Chapter 2.

Macroeconomic and innovation performance in Norway

This chapter discusses macroeconomic and framework conditions in Norway and the state of innovation capabilities and performance outcomes of the Norwegian innovation system. The first part presents macroeconomic and social developments and highlights salient features of the Norwegian economy, patterns of structural change and entrepreneurship. The second part looks at the current state of indicators of innovation inputs and outputs. It also compares Norway's innovation capacities to other relevant OECD countries in order to highlight qualitative and quantitative characteristics of Norway's innovation system.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Macroeconomic trends, well-being and framework conditions in Norway

Impressive economic and social development in recent decades

Norway's economic development has been transformed dramatically since the discovery of offshore oil and gas in the late 1960s. The offshore oil and gas (O&G) sector was developed by state-owned companies and other domestic and foreign companies that were awarded concessions for the exploitation of the Norwegian Continental Shelf. These concessions were coupled with specific tax and regulation instruments to favour long-term technological development, notably the requirement to invest in Norway's technological capacity. In places like Bergen, Stavanger and Trondheim, specific technological and engineering clusters emerged as a result of this policy, notably in shipbuilding and oil and gas. This sector has since then remained prominent in the national economy. It accounted for nearly a quarter of Norway's GDP over the 2000s (MER, 2016), starting from nothing in 1970 and oscillating between 10% and 15% in the 1990s (Engen, 2009).

Apart from the O&G sector, the Norwegian economy had long been dominated by agriculture, forestry, fisheries, mining and shipping, which resulted in the gradual growth of supplier firms and generated opportunities for smaller scale industrial development, for example in shipbuilding. In the first decades of the 20th century, extensive investment was made in hydropower for energy-intensive basic industries like aluminium smelters. A small number of academic innovators contributed to this development from the beginning.

Research and innovation began to play a more prominent role in the last third of the 20th century, with the emergence of knowledge producers and the pervasive economic and social influence of information and communication technologies (ICT). Some service companies with strong ICT competencies became important nodes in the large industrial network, especially in oil and gas.

Norway was able to seize the initiative where opportunities arose, and pursued an active industrial policy in the post-war era. This led to the development of successful clusters in resource-based sectors, predominantly in oil and gas, shipbuilding and also fisheries and aquaculture. These were supported by technology and engineering service companies that maintained a close relationship with universities and specialised research institutes. The revenues generated by these industry clusters became a driving force in the growth and technological upgrading of these sectors and helped to establish a virtuous circle for building strong, interlinked research and innovation capabilities.

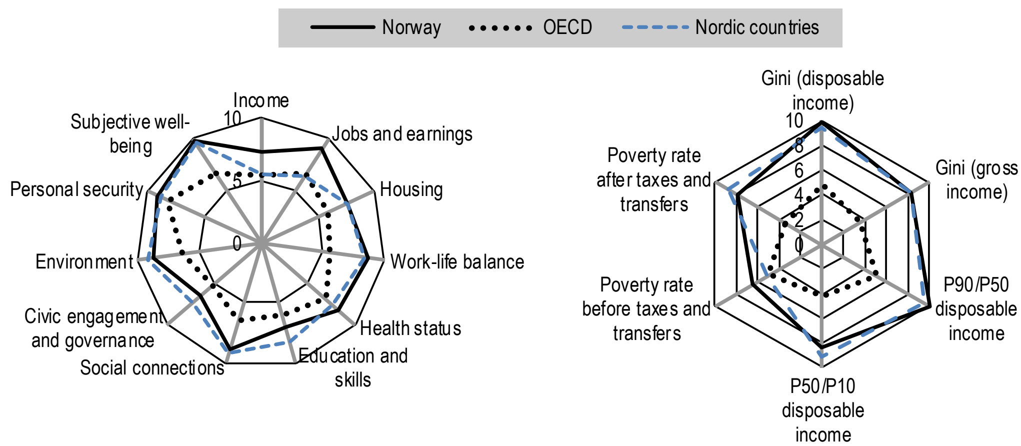
Smart management of the country's natural resources, with the help of Norway's sovereign fund, has helped Norway achieve standards of living that are among the highest in the world. It consistently ranks at the very top of countries in terms of human development index-related indicators (Figure 2.1, Panel B). It scores well in the OECD Better Life Index (Figure 2.1, Panel A) surpassing the OECD average in every dimension. In respect to education and skills dimensions, however, Norway ranks below other innovation-intensive OECD countries.

Despite these impressive achievements, the drop in oil prices suggests that it should prepare for an economic transition in the near future. Innovation will play a key role in this transformation, as well as integrating the highly skilled workforce from the oil and gas sector into emerging industries.

Figure 2.1. **Norway scores well in measures of well-being**

Panel A. Better Life Index

Panel B. Inequality index



Note: Indicators are normalised by re-scaling from 0 (worst) to 10 (best). Each well-being dimension is measured using 1 to 3 indicators from the OECD Better Life Indicator set with equal weights. Nordic is a simple average of Denmark, Finland and Sweden.

Sources: OECD (2016a), *OECD Economic Surveys: Norway 2016*, http://dx.doi.org/10.1787/eco_surveys-nor-2016-en based on OECD (2015a), "Better Life Index 2015", *OECD Social and Welfare Statistics*, http://dx.doi.org/10.1787/data-00823-en; OECD (2015d), "Income distribution", *OECD Social and Welfare Statistics*, http://dx.doi.org/10.1787/data-00654-en.

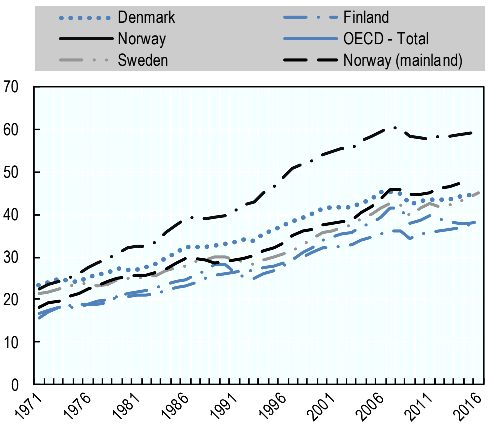
Macroeconomic trends

Norway has the second-highest GDP per capita in the OECD, after Luxembourg, with USD 63 000 PPP per head in 2016. GDP growth slowed from 1.9% in 2014 to 1% in 2016, mainly as a result of the impact of falling oil prices. Norway's GDP levels remain among the highest in the OECD, even when considering only the mainland economy (i.e. without the oil and gas revenues) (Figure 2.2). The oil economy accounts for a significant portion of the economic growth in recent decades, but the mainland economy has meanwhile showed strong productivity growth (Table 2.1). An estimated 230 000 workers are linked to the oil industry (8.7% of total employment). Supplies for the oil industry accounted for 14% of value added in mainland manufacturing industries in 2013; for service industries the share was 9%. Labour productivity has declined, (Table 2.1) although less than in comparable OECD countries, and the drop is attributable chiefly to the slump in oil prices rather than in mainland economic activities.

The Norwegian economy's drop in productivity since 2005 was heavily influenced by the petroleum sector, partly because the remaining oil resources are less easily accessible. Productivity in the mainland economy has continued to increase, though at a slower pace.

Norway's economic structure (Figure 2.3) is likely to progressively diversify and move away from petroleum-related activities (OECD, 2016a). As illustrated in Figure 2.3, its economy is now dominated by a wide range of service sectors, following the trend in most other OECD countries. While mainland exports of goods are primarily towards Europe (67% of mainland exports of goods), exports of services have become increasingly global (50% towards Europe and 50% to markets outside Europe).

Figure 2.2. **Norway's GDP per capita is high**



Sources: OECD (2017a), *National Accounts Database*, http://dx.doi.org/10.1787/na-data-en (accessed 24 April 2017); OECD (2016a), *OECD Economic Surveys: Norway 2016*, http://dx.doi.org/10.1787/eco_surveys-nor-2016-en.

