Chapter 4.

Enhancing competitiveness and innovation: The Norwegian research institute and business sectors

This chapter discusses the state-of-the-art and potential of public research institutes, universities and business firms to contribute to enhancing competitiveness and innovation capacity in Norway, which is one of the three overarching objectives of the government's Long-Term Plan. The chapter first describes the main features of public research institutes and their performance before addressing the governance and policy aspects affecting this sector. The second part analyses the structural conditions for and performance in commercialising universities' research, and the policy to support these activities. The third part on business firms addresses their innovation capacity using various proxies and a discussion of the innovation policy. The chapter concludes with a synthesis of the achievements to date and remaining challenges for enhancing competitiveness and innovation and present some high-level conclusions.

How successful Norway's economy will ultimately be in making the economic transition will depend on structural changes in its industry and service sectors. This challenge will mean helping its universities, public research institutes (PRIs), as well as the business firms that are closely linked to them, to innovate and contribute to diversification.

Public research institutes in Norway

In Norway, research institutes constitute an integral part of the public research system. They have traditionally been seen to play a "dual role" in the Norwegian system, as an R&D infrastructure supporting industry needs through the provision of knowledge, competence and equipment on the one hand, and as key "intermediators" between firms and universities on the other hand (Gulbrandsen and Nerdrum, 2007).

Key figures and main features of public research institutes

Structure of the institute sector

Norwegian PRIs are diverse and heterogeneous (RCN, 2013) in terms of size, activities, scientific orientation, customers and users, financial sources, legal status and forms of organisation. While some institutes, such as the SINTEF foundation, are large, cross-disciplinary organisations with several hundred employees, most of them are small and specialised. Research institutes in Norway have a long history of undertaking applied research in support of the country's industry and public sector. Research organisations in areas such as oceanography and marine sciences already existed in the late 19th century, but many of the institutes were established after World War II (Gulbrandsen and Nerdrum, 2009). The Royal Norwegian Council for Scientific and Industrial Research (NTNF), created in 1946 and linked to the predecessor of the Ministry of Trade, Industry and Fisheries (MTIF), was instrumental in the creation of several multidisciplinary, industry-oriented research institutes, particularly the Central Institute of Industrial Research (SI), which it owned and funded. SINTEF (Stiftelsen for industriell og teknisk forskning), now the largest Norwegian research institute, was established in 1950 by the Norwegian Institute of Technology (Norges tekniske høgskole, NTH), now part of the Norwegian University of Science and Technology (NTNU).

During the 1950s, a few institutes encountered financial problems and were absorbed by SI and SINTEF. The discovery and subsequent exploitation of Norwegian oil and gas resources in the 1970s, and the ensuing technological challenges and demand for solutions from large companies, ushered in a golden age for many research institutes, which became the main R&D sector until the early 1980s (RCN, 2016a).

The research institutes were "owned" by ministries or by ministries' research councils until the mid-1980s. Since then, most of the institutes have become foundations or non-profit organisations and operate as autonomous entities at arm's length from the government. This legal status differs from that of similar organisations in other countries, such as for instance the Netherlands Organisation for Applied Scientific Research (TNO), which are formally public organisations. The Fraunhofer centres in Germany have a semi-legal status, while the Danish centres (GTS-Advanced Technology Group) are limited companies.

The research institute sector in Norway

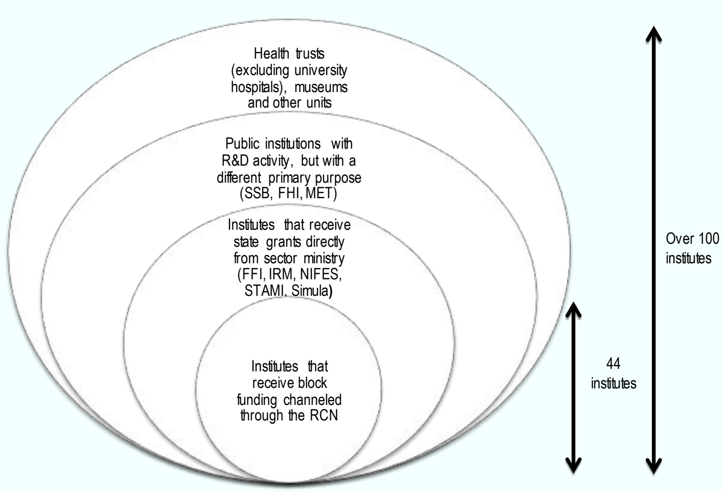
The institute sector in Norway in 2017 includes more than 100 organisations. All of them are entitled to apply for funding in the Research Council of Norway (RCN)'s competitive programmes, but only 44 research institutes can receive public funding from the government through the common block funding system as of 2017. These institutes are divided into four funding arenas reflecting their thematic and sector orientations. Other categories of institutes include publicly owned research centres directly funded by the ministries (such as the Institute of Marine Research), public institutions with significant R&D activity that are also tasked with specific public missions (Norwegian Institute of Public Health, Statistics Norway, Norwegian Polar Institute, etc.). Other entities, such as hospitals, museums and some public sector and private non-profit organisations, are also part of the institute sector at large (see Box 4.1).

Box 4.1. **The different categories of research institutes**

The research institutes that receive block funding (innermost circle) are grouped in four arenas for the allocation of block funding.

- The technical-industrial institutes (TI) undertake research in a broad range of areas. These include industrial processes, materials and chemistry and information and communications technology (ICT), marine technology, energy, petroleum, nuclear technology, geoscience, and technology and society.
- The primary industry institutes mainly meet the needs of the public administration and primary industry.
- The environmental institutes are dedicated to applied research in the fields of the environment, cultural history, social science and natural science. They conduct research and provide expert assistance to the Ministry of the Environment and undertake studies on commission from the ministry.
- The social science institutes undertake basic and applied research on a broad range of thematic areas. They are divided into national and regional institutes. The regional institutes conduct research with a greater regional scope, often commissioned by regional authorities, which have part ownership in them.

Figure 4.1. **The different layers of the research institute sector**



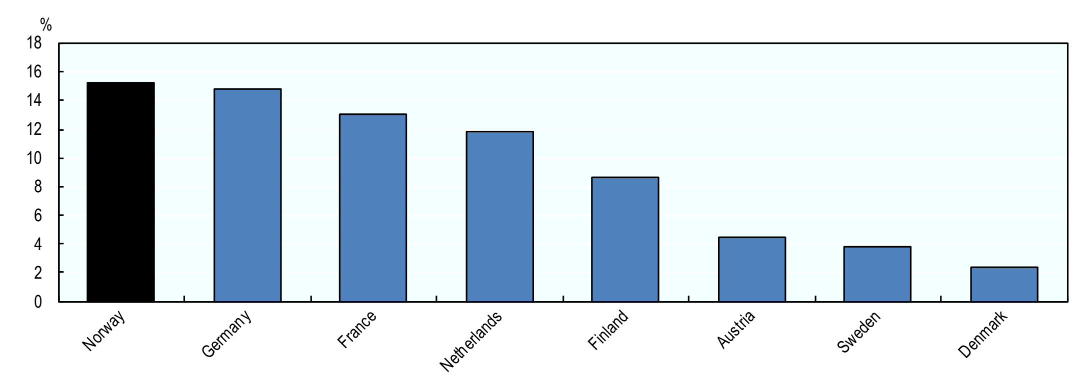
Notes: SSB: Statistics Norway; FHI: Norwegian Institute of Public Health; MET: Norwegian Meteorological Institute; FFI: Norwegian Defence Research Establishment; IRM: Institute for Advertising and Media Statistics; NIFES: National Institute of Nutrition and Seafood Research; STAMI: National Institute of Occupational Health; Simula: Research Laboratory.

The institute sector in Norway is larger in absolute numbers than those of other countries, but more fragmented in terms of the average institute size, with several evaluations noting that they are often too small to achieve critical mass, and that co-operation between them is limited (RCN, 2016a). The size of the largest institute in Norway (SINTEF) is around 2 100 employees, comparable to VTT (with 2 600 employees), Sweden's RISE centres (about 2 400) and smaller than the GTS Network in Denmark (over 4 000) (OECD, 2016c). Around a third of the institutes have less than 40 FTE staff. The social science institutes are the smallest on average (around 40 FTE), and the primary institutes the largest on average (around 300 FTE).

R&D expenditures

With R&D expenditure reaching NOK 13.7 billion in 2015 (around 23% of the total GERD, and an increase of NOK 1.4 million on the previous year), research institutes are key R&D performers for and with industry in the Norwegian system, particularly compared to other countries such as France, the Netherlands and all Nordic countries.[1] These countries have a larger share of R&D-intensive business as well as of R&D by consultancy and other knowledge-intensive business sector organisations (Solberg et al., 2012). This, and the stronger role played by the university sector in other Nordic countries such as Sweden, explains the higher contribution of the government sector to Norwegian gross domestic expenditure on R&D (GERD) compared to other countries (Figure 4.2).

Figure 4.2. **Percentage of gross domestic expenditure on R&D (GERD) performed by the government sector, selected countries, 2014**



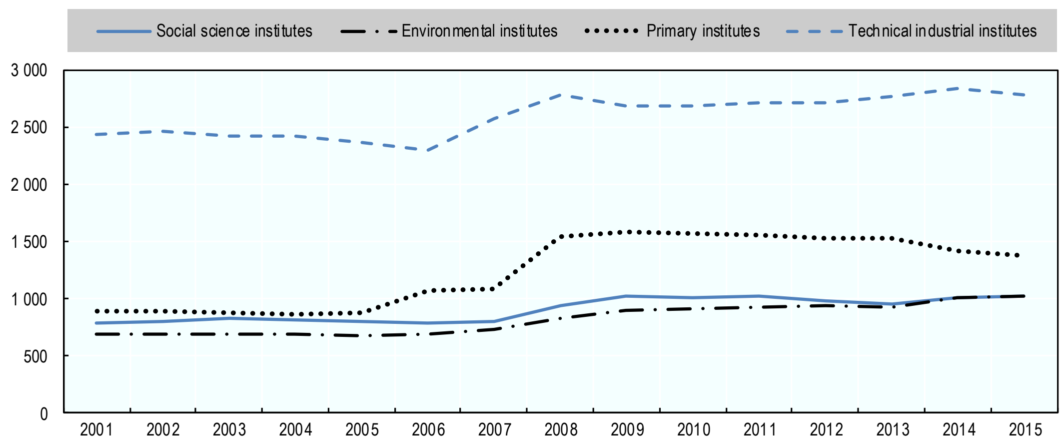
Source: OECD (2016d), *Main Science and Technology Indicators (Edition 2016/1)*, OECD Science, Technology and R&D Statistics (database), http://dx.doi.org/10.1787/db23df7c-en.

Human resources

The institute sector at large had 9 370 full-time equivalent (FTE) R&D personnel in 2015 (of which 71% are researchers). Of these, 6 221 (72% of which are researchers) are in the 44 institutes under the block-funding system guidelines. The number of staff employed by the institutes has remained more or less stable in the last five to six years (see Figure 4.3). This followed a sharp increase in the number of researchers in the period 2006-08, mainly driven by staff increases in the TI institutes and the primary institutes. With 2 486 FTE staff (70% of them researchers), the technical-industrial arena is the largest group, although there are significant differences in size within this arena, between, for example, the SINTEF institutes, with 1 487 total FTE, followed by the Institute for

Energy Technology (IFE) (595), and Norut with only 62. The share of researcher personnel with a PhD in the institute sector at large was 50% in 2015 and 47.6% in 2013. Among the institutes in the block funding system, the share was 60% in 2013, ranging between 74% on average in the primary institutes and 50% in the social sciences institute (RCN, 2015a). Around 37% of the FTE R&D personnel are female, with a higher (50%) and a lower (27%) percentage in the social sciences institutes and the TI institutes, respectively (NIFU, 2016).

Figure 4.3. **Numbers of full-time equivalent personnel in the different types of research institute (public research institutes under block-funding system only), 2001-15**



Source: NIFU (2016) "Key figures for the research institutes", www.foustatistikkbanken.no/nifu (accessed 2 February 2017).

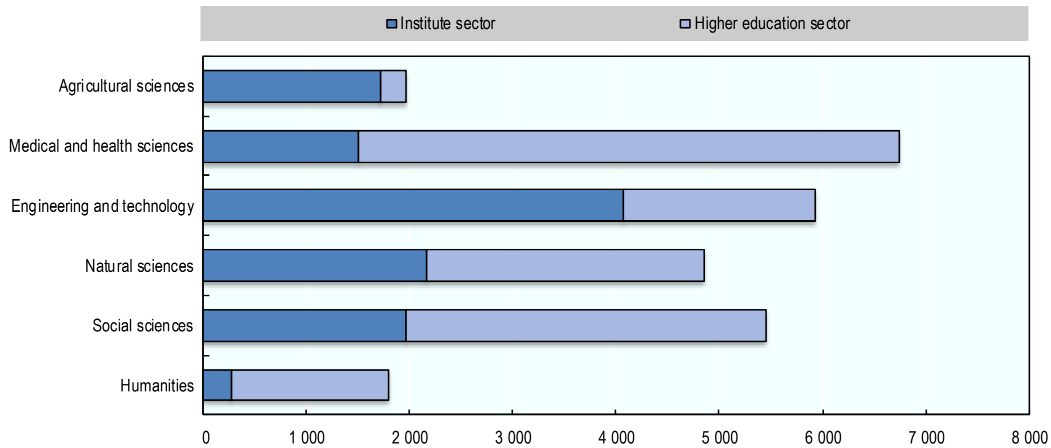
Research specialisation and productivity

The research institutes differ in their scientific focus and orientation, ranging from applied technical institutes to organisations dedicated to fundamental research. However, the majority can be categorised as research and technology organisations (RTOs), i.e. research organisations, partially funded by the state, that undertake research that addresses industrial needs (OECD, 2011).[2] Around 67% of the R&D undertaken in 2015 by the sector has been classified as applied research, 18% as experimental development and 15% as basic research (NIFU, 2016). A recent international comparative study of research institutes (Lekve, 2015) raised some concerns about the small share of fundamental research conducted by the Norwegian research institutes compared to other countries such as Germany, France and the United States.

The sector covers a wide range of disciplines, the most important of which in terms of R&D activity is engineering and technology, followed by natural sciences. Over half of the sector's R&D resources were conducted in these two areas in 2013. Compared to the HE sector, institutes dominate in agricultural sciences and engineering and technology, while most of the research in the humanities and medical and health sciences is conducted at universities and colleges (see Figure 4.4).

