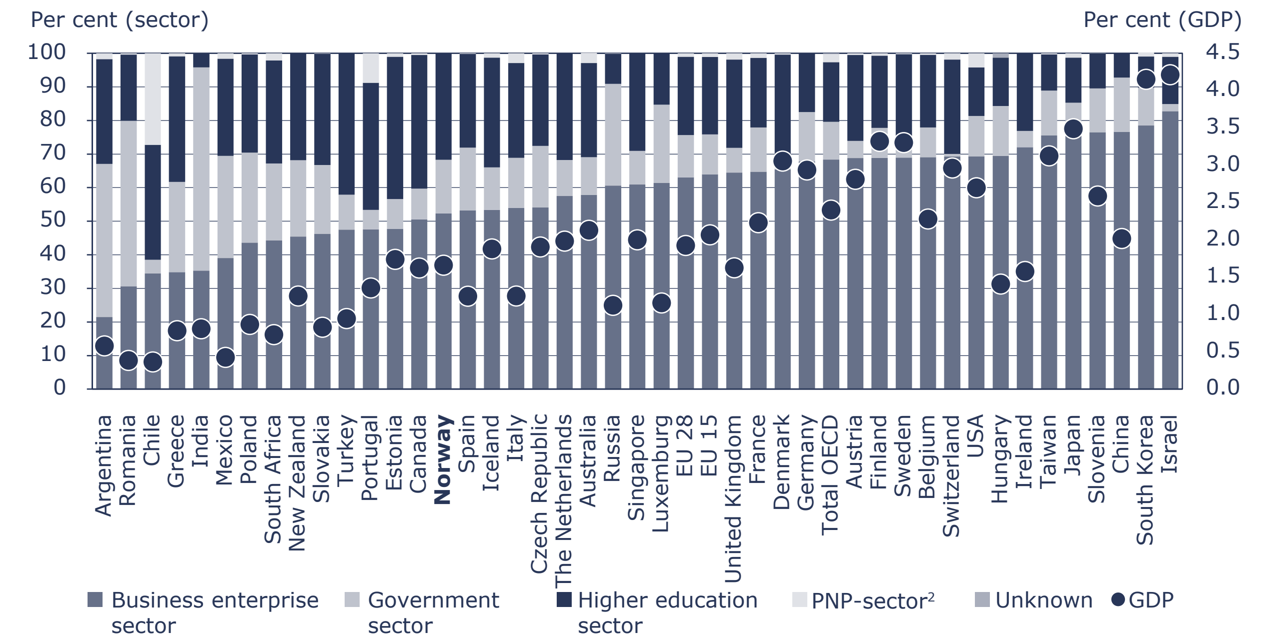
Four of the countries with the highest R&D share of GDP – South Korea,[2] Taiwan, Israel and Switzerland – have no numerical target for R&D investment. Other countries without quantified targets are Australia, Canada, the UK, New Zealand and Argentina. For half of the ten countries without targets for R&D investment the R&D share of GDP increased; for the other half it decreased.

For most of the 36 countries with quantified R&D targets, R&D as a share of GDP increased over the last five years. The exceptions are Finland, Iceland, Luxembourg and South Africa. The large decrease in Iceland is affected by technical factors. In other words, a far greater proportion of countries with quantified targets for R&D expenditure increased R&D efforts in relation to countries without a target: nearly 90 per cent versus 50 per cent. Among countries with a target for R&D investment, however, only Denmark has achieved the target at three per cent of GDP. Germany declared in 2013 that the goal was reached, but recently the level is below the target.

1 According to the new guidelines for national accounts, R&D should be treated as investment and not as expense. For OECD, this leads to an increase of GDP by 2.2 percentage points (calculated for 2010), while the increase for Norway is estimated at 1.4 percentage points. See also Chapter 2.

2 In 2009, South Korea had a five per cent target to achieve by 2013, no information was found for recent years.

Figure 1.6
R&D expenditure in selected countries by sector of performance (left axis) and a percentage of GDP (right axis): 2013 or last available year.[1]



[1] 2011 for India, Mexico, Australia. 2012 for South Africa, Singapore and Switzerland.

[2] PNP sector: private non-profit sector. For Iceland, the PNP sector is included in government sector.

Source: OECD MSTI 2015:1 and UNESCO

Large differences in where research is performed

In the majority of countries, the business enterprise sector accounts for more than half of R&D expenditure. Almost 70 per cent of R&D expenditure in the OECD countries and 63 per cent in the EU 28 is performed within the business enterprise sector. The proportion in the OECD is affected by a high proportion of R&D carried out in this sector in the United States. As shown in Figure 1.6, countries with high R&D intensity, measured as R&D expenditure as a share of GDP, also have a high proportion of R&D in the business enterprise sector. In Israel, South Korea and China up to 80 per cent of all R&D is conducted in the business enterprise sector.

Norway has the lowest share of business R&D among the Nordic countries

In Denmark, Sweden and Finland the business enterprise sector proportion of R&D is close to 70 per cent. Norway stands out among the Nordic countries with only 52 per cent of national R&D efforts going on in this sector. This is mainly because Norwegian industry is relatively commodity-based, with low production in industries with typically high R&D intensity: see more about this on the next page.

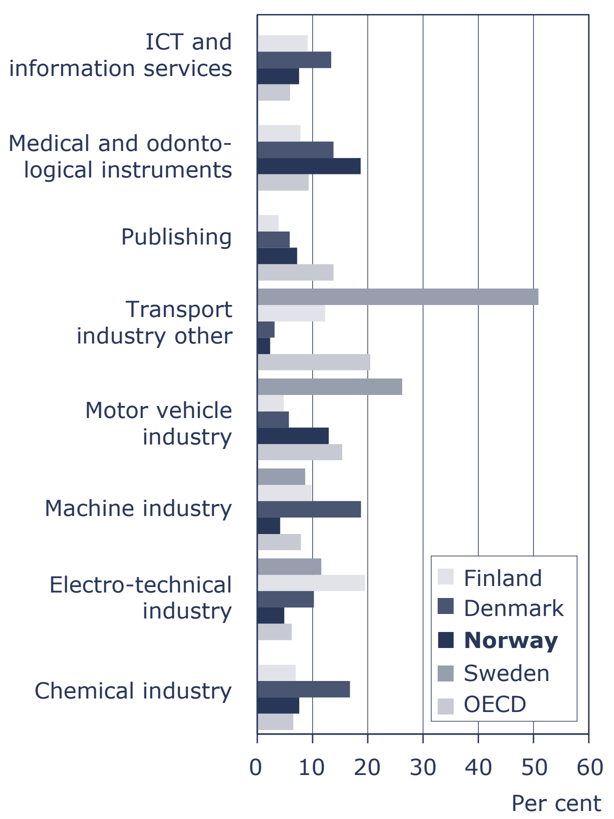
Countries with a large proportion of R&D in the public sector are Argentina, Romania, India and Russia. These are all countries with a relatively low R&D intensity. For the OECD total 11 per cent of R&D expenditure is performed in the government sector. In Norway, the government sector share of R&D is much higher than in the other Nordic countries. The Norwegian higher education sector at 32 per cent of total R&D is also relatively large compared with OECD at 18 per cent. Denmark and Iceland also have a large proportion of R&D performed in higher education sector, while this proportion is smaller in Finland and Sweden.

The PNP sector is by far the smallest R&D performing sector in all the countries in the Figure. Only in Chile and Portugal is the PNP sector of any size.

Low R&D intensity in Norwegian industry

As shown earlier in this chapter, Norway has a relatively low R&D intensity in relation to GDP. One important explanation for this is that the Norwegian industrial sector has a high value added from industries that traditionally spend few resources on R&D. Conversely, Norway has relatively low activity in within R&D-intensive industries that traditionally require a lot of research. Here we look at R&D efforts within

Figure 1.7
R&D as a share of value added in four Nordic countries and OECD by industry: 2011.



Source: OECD's STAN STructural ANalysis Database and OECD ANBERD (Analytical Business Enterprise Research and Development) database, Eurostat Structural business statistics and national sources.

various industries compared with other OECD countries, with particular emphasis on the Nordic countries, as shown in Figure 1.7. Generally, manufacturing industries have a higher R&D intensity than other industries. For OECD countries, the R&D intensity of industry amounted to 8.3 per cent compared with 4.6 per cent for Norway. The other Nordic countries are between 11 and 14 per cent.

The high-intensive industries (OECD classification) have a high intensity also in Norway, but generally somewhat lower than the average for OECD countries and the other Nordic countries.

For the medium-high-intensive industries, the picture is mixed. Norway scores low in the *industry other transport equipment (other than motor vehicles)*, where the *building of ships and platforms* is included. In *motor vehicles and components*, Norway has a high R&D intensity, but this is still a small industry in Norway. Although *software publishing* is a relatively large R&D industry in Norway, the share of value added is much lower than in the OECD.

High R&D intensity within metals and paper products

Regarding medium-intensive industries, *other manufacturing* has a high R&D proportion in Norway compared with other countries, but this is not a large industry. The contribution comes primarily from the *manufacture of medical and dental instruments and supplies.*

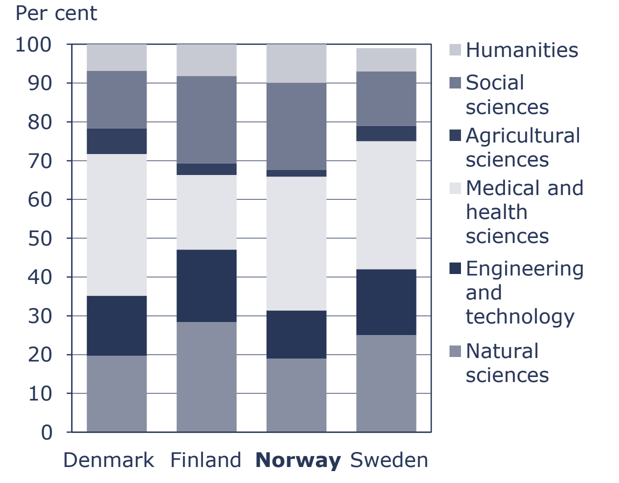
When it comes to medium-low-intensive industries, the R&D proportion is consistently higher in Norway than in the OECD. This applies particularly to the *manufacture of fabricated metal products*, a relatively large research industry in Norway. *Paper and paper products* have an even higher R&D intensity for Norway but this is a minor industry. *Telecommuni-cations* is also classified as medium-low by OECD but would be classified as medium-intensive in Norway. It is worth noting that *mining and quarrying* is also grouped here. This is a large R&D industry in Norway, but R&D intensity in Norway is still low due to the high value added within this industry.

Fishing and aquaculture is classified as a low-intensive industry in OECD. For Norway, it would have been classified as medium low. This also applies to *financial and insurance activities.*

R&D intensity by industry

This section addresses selected industries. The web version of the Norwegian S&T report includes in Table A.5.14 a complete list of R&D as a share of value added for all industries in Norway and selected OECD countries. OECD's new classification of industries' R&D intensity (from High to Low) is included there. At detailed level, the data for several countries are confidential, also for Norway, so that the representation is weaker for some industries. There are also substantial variations in R&D intensity between countries within the same industry. It may be difficult to determine whether this is mainly due to real differences or inconsistencies in the data (mismatch between R&D expenditure and value added). For technical reasons 2011 is the latest year with updated figures.

Figure 1.8
R&D expenditure in the higher education sector in Denmark, Finland, Norway and Sweden by field of research and development: 2013.



Source: National R&D statistics

Table 1.1
R&D expenditure in the higher education sector in Denmark, Finland, Norway and Sweden by funding source: 2013.

Source of funds	Denmark	Finland	Norway	Sweden
General university funds	57	42	**67**	45
Higher education sector	-	1	**2**	3
National research councils	11	28	**15**	15
Sector funding	12	10	**7**	16
Industrial sector	3	5	**4**	4
Private funds	11	4	**3**	10
Abroad	8	10	**3**	7
of which EU	*4*	*8*	*2*	*5*
Total	**100**	**100**	**100**	**100**

Source: National R&D statistics

Different size of higher education R&D expenditure in the Nordic countries

The proportion of R&D performed by the higher education sector naturally varies with the different countries' research systems. This sector accounts for 23 per cent of total R&D both in the EU 28 and in the OECD total. In Norway, the higher education sector has a relatively large share, with 32 per cent of total R&D. This is the same level as in Denmark, while Sweden and Finland have somewhat lower proportions, with respectively 27 and 22 per cent of national R&D performed in this sector. Both Finland and Sweden have a larger share of R&D performed in the business enterprise sector.

Although the divisions between sectors are relatively stable, there may be a trend that a larger proportion of R&D is carried out by universities and colleges. It applies to all the Nordic countries except for Finland, where the proportion over the years has been stable at just over 20 per cent of total R&D.

Medicical and health sciences important in the Nordic countries

Medical and health sciences is the largest field of R&D in the higher education sector of Denmark, Sweden and Norway: see Figure 1.8. R&D at the university hospitals naturally accounts for a large proportion within the medical field. Due to the close cooperation between university hospitals and universities, it is challenging to measure the real extent of R&D in the different types of institutions. A study prepared by Nordic producers of R&D statistics (Wendt, Söder, Leppälahti, 2015) shows that R&D at university hospitals makes up a far larger proportion in Denmark and Norway (20 and 17 per cent respectively) than in Finland and Sweden (about 4 per cent). Part of the differences can be explained by different coverage and methodological factors.

In Finland and Sweden, the proportion of R&D expenditure within natural sciences and engineering and technology is greatest, while the proportion is somewhat lower in Denmark and Norway. In social sciences and humanities, Finland and Norway have the biggest shares, about 10 percentage points higher than in Denmark and Sweden. Agricultural science is the smallest field in all countries, the proportion varying between two per cent in Norway and seven per cent in Denmark.

Norway has the lowest share of external funding

There are also differences in R&D funding in the higher education sectors of the Nordic countries. As shown in Table 1.1 Norway has the highest proportion of funding by general university funds (GUF) at 67 per cent, while Finland has the lowest proportion of this funding source. In Finland, funding from research councils plays a much greater role in financing higher education R&D than in the other Nordic countries.

The business enterprise sector funds a relatively modest share of R&D at universities and colleges in all the Nordic countries: between three and five per cent. However, both Denmark and Sweden have large private funds which contribute about ten per cent of the sector's R&D. With regard to funding from abroad, the Norwegian higher education sector receives the lowest percentage, and has the smallest proportion of EU funding. Finland has the largest share of funding from abroad.

This section provides an analysis of Norwegian scientific publications from an international comparative perspective. New knowledge, the principal objective of all basic and applied research, is communicated to the scientific community through publications. Publishing can therefore be used as an indirect measure of knowledge production. While the number of publications represents an expression of the extent of the scientific production in different countries and different disciplines, citations indicate the impact of this research.

During the 1981–2014 period, more than 30 million scientific journal articles were published globally. World production has increased throughout the period, from 550,000 articles in 1981 to over 1.5 million in 2014. Norwegian production has also grown substantially over this period. In 1981, Norwegian researchers published almost 2,500 articles. In 2014, that number had increased to 12,500. The growth reflects both the great expansion in the production of knowledge during the period and the increase in the number of scientific journals included. The proportion of Norwegian articles with author addresses from other countries has also increased. In 2013, there was international co-authorship in 60 per cent of the articles.

Norway - a small player in international research

There are large differences between countries in terms of article production. The US is by far the largest research nation globally with over 400,000 publications, or 19.9 per cent of the world's scientific knowledge production in 2014, measured as the sum of all countries' production.[3] China is the world's second largest producer of knowledge with about 250,000 articles and a share of 12.7 per cent: see Table 1.2. Then follow the UK and Germany with more than 100,000 articles each. Norway ranks as the second smallest research nation of the 18 countries in the table. Norway's share amounted to 0.62 per cent, identical to the proportion in 2013. Of the Nordic countries, Sweden is the largest research nation with 50 per cent more articles than the second largest, Denmark. The number of Norwegian articles is marginally lower than in Finland. In terms of population, Norway has 2.47 articles per thousand inhabitants, and ranks as fifth of the countries in Table 1.2. Switzerland clearly has the highest productivity of 3.64 articles per thousand inhabitants. Then follow Denmark and Sweden, which both have higher productivity figures than Norway, with respectively 3.10 and 2.72 articles per thousand inhabitants.

Differences in population size do not necessarily reflect differences in research. A better indicator would be to calculate the relationship between article production and inputs such as R&D expenditure and R&D employment. However, it is difficult to say more about differences in productivity, as differences in specialization profile will influence the picture.

Table 1.2
Number of scientific articles in 2014, per capita and relative growth in number of articles in selected countries: 2006–2014.

Country	Number of articles	Number of articles per 1,000 capita[1]	Percentage of the av World production[2]	Percentage growth in the number of articles from 2006 to 2014[3]
China	256,681	0.19	12.7	196.1
South Korea	55,484	1.10	2.7	90.4
Australia	59,345	2.52	2.9	90.4
Denmark	17,428	3.10	0.9	77.5
Norway	**12,564**	**2.47**	**0.6**	**69.1**
Ireland	8,070	1.75	0.4	65.6
Austria	15,070	1.78	0.7	57.1
Belgium	22,003	1.98	1.1	55.6
Switzerland	29,194	3.64	1.4	53.5
Netherlands	39,726	2.36	2.0	52.4
Sweden	26,157	2.72	1.3	44.2
Finland	12,903	2.37	0.6	41.1
Canada	66,704	1.90	3.3	37.3
Germany	105,764	1.29	5.2	31.1
United Kingdom	115,480	1.80	5.7	30.0
France	73,624	1.12	3.6	26.7
USA	402,915	1.27	19.9	24.4
Japan	79,466	0.62	3.9	0.2

[1] Number of articles in 2014 per 1,000 capita in 2013.
[2] Percentage of world production is calculated based on the sum of all countries' production.
[3] The expansion of the Web of Science database contributes to growth in the number of publications, particular after 2008.

Source: Data: Thomson Reuters/CWTS Web of Science. Computations: NIFU.

[3] To correct for the effect of international co-authorship the sum of all countries' article production is used as divisor. This number will be higher than the actual total world production of articles. In this way, the sum of all the world's countries articles equals 100 per cent and not more than 100 per cent, which would be the case if the latter figure had been used as a divisor. Some other reports and analyses may show examples of such an alternative method of calculation.

Trends in global knowledge production

Table 1.2 shows how article production in the different countries developed in the period 2006 to 2014. Particularly noteworthy is the increase in article production in China, which has more than tripled during the period (196 per cent increase). This is due to the expansion in the nation's research resources, incentives to publish in peer-reviewed journals as well as increased coverage of Asian scientific journals. In addition to China, Brazil has a particularly high growth rate and article production has increased in some other Asian countries, including India (not shown in table).

Norwegian production of articles has also increased greatly during the period. With an increase of 69 per cent, Norway ranks as number 5 of the 18 countries shown in the table. Most European countries have a significantly lower growth rate than Norway; an exception is Denmark with an increase of 77 per cent. The major European research nations, the United Kingdom, Germany and France, have had a growth of only around 30 per cent, while the United States has increased publishing volume by 24 per cent.

Large international increase in number of scientific journals

The development is measured within the universe Thomson Reuters database represents. A complicating factor in interpreting the figures is that the database has increased relatively widely in scope during the period. The coverage of journals published in Latin America and Asia increased, as well as non-English language journals in general. Whether the database expansion correlates with the real increase in the world's total scientific production is difficult to assess. The database probably covers a larger part of the research literature today than previously; this is especially true for non-Western countries.

In addition, a general increase in international co-publication contributes to a decrease of all countries' relative contribution to each article. It is therefore clear that the growth rate can be partially attributed to methodological issues and does not reflect a 'real' increase in research output.

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Bibliometric indicators

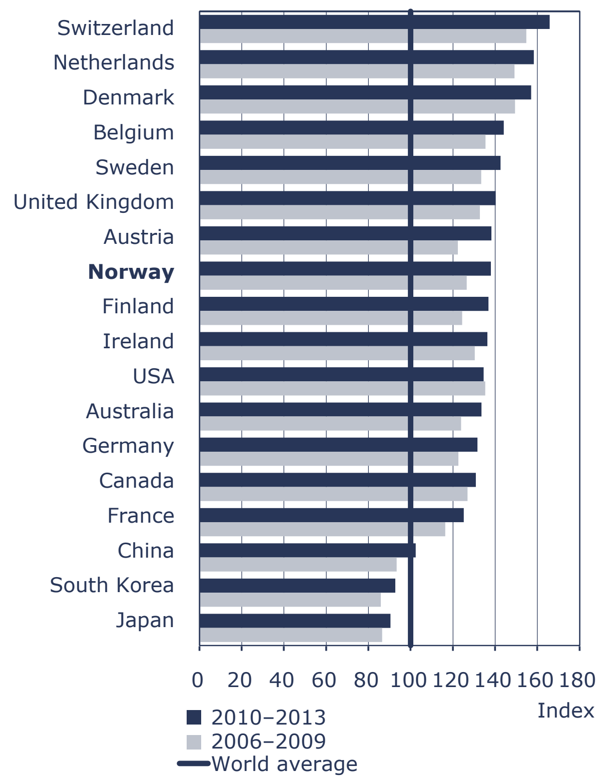
There is no international organization coordinating data collection on scientific publishing, as is the case for R&D and innovation statistics. Instead, the analyses are based on data from private companies, Thomson Reuters (Web of Science), and Elsevier (Scopus). For the analysis here, the Web of Science data are used, including the Science Citation Index (SCI), Social Science Citation Index (SSCI) and Arts and Humanities Citation Index (A&HCI). The database publications in specialised and multi-disciplinary peer-reviewed journals are registered, including all major international journals in science, medicine and technology. Also included are journals of social sciences and humanities. In total, the database includes more than 12,000 journals. The database is particularly suited to analysing academic scientific and medical research, where publication in international journals is the main way to communicate.

In this year's S&T report macro data from CWTS at the University of Leiden in the Netherlands are used in the analyses. The macro data are based on the Web of Science. CWTS uses a field classification system consisting of 35 different categories; some of these are presented in the discipline analysis.

The macro figures include ordinary articles, reviews, and conference papers published in periodicals; also included are letters. Other types of publications such as book reviews, abstracts etc. are not included in the figures. Generally, an article is attributed to a particular country when it has at least one author address from that country.

Bibliometric indicators have some limitations that are important to be aware of when interpreting the results. Among other things, coverage of journals between disciplines varies. The highest coverage is in fields such as physics, chemistry, biomedicine and clinical medicine. The coverage is also quite good in biology and technology. For the social sciences and humanities, coverage is poorer. The reason for these differences is partly that Thomson Reuters do not index all relevant journals, partly because the publication pattern varies between disciplines. In some fields, research communication is less oriented towards international journals, and publishing in national journals, books etc. plays an important role.

Figure 1.9
Relative citation index for selected countries: 2006–2009 and 2010–2013.



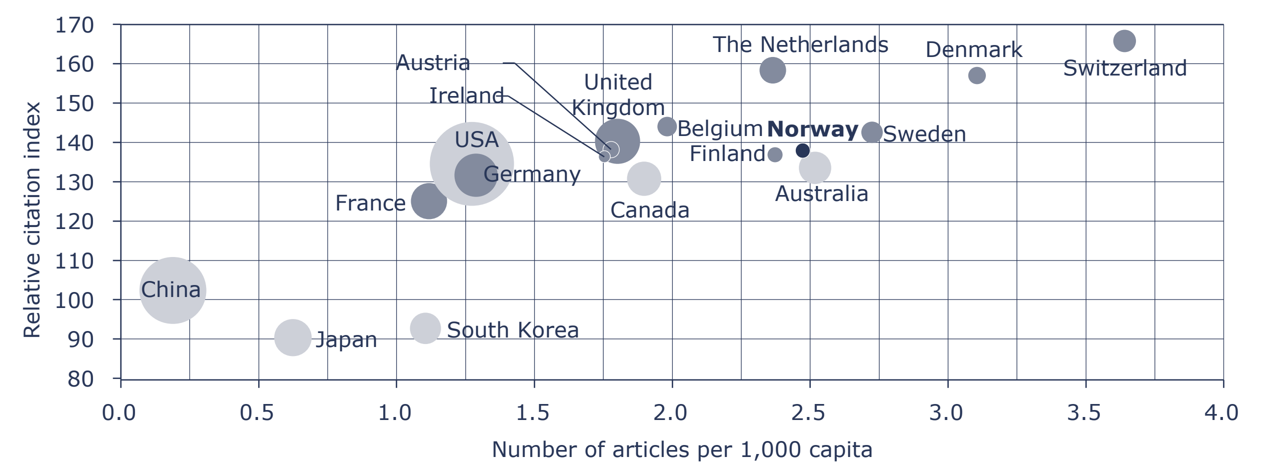
Source: Data: Thomson Reuters/CWTS Web of Science. Computations: NIFU.

From 1980 to 2014 Norwegian researchers published in total nearly 200,000 scientific articles. The articles have been cited more than 3.6 million times in the subsequent scientific literature. In absolute numbers, countries with the highest production of scientific articles naturally also receive most citations. However, size-independent measures are common to assess whether a country's articles are cited high or low. One such indicator is the relative citation index, which expresses the average number of citations per publication. It shows whether a country's publications are cited more or less than the world average, normalised at 100.

Switzerland, the top cited country

In Figure 1.9 we calculated the relative citation index for articles published in the two periods 2006–2009 and 2010–2013. The indicator covers all fields of science. In the latter period, Norway rated as number 8 of the 18 countries included in the comparison, with a citation index of 138. This means that Norwegian articles were cited 38 per cent above the world average from 2010 to 2013. Furthermore, the vast majority of countries in the table were cited more than the world average, and all the European countries had index values well over 100. Switzerland and the Netherlands achieved the greatest scientific impact, as measured by citations. The articles in these countries were cited respectively 66 and 58 per cent more than the world average. Publications from non-Western countries have the lowest citation frequency. China still scores significantly lower in terms of citation frequency than in terms of publication volume.

Figure 1.10
Number of articles per 1,000 capita (2014) and relative citation index (2010–2013) for selected countries.



Remark: The figure provides a graphic illustration of the countries' research intensity, measured as the number of articles per 1,000 inhabitants and their influence measured by citation frequency. There is a relatively strong linear correlation between the two indicators. Countries' size (number of articles) is illustrated as circular area. Several of the most cited nations are relatively small contributors in a global context.

Source: Data: Thomson Reuters/CWTS Web of Science. Computations: NIFU.

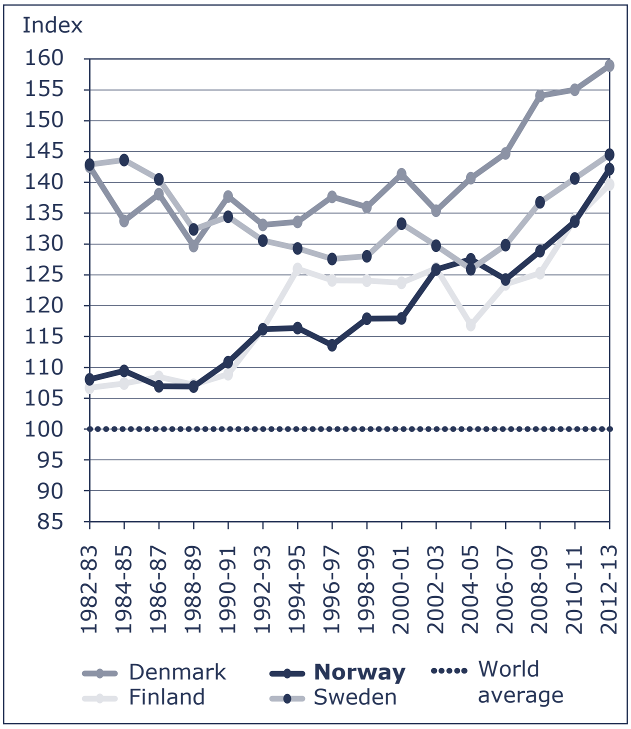
Norwegian research cited more

Figure 1.9 also shows citation indexes for two periods. All countries in the Figure, except the US, had an increase in their citation index in the period. The greatest increases were for Austria (16 points) and Finland (12 points), while Norway and Switzerland rank third with 11 points. The changes cannot only be attributed to the increased citation frequency of the nations, but also to methodological issues related to the expansion of journal coverage in the database. Many of the new journals are little cited. Nations publishing a lot in these journals will have a reduction in citation frequency, while nations which publish little in the new journals will have their value increased because of the world average influenced by the expansion of the database with little-cited journals.

In the early 1980s, Norwegian research was cited only slightly above the world average. The Norwegian citation frequency rose in the early 1990s. The growth rate decreased in the 1990s, but in recent years has again shown a significant increase. Figure 1.11 shows relative citation indexes for four Nordic countries from 1982 to 2013.

We see that the differences in citation frequency between the Nordic countries has levelled off over the period. In the early 1980s, there was a gap between Sweden and Denmark on the one hand, and Finland and Norway on the other. Sweden's and Denmark's scientific production has been highly cited throughout this period, and Denmark improved its position in relation to the other Nordic countries during the 2000s. In recent years, Norwegian and Finnish research had almost identical citation frequency. Both countries, like Denmark and Sweden, had a marked growth after the mid-2000s.

Figure 1.11
Relative citation index for four Nordic countries: 1982–2013.[1]



[1] Based on two-year publishing periods and accumulated citations of these publications including 2014.

Source: Data: Thomson Reuters/CWTS Web of Science. Computations: NIFU.

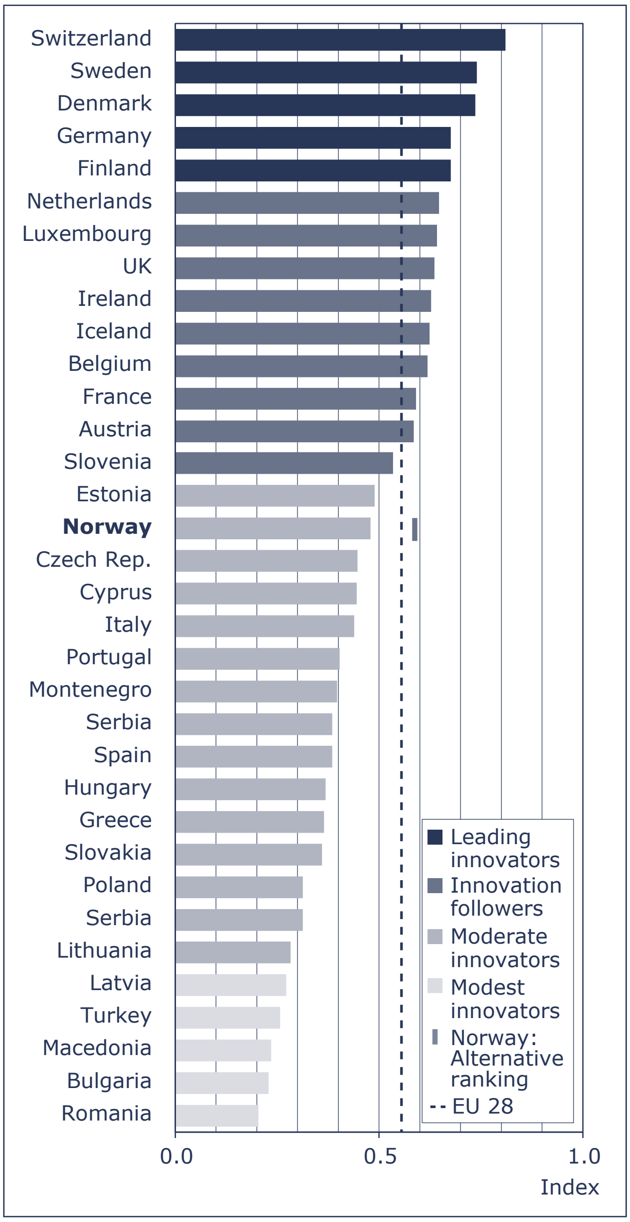
Citations as indicator

A characteristic of a scientific publication is that it contains references to earlier scientific literature. These references show the concepts, methods, theories, empirical findings, etc. on which the current publication is based, and how they are related to previous research. At Thomson Reuters, all references in the indexed literature are systematically recorded. This makes it possible to calculate how many times each publication has been cited in the subsequent scientific literature. Based on these statistics, it is possible to make a citation analysis on aggregated levels.

It is common to assume that articles are more or less cited by how big or small is the influence they have on further research. Based on these assumptions, citations are frequently used as an indicator of scientific impact, and thus as a partial measure of quality. A standard indicator is the average number of citations of a country's publications. Generally, this indicator is seen as an indirect expression of the attention the publications of a country achieve in the international scientific community. Citations have increasingly been used as indicators of evaluation of research. However, it is important to be aware that there are various limitations and weaknesses of citations as an indicator, and citation analysis cannot in any case replace an evaluation conducted by peers (cf. Aksnes, 2005).

There are large differences in the average citation frequency between different disciplines. For instance, an article on molecular biology is, on average, cited about ten times as often as an article on mathematics. Such differences are adjusted in the calculation of the citation index.

Figure 1.12
The Norwegian score in the Innovation Union Scoreboard 2015 with an alternative rank for Norway.



Source: The EU's Innovation Union Scoreboard 2015/ Statistics Norway Innovation statistics 2014

The European Commission publishes an annual index called the Innovation Union Scoreboard (IUS). This gives a comprehensive overview of the ability to innovate in the European countries. The rating currently covers 34 countries in and outside the EU, and draws up 25 indicators intended to capture inputs, innovation activity, and results of innovation.

A stable pattern

The IUS also ranks countries' innovation capabilities according to a composite indicator merging the results of the 25 indicators. As shown in Figure 1.12 Switzerland, Sweden, Denmark, Germany and Finland are at the top of the list as so-called 'innovation leaders'. Then the countries are categorised respectively as 'innovation followers', 'moderate innovators', and 'modest innovators'.

Norway is now in 16th place, just below the EU average, in the group of 'moderate innovators'. This is about the same level as before, but one position up from the 17th place of the previous three years. Norway scores below the EU average and well behind the other Nordic countries. In general, countries' relative rankings in the IUS have been stable over time. It is also signifies that many of the indicators highlight the structural conditions that rarely change overnight.

The difference in innovativeness decreases

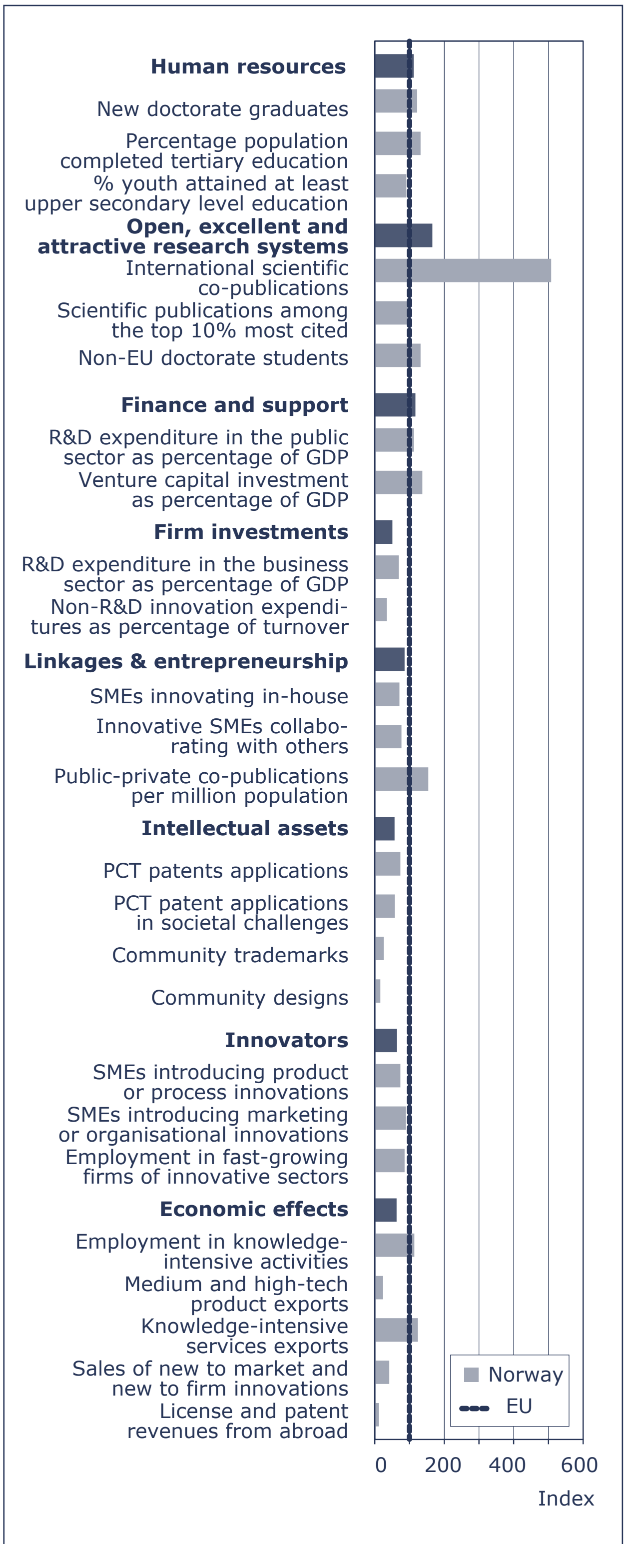
The European Commission nevertheless uses the IUS to follow patterns and trends over time. According to the Commission, the overall innovation index has increased throughout the EU by an average of one per cent annually over the past eight years. There is a slight downward trend over the past year. Moreover, there seems to be a general trend that the assumed moderate and weaker countries have had stronger growth than the leading nations, which has led to a reduction of the distance to the leading innovation nations. Among the leading nations, only Denmark had stronger growth than the EU average for the past eight years.