Table 2.1. **Norway's growth performance indicators**

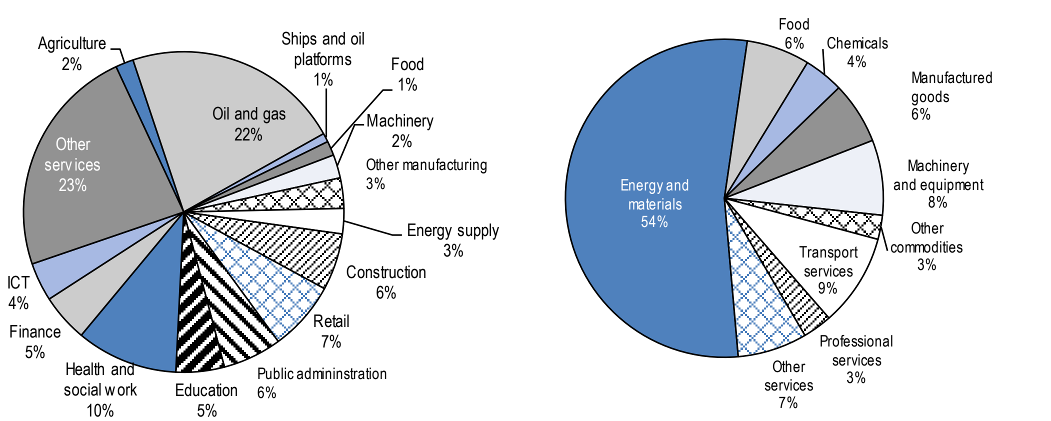
Average annual growth rates (%)		2003-09	2009-15
GDP per capita		2.4	0.9
Labour utilisation		0.8	-0.6
of which:	Labour force participation rate	0.3	-0.4
	Employment rate	0.2	-0.2
Labour productivity		1.3	1.2
of which:	Capital deepening	-0.5	-0.4
	Total factor productivity	1.9	1.6

Source: OECD (2017b), *Economic Policy Reforms 2017: Going for Growth*, http://dx.doi.org/10.1787/growth-2017-en.

Figure 2.3. **Norway's economic structure**

Panel A. Value added by sector as % of GDP

Panel B. Exports by type of commodity and service



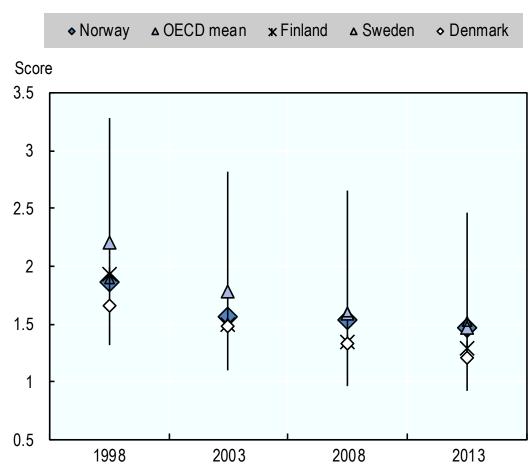
Source: OECD (2016a), *OECD Economic Surveys: Norway 2016*, http://dx.doi.org/10.1787/eco_surveys-nor-2016-en.

Trends in entrepreneurship

Given the challenge in cost-competitiveness faced by Norwegian companies (especially in the mainland economy), it is essential that policy makers provide very good framework conditions for entrepreneurship and innovation. Norway's corporate tax rate does not compare favourably with that of other OECD countries. The OECD product market regulation measure suggests that Norway compares relatively well with other countries, but that it has been cutting barriers to business more slowly than elsewhere (Figure 2.4). According to this index, Norway ranks at the OECD mean with respect to the restrictiveness of economy-wide procedures, protection of incumbents and barriers to trade and investment. Norway is below the mean when considering the administrative burden on start-ups. The government is aware of these problems and is moving forward to address the issues.

Self-employment is an indicator that helps illuminate the extent of entrepreneurship within a country. The self-employment rate in Norway is very low by comparison with other countries (Figure 2.5). Surprisingly, there are even fewer self-employed women than males, despite Norway's relatively low gender gap in other measures. However, cross-country comparisons of self-employment are complicated in two ways. Self-employment status is sometimes favoured by tax and social security provisions, or other regulatory practices, which differ across countries. Secondly, individuals who own all or part of a small firm may well be recorded as employees of the firm rather than as entrepreneurs.[1]

Figure 2.4. **Norway is losing ground on the OECD's product market regulation index**

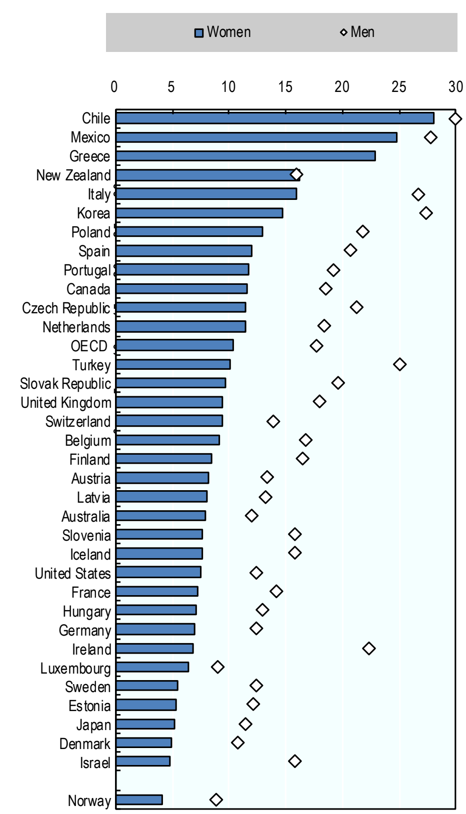


Notes: Scores potentially range from 0 to 6 and increase with restrictiveness. The OECD mean is depicted on a line connecting the minimum and maximum values within the OECD.

Source: OECD (2015b), "Economy-wide regulation", *OECD Product Market Regulation Statistics* http://dx.doi.org/10.1787/pmr-data-en.

Figure 2.5. **Self-employment by gender**

Percentage of total employment, 2014 or latest available year



Source: OECD (2016b), *Entrepreneurship at a Glance 2016*, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en.

Entrepreneurial activities and the formation of innovative ventures are also influenced by educational background. In that regard, the specific subject of study appears more influential on the entrepreneurship rates than on the level of education reached (OECD, 2014a). Entrepreneurship rates are highest among those who study dentistry, veterinary science and hairdressing, and the lowest among PhDs (though this last observation is undifferentiated across subjects). Among those studying at the master's level, entrepreneurship is higher among engineers and architects than among those studying business and administration, while the latter in turn have rates higher than among scientists (including computer scientists) and mathematicians. Although it is difficult to clearly distinguish between subjects that are conducive to research, innovation and entrepreneurship from the others, it should be noted that relatively few recent graduates in Norway have specialised in science and engineering relative to health, education and social sciences, which may also contribute to lowering the entrepreneurship rate.

Equally important to entrepreneurship and the growth of new firms is access to finance. Bank loans may be appropriate if a business has physical collateral to post as security, but may be less relevant for start-ups where knowledge-based capital is more important. In these cases, start-up finance, i.e. seed money beyond the entrepreneur's own resources, or that of family and friends, is sometimes provided by venture capital investors. A report on private equity funds by the Norwegian Venture Capital Association shows that almost no private equity investment is seed money for completely new start-ups (NVCA, 2012). Instead, between one-quarter and one-third of private equity investment is in the venture stage, when successful start-ups are looking to expand, the rest – twice as much – being buy-out finance.

Venture capital investment in Norway as a percentage of GDP is lower than in other innovation-intensive countries such as Israel, the United States, Canada or Sweden (Figure 2.6). However, in interpreting this figure, Norway's high GDP must be factored in. In absolute figures, venture capital investment in Norway is comparable to that of Denmark, Finland or Belgium, but lower than in other small advanced economies, such as Switzerland. Venture capital investment is relatively equally balanced between early- and later stage capital support and decreased over the period 2007-2014, a trend common in many other OECD countries (Figure 2.6).