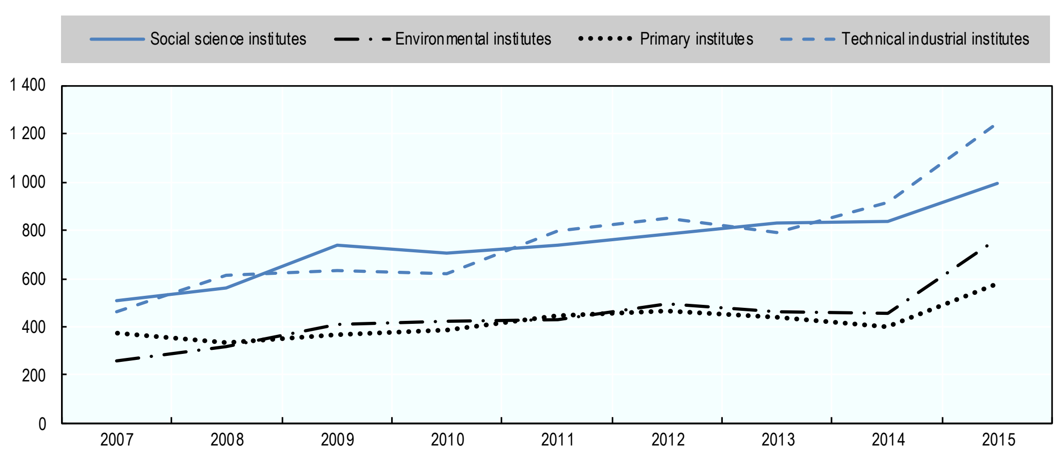
While obviously below the publication performance of HEIs, Norwegian PRIs make a significant contribution to scientific production. Publications in the institute sector rose significantly between 2007 and 2015 (see Figure 4.5). There are significant differences among the institutes in the volume of scientific publishing and their propensity to publish, given their difference in size and in specific balance between basic research and technology development. The social science institutes and the TI in particular have had the largest scientific production in recent years. The SINTEF institutes accounted for 62% of the scientific publishing of all the TI institutes in 2011-13.

Figure 4.4. **Current expenditure on R&D by field of science and sector, 2013**



Source: NIFU (2016) "Key figures for the research institutes", www.foustatistikkbanken.no/nifu (accessed 2 February 2017).

Figure 4.5. **Evolution of scientific publications by institute group (public research institutes under the block-funding system only), 2007-15**



Source: NIFU (2016) "Key figures for the research institutes", www.foustatistikkbanken.no/nifu (accessed 2 February 2017).

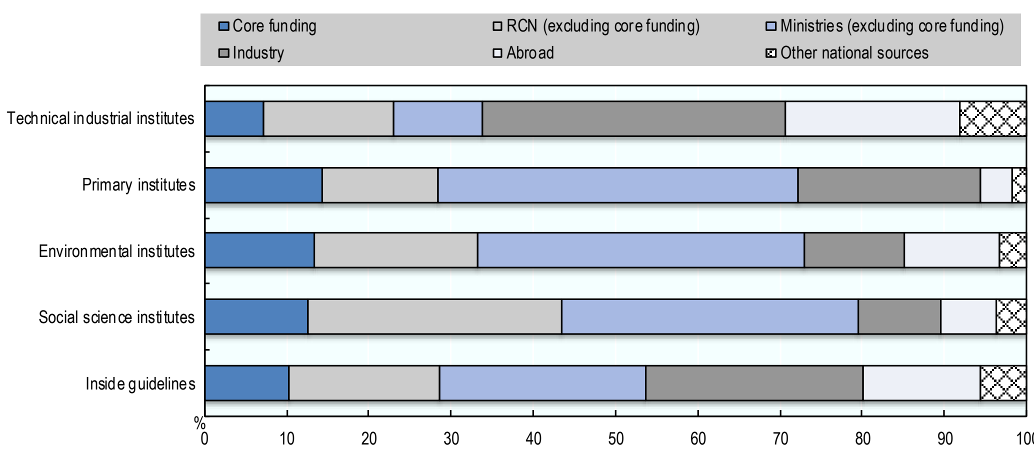
The research institute sector has a relatively high citation impact both nationally, when compared to the HEI and health sectors, and internationally, when compared to its natural benchmarks. Based on publications from 2008-10 (counting citations until 2011), the Norwegian institute sector had a citation impact factor of 1.3, compared to 1.2 for the higher education sector and 1.4 for the hospital sector (RCN, 2015a). Internationally, the government sector in Norway has a comparatively higher citation impact than Sweden and Denmark, on par with Finland, but lagging behind Austria and the Netherlands (see Chapter 2). The citation rate is higher in many engineering subfields, particularly in petroleum engineering and construction and building technology, where the publications of TI institutes are highly cited. Engineering science is not only above the average for scientific quality, but also significantly above the average in terms of the relevance of its research (RCN, 2015c).

Funding of public research institutes

Overall structure of funding of public research institutes

In 2015, approximately 60% of the funding of the institute sector under the block-funding system came from national public funding, of which 11% was core funding, 22% from industry and 12% came from abroad (see Figure 4.6). The proportion of revenue from the various types and sources of funding varies for the different types of institute (see Figure 4.6). For instance, the technical-industrial institutes have the highest proportion of income from business and from abroad, with 37% and 21%, respectively, of the institutes' total operating revenues, and the lowest proportion of revenue from the Research Council of Norway (23%).

Figure 4.6. **Operating revenue of the institute sector by source of funds and funding arenas (public research institutes under block-funding system only), 2015**



Source: NIFU (2016) "Key figures for the research institutes", www.foustatistikkbanken.no/nifu (accessed 2 February 2017).

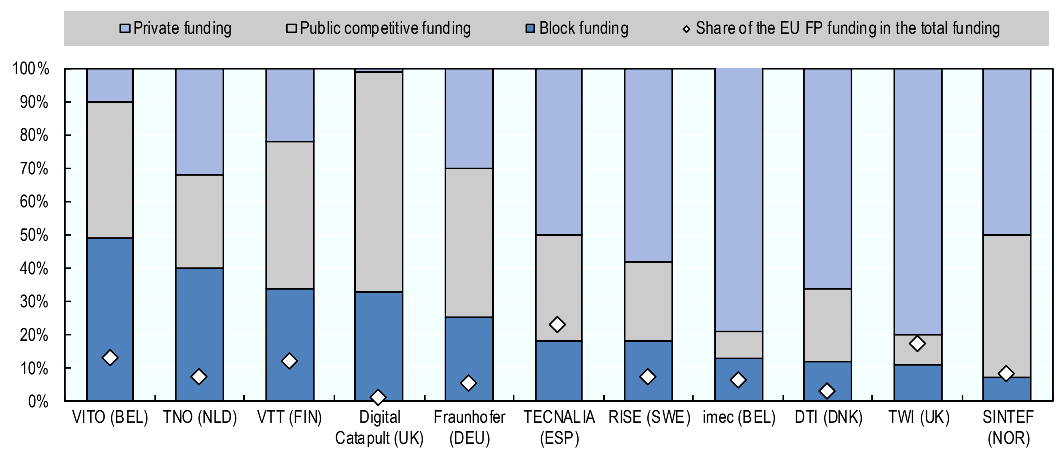
Block funding

The share of non-competitive block funding is around 11% of the institutes' operating revenues (ranging from 6% for TI institutes and around 15% on average for the rest). Internationally, this level of funding positions Norway at the lower end of the spectrum, compared to organisations such as VTT, TNO and Fraunhofer (around 30%) and the Swedish RISE institutes, with around 18% (Figure 4.7).

There is no clear consensus in the literature as to the right mix of funding for the institute sectors and the ideal share of block funding. The Sörlin report (Sörlin, 2006), commissioned by the Swedish Ministry of Industry to study the role of the research institutes, recommended that the institute system maintain a core funding of between

15-20%, to make a significant contribution to the national innovation system. In Norway the Thulin Commission (NOU, 1981) suggested a "golden rule" for financing research institutes consisting of one-third basic funding, one-third strategic funding and one-third contract research. It has also been argued that differentiated levels of core funding may be suitable for different areas and that opportunity may also emerge from linking the funding to the nature of the intended research and to collaboration with other knowledge partners (OECD, 2016c).

Figure 4.7. **Comparison of the structure of funding of selected institutes in Norway and comparator countries**



Source: Data provided by Research Council of Norway (RCN)

Participation in national research funding

More than half of institutes' operating revenue in 2014 is accounted for by the public sector, with the institutes receiving 46% of total public R&D funds, as well as more than 40% of the Research Council's funding (including core funding) (RCN, 2016b). Research institutes show very different levels of dependence on government funding, depending on their mission in the system. The technical-industrial institutes (TI) were awarded 40% of total RCN funding of the institute sector in 2015.

The participation of the institutes is particularly strong in some of the large-scale programmes, such as ENERGIX (42% of the funding goes to the institutes in 2015), PETROMAKS2 (44%), BIONÆR (58%) and MAROFF (68%) (RCN, 2017a). Their participation in the centres of research funding schemes, the centres of excellence, centres for research-based innovation and centres for environment-friendly energy research (SFF/SFI/FME) is also robust. For instance, out of the eight new FME (forskningssentre for miljøvennligenergi) centres created in 2016/17, three are hosted by institutes of the SINTEF group (which is the partner in the other five) and two by IFE. They also benefited from research infrastructure funding to cover infrastructure including advanced scientific equipment, electronic infrastructure, scientific databases and collections, and large-scale research facilities. TI institutes received 17% of the funding (mainly SINTEF) and were involved in almost half of the research infrastructure investment granted during 2009-2013. Most of them involved collaboration with the HE sector, and more than a third with other institutes (especially other TI institutes). Collaboration with industry or the public sector was less frequent. While this funding has contributed significantly to meeting the infrastructure needs of the institutes, it has been suggested (RCN, 2015a) that relatively less attention has been paid in the RCN infrastructure strategy to innovation infrastructure, namely facilities for testing and demonstration.

Revenues from abroad and participation in EU competitive programmes

Revenues from abroad accounted for a total of NOK 1.43 billion in 2015 (12% of the total revenues of the research institutes). The TI institutes receive the most income from international sources, and the primary institutes and the social sciences institutes are the least internationalised, with revenues from international clients accounting for 4% and 7% respectively.

The institute sector performs better than other actors, such as the higher education system, in the FPs. According to the eCORDA database, the institute sector participated in 754 projects under FP7, with a success rate of 27%. With 35% of approved projects and 39% of the funding, the institute had a higher engagement in FP7 than the HE sector (25% and 34%) and industry (29% and 21%). The latest data for H2020 (March 2017) suggest a more even participation, the institute sector accounted for 30% of the retained proposals and 30% of funding, the HE sector for 29% and 31% respectively, and industry for 29% and 28%.

TI institutes alone are responsible for approximately two out of five participations from the institute sector, and receive 57% of the total grant (RCN, 2015a). They also co-ordinate around of half of the projects in which institutes take the lead. Their participation was particularly strong in the ICT programme, and also in the energy and the NMP (nanotechnology, materials and production technologies) programmes.

The SINTEF Foundation is the largest single Norwegian actor participating in EU programmes, with EUR 117 million in revenues from the FP7, far ahead of the University of Oslo and the NTNU. Its participation grew significantly between 2009 and 2013, while it remained more or less stable for the other institutes. However, when compared with international competitors, SINTEF lags significantly behind institutes such as the VTT in Finland or the TNO in the Netherlands (MER, 2013).

According to Åström et al. (2012), the higher participation of research institutes in the EU Framework Programme (FP) can be explained by the less generous national funding conditions of the institutes compared to the HEIs and the hospital sector, which forces institutes to explore all available funding opportunities. The high cost of the institutes, however, limits the number of FP projects they can afford to participate in, since they are not able to charge their full costs. To offset this structural disadvantage in the competitive international context, the STIM-EU scheme was introduced in 2012 (and further revised in 2015) to incentivise the participation of the institute sector in the EU Framework Programme. Institutes receive 33.3% additional funding for each Norwegian krone they receive in funding from H2020. Of the STIM-EU funding, 8% is also set aside to reward institutes collaborating with the business and the public sector, as well as those taking on co-ordinator responsibility.

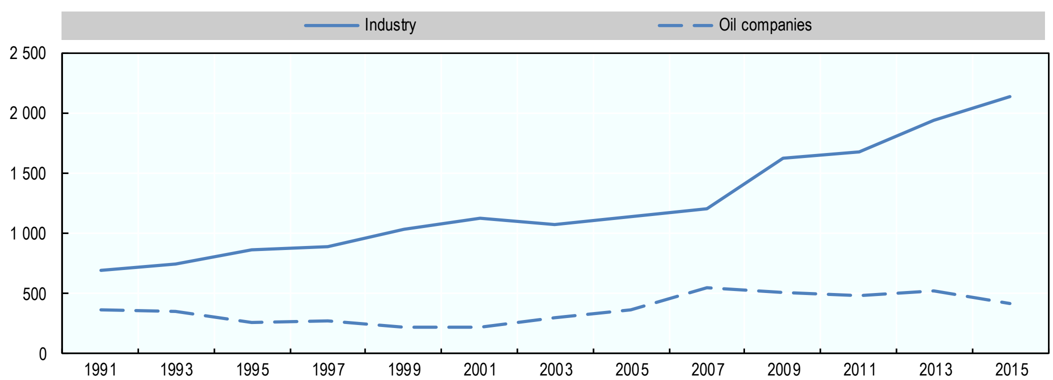
While STIM-EU has been a crucial mechanism for the TI institutes to overcome potential obstacles regarding EU funding, the 2016 evaluation of the TI institutes (RCN, 2016a) noted that more efforts are needed in terms of international co-operation. Many of the institutes have a weak international strategy, and only a limited number of successful institutes can compete at the international level.

Industry funding

The private sector purchased R&D services from the institutes for NOK 2.1 billion in 2015.[3] This accounted for around one-fifth of the institutes' revenues. Income from industry has increased steadily in recent years. The increase in industry funding has been more pronounced for PRIs in the TI arena, which derive the most income from industry (see Figure 4.8). The dependency of the institute on the oil industry has diminished over time, representing only 16% of all income from industry in 2015 (down from 34% in 1991) (NIFU, 2016).

Figure 4.8. **Industry funding of research institutes, 2001-15**

Million NOK



Source: NIFU (2016) "Key figures for the research institutes", www.foustatistikkbanken.no/nifu (accessed 2 February 2017).

Contribution of public research institutes to competitiveness and innovation

Impact of public research institutes on firms' performance

One of the defining features of the Norwegian system is the close relationship between the institute sector and industry. According to the EU's 2014 Community Innovation Survey data, an above-average number of Norwegian firms stated that government, public or private research institutes were the most valuable innovation partners (Eurostat, 2015). Extramural R&D, at 14% of total R&D expenditure in 2014, is also higher than the average value for European countries as a whole (10%) (Eurostat, 2015). Of all the Norwegian businesses reporting R&D co-operation, 29% had co-operated with research institutes. This co-operation was more intensive for larger enterprises (58% of the total number of firms with over 200 employees), manufacturing firms (33%) and firms in other industries (35%) (Statistics Norway, 2017).

Evidence from the Skattefunn scheme also suggests that research institutes are the most important partners for the companies benefiting from the tax credit schemes, with approximately 700 co-operative relationships in 2014 (50% of total collaborations), considerably higher than collaborative activity with universities and university colleges, which accounted for 30% of the total (RCN, 2015b).

Studies and evaluations of the institute sector have generally reported a high level of user satisfaction with the quality of the institutes' services, and significant benefits derived from their use (Åström et al., 2015; Fridholm et al., 2015).[4] Åström et al (2015) estimated that users of the TI institutes experienced 28% higher turnover and 5.5% more productivity compared to non-users and the effect remained positive up to four years after the collaboration. Further, repeat users experienced a higher turnover and productivity gain than one-time users. While TI institutes are highly rated by users for their collaborative skills and adaptability, ratings are lower for their capabilities in market intelligence and the cost of their services (Fridholm et al., 2015).