A controversial indicator

Although the IUS is a frequently used measure of national innovativeness, we point out that the ranking is the subject of much criticism and discussion. Among other things, there is a discussion whether the 25 selected indicators actually capture what is most central to innovation. The actual calculation of the indicators has also been subject to criticism. Many have raised questions about how appropriate it is to merge scores on all dimensions in one consolidated indicator. A recent example of criticism of the IUS is an alternative analysis made by the Swedish research institute CIRCLE, where indicators for inputs are seen in relation to performance indicators. This gave a quite different picture of which countries are innovative.[4]

[4] The article can be found here: http://swopec.hhs.se/lucirc/abs/lucirc2015_027.htm.

Figure 1.13
The Norwegian score in the Innovation Union Scoreboard 2015 compared with the EU 28 by type of indicator. (Dark columns show main categories.)



Source: Innovation Union Scoreboard 2015

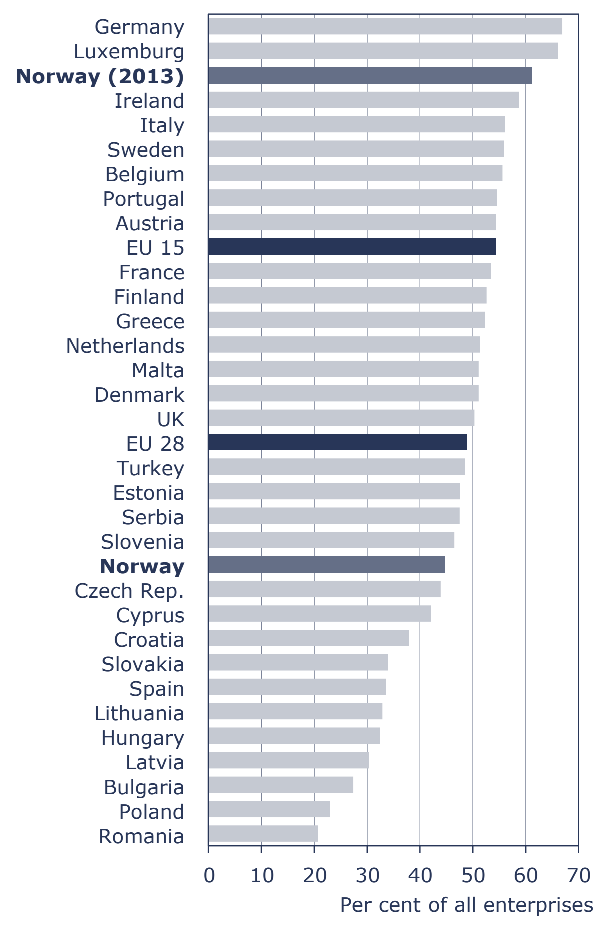
Figure 1.13 shows how Norway scores compared with the EU average of the 25 indicators included in the IUS. The bars indicate Norway's score as a percentage of the EU average, here set at 100. Bars to the left indicate numbers below the EU average.
Structural factors explain much of Norway's score
The overall picture is that Norway is among the leading countries in terms of its research system, primarily because of a very high proportion of co-publications by Norwegian and foreign researchers. It is debatable whether this is a strength or a consequence of Norway being a small R&D nation with a natural need for cooperation with foreign researchers. Norway scores relatively high in terms of education, public R&D investment and access to venture capital. On the other indicators, Norway scores poorly.

Three main issues have been highlighted to explain the modest Norwegian scores in the IUS: First, Norway scores consistently low on indicators relating to high-tech industries and research-based innovation. The Norwegian industrial structure with high value added in commodity-based industries is part of this explanation. Second, many of the indicators are measured in terms of countries' GDP. This means that Norway's high GDP is negative to the outcome of these indicators. Third, Norwegian enterprises report little innovation in the regular EU Community Innovation Survey (CIS). This will be highly significant as six of the indicators are based on data from this survey.

Methodological factors influence the IUS score

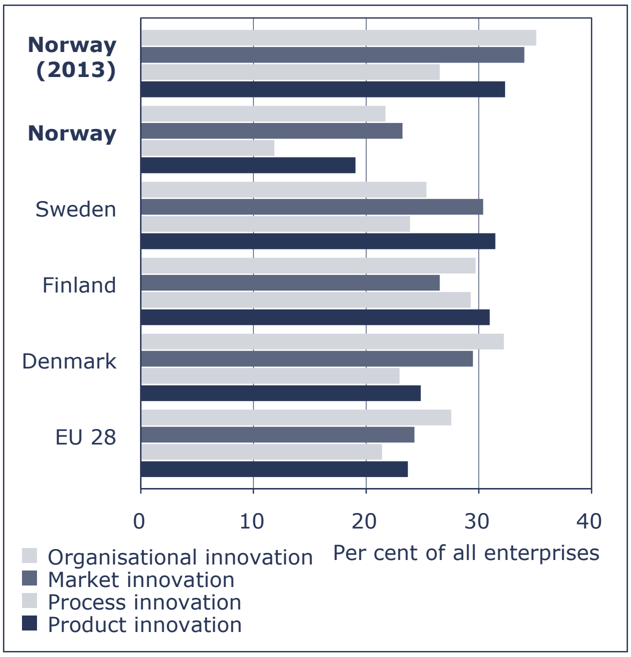
In 2013, Statistics Norway conducted an alternative innovation survey, using a method closer to the one that most other EU countries apply, with separate surveys of R&D and Innovation. This gave a notable increase in the share of innovative enterprises in Norway, which will affect several of the indicators in the future IUS. In Figure 1.12 an alternative Norwegian score is marked in the overall IUS ranking were these unofficial figures to be used. Norway would then improve its ranking in the IUS from 16th to 13th place. It has recently been decided that the Norwegian innovation study from now on will be conducted as a separate study, in line with the alternative survey carried out in 2011–2013. This could mean that Norway's overall position in the IUS will come closer to the alternate location specified in Figure 1.12.

Figur 1.14
Share of companies with innovation activity. EU 28 and associated countries: 2010–2012. Separate survey for Norway: 2011–2013.



Source: Eurostat and Statistics Norway Innovation statistics 2013

Figure 1.15
Types of innovation activities in four Nordic countries and EU 28: 2010–2012. Separate survey for Norway.



Source: Eurostat and Statistics Norway Innovation statistics 2013

Community Innovation Survey (CIS)

Eurostat coordinates the innovation surveys conducted by the European countries (CIS). The survey is carried out every two years and provides an opportunity to compare innovation activity between different countries. The collection and aggregation of these data takes a relatively long time. The last available figures used in this report are based on CIS 2012, which covers the period 2010–2012. In addition, Norway has conducted its own separate innovation survey for the period 2011–2013. This additional Norwegian survey was carried out to examine whether a separate innovation survey gave different results from a common survey of R&D and innovation. Starting with CIS 2014 the regular Norwegian innovation survey will be conducted separately from the R&D survey and be based on the same template as the 2013 survey.

Types of innovation and innovation activity

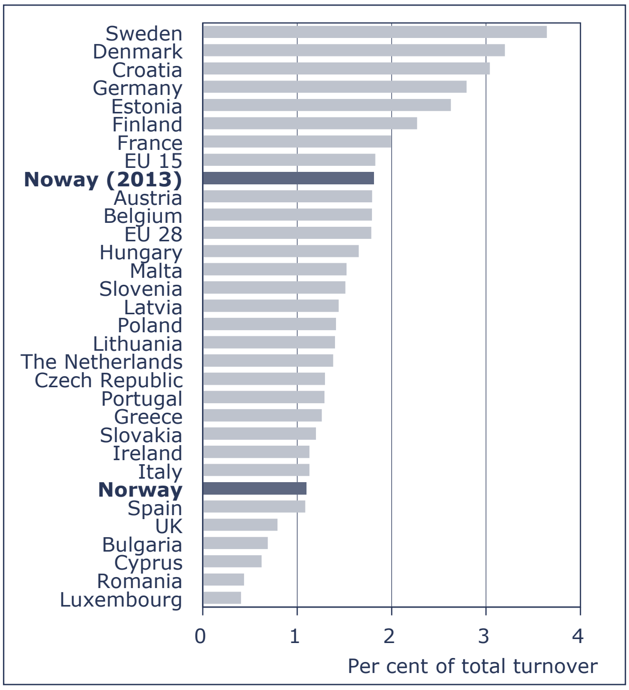
In Eurostat's international innovation survey (CIS) 45 per cent of Norwegian companies report that they had innovation activity in the period 2010–2012. Although Norway is approaching the EU average, the figures show that there is still a smaller percentage of Norwegian enterprises reporting on innovation activity than the average in other European countries.

A closer look at Norway's score based on the separate Norwegian survey (see fact box below) changes the picture considerably. Norway is now number three in Europe, above the EU 28 and EU 15 and just behind Germany and Luxembourg.

Compared with 'innovation leader' neighbours Sweden, Finland and Denmark, Norway goes from innovation dovetail all the way up to a level on a par with - or higher than - the other Nordic countries. This applies to all the different types of innovation, as shown in Figure 1.15.

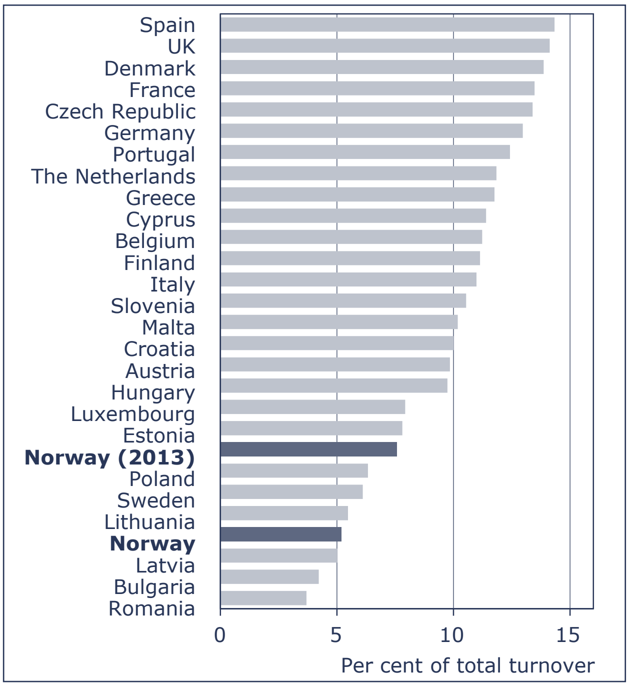
Norwegian enterprises have traditionally reported that they use a relatively small part of their turnover on expenditure on innovation. However, as shown in Figure 1.16, using the 2013 numbers for Norway changes this picture significantly. In 2012, the overall resources devoted to innovation in Norway amounted to 1.1 per cent of enterprises' total turnover, up from 0.9 per cent in 2010. In addition to intramural and purchased R&D expenditure, this number includes the purchase of machinery, equipment, software and other

Figure 1.16
Expenditure for innovation as part of total turnover in EU 28 and associated countries: 2010–2012. Separate survey for Norway: 2011–2013.



Source: Eurostat and Statistics Norway Innovation statistics 2013

Figure 1.17
Turnover from innovative products as share of total turnover in EU 28 and associated countries: 2010–2012. Separate survey for Norway: 2011–2013.



Source: Eurostat and Statistics Norway Innovation statistics 2013

external knowledge aimed at the development of new products and/or processes in enterprises. The EU average in 2012 was 1.2 per cent. Compared with Sweden, Denmark and Finland the business enterprise sector spent respectively 3.6, 3.2 and 2.3 per cent of turnover on innovation. Sweden and Denmark are at the top of the scale, while Norway places itself at the lower end of the scale.

It is also worth mentioning that the figures entail significant challenges, especially when it comes to international comparisons. High innovation costs as a percentage of revenue are moreover not entirely positive.

Increased innovation costs with separate study

When the 2013 results are used as a basis for the Norway score, the innovation costs increase from 1.1 per cent to 1.81 per cent of turnover. Yet it is a long way from the figures for Sweden and Denmark, which spent most on innovation in 2012. The largest cost in Norway from 2012 to 2013 was within categories that are not R&D. When the 2013 figures are used, Norwegian investment in innovation does not differ significantly from other countries.

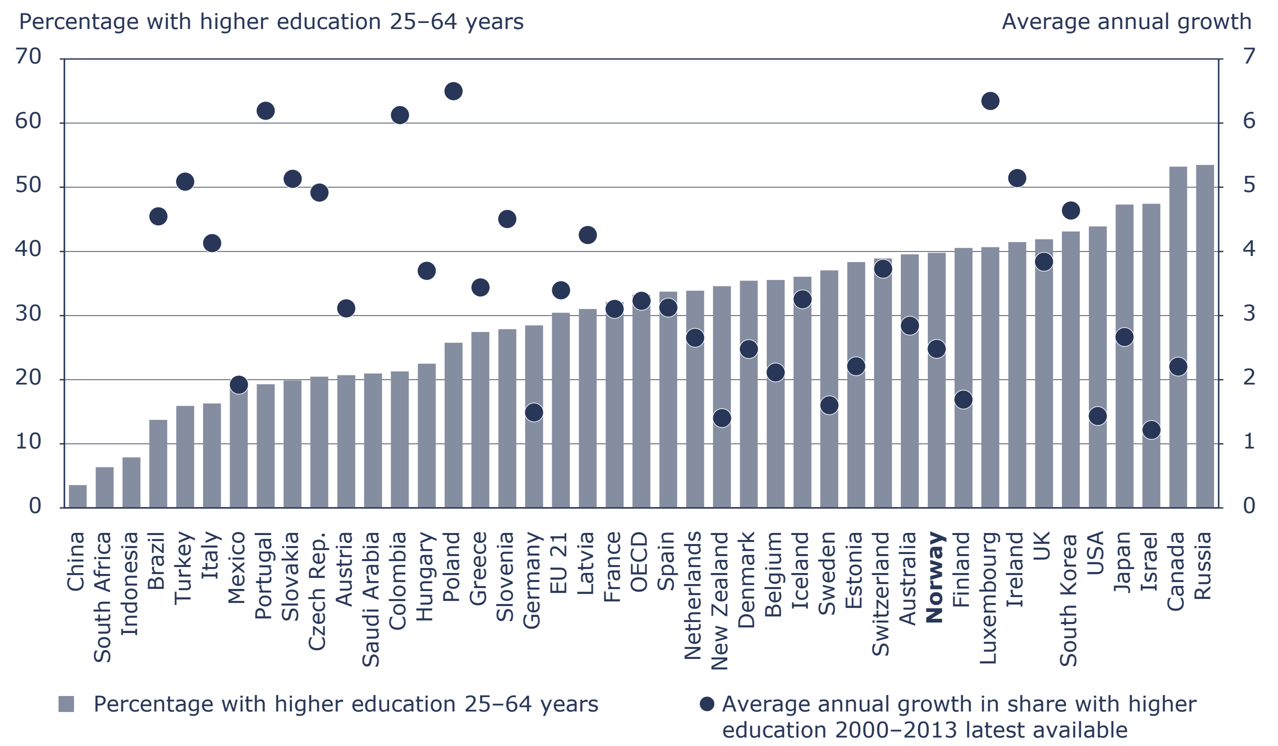
Little turnover from innovative products

When it comes to the share of turnover from innovative products, Norway is among the countries with the lowest percentage, as shown in Figure 1.17. In the 2012 survey, only 5.2 per cent of Norwegian enterprises' turnover was reported to come from innovative products. This is a slight decline of 0.8 percentage points from 2010. The 2013 figures increase the Norwegian share in a way largely coinciding with the increase in number of product innovators. Nevertheless, Norway still scores low on this indicator. Swedish innovators also have a relatively low percentage of their turnover from product innovations, while Denmark and Finland are considerably higher.

Industrial structure essential

Even if the 2013 figures have changed compared with earlier surveys, the traditional explanations of Norwegian strengths and weaknesses in the field of innovation are still valid. Some of the results can be explained by the structure of the Norwegian industry, with few companies within industries with a high degree of innovation activities. There is high turnover in the oil industry and its supply industry. They are certainly technology-intensive but not high-tech from a European perspective.

Figure 1.18
Share of population aged 25–64 years with higher education (2013) and average annual growth (2000–2013) of population with higher education (right scale) in selected countries.



Source: OECD Education at a Glance 2015 Interim Report

Educational attainment increases globally

Educational attainment is a frequently-used measure of skills and human capital in the population and labour force. In order to meet future changes in the economy and keep pace with international competition a highly-skilled workforce is important. In the OECD countries, the population's formal education is increasing (OECD 2015). A clear sign of this is that the proportion of the population with completed secondary or higher education is increasing, while the proportion without such education goes down.

In Figure 1.18 countries are sorted by level of the population with higher education. The highest level we find in Russia and Canada, where over 50 per cent of the adult population has tertiary education. Educational attainment is also high in Israel, Japan, USA and South Korea. Norway is in 11th place among countries in the Figure, with about 40 per cent of the population with higher education. Norway scores just behind Finland and slightly above the level in Sweden and Denmark. Globally, there are large differences in education, and at the bottom of the scale in this Figure is China, where only four per cent of the population has higher education.

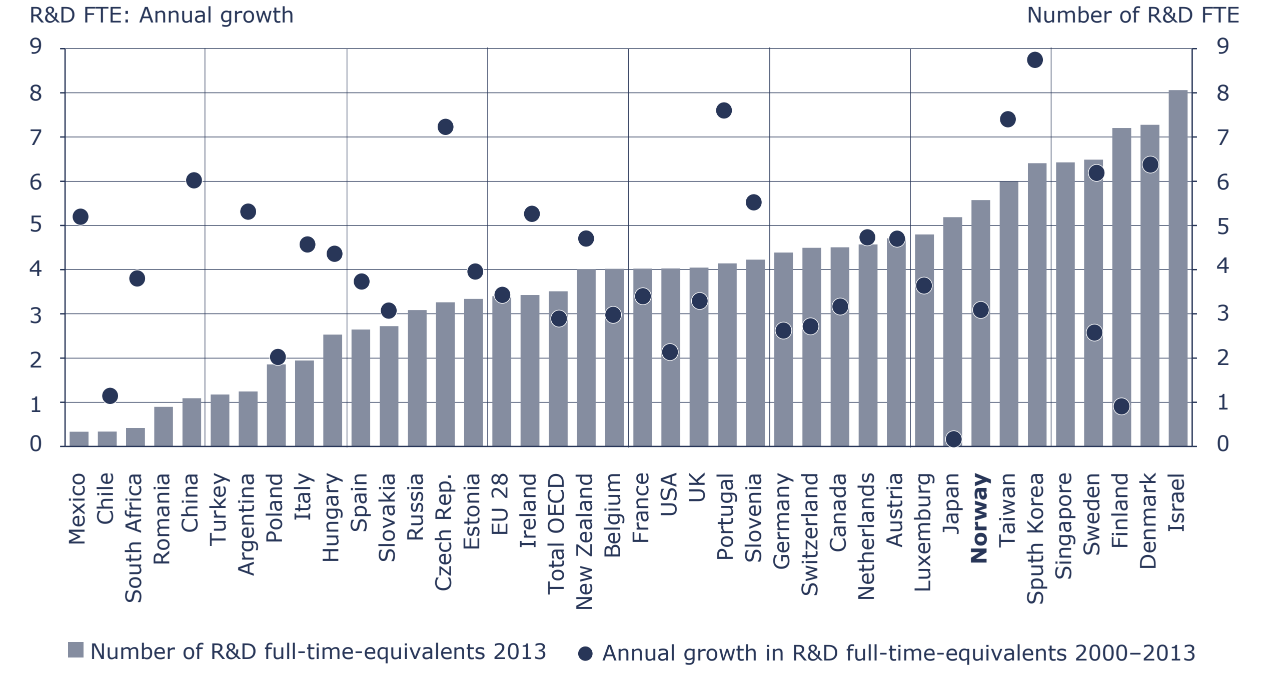
Differences in educational decreasing?

The Figure also shows the trend of proportions with higher education, there is a clear tendency of growth, highest among countries with lower educational levels. Most countries with a high level of education have relatively moderate growth in the level of education. South Korea, Ireland, and to some extent Switzerland and the United Kingdom, are exceptions in this respect, since they have both a high education level and high growth. Conversely, Mexico has a low educational level and simultaneously low growth.

Age differences in educational attainment

Figures for the education level of the population between 25 and 34 years gives an indication of the future level of education in various countries. In South Korea especially, but also in Poland, France and Japan, young people have a much higher level of education than the older part of the population. If these trends continue, the countries' educational level will increase in future years. In Israel and Finland the young population has a lower educational level than the population overall. Also for the United States, Iceland, and Germany there are small differences in the age groups of education, and the shares of educational attainment have reached a stable level.

Figure 1.19
R&D full-time equivalents (FTE) performed by researchers per 1,000 capita in 2013 and average annual growth: 2000–2013 or last year available.



Source: OECD - MSTI 2015:1

There are two main ways to measure human resources for R&D, either to count the number of people engaged in R&D activities, or to measure the time these individuals spend on R&D expressed in R&D FTEs. In an international comparison, we use the latter measure, as it contains the most complete data.

Continued growth in the number of scientists in the world

From 2010, China has had the highest number of researchers in the world measured as R&D FTEs performed by researchers. In 2013, there were almost 1.5 million researchers in China, while the corresponding number in the United States was barely 1.3 million (2012). The EU 28 countries had 1.7 million scientists, and throughout the OECD area there were 4.4 million researchers (2012).

There is continued growth in the number of R&D FTEs in the world, but similar to R&D expenditure growth is lower in the years after 2009 than before. We find a decline in the number of researchers in recent years in Canada, Russia, Finland and Spain. China has by far the largest absolute growth in the number of scientists in 2013 with 80,000 more researchers in 2013 than in 2012.

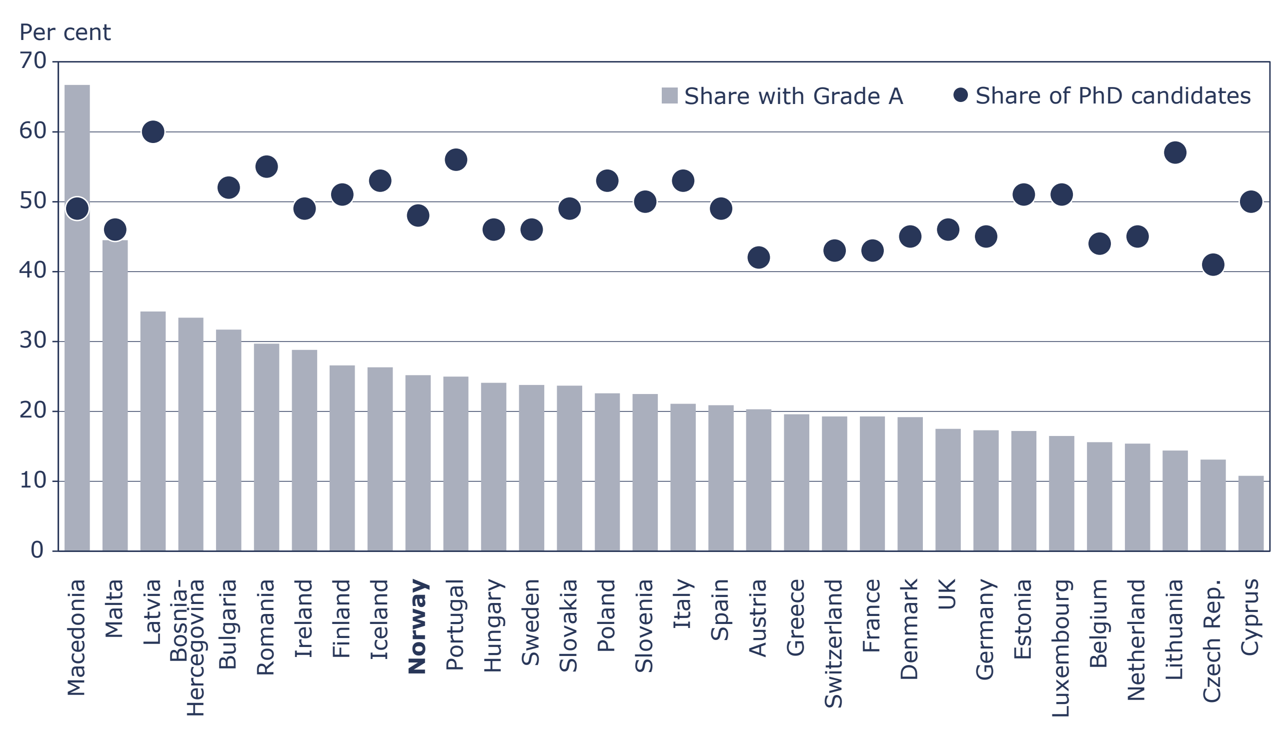
If we relate the number of researchers to population numbers, we see from Figure 1.19 that Israel is at the forefront with 8 researchers per 1,000 inhabitants. Then our Nordic neighbours and Singapore, South Korea and Taiwan follow. With 5.6 researchers per capita, Norway is in 8th place among the countries in the Figure. The average for OECD countries is 4 researcher FTEs per 1,000 inhabitants. The lowest proportion of researchers in the population is found in Mexico, Chile and South Africa. China remains low when the number of researchers is measured in this way, with barely more than one R&D FTE per 1,000 inhabitants.

Denmark has the highest growth in researcher density in the Nordic countries

The Figure also shows trends in researcher density from 2000 to 2013. We find some natural variations; strong growth in countries with high R&D expenditure growth in the period. This goes for South Korea, Taiwan, Portugal, the Czech Republic and Slovenia.

Several countries with a high expenditure growth have low researcher density: Mexico, South Africa, China and Turkey. Two countries with many researchers in the population, Japan and Finland, have low growth. Chile has both low growth and a low researcher level. Growth in R&D expenditure in Norway is above that in Finland and Sweden, but far below Denmark.

Figure 1.20
Share of women in academic top positions (Grade A): 2013 and PhD graduates in 2012 in European countries.



[1] Grade A: single highest grade/post at which research is normally conducted, Grade B: researchers working in positions not as senior as top position, but senior to newly-qualified PhD holders. Grade C: the first grade/post into which a newly-qualified PhD graduate would normally be recruited, Grade D: either postgraduate students not yet holding a PhD degree who are engaged as researchers, or researchers working in posts that do not normally require a PhD.

Source: She Figures 2015 Leaflet

European focus on gender balance in research

Gender balance in European research and innovation is a clear goal of the European Commission. This includes equal opportunities for women and men in research careers, board representation, and integration of the gender dimension in a research content. Gender balance has an ethical dimension. There is also research showing that increased gender balance in research teams and boards leads to better results for research and innovation both financially and qualitatively.

Switzerland has the highest proportion of doctorates in the population

If we look first at the total number of doctorates in the population (ISCED 6),[5] we find the highest proportion of PhDs in Switzerland, with 450 degrees awarded per million inhabitants in 2012. Then follow Slovakia, Germany, UK, Ireland, Croatia and Finland all with over 300 doctorates per million inhabitants in 2012. Norway is also high, in eighth place with 226 PhDs in 2012.

Gender balance at PhD level, but not at top academic level

Figures from the forthcoming publication She Figures 2015 show that the proportion of female doctoral graduates (ISCED 6) in 2012 is between 40 and 60 per cent; 47 per cent of the EU 28 countries and 48 per cent in Norway, as shown in Figure 1.20. Thirteen countries have a female proportion of 50 per cent or more. On average, there has been a growth in female PhD graduates at 4.4 per cent annually, with 2.3 per cent growth for male PhDs. As seen in the Figure there seems to be some relation between countries with a low level of female PhD graduates and a low level of females at Grade A level.

[5] ISCED 1997: International Standard Classification of Education. The UN's statistical framework for a common classification of different countries' levels of education. ISCED 6 is the highest level of education, equivalent to PhD or doctorate. The classification is revised ISCED 2011.

2 The Norwegian system of R&D and innovation

Pål Børing, Frank Foyn, Hebe Gunnes, Inger Henaug, Elisabeth Hovdhaugen, Bo Sarpebakken, Espen Solberg, Susanne L. Sundnes, Jannecke Wiers-Jenssen, Kaja Wendt, Ole Wiig, Lars Wilhelmsen

Resources for R&D

- In 2013, total Norwegian expenditure on R&D amounted to nearly 51 billion NOK. This gives a real growth of 1.5 per cent from 2012.
- The business enterprise sector accounted for 44 per cent of R&D expenditure, while the higher education sector and the institute sector accounted for 32 and 24 per cent respectively.
- R&D expenditure in the health trusts is included in the higher education sector and the institute sector and had the largest real growth from 2012 to 2013, with over 6 per cent.
- R&D expenditure constituted 1.62 per cent of GDP in 2012 and 1.65 per cent in 2013. Publicly-funded R&D amounted to 0.65 per cent.
- Funding from abroad had the greatest increase, at 25 per cent growth in real terms from 2011 to 2013. Research council funding had a real decrease in the same period.
- The higher education sector's R&D expenditure increased by over 1.7 billion NOK from 2011 to 2013; the strongest growth was at the university hospitals.
- Institute sector's R&D expenditure had a real growth of about 1.5 per cent from 2011 to 2013, but a real decline of 1 per cent in the last year of the period.
- R&D expenditure in the industrial sector amounted to 22.6 billion NOK in 2013, which corresponds to a 2 per cent real growth.
- ICT services and Extraction of crude oil, natural gas and related services had the strongest growth from 2012, at 19 and 28 per cent respectively.
- Purchased R&D expenditure amounted to 6.1 billion NOK in 2013; well over half purchased within Norway. Extraction of crude oil and natural gas was the largest purchaser of R&D from abroad.
- More than half of Norwegian enterprises introduced one or more forms of innovation during the three-year period from 2012 to 2014.
- Almost every fifth innovator sought intellectual property protection.
- Public funds support almost every third enterprise with product or process innovation.

Government budget allocations for research and development (GBARD)

- The Norwegian budget for 2015 is the third in a row with R&D grants showing significant real growth in research funding.

Human resources

- In 2013, 68,000 people participated in R&D in Norway, of whom nearly 48,000 were scientists. Of these, 36 per cent were women.
- 15 per cent of researchers in the industrial sector had a foreign background in 2013, compared with 8 per cent in 2007.
- 2014 was the first year with a higher number of women than men among doctoral candidates.
- Every third doctoral candidate in 2014 had non-Norwegian citizenship; the number of Norwegian male doctoral candidates is decreasing.
- Women account for the last year's growth in student numbers, while the number of men is fairly constant.

Although research and innovation is becoming increasingly international, the national dimension remains the key when activities and resources in this field are measured. For example, it is still the case that around 90 per cent of R&D in Norway is funded by national sources.

This chapter presents status and trends of the Norwegian R&D and innovation system. A central element in this system is the division into research performing sectors, and much of the description in the section follows this division. In official Norwegian R&D statistics, one operates with three sectors, namely the business enterprise sector, the institute sector and the higher education sector. The last includes university hospitals. In recent years, we have seen strong growth in health-related research. Norway is one of a few countries to establish a system for identifying and measuring research in the health trusts. The research at the health trusts, university hospitals, and private non-profit hospitals, is presented separately.

This year's report also presents updated figures for innovation activity in Norwegian industry for the period 2012–2014. Corresponding figures are not yet available for other countries, hence these figures are presented in a purely national context.

Finally, this chapter gives an updated overview of human resources, from students to professors.

The 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.

OECD (2002): Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development, OECD, 2002.

The OECD definition of innovation

The terms innovation, innovative and innovation activity are used about product or process innovations (PP innovation) that include 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 innovation*** 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.

OECD (2005): Oslo Manual. Guidelines for collecting and interpreting innovation data/ a joint publication of OECD and Eurostat. 3rd ed.

Table 2.1
Total R&D expenditure in Norway by sector of performance and type of institution: 2011–2013. Mill. NOK and per cent.

Sector/type of institution	2011	2012	2013	Share of total R&D 2013	Real growth 2012–2013 (%)	Average annual real growth 2003–2013 (%)
Industrial sector	20,066	21,176	22,557	44	2.3	1.0
Higher education sector	14,259	15,039	16,001	32	2.2	3.4
Of which: University hospitals	2,271	2,511	2,772	5	6.1	..
Institute sector	11,115	11,828	12,190	24	-1.0	2.3
Of which: Other health trusts and private non-profit hospitals	505	616	698	1	9.0	..
Total	**45,440**	**48,043**	**50,748**	**100**	**1.5**	**2.0**

Source: Statistics Norway/NIFU, R&D statistics

Total expenditure on research and experimental development (R&D) in Norway amounted to almost 51 billion NOK in 2013. This represents a real increase from 2012 of 1.5 per cent and 3.3 per cent from 2011, which is the last year of full-scale R&D survey of all sectors. Both the industrial sector and the higher education sector had a real growth of just over 2 per cent, the institute sector R&D had a real decrease from 2012 to 2013. The health trusts had the highest real growth in R&D expenditure at over 6 per cent from 2012, but slightly lower than in the previous period (2011–2012) at nearly 9 per cent real growth. About 80 per cent of health trusts' R&D expenditure is linked to university hospitals. In official R&D statistics, R&D at university hospitals is classified in the higher education sector, while other hospitals and private non-profit hospitals are included in the institute sector. In this report, we use mainly the official sector classification for R&D statistics, with some exceptions in the sector chapters: see also fact box about the Norwegian sectoral structure below.

New deflator for R&D costs at fixed prices

A new deflator for calculating R&D costs at fixed prices has been adopted for 2013 and the period back to 1970. It is based on the price index of production in industry 72 Research and development in the national accounts. This is a weighted cost index - an average index for the different types of expenditure for all R&D performing sectors. Previously there were different price indexes for the various categories of expenditure (wages, current expenditures and investments) and performing sectors. Main reasons for change of index are that the new index will also be used in the national accounts where R&D will be capitalized, and will simplify fixed price calculations significantly.

Higher education sector with strongest growth

In the decade 2003 to 2013, the higher education sector had the strongest increase in R&D expenditure among the R&D performing sectors, with over 3 per cent real growth per year.

The relative size of the R&D performing sectors has changed little over time. In 1983, the institute sector was the largest R&D performing sector in Norway, slightly larger than the industrial sector, which itself had significantly higher R&D expenditure than the higher education sector. In 2013 - 30 years later - just under half (45 per cent) of Norwegian R&D activity relates to private enterprises, and the institute sector is by far the smallest player. Health trust R&D expenditure is included in the higher education sector (university hospitals) and the institute sector (private non-profit hospitals). Each sector will be further described later in this chapter.

In the period 1983–2013, R&D expenditure in the industrial sector and the higher education sector had roughly the same average annual real growth of just over 4 per cent. The institute sector had real growth at around 1.5 per cent per year during the same period. See fact box about a new deflator for the introduction of new indices for fixed price calculations.

Norwegian performing sectors for R&D

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

The industrial sector: Companies and enterprises aimed at commercial production of goods and services for sale at an economical significant price.

The institute sector: Private-non-profit research institutes mainly serving industry (the business enterprise sector in OECD's classification); research institutes and other R&D performing institutes (other than higher education) mainly controlled by and funded by the government (government sector in OECD's classification)(PNP); and health trusts not conducting education and PNP hospitals.

The higher education sector: Units providing higher education; universities, specialized university institutions, state university colleges and university hospitals.

To highlight the R&D activities in health trusts these are presented separately where appropriate and possible (data from 2007).

OECD's sector classification, is used in Chapter 1.

Table 2.2
Total R&D expenditure in Norway by funding source and sector of performance: 2013. Mill. NOK.

		Industry			Government				Abroad	
Sector of performance	Total	Total	Industry and other	Oil companies	Total	Gov. excl. Research council[1]	Research council of Norway	Other sources[2]	Total	Of which: EU-commission
Industrial sector	22,557	17,918	17 918	..	934	509	425	653	3,052	99
Institute sector	12,190	2,467	1 944	523	7,965	5,138	2,827	445	1,313	444
Of which Research inst. Serving enterprises	4,079	1,746	1 381	365	1,535	543	992	203	596	224
Health trusts and private non-profit hospitals[3]	698	10	10	..	658	651	7	30	1	1
Research institutes serving government sector	7,413	712	554	158	5,773	3,944	1,829	213	716	219
Higher education sector	16,001	660	500	160	14,183	11,712	2,471	718	440	323
Of which Univerity hospitals	2,772	45	45	..	2,560	2,404	157	138	29	19
Total in Norway	**50,748**	**21,044**	**20 362**	**683**	**23,082**	**17,360**	**5,723**	**1,817**	**4,805**	**865**

[1] Includes grants from Innovation Norway.

[2] Includes private funds, own income and SkatteFUNN (tax deduction for R&D).

[3] Incl. private/non-profit hospital regional with health authority agreement.