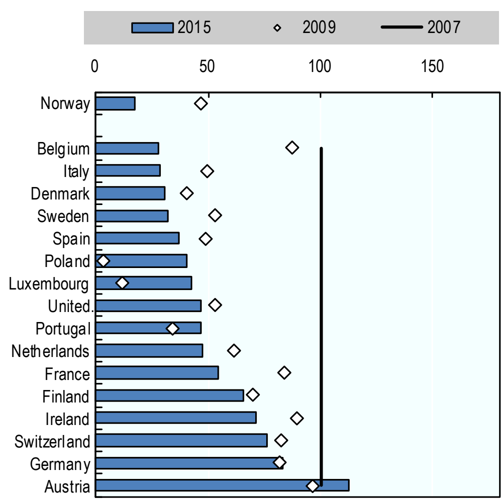
Employment created by enterprise start-ups, and the loss of jobs consequent on their failure, provides an indication of how enterprise contributes to overall employment changes in the economy, and in particular, start-ups' important contribution to employment growth. Employment creation is particularly dynamic in the services sector. At the level of the economy as a whole, net creation was positive, at over 1% of total employment, driven by the net creation of employment from enterprise start-ups in the service sector (Figure 2.7). New small and medium enterprises (SMEs), as in other countries but to a lesser extent, contribute disproportionately to job creation (Figure 2.8).

Access to the Internet and ICT

Information and communications technology (ICT) infrastructure, especially high-bandwidth connectivity – affects innovation and broader business outcomes in a variety of ways. For instance, Internet usage is associated with superior performance in small firms. ICT infrastructure facilitates innovation by enabling the circulation of data and information, whether or not publicly or privately generated and funded. ICT infrastructure also facilitates the data-driven delivery of key public services, from the management of smart electricity grids and transport systems to efficiency-enhancing patient data in healthcare.

Figure 2.6. **Trends in venture capital investment**

Index 2007=100



Source: OECD (2016b), *Entrepreneurship at a Glance 2016*, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en.

Table 2.2. **Education field of entrepreneurs at start-up, 2011**

Education field	All entrepreneurs
General programmes	24%
Humanities and arts	4%
Teacher training, social science, law	7%
Business and administration	18%
Natural sciences, vocational and technical subjects	36%
Health, welfare and sport	6%
Primary industries	2%
Transport and communications and other services	5%

Source: OECD (2016a), *OECD Economic Surveys: Norway 2016*, http://dx.doi.org/10.1787/eco_surveys-nor-2016-en.

Access to broadband communication networks and the services provided over them support existing economic and social activities and hold potential for innovation. According to Figure 2.9, fixed broadband penetration in Norway is significantly above the OECD average, below only Switzerland, Denmark, the Netherlands, France and Korea. Mobile broadband penetration is lower but still above the OECD average. Norway is also a leader in terms of M2M subscriptions and the number of devices used for online access at home. Indicators of online usage among young people are also very strong. In Norway, children obtain access to the Internet earlier than in most OECD countries, and in 2012, the availability of Internet connections in schools is the third highest after Denmark and Australia. According to 2014 data, the share of individuals using the Internet to interact with public authorities was also very high: more than 80%, the third-highest share after Iceland and Denmark.

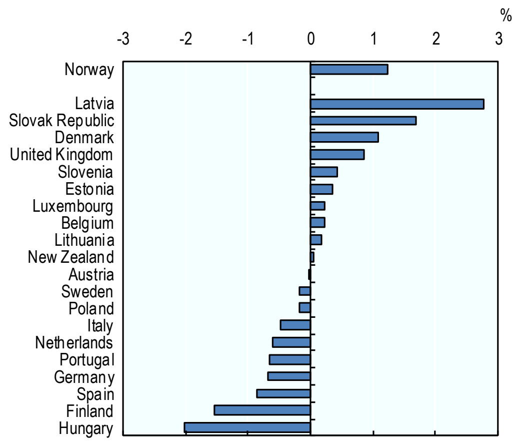
Innovation performance in Norway

Innovation inputs

The ability to mobilise resources for innovation differs markedly across countries. Innovation-intensive countries devote considerable financial resources investing in R&D, skills for innovation and science and technology. The assessment of the innovation performance of a country should take into account a wide range of indicators, including R&D expenditure, educational and skills characteristics across the population over time and across sectors (notably government, business and higher education).

Figure 2.7. **Net employment creation due to employer enterprise births and deaths, total business economy**

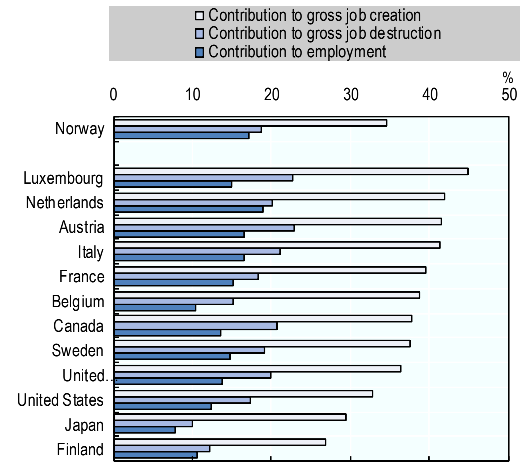
Percentage of total employment in employer enterprises (2013)



Source: OECD (2016b), *Entrepreneurship at a Glance 2016*, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en.

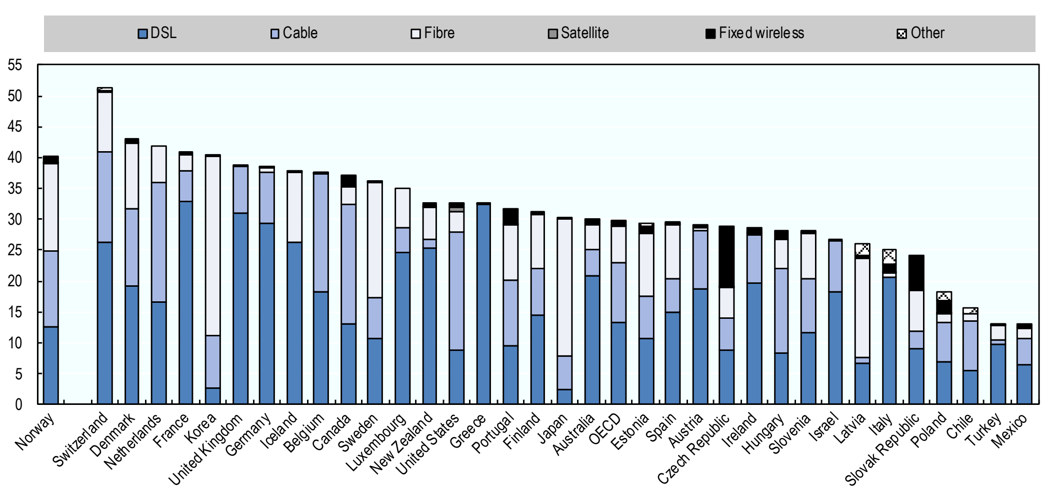
Figure 2.8. **Young SMEs contribution to job creation in each country, 2001-2011**

Share of total employment/job creation/job destruction



Source: Criscuolo, C., P.N. Gal and C. Menon (2014a), "The dynamics of employment growth: New evidence from 18 countries", http://dx.doi.org/10.1787/5jz417hj6hg6-en.

Figure 2.9. **Fixed broadband subscriptions per 100 inhabitants, by technology, 2016**



Source: OECD (2017c), Broadband Portal, www.oecd.org/sti/broadband/oecdbroadbandportal.htm (accessed 24 April 2017).