The dense interaction between industry and research institutes illustrated above can be interpreted as a successful model of collaboration. However, a number of observers have suggested a less than ideal situation of systemic co-dependency whereby institutes are financially dependent on the provision of R&D services to industry and thus mainly undertake research with a short-term industry focus (Narula, 2002; Wicken, 2009), and firms use research institutes to compensate for a lack of, rather than to complement, own intramural R&D efforts (OECD, 2008; Herstad et al, 2010; Solberg et al, 2012).

RCN managed funding programmes mainly focus on fostering collaborations across the different sectors of the innovation system, funding being contingent on the research being done with an external research partner. The flipside of this it that it favours pre-existing relations between incumbent industries and leading research institutes and may disincentivise the building up of internal R&D capacity in firms. For instance, Herstad et al. (2010) point to the danger of funding designed to promote collaborative ventures inducing arm's-length contract R&D with limited impact on the development of knowledge and absorptive capacity of Norwegian firms.

Patents, licenses and spin-off companies

The research institutes also have significant impact indirectly through licensing, patenting and spin-off activities (RCN, 2015a). For the TI institutes, this economic impact was estimated at around NOK 11 billion between 1997-2013 (Åström et al., 2015).

The institutes were responsible for 47 patent applications in Norway and abroad in 2015, and for 31 granted patents (see Table 4.1), up from 33 and 20 respectively in 2014. These numbers do not show significant improvement in the last 20 years, since research institutes applied for between 34 and 71 patents per year during the period 1998-2003 (OECD, 2008). The TI institute and particularly SINTEF Foundation is a major contributor to the overall patent numbers, together with IFE and SINTEF Petroleum. The majority of patent applications have been from the area of instruments, followed by chemistry and electrical engineering.

Table 4.1. **Start-ups, licenses and patents, by institute groups (public research institutes under block-funding only), 2015**

	Number of start-ups	Number of patent applications		Number of patents granted	Number of new licenses sold	Total license revenues NOK 1 000 million
		Norway	Abroad			
Social science	0	0	0	0	0	
Environmental institutes	1	0	4	1	0	100
Primary institutes	3	5	7	4	6	1 823
Technical- industrial institutes	6	16	36	26	176	40 889
Total under Guidelines	10	21	47	31	182	42 812

Source RCN (2016b), *Annual Report 2015 Research Institutes: Summary Report*, www.forskningsradet.no.

There are also big differences across institutes in terms of licensing income. Licensing constitutes a significant source of income for some centres, such as the Norwegian Geotechnical Institute, but a marginal activity for others. Using the number of citations per patent application filed in in 1998 by different categories, it is estimated that the knowledge created by the institutes is of higher quality and impact than the knowledge patented by other Norwegian organisations, particularly in the areas of electrical engineering and instruments (Åström et al., 2015). About 117 companies have spun off from the TI institutes since 1997, although this is a declining trend. Extrapolating from data from a sample of 81 spin-off companies, it is estimated that these companies generated around NOK 10.8 billion in 1998-2013 (Åström et al., 2015).

Despite this positive economic impact, patent, spin-off and licensing activities are a marginal activity for most institutes. The TI institute evaluation (RCN, 2016a) concluded that the institutes could play a larger role in innovation but that they have limited encouragement to do so, in terms of incentives and clear guidelines. Institutes would be more likely to choose publishing than patenting, since the former gives them credit for funding and is less expensive. The evaluation of Norwegian engineering science 2014-15 (RCN, 2015c), in which the institutes play a dominant part, concluded that this field was suffering from a lack of a "visible environment for technology innovation" in areas of engineering research, including support and guidance for spin-off companies, commercialisation of intellectual property rights and incentives for inventors and risk-based financing.

Educational activities

The role of the institutes in doctoral training has increased in recent years. The number of doctoral degrees awarded in which the institutes made a strong contribution increased from 58 to 90 in the period from 2007-15.[5] Note that the total number of degrees awarded has also increased. As a share of the national total, the increase is from 5.6% to 6.2%. Social science institutes are the arena with the highest numbers and growth (35 doctoral degrees awarded in 2015), followed by the TI institutes and the primary institutes.

The Long-Term Plan for Research and Higher Education 2015-2024 (MER, 2014) reiterated the role of the institutes in doctoral training and recruitment, particularly in mathematics, natural sciences and technology subjects, based on the premise that their thematic specialisation and close co-operation with industry and other actors allow them to offer doctoral candidates experience from interdisciplinary and relevant research. The RCN's strategy for the research institute sector from 2014 to 2018 also highlighted the role institutes must play in doctoral education, in order to attract and retain young talented researchers who may not wish to work in higher education. To make this possible, the strategy stressed the need for collaboration between the institutes and degree-conferring institutions, based on institutional agreements that reflect the use of resources and division of labour. In 2016 and 2017 the national budget included additional funding to PhDs for the institute sector. Forty-five fellowships in natural sciences, engineering and technology were announced to be distributed by the RCN, allocated according to criteria related to size but also to R&D expertise and capacity, research quality and experience of doctoral education.

Public research institutes' collaboration with higher education institutions

Research institutes have traditionally had close connections with the university sector. Co-operation takes place through joint projects, co-publications, doctoral projects, joint affiliations as well as other formal and informal means of collaboration. However, concerns have been raised about an increasing overlap between the roles of the institutes and universities. Universities are under mounting pressure to adapt to a "third-mission" agenda of responding to the needs of society. They are thus becoming gradually more engaged in contract research with industry, which is sometimes perceived as unfair competition by institutes.

At the same time, in recent years, the role of the institutes in doctoral education, an activity traditionally performed mainly by the university sector, has grown. Some recent studies (Fridholm et al., 2015) suggest that businesses use research institutes and universities for different tasks and argue that their competition should not be exaggerated. Statistics for the institute sector (RCN, 2015a; NIFU, 2016) indicate that higher education institutes (HEIs) have steadily increased their R&D income from industry in the last year, but the balance of industry R&D going to the institutes and HE has remained stable. The inclusion of industry research contracts as part of the performance-based indicator for the HEI sector may introduce a distorting, thus potentially damaging, bias to existing collaborative relations or prevent new ones from happening. The converging logics, with a growing focus on external industry contracts on the one side and greater pressure for scientific publishing on the other, were found to generate tensions and new challenges for co-operation between the NTNU and the SINTEF (Brother et al., 2015).Finally, the lack of collaboration between institutes has been identified as a concern in several evaluations (RCN, 2002; 2016a). The 2015 TI evaluation exercise (RCN, 2016a) suggests that, outside the SINTEF group, institutes seem to compete rather than collaborate. Only 6% of the institutes' scientific publications are co-authored with other TI institutes, and they only collaborate with each other in 13% of the RCN funded projects (mostly within the SINTEF group).

Governance of public research institutes and support policy

RCN's responsibility for research institutes, and RCN as a funder

The Research Council of Norway has strategic responsibility for the research institutes, a mandate that was reinforced in response to the 2005 white paper (Meld, 2004-05), which asked for its role to be clarified in relation to the institutes. It recommended that the RCN play a role in defining a mix of complementary instruments to ensure the quality and relevance of the sector and promoting a unified policy for the sector. The responsibilities of the RCN include the management of the core funding system, provision of competitive grant funding, performance monitoring and strategic dialogue with the sector (RCN, 2014).

In 2014, RCN published its four-year strategy for the institute sector (RCN, 2014), acknowledging the need to strengthen and develop the role of the institute sector, and committing to support and increase basic funding, support internationalisation, reinforce the institute's role in doctoral education and improve RCN's knowledge base and dialogue with the sector. The mandate of the RCN is not to manage the individual institutes, which are independent organisations, but to ensure their appropriate development, through competitive funding and the management of the block funding system (see below). RCN is in an unusual position of being the main source of funding for the institutes and having the overall strategic responsibility for the sector. In other countries, this is typically done by an umbrella organisation such as the Fraunhofer

Society in Germany, yet RCN is the main source of funding for the sector. RCN therefore has many tasks but the steering power it exercises is limited. The multiple funding programmes – which are vital for many institutes – send a multitude of signals, while the block grants are too small to allow for any real strategic development of the institutes.

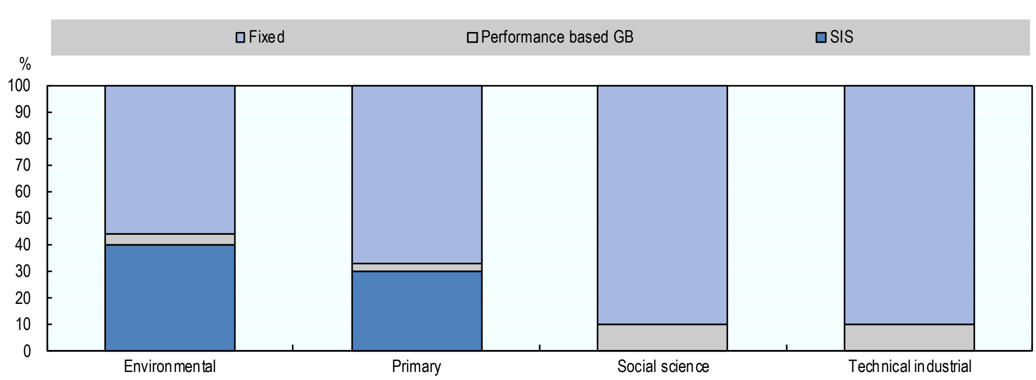
Governance through block funding

The use of the block funding is regulated by the national guidelines introduced in 2009,[6] which were revised in 2013 to include clearer information on eligibility conditions to the scheme. The guidelines sought to address the earlier fragmentation of funding to the institutes, whereby institutes received funding from multiple ministries under different rules and through different channels. Institutional funding had previously been based partly on historical facts and judgement, and partly on funding for strategic institutional programmes (SIP) awarded in competition.

The current model maintains a dual-tier system of basic funding, which comprises a fixed amount and a performance-related amount, plus separate funding for strategic institutional initiatives (SIS) that are funded through dialogue between the institutes, ministries and the RCN within each funding arena[7]. The performance-based component sought to address the market failure associated with excessive market orientation, by rewarding high-quality research and ensuring that that institutes developed long-term capabilities, rather than simply responding to short-term market needs (OECD, 2008). It considers four key performance indicators that are weighted differently: contract R&D (45%), scientific publications (30%), funding from international sources (20%) and number of doctoral degrees completed (5%).

The percentage of the funding distributed on the basis of performance (according to the indicators mentioned above) varies across the different institute arenas (see Figure 4.9). It was initially intended to account for around 10% of the institutional block funding, according to the 2008 guidelines, but at present, the 10% share has only been put into effect in the TI and social science arenas. The performance-based component accounts for a small proportion of the base funding for the environmental and primary institutes, which benefit from the SIS (with a ceiling of 40% and 30%, respectively, of the institute's basic allocation). Despite representing a relatively small incentive, an early evaluation of the performance-based system (RCN and DAMVAD, 2012) suggested that it has brought about behavioural changes, for instance in terms of the greater attention paid to academic publishing.

Figure 4.9. **Distribution of block funding across arenas, 2016**



Source: RCN (2015a), "Technical-industrial institutes. Facts report: Key R&D indicators", www.forskningsradet.no.

The Norwegian system of performance-based research funding of institutes is unusual in the international context. Several other countries have performance agreements that require centres to meet certain targets related to, for example funding, outputs (e.g. publications) and outcomes, for instance in Finland and Luxembourg, and many countries link performance and evaluation results to funding (OECD, 2011). However, monitoring, evaluation and judgement are more frequent forms of assessment (Arnold and Mahieu, 2012). Block funding is to be used for long-term knowledge and competence building, including doctoral degree programmes related to their area of activity, and to stimulate scientific quality, internationalisation and collaboration. In their annual report, institutes need to provide precise information on how they use the block funding, as per the funding provisions in the context of EU research and development and innovation state aid rules, in order to make a clear distinction between economic from non-economic activities. The use of the block funding is thus to a large extent left to the discretion of the institutes.

Other countries have a greater degree of oversight and decision-making power over PRIs' budgets and strategic missions, particularly those whose status as public organisations means that they are more tightly bound to the public sector (OECD, 2011). Steering is greater in Denmark and Finland through the use of performance agreements, and in the Netherlands, TNO is expected to contribute to the priorities set by the "top sectors" policy (Solberg et al., 2012). In Germany, the Fraunhofer centres, on the other hand, have a high degree of autonomy in their use of core funding. Governmental influence is limited to deciding on the setting up of new institutes. Norwegian institutes are similarly autonomous actors operating at arm's length from the government, with less opportunities for direct steering. In Norway, steering is mainly through the quasi-market mechanism of the performance-based component of the base funding and the competitive funding programmes (e.g. by defining thematic priorities). These mechanisms have been considered by some observers to be insufficiently suited to guarantee the institutes' contribution to the government's policy objectives and their ability to undertake the forward-looking, multidisciplinary measures that the industrial transition requires (Solberg et al., 2012, Arnold and Mahieu, 2012).

Further, the performance-based system still only regulates a small fraction of the institutional funding, below the 10% originally stipulated, and not all ministries have been willing to transfer their core transfer to the performance-based part of the funding arena. Strategic funding and dialogue are proposed as additional, more direct, forms of steering, in order to build capacity in institutes and enable them to undertake research that is longer term and more challenge-oriented (see Solberg et al., 2012). The strategic institute programmes now provide institutes with space to undertake strategic research but are in place only in some arenas. Similarly, the evaluation of the TI institutes recommended that a significant fraction of base funding be linked to ongoing innovation contributions, for instance through a panel assessment of these contributions.

Steering through evaluations and consultations

RCN is also in charge of monitoring and evaluation of the institutes. The RCN annually reviews the institutions that are within the basic funding scheme, according to a set of minimum requirements that research institutes must satisfy to qualify for basic funding. Criteria relate to the size of the centres, their publication performance, revenues from national commissioned research, as well as national and international research funding. If an institute fails to meet the requirements, the RCN and the institute engage in discussions regarding necessary structural changes. This involves, in particular, considering whether the underperforming institute should remain independent, join a larger organisation, or merge with other institutions. In recent years, following the trend towards institute sector restructuring seen in other countries (Arnold et al., 2010; OECD, 2011),[8] Norwegian institutes have been given incentives to stimulate mergers across the sector and with higher education organisations.[9] Mergers have been voluntary, encouraged by soft steering and additional funding, rather than enforced, as in the case of Denmark.

Before the 2009 institute funding reform, institutes were evaluated on an individual basis, but since then, evaluations have covered entire arenas. Recent evaluations include the 2012 evaluation of the regional social science institutes, the 2015 evaluation of the environmental institutes, the 2016 evaluation of the technical-industrial institutes, and the evaluation of the social science institutes in 2017. Evaluations are thorough and have been positively received. While arena-level evaluations may have come at the expense of detailed individual feedback (Arnold and Mahieu, 2012), the evaluations include concrete assessment and recommendations for each of the centres.

RCN also supports strategic planning of the institutes, which has so far involved dialogues, soft power and the right to nominate board members in some PRIs (has played a role in nominating board members for around half of the institutes in the block-funding system). The RCN strategy for the institute sector acknowledged that dialogue with the institutes needed to be improved and its role in the governance of the institutes clarified. In particular, RCN's role in appointing members to the research institute's boards has been left ambiguous. The institute sector has not been well represented on the RCN's governing bodies, something that has only recently been addressed. RCN's prerogative to nominate board members is now being phased out.