Source: Statistics Norway/NIFU, R&D statistics

R&D funding by the industrial sector amounted to a little over 21 billion NOK, or 41 per cent of total R&D expenditure of almost 51 billion NOK in 2013. Government sources (excluding tax deduction 'SkatteFUNN') funded 45 per cent of R&D expenditure, corresponding to around 23 billion NOK, while the contribution from abroad was just under 5 billion NOK, or nearly 10 per cent. Approximately 1/5 of the financing from abroad in 2013 is funding from the European Commission. Other sources include the institutions' own revenues, funds, gifts, etc., as well as the part of SkatteFUNN disbursed as grants to businesses that are not liable for tax: see fact box on R&D funding sources. The category 'other sources' contributed almost 2 billion NOK, of which approximately 650 million NOK is grants under SkatteFUNN.

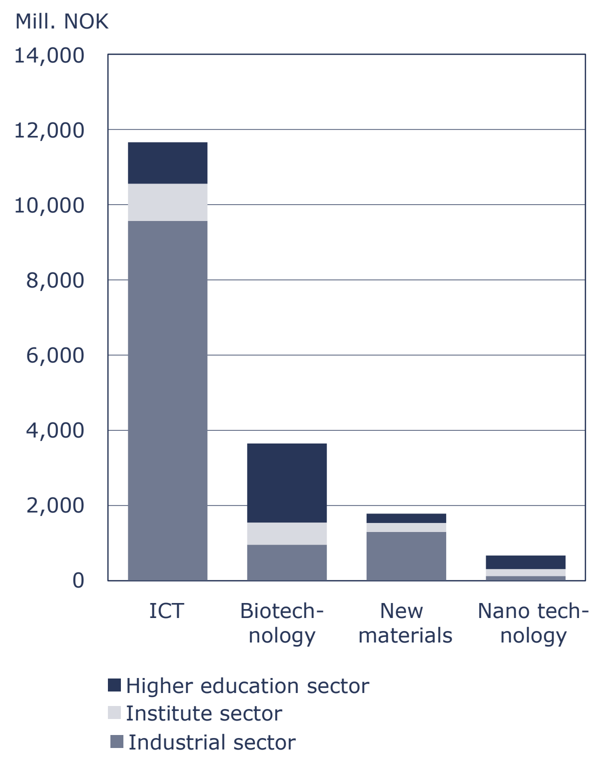
Most industrial sector funding goes to funding R&D in that sector, while public funds are mainly channelled to universities, colleges and research institutes. Two thirds of the funding from abroad went in 2013 to the industrial sector, while the institute sector had the highest proportion of EU funds. 11 per cent of total R&D expenditure is linked to R&D performed abroad.

From 2011, the last year with a full R&D survey in all sectors, the total financing of Norway's R&D expenditure grew in 2013 by 3.3 per cent, measured in constant prices. During the same period, funding from the industrial sector saw a slight real growth of under one per cent. The largest change in the period concerns financing from abroad, including funds from the European Commission. Global funds had a formidable real increase from 2011 to 2013 at 25 per cent. Isolated, the corresponding increase in funding from the EU was almost 20 per cent. Research council funding had a real decrease from 2011 to 2013.

R&D funding sources

- **Industrial sector:** Funds from private enterprises. Most go to R&D in own enterprises.
- **Government sources:** Funding from ministries' budgets. Mostly institutional grants, for example general university funds, and funds distributed through the Research Council of Norway, but there are also funds for programmes and projects by ministries and other state institutions. A smaller portion comes from counties, municipalities, state banks etc.
- **Other sources:** Own revenues at universities and research institutes; private foundations and gifts, loans, funds from NGOs and SkatteFUNN. SkatteFUNN is in principle public funding, but according to international guidelines (OECD Frascati manual) any tax incentive schemes are classified as own funding of the relevant sector. This is because the tax incentives are very different, and in many countries there are period-related discrepancies between actual R&D activity and the associated tax benefits.
- **Abroad:** Funds from foreign enterprises and institutions, funds, EU, Nordic and other international organizations. Abroad includes both public and private funding, but often classified as private funds when total financing is divided into two main categories, public and private.

Figure 2.1
Current expenditure on R&D by field of technology: 2013.



Source: Statistics Norway/NIFU, R&D statistics

R&D statistics have for years captured the extent of R&D within various generic technologies: Information and communication technology (ICT), Biotechnology, New materials and Nanotechnology. Figure 2.1 shows the extent of R&D expenditure in these areas in 2013 divided in the three R&D-performing sectors. The figure illustrates the industrial sector's dominance in technology-oriented R&D activities and especially in the ICT sector, where the sector accounts for over 80 per cent of R&D expenditure. The higher education sector accounts for much R&D in Biotechnology and Nanotechnology. Health trusts (in the figure included in the higher education sector and the institute sector) had a large proportion of research in Biotechnology, with almost a quarter of R&D expenditure. Also within Nanotechnology and ICT, health trust R&D was high.

From 2011 to 2013, R&D expenditure within Nanotechnology had the strongest growth in relative terms, but in absolute terms, ICT had the strongest growth at more than 1.3 billion NOK. The industrial sector and the higher education sector account for the growth. Biotechnology had a lower level of R&D expenditure in 2013 than in 2011, due to lower investments by the industrial sector.

Government priority areas

The Norwegian R&D statistics questionnaire contains a module that asks respondents indicate the proportion of R&D activity within the government's policy priorities. In the 1990s, these were: Information technology, Biotechnology, Aquaculture/marine research, Materials technology, Offshore technology/oil and gas related research, Health, safety and living conditions (not in 1995 and 1997), Environmental Technology and energy supply/usage, Management, organization and management systems (until 1995) and Culture and tradition mediating research (until 1995).

In 2005, the thematic priorities were revised. The thematic areas were Energy and Environment, Food, Sea, Health and Welfare. From 2007, Energy and Environment were divided into subcategories: Renewable Energy, Other environmentally related energy, Petroleum activities, Other energy, Other climate research and technology, CO2 management and Other environmental research. In 2009, Development Research included in the Energy and Environment and renamed Global challenges. Areas Education, Welfare and Tourism were added in 2007 and 2009, and Sea was divided into Marine and Maritime research. The technology areas include ICT, Biotechnology and New materials. From 2007, Nanotechnology was separated from New materials.

Government priority area Sea includes petroleum, marine and maritime industries. The 1990s saw aquaculture and oil and gas related research areas included in the R&D statistics questionnaire. The portion of the offshore operations related to petroleum was assigned in 2005 to priority Energy and Environment. As Energy and environment was first specified in sub-categories from 2007, this activity cannot be identified in 2005. In 2009, Sea divided into categories Marine and Maritime.

In the Government Long-Term Plan for research and higher education 2015–2024 (Meld. St. 7 (2014–2015)) the thematic priorities are clustered around six areas:

1) Sea;
2) Climate; Environment and green energy;
3) Renewal of the public sector and better and more efficient welfare, health and care services;
4) Enabling technologies;
5) Innovative and adaptable businesses; and
6) World-leading experts.

The national accounts provide a comprehensive and systematic overview of the economy of a country, in both private and public sectors. The accounts follow the international guidelines for national accounts, from the United Nations (SNA2008) and Eurostat (ESA2010). Until recently, spending on R&D has been regarded as intermediate consumption in the national accounts. One of the most important changes in recent versions of national standards is that R&D should be considered as an investment and thus capitalized.

In the Norwegian national accounts, R&D is now capitalized for the period 1995–2013. It provides a new opportunity to assess the extent of research covering all sectors of the Norwegian economy, including the public sector. Capitalization of R&D causes an increase in the national accounts figures for investment and production, giving a slight increase in GDP at 1.4 percentage points.

Table 2.3
R&D expenditure in R&D statistics and in National account: 2011. Mill. NOK.

Total R&D expenditure, incl. investments (R&D statistics)	45,440
Calculated production of R&D services in National account	45,264
Of this: Production of own investments in R&D in National account	33,720
Import of R&D (from Balance of payments)	2,288
Total input R&D, base value	47,552
Product subsidies for research	-2,375
Used for export (from Balance of payments)	3,133
Used for investments in oil prospecting	40
Used for investments in R&D capital	8,284
Own investments in R&D	
Used for investments in R&D capital	33,720
Memo:	
Total investments in R&D capital	**42,004**

Source: Statistics Norway

Main results of R&D calculations

Table 2.3 shows the relationship between figures in the R&D statistics and estimated production of R&D services in total as well as supply to and use of R&D services in 2011. Total R&D expenditure in the R&D statistics was 45.4 billion NOK. Production of R&D services in the national accounts terminology was 45.3 billion NOK. Although this is very close to the figures in the R&D statistics, it made various calculations that draw equally in both directions. The figures in the R&D statistics exclude investments in machinery, equipment and buildings and investments in software and public subsidies. Depreciation and adjustments for R&D in smaller units not covered by the R&D statistics are added.

Services for own use constitute 33.7 billion NOK of total production of R&D services. The difference is mainly R&D services provided domestically to others. To get total supply for Norway import of R&D is added. This was estimated as NOK 2,288 million in 2011. Total supply is used internally (private investment work) or delivered to others (to purchase prices net of subsidies on products). For 2011, an estimated 3,133 million NOK is exported; the rest for domestic use by others. Total investment in R&D capital constitutes the sum of R&D for own investments and investments used by others. For 2011, this amounts to 42 billion NOK.

Healthcare a major user of R&D services

In the national accounts total investment in R&D capital can be broken down by industry. Figures by industry are difficult to compare with the R&D statistics because the institute sector and higher education sector are also regrouped by industry. For the industrial sector, small enterprises are included for the years in which these figures have been collected (2006, 2008, 2010 and 2012) and figures for small enterprises are estimated for the other years.

Broken down by industry, education (which includes universities and high schools) is by far the largest research sector in the Norwegian economy. Healthcare (where university hospitals are included) is also a major user of R&D services. Both these industries perform all R&D themselves. The industry Research and development is also large, but still significantly smaller than the institute sector. This is partly because several units in the institute sector are classified as public administration. These two industries have a significant contribution of R&D services performed by others. Also mining and oil has a high proportion of R&D services received by others, in accordance with the primary statistics.

Table 2.4
Total R&D expenditure in the higher education sector by type of institution and expenditure: 2011 and 2013. Mill. NOK. Current prices and growth in fixed 2010-prices.

	2011			2013			Average annual real growth. 2011–2013 (%)		
Institution type	Total	Current expenditure	Capital expenditure	Total	Current expenditure	Capital expenditure	Total	Current expenditure	Capital expenditure
Universities and university colleges	11,989	11,120	869	13,229	12,350	879	1.0	1.4	-3.3
University hospitals	2,270	2,267	3	2,772	2,719	53	6.3	5.3	304.3
Total	**14,259**	**13,387**	**872**	**16,001**	**15,070**	**932**	**1.9**	**2.1**	**-0.6**

Source: NIFU, R&D statistics

In 2013, R&D expenditures in the Norwegian higher education sector amounted to 16 billion NOK. University hospitals accounted for close to 2.8 billion, 18 per cent of the sector's total R&D expenditure.

Compared with the last total survey in 2011, higher education sector R&D expenditure grew in 2013 by more than 1.7 billion NOK. Adjusted for wages and prices, this gives an average annual real growth of nearly 2 per cent. By comparison, there was a real decline in the sector from 2009 to 2011 of almost 1 per cent. The decline in the preceding two-year period was mainly due to reduced investments in buildings and infrastructure, as several major construction projects were completed in 2011. In 2013, capital expenditure in the sector increased with 60 million NOK in absolute numbers, which in total gives a slight real decrease in expenditure.

The strongest growth at university hospitals

From 2011 to 2013, the universities had the strongest growth in absolute numbers. R&D expenditure increased by 1.2 billion NOK. However, university hospitals had the strongest growth with an average annual real growth of over 6 per cent. The higher education institutions with the greatest growth in R&D expenditure from 2011 to 2013 were the Norwegian University of Science and Technology (NTNU), University of Oslo, and Oslo and Akershus University College of Applied Sciences. From 2011 to 2013, capital expenditure at the university hospitals grew significantly, ranging from 3 to 53 million NOK. This is due both to the repeal of a general income freeze, and survey improvements better adapted to units at the university hospitals in 2013.

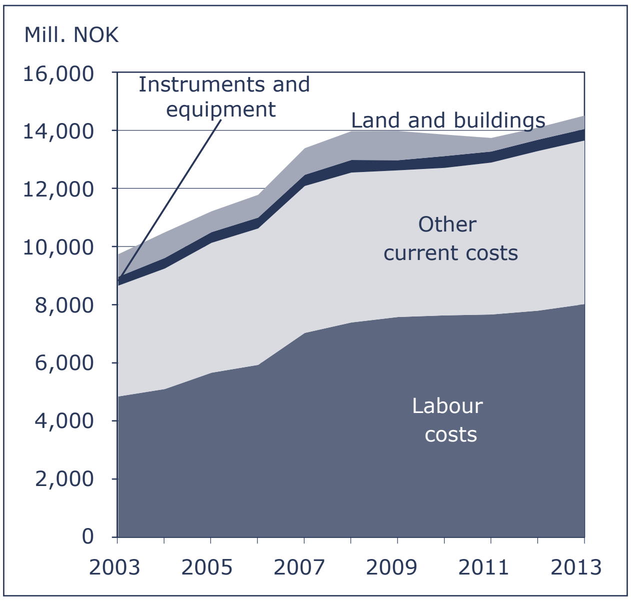
Current expenditure dominate

Since the mid-2000s, total R&D expenditure in the higher education sector accounted for nearly one-third of Norway's total R&D expenditure. We can see from Figure 2.2 that wages represent the largest share of R&D expenditure in the sector from 2003 to 2013, followed by other current costs. Capital expenditures fluctuate naturally more from year to year depending on the investments in the current year. Construction costs include the R&D share of investment in new construction. This kind of spending was higher earlier in the decade with major investment in, among others, St. Olav's Hospital, the informatics building at the University of Oslo, and the research building at the Radium Hospital.

Weak growth in scientific equipment

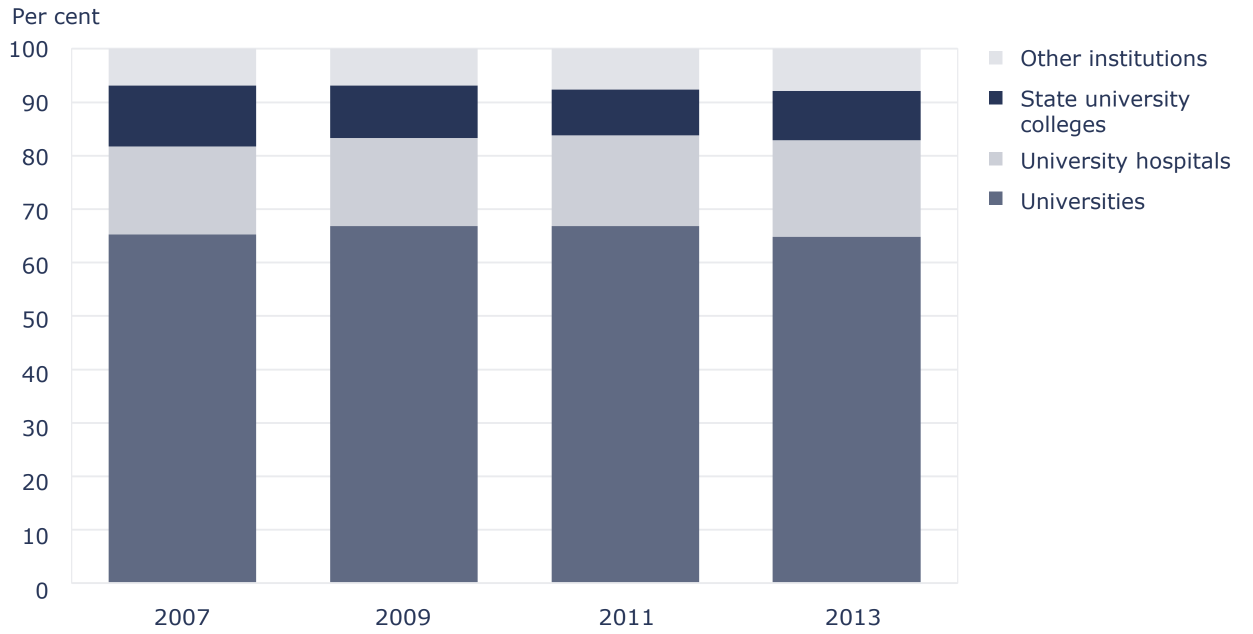
R&D expenditure in scientific equipment remained at about the same level over the last decade. The investments in scientific equipment are challenging to measure as these grants are not always visible in the accounts, and are often not linked to individual departments (the respondent level in the Norwegian R&D survey), but to faculties or institutions.

Figure 2.2
Total R&D expenditure in the higher education sector: 2003–2013. Fixed 2010-prices.



Source: NIFU, R&D statistics

Figure 2.3
Current expenditure in R&D in the higher education sector by type of institution: 2007–2013.



Source: NIFU, R&D statistics

Several structural changes are expected in the Norwegian higher education sector

After the millennium, there were several structural changes in the Norwegian higher education sector. The number of institutions receiving university status increased from four to eight, and over a relatively few years, several mergers of state university colleges reduced their number from 26 to 19. The Government stated in a White paper (Meld St. 18 (2014–2015)) that it wants fewer, more robust institutions. Several merger processes are underway.

The Norwegian higher education sector also includes a number of other institutions, both governmental and private, with different accreditation status.

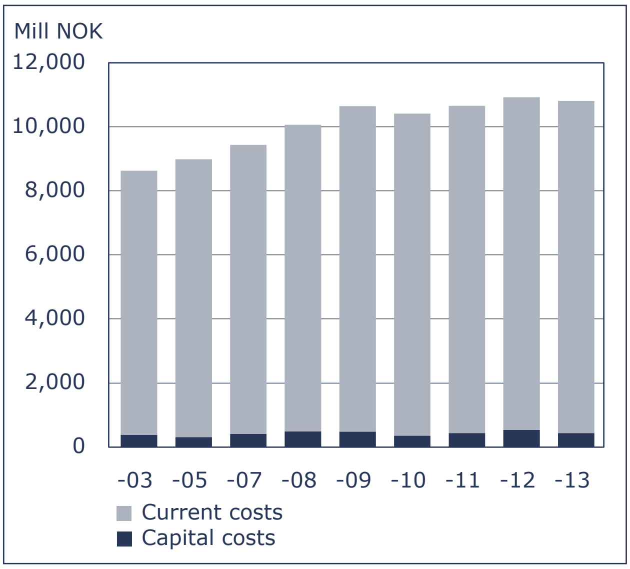
In 2013, university R&D accounted for 65 per cent of all R&D expenditure in the higher education sector: university hospitals accounted for 18 per cent, state university colleges for 9 per cent and other institutions accounted for 8 per cent of R&D: see Figure 2.3. The division of R&D expenditure between the various types of institutions has been rather stable in recent years.

University hospital' share of R&D expenditure has increased, as has the proportion at other institutions, while the share of R&D at state university colleges declined from 11 to 9 per cent. The universities' share of R&D was 65 per cent in 2007 - the same as in 2013, while it was slightly higher in 2009 and 2011 at 67 per cent. Trends in the sector show an increase of the universities' share of total R&D in future years, with fewer, larger, state university colleges.

Higher education sector institutions

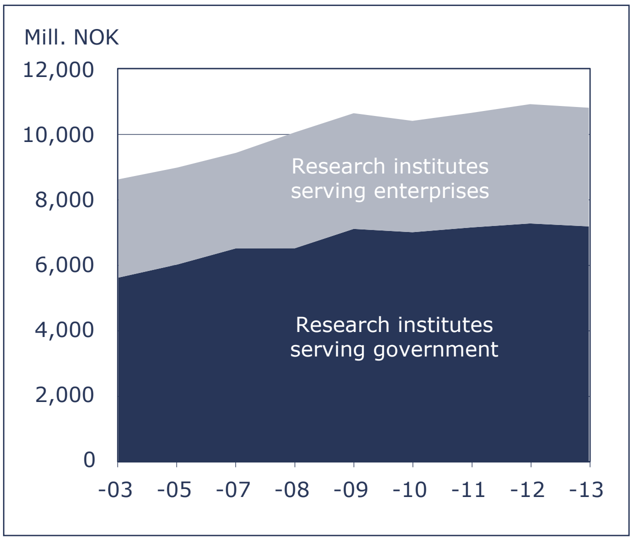
In accordance with international guidelines for R&D statistics the sector includes universities, colleges, state university colleges, art colleges, other educational institutions and university hospitals. In practice the sector includes all higher education institutions that to some extent carry out R&D. In 2013, four new institutions were included in the R&D statistics of the sector: Campus Kristiania, Norwegian School of Information Technology, Lovisenberg Diaconal College and Haraldsplass Diaconal College.

Figure 2.4
R&D expenditure in the institute sector: 2003–2013. Fixed 2010-prices.



Source: NIFU, R&D statistics

Figure 2.5
R&D expenditure in the institute sector by public- and industry-oriented institutes: 2003–2013. Fixed 2010-prices.



Source: NIFU, R&D statistics

Although the institute sector is the smallest R&D performing sector in Norway, it has an important position as a supplier of knowledge to the private and public sectors. The sector includes institutes where R&D is a core activity; private and public units with a primary activity other than R&D, but where R&D activity can still be significant, and institutions where research represents only a small part of the overall business.

Common features for an otherwise heterogeneous sector is that none of the units will pay a dividend, and that the organization is not directly subject to an educational institution. Most units in the sector are organized as foundations or corporations, or are part of government activities.

In 2013, the R&D survey of the institute sector comprised just under 100 institutions. In addition, several museums, non-university hospitals and private non-profit hospitals are included.

About half of the units in the sector can be referred to as research institutes. This applies to most of the units where R&D is the core activity. The majority of these fall under the guidelines for government funding of research institutes. These institutes receive basic funding from the Norwegian Research Council. Some governmental research institutes receive their basic funding direct from the relevant ministry. In addition to the research institutes, the Institute sector includes about 40 institutions, both private and public, which perform R&D to a greater or lesser degree.[1]

A year of slight decline

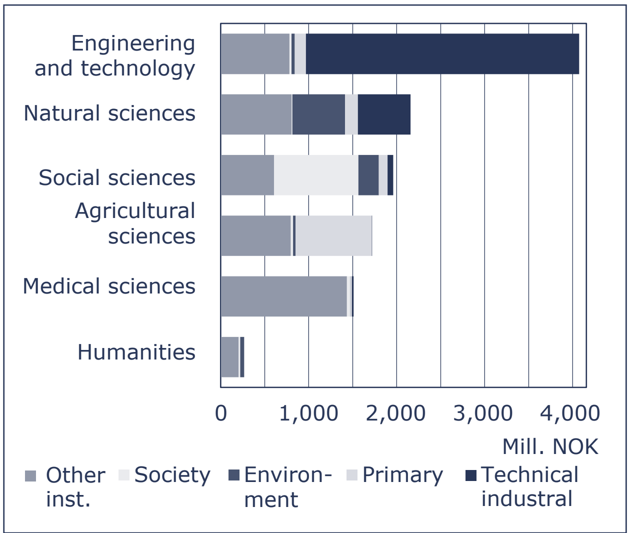
In 2013, R&D of 12.2 billion NOK was carried out in the institute sector, an increase of 360 million from the previous year. R&D in the institute sector comprised just under a quarter of all R&D in Norway in 2013. There was a nominal increase in resources for R&D at around 2.5 per cent, when a minor expansion of the database is taken into account. Adjusted for wage and price inflation, there was a real decline in the sector's R&D expenditure of around 1 per cent compared with 2012. This was mainly due to lower investment in equipment and infrastructure. This expenditure fluctuates widely from year to year. If we only look at the salaries in the sector, there was a real growth of 1 per cent compared with the previous year.

Over the decade from 2003 to 2013, R&D expenditure in the institute sector has grown by 25 per cent in fixed prices. Most of the growth came in the first half of the period. After 2009, the increase overall was low, and more erratic from year to year.

There is considerable variation in the sector when it comes to which markets the units supply. The private sector demands R&D services that it does not have the capacity, expertise or incentive to perform, while the public sector has a need for research as a basis for making political decisions or to address specific societal challenges. Many of the research institutes also have a substantial portfolio of research funded by contributions from both domestic and foreign sources.

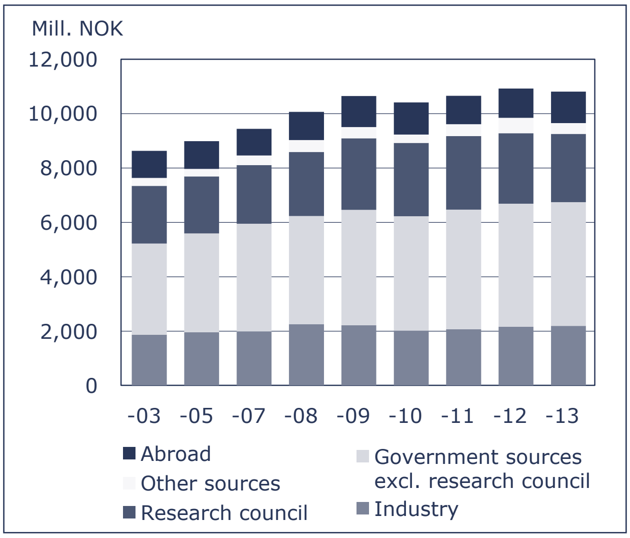
[1] For a complete overview of units included in the Institute sector, there is a catalogue here: http://www.nifu.no/en/publikasjoner/institutes/.

Figure 2.6
Current expenditure on R&D in the institute sector by field of R&D and institute group: 2013.



Source: NIFU, R&D statistics

Figure 2.7
R&D expenditure in the institute sector by funding source: 2003–2013. Fixed 2010-prices.



Source: NIFU, R&D statistics

According to OECD guidelines (Frascati Manual, 2002), entities primarily serving the private sector are to be classified together with enterprises in the business enterprise sector. It is primarily technological and industrial research institutes that are reclassified to the business enterprise sector. Public institutions and public-oriented institutes belong to the government sector in the context of international statistics. This implies that units in the institute sector are split into these two categories, and that the institute sector is not reflected as a separate category in international R&D statistics, as in chapter 1 of this report.

R&D resources in research institutes serving governments in 2013 amounted to 8.1 billion NOK, while research institutes serving enterprises amounted to 4.1 billion NOK. The institutes serving government accounted for two-thirds of the sector's R&D expenditure. This relative relationship between the two groups has been stable over the last decade. In the longer term, however, public-oriented institutes increased their share of R&D activity in the institute sector. In the mid-1980s, level the extent of R&D was the same in the enterprise- and government-oriented institutes. See Table B.3, in the online version of the (Norwegian report) for a list of those institutes classified as public- and industryoriented.

R&D in science, technology and engineering dominate

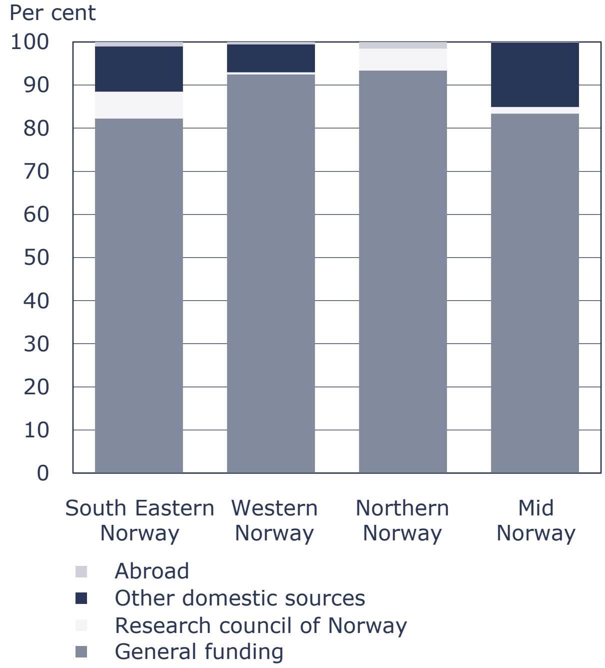
The institute sector covers a relatively wide range of disciplines, with significant R&D activity in most areas. Technology is, however, the leading domain, with approximately one third of the sector's R&D expenditure, while just under a fifth of the resource is classified as natural sciences. In total, well over half of the sector's R&D resources were conducted in these two areas in 2013. Social sciences accounted for 17 per cent, 15 per cent were within agricultural sciences, while 13 per cent of the resources were classified as medical sciences. Humanities had 2 per cent of the R&D resources, a relatively small field of science in the institute sector.

Diverse funding profile

The diversity of institutes' markets is also very visible when we look at funding. The Norwegian public sector is the largest contributor, funding 8 billion NOK in 2013, or nearly two thirds of all R&D in the sector. The Research Council contributed 23 per cent of public R&D expenditure. This funding includes both basic funding to strengthen long-term knowledge and expertise, and allocations from the Research Council's various programmes and instruments.

The business enterprise sector purchased R&D services from the institute sector for 2.5 billion NOK, amounting to one fifth of the research institutes' income. In addition, foreign and other national sources contribute respectively 11 and 4 per cent. Funding from abroad increased slightly more than other income in 2013 at 1.3 billion NOK. Commissioned research for foreign businesses and EU funding programmes were by far the largest sources, at respectively 480 and 440 million NOK.

Figure 2.8
R&D expenditure in health trusts by health region and source of funding: 2013.



Source: NIFU, R&D statistics

R&D statistics also cover research in hospitals. In Norway, the health sector is divided into four regions, each governed by a regional health authority (RHA). At the R&D performing level, this includes 6 university hospitals, 18 other health trusts and 14 private non-profit hospitals operating on behalf of a regional health authority. The data are collected through a separate measurement system that provides the Ministry of Health and Care Services with management information in the field of R&D. In R&D statistics, the university hospitals are included in the Higher Education Sector, while other health trusts and private non-profit hospitals are included in the Institute Sector. In this section, we present figures covering university hospitals, as well as other regional health trusts and private non-profit hospitals.

Increase in health trusts' research

Total R&D expenditure in Norwegian health trusts amounted to nearly 3.5 billion NOK in 2013, which was about 6.8 per cent of total R&D in Norway. It is roughly the same share as in 2012 (6.5 per cent), while the percentage in 2011 was 5.5 per cent. There was a nominal increase in R&D expenditure of 344 million NOK or 11 per cent from 2012 to 2013, corresponding to a 6 per cent real growth. The percentage of growth was higher in experimental development than in basic research.

The South-East health region accounts for two-thirds

Among the four health regions the South-Eastern is the largest, with total R&D expenditure of around 2.3 billion NOK in 2013. This represents about two-thirds of the health trusts' overall resources for R&D. The high proportion reflects the fact that several heavy R&D contributors are situated in the region, especially the Oslo University Hospital (OUS). The OUS alone accounted for around half of the total R&D resources in the health trusts in 2013.

The Western health region is the second largest with 616 million NOK, accounting for 18 per cent of the resources devoted to R&D in 2013. Helse Bergen and Haukeland University Hospital is the largest institution in this region. The Central Norway and Northern Norway regions accounted for respectively 8 and 7 per cent of the health trusts' total R&D expenditure in 2013.

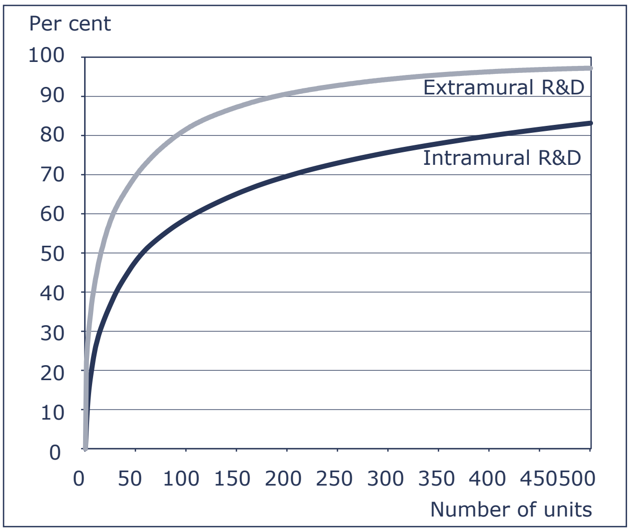
University hospitals account for 80 per cent

Six health trusts are formally approved as university hospitals. Looking at all the resources of the health trusts, the university hospitals account for a slightly smaller share than the other health trusts and the private non-profit hospitals. When it comes to R&D, however, university hospitals dominate. With R&D expenditure of almost 2.8 billion NOK, they accounted for 80 per cent of the total R&D expenditure of the health trusts. Other health trusts and private non-profit hospital reported R&D expenditure of about 700 million NOK in 2013.

Ministry of Health and Care Services is main source of funding

Medical sciences are largely publicly funded in Norway. Health trusts' R&D activities are mainly funded by the Ministry of Health and Care Services (HOD). Most of this funding is channelled as basic funding through the RHA or earmarked as other research funding distributed through the regional health authorities or regional institutions for cooperation. The latter is given on the basis of application or as strategic funds for infrastructure or other specific measures. More than 2.9 billion NOK, or 85 per cent of the health authorities' total R&D expenditure was distributed through these mechanisms in 2013. Other R&D funding, totalling approximately 527 million NOK, came from external sources.

Figure 2.9
Share of R&D expenditure at the 500 largest units in industrial sector: 2013.



Source: Statistics Norway, R&D statistics

The business enterprise sector is the largest R&D performing sector in Norway and in most other countries. In Norway, the sector's relative size is somewhat smaller than is common internationally. The business enterprise sector R&D accounts for over 50 per cent of total R&D in Norway. The share of the EU total is 60 per cent, while in the other Nordic countries the proportion is close to 70 per cent: see chapter 1. In this section, we present R&D in the industrial sector only. This is the main part of the business enterprise sector, excluding the research institutes serving enterprises. In international comparisons, as in Chapter 1, research institutes are part of the business enterprise sector according to the international recommendations (OECD Frascati Manual, 2002).

Raw materials important in Norwegian industry

One explanation for these differences is that Norwegian industry is relatively raw material-based with low production in industries with typically high R&D intensity. This means that the industrial sector accounts for a low proportion of R&D expenditure in Norway, and that overall R&D as a share of GDP is relatively low. Nevertheless, Norway is among the countries with the highest R&D growth in the business enterprise sector over the past few years, with an increasing share of GDP. For Denmark, the business enterprise sector's share remained stable, while in Sweden and Finland the sector has declined over several years from a relatively high level.

19 per cent of all enterprises with at least 10 employees performing R&D in 2013, compared with 20 per cent in 2012. Among the largest enterprises, with at least 500 employees, about 50 per cent had R&D activity. In manufacturing industries, 26 per cent of enterprises had R&D, while the corresponding proportion in the service sector was 18.5 per cent.

Costs of intramural R&D

The industrial sector performed R&D worth almost 22.6 billion NOK in 2013. This represents growth at current prices of 6.5 per cent compared with 2012. At constant prices, growth was at 2.3 per cent.

Manufacturing industries accounted for 37 per cent of R&D in the sector, while service industries accounted for 51 per cent. Until 2007, manufacturing industries were larger than services; since then, the service sector has had the stronger growth.

The industries that contributed most to growth in 2013, were ICT services, with a growth of 19 per cent from 2012, and extraction of crude petroleum, natural gas and related services by 28 per cent. These two industries accounted for respectively 16 and 9 per cent of total R&D in the industrial sector in 2013.

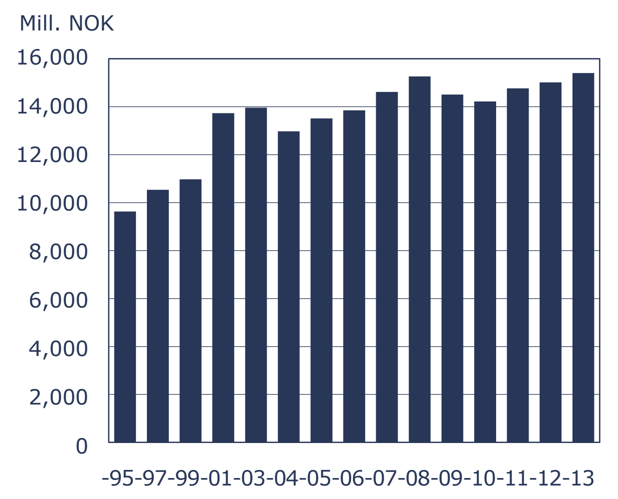
Enterprises with at least 500 employees, a total of 100 enterprises, accounted for 44 per cent of spending on R&D in 2013. In comparison, R&D at enterprises with between 10 and 19 employees accounted for 11 per cent. Growth at smaller enterprises with fewer than 100 employees was still a bit higher than for larger enterprises in 2013.

Large parts of overall R&D activities in the industrial sector are concentrated in some large enterprises. The 100 companies with the highest R&D expenditure accounted for 59 per cent of total R&D in 2013. This proportion has been relatively stable from year to year. Similarly, the 200 largest enterprises accounted for 70 per cent of total R&D. The concentration is a bit stronger in manufacturing industry, where the 100 largest enterprises contributed 75 per cent of total R&D, while the 100 largest service industries accounted for 66 per cent.