R&D expenditures

Gross domestic expenditures on R&D (GERD) in Norway increased considerably over the last decade from 3.2 in 2005 to USD 6.2 billion PPP in 2015. The 2015 figure was NOK 60 billion. GERD in Norway is comparable to Finland's (USD 6.7 billion PPP in 2015) but lower than other Nordic countries like Denmark (USD 8.2 billion PPP in 2015) and Sweden (USD 15.3 billion PPP in 2015). Business expenditure on R&D (BERD) increased from USD 1.7 billion PPP in 2005 to USD 3.3 billion PPP in 2015. Government expenditure on R&D (GOVERD) and higher education expenditure on R&D (HERD) also increased, but at a slower pace, and in 2015, accounted respectively for USD 0.8 billion and USD 1.8 billion (Figure 2.10).

The share of GERD accounted for by the business sector was 54% in 2015, a figure around the OECD median and below the OECD average (69%). Other comparable Nordic countries exhibit shares closer to the OECD average: 64% in Denmark, 66% in Finland and 69% in Sweden.

BERD intensity (BERD as a % of GDP) in Norway has increased in the last decade (from 0.79% in 2005 to 1.05 % in 2015). However, it remains below the OECD average (1.09% in 2015) and the shares in other Nordic countries (around 2%). Figure 2.11 shows that BERD per capita is USD 690 PPP, whereas the OECD median is USD 554 PPP per capita. It must be noted, however, that this share is in line with that of other natural resources-based OECD economies, like Canada, New Zealand or Australia.

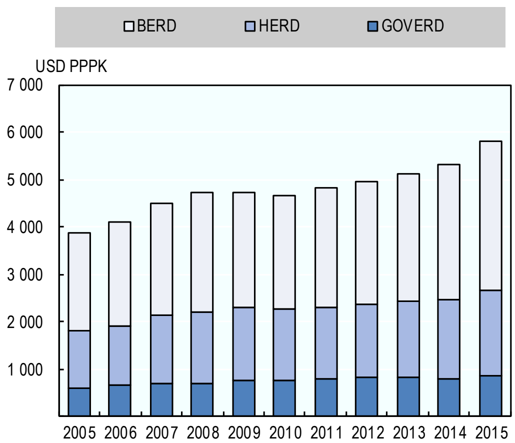
The higher education sector has had the highest increase in R&D expenditure since 2003, with average annual growth of 3.4%. Universities (including university hospitals) account for more than 80% of the HEI sector's total R&D expenditure in 2015. The rest is conducted by university colleges and specialised university colleges. Instead, HERD intensity in 2015 was at 0.6% of GDP, higher than the OECD average of 0.5%. GOVERD intensity was 0.3% in 2015, similar to the OECD average of 0.2% (Figure 2.11). The Norwegian GOVERD per capita indicates USD 192 per capita for 2015, higher than the OECD median and Nordic selected countries.

Like other countries, Norway has set ambitious targets for levels of R&D expenditure. A target of increasing R&D investments to 3% of GDP was introduced in 2005, in line with the EU Lisbon strategy, and was reclassified in 2009 as a long-term objective rather than as a target (Solberg, 2016). The LTP has restated the 3% goal to be reached by 2030. In addition, the LTP has specified that government allocations to R&D (GBAORD) should reach 1% by 2019-2020. While the target of 1% public R&D expenditures was reached in 2016, the consensus is that reaching the overall 3% target with two-thirds of business spending would require a substantial restructuring of the structure of Norway's industry.

It should be noted that the relatively low level of business R&D in Norway is linked to the country's industrial structure. For international comparison, the impact of differences in industrial structure, expressed as R&D intensity, varies considerably across sectors. BERD intensity adjusted for industrial structure is a weighted average of the R&D intensities of a country's industrial sectors, using the OECD industrial structure's sector value-added shares as weights instead of the actual shares used in the unadjusted measure of R&D intensity. Even with the adjusted structure, Norway remains at the level of the OECD median.

Business R&D expenditures in Norway tend to be higher in natural resources-based industries, whereas non-natural resources-based manufacturing, including high-technology manufacturing, have lower shares. The share of business R&D in services is above the OECD median, especially for knowledge-intensive services (OECD, 2015c).

Figure 2.10. **Evolution of GERD performance in Norway, constant prices**

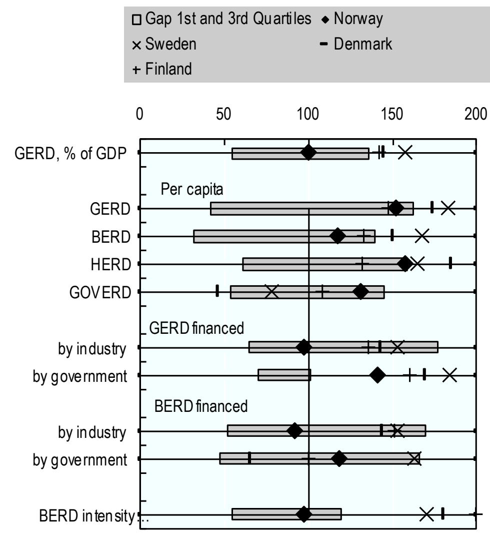


Notes: Values for 2015 are provisional. In 2007, change in compilation methods for health institutions. This affects both the higher education sector (university hospitals) and the government sector (other hospitals).

Source: OECD (2017d) *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti (accessed 12 April 2017).

Figure 2.11. **R&D performance and funding, OECD and selected countries**

Index of performance relative to the median values in the OECD area (Index median = 100)



Notes: 2015 or latest available data. All indicators are presented in indices and reported on a common scale from 0 to 200 to make them comparable (0 being the lowest OECD values and 200 the highest). The median OECD value is represented by the bar at 100.

Sources: OECD (2017d), *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti; *OECD Historical Population Data and Projections Database*, http://dx.doi.org/10.1787/d434f82b-en

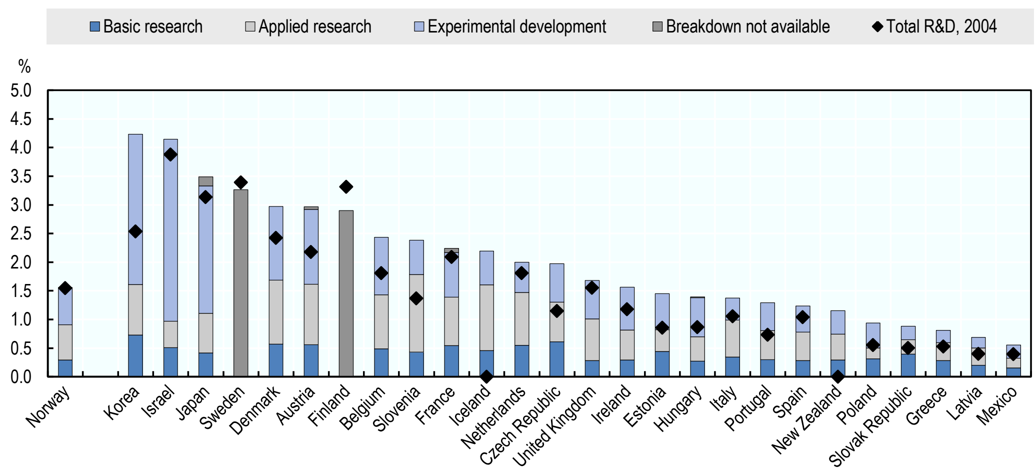
GERD in Norway shows a relatively balanced distribution between applied and experimental research, while the share of basic research is markedly lower (Figure 2.12). This distribution is commensurate with that of other OECD countries, but significantly different from the distributions in Israel, Korea, Japan, Denmark or the United States, where experimental development in GERD accounts for the largest share. While Norway's share of is perceptibly lower than that of other Nordic countries, it is noteworthy that its high GDP by comparison with other countries creates a bias towards a low GERD intensity.

R&D personnel

R&D personnel include researchers and other support staff, such as technicians and managers. The evolution of the number of R&D personnel over time provides a perspective on the changing nature of R&D activities. R&D expenditure and R&D personnel generally follow similar trends, for the simple reason that for the most part, R&D expenditure consists of the salaries of research personnel.