Conclusions on public research institutes

The institute sector is a key actor in the Norwegian innovation system. It is strong in terms of the quality and relevance of R&D and dominates Norwegian R&D in engineering and technology areas, particularly in areas such as geological engineering, petroleum engineering and ocean engineering, which are also areas of high impact measured by number of citations. By international standards, the Norwegian institute sector is bigger in terms of number of organisations, more prominent in terms of their contribution to national R&D, but more fragmented and diverse, and also comparatively less generously funded in terms of their non-competitive base funding. Despite a low share of basic funding, the institute sector is highly dependent on public sector funding, via competitive funding, commissioned research for the public sector and other income from ministries. However, RCN's efforts and ability to steer the institute's activities have been limited.

An important mission of the institute sector is to supply high-quality research of relevance to industry, the public sector and society at large. The policy governing the institutes has in recent years evolved towards clearer and more precise performance criteria based on research excellence, doctoral training, internationalisation and privately commissioned research. However, the low share of basic funding, as well as the multiple ownership and independent legal status of the institutes, has limited the RCN's capacity to guide the institutes towards particular policy goals, including support for system transition. The steering capacity of the RCN and its principals has as a result been piecemeal, in the form of specific activities and sources of funding, for instance with the STIM-EU or additional PhD funding for some of the institutes. It is questionable whether these efforts are sufficient to support capacity building in the institute sector.

The block funding system has been implemented unevenly across funding arenas, in terms of the use of strategic programmes and the weight of the performance-based component across the different arenas. Ministries have in some cases shown reluctance to transfer their core funding to the performance-based part of their funding arena. A more uniform application of the performance-based component has been called for, increasing its weight in arenas that have the lowest share. The 10% share already seems to shape institutes' incentives towards activities such as publishing. A higher share could have a distorting effect on the institutes' activities and exacerbate existing tensions between, for instance, efforts towards publishing and industrial engagement.

Table 4.2. **Summary of inputs and outputs of the public research instutute sector**

Main elements of diagnostic
Research institute sector inputs
– Among the 100 organisations in the PRI sector in 2017, 44 research institutes, accounting for 70% of the total R&D in the sector, receive block funding.
– The sector in Norway is comparatively larger than in other countries in terms of number of research institutes, but also more fragmented in terms of the average institute size.
– R&D expenditures of the PRI sector increased at a slower pace than those of universities and business companies, which now account for a larger share of the GERD.
– Research institutes account for a larger share of R&D expenditures than in most comparator countries and all Nordic countries.
– Research institutes in Norway are specialised in applied research for industry and the public sector and conduct relatively less fundamental research.
– The sector's share of block funding is significantly lower (11% of total funding) than in most comparator countries, especially for TI institutes (6%).
– Income from industry has increased, despite the stagnation of revenue from the oil and gas sector.
Research institute sector outputs
– Publications of the institute sector have significantly increased between 2007 and 2015.
– The scientific production of PRIs, as well as their productivity per FTE staff remain lower than the HEIs'.
– The citation impact of PRIs, compared to the HEI and health sectors in Norway and to the institute sector in Sweden and Denmark, is high.
– Data over the two last decades do not show a significant increase in the number of patents applied for by PRIs.
– Despite their positive economic impact, patent, spin-off and licensing activities remain a marginal activity for most institutes.
– The role of the institutes in doctoral training in recent years has been increased, in line with the guidance of the Long-Term Plan for research and higher education 2015-2024 and of the RCN's strategy for the research institute sector 2014-2018.
– Consolidating the use of PhD training could help institutes develop and renew capabilities.

RCN's strategy for the institute sector suggested that more funds be channelled through the competitive calls for research projects and away from direct funding from ministries. However, short-term competitive projects are already a big component of institute funding and unlikely to lead to long-term capacity building. The different calls and programmes come with a multitude of signals that can distort the developmental paths of PRIs. Institutes often cannot choose where to apply for grants but have to hunt for every opportunity. The low block funds, and the varying signals and multiple requirements of RCN programmes, often preclude building strategic portfolios in PRIs.

Levels of block funds are too low, given the obvious need for more strategic research agendas and new customer groups. Greater efforts are called for, both through more block funds without strings attached, and in the form of strategic funding schemes for long-term, cross-sectoral, multidisciplinary projects that can support Norway's industrial transition. For instance, an instrument similar to, albeit better resourced than, the old Strategic Institute Programmes in place before the 2009 reform, could give institutes a platform from which to develop long-term capacity.

The PRI sector is therefore in need of ample programme and project funding to secure its short-term future and has difficulties consolidating and growing, in size, ambition and new markets. RCN allocates more than 40% of its budget to the institute sector and has strategic responsibility for it. However, it cannot boldly help this sector to grow in size, find new customer groups and reduce the existing systemic co-dependencies between institutes and industry. (Short-termism, outsourcing of industrial R&D, "clubs" of incumbent companies with recurrent collaboration are among the possible drawbacks.) A first step to alleviate this co-dependency would be to increase the room for manoeuvre for the PRIs by raising the amount of block funding (in part unconditional, in part linked to criteria and incentives, see below). The current transition imperative for the Norwegian economy is an additional argument for such a step.

The institutes play a key role in the competitiveness of the Norwegian industry. The institute sector has a very close relationship with industry, and many companies outsource a significant share of R&D to the institutes. To some extent, the institutes act as substitutes for these firms' internal R&D. Collaboration with institutes has been found to add significant value to firms' innovation and profitability. This symbiotic relationship means that the institute sector can potentially play a key role in the transition process. Recent evaluations of the research institutes have identified a number of potential barriers preventing the institutes from effectively delivering on this role. Firstly, their financial situation may not be robust enough to build existing and new technological competences. Their low base funding means that institutes do not have sufficient space to develop and upgrade capacities. Further, the evaluation of TI institutes noted a certain inertia in the institutes' activities. They appeared to be more focused on well-honed methods and activities (exploitation) than on exploring new market and technological opportunities. Most of the users of institute services are returning clients, which may reduce the institutes' capacity to learn from their clients and engage in strategic long-term thinking. The TI institute's clients rated them lowest for their market intelligence, noting a shortage of staff with industry background and a distinct disinclination to engage in forward-looking, strategic dialogues, with potential new clients and other partners. Some institutes thus face a tension between staying in business and thinking strategically, which may constitute a barrier to industrial diversification.

The institutes' relationships with universities has increased significantly. There is nevertheless room for greater collaboration, particularly in doctoral education. Collaboration agreements can be reinforced for the delivery of doctoral training, particularly in disciplines such as health, natural sciences and engineering subjects. The RCN strategy for the institute sector 2014-18 emphasised the need to identify and address barriers to co-operation between the research institute and HEIs.

The combination of a competitive funding system around collaborative projects, the low innovation intensity of Norwegian firms and the relatively low base funding of institutes suggests that the system may be locked in existing relationships between incumbent industries and leading research institutes, rather than opening up opportunities for renewal and competence development in new and relevant areas. An increase in the base funding should be considered, at least for institutes with good performance that have a low share of block funding. These additional and, in part, unconditional funds should be linked to the institutes that demonstrate their ability to contribute to the industrial or societal transition. A more strategic approach could be based on dialogue (including in the context of possible mergers). Performance agreements (for example using indicators associated with knowledge transfer and industrial diversification activities) would also help advance this agenda. International experience shows that enhancing collaboration with universities and consolidating the use of PhD training – as suggested in the LTP – can also help the institutes develop and renew their capabilities. Intervention on the supply side could help shaping incentives for research institutes to undertake research directed towards future needs and the needs of innovating firms. Demand-side schemes like innovation vouchers, which have been little used, could encourage firms to reach out to research institutes for the first time.

The Long-Term Plan stresses the need to support innovation, start-ups and commercialisation based on research. Some institutes' good performance in terms of generating patents and licenses has been found to have a strong positive, indirect economic effect. Licensing, patenting and spin-off are a relatively marginal activity for most institutes, which do not have the necessary incentives and clear guidelines to encourage them to pursue them. Overcoming potential barriers for research institutes' knowledge-transfer activities and supporting them with better guidelines and additional funding should be made a priority. This would include dedicated commercialisation funds, and/or the inclusion of knowledge-transfer indicators, in the performance-based funding system (including, but not limited to, commercialisation).

Infrastructure is key for the institute sector, requiring significant investment in the acquisition, maintenance and upgrading of large-scale research infrastructure, such as the Ocean Space Centre to be established in Trondheim, as explicitly referred to in the Long-Term Plan. Besides infrastructure for research, it has been suggested (RCN, 2015a) that relatively less attention has been paid in the RCN infrastructure strategy to innovation infrastructure, namely facilities for testing and demonstration. In order to support industry access to such facilities, the 2017 budget allocated NOK 50 million to a new programme ("Norwegian Catapult"), to develop multi-user facilities for testing, piloting, visualisation and simulation. Siva will administer the scheme in collaboration with other funding agencies.

In contrast to the largest and best-performing institutes, the fragmentation and relatively small size of many institutes is a constraint. This holds them back from competing in international arenas and developing quality and competence. A number of voluntary mergers have taken place in recent years to build critical mass in PRIs, in some cases involving the merging of two or more institutes, and in other cases merging with HEIs. Restructuring is ongoing and likely to increase in the future. In addition to encouraging formal mergers of institutes, there is scope for generating greater synergies between them.

Norwegian research institutes have traditionally maintained close connections with the university sector. They co-operate on joint projects, co-publications, doctoral projects and through joint affiliations, and in other formal and informal ways. However, the functions of universities and applied research institutes increasingly overlap, with universities extending their role towards applied research and consultancy activities directly with industry, and the institutes becoming more actively engaged in education activities. There are many instances of synergies between institutes and universities, sometimes leading to mergers or to close partnerships such as the one between NTNU and SINTEF. It could be argued that the activities and areas of specialisation of the institutes and universities are different and complementary rather than in competition, and that industry appears to use institutes and universities for different activities and purposes. There is thus no evidence that this overlap is significant and problematic at present. However, maintaining clearly defined roles and responsibilities between the two sectors that encourage collaboration between HEIs and institutes is important.

Table 4.3. **Achievements and challenges related to the public research instutute sector**

Achievements and progress	Remaining challenges
Public research institutes' collaborative activities	
– A close relationship between Norway's institute sector and industry has been developed, as indicated by a survey of firms, public research institute evaluations and Skattefunn monitoring data. – Collaboration with institutes has had a positive effect on firms' economic performance. – RCN incentivises collaboration with industry in its programmes. – While the overlap between the roles of the institutes and universities has raised some concern, the balance of industry R&D going to the institutes and higher education has remained stable in recent years.	– Dependence of PRIs on industry contracts tend to restrict them to short-term research. – Collaboration with PRIs appears too often to be a substitute for, rather than a complement to, firms' in-house research (although this is difficult to measure). – Questions have been raised over PRIs' contribution to the emergence of new areas. – Insufficient collaboration between institutes
Governance and strategic steering of PRIs	
– The specific guidelines governing the use of the block funding by the 44 institutes makes it possible to enhance the consistency of rules and obligations across the different types of institutions. – Strategic institute initiatives (SIS) complement the basic allocation in the primary and environmental institutes and allow the development of long-term expertise in the institutes' fields of research. – Despite its modest share of the block funding, the performance-based component for PRIs has proved effective in influencing institutes' behaviour.	– Norwegian PRIs are subject to a lesser degree of oversight and decision-making power over their budgets and strategic missions than most of their foreign counterparts (in particular through performance agreements). – The Norwegian PRI funding model's ability to finance the forward-looking and multidisciplinary activities needed for the economy to make a major transition remains in some doubt. – RCN has limited capacity to strategically guide public research institutes. – There are few incentives and demand-side schemes such as innovation vouchers, to encourage firms to reach out to research institutes for the first time.

Commercialisation of research in universities

Universities and other HEIs are expected to play multiple and ever-increasing roles in innovation systems, in addition to the traditional roles of research and teaching, including the contribution to the economic and welfare development of their surrounding regions. The third mission of universities is increasingly acknowledged and supported in Norwegian universities and colleges, and the Long-Term Plan emphasises the contribution of research and education to societal and economic development.

Governments in most OECD countries actively support the "third mission" of universities in addition to teaching and research in order to stimulate and strengthened the relationships between the actors in the "knowledge triangle". For instance in England, the Higher Education Innovation Fund (HEIF) supports universities to work with business, public and third-sector organisations.

In Norway, industry funding stands at 4.1% of R&D performed in the HE sector (HERD), which is moderate by international standards. Variation in industry share of HE R&D can be explained by a range of factors, including the size and organisation of the HE sector and differences in core institutional funding. According to the 2015 Norwegian innovation survey, around 5% of all firms reported having links with HEIs. Considering only firms with innovation activity, this ratio goes up to 13% and 33% in the case of firms involved in innovation collaboration. HEIs are also frequent research partners in Skattefunn funded collaborative projects, with a participation of around 30% of the collaborative Skattefunn projects in 2014, after research institutes (50%) (RCN, 2016a).

Regulatory and policy reform of research commercialisation in universities

A series of legislative changes in the early 2000s in Norway gave universities a mandate to develop the incentives and framework conditions for commercialisation of academic research. The so-called professors' privilege was removed and universities were required to promote the diffusion and application of research, and become more active in commercialisation. Universities have since then increasingly set up technology transfer offices (TTOs) and other infrastructure, such as science parks and incubators, to link up with industry. Similar legislative changes took place in Germany, Austria, Denmark, Norway and Finland during the same period, while Sweden has maintained its professors' privilege. It is unclear, however, whether these changes have led to increases in academic patenting. Some studies have found a sharp decline in the quantity of start-ups and patenting by Norwegian university researchers (Hvide and Jones, 2016).

Changes in the governance structures of universities have also been introduced to strengthen the links between universities, industry and the broader society. For instance, universities have been mandated to incorporate in their governing boards external members representing society and working life and establish "Councils for Co-operation with Working Life" (RAS) tasked with ensuring relevance in education (see Chapter 3).

Norwegian universities are increasingly expected to play a strong third-mission role. There is no dedicated separate government funding stream for universities to support third-mission activities as exists for instance in the United Kingdom. However, since 2017, the performance-based funding system includes an indicator for contract research and sponsored funding (grant-supported activities). No similar incentives exist for staff to engage in research commercialisation (patents, spin-outs, licensing income) in external engagement related to teaching (internships, engagement of external actors in the curricula, continuous education) or outreach activities. In the framework of a pilot initiative, some universities are encouraged to develop their own approach through institutional performance agreements negotiated with MER. Norwegian universities thus differ in the extent to which they see themselves as a regional, national or even international institutions (Borlaug et al., 2016, see Box 4.2).

Despite the lack of an explicit policy for the regional mission of universities, a number of instruments encourage the development of collaborative research links between universities and regional stakeholders, including the Norwegian Clusters programme, the Programme for Regional R&D and innovation programme (VRI) and the centres for research-based innovation (SFI). However, these initiatives tend to benefit those regions with more dense industrial configurations, populated with users more able to co-fund research rather than those regions arguably most in need of regional investments (Benneworth et al, 2017).