In the survey for 2013, 35 enterprises reported spending more than 100 million NOK on R&D. These enterprises use 9.5 billion NOK on R&D, or 42 per cent of total R&D expenditure in the industrial sector. Service enterprises accounted for 4.7 billion NOK of this, approximately as much as industrial and oil industries together.

Labour costs are the largest expenditure component and account for nearly 2/3 of the total R&D expenditure. Other current expenditure, however, increased the most from 2012, by 15 per cent, while capital expenditure had a 5 per cent decline from 2012. This was due to lower investment in machinery and equipment.

Figure 2.10
R&D expenditure in the industrial sector: 1995–2013. Fixed 2005-prices.



Source: Statistics Norway, R&D statistics

R&D trends by industry

Until 2008, the main trend of R&D expenditure in the industrial sector was steady growth. However, activity was particularly high in the years 2001–2003 with a subsequent fall the next year before growth continued to the level of 2003. The financial crisis resulted in a drop in R&D activity in 2009 and 2010 before growth again picked up, as shown in Figure 2.10. The decrease in R&D activity since the financial crisis was far less than in most other European countries.

R&D activity has evolved differently in the various industries. In extraction of oil and natural gas, the level has been stable for a long period, but with a clear real growth over the past couple of years. In the main industries manufacturing and services, the development is very diverse, see Figure 2.11. The service sector has had steady real growth in the period from 1995. There was only a slight decline in 2009. Just before the financial crisis (2008) R&D in the service sector was larger than the manufacturing industries and has since increased its lead.

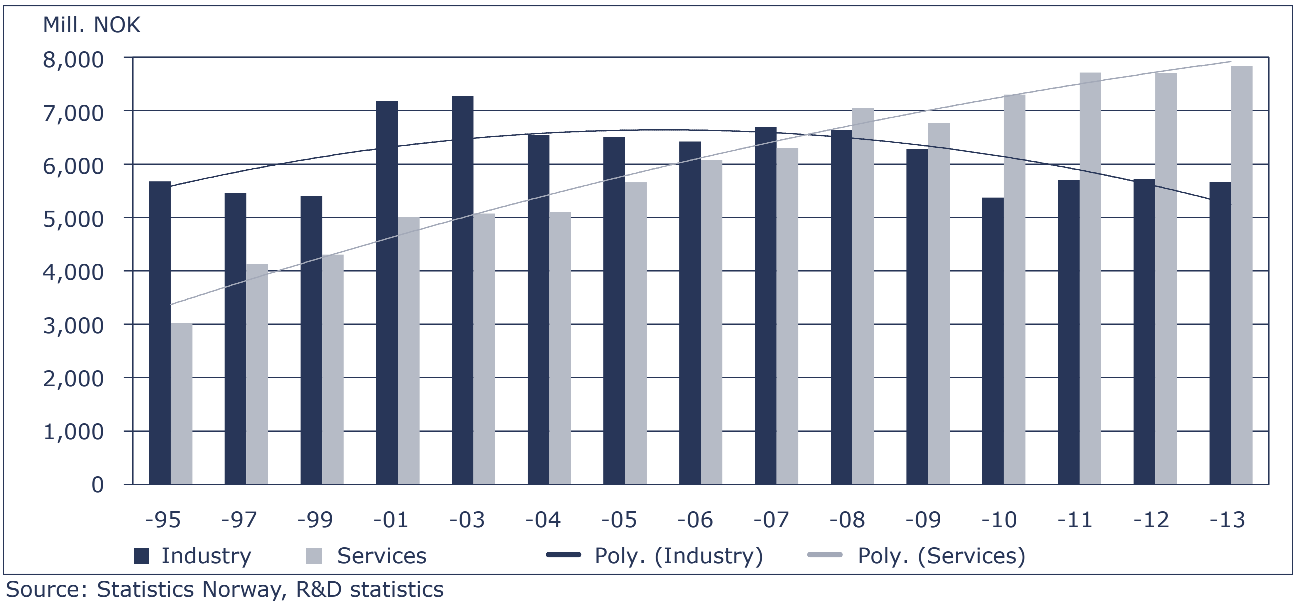
R&D activity in the industry has been changing, but the trend is clear. Essentially, there was some real growth until 2007. The financial crisis turning more significant for the industry, but the trend has stabilized in recent years.

Part of the shift between manufacturing and services is due to a reclassification of units.

How has the trend from 1997 to 2013 been within the various industrial branches? Several industries had a higher R&D activity in 2013 than in 1997. This applies particularly to machine industry and fabricated metal products. Also the food industry has higher R&D activity in 2013 than in 1997, but this industry also had significantly higher R&D activity in other years in the period. Both the computer and electronic industry and pharmaceutical industry had lower R&D activity in 2013. The decline in the pharmaceutical industry occurred over the last two years of the period. The trend in computer and electronic industry varied over time, but remained at a stable lower level after 2010.

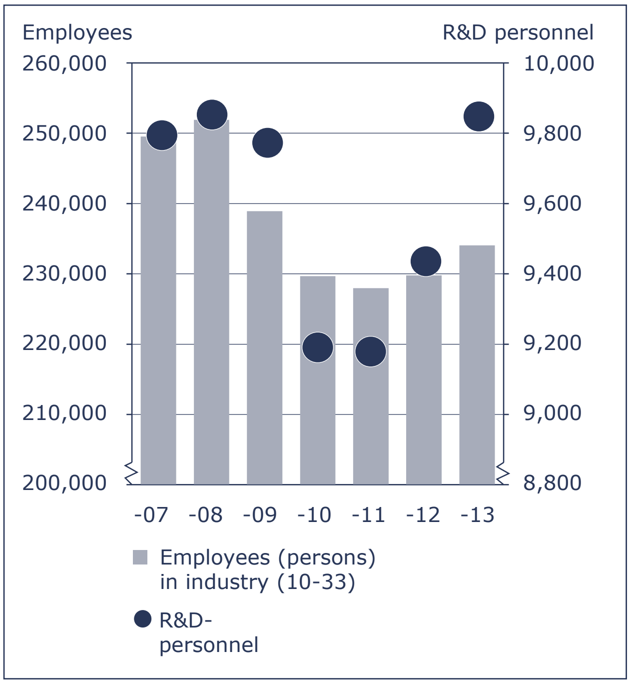
Changes in industry standard for industrial classification within the service sector make it harder to create a comparative time series for the entire period for detailed industries. ICT services strongly contribute to the strong development in the service sector, followed by engineering services.

Figure 2.11
R&D expenditure by main industry: 1995–2013. Fixed 2005-prices.



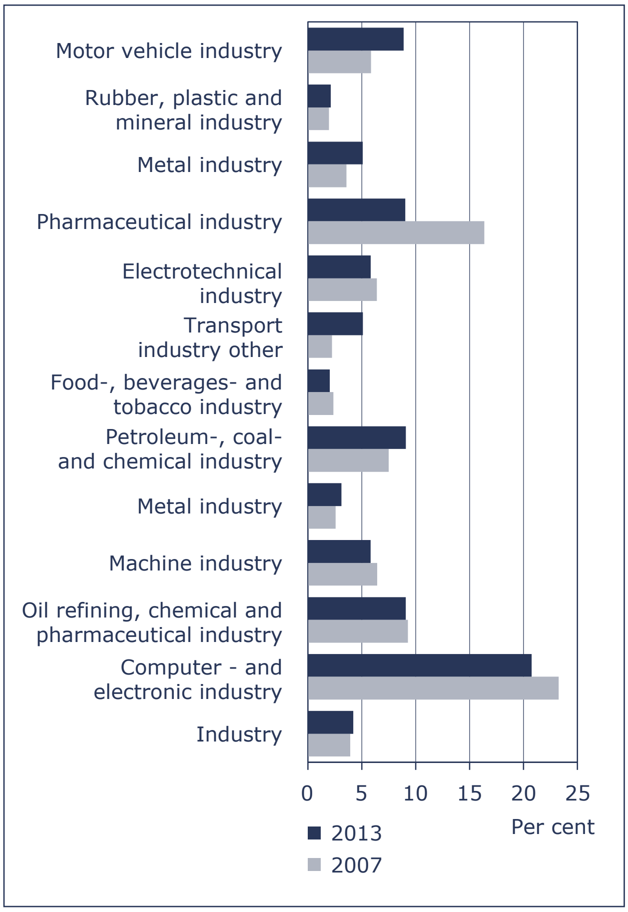
Source: Statistics Norway, R&D statistics

Figure 2.12
Total number of employees and R&D personnel in the manufactoring industry: 2007–2013.



Source: Statistics Norway, R&D statistics

Figure 2.13
Number of R&D personnel as share of total employees in selected industries: 2007 and 2013.



Source: Statistics Norway, R&D statistics

Development in R&D and production

Whether R&D activities in the industrial sector are cyclical or not has been discussed. One argument is that during a period of recession the enterprises must cut spending, and this affects R&D activities. Counterarguments are that during a recession it is more necessary to develop new products/processes, and enterprises can release resources for R&D activities.

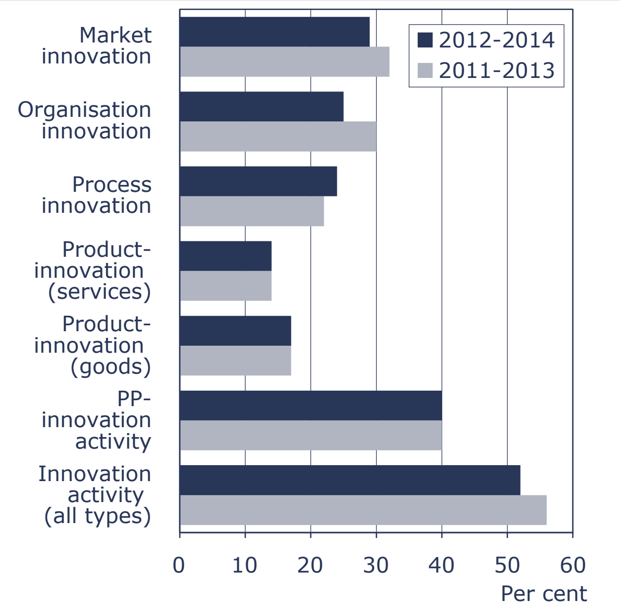
Stable share of R&D personnel in total employment

Figure 2.12 shows the trend in total employment in manufacturing and the corresponding growth in the number of R&D personnel from 2007 to 2013. We restrict the comparison to industry for 2007–2013 because of the availability of comparable time series. It is also easier to use the number of persons as targets for production development than economic variables such as production value or value added. The figure shows about the same development until 2011, but with a faster decrease in total employment due to the financial crisis. In the last few years, the number of R&D personnel in manufacturing industry grew faster than total industry employment. Still there are small changes in R&D personnel as a proportion of total employment; the proportion was 3.9 per cent in 2007 and 4.1 per cent in 2013.

Decrease in R&D personnel in some industries

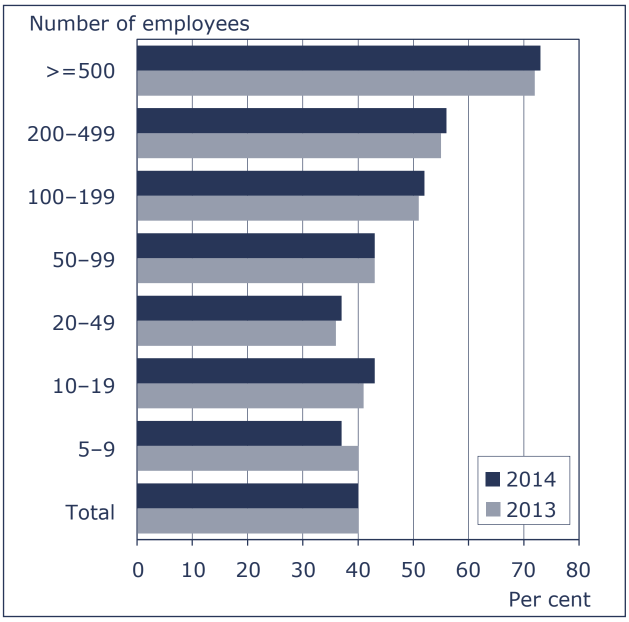
Figure 2.13 shows R&D intensity for major R&D industries in 2007 and 2013. The figure shows, first, that there are significant variations in R&D intensity across industries from the average of four per cent. Computer and electronic industry has the highest share but this is still one of the industries with a dwindling share of R&D personnel in relation to total employment. Relatively speaking, the pharmaceutical industry is the sector where the number of R&D personnel is reduced most in relation to total employment in the industry.

Figure 2.14
Types of innovation activity: 2011–2013 and 2012–2014.



Source: Statistics Norway, Innovation survey

Figure 2.15
Product-process (PP)-innovation activity by size group. 2013 and 2014.



Source: Statistics Norway, Innovation survey

Half of Norwegian enterprises innovate

The Norwegian business enterprise innovation survey measures four main types of innovation: product innovation (either within goods or services), process innovation, organizational innovation and marketing innovation: see definitions in fact box at the start of Chapter 2. Half of the enterprises covered by the survey introduced one or more forms of innovation during the three-year period from 2012 to 2014. For all types of innovation and innovation activities as a whole, this represents a decrease of 3 percentage points from the period 2011 to 2013.

All types of innovation equally common

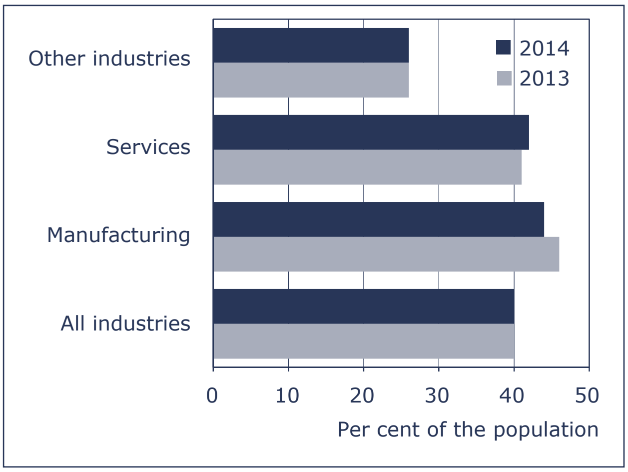
For the sector as a whole, the four types of innovation are roughly equally common. 27 per cent of the enterprises introduced product innovations while 24 per cent introduced process innovations. For organizational innovation and market innovation, the figures were 25 and 29 per cent respectively. In addition, about 2 per cent reported that they conducted activities with the goal of introducing product and/or process innovations (PP-innovations) during the period, but that these either were cancelled before completion or were still ongoing without having led to innovations during the period.

Compared with the previous survey, covering the period from 2011 to 2013, there was no change in the share of product innovators, while the percentage of firms reporting process innovation increased by 2 percentage points. Both the share of enterprises with organizational and marketing innovation decreased somewhat. The change was greater for organizational innovation, with a reduction of 5 percentage points. Taking the margin of error into account, the share of enterprises with product or process innovations was substantively unchanged, while the share of enterprises with marketing or organizational innovations decreased.

PP-innovation is most common in large manufacturing enterprises

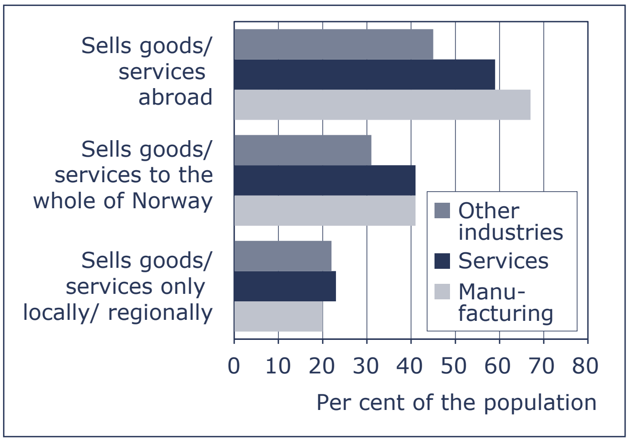
Compared with the period 2011 to 2013, there was a slight decline in the share of enterprises with PP-innovation activity in the manufacturing industries, and a slight increase in the service sector. With 44 and 42 per cent of the enterprises respectively, there was no substantial difference between these two main industry groupings overall. However, for enterprises with more than 100 employees, the propensity to innovate was higher in the manufacturing industries than it was in services. The share of enterprises with PP innovation activity remained unchanged in «other industries» (including the extraction of oil and gas), and as in the previous survey these enterprises were significantly less likely to innovate than either the manufacturing or service industries.

Figure 2.16
Product/process (PP)-innovation activity by main industry. 2013 and 2014.



Source: Statistics Norway, Innovation survey

Figure 2.17
Product/process (PP)-innovation activity by market orientation of the enterprise and main industry. 2012–2014.



Source: Statistics Norway, Innovation survey

Less PP-innovation among small manufacturing enterprises

It was mainly the smallest manufacturing enterprises that had a decrease in the number of enterprises with PP-innovation activity compared to the 2013-survey, but this is also a group for which the margin of error is high. There was a significant decrease in the share of PP-innovative enterprises among those with 50–99 employees in "other industries", but this is a much smaller group. For most other combinations of main industry and size group, the changes are moderate; in sum showing a slightly higher share of PP-innovation active enterprises than in 2011-2013. In services, there was an increase in the share of PP-innovators for several industries which have historically reported little innovation. Among these industries were the transport, accommodation and food service industries. In contrast, certain technology-intensive industries, traditionally with a high share of innovators – such as telecommunications and ICT services – showed a decline.

Most PP-innovations are developed in-house

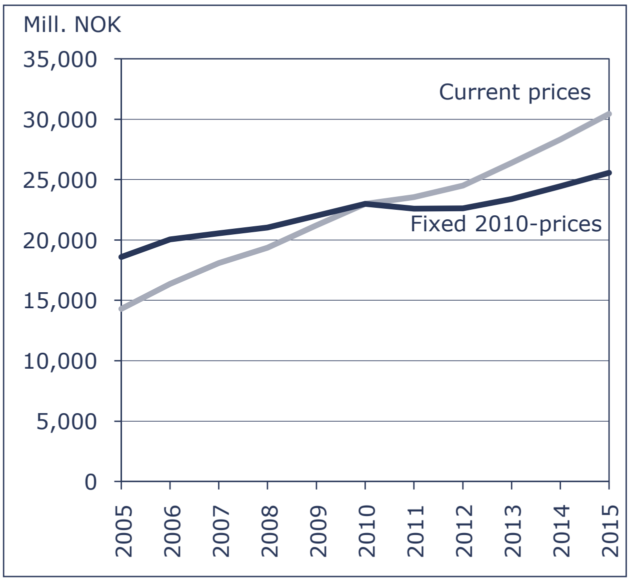
Most innovators report having introduced PP-innovations that were developed by the enterprise itself. This applies to both product and process innovation, but in-house development is more common for products. 67 per cent of the PP-innovators reported that at least one of their innovations was developed in-house. Innovations developed in partnership with their own enterprise group or in collaboration with other enterprises were reported by 43 per cent. 29 per cent introduced innovations that were either fully developed by others or originally developed by others but subsequently modified by the enterprise.

Among enterprises with product innovation, it was equally common to introduce innovations that were new to the enterprises' markets as it was to introduce innovations that were only new to the enterprises themselves, both reported by 65 per cent of the product innovators. As a percentage of all enterprises covered by the survey, this means that almost 17 per cent launched products that were new to their market during the period. 76 per cent of these enterprises reported that they introduced an innovation that was new to the Norwegian market. 29 per cent had an innovation that was new to the European market, while 39 per cent reported innovations new to the world market. Among process innovators 34 per cent responded that they had innovations new to the enterprises' market.

PP-innovators have larger markets

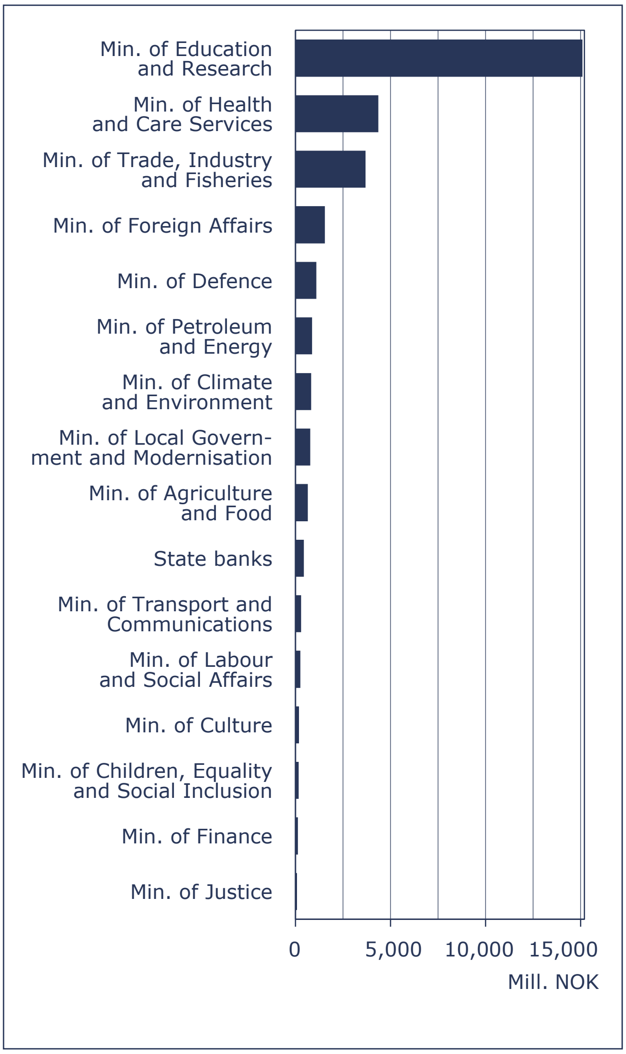
The larger the markets enterprises operate in, the greater the chance that they will be PP innovative. Among enterprises that sell goods or services throughout Norway, the share of innovators was twice as high as among enterprises operating only locally/regionally. Enterprises that (also) sell goods or services abroad have about a 50 per cent higher innovation rate than firms with a national market, regardless of the size of enterprises. The tendency is stronger in the manufacturing industries, but evident across all three main industry groupings. One possible explanation for this may be found in the Norwegian geography and population structure. Relatively sparse settlement and large distances may simultaneously protect from external competition and limit opportunities for expansion, thus also reducing the incentives to innovate.

Figure 2.18
Norwegian Government budget allocations for research and development (GBARD): 2005–2015. Current prices and fixed 2010-prices.



Source: NIFU, GBARD

Figure 2.19
Norwegian GBARD by funding ministry: 2015.



Source: NIFU, GBARD

Three growth budgets

R&D allocations in the Norwegian state budget for 2015 are estimated to amount to 30.4 billion NOK. Compared with 2014, the R&D allocations increased by 2.1 billion NOK, which represents a nominal growth of well over 7 per cent. In fixed prices, this means that the 2015 budget will provide a real growth in R&D funding of around 4.5 per cent, given the current expectations on wage and price inflation.

The approved budget for 2015 is the third in a row with significant real growth in research funding. The 2014 budget contained a real increase at the same level as in 2015, while the 2013 budget had around 3.5 per cent growth. Hence, since 2012 there has been an overall average annual real growth of over 4 per cent in appropriations for R&D. By comparison, the average annual increase in research funding in the period 2005–2012 is estimated at about 2.8 per cent.

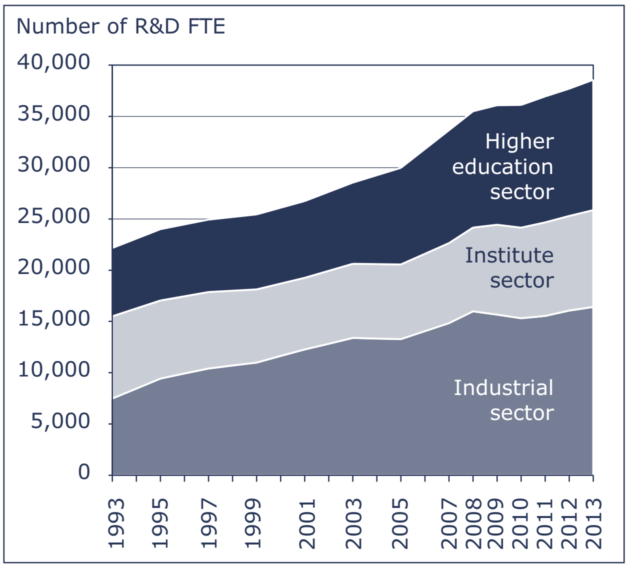
Large concentration of grants

The Norwegian budget analysis calculated R&D in more than 130 chapters of the state budget. All ministries consider R&D an important area, but there are significant differences in the extent of ministries' R&D expenditure. A large part of government R&D funding is channelled through the budgets of a few ministries.

In 2015, the five largest ministries accounted for 85 per cent of R&D funding. The Ministry of Education and Research is in a class of its own, allocating 15 billion NOK for R&D activities in 2015, as shown in Figure 2.19. This ministry's R&D portfolio consists primarily of funding for higher education institutions, the Research Council and the EU's framework programmes for research.

The Ministry of Health and Care Services and The Ministry of Trade, Industry and Fisheries are also large R&D ministries, with respectively 4.4 and 3.7 billion NOK in R&D allocations in 2015. The Ministry of Health and Care Services is responsible for funding R&D at the health trusts, whereas The Ministry of Trade, Industry and Fisheries focus on industrial R&D through the Norwegian Research Council. In addition to these three main R&D ministries, both the Ministry of Foreign Affairs and the Ministry of Defence had R&D expenditure of well over 1 billion NOK in 2015.

Figure 2.20
R&D full-time equivalents (FTE) in Norway by sector of performance: 1993–2013.



Source: NIFU/Statistics Norway, R&D statistics

In Norway in 2013, overall approximately 38,600 FTEs (full-time equivalents) were performed in R&D. This is an increase of 1,600 R&D FTEs from 2011, amounting to 4 per cent. The higher education sector had 400 more R&D FTEs in 2013 than two years earlier, and in the institute sector, the number of R&D FTEs increased by 300 in the period.

The industrial sector had the strongest growth in R&D employment; 16,400 R&D FTEs were performed in this sector in 2013, an increase of over 800 R&D FTEs from 2011 and 300 from 2012. Enterprises with 20–49 employees and 200–499 employees showed the greatest increase in R&D FTEs since 2012, respectively 12 and 13 per cent. The service sector was the main industry with the highest growth, with just over 7 per cent more R&D FTEs in 2013.

Growth in the number of R&D FTEs in all sectors

The number of R&D FTEs increased by 10,000 in the past decade (2003–2013). Over time growth has been greatest in the higher education sector; half of the increase took place in this sector: see Figure 2.20. In the industrial sector, the number of R&D FTEs increased by 3,000, and by 2,000 in the institute sector. In the past decade, there has been huge investment in R&D in the health trusts after the health reform in 2003. This contributed to growth both in the higher education sector, which includes university hospitals, as well as in the institute sector, where other hospitals and private non-profit hospitals are classified. The industrial sector saw a slight decline in the number of R&D FTEs in the wake of the financial crisis, but after 2010 the number has been increasing, and in 2013 was slightly higher than in 2008.

Researchers/academic staff performed 73 per cent of R&D FTEs in 2013; the remaining proportion was performed by technical/administrative staff. In the higher education sector almost 80 per cent of R&D FTEs were performed by researchers/academic staff, while the proportion was 71 per cent in the institute sector and 70 per cent in industrial sector. There have been only minor changes in the relationship between the proportion of R&D FTEs conducted by researchers/academic staff and technical/administrative research positions from 2003 to 2013.

Highest number of R&D FTEs in medical and health sciences

In total, 5,900 R&D FTEs were performed in medical and health sciences in the higher education sector and the institute sector in 2013. Social science was the second largest field of science with 4,800 R&D FTEs, followed by engineering and technology with 4,400 R&D FTEs.

Medical and health sciences was the largest field of science in the higher education sector in terms of number of R&D FTE, with 4,500. 2,300 R&D FTE were performed at the university hospitals. In the institute sector, non-university hospitals accounted for about half of the 1,400 R&D FTEs in this discipline.

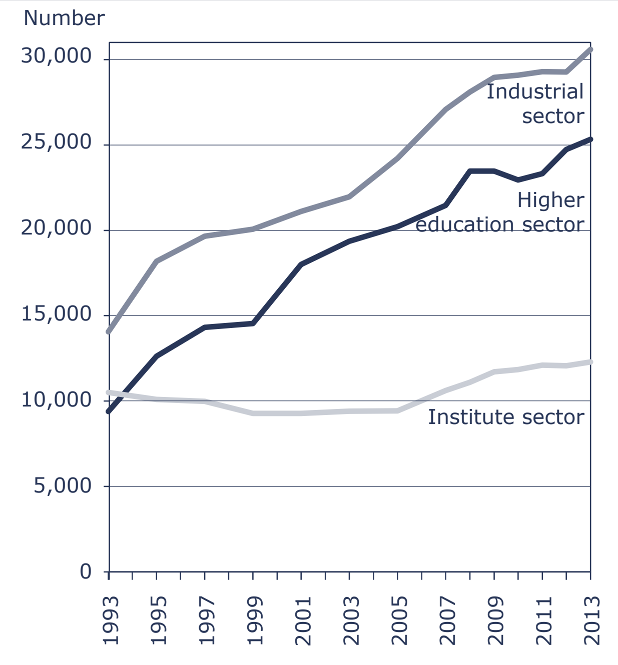
Social sciences was the second largest field in the higher education sector with 3,000 R&D FTEs, and the third largest in the institute sector (1,700 R&D FTEs). Engineering and technology was the largest field in the institute sector, with 2,900 R&D FTEs, most of these performed by technological and industrial research institutes. In the industrial sector, R&D resources are not classified by field of R&D.

Total R&D personnel

In 2013, over 68,000 people participated in R&D in Norway (headcount). Of these, 30,500 were employed in the higher education sector, 25,300 in the industrial sector and about 12,300 in the institute sector.

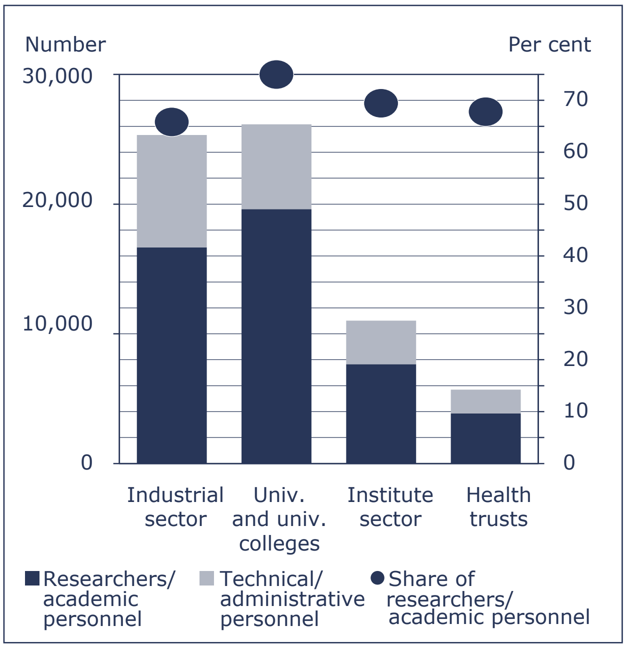
The higher education sector has been the largest performing sector in terms of number of R&D personnel in the period from 1993 to 2013. In the late 1980s, about as many people participated in R&D in the industrial sector as the institute sector. The data in the industrial sector were revised in 1995, and there has been strong growth in the sector since then. The institute sector had a decrease in the number of R&D participants between 1993 and 2001, then the number of researchers in the sector was stable until the

Figure 2.21
R&D personnel in Norway by sector of performance: 1993–2013.



Source: NIFU/Statistics Norway, R&D statistics

Figur 2.22
R&D personnel by sector of performance and category of personnel: 2013. Share of researchers/academic personnel.



Source: NIFU/Statistics Norway, R&D statistics

mid-2000s: see Figure 2.21. Non-university hospitals were included in the statistics for the institute sector from 2008, and there has been a noticeable growth among staff in health authorities up to 2013.

Researchers/academic staff represented 70 per cent of R&D personnel in Norway in 2013. A total of 47,800 researchers participated in R&D this year, along with 20,400 in technical/administrative positions. The higher education sector had most researchers/academic staff, close to 22,600; about 3,000 were at the health trusts, as shown in Figure 2.22. The industrial sector had about 17,000 researchers, while the corresponding number in the institute sector was 8,500; just under 900 of these were at other hospitals or private non-profit hospitals.

The share of R&D personnel with foreign citizenship in the industrial sector has been increasing over several years. In 2013, their share amounted to 15 per cent of the total R&D workforce with higher education, while the proportion in 2007 was 8 per cent.

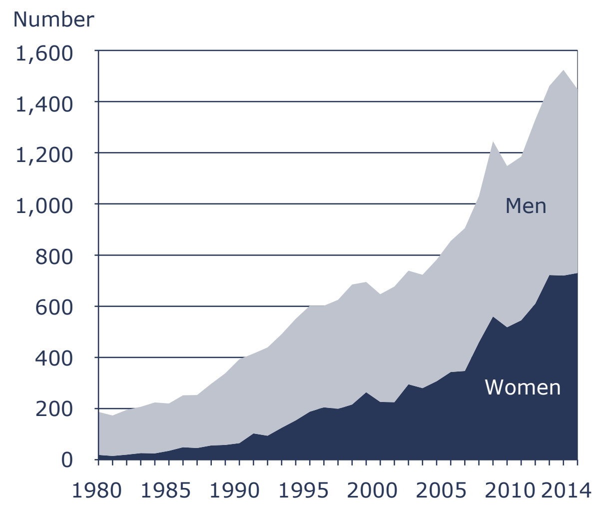
The relationship between R&D FTE and R&D headcount

From 2011 to 2013, growth in R&D headcount was larger in percentage terms than the increase in R&D FTEs. This means that more people participate in R&D, but they spend less of their time on R&D than before.

Time spent on R&D varies between the performing sectors, but also between job category and position. In 2013, every participant in R&D in the industrial sector performed an average of 0.65 R&D FTEs. The R&D ratio was slightly higher for research staff than for technical/administrative staff, and varied with the size of enterprises. The smallest firms, with 10 to 19 employees, reported 0.55 R&D FTEs per person, while enterprises with at least 500 employees reported 0.75 R&D FTEs per person. The institute sector had the highest R&D share in 2013; every participant in the research, on average, performed 0.79 R&D FTEs. The proportion was similar for researchers/academic staff and technical/administrative staff.

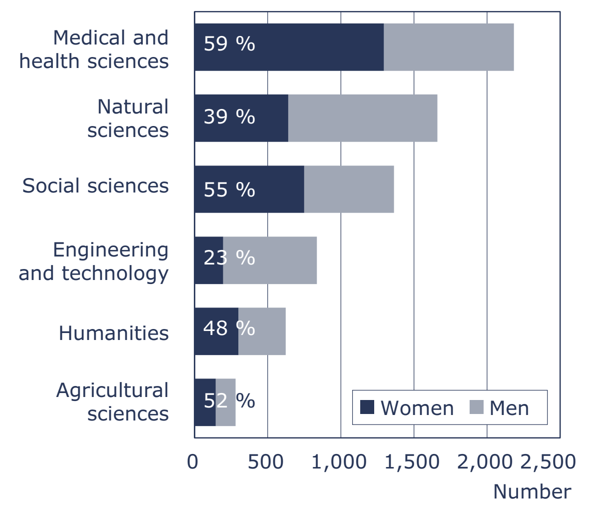
In the higher education sector a research participant performed on average 0.44 R&D FTE - slightly higher for researchers than technical/administrative staff. At universities and university colleges all personnel with R&D time as part of their job description are included as R&D personnel. At these institutions, most academic staff have two main tasks, teaching and research, and many employees have a low R&D share in their job description. For instance, many university lecturers spend less than 20 per cent of their working hours on R&D. The R&D proportion among professors and associate professors at universities is just under 50 per cent, while students and postdocs use between 70 and 100 per cent of their time on R&D.

Figure 2.23
Awarded doctoral degrees in Norway by gender: 1980–2014.



Source: NIFU, Doctoral Degrees Register

Figure 2.24
Awarded doctoral degrees in Norway by field of research and development: 2010–2014.



Source: NIFU, Doctoral Degrees Register

2014: the first year with the higher number of women among doctoral candidates

In 2014, 1,448 doctoral degrees were awarded at Norwegian educational institutions. This involves a slight decline from the earlier peak year of 2013, when 1,524 degrees were awarded. After a significant increase in the number of awarded doctoral degrees from the early 2000s, the number seems to have stabilized in recent years.

A significant contribution to the recent increase has been that more women gain doctorates, see Figure 2.23. In 2014, 730 women and 718 men gained a PhD/doctoral degree. From a gender perspective, 2014 was a milestone; women were for the first time in the majority.

In the early 1980s, women accounted for around 10 per cent of doctorates. The proportion rose to about one-third during the 1990s, and continued to grow after the millennium. Since 2008, the proportion of women annually varied between 45 and 49 per cent, until it in 2014 actually turned 50 per cent.