Figure 2.12. **Gross domestic expenditure on R&D by type**

2013 or latest data available, as a percentage of GDP



Notes: For Ireland, data for total GERD refer to 2012. For Switzerland, data for total GERD refer to 2004 and 2012.

Source: OECD, *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti.htm, and OECD, *Research and Development Statistics Database*, www.oecd.org/sti/rds (accessed 2 June 2017).

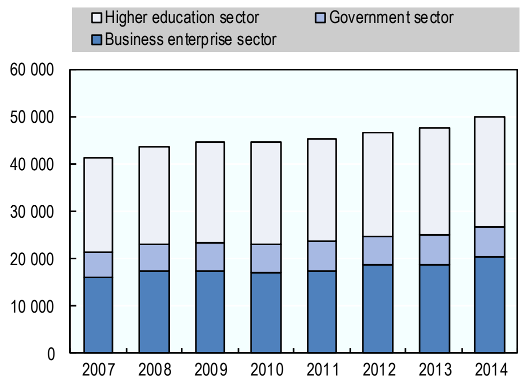
Between 2007 and 2014, with the deterioration of the economic conditions in many European countries and thanks to the high standards of working conditions in Norway, the number of international researchers in the public research system has increased considerably, by 50%. Foreign researchers accounted for around 60% of the total increase in the period and the share with a foreign nationality rose from 15% to 20%. Overall, while the number of researchers increased across all sectors between 2007 and 2014, the relative shares of researchers in the higher education, government and business enterprise sectors remained relatively stable (Figure 2.13). R&D personnel per thousand employment is above the OECD and the EU average but behind other advanced Nordic countries, especially in terms of researchers. Norway has achieved very good results in terms of the participation of women in science and research compared to other OECD countries. (Figure 2.14).

Skills for science, technology and innovation

Skilled people generate knowledge that can be used to create and introduce an innovation. Carlino and Hunt (2009) found that an educated workforce is the decisive factor in the inventive output of American cities; a 10% increase in the share of the workforce with at least a college degree raises quality-adjusted patenting per capita by about 10%. Data on Spanish regions also found a positive relationship between human capital and number of patent applications (Gumbau-Albert and Maudos, 2009).

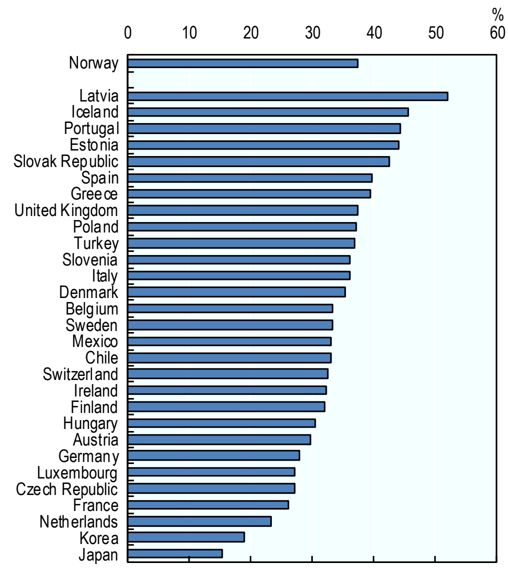
The percentage of people in Norway with tertiary education is high: 43% in the age group of 25-64 year-olds in 2015, considerably higher than the OECD average of 35% (OECD, 2016c). This positive achievement has been made possible thanks to an education system free of tuition fees and a high investment in higher education, above the OECD average country. However, although many students are attracted to higher education programmes, only 62% of students complete their postgraduate master’s degree within three years of study (MER, 2016).

Figure 2.13. **Number of researchers by sectors of employment in Norway, 2007-14 (headcounts)**



Source: OECD (2017d), *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti.htm (accessed 13 April 2017).

Figure 2.14. **Share of female researchers, 2014 or latest year available, as a percentage of total (headcounts)**



Source: OECD (2017d), *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti.htm (accessed 21 April 2017).

Norway has more PhDs than the EU average relative to population size. However, with 27 PhD graduates per 100 000 people, in 2016, Norway lags behind advanced innovation countries like other Nordic countries (33 on average) or Switzerland (47). In the age group 25-34, Norway is even further behind, and below the European median. The number of PhDs has increased in the last 20 years, and in 2013, was twice what it was in 2003. This increase can be mainly linked to a considerable increase in female as well as foreign PhD students.

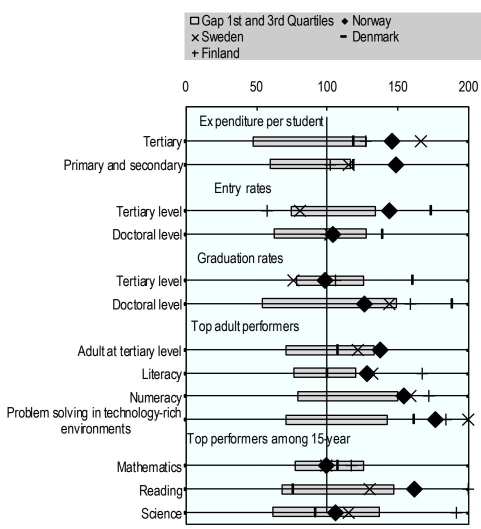
The OECD Survey of Adult Skills Programme for International Assessment of Adult Competencies (PIAAC) shows that on average, adults in Norway are more proficient in literacy, numeracy and problem-solving in technology-rich environments than the average across all participating countries (OECD, 2014a) (Figure 2.15). However, around 10% of 20-34 year-old tertiary graduates in Norway attain only low levels of literacy. Even if Norway scores better than the OECD average in the PIAAC survey, this share is still worrying. The PIAAC survey also identifies issues with respect to the usage of migrants' skills. The survey shows that over-qualification is relatively widespread among the foreign-born population in Norway (OECD, 2014a). This group is 2.5 times more likely to be over-qualified for their job than native- born Norwegians. This rate is higher than in comparable countries such as Austria, Sweden or Germany, and indicates that migrants could potentially contribute a stock of untapped skills.

Despite the overall positive development in the educational level of Norwegians, student skills in primary and secondary education are not outstanding, despite a high level of spending. Norway ranks in the middle on the OECD Programme for International Student Achievement (PISA) test (Figure 2.15), while spending per student on a PPP basis ranks the third-highest in the OECD. Completion rates are weak in many vocation training and upper-secondary education courses.

In addition, there are concerns that the Norwegian system is not fully able to produce skills that are in demand from industry, and which will be even in greater demand as Norway's industrial diversification process and economic transition further develops. Graduates in Norway are concentrated in the fields of the health sciences, social sciences and humanities. Instead, in the natural sciences, agricultural sciences and engineering and technology, its shares are below the OECD median. In particular, the shares of engineering and technology are among the lowest in OECD countries. Graduates at the doctoral level as a percentage of all graduates in the sciences and engineering, manufacturing and construction are also below the OECD average (Figure 2.16).

Figure 2.15. **Education funding and overview, OECD and selected countries**

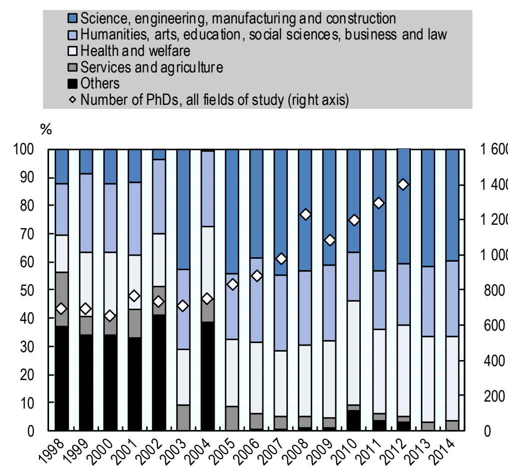
Index of performance relative to the median values in the OECD area (Index median = 100)



Note: 2015 or latest available data. All indicators are presented in indices and reported on a common scale from 0 to 200 to make them comparable (0 being the lowest OECD values and 200 the highest). The median OECD value is represented by the bar at 100.