Contribution of universities to research commercialisation and economic development

Evaluations of the system of research commercialisation in Norway suggest that, while the system is still immature and fragmented, a fairly well-functioning system of commercialisation has developed around several universities, supported by more professionalised TTOs and a more effective system of project selection and entrepreneurship and funding support (Borlaug et al., 2009; Spilling et al., 2015;). Over time, many universities, institutes and hospitals have established joint TTOs or merged existing ones to encourage critical mass and specialised expertise (for instance in Oslo and Tromsø). *Bergen Teknologioverføring* (BTO) is unusual in this respect since it was already set up in 2005 to serve all research institutions in Bergen (including the hospitals, the universities and the Institute of Marine Research), which makes it a long-standing actor and key intermediary in the regional innovation ecosystem of Bergen.

Box 4.2. **Different engagement profiles of Norwegian universities: UiT and NTNU**

The Artic University of Norway (UiT) is an example of a regionally oriented university. UiT is a multi-campus universities located in Nordland, Tromsø and Finnmark which emerged out of the merger of the University of Tromsø with the University College of Tromsø. In 2009, it developed a central strategy encompassing the missions of research education and innovation and aimed at contributing to the economic, cultural and social development of the High North. The strategy has consisted of several pillars, namely the development of research-based and innovative education of relevance to industry and working life; commercialisation and research and innovation collaboration with applied research institutes and industry; research in areas of relevance to the region (such as energy production and the sustainable use of marine resources, as well as areas related to public health and welfare services). Initiatives geared towards increasing co-operation with industry and working life have included the creation of a Council for co-operation with working life (RSA), the centre for career and working life and the creation of "industry professor" positions held by people from industry to contribute to education activities. It also offers entrepreneurship education offered through the Masters programme in Business Creation and Entrepreneurship at the School of Business and Economics, which includes teaching from academic staff and business sector representatives, as well as practical training in developing entrepreneurial ideas or innovation projects. Commercialisation support and incubation services are provided by Norinnova Technology Transfer (NTT), which is the TTO for UiT and the University Hospital of North Norway (UNN), which a particular focus in areas such as marine biotechnology.

NTNU has adopted a different strategy based on national and international research. NTNU is one of the more traditional universities in Norway, as well as the largest university with nearly 40 000 students and a leading institution for technology development in Norway. Knowledge transfer is an integral part of NTNU activities, with significant investment in infrastructure for commercialisation of research and entrepreneurship education. This commitment to entrepreneurship and innovation is embedded in its governing structures, which include a pro-rector for innovation alongside a pro-rector for education and a pro-rector for research. Instruments and structures directed at co-operation with industry include the co-operation forums for the development of educational programmes with industry; Technoport, an initiative aimed at providing meeting arenas for industry, researchers, students investors and entrepreneurs. They have also developed a range of entrepreneurship education initiatives, including a master programme in entrepreneurship, and a number of mentoring (e.g. Spark NTNU), idea contests (such as AppLab), internships in the TTO for commercialisation projects. Technology transfer and incubation is supported by the NTNU Technology Transfer (TTO), as well as the Innovation centre at Gløshaugen and the NTNU Accel providing support for knowledge-based start-ups.

Source: Borlaug, S. et al. (2016), "The knowledge triangle in policy and institutional practices: The case of Norway", www.nifu.no/en/publications/1424180.

Further, while scientists appear to have a more positive attitude towards commercialisation than was the case in the past, missing incentives for commercialisation are preventing a more active engagement with industry. Against this backdrop, Spilling et al. (2015) recommended a better integration of commercialisation activities within HEIs broader activities and institutional strategies, a better alignment of expectations regarding commercialisation and collaboration with industry with the funding agreements of HEIs, and a better system of reporting of commercialisation activities of universities.

Beyond commercialisation activities, the contribution of universities to economic development occurs through a wider range of mechanisms and actors. In fact commercialisation of formal IP is a relatively infrequent form of interaction compared to other means such as consultancy and training activities and Norway is no exception to this. A recent survey (Thune et al., 2014; 2016) reported that a relatively small percentage (7-8%) of academics are involved in research collaboration with private industry, of which only 13% were involved in commercialisation activities. Collaboration was by contrast more extensive with the public sector and with hospitals (30% and 17% respectively). Exchange mainly happened through dissemination of research to user groups and the general public (78%), training (including continuing education and training of employees outside campus) (59%) and research collaboration (32%). While 44% of surveyed staff participate in industry-oriented continuing education programmes, particularly in state university colleges, relatively little attention has been paid to continuing education as mechanism for engagement (Borlaug et al., 2016). The LTP seems to also neglect the innovation-education forms of knowledge exchange in addition to traditional forms of technology transfer. The recent white paper on industrial policy (MTIF, 2017), by contrast stress the importance of vocational education and the need to strengthen the college sector.

The differentiated role that university colleges play in commercialisation and knowledge exchange in their regions has tended to receive relatively little attention (Herstad and Brekke, 2012). Compared to universities, university colleges have a more extensive interaction with regional private and public actors, and are more active when it comes to offering industry-oriented continuing education (Spilling et al, 2014).

As previously mentioned (see Chapter 3), the current focus on world-class research excellence in Norway may come at the expense of local relevance, with universities potentially changing their research, teaching and engagement activities in order to fulfil the performance expectations associated with the current funding model. National level policies on HE teaching, research and administration – driving mergers and increased centralisation – may be unintentionally crowding out the regional engagement activities of universities in Norway, for which there are no incentives (Benneworth et al., 2017) and may endanger the traditional role of regionally oriented universities located in more peripheral areas.

Policy to support research-based innovation

The Long-Term Plan emphasises the need to facilitate research-based new businesses and commercialisation of public research results, and announced the strengthening of the FORNY (Commercialisation of R&D Results) programme. FORNY is the main support mechanism for commercialisation of public funded research in Norway. It provides funding mainly to TTOs and research institutions (universities, colleges, research institutes and university hospitals) for infrastructure activities and commercialisation projects. FORNY was reorganised in 2011 with a clearer focus on creating value and stricter selection criteria. The revised FORNY2020 programme focuses more on proof-of-concept project funding and less on basic infrastructure funding. FORNY2020 also includes a scholarship programme of NOK25 million to promote student entrepreneurship.

Another mechanism for enabling collaboration between innovation and research is the Centre for Research-based Innovation (SFI). Modelled after competence centre schemes found in other countries such as Australia, Sweden and the United States, the Centres for Research-based Innovation (SFI) scheme was introduced in 2007 with the aim of supporting business sector innovation through collaboration between research-intensive firms and research institutions. They receive substantial funding (around NOK 10 million per year from RCN, match funded by partners) over a period of up to 8 years to research groups that collaborate with public/industrial partners. SFI can be hosted at a university, university college, research institute or an enterprise.

Thirty-eight centres have received SFI status so far, 14 during the period 2007-15. Seven were established in 2011, and 17 in 2015. One SFI has been hosted by an industry partner (Microsoft Development Center Norway), 15 by research institutes, 16 by universities, 4 by university hospitals and 2 by university colleges. These tend to be strong research organisations. For instance NTNU has hosted ten SFIs (seven currently) and is a partner in eight of them. SINTEF has hosted 6 SFIs. More than half are hosted by SINTEF or NTNU, or have either one as research partner.

The mid-term evaluation of the first centres (RCN, 2010) found the SFI to be a very important tool for stimulating of research-based innovation. It pointed to some areas for improvement, including a more active participation of all partners in the generation of new projects, greater international visibility, the need for an international scientific advisory board and a development plan for PhD students.

Conclusions on research commercialisation

The LTP stresses the importance of knowledge sharing across the business community, academia and investor groups through strengthening the commercialisation system. The last decade has witnessed sustained efforts towards developing a commercialisation infrastructure, particularly the establishment of technology transfer offices, science parks and incubators. As a result, a fairly well-developed system of commercialisation has emerged, and the third mission is increasingly acknowledged and supported in universities and colleges. However, the third mission is not integrated in the university-wide strategies except in a few cases, most notably NTNU, where innovation and knowledge transfer is deeply embedded in its governing structures.

Norway does not have a comprehensive mechanism for incentivising knowledge-exchange activity of its universities. Support for commercialisation support has an implicit linear model of knowledge transfer that neglects the diversity of knowledge-transfer modes (e.g. through training and continuing education), actors (not just in industry but also in the public sector and hospitals) and universities (different roles of universities and colleges). Acknowledging this diversity in knowledge diffusion is important for Norway's economic transition but may at present not be sufficiently encouraged by a system overly preoccupied by academic excellence.

Table 4.4. **Achievements and challenges related to research commercialisation**

Achievements and progress	Remaining challenges
– A fairly well-functioning system of commercialisation has developed around several universities, supported by more professionalised technology transfer offices. – Researchers now take an increasingly positive attitude towards commercialisation. – Centres for Research-Based Innovation (SFI) have been evaluated as a very important tool for stimulating research-based innovation.	– Limited incentives for commercialisation in higher education institutions – Lack of support and attention to industry-oriented continuing education programmes (including in the Long-Term Plan) – The third mission is not integrated in the higher education instutions' strategies. – No dedicated mechanism for incentivising knowledge-exchange activity of higher education instutions

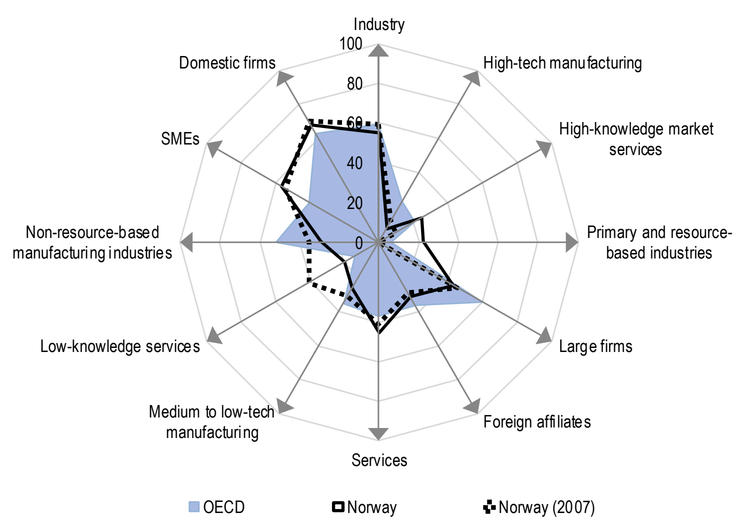
Innovation in business firms in Norway

Business firms' R&D and innovation capacity

Business firms' R&D

BERD intensity (BERD as a per cent of GDP) in Norway has increased over 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%).This low performance is partially explained by the structure of the Norwegian economy, with its significant share of commodity-based activities and few industries of high R&D intensity (see Figure 4.10). Norwegian innovation is closer to "doing, using and interacting" than to science, technology, and innovation (STI) modes of innovation (Jensen et al., 2007). This may mean that much of Norway's innovation activity is not reported in official statistics (Cooke, 2016). Adjusting for industry structure[10] brings the business R&D intensity for Norway closer to the OECD average (OECD, 2013; 2015a).

Figure 4.10. **Structural composition of business enterprise R&D, 2013**



Source: OECD (2016e), OECD (2016), *OECD Science, Technology and Innovation Outlook 2016*, http://dx.doi.org/10.1787/sti_in_outlook-2016-en.

Compared to the OECD average, a large proportion of R&D is performed by SMEs in Norway (see Figure 4.10). The largest 100 R&D performing firms are responsible for less than half of the total business R&D expenditures in Norway. There are relatively few large R&D-intensive companies in Norway. The main R&D performing firms are in the oil and gas sector, with the state-owned company Statoil heading this group. State ownership remains extensive in Norway, with around 11% of total employment (OECD, 2016a), not only in oil and gas but also in telecommunications (Telenor), energy and aluminium production (Norsk Hydro), chemicals (Yara International, ASA), banking and financial services (DNB Bank) and manufacturing (Kongsberg Gruppen). Only 10 Norwegian companies appear in the list of the world's top 2 500 R&D companies (European Commission, 2016, see Table 4.5). A large proportion of R&D in the petroleum sector is performed outside the companies, generally in research institutes serving the sector.

Table 4.5. **The ten largest R&D performers in Norway, 2016**

World rank	Name	Industrial sector	R&D, million EUR (2015/16)	Sales, million EUR (2015/16)	R&D intensity, %	Employees (2015/16)
386	Statoil	Oil and gas producers	281.5	50 336.5	0.6	22 300
741	Visma	Software and computer services	124.4	869.3	14.3	0
763	DNB	Banking and financial services	120.3	5 629.3	2.1	11 380
955	Kongsberg Gruppen	Aerospace and defense	88.4	1 775.7	5.0	7 688
1 127	Telenor	Telecommunications, IT and media	70.7	13 363.5	0.5	35 000
1 186	Aker Solutions	Oil equipment, services and distribution	66.9	3 325.5	2.0	15 395
1 655	Norsk Hydro	Industrial metals and mining	40.6	9 142.9	0.4	13 263
1 726	Petroleum Geo Services	Oil equipment, services and distribution	38.1	883.5	4.3	2 153
2 071	Tomra Systems	Industrial engineering	29.0	645.7	4.5	2 475
2 198	Orkla	General industrials	26.3	3 399.9	0.8	14 532

Notes: The data used for the Scoreboard are different from BERD data provided by statistical offices. The Scoreboard refers to all R&D financed by a particular company from its own funds, independent of where that R&D activity is performed, while BERD refers to all R&D activities performed by businesses within a particular sector and territory.

Source: European Commission (2016), "The 2016 EU Industrial R&D Investment Scoreboard", http://iri.jrc.ec.europa.eu/scoreboard16.html (accessed 10 February 2017).

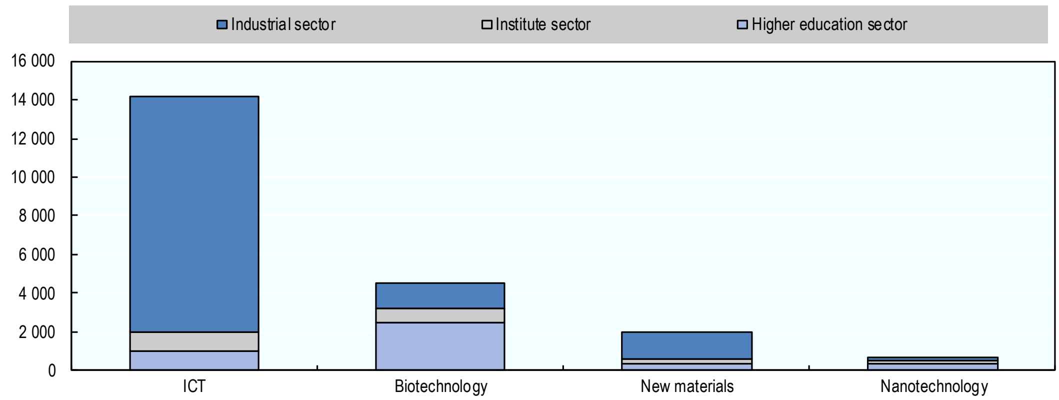
Despite its relatively low share of total GERD by international standards, Norway's business R&D spending has been one of the fastest-growing in recent years, with an increase of 12% between 2014 and 2015 (9% at constant prices).[11] As in other countries, its service industries have experienced the strongest growth in R&D, and now account for more than half of private R&D. Geographically, the capital region (Oslo and Akershus) dominates R&D spending with 42% of the total, followed by Trøndelag and Western Norway. Oslo, Sør-Trøndelag, Akershus and Hordaland were the four largest counties in terms of R&D and accounted for around 70% of Norwegian R&D expenditure in 2014. Trøndelag has the highest R&D expenditure per capita. The share of industrial R&D in the capital region is just below the national average. It is substantially higher in South-Eastern Norway, while in Northern Norway the share of industrial R&D is very low compared to higher education.