There are still major differences in gender balance at fields of R&D. Over the past five years, three-fifths of all PhDs in the largest field, medical and health science, were awarded to women. Women have also been in the majority in social sciences, with 55 per cent of the PhDs in the same period. Regarding the humanities and agricultural sciences, both genders are fairly equally represented, while men are still in clear majority in natural sciences and engineering and technology. Over the past five years, men accounted for three-fifths of all doctoral degrees in natural sciences, while the proportion of men in engineering and technology was even higher at 77 per cent.

Every third doctoral candidate from abroad

Another factor with great significance for recent Norwegian growth in awarded PhDs is the sharp rise in the number of people with non-Norwegian citizenship who take a PhD in Norway; while they accounted for less than 10 per cent of doctoral degrees at the start of the 1990s, the proportion in recent years made up more than a third.

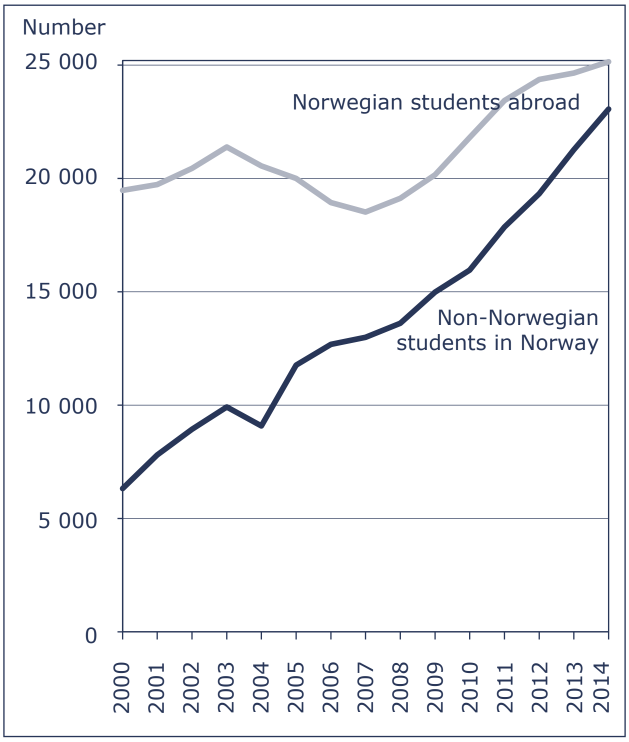
The increase in the total number of doctorates is partly due to the increase among Norwegian women, but non-Norwegian citizens are contributing to an even greater extent.

For Norwegian men the development has been quite different. Almost 100 fewer men received their doctorate in 2014 than six years earlier. The 2014 figure, at just over 400 doctorates, was actually almost identical to the level in 1998. In comparison, the number of degrees awarded to Norwegian women tripled during the same period, and foreign doctoral students are almost six times as many now as in the late 1990s.

In the 2010–2014 period, about 2,300 people with non-Norwegian citizenship gained a PhD in Norway. Almost half of the foreign doctoral candidates came from Europe, with 32 per cent from Asia, while about every seventh foreign doctoral candidate was from an African country. Germany tops the list of countries with 250 doctorates, followed by China.

There is a majority of men among the foreign citizens who take a PhD in Norway; over 60 per cent over the past five years, but there are significant differences in gender balance between individual nations. For a number of Asian countries the proportion of men is particularly high, while there is generally an even gender distribution among European candidates.

Figure 2.25
Norwegian students abroad and non-Norwegian students in Norway: 2000–2014.



Source: Database for Statistics on Higher Education (DBH) and Norwegian State Educational Loan Fund

In the post war period, Norway had a higher proportion of its students abroad than most other Western countries, partly due to a generous public funding scheme that includes Norwegian students abroad. Until the millennium, there were relatively few foreign students who found their way to Norway, but their number has more than tripled since then. Figure 2.25 shows the number of outbound and incoming students in the period 2000–2014. Both those taking a full degree, and those on exchange programmes are included in the statistics. We see that the curves of ingoing and outgoing students are approaching each other.

Non-Norwegian students in Norway

Foreign nationals accounted for roughly 9 per cent of the total student population in Norway in 2014. One important reason why many international students choose to study in Norway, is that educational institutions, to a greater extent than previously, offer courses and programmes in English. Internationalization is high on the agenda both in education policies (Meld. St. 14 (2008–2009)) and in educational institutions' strategies (SIU 2013, Frølich, Waagene, Stensaker 2014), and we have seen an increased focus on recruiting international students. A survey of foreign students in Norway shows the absence of tuition fees as an important reason to choose Norway as a study destination for three out of four who take a full degree in Norway (Wiers-Jenssen 2014).

Not all foreign students can be considered as incoming students: some were living in Norway before they started in higher education. A survey shows that 15 per cent of students with foreign citizenship initially came to Norway for reasons other than studies (Wiers-Jenssen 2014). Among those taking a full degree in Norway, this applies to roughly every fourth student. This illustrates that labour mobility, and other forms of immigration, contributes to the high number of foreign students in Norway.

Students with foreign citizenship come from a wide range of countries. The majority come from European countries, currently most from Sweden and Germany. But there is also a significant number of students coming from outside the EEA. Figure 2.25 shows the trend in the number of students from countries that had more than 500 students in Norway in 2014. Students from these countries account for about two-thirds of all foreign students in Norway. Roughly three out of ten foreign students are exchange students on shorter stays, and ERASMUS is the largest programme, with approximately 4,000 incoming students per year (SIU 2015).

Among those taking a full degree in Norway, the Swedes are now the largest group. We believe that part of this influx is related to the recent immigration from Sweden. There are also many students from China, Russia, Poland, and from developing countries, who take a full degree in Norway. Approximately 1,100 students are in Norway through the so-called «quota system», where students from selected countries (developing countries, Eastern Europe, the Balkans and Central Asia) on condition that they return to their home country once the education is completed. The number of students who come through this scheme has been relatively stable.

Norwegian students abroad

About 25,000 Norwegian students are studying abroad, accounting for up to 8 per cent of the Norwegian student population. Former student flow due to foreign capacity shortage, but today foreign students travel primarily because they seek new experiences and alternative education programmes (Wiers-Jenssen 2008). For some groups (such as medical students) however a lack of student places is still the main reason for mobility.

3 Knowledge sharing and cooperation

Chapter 3

Dag W. Aksnes, Fredrik Piro, Gunnar Sivertsen, Espen Solberg, Elisabeth Wiker, Lars Wilhelmsen

Norwegian participation in EU research

- The Norwegian rate of return in Horizon 2020 is higher than it was under the Seventh Framework Programme. Figures so far show that Norway obtains more funds from the EU than previously.

- Norway is represented in a smaller percentage of the applications in Horizon 2020 compared with the Seventh Framework Programme. Adjusted for population, we are less active on the application side than Sweden, Denmark and Finland.

Cooperation on scientific publishing

- In 1995, there was international co-authorship in 35 per cent of the articles in the Web of Science with at least one author address from Norway, while 62 per cent of these articles had contributions from abroad in 2014.

- Small countries have a higher tendency for international co-authorship than large countries. Norway's share is approximately the same as in the other Nordic countries and in other small countries.

- Norwegian researchers collaborate with researchers from more countries. In the period 2010–2014, Norwegian researchers cooperated with 167 countries. The US is still our biggest partner, but growth in international cooperation with other EU countries has been particularly strong in recent years.

Collaboration on innovation

- Innovation collaboration with suppliers is the cooperation most used by enterprises. Enterprises consider this partner to be the most important.

- Enterprises with innovation cooperation most often have partners locally, regionally or in Norway in general. Foreign partners are located mostly in Europe outside the Nordic region. 36 per cent of enterprises have had a partner in Europe outside the Nordic region, and 26 per cent have had a Nordic partner.

Collaborations in SkatteFUNN

- Of all SkatteFUNN projects, 28 per cent planned cooperation within an R&D environment.

- The institute sector is the most important partner for SkatteFUNN companies. Approximately 50 per cent of all cooperative relationships were with this sector, compared with about 30 per cent with the higher education sector. SINTEF and NTNU are by far the biggest partners.

Table 3.1
International indicators for cooperation on R&D and innovation.

Ranking	Share of national R&D financed from abroad[1]	Share of scientific publications with international co-authorship	Share of higher education sector and government sector's financed by the industrial sector	Share of innovative small and medium sized enterprises cooperating with other enterprises	Share of the universities' publications with co-authors from the business enterprise sector[2]	Public-private cooperation publications per million capita
1	Israel	Switzerland	Russia	Belgium	Denmark	Switzerland
2	Czech Republic	Iceland	China	United Kingdom	Hungary	Iceland
3	Luxembourg	Denmark	Romania	Iceland	Sweden	Denmark
4	Ireland	**Norway**	Germany	Denmark	Austria	Sweden
5	United Kingdom	Sweden	New Zealand	Estonia	The Netherlands	The Netherlands
6	Slovakia	Luxembourg	Slovenia	Austria	Germany	Belgium
7	Austria	The Netherlands	The Netherlands	Cyprus	Finland	Finland
8	Hungary	Finland	Hungary	Slovenia	Belgium	Slovenia
9	Greece	Belgium	Iceland	The Netherlands	Croatia	**Norway**
10	Iceland	Austria	United Kingdom	Finland	Slovenia	United Kingdom
Norwegian ranking	18	4	18	20	16	9
Selection	OECD 31	EU 34	OECD 36+4	EU 34	Europe[2]	EU 34
Source	OECD/MSTI 2015:1	Innovation Union Scoreboard 2015	2014 STI-Scoreboard	Innovation Union Scoreboard 2015	Leiden ranking 2015	Innovation Union Scoreboard 2015

[1] Average for 2010–2103.

[2] This indicator in the Leiden ranking includes Europe's 285 biggest universities by volume on scientific publishing. In all, 26 countries are represented on this list. Norway is represented by the Universities of Oslo, Bergen, Tromsø and Trondheim (NTNU).

In this chapter, we present indicators that describe cooperation and collaboration patterns in the Norwegian R&D and innovation system, both nationally and internationally. As Table 3.1 illustrates, there are many approaches to study the extent and pattern of R&D cooperation. Many cooperation indicators are based on the buying and selling of research across disciplines, institutions, sectors or countries. Such indicators, however, do not capture other aspects of the cooperation and dissemination of knowledge, such as cooperation on scientific publications. Moreover, many indicators are vulnerable to the fact that different countries have different systems. In Norway, research institutes are key partners of the business enterprise sector, but since the institute sector does not exist as a separate sector in international statistics, many comparisons of cooperation are difficult to make.

In subsequent paragraphs, we highlight international cooperation, cooperation on scientific publications, and the sharing of knowledge that occurs through other forms of publishing.

Furthermore, we highlight various aspects of the business enterprise sector's cooperation on research and innovation. The business enterprise sector also has extensive knowledge sharing through the purchase of R&D and hiring of expertise. This featured in last year's Science and technology (S&T) report (see section 2.5.2 in the Norwegian S&T Report 2014). We also devote a section to Norwegian participation in European research cooperation, where there are strong demands for extensive international cooperation and networking to succeed.

Table 3.2
Norwegian participation in the EU 7th Framework Programme: Applications[1] and approved projects. Number and percentage.

Programme	Applications Total	Applications Norway	Applications Norway (%)	Approved projects Total	Approved projects Norway	Approved projects Norway (%)
HEALTH	3,920	339	8.6	974	93	9.5
BIO (Food, agriculture, fisheries and biotechnology)	2,822	462	16.4	510	111	21.8
ICT	16,020	1,166	7.3	2,406	183	7.6
NMP (Nano science, nanotechnology, new mat. and prod. techn.)	2,624	261	9.9	789	84	10.6
ENERGY	1,587	229	14.4	359	74	20.6
(incl. climate change)	2,586	451	17.4	485	134	27.6
TRANSPORT	3,001	256	8.5	751	78	10.4
SSH (Social sciences and humanities)	2,574	356	13.8	236	46	19.5
SPACE	988	101	10.2	246	37	15.0
SECURITY	1,787	259	14.5	299	66	22.1
JTI (Joint technology initiatives)	2,282	106	4.6	884	59	6.7
TOTAL: COOPERATION	**40,225**	**3,992**	**9.9**	**7,965**	**970**	**12.2**
RI (Research infrastructure)	844	135	16.0	323	68	21.1
SME (Research in favour of small and medium sized enterprises)	5,444	627	11.5	987	160	16.2
SiS (Science and society)	825	121	14.7	223	43	19.3
SUM CAPACITY	**10,305**	**934**	**9.1**	**2,010**	**295**	**14.7**
ERC	35,331	575	1.6	4,208	51	1.2
MCA (Marie-Curie activities)	49,643	977	2.0	10,840	167	1.5
TOTAL ALL PROGRAMMES	**135,792**	**6,494**	**4.8**	**25,155**	**1,496**	**5.9**

[1] The numbers do not include one-step-applications by two-step-processes and invalid applications.

Source: EU Commission database E-Corda

The EU's Seventh Framework Programme for Research and Technological Development (FP7) is now terminated. In this section we give a summary of how Norway succeeded in the Seventh Framework Programme, both across sectors in Norway and compared with selected countries. Secondly. Later we also look at the preliminary results from the EU Framework Programme Horizon 2020, the world's largest programme for innovation and research. This programme will allocate €77 billion in the period 2014–2020. Key questions are: How much do different countries retrieve of the total allocated EU grant (return rate)? How many applications are submitted to EU programmes, and how many of those are granted funding?

EU projects reflects internationalisation

The EU Framework Programmes are large and open competition venues. Participation often takes place through cooperation in larger consortia of institutions across national borders, and demands from the EU on the international network are considerable. As such, participation in EU research is seen as an indicator of both international orientation and impact.

Participation in EU projects is also an expression of the ability to manage international cooperation projects, especially where there is talk of coordinating applications and projects with many partners.

The Seventh Framework Programme: a summary

The S&T report of 2014 (Norwegian version only), showed that Norwegian researchers had a moderate propensity to apply for EU funds, but with great effect once the application is sent. Throughout FP7, 23 per cent of all applications with Norwegian participants were recommended for funding. Overall, Norway was represented in 6,494 of a total of 135,792 applications - i.e. 4.8 per cent. However, if we relate the number of applications from Norway to the number of R&D FTEs, Norway is far from one of the most active candidate countries.

Norway had a coordinator role in 350 projects. To undertake such a role is one of the best opportunities to influence and benefit from the collective knowledge production in the EU. Four institutions stand out in that they coordinated approximately half of all projects with a Norwegian coordinator: the University of Oslo coordinated 53 projects, SINTEF 46, the University of Bergen 38 and NTNU 36.

Relatively few Norwegian applicants for the main programmes

In Table 3.2, we show in which FP7 programmes Norwegian scientists participated in applications, and how many projects with Norwegian participation that were approved for EU funding within each programme. We only show figures where there is a minimum of 50 applications with Norwegian participation. Most applications to FP7, both internationally and from Norway, were to the ICT programme, where Norwegian players participated in 7.6 per cent of all applications. Relatively speaking Norwegian applicants were most active within BIO and ENVIRONMENT - programmes with significantly lower total budgets than ICT.

Applicants from the higher education, institute, and industrial sectors are represented in a larger number of applications for the ICT programme. Beyond this, the three sectors differ from each other by directing the bulk of their applications to various programmes. The higher education sector's focus is on (besides the ICT programme) the health programme (total 264 contributions to applications) and Marie Curie fellowships for research training and mobility (697 contributions to applications). The institute sector has the environmental programme as its second largest area (330 contributions to applications), while the industrial sector primarily applied for research to benefit small and medium-sized enterprises (552 contributions to applications).

Good Norwegian results in environmental and climate programmes

Table 3.3 shows Norwegian return rates and success rates in FP7, see fact box at the next page. We only show figures where there are more than 50 applications with Norwegian participation. In all, Norway received €725.5m in FP7 – or 1.69 per cent of all undistributed funds. Such a return rate is lower than the other Nordic countries (Sweden 3.79 per cent, 2.38 per cent and Denmark and Finland 1.93 per cent). The institute sector acquired the largest share of funding from FP7 (about 39 per cent). Then follow the higher education sector with 34 per cent and the industrial sector with 21 per cent.

The highest Norwegian success rate achieved was within the capacity programme for research infrastructure, but this is a small programme. The highest success rate among the cooperation programmes was in somewhat smaller programmes (measured by the budget) for energy and space activities, in contrast to the three major programmes ICT, HEALTH and NMP.

For Norway in total, there is indeed a significant negative correlation between the number of applications submitted per programme, and the level of the success rate. ICT programmes received most Norwegian applications, but have one of the lowest success rates at 15 per cent. Because of the large volume of applications to the ICT programme, applications through this programme nevertheless represented the majority of Norway's EU 7RP funding (€868m).

Most money was subsequently retrieved in the programmes for environment and energy, and here Norway's return rate is highest (respectively 4.4 and 3.6 per cent of allocated funds from the EU). Given that the ICT application example has a total budget almost five times as large as that of environment, it is surprising that Norwegian participation in this programme only brought in 1.4 times as much as Norwegian participation in the environmental programme. Conversely, the Norwegian payoff in the environmental programme (and energy programme) has been good.

In an international context, the Norwegian success rates were consistently higher than the world average, with the exception of the applications to the European Research Council and the MCA activities.

Norway has in particular comparatively high success rates within the environment and energy, as well as in space activities. Norway's success rate of 23 per cent overall is 4.5 percentage points higher than the world average.

Table 3.3
Norwegian participation in the EU 7th Framework Programme. Rates of success and return.

Programme	Norwegian EU grants for approved projects (mill. NOK)	Rate of return for Norway (%)	Rate of success for Norway	Deviation all countries
HEALTH	401.8	1.0	27.4	2.6
BIO (Food, agriculture, fisheries and biotechnology)	343.6	2.3	24.0	6.0
ICT	868.0	1.4	15.7	0.7
NMP (Nano science, nanotechnology, new mat. and prod. techn.)	400.5	1.5	32.2	2.1
ENERGY	493.2	3.6	32.3	9.7
ENVIRONMENT (Incl. climate change)	601.2	4.4	29.7	11.0
TRANSPORT (Transport, incl. aircraft and ships)	229.4	1.3	30.5	5.4
SSH (Social sciences and humanities)	95.5	2.1	12.9	3.8
SPACE	170.8	3.0	36.6	11.7
SECURITY	256.8	2.5	25.5	8.8
JTI (Joint technology initiatives)	190.4	1.2		
TOTAL: COOPERATION	**4 059.1**	**1.8**	**24.3**	**4.5**
RI (Research infrastructure)	203.5	1.7	50.3	12.1
SME (Research in favour of small and medium sized enterprises)	432.2	4.3	25.5	7.4
SiS (Science and society)	65.2	2.8	35.5	8.5
SUM CAPACITY	735.8	2.4	31.6	12.1
ERC	705.5	1.1	8.9	-3.0
MCA (Marie-Curie activities)	529.3	1.4	17.1	-4.7
TOTAL ALL PROGRAMMES	**6 029.7**	**1.7**	**23.0**	**4.5**

Source: EU Commission database E-Corda

Chapter 3

So far (as of March 2015), 418 Norwegian institutions participated in applications for Horizon 2020. Of these, 116 obtained EU funding, while 302 institutions participated in applications without success. Of 1,067 applications with Norwegian participation, 161 projects were approved by the EU. Projects from Norway represented 4.3 per cent of all projects (against 5.9 per cent in FP7). Norwegian participants led 49 of the approved projects.

The University of Oslo and NTNU participated in the highest number of applications (respectively 163 and 133), followed by SINTEF (98), University of Bergen (68), University of Tromsø (37), Norwegian University of Life Sciences (34), Oslo University Hospital (34), Simula Research Laboratory (18), SINTEF Energy (17) and the Research Council of Norway (16). The University of Oslo, Bergen and SINTEF had 16 applications approved, while NTNU participated in 15 projects.

Table 3.4
Key figures for Norwegian participation in Horizon 2020. Number and percentage.

Programme	Rate of return (per cent)	Number of applications	Norwegian share of all application (per cent)	Number of approved projects Norway	Rate of Success (per cent)
Excellence in research	1.1	335	2.3	38	11.3
Industrial leadership	1.7	230	4.6	34	14.8
Societal challenges	2.6	498	8.4	87	17.5
Total Horizon 2020[1]	**1.7**	**1 067**	**4.1**	**161**	**15.1**

[1] Incl. EURATOM.

Source: EU Commission database E-Corda (March 2015)

Higher Norwegian return rate in Horizon 2020 than in FP7

Norway is participating so far in Horizon 2020 in 4.3 per cent of the recommended projects, which is 1.6 percentage points lower than in FP7. Nevertheless, Norway retrieved a larger share of the announced funds than was the case in FP7. The return stake in Horizon 2020 was 1.87 per cent compared with 1.69 per cent in FP7. This means in short that Norway now on average receives more EU funding per project than was the case in FP7. In relation to the government's goal of a return rate of two per cent, Norway has not yet achieved its goal. It is also important to note that these results are characterised by a few large projects, with many Norwegian actors and much EU support.

The figures also show the situation at a very early stage of Horizon 2020. The results we have seen so far might change. It is also worth noting that the total number of applications to Horizon 2020 has been much higher than under FP7 - perhaps because of the economic crises/cuts in research funding in a number of countries - so that the success rate overall in Horizon 2020 is much lower than it was in FP7. As of March 2015 Horizon 2020 received 25,903 applications and 3,765 projects are recommended for funding. The overall success rate of 14.5 per cent is thus slightly lower than the Norwegian success rate.

In Table 3.4, we look at the key figures for Norwegian participation in Horizon 2020 as of March 2015. See Table B.5 in the online version of the report for a more detailed overview. We see a certain pattern in the three programmes. The greater proportion of the applications we are involved in, the greater the chances that the applications are approved.

Horizon 2020 cannot be directly compared with FP7, since not all programmes are substantive or otherwise comparable. Horizon 2020 consists of three main parts (also called priorities or pillars): «Excellent Science», «Industrial Leadership» and research to tackle «Societal Challenges». In addition, there are separate applications under two so-called specific goals: «Science with and for Society» and «Spreading Excellence and Widening Participation».

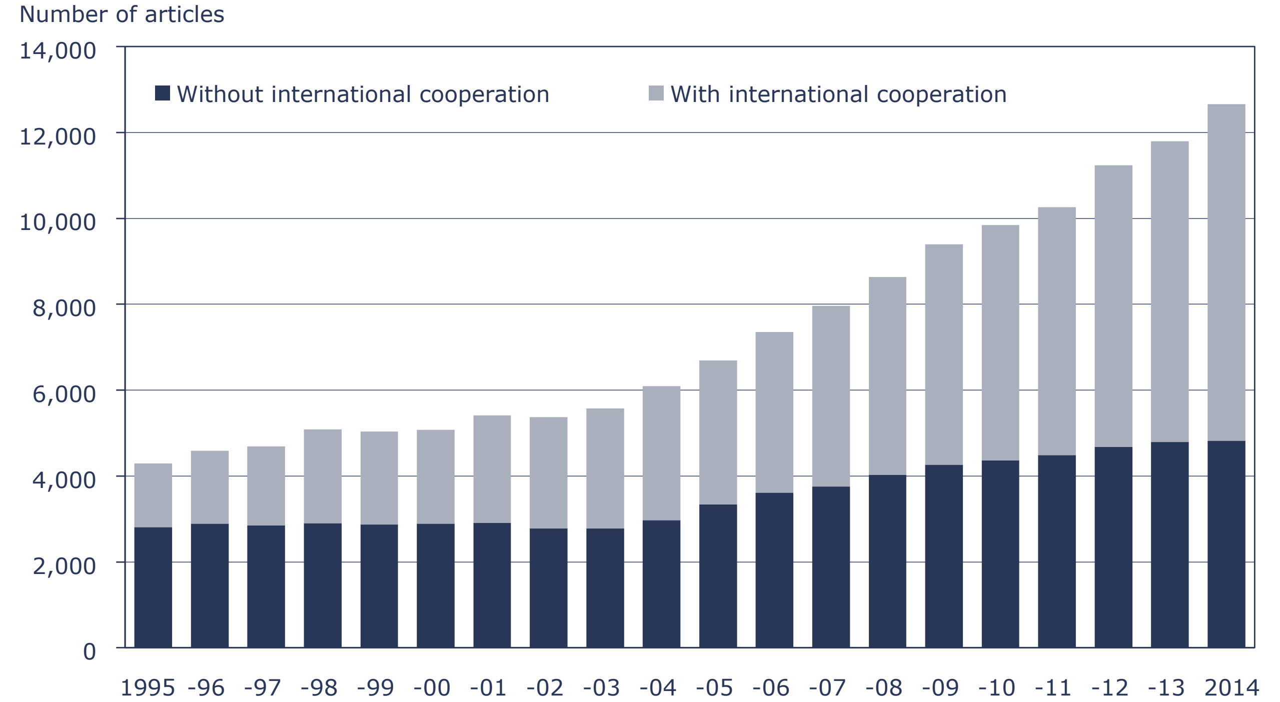
EU research programme participation – the nature of return/success rates

Approval of an EU application could be seen as an indicator of quality and relevance, but some would argue that success in this regard just as much reflects the quality and relevance of the application as of the research itself.

The success rate indicates the relationship between the number of a country's applications for EU funds and how many of them are approved. It does not say anything about how difficult it is to get funding from the EU, or how much will be funded. When the success rate is calculated, an application for a relatively small budget competing with few other applications counts the same as an application for large funds competing with a large number of other applications.

The return rate shows the share of funding granted to an applicant country. It is thus more appropriate to speak about a country's success in EU calls for proposals at the national level, since it provides a better overall picture of how much EU funding a country manages to bring home. It says nothing, however, about the number of applications for the allocated funds. Two countries can have the same return rate, but with large differences in the number of applications submitted.

Figure 3.1
Norwegian scientific articles with and without international cooperation: 1995–2014.



Source: The database National Citation Report for Norway (Thomson Reuters), NIFU

International cooperation has always been an important part of research activities. A well-established and widely used method to measure such cooperation is to look at the scientific journal articles that have collaborators in different countries. Such a measurement of co-authorship provides both a picture of the extent and patterns of international research.

The authors publish their addresses in journals, and these addresses are registered in the bibliographic database Web of Science (Thomson Reuters). The data for this analysis are based on 148,226 scientific journal articles registered over a twenty-year period from 1995 to 2014, and which have at least one author address in Norway.[1] This is the bulk of all articles that Norwegian researchers have published in international scientific journals in the period.

Most Norwegian articles have international co-authors

An increasing proportion of these articles also have author addresses from other countries. In 1995, international co-authorship appeared in 35 per cent of the articles. Ten years later, the proportion had increased to 50 per cent, and in 2014, 62 per cent of the articles combined Norwegian addresses and addresses in other countries. Most other countries have seen similar increases. The percentage of articles with international co-authorship is generally higher in small countries than in big countries. This is related to the fact that bigger countries often have a larger academic environment within the country, while researchers from smaller countries require contact with institutions in other countries.

In the two countries with the most scientific articles, the United States and China, the proportions of international cooperation articles were respectively 35 and 26 per cent. Norway's share is approximately the same as in the other Nordic countries and other small European countries.

Generally, the highest-cited publications have an even greater degree of international co-authorship than other publications (Schneider et al 2010).

In Figure 3.1 we see that the number of articles from Norway has increased significantly during the period, and this is mainly due to articles with international co-authorship. The total number of articles has increased from 4,297 in 1995 to 12,655 in 2014. The number of articles in the Web of Science for the World in total has also increased, but not to the same extent. In recent years, the increase in Norway has been clearly greater than in Sweden and Finland, but somewhat lower than in Denmark.

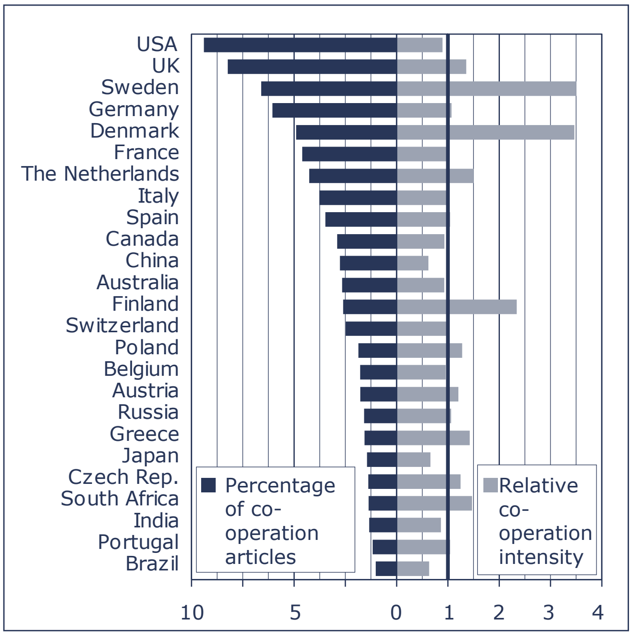
[1] The data selection is explained in the fact box on bibliometric indicators in Chapter 1. 1,372 articles with more than 200 authors are excluded - most of them from the Cern laboratory. These articles would have given a biased picture of Norwegian international research collaboration.

Table 3.5
The 25 countries Norway had most research cooperation with over four periods: 1995–2014.

Country	1995–1999	2000–2004	2005–2009	2010–2014
All Norwegian articles with cooperation	9,361	13,201	21,057	32,659
USA	2,482	3,587	5,675	8,625
United Kingdom	1,535	2,594	4,255	7,123
Sweden	2,013	2,561	3,897	6,084
Germany	1,154	1,642	2,988	5,227
Denmark	1,061	1,616	2,534	4,027
France	856	1,364	2,217	3,730
The Netherlands	676	1,058	1,853	3,426
Italy	510	812	1,610	2,839
Spain	339	554	1,257	2,622
Canada	462	756	1,527	2,501
Finland	671	959	1,411	2,183
Australia	246	416	945	2,030
China	118	235	609	1,814
Switzerland	381	515	934	1,772
Belgium	255	409	726	1,579
Austria	147	289	646	1,196
Poland	194	343	602	1,075
Japan	322	407	607	990
Russia	498	590	765	970
Greece	142	193	436	840
Portugal	89	155	321	740
Czech Republic	99	176	331	728
South Africa	37	122	360	726
Iceland	136	246	372	548
Israel	117	159	311	547

Source: National Citation Report for Norway (Thomson Reuters), NIFU

Figure 3.2
25 countries with highest degree of cooperation with Norway: 2014.



Note: Left side shows the share of articles with cooperation, while the right side compare this share with the Norwegian share and the other country's share in the network as a whole. The value 1 means that cooperation with Norway is as expected in perspective of the general cooperation. Values over 1 shows that the relation is particularly active, while values under 1 means that other relations are more active.

Source: NIFU, based on calculations of the Web of Science database, CWTS, Leiden.

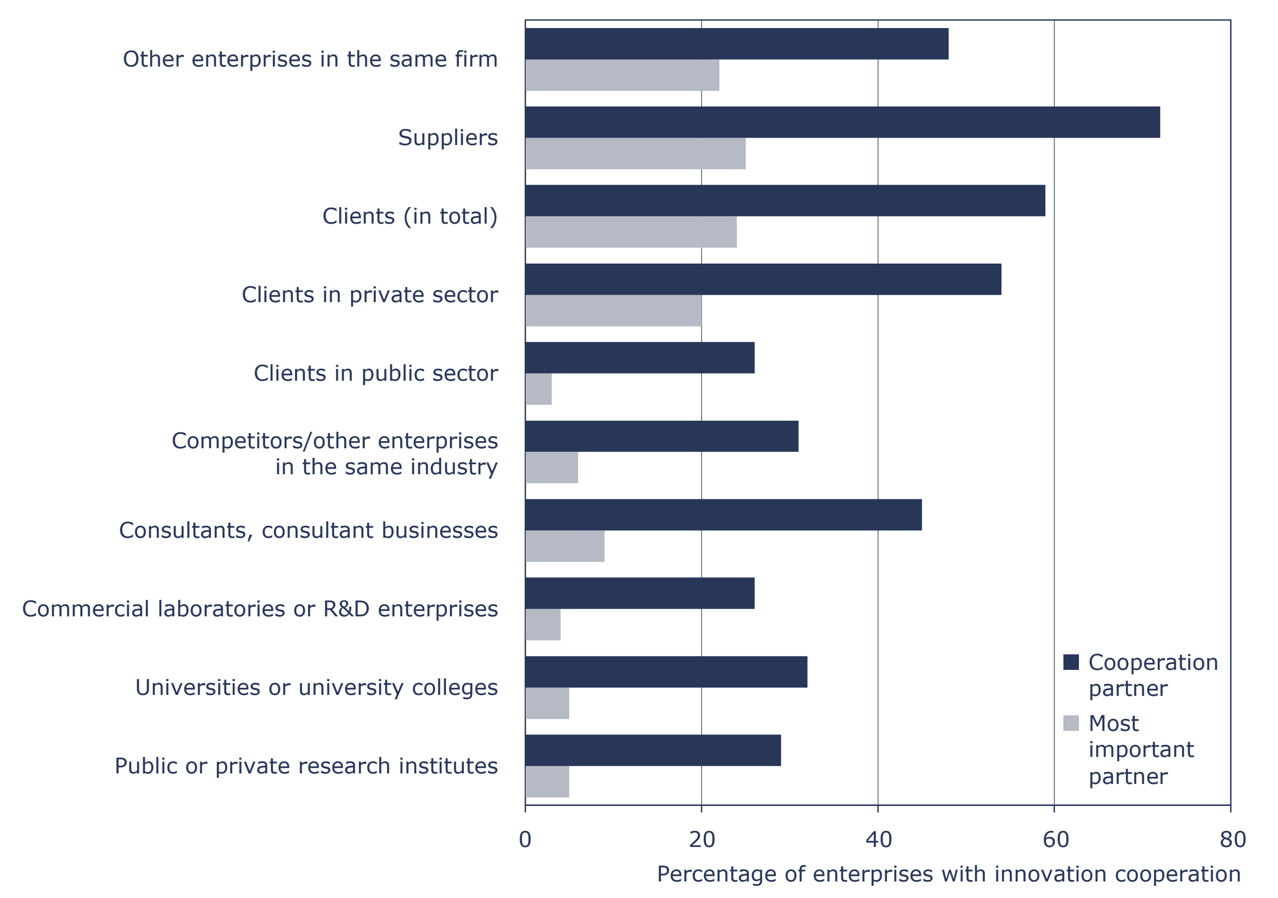
Table 3.5 shows the 25 countries with which Norway had most research in the 1995–2014 period. Twenty years ago, five countries dominated Norwegian cooperation in articles: USA, Sweden, UK, Germany and Denmark. Now the cooperation profile is wider. Within the EU, Norwegian scientists had the greatest increase in relations with countries with which there has traditionally been little collaboration, such as Austria, Ireland, Spain, Portugal and Greece.

There has also been significant increase in cooperation outside Europe with Canada, China, Australia and South Africa. In the first five-year period there was cooperation with 117 different countries, while the number was 167 in the last five years.

Norwegian researchers collaborate relatively more with British and Nordic researchers

Figure 3.2 shows that the USA remains the most important partner for Norwegian researchers in terms of publications. However, this is not unique to Norway and should be seen in conjunction with the position held by the USA as the world's largest research nation in terms of the number of articles in the Web of Science. Therefore, cooperation frequency also must be related to the activity in cooperation networks in the World as a whole. On the right side of the figure, the bilateral cooperation is compared with the two countries' activity in the network as a whole. A value of 1 means that the country's cooperation with Norway is as expected from the cooperation in the world as a whole. Values above 1 shows that the relationship with Norway is particularly active, while values below 1 show that other relationships are more active. Cooperation between the USA and Norway is slightly less active than expected. The opposite is true for example for the cooperation between Norway and the UK, and in particular in relations with other Nordic countries. This means that Norwegian researchers are more oriented towards cooperation with British and Nordic researchers. The method of calculation means that the pattern is mutual in all bilateral institutions. Also in the UK profile, Norway has a high relative collaboration intensity, but the proportion of collaborative articles is much lower than from the Norwegian point of view. As we can see, Norway has lowest relative intensity of cooperation with Brazil, India, China and Japan.

Figure 3.3
Enterprises with innovation cooperation by type of partner: 2012–2014.



Source: Statistics Norway, Innovation survey 2012–2014

Cooperation patterns in the innovation survey for 2012–2014 are more or less unchanged from the previous survey covering the period 2011–2013. There is a certain decrease in the share of enterprises with product/process (PP)-innovations activity having had cooperation: the proportion has fallen from 44 to 40 per cent. There is also a decline in all the various types of cooperation, which means that the average number of different partners provided by enterprises with innovation cooperation has declined somewhat. However, given the uncertainty in the survey, we cannot say that these effects are significant.