Sources: OECD (2016c), *Education at a Glance 2016: OECD Indicators*, http://dx.doi.org/10.1787/eag-2016-en; OECD (2016d), *Skills Matter: Further Results from the Survey of Adult Skills*, http://dx.doi.org/10.1787/9789264258051-en; OECD (2016e), *PISA 2015 Results (Vol. II): Policies and Practices for Successful Schools*, http://dx.doi.org/10.1787/9789264267510-en.

Figure 2.16. **Evolution of graduation at doctoral level by field**



Source: OECD (2016c), *Education at a Glance 2016: OECD Indicators*, http://dx.doi.org/10.1787/eag-2016-en and *OECD Education and Skills Database*, http://stats.oecd.org/Index.aspx?/DataSetCode=EAG_GRAD_ENTR_FIELD (accessed 21 April 2017).

Innovation output

Innovation output is difficult to measure for a number of reasons. The indicators available only partly cover various forms of innovation. For example, does basic education play a role in shaping the skills of future innovators and entrepreneurs? The activities of entrepreneurs and their impact on innovation are not easy to measure. Furthermore, entrepreneurial activity consists not only of launching new ideas in the market, but applying new business processes. Other indicators that are generally available and commonly used to measure the impact of innovation input include patent data and scientific publications.

Scientific publications

Norway has seen a substantial increase in the number of its scientific publications in the past decade, and is now included in the group of publication-intensive countries (Figure 2.17). Its output is on a par with Finland's but below that of Denmark, Sweden and Switzerland. Its relative citation impact is also in the upper third of OECD countries, but behind top performers such as the Netherlands, Denmark and Switzerland (Figure 2.18).

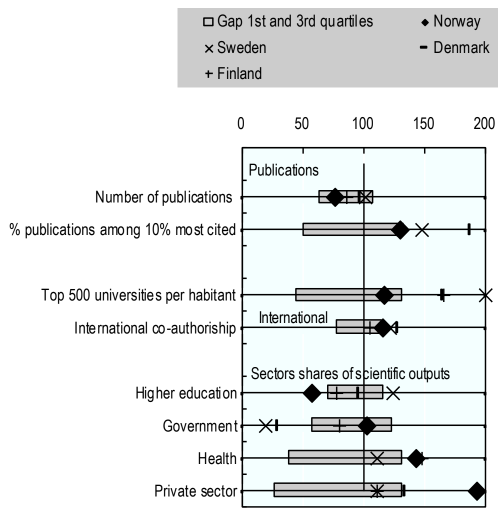
Norway has improved its relative citation impact, which was around the global average in the 1990s, consistently scoring above the average in the period 2000-10. Clinical medicine, physics and materials, earth and environmental sciences and health sciences have high relative citation impact, while biomedical sciences and particularly chemistry have rather low citation impact. This is also the case for several engineering disciplines, including energy sciences and technology. The relative citation impact is highest in the themes of climate change and the environment, but also fairly high in the themes of marine biology and fisheries and aquaculture, and the technological themes of nano- and biotechnology.

In terms of publications per capita, Norway ranks fifth after Switzerland, Sweden, Denmark and Iceland. Comparator countries like Finland or Netherlands come next, while Austria and Ireland lag behind. Quality indicators also place Norway on a high, though not top-ranking position. The relative citation index, for instance, puts Netherlands, Belgium and the United Kingdom in a better position.

International co-operation is crucial for increasing quality in science and innovation. It is even more important for small countries like Norway, which, for instance, represents less than 1% of the world's scientific output. International co-operation in science has continued to increase: around one-third of the Norwegian publications had a co-author from abroad in 1995 (Web of Science data), whereas this percentage increased to 60% in 2014. Norway today has a level of international co-authorship in scientific publications comparable to that of other small countries, for example, Ireland, Finland, New Zealand and the Netherlands, but lower than Switzerland or Sweden (Figure 2.19). The main co-authorships partners of Norway's researchers are located in the United States, the United Kingdom, Sweden and Germany (RCN, 2015a).

Figure 2.17. **Scientific outputs, international comparison, OECD and selected countries**

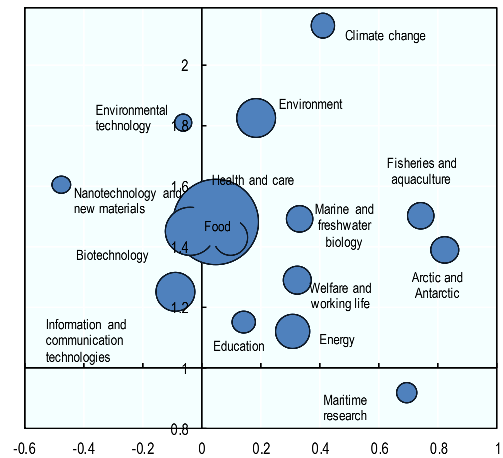
Index of performance relative to the median values in the OECD area (Index median = 100)



Note: 2016 or latest year available. All indicators are presented in indices and reported on a common scale from 0 to 200 to make them comparable (0 being the lowest OECD values and 200 the highest). The median OECD value is represented by the bar at 100.

Sources: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en; ARWU (2016), Ranking of university 2016, www.shanghairanking.com/ARWU-Statistics-2016.html#2 (accessed 20 April 2017); OECD and SCImago Research Group (CSIC) (2016), *Compendium of Bibliometric Science Indicators,* http://oe.cd/scientometrics.

Figure 2.18. **Relative specialisation and relative citation impact**



Notes: The *x* axis shows a relative specialisation index, where a positive number means that the theme accounts for a larger number of Norwegian publications than the world average. The size is proportional to the number of (fractionalised) publication, and citations are calculated using the full counts.

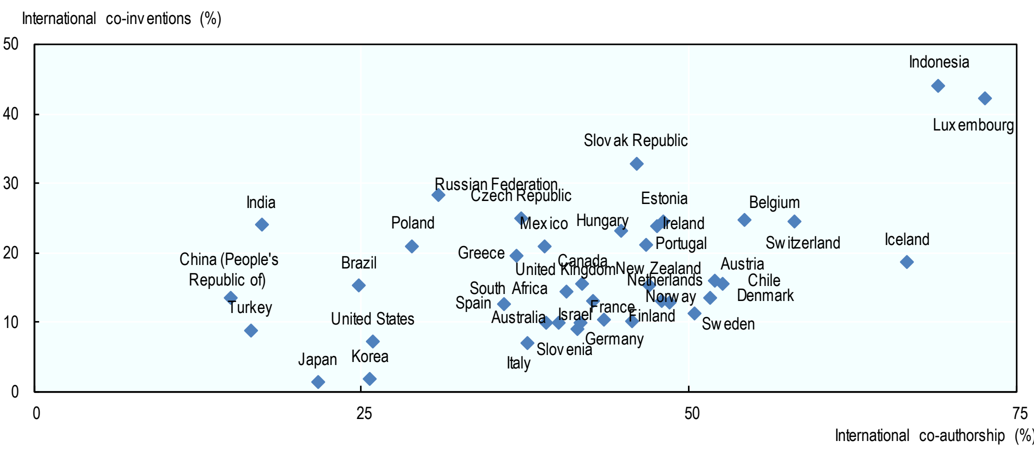
Source: ScienceMetrix (2014), *Bibliometric Study in Support of Norway's Strategy for International Research Collaboration: Final Report.*

Norwegian higher education institutions represent a significantly lower share of the most cited documents than it is the case in most comparator countries. The health sector accounts for a large share of the “best” publications in international comparison. Joint analysis of excellence and leadership information can provide further insights into the source of a country’s highly cited publications. In the United States, for example, 17% of publications are among the 10% top cited, of which 14% had a US-based leading author, while only 3% are led by authors with affiliations abroad(Figure 2.20). Accordingly, the United States has the largest share of top-cited publications led by domestic authors, followed by the Netherlands and the United Kingdom. Other countries with higher overall excellence rates display lower levels of leading excellence because of the higher importance of collaborative articles led by authors from other countries. The institute sector covers both privately and publicly funded research institutes, including SINTEF (*Stiftelsen for industriell og teknisk forskning*), which is the largest research institute in

Norway and one of the biggest in Europe. The institute sector performs a relatively high percentage of R&D compared to other countries.