With regards to the enabling technologies identified as national priority areas by the Long-Term Plan, the industrial sector dominates expenditure in new materials and ICT, while the higher education sector accounts for more than half of R&D expenditures in biotechnology and nanotechnology (Figure 4.11). Health trusts are key R&D performers in biotechnology. Since 2013, R&D expenditures in ICT have grown more than NOK 2.5 billion in current prices, and biotechnology has also experienced considerable growth (by almost NOK 1 billion).

In the last few years, R&D personnel levels have grown faster in industry than total industry employment. The industrial sector has seen the strongest growth in R&D employment, compared with the higher education and the institute sector (see Chapter 2).

The service sector (with 55% of the total R&D FTEs) experienced a higher growth than manufacturing, with 8% and 5% growth respectively, between 2014-15. Within manufacturing (37% of the total) the highest growth has been in instrumentation, electrical equipment and machinery and equipment.

Figure 4.11. **R&D expenditures in selected technology areas, by sector, 2015**



Source: NIFU (2016).

Innovation in business

Norwegian enterprises reported innovation expenditure of NOK 59.7 billion in 2014, which accounted for 2.4% of the turnover of innovative enterprises, and 1.6% of turnover of all enterprises (RCN, 2015b). In terms of the results of innovation, 5.9% of the enterprises' combined turnover came from product innovations introduced during the three-year period from 2012-14.

The EU's 2015 Innovation Union Scoreboard (IUS) classifies Norway as a moderate innovator and places it in 16th place, just below the EU average and one position up from the previous three years. Looking at the indicators that make up the IUS, Norway is rated particularly low on indicators related to high-tech industries and research-based innovation.[12]

The relatively low performance of Norway in the IUS can be attributed to structural factors, in particular its industrial structure (with a high weight of commodity-based industries) and the high value of GDP. Another factor is its relatively low innovation rate, as reported by Norwegian firms in the Community Innovation Survey. However, data from the most recent Norwegian innovation surveys[13] show a much improved performance in these indicators, including a considerable increase in reported innovation activities by Norwegian firms. In the CIS 2014, the percentage of "innovative enterprises" is 57.6% in Norway, 49.1% in the EU and 50%, 54%, 55% in Denmark, Sseden and FInland respectively. Using these CIS 2014 figures for the relevant indicators in the IUS, the position of Norway would improve significantly, and rise several places in the IUS ranking (from 16th to 13th place).

As noted earlier (Chapter 2), new enterprise creation is of key importance for Norway if it is to secure long-term growth and diversification of the economy. Analyses undertaken by the Productivity Commission (NOU, 2016) and the OECD (2016a) suggest that Norway has an institutional setting and regulatory conditions conducive to venture creation. Moreover, new enterprise creation has increased in recent years (OECD, 2016a), start-ups are larger and enjoy a higher survival rate, and young SMEs contribute disproportionately to job creation in each country (although less than in most other comparator countries).

R&D and innovation policy

Recent evolution of innovation policy in Norway

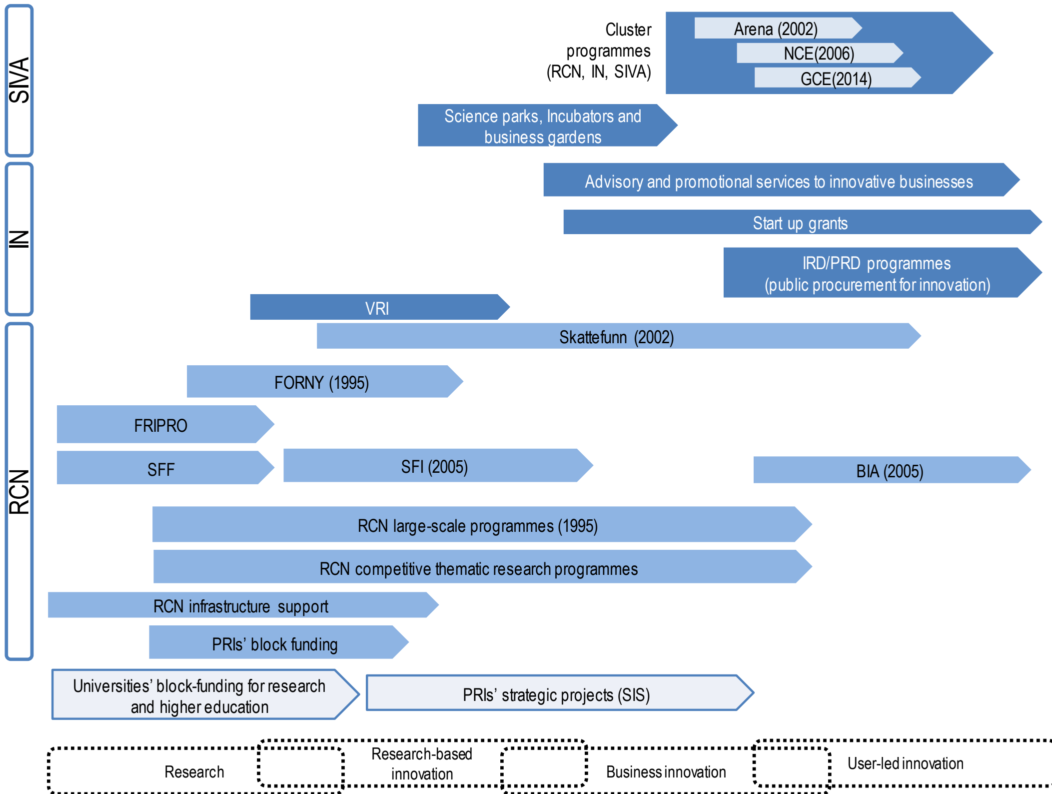
Stimulating R&D activity has been among Norway's main policy goal for decades, at different intensities depending on the period (see Chapter 6). In 2005, Norway, like many other countries, adopted the general target of increasing total R&D expenditure to 3% of GDP, in line with the original EU Lisbon strategy. The 2005 and 2009 research white papers proposed thematic priority areas around energy and the environment, oceans, food and health. The 2009 white paper placed a stronger emphasis on the challenges faced by the public sector and on global research perspectives, and proposed the introduction of national R&D strategies for biotechnology, nanotechnology and ICT. According to Arnold et al. (2011), the thematic priorities have tended to reflect existing structures and priorities, and as such, are conservative rather than disruptive. Private R&D and innovation were given renewed attention in the 2013 election, and placed emphasis on the need to take the economy in a more sustainable direction (Fagerberg, 2016). In 2014, the Long-Term Plan for Research and Higher Education reiterated these R&D intensity targets, stating that the 3% target should be reached in 2030, and setting three generic and four thematic priorities.

To support entrepreneurship, the "Entrepreneurship plan" launched in 2015 by the Ministry of Trade, Industry and Fisheries proposed a number of measures to improve access to capital for start-ups in an early stage, facilitate access to competence and make Norway an attractive place for entrepreneurs. The recent white paper on industrial policy (MTIF, 2017) "Industry: Greener, smarter and more innovative" expresses strong support for environmentally friendly development. It stresses the need to diversify from petroleum-based activities and contemplates a series of expedients for achieving this. These include increased funding for enabling technologies such as biotechnology, nanotechnology and ICT; greater use of procurement as a driving force for innovation; increasing the block funding of the TI institutes; and improving businesses' infrastructure access, in terms of testing, prototyping, etc.

Analysis of the policy mix

Support for business R&D and innovation is provided mainly through R&D tax credits, as well as in the form of grants and other financial and technical instruments. Like most advanced countries, Norway has broadened its portfolio of direct and indirect support to business R&D and innovation. The policy mix is now comprehensive, and covers the various needs of the different communities of research and innovation actors, throughout all stages of the innovation process (Figure 4.12). None of the numerous evaluations of the Norway STI system has revealed any major missing support instruments, and the debate has focused mainly on the balance between the types of initiatives. The policy mix reflects a division of labour between the different ministries and agencies (the Research Council of Norway [RCN], Innovation Norway [IN] and Siva), in charge of different but related dimensions of R&D policy, innovation policy and industrial policy, with some instruments jointly managed between the three agencies. Besides RCN and IN, the county municipalities also have responsibility for economic development and innovation, especially in relation to the regional research funds (RFF) and also in the regional collaborative initiatives of the Ten-Year Programme for Regional R&D and innovation (Virkemidler for regional Forskning og Utviklingsarbeid og innovasjon, VRI) programme.

Figure 4.12. **Overview of Norway's main research and innovation support schemes and programmes**



The share of direct and indirect funding is more or less evenly split in Norway, but the share of indirect funding has increased in recent years. From 2014 to 2015, the funding via Skattefunn has increased by 47%. By contrast, business R&D support in Sweden and Finland has mainly consisted of direct funding, while in Denmark, indirect support predominates over direct funding (see Figure 4.13).

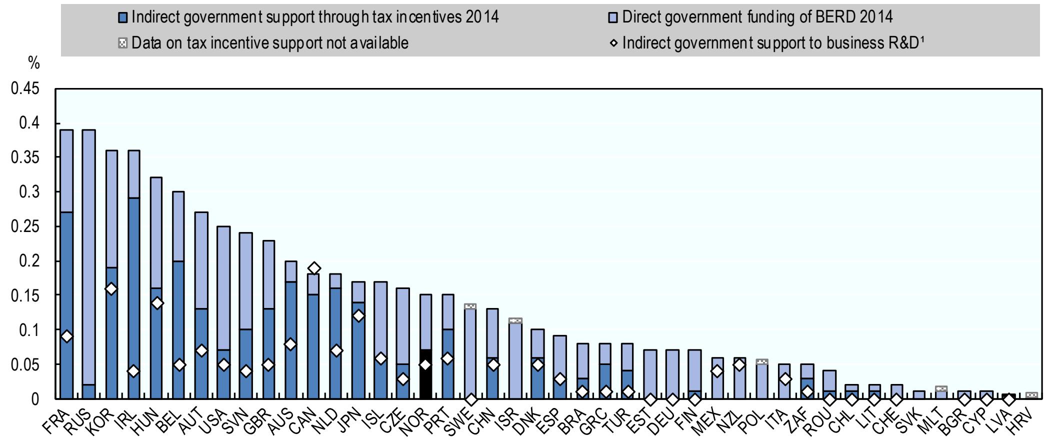
Between 2007 and 2015, direct government funding of business R&D increased nominally by 104%, while indirect support increased by 200%. In 2007, direct and indirect funding accounted for 57% and 42% of government-funded intramural business R&D respectively, while in 2015, these shares had changed to 47% and 53%.[14]

RCN provides R&D subsidies for firms in the form of research grants, mostly on a competitive basis. Innovation Norway provides a suite of services including funding, advice, competence building, networking and promotional services aimed at supporting entrepreneurs, companies with growth potential and innovative clusters.

The combined appropriations for research and innovation through IN, RCN and Skattefunn amounted to NOK 12.6 billion in 2014, NOK 1.3 billion higher than 2013. This increase was mainly due to a 30% increase in the budgeted tax deduction for Skattefunn projects, and a growth of 12% in RCN funding, while net grants from Innovation Norway were reduced by 3% compared with 2013 (RCN, 2015a). Allocations from the RCN and Skattefunn tend to be stronger in counties with a strong concentration of research and industrial R&D respectively, while the funding from Innovation Norway has a greater distributive effect, a larger share of its funding going to peripheral regions in the country.

Figure 4.13. **Direct government funding of business R&D and tax incentives for R&D, 2014**

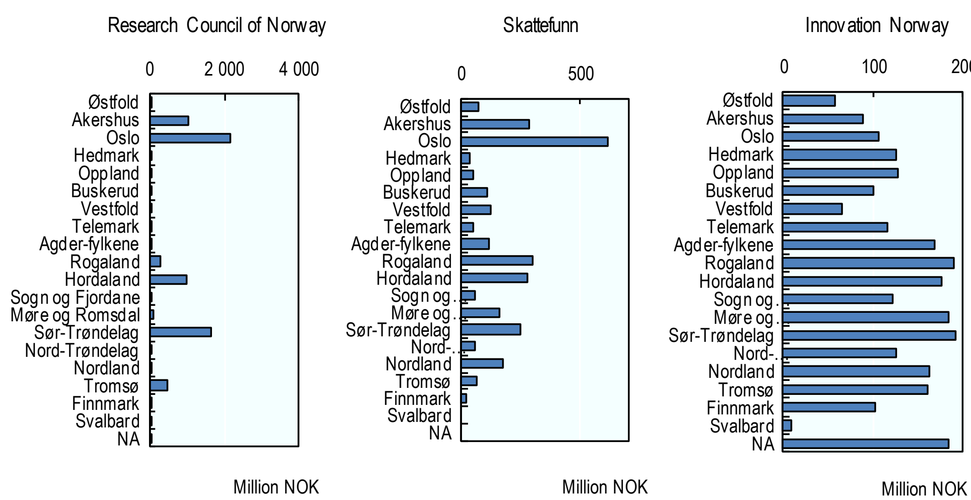
As a percentage of GDP



Note: 1. 2006 or nearest year, where available.

Source: OECD, R&D Tax Incentive Indicators, www.oecd.org/sti/rd-tax-stats.htm.

Figure 4.14. **Funding from the Research Council of Norway, tax deduction (Skattefunn) and net grants from Innovation Norway by county, 2014**



Source: RCN (2015b), *Report on Science and Technology Indicators for Norway*, www.forskningsradet.no/en/Report_on_Science__Technology_Indicators_for_Norway/1254017091560 (accessed 7 June 2017).

RCN business R&D funding instruments

RCN awarded approximately NOK 1.3 billion to industry through its various funding instruments in 2015. RCN's programme portfolio encompasses four programme categories: basic research programmes, large-scale programmes, policy-oriented programmes and user-directed innovation programmes. The industry share is around 60% in the user-driven programmes, and almost 20% in large-scale programmes.

User-driven programmes have grown significantly in recent years, with a growth in budget of 46% between 2011 and 2015. They represented around half of the RCN funding received by businesses. The main programme is BIA (*Brukerstyrt Innovasjonsarena*, or

User-Driven Research-Based Innovation), which part-funds (up to 50%) R&D projects of any industry for which there are no targeted RCN programmes to be developed in collaboration with companies and R&D institutions. Other user-driven innovation programmes with significant funding of industry actors include MAROFF (Maritime activities and offshore operations), BIONÆR (Sustainable innovation in food and bio-based industries), PETROMAKS2 (Large-scale Programme for Petroleum Research) and DEMO 2000 (Project-oriented technology development in the petroleum sector).

The large-scale programme focuses on eight areas: ICT, bio- and nanotechnology, aquaculture, energy, petroleum and climate change. Typically, the programme funds up to 50% of the project cost of the company and its R&D partners. The largest programmes in terms of funding in 2015 were ENERGIX, PETROMAKS, NANO2021 and HAVBRUK (aquaculture). The institute sector is the biggest recipient in the programmes, particularly the PETROMAKS2, BIONÆR and MAROFF, but industry participation is strong in the ENERGIX programme, with 37% of the funding (RCN, 2017b).