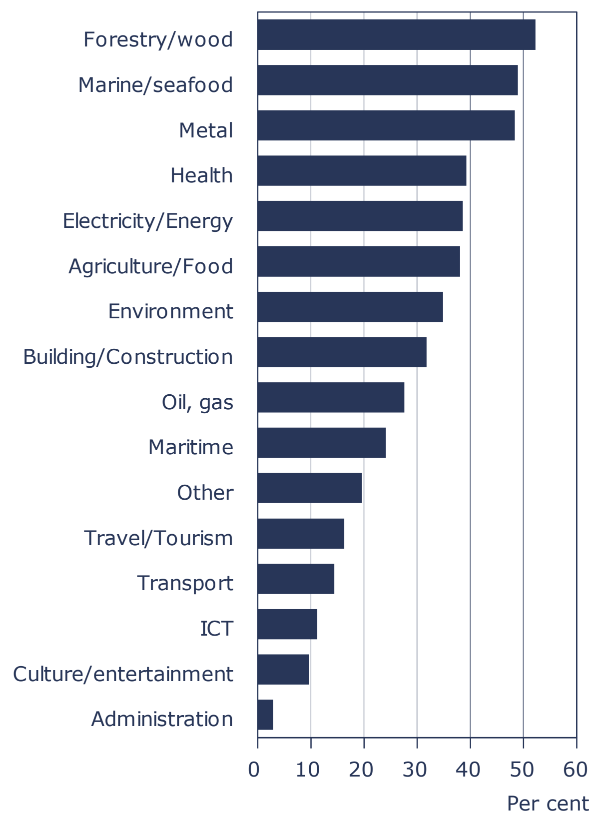
Cooperation with the public sector is relatively unimportant

Innovation collaboration with suppliers is the cooperation type most used by enterprises (Figure 3.3). A supplier is also the partner considered by most cooperative enterprises as most important. As a percentage of enterprises with a given type of cooperation, enterprises within the same firm are most frequently stated as the main partner. If adjusted for the fact that not all companies are affiliates, intragroup cooperation is both common and important for enterprises in the group. These results are essentially the same as the results of previous surveys, although level figures vary slightly.

Overall, cooperation with clients or customers was both the second most common and second most important type of collaboration. Previously the survey did not separate the private and public sectors, but when you look at these groups separately, customers in the private sector are the second most reported partner. Cooperation with customers in the public sector is reported less than half as often.

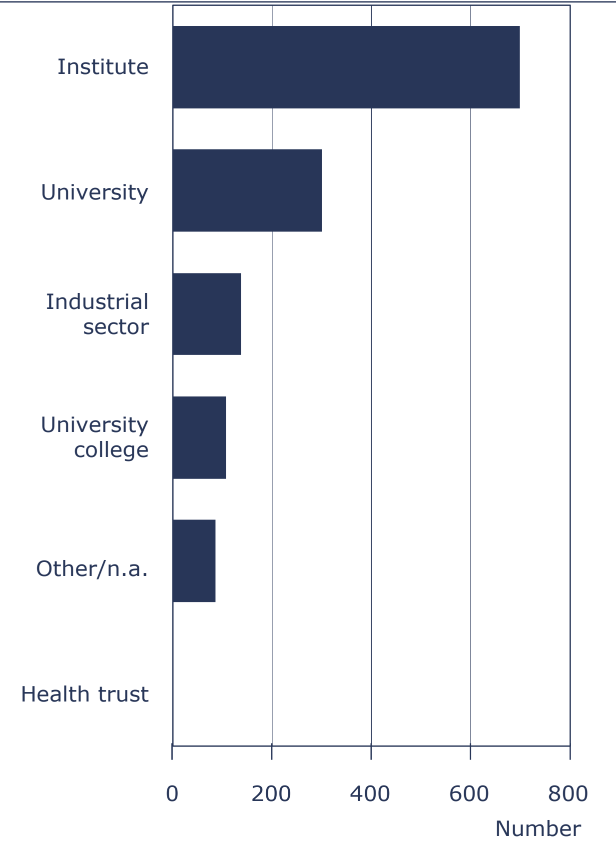
Of enterprises that collaborate with clients or customers in the private sector, for as many as 37 per cent this partnership is paramount. Meanwhile, only 12 per cent of the enterprises cooperating with clients or customers in the public sector responded that this cooperation was important. This is the lowest proportion given for all types of partner. Innovation collaboration with the public sector is therefore the least used and also least likely to be most important when it occurs. This result does not differ significantly from the results in other European countries.

Figure 3.4
Share of SkatteFUNN projects with cooperation by industry: 2014.



Source: Research Council of Norway

Figure 3.5
Partners for SkatteFUNN companies: 2014.



Source: Research Council of Norway

SkatteFUNN is the most important instrument in Norway to stimulate more research activity in the industrial sector. SkatteFUNN is a tax incentive scheme, where R&D support is provided as a deduction from assessed taxes. In 2014, there were over 4,900 approved projects with more than 3,800 companies involved. In the scheme, there is added incentive for cooperation between enterprises and R&D institutions in the sense that projects that involve this kind of cooperation are granted more than to projects undertaken by the company alone. SkatteFUNN thus creates an important arena for cooperation between enterprises and research institutions.

Among the projects active in 2014, 28 per cent were scheduled to take place in cooperation with an R&D institution, given a budget of €1.2 billion for the procurement of R&D services.

There are wide variations between sectors with regard to the scope of cooperation. As seen in Figure 3.4, we find the highest proportions of projects with cooperation within forestry/wood, marine/seafood and metal, in which the shares are around 50 per cent. At the other end of the scale travel/tourism, transport, ICT, culture/entertainment, and administration, have relatively small proportions of cooperation projects. The low shares are probably linked with innovation activity in these industries being mainly based on experience, and for the work mainly to emphasise the D in R&D. In particular, it may be worth noting that the ICT industry is included in this group. This is a very large industry, with the largest share of SkatteFUNN projects at 15 per cent of the projects and 17 per cent of budgeted costs (see also Table B.4.1 in the online version of the Norwegian report).

The institute sector is important for SkatteFUNN companies

The research institutes are the most important partners for SkatteFUNN companies, with approximately 700 cooperative relationships in 2014; some 50 per cent of all cooperative relationships (Figure 3.5). Universities are the second largest group with around 300 cooperative relationships or 22 per cent. If we include university colleges, the higher education sector participated in around 30 per cent of the collaborative activity, considerably less than the research institutes.

4 Results and effects on R&D and innovation

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Scientific publishing and citation

- Compared with the rest of the world Norwegian publishing specializes in biology, earth sciences and social sciences. Conversely, Norwegian researchers publish relatively little in physics, chemistry and certain technological disciplines.
- Norwegian articles are cited above the world average in most disciplines. Top levels of citation are found for political science and clinical medicine, while chemistry and chemical technology is the only discipline where Norwegian articles are cited below the world average.
- Traditional research universities account for nearly half of the national scientific publications in 2014. The largest proportions of publications came from the University of Oslo with 17.9 per cent, followed by NTNU (14.2 per cent) and the University of Bergen (9.1 per cent). Oslo University Hospital (3.9 per cent) and SINTEF (1.8 per cent) have the highest proportions of health authorities and independent research institutes respectively.

Results of innovation

- In 2014, Norwegian enterprises reported innovation investments totaling 59.7 billion NOK. This corresponds to 1.6 per cent of total turnover.
- Nearly 6 per cent of turnover in Norwegian enterprises is believed to come from product innovations. For product-innovative enterprises such innovations correspond to 11 per cent of turnover.

Productivity

- Norway has the highest labour productivity in the OECD, but the productivity growth is far below the OECD average.
- Low growth characterizes many of the countries with the highest labour productivity, while countries with the lowest productivity had the highest growth in recent years.

Patents, trademarks and designs

- In 2014, the Norwegian Patent Office received 1,570 patent applications, a decrease of 10 per cent from the year before. The number of national patent applications from domestic applicants has remained stable in recent years.
- Trademark registrations have had a solid increase in the last 20 years. 4,050 applications were delivered from Norwegian players in Norway in 2014, while foreign players accounted for 11,500 applications. Norwegian actors seek trademark protection abroad to a small degree compared with other countries.
- There has been a slight increase in the number of design applications in recent years. In 2014, there were 1,200 applications to the Patent Office, of which Norwegian applications accounted for a quarter.

Norway spends annually more than 50 billion NOK on research and experimental development (R&D), with almost 70,000 persons estimated as involved in R&D. The resources spent on innovation activity are even higher. The Norwegian innovation survey estimates that Norwegian enterprises spend approximately 60 billion NOK on innovation. Resources for innovation in other sectors, so far not covered by the statistics, come in addition to this.

With so many resources involved, it is interesting and timely to study what this effort produces. Both in Norway and internationally there is now increasing interest in measuring and recording the results and impacts of research. In many countries, this has also given concrete results in the form of public research funding distributed more by results than by inputs. In Norway, performance-based components in basic funding were introduced over the last 10–15 years at universities, colleges, research institutes, and health trusts.

From measuring results to effects

R&D statistics and indicators have traditionally been oriented towards the cost side, with the measurement of publications, citations, and patents on the results page. Currently the United Kingdom leads the way in efforts to develop and apply indicators, by establishing a national system for systematic measurement of social impact of research (limited to higher education). The methodological challenges are significant (see Bugge, 2015).

So far, Norway has had an indicator-based system to provide incentives for results, though, as elsewhere new approaches are being discussed. Among other things, the Ministry of Health and Care Services took the initiative to develop a national «Health Monitor» to systematize all kinds of indicators for health-related R&D and innovation. Here, all R&D and innovation within the health care sector is followed from money flow into research through to its impact on society.

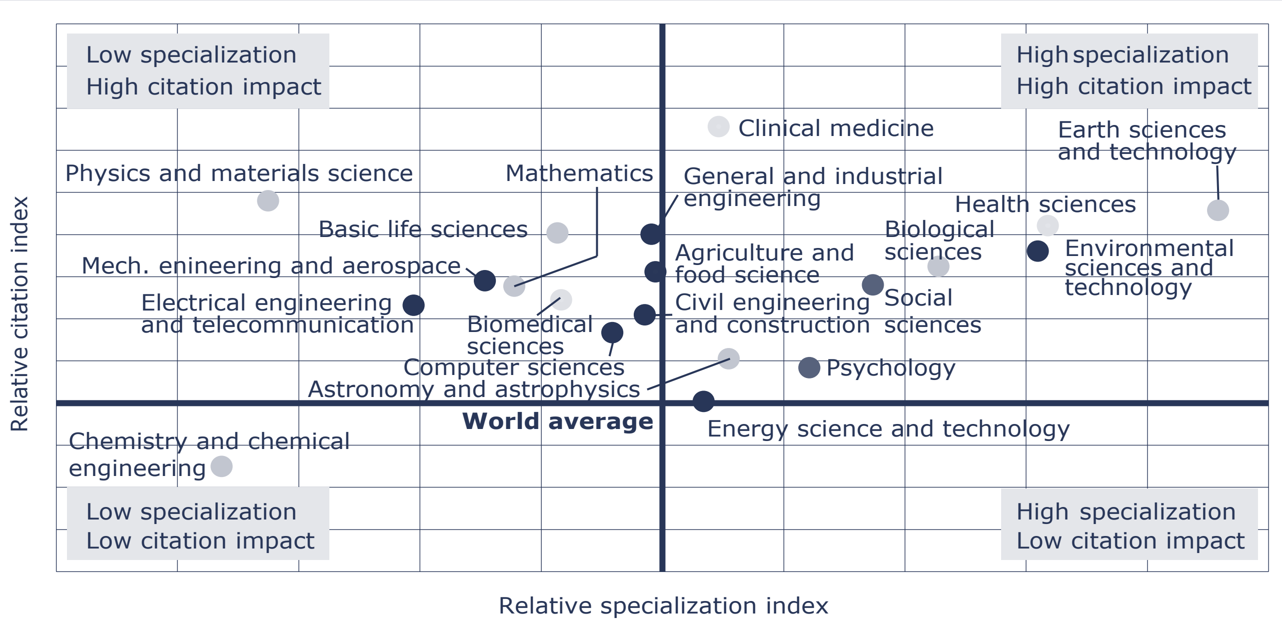
Indicators complement each other

A nuanced picture of the results and effects of this field requires a wide range of indicators. In this chapter, we look first at publications and citations, which are widely used indicators of results and impacts of research. Moreover, we show figures for Norwegian participation in the European Research Council (ERC), which constitutes an important competitive arena for basic research.

Measuring effects is especially interesting for the industrial sector. Therefore, this chapter presents and discusses indicators for results of innovation and industrial property rights (patents, trademarks and designs).

Finally, we discuss different issues related to measuring productivity in research and innovation. These include the research and innovation contribution both to society's productivity and to productivity in the R&D and innovation system. We show that there are major preconditions related to connecting inputs and results directly in this area.

Figure 4.1
Discipline profile in Norwegian research - relative specialization index and citation index: 2010–2013.



Source: Data: Thomson Reuters/CWTS Web of Science. Calculations: NIFU.

Norway's level of publication activity and citation rate varies considerably by discipline. In this section, we provide an analysis of the discipline profile, based on statistics on publication and citation from 2010 to 2013. The analysis includes selected disciplines; technology, medicine and social sciences, which together represent more than 95 per cent of the total publishing in over 45,000 scientific journals. The categorization of disciplines is based on a classification made by CWTS at the University of Leiden based on the scientific affiliation of the journal publishing the article. In interpreting the results, it is important to be aware that the selected disciplines vary widely in size.

Two types of indicators have been calculated. First, a specialization index, which is an indicator of whether a country has a higher or lower percentage of publications in a specific field of study in relation to the average for all countries. Second, we have calculated the relative citation frequency in various fields (citation index). This indicator measures whether a country's publications in a specific discipline are cited more or less than the world average in that discipline.

Strong specialization in geosciences

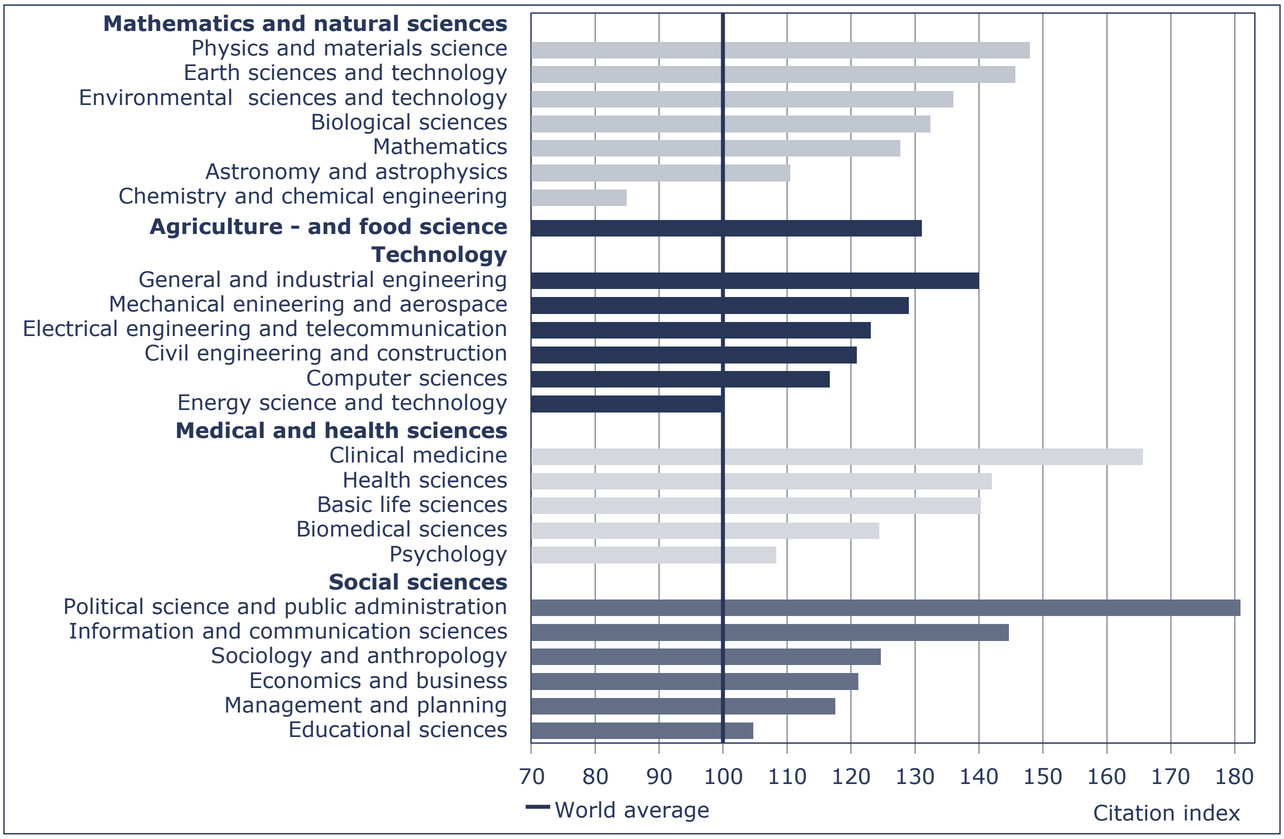
As we can see from Figure 4.1, a strong specialization in a particular field does not necessarily imply a high citation frequency in the field, and vice versa. The specialization index shows that Norway has an academic profile that differs widely from the average, but this is a common feature of all small countries.

Generally, Norwegian research activity is relatively high within biology, earth sciences and social sciences, and relatively low within physics, chemistry and some technological disciplines. The specialization pattern has its roots in historical traditions.

We find the strongest specialization in earth sciences and technology. A sharp increase in the earth sciences´ share of the Norwegian articles is the most significant change in Norwegian academic profile since the beginning of the 1970s. This is clearly due to Norway's emergence as an oil nation. Among other disciplines within natural sciences and technology, we find a strong specialization in environmental sciences and technology and biology. Norway has very few publications in chemistry and chemical engineering and physics and material sciences, and moderately negative specialization in electrical engineering and telecommunications as well as in mechanical engineering and aerospace. Norwegian academic profile is in line with the world average in many disciplines, including agriculture and food science, astronomy and astrophysics, and other technology subjects.

Within medicine and social sciences, there are also big variations; but a positive specialization in most of the disciplines. The exception is biomedical sciences and basic life sciences. Norway has a strong positive specialization in health (including nursing science and public health medicine), and there is a positive specialization value for psychology. Regarding clinical medicine, the largest field in terms of publishing volume, Norway is in line with the world average.

Figure 4.2
Relative citation index for Norwegian publications by discipline:[1] 2010–2013.



[1] Relative citation index for articles published 2010–2013, world average for all articles in the discipline = 100.
Source: Data: Thomson Reuters/CWTS Web of Science. Calculations: NIFU.

Norwegian clinical medicine highly cited

Figure 4.1 showed that the relative citation index is below the world average in only one of the fields: chemistry and chemical technology. Figure 4.2 also shows a citation index for different subdisciplines. Norway had a citation index of 138 in 2010-2013. This represents an average for all disciplines. At a discipline level, citation index varies greatly.

Within the natural sciences, the highest citation index for Norway is found in physics and materials science, and earth science and technology; cited respectively 48 and 46 per cent above the international average in the fields of science. As mentioned, earth science is the discipline where Norwegian research has strongest degree of specialization. Environmental sciences and technology also have relatively high citation indexes (136). Norwegian publications in chemistry and chemical technology are, however, little cited; the index value of 85 is below the international average and significantly below the Norwegian average for all disciplines.

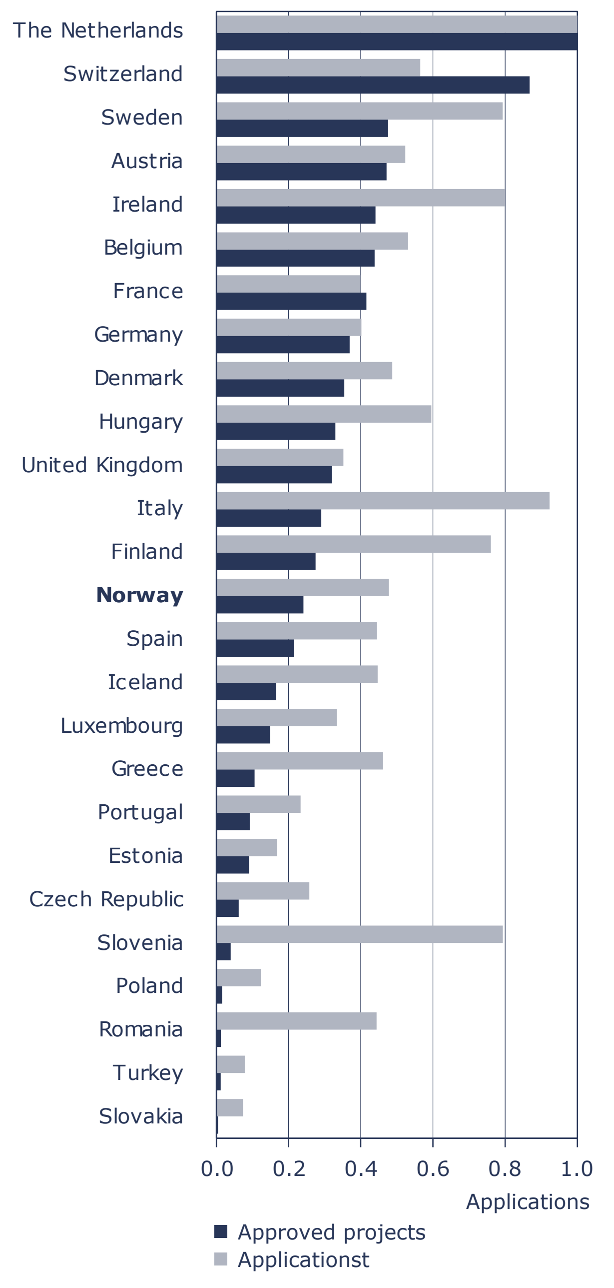
In technology, we also find a complex picture. General and industrial engineering (index 140) has the top citation index. Energy and technology has the lowest citation index of 100, on a par with the world average, but significantly below average for Norwegian research in total.

Within medical and health sciences, clinical medicine has the highest citation index: 166. Clinical medicine is also by far the largest discipline measured in publishing volume, and therefore contributes much to raise the Norwegian total citation index. Norwegian biomedical science is less frequently cited, and its citation index of 124 is below the national average for all subjects. Psychology has the lowest citation frequency (108).

In social sciences, the citation index is particularly high in political science and public administration (180), followed by information and communication sciences (145). The other subdisciplines have index values under the overall Norwegian average. The lowest citation frequency is found in educational sciences (105). However, only a relatively small portion of the publications within social sciences is indexed in the database.

Citation frequencies in underlying fields vary considerably. They are particularly high in emergency medicine, rheumatology, design and building technology, meteorology and atmospheric research, political science, and paleontology (indexes over 180).

Figure 4.3
Applications and approved projects to the ERC (adjusted for R&D FTE[1] in the higher education sector standardized according to the Netherlands): 2007–2014.



[1] R&D FTEs are measured as an average for the period 2007–2013.

Source: ERC and OECD MSTI 2015: 1. Data processed by NIFU.

The European Research Council (ERC) accounts for €13.1 billion, or 17 per cent of the Horizon 2020 budget (an increase of two percentage points compared with the proportion in the Seventh Framework Programme). ERC funding is distributed according to scientific quality, regardless of gender, age, nationality or institutional affiliation. The ERC offers promising researchers and research groups generous, long-term funding and includes relatively recent graduate doctors (starting grant, 2–7 years after completed degree), more established researchers (consolidator grant, 7–12 years after completed degree, new in 2013) and excellent established researchers (advanced grants). The ERC also supports innovation potential for formerly ERC-funded projects (proof of concept grant), and small groups of excellent scientists (synergy grant). Unlike other parts of the EU Framework Programme ERC funds target individual researchers and research groups. The approval of an ERC application may therefore be an indicator of how well a country's individual researchers are doing in competition with the best scientists in the rest of Europe.

Universities gain by far the most ERC Grants

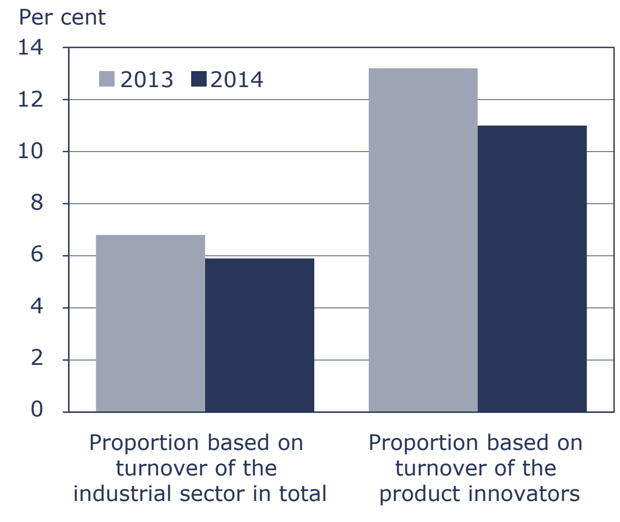
It is mainly institutions in the higher education sector that seek support from the ERC in Norway. In the period 2007–2014, the following Norwegian institutions were granted ERC funds: University of Oslo (22 scholarships), University of Bergen (9), NTNU (8) and University of Tromsø (3). Other grant recipients were: Norwegian University of Life Sciences, The National Institute for Consumer Research (SIFO), The Peace Research Institute Oslo (PRIO), Norwegian Institute for Water Research (NIVA), Uni Research AS and the Norwegian Institute of Public Health.

Norway on an average level in Europe

When we take into account a country's number of researchers in universities and colleges, Norway fits roughly «in the middle» in Europe when it comes to seeking and receiving ERC support. Figure 4.3 shows applications and approved applications from ERC corrected for the number of researchers in each country. The levels are standardized in relation to the Netherlands (set to 1.00), which is the country with the most applications and most approved projects per scientific positions.

Related to the levels of FTEs performed by researchers, the number of Norwegian applications is about half (0.48) of the number from the Netherlands, but looking at approved applications, the Norwegian level is at a quarter (0.24) of applications compared with the Netherlands. Such a tendency is visible for most countries. Norway ranks behind Sweden and Denmark both for the number of applications and number of approved applications per researcher FTEs. Norway is slightly behind Finland when it comes to granted applications, but the number of applications is much lower.

Figure 4.4
Proportion of the enterprises' turnover derived from product innovations. All enterprises and PP innovation active enterprises: 2013 and 2014.



Source: Statistics Norway, Innovation Survey.

Innovation activity is believed to be of great importance for companies' capacity for growth, development and restructuring. However, innovation is also associated with costs and risks. In the following, we look first at Norwegian enterprises' investment in innovation, before looking at the figures for the part of their turnover believed to come from innovative products.

Just over half of innovation investment is R&D

In the Norwegian innovation survey for 2014, enterprises reported innovation investments of 59.7 billion NOK. This accounted for 2.4 per cent of the PP innovating enterprises' total revenue, and 1.6 per cent of the turnover of all enterprises.

The largest part of innovation investments is related to research and development. Total intramural or purchased R&D was 56.5 per cent of the total innovation investments in 2014. Then follow expenses for the purchase of machinery, equipment and software, which accounted for about 25 per cent of innovation costs.

Considerable variation in innovation costs in the industrial sector

Measured in absolute figures, the service sector invested almost twice as much in innovation as did manufacturing industry, respectively around 33 and around 17 billion NOK. Other industries invested a little more than 9 billion NOK. As a percentage of revenue however, innovation investments were of equal size in manufacturing as among service providers, both with 3.2 per cent. For other industries, the proportion was smaller, with 1 per cent of turnover. The latter industry group includes *production of oil and gas*. The high turnover here reduces the overall innovation investment as a share of turnover in the Norwegian industrial sector.

Among the industries of a certain size, *services connected to information technology* are singled out as an industry with high investments in innovation: almost 5 billion NOK and 7 per cent of the industry's turnover. The four industries with the highest turnover are at the other end of the scale, namely *mining and quarrying, wholesale trade, financial and insurance activities*, as well as *construction*. In these industries, innovation investments constitute between 0.4 and 0.8 per cent of turnover. In absolute numbers, this may still be substantial.

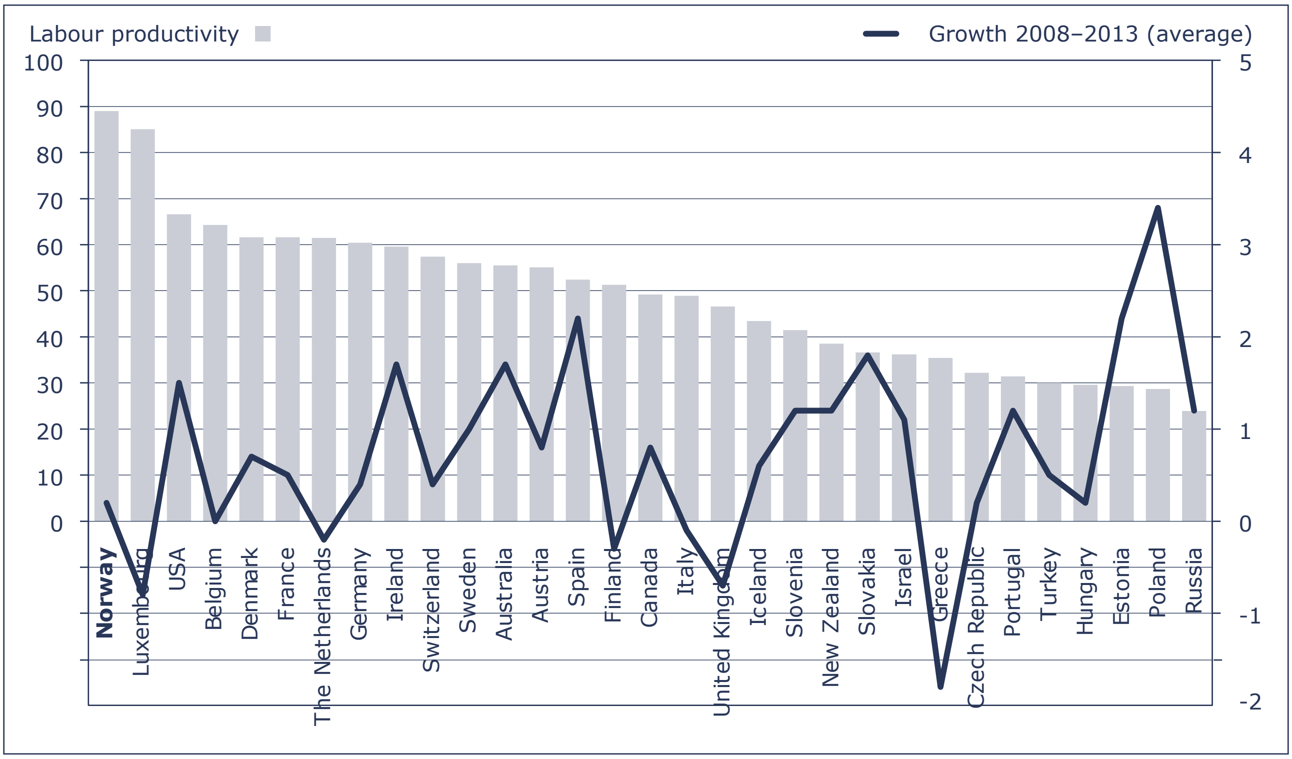
Reduced turnover from product innovations

Now that we have a picture of how much the industrial sector invests in innovation, it is also interesting to know what firms received in return for these innovation investments. Process innovations could lead to reduced costs, increased efficiency and other incremental benefits. However, such gains are difficult to measure.

The only indicator in the innovation survey that directly looks at the results of innovation is the proportion of turnover originating from product innovations. This includes both products that were new to the enterprise market and those that were only new to the firm. These shares are then related to the turnover of the industrial sector in total, in order to say something about the importance of innovation for the economy. To examine the importance of these innovations for the product innovators, the shares are related to the turnover of the innovative enterprises.

In 2014, enterprises report that products new to enterprises' markets accounted for a turnover value of just over 120 billion NOK, while products new to the company amounted to 90 billion NOK. That means nearly 6 per cent of turnover in Norwegian enterprises is believed to originate from the product innovations of the last three years. Among the enterprises with product innovation, innovations account for 11 per cent of turnover. Compared with the previous survey in 2013, there is a certain decline in all industries, but the differences are not particularly large. At a more detailed level, however, there is considerable variation in the numbers - both in terms of size groups and specific industry.

Figure 4.5
Labour productivity in selected countries (2014) and productivity growth: 2008–2013.



Source: OECD - STI Scoreboard 2014. Adapted by NIFU.

Productivity growth is often used as an indicator for the results of R&D and innovation. The causal mechanism between R&D and innovation and productivity is difficult to detect. A number of studies have indeed shown that there is a correlation between productivity and investment in education, research and innovation, but there are several conditions related to productivity growth as an indicator.

High productivity - low productivity growth

Labour productivity is the most common measure of productivity, because it is relatively easy to measure and explain. It measures production compared only with work effort. It may also give a misleading picture, since the indicator does not take into account that factors other than labour affect production. In Figure 4.5 we see that Norway has the highest labour productivity in the OECD, but also that the Norwegian productivity growth has been much lower than most other comparable countries. A growth of 0.2 per cent in the years 2008–2013 is well below the OECD average of 0.8 per cent.

The Productivity Commission (NOU 2015:1 Produktivitet – grunnlag for vekst og velferd) was appointed by the Government in 2014 to find reasons for the slower productivity growth in Norway in recent years compared with the growth in the 1990s and until the middle of last decade. The Commission's report attaches importance to education, research and innovation (separately - and seen in context) and emphasizes their role as catalysts for productivity.

Difficult to measure productivity in research

The Productivity Commission shows that a country's productivity is affected by factors related back to basic education. However, it is very difficult to prove causal relationships between the quality of basic education, higher education and R&D efforts in the industrial sector and productivity at the national level. Nor is this the scope here. Rather, we will look at productivity within one of the sectors - the higher education sector. In this context, there will also be discussions about the numbers and variables to be included in a productivity analysis, but it is common internationally to measure research productivity as a function of researcher FTEs and scientific publishing. Thus, the analysis in the next section follows established practice, though such analyses encounter some methodological problems.

In S&T reports, there are separate analyses of inputs and outputs in terms of scientific publications. Traditionally, these indicators have been developed and analysed separately. However, there is growing interest in combining these types of indicators, for example in order to assess the productivity of the research system, and to what extent research efforts result in scientific publications. The reasons why these composite indicators are rarely used are in particular linked to some relatively significant methodological challenges involved.

However, there are some Norwegian examples of this type of indicator being calculated. These include the reports of the Productivity Commission (NOU 2015:1) and the Fagerberg Committee (NOU 2011: 6). Norwegian Social Science Data Services (NSD) calculate the number of publication points per academic position, an indicator included among others in the annual status report for the higher education institutions published by The Ministry of Education and Research.

Productivity can be calculated in relation to the various input variables such as number of people, FTEs, R&D FTEs or costs. In the following, we present a mini study carried out by NIFU, in which the number of publishing points are calculated per R&D FTE and per employee in professional/academic positions for the various types of institutions in the higher education system, as well as for health trusts and research institutes. While the first indicator is based on data from NIFU's R&D statistics, the last is an indicator calculated by NSD. In both instances, the number of publishing points in 2014 is the result indicator. Since there is a delay from the research carried out to the publications available, R&D FTEs for 2013 are used. However, NSD's indicator is based on employment figures for 2014. The difference here has little effect on the aggregate level. Since the system for calculating publication points varies between sectors, publication points for the health trusts and the institutes are calculated according to the system used in the higher education sector.

Who are the most productive depends on the indicator used

Measured per employee in professional positions, the general-oriented universities have the highest publishing productivity with 1.03 publication points per academic position (Figure 4.6), followed by the new universities (0.80) and the state specialized university institutions (0,76). State university colleges have the lowest with 0.46 points. Figures for health trusts and research institutes are not available for this indicator.