Figure 2.19. **International collaboration in science and innovation, 2003-12**

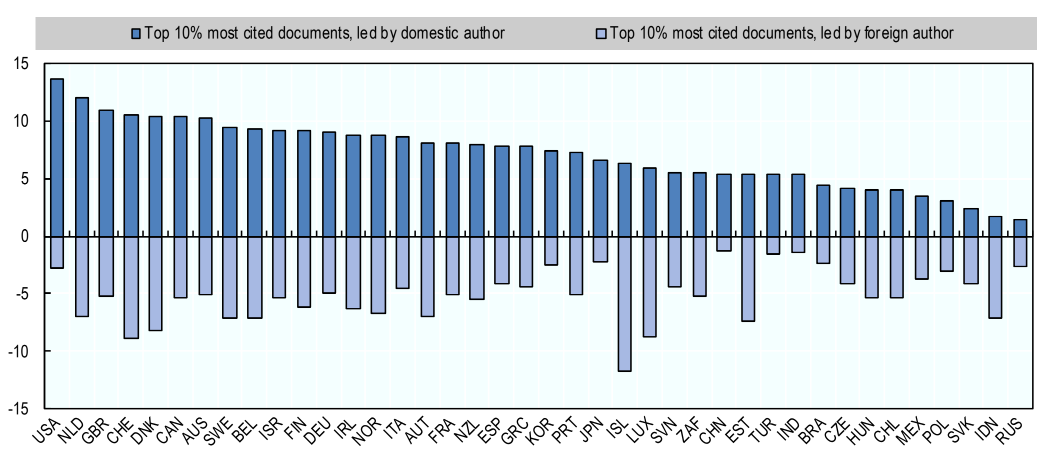
As a percentage of scientific publications and IP5 patent families



Source: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

Figure 2.20. **Top 10% most cited documents and scientific leading authorship, 2003-12**

As a percentage of all documents, whole counts



Source: OECD and SCImago Research Group (CSIC) (2014), *Compendium of Bibliometric Science Indicators 2014*, based on Scopus Custom Data.

The Norwegian research system has considerable degrees of specialisation in fisheries and aquaculture, the Arctic and Antarctic, climate change, maritime, marine biology, environment and climate change. A number of its areas of specialisation, like fisheries and aquaculture, marine biology, environment and notably climate change, also have a relative citation impact well above world average.

These areas also correspond to some of the large Norwegian economic clusters, whose success was partly based on the scientific achievements of Norway's research community. The recent RCN evaluation of Engineering Science in Norway noted that its leading fields, of marine and climate/fossil fuel research correspond with its key industrial clusters (RCN, 2015b). However, the evaluation stated that the country's engineering research was not sufficiently visible in journals with high impact factors.

Another weak point is Norway's lower degree of research specialisation in enabling technologies (ICT, nanotechnology and biotechnology), the basis for some of the most promising emerging industries (OECD, 2016f).

Performance in EU research programmes

Research actors from Norway are quite successful in EU framework programmes (FPs). However, there are a number of other participating member or associated countries, which yields higher participation and success rates.

Comparing the returns from FP7, Norway scores below other Nordic countries of similar size: Norway accounted for 1.69% of EU FP contributions, amounting to EUR 725 million. Denmark and Finland, countries of comparable size, scored higher, with 2.38% and 1.93% respectively (Solberg, 2016, Fresco et al., 2015). The Norwegian EU strategy is specifically concerned with the comparatively low university participation (MER, 2016).

The challenge for Norway appears even greater when looking at the input-output ratio: the Norwegian contribution is tied to the very high and constantly growing national GDP. The EU FPs themselves constitute a second accelerator, as their budget has been growing with each framework. As a result, Norway currently spends more than EUR 250 million annually for the FP participation. This amounts to nearly 8% of total public spending for R&D (Solberg, 2016).

The first two years into Horizon 2020 (H2020, the 8th EU FP 2014-2020) have revealed a similar, and "relatively robust", pattern as in FP7: good but not excellent performance and skewed success rates: while Norwegian actors perform very well in some of the programmes in the societal challenges pillar – like environment, energy, security and notably food security – it does not fare as well on health. The industrial leadership pillar shows strong performance in advanced materials as well as the small biotech programme, but is less successful in the ICT and nanotech programmes. The weakest pillar so far is people, where Norway has a comparatively weak record in ERC and MSCA grants. The statistics (FFG, 2016) show more than 700 Norwegian participations, making up for 1.6% of all participations, which is slightly below what Norway would have if it had an average share. The share of funding amounts to 1.9% of the total funding commitment so far and is therefore higher. The ratio between applications and grants is also a little higher than the average of all countries (15.8% vs. 14.3%).

The record with the prestigious European Research Council (ERC) reveals a continuation of the FP7 pattern, i.e. a low participation share (0.9%) and a very small number of Norwegian universities successfully competing for ERC grants. The University of Oslo alone accounts for half of the Norwegian share of these highly competitive and prestigious grants. The success rate for ERC grants is strikingly low in H2020: while the European average is 12.8%, only 6.7% of the Norwegian applicants are successful (FFG, 2016).

The FP7 final evaluation states that there are three associated countries that managed to win a substantial share of FP7 funding, therefore assessing the Norwegian participation as in principle successful. 19% of all the funds going to organisations in associated countries went to Norwegian participants. 22% were allocated to Israeli actors and 51% to Swiss organisations. Another 10% went to 11 other associated countries (Fresco et al., 2015). However, the Israeli and Swiss success stories are more impressive: Israel because of the active global sourcing policies of its HEIs (also given the scarce competitive national funding) and Switzerland through the sheer numbers, e.g. of ERC grantees in the major universities or the co-ordination of very large international projects.

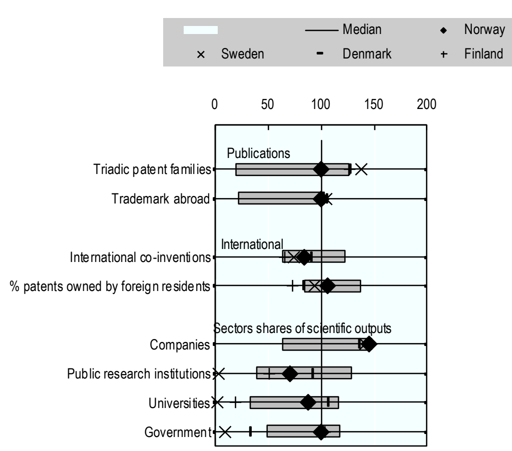
Patents and trademarks and innovation in the business sector

International patenting is used as an indicator of economically valuable technological invention. This indicator is particularly relevant for developed innovation systems. The percentage of foreign inventions (as measured by patents) owned by Norwegian companies (or other actors) is lower than the European average or of innovation-intensive countries like Switzerland, Denmark, Finland, Sweden (Figure 2.21). This may reflect the lower presence of multinational enterprises in Norway compared to other OECD countries.

International trade linkages, as measured by receipts and payments in knowledge assets as a percentage of GDP (Figure 2.22), are lower in Norway than in comparable countries, such as the Netherlands, Israel, Switzerland, Sweden or Finland. Norway's high GDP, however, may in part be lowering its ranking. The average annual growth rate of its international flows of knowledge assets has increased. Revenues from licensing and patents from abroad have been stable in recent years and are lower than in comparable economies.