In recent years, RCN has placed greater focus on technology and technology transfer between the sectors, particularly between the petroleum sector and the maritime and marine sector (see Box 4.3).

Evaluations of RCN programmes (innovation projects in industry, IPN) are regularly undertaken (Bergem and Bremnes, 2014). Economic benefits identified have included competence building, innovation and dissemination and a positive input additionality, with firms reporting that without support, the projects would not have happened or would have been smaller in scale. A wider evaluation of the impact of innovation support instruments during 2001-13 (Cappelen et al., 2016), including RCN R&D programmes, Skattefunn, innovation-oriented instruments of Innovation Norway (IN) and export support programmes, revealed positive effects in value creation, sales income and employment. The effects increased with the amount of support, and showed no effects on productivity. This does not necessarily reflect a causal relationship, since many other factors can influence the likelihood of getting funding and the success of the measures.

This seems consistent with international comparative reviews (OECD, 2011; Cunningham et al., 2016) which find evidence of positive input additionality but less clear-cut evidence of impact in terms of new products or services, greater market shares, increased exports, employment, productivity or behavioural changes. The modes of implementation, in particular the selection process, marketing and advice for potential bidders, have been found to have a key influence on the adoption and success of R&D measures (OECD, 2011).

Innovation Norway's support for innovation and entrepreneurship

Innovation Norway provides funding and services with the aim of promoting innovation at the regional and national level, with a focus on small and medium-sized companies. The main target groups are entrepreneurs, young companies and SMEs with growth potential, which are assisted in four main key areas: internationalisation (assistance in the form of market advisory services and promotional services), funding (loans or grants), cluster support and advisory services/expertise in other areas of internationalisation. It supports all sectors, but a large percentage of allocated funding (approximately 25%) is with the agricultural sector. Of the funding, 43% is in the form of grants and around 50% in loans, of which only 20% are high-risk loans. Enterprises received 73% of the total funding in 2015, and entrepreneurs 18% (Innovation Norway, 2016).

Box 4.3. **Seas and oceans: A successful example of the innovation-based growth of a sector**

Economic activities in the marine sector represent a growing sector of Norway's economy. In recent years, aquaculture and seafood have grown steadily in importance as a source of income. In 2016, Norway was the second-largest export nation of seafood. It exported around NOK 92 billion to 146 countries, corresponding to 36 million meals every day. The value of Norway's seafood exports had increased by 23% since 2014, mostly due to an increase in aquaculture production in volume and, even more, value, since fisheries have been relatively stable.

Research and innovation have been crucial for the development of this industry. The success of Norway's aquaculture industry is a result of technologies that have made this industry more productive than in other countries since the 1970s. The quality of research in this area significantly contributed to this virtuous circle between innovation and economic value. In fisheries and aquaculture, Norwegian research is the 7th-largest in volume globally (4.2% of global publications) and in marine and freshwater biology, the 12th-largest in volume (2.5% of global publications). Norway is also very successful in Horizon2020 in these fields, with a success rate of approximately 11%.

According to NIFU, in 2015, NOK 4.7 billion was allocated to research and development in the seas and (including aquaculture, excluding the maritime and offshore sector), 8% of the total R&D expenditure in the country. Forty-five per cent of the research on marine activities is performed by the institutes, followed by universities (18%) and the business sector (36%). The RCN also promotes research and innovation in marine-related areas by means of a number of programmes. These include thematic research programmes such as MARINFORSK, HAVBRUK2, BIOTEK2021, BIONAER, MAROFF,the Norwegian centres of excellence, the Norwegian innovation clusters, as well as infrastructure.

To encourage collaboration and knowledge transfer between the petroleum sector and the maritime sector, and also other sectors such as aquaculture and fisheries, joint calls for proposals have been launched to provide funding for technology projects that would cross-cut the maritime industries with applications in the petroleum, renewable energy, fisheries and aquaculture sectors. One of the calls, for instance, consisted of joint efforts between the programmes ENERGIX (renewable energy), PETROMAKS2 (petroleum research) and MAROFF (Maritime activities and offshore operations), and another was undertaken jointly between the MAROFF and HAVBRUK2 programmes. The former call aims to leverage the knowledge and expertise from the petroleum industry in the renewable energy industry so it can be used to develop novel applications in areas such as offshore engineering, construction of wind turbine foundations, maintenance of offshore installations, etc. Its objective is also to support the transfer of technology of the renewable energy sector into the offshore oil and gas energy system. The latter call aims to use technology from the offshore industry to develop solutions to address environmental problems facing the aquaculture industry, for instance to develop solutions for offshore farming.

In 2016, approximately NOK 1.7 billion was allocated to ocean-related research and innovation programmes (including marine, maritime and offshore). Currently, exports of fish and fish products are subject to a fee of 0.3% that goes to R&D through the Norwegian Seafood Research Fund. Part of these funds are also managed by RCN.

To promote research and innovation in the maritime field, the initiative Hav21 (Ocean 21) was initiated by the Ministry of Fisheries and Coastal Affairs, to develop an integrated research strategy for the maritime and ocean economy. The steering committee of Hav21 included representatives from marine sector, industry, research institutions, public authorities and NGOs. However, the Hav21 committee convened only to formulate a strategy, and it is not a permanent committee.

Seas and oceans are one of the six long-term priorities of the Ministry of Education and Research's Long-Term Plan. As for the other priorities, working groups of experts have been created to draw it up. These working groups are re-enacted to participate in the discussions of the allocation of the budget to each priority area. In addition, in the framework of the LTP, the Ocean Space Center, a research facility in Trondheim, is being upgraded and expanded.

The government is developing a new strategy for the ocean economy, aiming to make Norway a global leader in the field. The strategy was published on 21 February 2017.

According to recent assessments, these efforts are yielding positive results (see Box 4.4). A key question, however, is the extent to which they can contribute to the economic transition. In order to work towards a more solid foundation for Norway's economic restructuring process, Innovation Norway initiated a strategic process during 2014-15 in consultation with Norwegian industry and other players. The"Dream Commitment" report that resulted from this exercise identified several opportunity areas for Norway's future, including clean energy, ocean space, bio-economy, tourism and creative industry, health and welfare and smart societies. There is strong overlap between the research priorities identified in the LTP and the opportunity areas identified by Innovation Norway's "Dream Commitment" report. However, it is unclear how the commitment to the priority areas will be co-ordinated between ministries and agencies and how Innovation Norway and RCN are working together on the objectives of the LTP.

This strategic orientation has not translated into new instruments, for which it has little room for manoeuvre. It has sought instead to steer existing tools, such as clusters and other instruments (loans and financial support), in order to promote greater connectivity across industries to support the opportunities identified. IN's strong regional presence and customer orientation puts it in a good position to identify such "crossover" opportunities. In one example of such innovation platforms, Cooke (2016) notes how in Hordaland, shipping activities are connecting oil, gas and marine engineering clusters with a thriving tourism sector (see also next section).

Box 4.4. **Evaluation of Innovation Norway innovation support**

The impact of innovation and entrepreneurship policies, particularly soft forms of intervention such as advisory services and cluster support, can be difficult to assess, given the difficulty of defining the units of input, the presence of confounding factors and given the length of time over which effects can build (Rigby and Ramlogan, 2016; Uyarra and Ramlogan, 2013). Many of the programmes to support entrepreneurship reviewed by Rigby and Ramlogan (2016) were not evaluated, and when they were, evaluations showed mixed results in terms of sales, employment and survival.

An evaluation of Innovation Norway conducted in 2010 concluded that the agency probably contributed to increased value creation. to the Norwegian economy. However, it recommended that it should have a clearer goal of supporting high-risk innovation and firms with an international orientation, and that it should further simplify and prioritise support for business. As a result, internationalisation and early-stage support have received greater attention in recent years. IN has also attempted to reduce the complexity of supporting businesses, developing a simpler, web-based interface with customers and simplifying funding applications. Statistics Norway estimates that enterprises that were supported by Innovation Norway achieved 9.7% percentage points higher growth in 2015 than similar, non-supported firms; 2.5% higher productivity growth and 0.3% higher return on capital. However, these results are similar or lower (for productivity growth and profitability) than the effects found for 2013.

Not all elements of IN have been found to be equally effective. According to a recent evaluation (Cappelen et al., 2015) participation in IN's innovation and regional development programmes resulted in improved performance in terms of employment, sales revenues and valued added in firms, while no effect was observed on labour productivity and returns to total assets. Firms that participated in cluster programmes also exhibited higher sales and employment in the immediate period after enrolment. In relation to lending activities, the evaluation found no evidence that the commercial and low-risk loans enhanced firms' performance. The programmes targeting start-up firms did not appear to improve the chances of a firm's survival, compared to those of a control group.

Source: Innovation Norway (2015), "Norwegian Clusters 2015: For the future's innovative industries", www.innovationclusters.no/globalassets/filer/nic/publikasjoner/norwegian-clusters-2015.pdf.

Siva support for innovation and technology transfer

Complementing Innovation Norway's innovation promotion activities, Siva supports industry through physical and organisational infrastructure for innovation. Siva operates throughout Norway, but has a special responsibility to promote growth in rural areas.

Its main instruments are the incubation and business garden programmes, which include 35 incubators and 39 business gardens, normally in rural areas; investment in real estate and infrastructure; and the ownership of around 84 so-called innovation companies, both small and large. Many of these innovation companies are, in addition to managing assignments from other public and private stakeholders, operators of Siva's industrial cluster and incubation programmes, or providers of front-line service and various business development projects.

Since 2002, Siva's real estate business has been handled by a separate subsidiary, Siva Eiendom Holding AS (SEH). Siva's property portfolio consists mainly of industrial and production buildings, commercial parks and buildings, and research and knowledge parks. In the past ten years, the composition of its property portfolio has changed, shifting from an emphasis on industrial and production buildings to commercial buildings and knowledge and research parks (Jakobsen et al., 2015). A recent evaluation of Siva's real estate activities suggested that there are substantial synergies between property and innovation activities, and that these could be increased by integrating the physical organisation of collaborative activities with innovation activities (Jakobsen et al., 2015). A recent report (Oxford Research, 2016) suggested that Siva and IN's responsibilities for activities such as counselling and mentoring support for entrepreneurs and firms tend to overlap should therefore be clarified. They suggest that Siva should take on a stronger leadership role in advisory and mobilisation activities, and recommend that they be integrated within IN's organisational structures and strong regional apparatus.

Incubator programmes in Norway are considered rather specialised (Cooke, 2016; Clausen and Rasmussen, 2011), and newly created incubators (such as the new Oslo Cancer Incubator or the CERN incubator in Trondheim) are oriented towards exploiting innovative ideas in specific technical fields and disciplines. This raises the question of whether these incubators sufficiently exploit the opportunities of knowledge recombination across sectors and technologies, and whether "crossover incubation" approaches as described by Cooke (2016) could complement these efforts.

Recently the government has stressed the need to develop high-quality and accessible facilities for piloting, demonstrations and simulations. In 2016, the MIF commissioned a study to map private and public demonstration plants in Norway and found that these exist across the country and in a variety of industries. They mainly consist of pilot and test plants owned by large companies and R&D facilities by research institutes and universities (Menon Economics, 2016). In order to make it easier for Norwegian industrial companies, particularly SMEs, to gain access to infrastructure and other equipment, the 2017 budget earmarked NOK 50 million to support a national multi-purpose facility for testing, piloting, simulation and visualisation. Siva will use the funds to support investments in the necessary equipment. According to the recent white paper on industrial policy (MTIF, 2017), plants should be established where there is a critical mass of business and thus a large customer base.

Cluster support

There is evidence of strong specialisation and clustering in Norwegian regions (see e.g. Isaksen, 2009; Strand and Leydesdorff, 2013). Examples include the maritime, offshore and marine industries on the industrial counties on the west coast, in particular the maritime cluster in Møre og Romsdal and the oil and gas cluster in Rogaland, with its main city, Stavanger; or the electronic industry cluster in Vestfold, close to Oslo.

Cluster policies have been a staple regional innovation policy in many OECD countries. They have been given renewed impetus in the context of the smart specialisation agenda, which has aimed at helping regions to focus on their respective comparative advantages so that they can identify new areas of diversification (OECD, 2013).

Norway's support for clusters is consistent with a life cycle cluster model that considers the emergence, growth and maturity stages of clusters (Menzel and Fornahl, 2010; Fornahl and Hassink, 2017). Clusters are thus supported according to their developmental stages. These include newly established or immature collaboration initiatives (for example, Arena, created in 2002); clusters that are well established nationally and with further growth potential (the Norwegian Centres of Expertise, or NCE, programme, introduced in 2006); and clusters that are fully functioning and well-established in global value chains (global centres of excellence, or GCE, introduced in 2014). In 2016, there were 22 Arena clusters, 14 NCE clusters and 3 GCE clusters.

The goals of the cluster programme are to increase capacity for innovation and renewal, increase value creation in the cluster and strengthen attractiveness and position in global value chains. The programme is open to all industries, according to selection criteria specific to the three programme levels, whose common denominator is that they must demonstrate potential for collaboration-based growth.

The programme, with a total budget of around NOK 150 million in 2015, is managed jointly between Innovation Norway and the RCN, and provides a combination of financial and expert services, including advisory, networking and promotional services, and services to upgrade the level of clusters' competences.

The results of several studies and evaluations conducted since the creation of the cluster programme have shown that, overall, it can encourage collaboration between cluster members and business growth, but that its effects on innovation capacity are hard to measure (see Box 4.5). Innovative clusters have been expected to take "a leading role in the restructuring and renewal of Norwegian industry" (Innovation Norway, 2015), but past evaluations have suggested that the clusters have been too narrowly conceived and have tended mainly to support interactions between relatively homogenous actors within existing value chains (Isaksen and Jakobsen, 2017).

Support for cross-sector collaboration has been increased in recent years. Cluster-to-cluster collaboration is one of the priority areas for cluster funding support. This would include collaboration with other cluster environments at regional, national or international levels, to foster learning across sectors, technologies or value chains. Both the NCE and GCE clusters have to report on issues related to such collaborative activities. Selection criteria for cluster support is also shifting. The most recent call for cluster projects[15] states that the programme aims to "stimulate new cluster initiatives that have as an explicit aim to renew an existing industry or to innovate through development of new industries". The call encourages projects with a particular focus on solving challenges at the intersection between different fields and disciplines.

Box 4.5. **Results of the main evaluations of the cluster programme**

According to an analysis by Statistics Norway for Innovation Norway, businesses supported by the cluster programme had 13 percentage points higher growth in turnover and an 8% increase in the number of employees in the first three years of the company's membership, compared to those who were not supported by the programme. Profitability, however, was lower than that of the control group after three years (Innovation Norway, 2016). Innovation Norway is conducting an evaluation of the cluster programme that is expected to be completed in summer 2017.