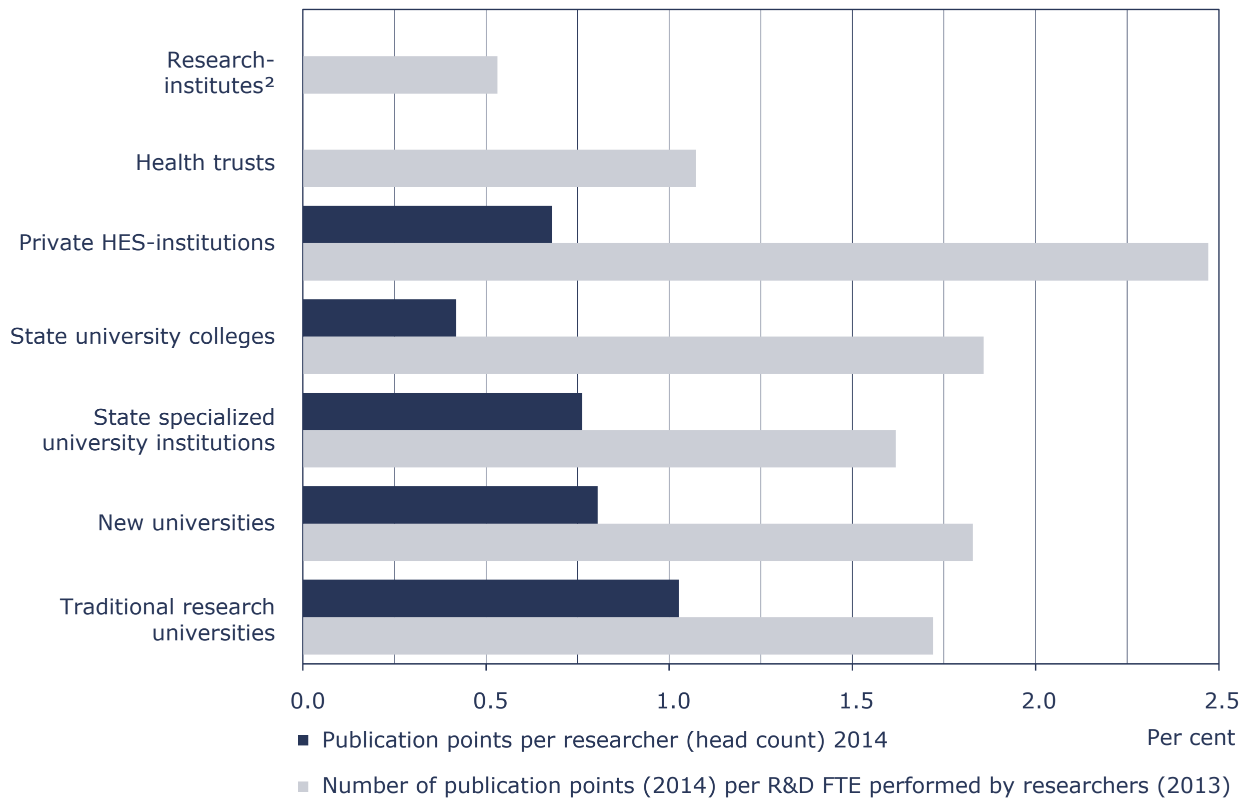
Measured per R&D FTE, however, the picture is different. Using this indicator, the productivity of the state colleges and private institutions is significantly higher than for the first indicator. The private higher education institutions have the highest productivity with 2.47 publication points per R&D FTE performed by academic/scientific staff. General-oriented universities, the new universities and state university colleges score relatively equally on this indicator, respectively 1.76, 1.83 and 1.86 publication points per R&D FTE, followed by the state specialized university institutions with 1.62 points. Lowest productivity has research institutes with 0.53 points per R&D FTE, and health authorities with 1.07. It should be noted that the size of the various types of institutions varies greatly, and private institutions only contribute 3.5 per cent to the total volume of publications.

What factors explain differences in productivity?

The main explanations for the differences between the two indicators are the variations in the composition of different staff categories between institutions, and the research conditions associated with the positions. At institutions that historically had status as a university or specialized university college, the permanent academic staff have research time, which averaged close to 50 per cent of their working hours. At university colleges, teaching positions such as assistant professor dominate, and the scientific and academic staff at the university colleges have on average a significantly lower proportion of research time. Therefore, productivity decreases much for these types of institutions when it is calculated based on the number of academic positions. The financing conditions for the university colleges, which have recently achieved accreditation as a specialized university institution or university, have not changed. Among the four new universities, three are former state colleges.

Observing such large differences in productivity may seem surprising. That research institutes come out with the lowest figures can probably be explained by their carrying out much commissioned research, mainly published as reports, a publication type that does not provide benefits in the form of publishing points. Health trusts have few publication points compared with the research effort. Many people engaged in research at health trusts are employed both at a hospital and at a university, therefore, publication points are often divided between the two institutions. It is also noteworthy that the private institutions have much higher productivity per R&D FTE than the other types of institutions.

Figure 4.6
Number of publication[1] points in 2014 per R&D FTE and per employee in professional/academic positions per type of institution in 2013.



[1] Includes total scientific publications (scientific monographs/books, scientific articles in journals, serials and anthologies). Health trusts and research institutes publishing points are recalculated by the system used in the higher education sector classification based on the institutions' accreditation in 2014.

[2] Includes departments in the institute that report figures to the Research Council of Norway.

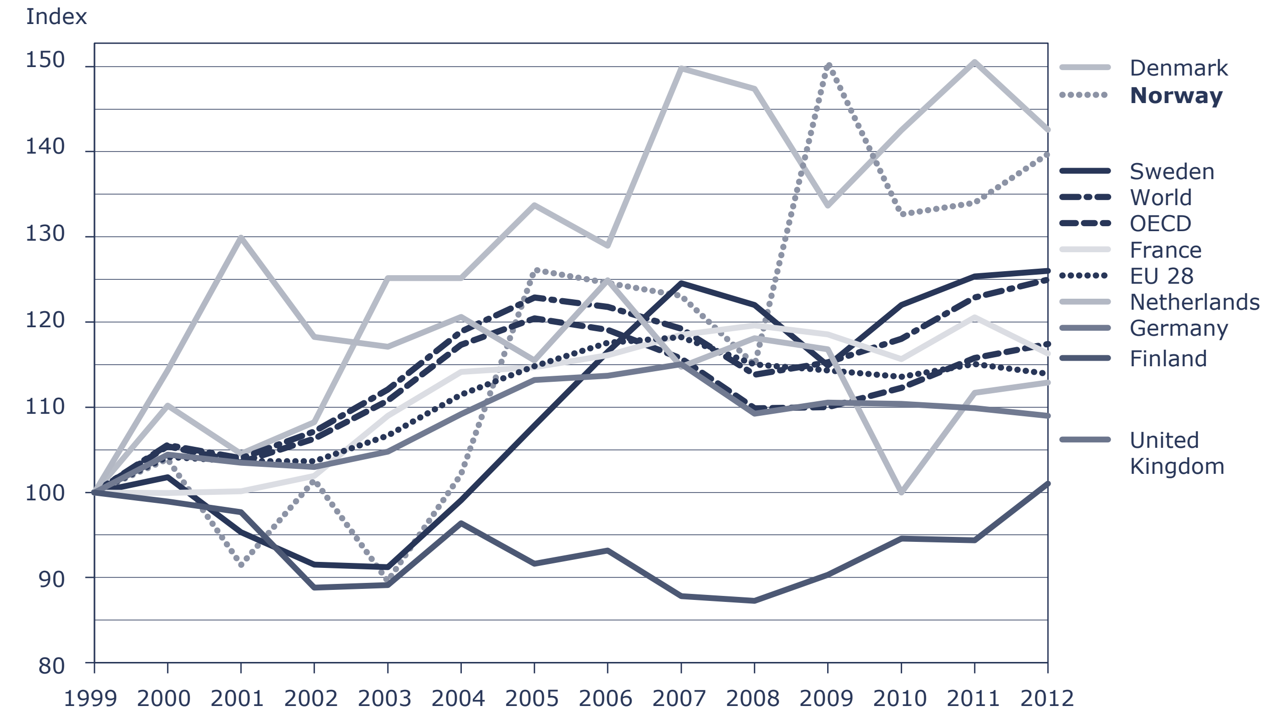
Source: Publication points per R&D FTE: NIFU. Publication points per academic employee: NSD.

In the interpretation of the indicators, there are several methodological considerations:

- Differences in employment composition. The calculation of R&D FTEs includes, for example, a PhD student with an average R&D share of ca. 80 per cent, while a professor only has about 37 per cent on average (all institutions and disciplines). However, a PhD student publishes considerably fewer publications per year than a professor does. Institutions with many PhD students therefore have many R&D FTEs, but relatively few publishing points. For example, the state colleges have relatively few PhD students compared with universities.
- Differences in academic profile. The evaluation of the publishing indicator has further shown that it is not discipline neutral, but favours humanities and social sciences where the extent of co-authorship is relatively low. Institutions with greater focus on these areas will therefore have a comparative advantage, and types of institutions with high productivity have a greater proportion of these disciplines.
- Concerns regarding the calculation of R&D FTEs is based on the time spent for research staff at the different types of institutions. The investigations were conducted about 10 years apart, and it has been shown that R&D units are stable over time. With the increasing research activity at universities and the new universities, there may be a need for conducting time use surveys more frequently.
- Differences in research type. An institution with a high proportion of basic research will have a greater propensity to publish than an institution with a high proportion of more applied research.

It is therefore difficult to conclude about how many of the differences can be attributed to methodological conditions and how many reflect real differences in productivity.

Figure 4.7
Propensity to patent: Number of patent aplications[1] for a selection of OECD countries: (100= number of applications in 1999): 1999–2012.



[1] Applies for applications (EP-A) handed in to the European Patent Organization (EPO). Country affiliation is based on inventors´ address; year is based on application year.

Source: OECD: Stat data (2013), Patent applications to the EPO.

In 2012, more than 138,000 patent applications were submitted in Europe, the majority (128,000) stemming from European and other OECD countries. The total number of applications increased by 25 per cent compared with the level in 1999. 2005 represented a peak, and after a few years of decline, the number of applications in 2012 caught up to this level again.

Figure 4.7 shows the development in a range of OECD countries. In 2012, the number of applications from inventors resident in OECD countries was 17 per cent higher than in 1999, while the level for the EU 28 countries was 14 per cent higher.

The development in European patenting through the first decade of the 2000s has been uneven, both comparing over time and across countries. The USA is the dominant country for the European market and accounts for 24 per cent of all applications (2012), but the proportion is declining. Japan is also dominant with a share of 17 per cent. China has experienced the largest growth in the number of patent applications, more than doubling from 2008 to 2012. According to unofficial figures, growth for China continued in 2013 and 2014.

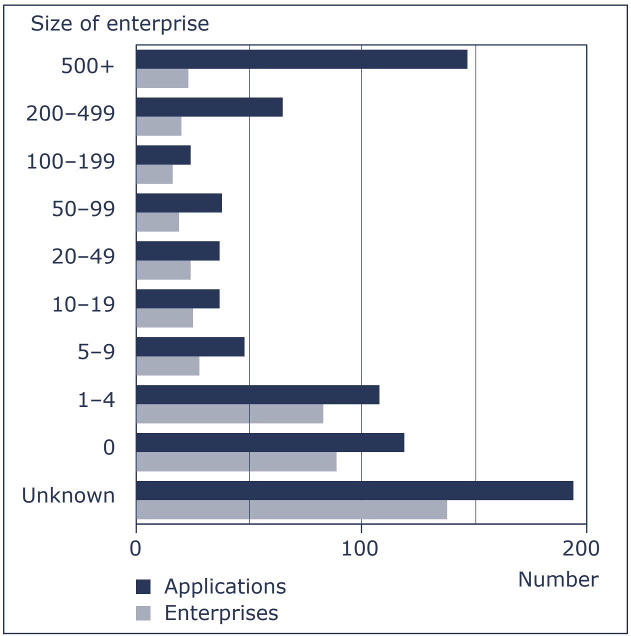
Of the European countries, Germany is very dominant, accounting for 17 per cent of all patent applications. The number of German applications increased by 8 per cent from 1999, while the French growth was 20 per cent. The number of applications from Great Britain fell by 9 per cent from 1999 to 2012.

Norwegian patenting in Europe has evolved more unevenly than in other Nordic countries. The development is primarily characterized by the fact that Norway became a full member of the European Patent Organization (EPO) on 1 January 2008. The level increased markedly after this, before the financial crisis led to a reduction. The number of Norwegian applications in 2012 was 40 per cent higher than in 1999.

National: Stable number of Norwegian patent applications

The number of national patent applications from Norwegian applicants has remained stable since Norway joined the European Patent Office (EPO) in 2008. In 2014, the Norwegian Patent Office received 1,570 patent applications. This is 10 per cent less than the year before, but at the same level as in 2012. The decline in applications from 2013 to 2014 is due to a decline in forwarded international patent applications via the PCT system. The number of Norwegian applicants is more or less at the same level. Around three

Figure 4.8
Number of enterprises and patent applications by firm size: 2014.



Source: The Norwegian Industrial Property Office. Calculations by Statistics Norway.

quarters of the Norwegian applications originate from enterprises. As expected, Norwegian membership of EPO has caused a strong decline in the number of international patent applications forwarded to the Norwegian Patent Office.

Patenting is unevenly distributed in the business enterprise sector, and highly skewed by type of industry. The likelihood of an enterprise applying for a patent is quite high in some industries, while patent activity is totally absent in others. In absolute terms, patenting is clearly highest in *engineering*. Other industries with patent activity are located in both *manufacturing* and *services*.

Patents are mainly applied for by very small enterprises, with fewer than 10 persons employed, or large enterprises, with more than 200 persons employed. Compared with the total number of enterprises, there is a higher share of large enterprises applying for patents. Figure 4.8 also shows that the number of applications per large enterprise is higher than for small enterprises on average. Enterprises lacking information about the number of persons employed are normally small enterprises.

About intellectual property rights (IPR)

Intellectual property rights are often used as an indicator for creativity and as an output indicator for R&D and innovation, in particular for patents. However, there are a number of reservations about using such rights as output indicators in this field.

Patents
A patent protects a practical solution to a technical problem. Patents are granted for inventions. The invention must represent a practical solution to a problem where the solution has a technical nature, technical effect and is reproducible. An idea or business concept cannot be patented without explaining or showing how it can be implemented in practice. Processes, products, systems and applications can be patented, such as blood analysis, computer technology and zips.

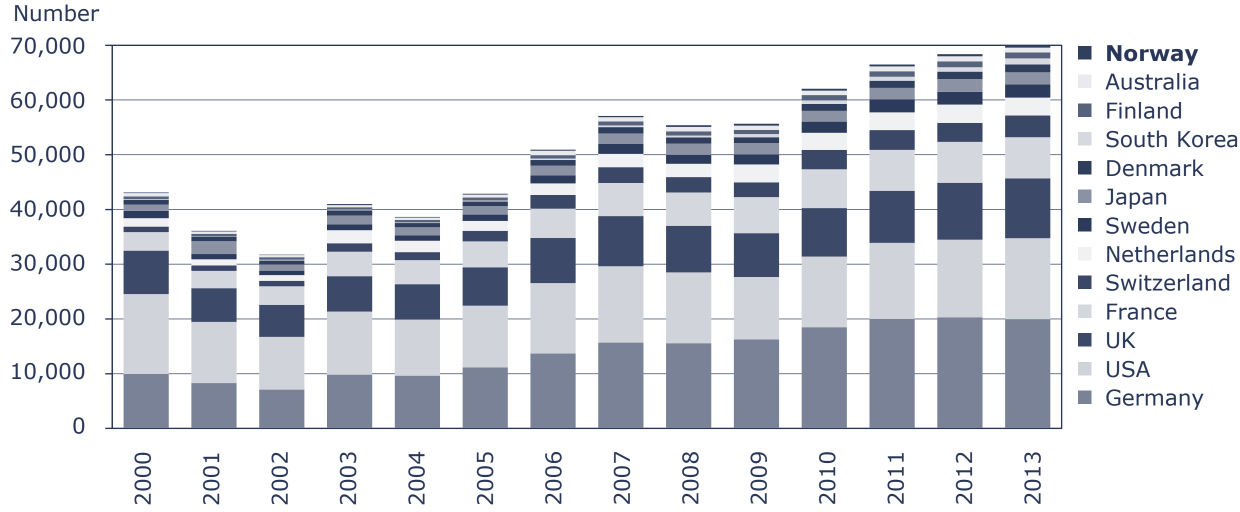
Trademarks
A trademark is a distinctive characteristic of a product and/or service. A trademark can consist of all kinds of characteristics, and must be capable of being represented graphically. A trademark may for example consist of words and combinations of words (e.g. slogans), names, logos, characters and images, letters, numbers, packaging, sound and motion, or combinations thereof.

Design
Design refers to the appearance and shape of a product or a part of a product.

The following can be protected by design:

- The shape and appearance of a product, such as the design of a toothbrush, car, ship, phone or a piece of furniture.
- Parts of the product, such as a toothbrush head, chair legs, phone keyboard.
- Appearance on non-physical objects such as layouts for the web, mobile design, typographic fonts and graphic symbols. Computer programs are not eligible for design protection.
- An ornament, such as the decor of crockery or figures on textiles and wallpaper.
- An interior arrangement, such as a café or shop interior.

Figure 4.9
International trademark applications in Europe (OHIM) by applicant nationality: 2000–2013.



Source: WIPO statistics database, 2015. Applications registered with OHIM «Office for Harmonization in the Internal Market», direct or via the 'Madrid system'.

For more than 20 years, there has been a solid growth in trademark registration worldwide. In line with international trade, the development has generally pointed upward, except for periods with financial crises. According to the World Intellectual Property Organization (WIPO), the number of trademark applications increased by 67 per cent worldwide, from 4.7 million in 2004 to over 7 million in 2013. This trend is clear when we look at trademark registrations applied (or forwarded) to European countries. Demand for European brands through the European trademark office (OHIM) totaled 114,000 applications in 2013, increased by 5 per cent from the year before.

Figure 4.9 shows the development in international trademark applications from 2000 to 2013. The trend is upward in spite of a significant decline in the aftermath of 2000 (also of 2008, but to a lesser extent). Half of European applications (57,200) stemmed in 2013 from five countries (Germany, UK, France, Switzerland, and the USA). Among countries with the strongest growth in the decade 2004–2013, we find South Korea, Switzerland, Finland, and Norway. The number of Norwegian trademark applications that find their way to Europe has more than doubled in the past decade. Norwegian actors sought 380 European trademarks in 2013, compared with 180 in 2003.

Domestic market most important for Norwegian trademark applicants

Norwegian actors apply for trademark protection primarily in Norway. This orientation towards the domestic market is far stronger than in surrounding markets abroad. Trademark applications from actors in the other Nordic countries are far more international. Trademarks applied (or forwarded) of Norwegian actors with OHIM in 2013 represented about 11 per cent of the applications submitted in Norway the same year, according to WIPO figures. Corresponding figures for Sweden (and Finland) were about 30 per cent, and 50 per cent for Denmark.

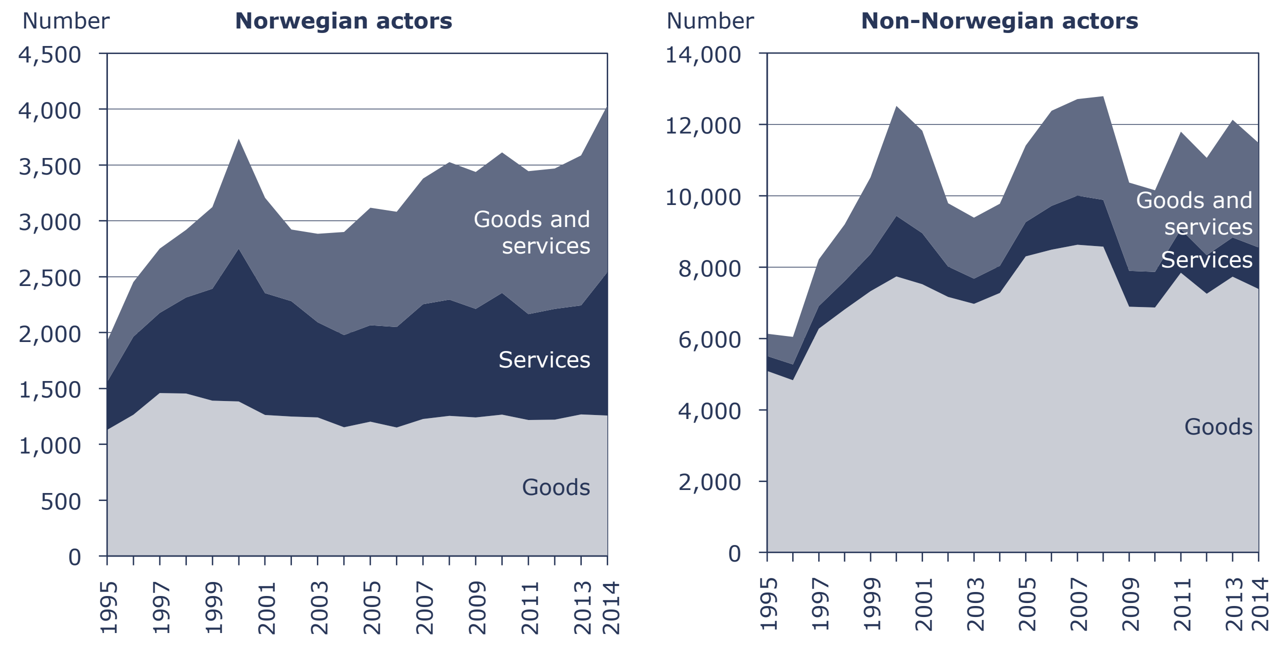
Several factors may explain the strong orientation of Norwegian trademark applications to the Norwegian market. The most important explanation seems to be Norwegian business demographics. International trademark registrations are closely linked to marketing across borders.

That is especially true in industries which are directly exposed to the consumer market, such as retailing, foodstuffs and electronics. Brands and marketing are less important for industries such as oil production or salmon farming. In short, there are fewer large Norwegian undertakings active in the European consumer markets compared with neighboring countries.

Increased trademark protection of services

Traditionally, goods have been protected by trademarks. However, a large part of the growth in trademarks in the last 20 years is due to services, in particular when combined with goods. The development in Norway shows that applications relating to goods alone have largely been stable over the past 20 years, while the increase in 2000 was particularly driven by service-oriented brands. A considerable part of the

Figure 4.10
Trademarks applied for in Norway by Norwegian (left) and Non-Norwegian (right) actors: Applications by type of class[1] (normal count): 1995–2014.



[1] Number of NICE classes for goods, services and their combination respectively (fraction count).
Source: NIFU based on raw data from the Norwegian Industrial Property Office (February 2015)

growth in recent years has been in the field of trademarks combining goods and services.

Foreign applications, in contrast to Norwegian ones, mainly related to goods - and then primarily to goods alone. Trademark protection related to services alone accounted for only 10 per cent of the foreign applications in 2014, but 32 per cent among the Norwegian ones.

The number of trademark applications in Norway in 2014 was 15,540. Norwegian actors had 4,050 applications (or 26 per cent), while foreign actors accounted for 11,490. Thus, most applications stem from characteristics originally sought abroad. This 'small country effect' is well known, not least from patent statistics.

The structure of industries applying for patents and trademarks (and design) respectively is different. However, there is a tendency for trademarks and designs to overlap. Both types of protection are most common in wholesale trade, but are also popular in retail trade. In addition, trademark protections are often applied for in other professional, scientific and technical activities. The *manufacture of food products* has a large number of trademark applications; the same is true for *computer programming and consultancy.*

Large enterprises are less dominating in applications for trademarks than for patents. The number of trademark applications per large enterprise is smaller than for patent applications. The share of trademark applications submitted by very large enterprises is 13 per cent, with 26 per cent for patent applications.

Design

The number of applications for design was 1,218 in 2014, and is thus lower than the number of patent applications. Predominantly, this applies to applications from Norwegian entities. Overall, there has been a slight increase in the number of design applications in recent years, but applications from international actors constitute a significantly higher share than is the case for patents.

The structure of industries applying for design (and trademarks) is different from patents. Design protections are most common in wholesale trade, but are also popular in retail trade. Design protection is also applied in technical services and other industries.

Large enterprises are less dominating in applications for design (and trademarks) than for patents. The number of design applications per large enterprise is considerably smaller than for patent applications. The share of design applications submitted by very large enterprises is only 5 per cent.

5 Regional comparisons of R&D and innovation

Chapter 5

Hebe Gunnes, Tore Sandven, Olav R. Spilling

Strong concentration of R&D activity

- The four largest counties measured by R&D expenditure are Oslo, Rogaland, Akershus and Hordaland. Together they account for over 70 per cent of total R&D in Norway in 2013.
- Sør-Trøndelag had the highest R&D activity measured in NOK per capita, followed by Oslo, Troms, Akershus and Hordaland.
- The industrial sector is the largest sector for R&D activity in 13 counties. The highest proportions of R&D full-time equivalents (FTEs) in the industrial sector we find in Buskerud, Vestfold, Telemark and Møre og Romsdal.
- The higher education sector is the largest sector for R&D activity in six counties. By far the highest proportion of R&D FTE we find in Troms, while there are also high proportions in Finnmark and Hordaland.

Industrial sector R&D

- R&D activity in the industrial sector largely follows the industrial structure, but Sør-Trøndelag especially has a significantly higher R&D activity in the industrial sector than the industrial structure would imply.
- Also Akershus, Buskerud and Oslo have higher R&D activity in the industrial sector than their industrial structure would imply.

Regional distribution of instruments

- Allocations from the Research Council largely follow the same distribution as the total R&D activity with the largest allocations to Oslo, Rogaland, Akershus and Hordaland.
- SkatteFUNN funds (tax deduction) largely follows this pattern, but the relative proportions of Akershus, Buskerud and Oslo are lower than the counties' share of the industrial sector's R&D.
- Funding from Innovation Norway is allocated both by regional policy guidelines and by where the innovative industry is located. Measured by the number of grants Hedmark, Hordaland, Møre og Romsdal and Sør-Trøndelag receive most from Innovation Norway; measured by amount Møre og Romsdal receives the most, and more than twice as much as Sogn og Fjordane which comes closest.
- There are large variations between counties with regard to level of innovation funds allocated from Innovation Norway. Oslo scores highest with regard to the proportion of grants for innovation at national and international level, followed by Akershus and Sør-Trøndelag. Also with regard to the four most innovative instruments (IFU/OFU, environmental technology and nationwide start-up grants), Oslo receives the highest number of grants, followed by Rogaland, while measured in NOK Rogaland scores highest followed by the counties of Agder and Sør-Trøndelag.

The regional perspective on research, innovation and economic development is important. All industrialized countries are characterized by strong regional differences. A main pattern is that much of the research and innovation activity is concentrated in particular regions, and often some regions appear to be more dynamic than others. As shown in previous editions of this report, the capital region appears as important, in many cases the most important. This also applies to Norway, where the capital region in 2013 accounted for 43 per cent of total R&D expenditure in Norway.

Regional concentration is natural

There are many reasons why R&D and innovation activity is concentrated in certain regions. Industrial structure and localization of universities, research institutes and other knowledge institutions have great significance. Another important point is that knowledge is related to people, and people are connected to places. Where highly educated people find it attractive to live also has great significance for the localization of R&D and innovation. Regional R&D and innovation should therefore be understood in a wider systemic perspective.

Regional innovation systems

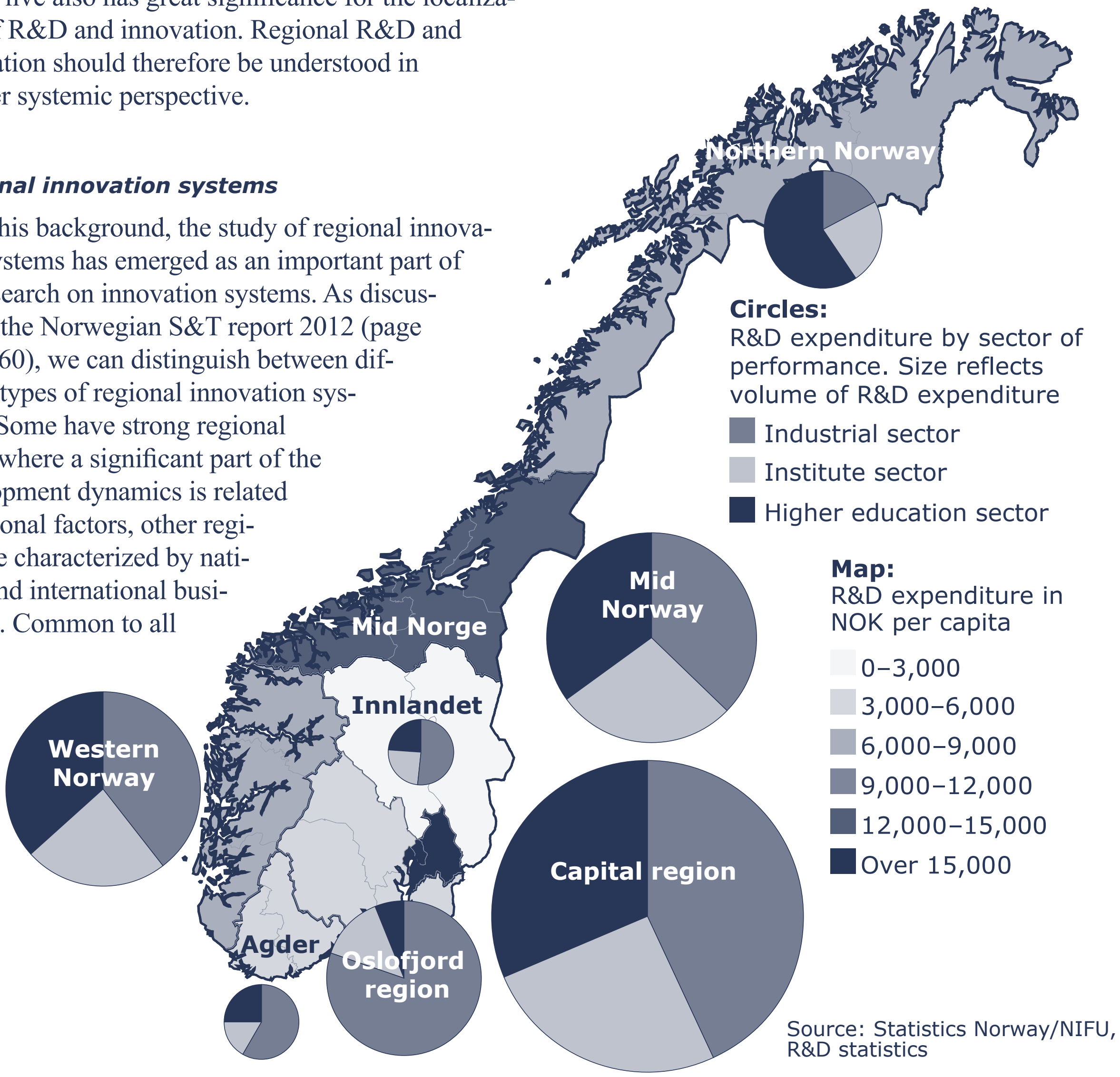
With this background, the study of regional innovation systems has emerged as an important part of the research on innovation systems. As discussed in the Norwegian S&T report 2012 (page 159–160), we can distinguish between different types of regional innovation systems. Some have strong regional roots, where a significant part of the development dynamics is related to regional factors, other regions are characterized by national and international businesses. Common to all regions is an increasing importance of networking and collaboration, both internally between the players in the regions and externally with other stakeholders nationally and internationally.

Focus on county distribution

The purpose of this chapter is to provide greater insight into the regional organization of R&D and innovation in Norway.

Regional distribution of R&D and innovation activities can follow different patterns, by large regions, counties and municipalities. This chapter is primarily based on analyses of the situation in the counties, and the chapter deals with the regional distribution of R&D activity and the regional distribution of various instruments for research and innovation. Also included is an overview of the regional distribution of human resources.

Figure 5.1
R&D expenditure by region: 2013.



Source: Statistics Norway/NIFU, R&D statistics

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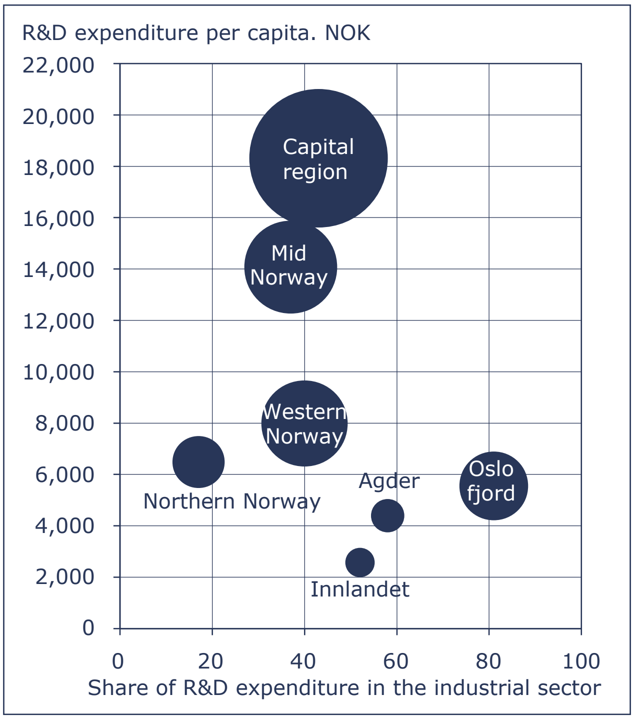
Figure 5.2
R&D expenditure per capita, share of R&D in the industrial sector and total R&D expenditure by research funding region: 2013.



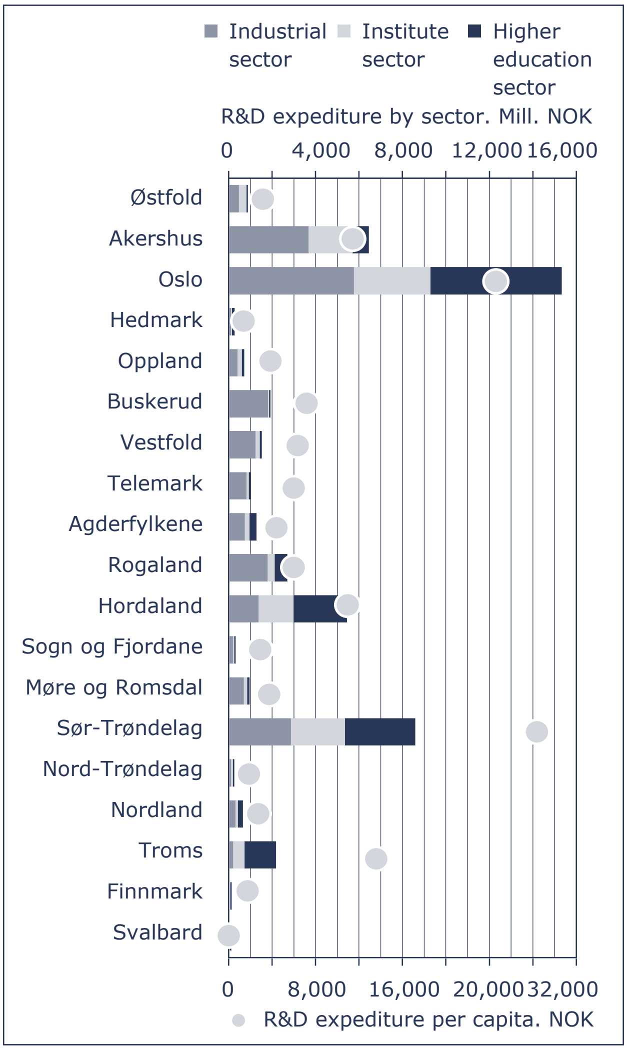
Source: Statistics Norway/NIFU, R&D statistics

The capital region dominates the Norwegian R&D system and in 2013 had the largest share of R&D expenditure at 43 per cent, and the highest R&D expenditure per capita, about 18,000 NOK. The industrial sector was the largest performing sector in the region with 43 per cent of R&D expenditure, while the higher education sector and the institute sector accounted for 31 and 26 per cent respectively.

Mid-Norway had the second highest R&D expenditure per capita at 14,000 NOK. In this region, the three performing sectors were about equal in size with the industrial sector marginally largest, with 37 per cent of total R&D expenditure. Third largest region was Western Norway, both in terms of the proportion of R&D spending (17 per cent) and R&D expenditure per capita (8,000 NOK). Here too, the industrial sector was the largest, followed closely by the higher education sector.

The Oslo fjord region was the fourth largest region in terms of R&D expenditure, while Northern Norway had higher R&D expenditure per capita. 81 per cent of R&D expenditure in the Oslo fjord area was conducted by the industrial sector. In this region, the higher education sector is relatively weakly developed. In Northern Norway, R&D in the industrial sector amounted to scarcely 17 per cent of R&D expenditure. Here the higher education sector dominates with about 60 per cent of R&D expenditure.

Figure 5.3
R&D expenditure by county, sector of performance and per capita: 2013.



Source: Statistics Norway/NIFU, R&D statistics

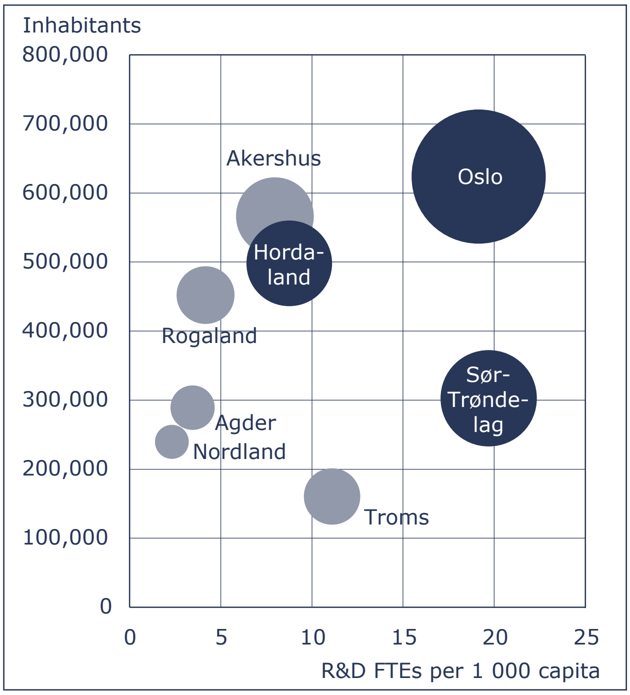
Agder and Innlandet are marginal regions measured in both R&D expenditure per capita and total R&D. The industrial sector is the main R&D performing sector with more than half of total R&D.