Figure 2.21. **Inventions, OECD and selected countries**

Index of performance relative to the median values in the OECD area (Index median = 100)

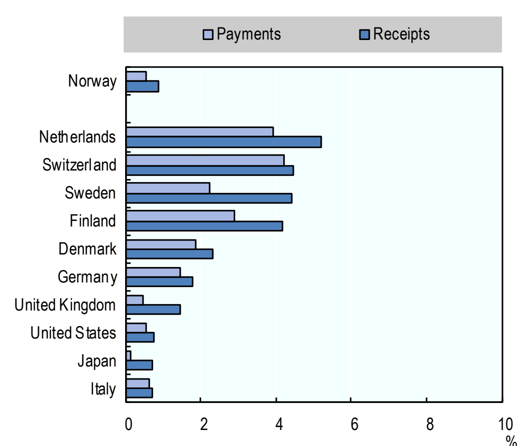


Note: 2015 or latest year available. All indicators are presented in indices and reported on a common scale from 0 to 200 to make them comparable (0 being the lowest OECD values and 200 the highest). The median OECD value is represented by the bar at 100.

Sources: OECD (2015c), *Science, Technology and Industry Scoreboard 2015*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

Figure 2.22. **International trade in knowledge assets, Norway and selected countries**

Receipts and payments, as a percentage of GDP, 2013 or latest year available



Source: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

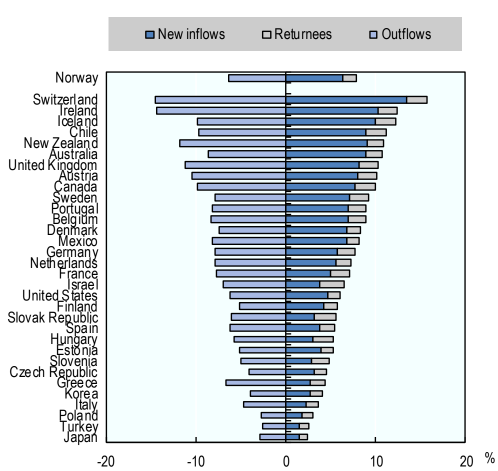
Mobility, attractiveness and performance

Norway is an increasingly appealing destination for scientific activities, which is reflected in the increasing number of Norwegian articles that include the participation of a foreign author, which is the case for 61% of the articles published in 2014 (RCN, 2015a). According to 2013 data, the mobility of researchers appears to have had a positive impact on the quality of its scientific research output.

Figure 2.23 illustrates how researchers who leave the country and then return tend to have a higher citation impact than newcomers or those who do not move. This pattern is certainly a positive development and does not raise the same concerns as in those countries where those who leave (outflow in the figure) are those with the highest citation impact. However, it must be noted that newcomers in other small innovation-intensive countries, such as Switzerland, Denmark or Sweden, have a higher citation impact. This highlights a potential issue: the Norwegian research system’s limited appeal by comparison with other comparable OECD countries. The difference in this respect between Norway and Switzerland is particularly striking.

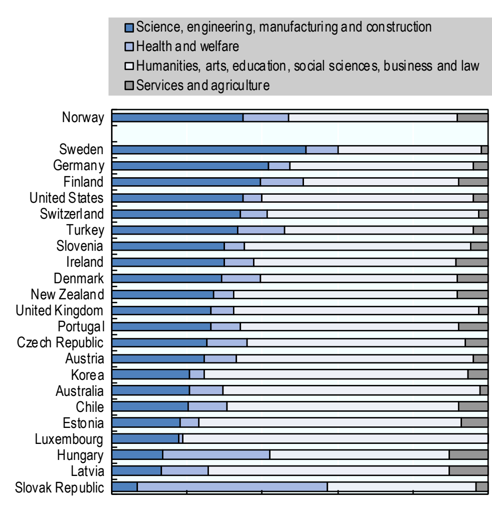
However, according to 2012 data, tertiary education international students in Norway are primarily concentrated in social sciences and humanities (Figure 2.24). Sweden, Finland, Germany and Switzerland are able to attract higher numbers of foreign students in science and technology. More recent data on the distribution of mobile graduates by field show a slightly different picture for Norway, as 39% of mobile graduates are in social sciences and humanities, which is a lower share than in Denmark and Finland, and just somewhat higher than in Sweden (OECD, 2016c).[2] The share of foreign-born PhDs in Norway is lower than in other innovation-intensive small countries (around 30% in Norway, as compared with more than 50% in countries such as Luxembourg, New Zealand, Canada or just below 50% in Austria). Other Nordic countries such as Denmark, Sweden or Finland, however, exhibit lower shares.

Figure 2.23. **International mobility of scientific authors as a percentage of authors, by last main recorded affiliation, 2013**



Sources: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en; OECD, calculations based on Scopus Custom Data, version 4.2015, http://oe.cd/scientometrics.

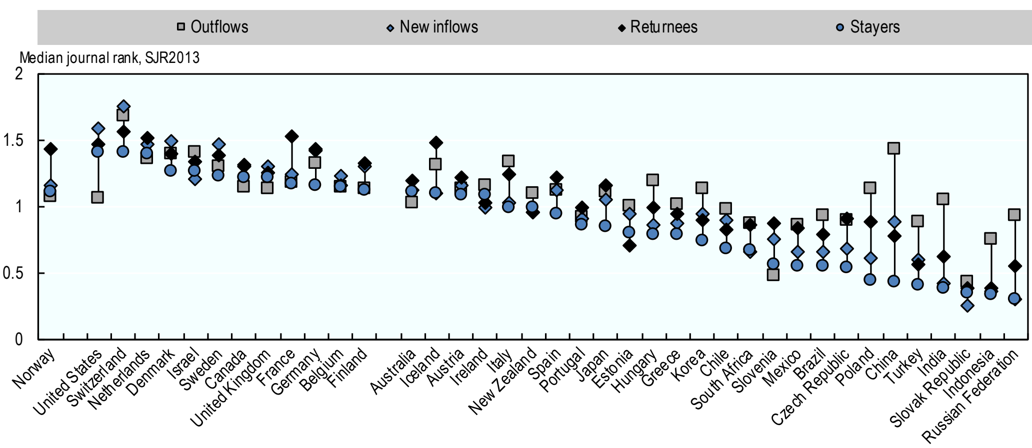
Figure 2.24. **International graduate students in tertiary education, breakdown by field of education, 2014**



Source: OECD (2016b), *Education at a Glance: OECD Indicators*, http://dx.doi.org/10.1787/eag-2016-en.

A proxy for understanding the scientific impact of researcher mobility can also be estimated by calculating the median SCImago Journal Rank (SJR) impact score for each author and mobility profile. SJR is a measure of the scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals in which the citations appear. This is a variant on the eigenvector centrality measure used in network theory. With few exceptions, individuals not changing affiliations (stayers) are more likely to publish in journals of lower "prestige". For countries with lower median citation impact values, outflows tend to be associated with higher-rated publications than their staying or returning counterparts. In the case of Finland, returnees and new inflows score significantly higher in terms of journal impact scores (Figure 2.25).

Figure 2.25. **Impact of scientific authors by type of mobility, median SCImago Journal Rank scores, 2013**



Sources: OECD (2015c), *OECD Science Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en; OECD calculations based on Scopus Custom Data, Elsevier, version 4.2015, and on Scopus journal title list, http://oe.cd/scientometrics (accessed May 2015).

Estimates are based on the comparison of 2013 Scimago Journal Rank (SJR) scores for articles published by scientific authors, and based on the journal rank corresponding to an author publishing in 2013. Only authors with two or more publications are considered. A mobility episode is identified in 2013 when an author who is affiliated with an institution in a given economy in his/her last publication in 2013 was previously affiliated with an institution in another economy. In the case of multiple publications per author in a given year, the last publication in any given year is used as reference, while others are ignored. Authors are assigned a given status from the perspective of the last destination in 2013. They are designated stayers if the main affiliation for both 2013 and pre-2013 correspond to the reference economy. Returnee status is assigned to those who move affiliation into the reference economy, but were affiliated with it in their first recorded publication. From the perspective of the previous economy of author affiliation, individuals can be computed as outflows, and the count incorporated into the data presentation.

Notes

1. In Norway, business owners who work in their incorporated businesses are counted as employees and are therefore not included in data for self-employment.
2. It should be noted that the number of international students in Norway is underestimated, as some international students are granted residency during their studies (OECD, 2014a).

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