Wide variations in the counties' R&D efforts

The four largest counties in Norway measured in R&D expenditure were Oslo, Rogaland, Akershus and Hordaland. Together these counties accounted for over 70 per cent of Norwegian R&D expenditure in 2013. In all these counties, there are universities. Finnmark, Hedmark and Nord-Trøndelag were the least R&D-intensive counties.

Sør-Trøndelag and Oslo was in a unique position when it comes to R&D expenditure per capita, then follow Troms, Akershus and Hordaland. Lowest R&D expenditure per capita is found in Hedmark, followed by Finnmark and Nord-Trøndelag.

Figure 5.4
Number of inhabitants, total R&D full-time equivalents (FTEs) and number of R&D personnel in university counties: 2013.



Source: Statistics Norway/NIFU, R&D statistics

In 2013, about 68,000 people participated in R&D in Norway. They performed 38,600 R&D FTEs. Oslo had the largest proportion of those with over 30 per cent. The second largest county in terms of share of total R&D FTEs was Sør-Trøndelag (15 per cent), followed by Akershus (12 per cent) and Hordaland (11 per cent).

Among the university counties Oslo had the highest number of people employed in R&D in 2013 (20,000). With 20 R&D FTEs per thousand capita Sør-Trøndelag had the highest ratio in 2013, followed closely by Oslo with 19 R&D FTEs per thousand capita. Troms came in third with 11 R&D FTEs per thousand capita, while Hordaland had 9 R&D FTEs per capita. Nordland and Agder counties had the fewest R&D FTEs per capita.

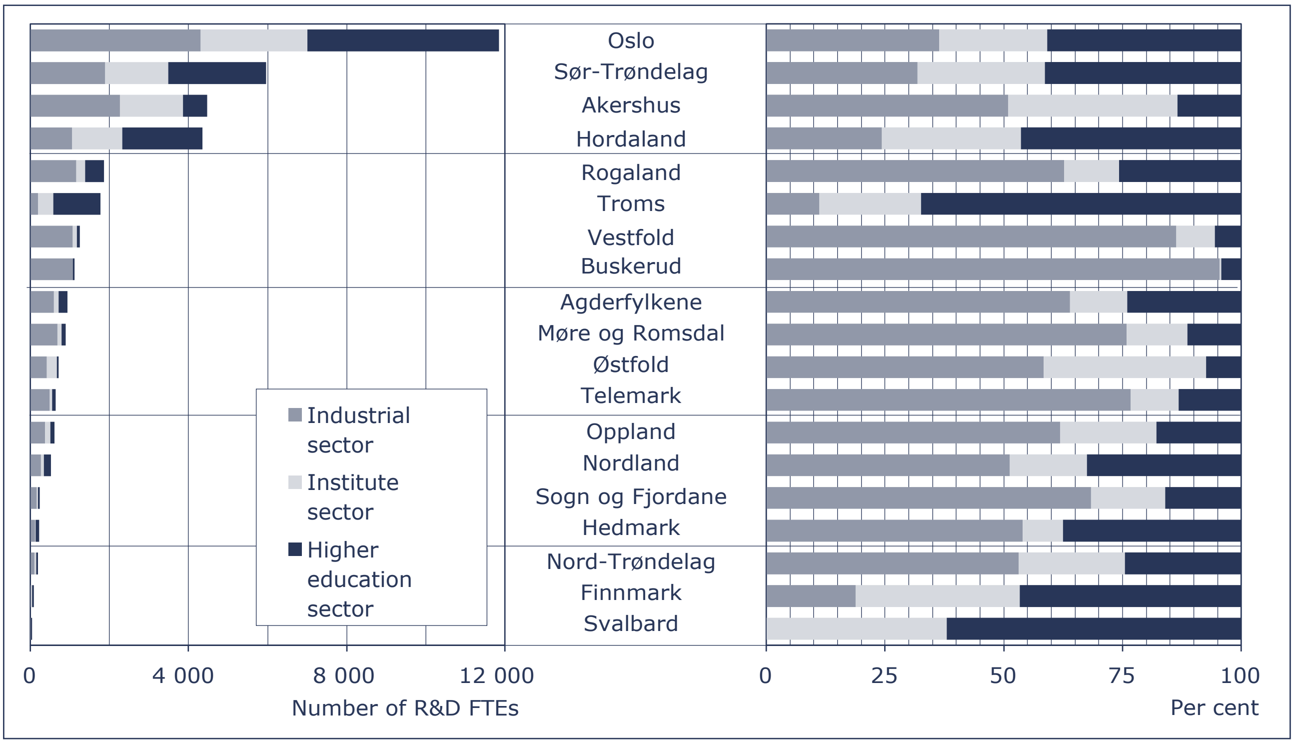
In 2013, most R&D FTEs were performed in Oslo, followed by Sør-Trøndelag, Akershus and Hordaland.

The higher education sector was the largest R&D performing sector in Oslo in 2013; about 40 per cent of R&D FTEs were performed here. The education sector dominated in Troms and was the largest performing sector in Finnmark, Hordaland and Sør-Trøndelag, measured in R&D FTEs.

The industrial sector had the largest share of R&D FTEs in 13 counties. Top R&D/FTE share was in Buskerud (95 per cent), Vestfold (86 per cent), Telemark (77 per cent) and Møre og Romsdal (76 per cent).

The institute sector was not the largest sector for any of the counties. In 2013, this sector was relatively largest in Akershus, Østfold and Finnmark at 36, 35 and 34 per cent of R&D FTEs respectively.

Figure 5.5
R&D full-time equivalents (FTEs) by county and sector of performance: 2013.



Source: Statistics Norway/NIFU, R&D statistics

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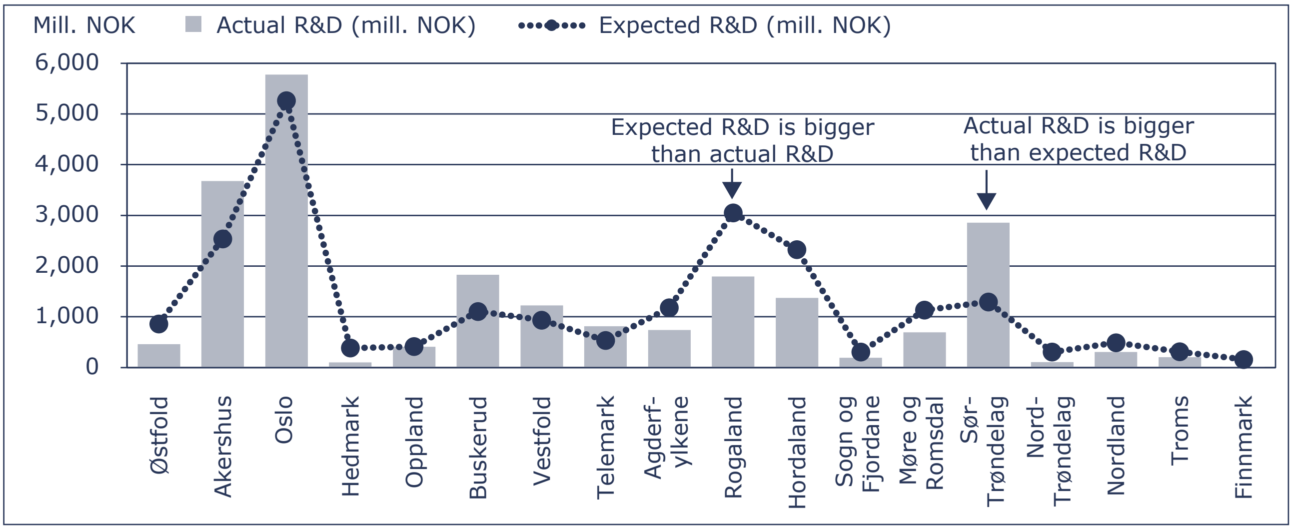
Figure 5.6
Actual R&D expenditure in the industrial sector compared to the expected activity based on the counties' industrial structure: 2013.



Source: Statistics Norway, R&D statistics, calculations at NIFU.

As we have seen, industrial sector R&D activity is very unevenly distributed among the counties. Oslo, Akershus and Sør-Trøndelag have together 54 per cent of this activity, while other counties have very little R&D in this sector.

One explanation for this concentration may be that the R&D activity varies widely across industries, and that the more R&D-intensive industries are concentrated in specific counties. For example, the ICT industry has the highest R&D expenditure, and much of this industry is concentrated in Oslo and Akershus. Similarly, it would appear that other R&D-intensive industries tend to concentrate their activities in certain parts of the country, and that they have localization patterns that are different from the less R&D-intensive business sectors. Another possible explanation could be that the various industries have different localization patterns for R&D activity and the other activity.

To investigate this further, we compared actual R&D activity in the industrial sector with what can be expected from the industry structure in the counties (see fact box) and the results are shown in Figure 5.6. We see a certain correlation between the actual intramural R&D activity and the expected level from the industrial structure. The strong concentration of industrial sector R&D in Oslo correlates with the actual activity of 5.8 billion NOK, only slightly higher (350 million NOK, equivalent to 6 per cent) than the expected R&D level. For three of the counties actually performed R&D is significantly higher than expected: especially in Sør-Trøndelag it is more than twice as large as would be expected from the industry structure, while Buskerud and Akershus show 66 and 45 per cent respectively over expected value. Also in Vestfold and Telemark the actual R&D activity is higher than expected. This concentration of industrial sector R&D activity in some geographical areas has to be taken as an indication that enterprises finds it attractive to locate their R&D activities where there are skilled labour and attractive research environments. For Sør-Trøndelag, it is natural to highlight the the importance of NTNU –Norwegian University of Technology and Science, and SINTEF, the largest research institute in Norway.

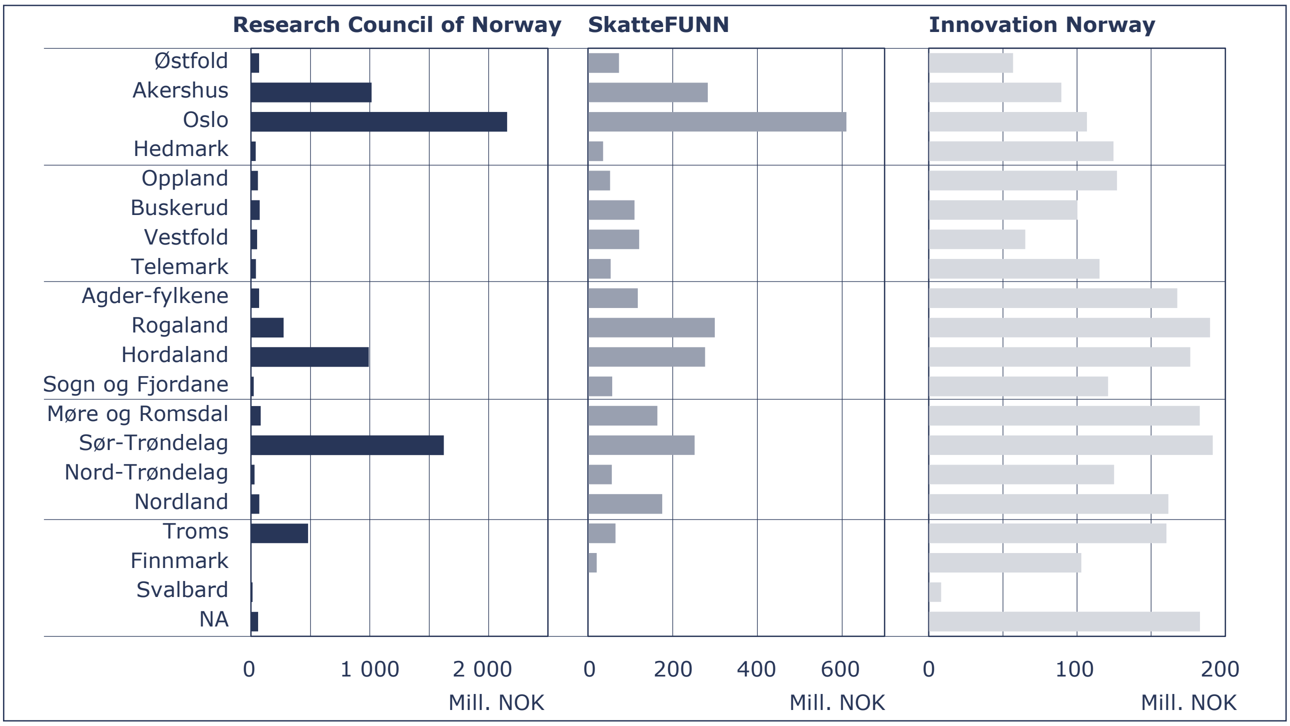
Expected R&D activity from industry structure

Expected R&D are the costs the enterprises would have in a county if R&D activity in the various industries in the county had been on the same level as the national average for the same industries. For individual industries R&D expenditure per employee is calculated, and expected R&D activity in each county is calculated from the county's employment in the relevant industries.

The population is bounded by industry (not all industries are included) and enterprise size (in most industries only enterprises with at least 5 employees, but in *construction* and *transport* a lower limit of 25 employees).

We use information about R&D at the business level, as opposed to the enterprise level. This provides a more detailed picture of where research actually takes place than if using the entity address definition of localization.

Figure 5.7
Funding from the Research Council of Norway, tax deduction (SkatteFUNN) and net grants from Innovation Norway by county: 2014.[1]



[1] Figures include total allocations from the Research Council of Norway, revenue related to SkatteFUNN and net grants from Innovation Norway.

Source: Research Council of Norway/Innovation Norway

In this subsection, we give an overview of the county distribution of the main financial instruments to stimulate research and innovation in Norway. This applies to:

- Allocations for research through the Research Council of Norway in 2014.
- Budgeted tax deduction in SkatteFUNN projects that have been active in 2014.
- Subsidies (net grants) by Innovation Norway in 2014.

In 2014, the Research Council allocated 7.2 billion NOK in grants for research. Through SkatteFUNN over 4,900 projects had planned R&D activity in 2014, with a total budget of 16.6 billion NOK, and a budgeted tax deduction of 2.8 billion NOK. In 2014, Innovation Norway gave loans and grants for over 6,000 projects or 6.6 billion NOK, characterized as gross commitments. Since a significant portion of the amount are loans to be repaid on commercial terms, it operates also with net commitments, which amounted to 2.6 billion in 2014.

Together, the total appropriations for research and innovation through the Research Council, Innovation Norway and SkatteFUNN amounted to 12.6 billion NOK, 1.3 billion NOK higher than in 2013. The increase primarily reflects a strong growth in SkatteFUNN projects where budgeted tax deduction has increased by 30 per cent, or 649 million NOK. The Research Council of Norway also had a significant growth of 12 per cent, which corresponds to about 770 million NOK. Allocations from Innovation Norway, however, are slightly lower than the year before; net grants have been reduced by 90 million NOK (three per cent).

County allocation of funding from the Research Council, SkatteFUNN and Innovation Norway differs, as shown in Figure 5.7. Allocations from the Research Council are strongly concentrated in the counties with the oldest universities and where the larger research institutes are also located. The distribution of the tax deduction funds follows a pattern more closely aligned with the distribution of R&D expenditure in the industrial sector, with a slightly decentralizing effect in that the central urban areas, especially Oslo and Akershus, have a smaller proportion of these funds.

Grants from Innovation Norway have a different geographical pattern. Partly the funds are channelled to the innovative business community; most important however are the guidelines provided through agricultural and regional policy, which means that a relatively significant proportion of funds go to the more peripheral parts of the country.

Appendix

Tables

Table 1
Total R&D expenditure in Norway by sector of performance and source of funds: 2013. Million NOK.

Sector of performance	Total	Industry		Government		Other sources[1]	Abroad	
		Total	Oil companies	Totalt	Research Council of Norway		Total	Of which: EU-commission
Business enterprise sector	26,635	19,663	..	2,469	1,416	856	3,648	2,052
Of which: Industrial sector[1]	22,557	17,918	..	934	425	653	3,052	1,829
Institutions serving enterprises[2]	4,079	1,746	365	1,535	992	203	596	224
Government sector	8,112	722	..	6,430	1,835	243	717	220
Of which: Institutions serving government	7,413	712	158	5,773	1,829	213	716	219
Health trusts without university functions	698	10	-	658	7	30	1	1
Higher education sector	16,001	660	160	14,183	2,471	718	440	323
Of which: Universities and specialized university institutions	11,817	583	159	10,279	2,171	562	393	292
University colleges	1,413	32	1	1,344	144	19	18	12
University hospitals	2,772	45	-	2,560	157	138	29	19
Total Norway	**50,748**	**21,044**	**..**	**23,082**	**5,723**	**1,817**	**4,805**	**2,595**

1 Includes private funding, gifts and SkatteFUNN in the industrial sector.

2 Includes private, non-profit hospitals operating on behalf of a regional health trust.

Source: NIFU/Statistics Norway, R&D Statistics

Table 2
Current expenditure on R&D by sector of performance and field of research and development: 2013. Million NOK.

Field of research and development	Total	Industrial sector	Institute sector	Higher education sector
Humanities	1,800.0	..	266.7	1,533.3
Social scienes	5,461.5	..	1,959.7	3,501.8
Natural sciences	4,854.6	..	2,158.0	2,696.6
Engineering and technology	5,931.5	..	4,074.5	1,857.0
Medical and health sciences	6,745.8	..	1,510.0	5,235.8
Agricultural sciences	1,965.2	..	1,720.1	245.1
Not elsewhere classified	21,059.1	21,059.1	..	..
Total	**47,817.7**	**21,059.1**	**11,689.0**	**15,069.6**

Source: NIFU/Statistics Norway, R&D Statistics

Table 3
Current expenditure on R&D by type of R&D and sector of performance: 2013. Million NOK and per cent.

Sector of performance		Total	Basic research	Applied research	Experimental development
Industrial sector	Million NOK	21,059.1	696.1	4,381.6	15,981.4
	Per cent	100	3	21	76
Institute sector	Million NOK	11,689.0	1,576.0	7,918.1	2,194.9
	Per cent	100	13	68	19
Higher education sector	Million NOK	15,069.6	6,738.4	6,606.1	1,725.1
	Per cent	100	45	44	11
Total	**Million NOK**	**47,817.7**	**9,010.5**	**18,905.8**	**19,901.4**
	Per cent	**100**	**19**	**40**	**42**

Source: NIFU/Statistics Norway, R&D Statistics

Table 4
R&D expenditure in Norway by sector of performance and type of cost: 1970–2013. Million NOK. Current prices.

	Total			Industrial sector[1]			Institute sector			Higher education sector		
Year	Total	Current ex-penditure	Invest-ments	Total	Current ex-penditure	Invest-ments	Total	Current ex-penditure	Invest-ments	Total	Current ex-penditure	Invest-ments
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	1,008.8	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	143.8	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[2]	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	27,245.8	24,813.3	2 432.5	13,390.7	12,077.1	1,313.6	6,360.0	6,075.3	284.7	7,495.1	6,660.9	834.2
2004	27,552.7	25,280.5	2 272.2	12,707.7	11,735.5	972.2	6,620.0	6,320.0	300.0	8,225.0	7,225.0	1,000.0
2005	29,514.8	27,442.6	2 072.2	13,511.7	12,591.3	920.4	6,906.8	6,660.9	245.9	9,096.3	8,190.4	905.9
2006	32,274.8	29,844.9	2 429.9	14,734.8	13,614.9	1,119.9	7,650.0	7,350.0	300.0	9,890.0	8,880.0	1,010.0
2007	36,788.2	33,955.8	2 832.4	16,755.4	15,481.6	1,273.8	8,309.9	7,941.7	368.2	11,722.9	10,532.5	1,190.4
2008	40,545.3	37,354.4	3 190.9	18,294.7	16,928.9	1,365.8	9,266.6	8,812.5	454.1	12,984.0	11,613.0	1,371.0
2009[3]	41,884.5	39,061.7	2 822.8	18,201.9	17,180.2	1,021.7	10,262.4	9,794.2	468.2	13,420.2	12,087.3	1,332.9
2010	42,759.1	40,000.6	2 758.6	18,513.8	17,264.4	1,249.5	10,415.3	10,051.2	364.1	13,830.0	12,685.0	1,145.0
2011	45,440.4	42,577.5	2 862.9	20,065.9	18,532.5	1,533.4	11,115.1	10,657.4	457.7	14,259.4	13,387.6	871.8
2012	48,043.5	45,140.2	2 903.3	21,176.3	19,718.3	1,458.0	11,828.2	11,237.9	590.3	15,039.0	14,184.0	855.0
2013	50,748.2	47,817.7	2 930.5	22,556.9	21,059.1	1,497.8	12,190.1	11,689.0	501.1	16,001.2	15,069.6	931.6

1 Due to new information from important R&D units in the industrial sector, R&D statistics from 2001 till 2007 have been corrected.

2 Data from 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.

3 In 2009, some research units were reclassified, mainly from the higher education sector to the institute sector.

Source: NIFU/Statistics Norway, R&D Statistics

Table 5

R&D personnel (head count) in Norway by sector of performance and gender: 1974–2013.

	Total			Industrial sector[1]			Institute sector			Higher education sector		
Year	Total	Researchers[2]	Women (%)	Total	Researchers[2]	Women (%)	Total	Researchers[2]	Women (%)	Total	Researchers[2]	Women (%)
1974	9,756	..	..	1,419	..	..	3,286	306	9	5,051	606	12
1977	10,818	..	..	1,688	..	..	3,517	334	9	5,613	775	14
1979	11,851	..	..	2,017	..	..	3,982	375	9	5,852	841	14
1981	12,939	..	..	2,316	..	..	4,376	511	12	6,247	955	15
1983	14,002	..	..	2,909	..	..	4,663	504	11	6,430	1,032	16
1985	15,923	..	..	4,475	..	..	4,792	638	13	6,656	1,178	18
1987	18,128	..	..	5,897	..	..	5,343	843	16	6,888	1,336	19
1989	19,515	3,599	18	5,861	741	13	5,882	1,131	19	7,772	1,727	22
1991	20,118	4,020	20	5,671	780	14	5,909	1,204	20	8,538	2,036	24
1993	21,879	4,837	22	6,192	966	16	6,339	1,500	24	9,348	2,371	25
1995[3]	26,712	6,454	23	8,012	1,209	15	6,048	1,551	26	12,652	3,694	29
1997	30,280	7,907	26	10,377	1,815	18	6,118	1,730	28	13,785	4,362	32
1999	30,994	8,629	28	10,710	2,063	19	5,920	1,727	29	14,364	4,839	34
2001	34,549	9,904	29	13,308	2,574	19	6,077	1,912	31	15,164	5,418	36
2003	35,307	10,350	29	12,741	2,202	17	6,350	2,049	32	16,216	6,099	38
2005	36,570	11,570	32	11,999	2,242	19	6,484	2,207	34	18,087	7,121	39
2007	41,347	13,867	34	14,068	2,788	20	7,467	2,730	37	19,812	8,349	42
2008	43,715	14,902	34	15,412	3,100	20	7,713	2,925	38	20,590	8,877	43
2009[4]	44,762	15,770	35	15,249	3,191	21	8,198	3,187	39	21,315	9,392	44
2010	44,774	15,998	36	14,854	3,121	21	8,277	3,270	40	21,643	9,607	44
2011	45,578	16,504	36	15,332	3,304	22	8,434	3,417	41	21,812	9,783	45
2012	46,747	..	..	16,460	..	..	8,386	3,438	41	21,901	10,010	46
2013	46,747	17,219	37	16,460	3,148	19	8,386	3,567	43	21,901	10,504	48

[1] Due to new information from important R&D units in the industrial sector, R&D statistics from 2001 till 2007 have been corrected.

[2] Personnel with a higher education degree (ISCED-level 5A and 6). Only academic staff are included in the higher education sector.

[3] Data from 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.

[4] In 2009, some research units were reclassified, mainly from the higher education sector to the institute sector.

Source: Statistics Norway/NIFU, R&D statistics

Table 6
R&D personnel (FTE) in Norway by sector of performance: 1970–2013.

	Total			Industrial sector[1]			Institute sector			Higher education sector		
Year	Total	Resear-chers[2]	Others	Total	Resear-chers[2]	Others	Total	Resear-chers[2]	Others	Total	Resear-chers[2]	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[3]	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	26,745	19,714	7,031	12,273	9,321	2,952	6,988	4,723	2,265	7,484	5,670	1,814
2003	28,546	20,581	7,965	13,390	9,368	4,022	7,238	4,962	2,276	7,918	6,251	1,667
2005	29,984	21,216	8,768	13,288	8,617	4,671	7,276	5,088	2,188	9,420	7,511	1,909
2006	31,251	22,600	8,651	13,881	9,530	4,351	7,500	5,200	2,300	9,870	7,870	2,000
2007	33,655	24,369	9,286	14,848	10,372	4,476	7,796	5,523	2,273	11,011	8,474	2,537
2008	35,502	25,593	9,909	15,996	11,027	4,969	8,165	5,796	2,369	11,341	8,770	2,571
2009[4]	36,091	26,273	9,818	15,673	10,783	4,890	8,763	6,328	2,435	11,655	9,162	2,493
2010	36,121	26,450	9,671	15,321	10,622	4,699	8,832	6,360	2,472	11,968	9,468	2,500
2011	36,950	27,228	9,722	15,545	10,925	4,620	9,123	6,543	2,580	12,282	9,760	2,522
2012	37,707	27,841	9,866	16,062	11,375	4,687	9,232	6,611	2,621	12,413	9,855	2,558
2013	38,534	28,311	10,223	16,371	11,508	4,863	9,449	6,749	2,700	12,714	10,054	2,660

1 Due to new information from important R&D units in the industrial sector, R&D statistics from 2001 till 2007 have been corrected.

2 Personnel with a higher education degree (ISCED-level 5A and 6). Only academic staff are included in the higher education sector.

3 Data from 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.

4 In 2009, some research units were reclassified, mainly from the higher education sector to the institute sector.

Source: Statistics Norway/NIFU, R&D statistics

Table 7
R&D and innovation indicators per county: 2013 or latest year for available data.

County	Percentage of employees with a higher education	R&D expenditure in the higer education sector per capita (NOK)	Percentage of R&D expenditure in the industrial sector	Percentage of innovative companies involved in cooperation on innovation[1]	Innovation activity financed by Innovation Norway Per cent[2]	R&D intensity in the industrial sector	Percentage of publicly financed R&D	Percentage of funding from Research council of Norway
Norway	**9**	**3 150**	**44**	**69**	**100**	**1.05**	**45**	**100**
Østfold	6	235	52	83	1.7	0.56	26	0.9
Akershus	12	1 306	57	65	6.4	1.64	35	14.3
Oslo	19	9 620	38	67	5.5	1.26	54	30.1
Hedmark	5	594	37	87	2.5	0.17	62	0.4
Oppland	5	633	57	51	3.9	0.73	35	0.8
Buskerud	7	252	94	76	2.9	1.89	10	1.0
Vestfold	7	374	81	72	2.4	1.64	19	0.7
Telemark	6	554	80	68	4.3	1.46	21	0.6
Agder counties	7	1 080	58	75	5.6	0.72	42	0.9
Rogaland	9	1 275	67	59	8.4	0.79	27	3.8
Hordaland	10	4 913	25	70	9.2	0.60	64	13.9
Sogn og Fjordane	5	503	62	78	9.0	0.48	41	0.3
Møre og Romsdal	5	453	72	71	13.6	0.64	24	1.1
Sør-Trøndelag	12	10 630	33	62	7.3	2.31	46	22.9
Nord-Trøndelag	5	420	42	90	2.3	0.25	53	0.3
Nordland	5	919	47	74	3.6	0.37	54	1.0
Troms	9	8 993	9	59	4.7	0.34	84	6.7
Finnmark	5	849	14	100	2.8	0.07	82	0.0

[1] 2012.

[2] 2014.

Source: Statistics Norway/NIFU, R&D statistics

6 Appendix

Table 8
EU indicators for science, technology and innovation. Indicators for benchmarking in selected countries: 2013 or latest year for available data.

	EU innovation scoreboard 2015	Year of reference	EU 28	Austria	Belgium	Denmark	Estonia	Finland	France	Germany	Iceland	Ireland	Italy	The Netherlands	**Norway**	Poland	Portugal	Slovenia	Spain	Sweden	Switzerland	Czech Rep.	United Kingdom
	Composite index		0.555	0.313	0.619	0.736	0.489	0.740	0.591	0.676	0.624	0.628	0.445	0.585	**0.479**	0.403	0.204	0.360	0.385	0.636	0.810	0.447	0.313
	ENABLERS																						
	Human resources																						
1.1.1	New doctorate graduates	2012	1.8	2.2	1.6	2.4	1.0	2.7	1.7	2.7	0.9	2.0	1.6	2.0	**2.2**	0.6	2.1	1.9	1.4	2.8	3.4	1.7	2.4
1.1.2	Population completed tertiary education	2013	36.9	27.3	42.7	43.4	43.7	45.1	44.0	33.1	43.9	52.6	22.4	43.1	**48.8**	40.5	29.2	40.1	42.3	48.3	46.1	26.7	47.6
1.1.3	Youth with upper secondary level education	2013	81.0	87.4	83.1	71.8	84.2	85.9	86.4	76.8	59.1	89.4	77.9	78.2	**73.7**	89.7	69.9	91.5	63.8	86.2	85.2	90.9	82.9
	Open, excellent and attractive research systems																						
1.2.1	International scientific co-publications	2012	363	1314	1380	1916	864	1490	745	784	2825	1194	574	1525	**1844**	237	803	1096	660	1791	3028	598	1070
1.2.2	Scientific publications among top 10% most cited	2009	10.98	11.05	13.36	14.56	8.45	11.45	10.44	11.72	11.55	11.53	10.57	15.57	**11.46**	3.81	9.88	6.89	10.42	12.73	16.47	5.64	13.40
1.2.3	Non-EU doctorate students	2012	25.48	9.00	21.97	18.44	4.72	7.92	35.40	11.32	23.89	18.41	9.04	24.52	**33.51**	1.88	13.70	6.15	20.44	24.01	50.17	4.41	30.78
	Finance and support																						
1.3.1	Public R&D expenditure	2013	0.72	0.86	0.69	1.04	0.90	1.01	0.75	0.94	1.10	0.43	0.54	0.84	**0.81**	0.48	0.59	0.61	0.58	1.01	0.90	0.87	0.55
1.3.2	Venture capital	2013	0.062	0.017	0.089	0.097	..	0.083	0.081	0.041	..	0.049	0.015	0.068	**0.084**	0.036	0.042	..	0.028	0.078	0.065	0.002	0.119
	FIRM ACTIVITIES																						
	Firm investments																						
2.1.1	Business R&D expenditure	2013	1.29	1.93	1.58	1.99	0.83	2.29	1.44	1.99	1.33	1.14	0.67	1.14	**0.89**	0.38	0.65	1.98	0.66	2.19	2.17	1.03	1.05
2.1.2	Non-R&D innovation expenditure	2012	0.69	0.46	0.60	0.37	1.55	0.37	0.37	1.35	..	0.39	0.57	0.18	**0.24**	1.04	0.60	0.48	0.31	0.79	2.01	0.73	0.30
	Linkages & entrepreneurship																						
2.2.1	SMEs innovating in-house	2012	28.68	31.81	37.38	30.43	27.43	36.46	28.79	38.60	..	38.76	36.63	38.94	**20.30**	10.13	33.78	25.79	15.50	38.31	45.21	27.33	..
2.2.2	Innovative SMEs collaborating with others	2012	10.32	15.25	22.88	17.26	15.78	14.28	11.47	11.54	17.46	12.00	4.81	14.46	**7.92**	3.85	6.79	14.60	6.04	12.69	9.40	11.63	22.36
2.2.3	Public-private co-publications	2012	50.3	71.0	94.6	193.0	16.9	87.7	51.3	73.2	271.2	33.1	29.7	119.9	**77.7**	4.7	15.2	80.6	28.1	140.3	294.4	25.1	74.0
	Intellectual Assets																						
2.3.1	PCT patent applications	2011	3.78	4.96	3.64	6.93	1.61	9.37	4.19	6.89	3.24	2.67	2.02	6.00	**2.80**	0.42	0.67	2.79	1.57	9.16	8.51	0.79	3.17
2.3.2	PCT patent applications in societal challenges	2011	0.98	1.09	0.87	2.67	0.25	1.65	0.92	1.70	0.81	0.92	0.47	1.73	**0.57**	0.09	0.18	0.90	0.50	1.88	2.47	0.20	0.85
2.3.3	Community trademarks	2013	5.83	10.07	5.19	7.47	9.83	6.57	3.96	7.49	10.06	5.84	5.24	6.74	**1.47**	3.61	4.98	5.41	7.16	7.30	11.62	3.89	5.80
2.3.4	Community designs	2013	1.13	1.65	1.03	2.20	1.64	1.82	1.01	1.32	0.50	0.50	1.16	1.48	**0.18**	1.62	0.87	1.82	0.79	1.99	0.93	1.14	0.97
	OUTPUTS																						
	Innovators																						
3.1.1	SMEs introducing product or process innovations	2012	30.60	35.69	42.27	33.94	33.00	40.06	32.36	42.44	54.17	35.67	38.81	40.86	**22.50**	13.07	38.28	32.61	18.43	39.91	32.61	30.86	27.78
3.1.2	SMEs introducing marketing/organisational innovations	2012	36.19	44.71	36.67	40.45	31.17	37.03	41.18	46.23	45.96	49.63	44.73	35.16	**32.41**	14.19	42.80	35.89	22.56	38.19	..	30.19	39.10
3.1.3	Employment in fast growing firms in innovative industries (% of workforce in fast growing firms)	2012	17.90	17.20	15.60	18.50	14.70	17.10	20.80	19.10	16.74	21.80	15.30	16.20	**15.40**	19.30	14.70	15.30	15.90	18.90	18.97	18.70	18.60

	EU innovation scoreboard 2015	Year of refe-rence	EU 28	Austria	Bel-gium	Den-mark	Estonia	Finland	France	Ger-many	Iceland	Ireland	Italy	The Nether-lands	**Norway**	Poland	Portu-gal	Slove-nia	Spain	Swe-den	Swit-zerland	Czech Rep.	United King-dom
	Economic effects																						
3.2.1	Employment in knowledge-intensive activities	2013	13.80	14.60	15.30	15.20	11.90	15.50	13.80	14.60	17.20	20.10	13.40	17.10	**15.80**	9.60	9.40	14.00	12.50	17.70	20.40	12.90	17.80
3.2.2	Medium and high-tech product exports	2013	53.00	56.60	45.92	43.87	42.68	38.69	56.72	65.94	10.05	47.00	50.43	42.10	**12.53**	48.60	35.18	54.57	46.05	52.47	64.49	62.54	47.82
3.2.3	Knowledge-intensive services exports	2012	49.53	26.61	42.95	68.05	42.52	43.93	41.14	58.13	53.57	76.12	33.34	30.61	**61.20**	33.56	33.49	25.73	30.04	41.78	25.04	35.16	66.44
3.2.4	Sales of new to market and new to firm innovations	2012	12.40	9.85	11.23	22.10	7.80	11.14	13.48	12.97	6.07	9.32	10.98	11.84	**5.18**	6.33	12.42	10.55	14.34	6.11	16.08	13.39	14.12
3.2.5	Licence and patent revenues from abroad	2013	0.65	0.24	0.63	0.70	0.04	1.39	0.42	0.78	0.92	2.28	0.18	3.75	**0.08**	0.06	0.02	0.12	0.07	1.09	3.24	0.13	0.46

Source: DG Enterprise

Acronyms

List of acronyms

BES	Business enterprise sector
CIS	Community Innovation Survey (of the European Union)
EC	European Commission
EEA	European Economic Area
EFTA	European Free Trade Association
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
GBARD	Government Budget Allocations for R&D
GDP	Gross Domestic Product
GUF	General University Funds
HES	Higher education sector
ICT	Information and Communication Technology
ISCED	International Standard Classification of Education (of UNESCO)
ISI	Institute of Scientific Information
NIFU	Nordic 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	Philosophiae Doctor
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
UNESCO	United Nations Educational, Scientific and Cultural Organization

Nowegian Ministries and their Acronyms

English name	Norwegian name	Acronym
The Office of the Prime Minister	Statsministerens kontor	SMK
Ministry of Agriculture and Food	Landbruks- og matdepartementet	LMD
Ministry of Children, Equality and Social Inclusion	Barne-, likestillings- og inkluderingsdepartementet	BLD
Ministry of Culture	Kulturdepartementet	KUD
Ministry of Defence	Forsvarsdepartementet	FD
Ministry of Education and Research	Kunnskapsdepartementet	KD
Ministry of Climate and Environment	Klima- og miljødepartementet	KLD
Ministry of Finance	Finansdepartementet	FIN
Ministry of Trade, Industry and Fisheries	Nærings- og fiskeridepartementet	NFD
Ministry of Foreign Affairs	Utenriksdepartementet	UD
Ministry of Health and Care Services	Helse- og omsorgsdepartementet	HOD
Ministry of Justice and Public Security	Justis- og beredskapsdepartementet	JD
Ministry of Labour and Social Affairs	Arbeids- og sosialdepartementet	ASD
Ministry of Local Government and Modernisation	Kommunal- og moderniseringsdepartementet	KMD
Ministry of Petroleum and Energy	Olje- og energidepartementet	OED
Ministry of Transport and Communications	Samferdselsdepartementet	SD