Mid-term evaluations of the Arena and NCE programmes (Econ Pöyry, 2011; Jakobsen and Røtnes, 2012) identified positive impacts in terms of increased collaboration among cluster members. Another benefit was softer impacts, such as the creation of a common identity for the participating actors and providing greater visibility and increased attractiveness for potential investors, new businesses and potential employees. The evaluation noted that the success of the projects owed much to the high calibre and competence of cluster managers, who had gained credibility and legitimacy in dealing with the different stakeholders. Innovation effects were difficult to measure, however, and a stronger emphasis on innovation was recommended. Greater coherence in the interface between RCN and Arena programmes as well as with other policy instruments, was also recommended, to support collaborative R&D and innovation projects with long-term potential. Concerns were raised, however, about the potential of cluster support schemes to support industrial diversification and path renewal. Evaluations of the Norwegian Centres of Expertise programmes (Oxford Research, 2013; Njøs and Jakobsen, 2016), suggest that projects have tended to support groups that are already collaborating, and existing value chains, raising issues about whether the programme can generate new synergies. Njøs and Jakobsen (2016) recommended broadening the scope of cluster policy to stimulate regional cross-industry co-operation.

Examples of cross-sector learning in clusters and the use of collaborative projects as platforms for restructuring are becoming increasingly common. They include the developments in green shipping at the NCE's Maritime CleanTech, and the launch in 2015 of the world's first "plug-in hybrid ferry". NCE Smart Energy Halden's expertise in ICT and big data has helped to launch profitable new IT solutions by sharing its expertise with other clusters. The Norwegian Smart Care Cluster is taking solutions developed in the oil and gas sector for safety, training and use of robots and signal handling, and exploring their application for welfare technology (Innovation Norway, 2016). GCE Subsea and NCE Seafood have jointly launched several cross-cluster or "crossover" initiatives to develop projects using competences and technology from the oil and gas industry to address challenges in aquaculture (Isaksen and Jakobsen, 2017).

Programme for Regional R&D and Innovation

Another Norwegian initiative in line with similar European initiatives to support regional innovation systems and smart specialisation, was VRI, the Programme for Regional R&D and Innovation, in operation between 2007 and 2017. The programme has two components: regional collaborative projects/initiative (to strengthen knowledge diffusion between businesses, research institutions and public actors), and support to research projects on innovation/(regional) innovation policy. The two components were initially supposed to complement each other; however, in later stages research projects were granted on merit of scientific quality, not geography. The county municipalities are responsible for the regional collaborative initiatives, with a steering group with regional participation. A total of 15 VRI collaborative initiatives have been funded by the RCN, with an approximate annual budget of NOK 70 million, each with its own organisation, strategies and projects.

The programme adopts s a bottom-up approach to priorities and regional collaboration and emphasises the importance of research institutions in regional development. It builds on previous regional policy initiatives, such as VS2010 and Competence Brokering, which were merged under VRI. It inherited from these programmes a broad definition of regional innovation strategies (RIS) as regional development coalitions (VRI1), and later on (VRI2) adopted a more explicit aim of linking regional industry to regional research organisations to promote a more R&D-based mode of innovation (Herstad and Sandven, 2017). Following the VRI, the RCN launched FORREGION ("Research-based innovation in the regions"), aimed at stimulating linkages between firms and the R&D sector in Norwegian regions, and more recently FORKOMMUNE, aimed at supporting research-based innovation in Norwegian municipalities.

The VRI programme has been found to help build regional capacity to support learning and innovation and building social capital (see Box 4.6), with varying degrees of success. Studies of the VRI programme have highlighted some key challenges and raised important questions about the co-ordination of policies for innovation and industrial renewal at multiple levels. First, efforts to build regional innovation systems have been deemed insufficient since they are set against a (sector-neutral) national funding system for R&D since the weights of sectors are very unevenly distributed geographically. Furthermore, regions are encouraged to identify their own priorities, which contrasts with the less selective approach of national policy and raises questions about lack of overall co-ordination and potential fragmentation of regional innovation efforts (Arnold et al., 2011). Finally, it is not clear whether the degree of policy tools being devolved to the regional level is sufficient to facilitate self-discovery processes and interactive learning (Rodrik, 2004; Dahl Fitjar, 2016).

Partly in response to this gap, in addition to the VRI the RFF were established in 2010. The RFF regions (seven in total, consisting of two to four county municipalities each) appoint independent boards for the funds, which award competitive R&D funding based the regions' strategies to promote regional innovation and development. Funding is provided by the Ministry of Education and Research, which also has established guidelines for the scheme. The RCN provides administrative support for the RFF boards. The funding amounts to NOK 215 million in 2017, and NOK 267 million in 2016 (including one-off additional support for South-Western Norway, due to the oil-price induced unemployment increase).

An evaluation was commissioned in the first year of the programme, which also delivered reports the three following years, the last of which was in 2013. The evaluation concluded that the scheme had been well established, and functioned well according to its objectives. It was found to work in interplay with other regional actors and initiatives, have strong anchoring in the regions and high legitimacy. The evaluation also raised the issue that although filling a role in the policy mix and contributing to the development of the research and innovation system, the introduction of new schemes also increases complexity. The evaluation recommended looking more broadly at the policy mix with a view to simplifying and consolidating it. As the evaluation followed the programme in its first years, the possible conclusions on its impact were limited.

Box 4.6. Results of the main evaluations of the Programme for Regional R&D and Innovation (VRI)

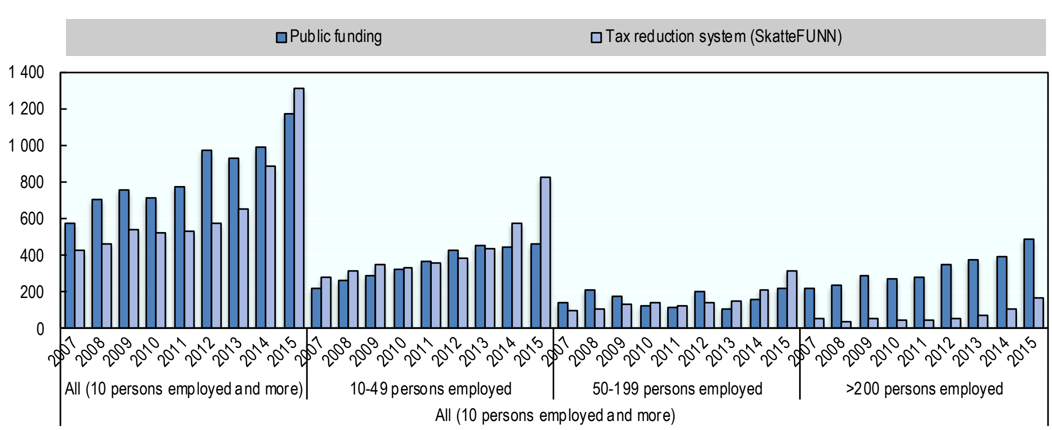
A mid-term evaluation of VRI (Furre et al., 2012) concluded that the initiative had contributed significantly to strengthening regional partnerships, including the relationships between research institutions and industry. The programme helped build regional capacity for formulating policy, and also to set regional priorities based on the regions' individual weaknesses and strengths (Fløysand et al., 2015; Sörvick and Midtkandal, 2016). However, differences between the regions meant that some did not have functioning partnerships or the social capital required to build regional innovation systems. This suggested a need to account for different stages of RIS evolution and to provide better support for institutional and organisational development.

A recent study on the influence of the VRI on the development of regional innovation systems in Norway (Herstad and Sandven, 2017) found that during the period there was a decline in the share of employment in innovation-active firms and a weakening of collaboration within the local industrial and research system. Some regions performed well, and developed dense local research collaborations and industrial linkages, but most had a weak RIS configurations. An overall conclusion was that few regions displayed the characteristics of a truly networked regional innovation system. This raises the question whether regional innovation policies are building on too narrow definition of RIS, and failing to mobilise broader industrial capabilities. The study also suggested that the efforts of VRI to build diverse regional innovation systems were overshadowed by the centralising effect of national funding schemes like Skattefunn and BIA, which have tended to reinforce linkages with national research institutions and international networks rather than with the regions.

R&D tax incentives

With a total support of approximately NOK 2.9 billion in 2015, the R&D tax incentive scheme Skattefunn is the main public support programme for business R&D in Norway (see Figure 4.15). Skattefunn has expanded in recent years, in line with the expansion of R&D fiscal instruments in other countries (CPB, 2014; OECD, 2016b). Its total tax credits more than doubled between 2013 and 2015, and it now commands more public funding for the business enterprise as a whole, particularly in the case of small firms and service sector firms (see Figure 4.15).

Figure 4.15. **Funding of intramural R&D in the business enterprise sector, from Skattefunn and other sources of public funding by firm size, 2007-15**
Million NOK



Source: Statistics Norway (2017), "Research and Development in the business enterprise sector", www.ssb.no/en/statistikkbanken.

Originally, Skattefunn only targeted SMEs, but eligibility was extended to include all firms after 2003. However, SME are still the main beneficiaries of this scheme. Firms can receive a tax credit of up to 20% in the case of SMEs (18% for large firms) of the eligible costs of approved R&D projects. Ceilings set for eligible costs have increased over the years and are higher if the enterprise collaborates with an approved R&D institution (universities and research institutes). In international terms, the scheme scores moderately in terms of the relative generosity of R&D tax incentives, but it is among the most generous for profitable and loss-making SMEs (OECD, 2016b) and one of the easiest for firms to use in terms of its administrative requirements (CPB, 2014).

In line with international evidence, the programme appears to be especially beneficial for small and inexperienced R&D performers (see Box 4.7). The increase in the use of Skattefunn in the last two years has coincided with a notable rise in the figures of recorded business R&D spending. It is thus likely that the tax credit has stimulated additional R&D and encouraged firms to start doing R&D. This applies particularly to smaller firms and firms in service industries, which are not targeted by means of direct R&D funding. But it is also possible that firms claim tax credits against spending that they would not have classified as R&D in the past. Other types of biases exist, which explain why the recorded increase in nominal R&D may not translate into an increase in innovation levels (Appelt et al., 2016).[16]

This suggests that the use of R&D tax incentives does not guarantee innovation or greater diversification that replaces existing technological trajectories (which is admittedly not the aim of the scheme). This calls for a careful balance between indirect support and direct support measures in technological and geographical areas where the market is unlikely to provide sufficient incentives on its own.

Box 4.7. **Impact assessments of Skattefunn R&D credits**

Comparing the impact of R&D tax incentives is difficult, given the wide variety in their designs and features (see e.g. CPB, 2014; Laredo et al., 2016; Appelt et al., 2016). However, studies generally show positive effects for SMEs, while the effects on larger firms, as well as on productivity and other measures of firm performance, are less clear (Laredo et al., 2016).

SkatteFUNN has been evaluated on several occasions to assess its impact on R&D expenditure, innovation, productivity and its interaction with direct R&D policy instruments and a new evaluation is under way (to be published in 2018). For instance, Hægeland and Møen (2007) found that the scheme significantly increased private R&D expenditure, with input additionality effects ranging from 1.3 to 2.9 per unit of support. They also found that the strongest impact was for firms without or with limited previous R&D activity, which may suggest that the scheme encouraged some firms to start doing R&D. Focusing on innovation success, Cappelen et al. (2012; 2016) found that firms using SkatteFUNN innovated more frequently, but that it led to product and process innovations that were new to the firm, rather than innovations that were new to the market or that could be patented. This is in line with other studies that suggest that the R&D supported by tax incentives is mainly associated with incremental rather than radical innovation innovations (CPB, 2014). When compared to other forms of support for R&D, Hægeland and Møen (2007) found that tax credits had a slightly larger effect than direct support measures on Norwegian firms. This contrasts with other studies such as Westmore (2013), which found the impact to be larger for direct support schemes compared to R&D tax incentives.

Finally, in terms of behavioural additionality of the scheme, its effect on collaboration seems to be limited according to Hægeland and Møens (2007), who show that few firms start collaborating with approved R&D organisations as a result of Skattefunn, and those with a history of collaboration do not collaborate more. Isaksen et al. (2017) focused on the geographical effects of Skattefunn and found that funding tended to favour firms in specific industries and in regions with a relatively developed regional innovation system.

Conclusions on business firms' innovation

Enhanced competitiveness and innovation is one of the core objectives of the Long-Term Plan, which emphasises the need to diversify and increase the absorptive capacity of industry, to prepare for the transition to a low-emission society. This is particularly pressing for the Norwegian economy, which is characterised by strong specialisation and at the same time low GERD, innovation and entrepreneurship levels.

Table 4.6. **Main elements of the diagnostic on business innovation**

Main elements of diagnostic
– Low level of business R&D expenditures in international comparison, even when adjusting for industry structure (but rapidly growing)
– Few large R&D-intensive companies, the main ones being in the oil and gas sector
– High share and fast growth of the R&D in the service sector
– Share of Norwegian innovative firms on a par with or slightly higher than neighbouring Nordic countries

Public funding to support business innovation has risen substantially in recent years. RCN and Innovation Norway offer a comprehensive portfolio of financial support schemes and technical services to support it. Evaluations of R&D and innovation support instruments generally show promising results, and industry is well-served in terms of R&D support, with no obvious gaps in the policy mix for innovation. It could be argued, however, that the policy mix has traditionally been better suited to support existing strengths than new sectors and new areas for diversification.

As in many countries, Norway has strengthened generic, neutral policies, for instance through investments in the Skattefunn programme and user-led R&D schemes. Investment in Skattefunn has increased significantly, and it is now the largest mechanism for R&D funding in firms. While tax incentive schemes have a positive effect on firms' R&D investment, their wider effects on innovation, productivity and, more importantly, industrial renewal, is much less clear. Supposedly neutral instruments are never neutral in practice, and are likely to further reinforce relationships between strong incumbents in existing supply chains, at the risk of reducing variety and generating systemic lock-in.

Diversification of the economy will require tools to facilitate connections between different but related sectors and technologies. There are signs that this is happening. For instance, several of the Research Council programmes are aimed at transferring knowledge across existing clusters and technologies. Cluster support is also increasingly encouraging cluster-to-cluster interaction. Cross-sectoral linkages are now being used as criteria for cluster selection. Recent developments in "smart" maritime activities, ocean mining and ocean fish farming, drawing on the accumulated technological expertise of the oil and gas sector, are some examples where this transfer is already occurring.

In order to favour diversification and industrial renewal, an institutional framework is needed to provide incentives for self-discovery processes, interactive learning and trial and error. Concerted action is needed across policy areas, actors and levels to encourage activities that contribute to diversification and increased economic welfare. As the LTP notes, this requires that the agencies involved (RCN, Innovation Norway and the Industrial Development Corporation of Norway) adopt a "co-ordinated and cohesive commitment to prioritised areas". The current division of labour between the three may not be sufficiently stimulating productive linkages between research and public funding and the more distributed landscape of innovation capabilities. Greater co-ordination is needed to tap into entrepreneurial discovery processes driving diversification, further leveraging regional structures for the purposes of diversification and renewal and informing instruments at the national level.

The LTP does not address the spatial dimension of economic transition and diversification. Support for innovation and structural change requires that interregional variety and regional specificity be taken into account. Regions are not only the places where the effects of external shocks (such as the decline of the oil industry) are being felt. They are also where innovation leading to structural change happens, where competences are located in R&D departments of firms and research institutes and where collective learning through spillovers occurs.

Table 4.7. **Achievements and challenges related to business innovation support**

Achievements and progress	Remaining challenges
Innovation support scheme	
– A comprehensive policy mix covering the various needs of the different communities of research and innovation actors, throughout all stages of the innovation process – Increased focus of RCN on technology and technology transfer between the sectors – Evaluations of RCN thematic programmes and other innovation support scheme show significant positive impacts	– The share of indirect funding has increased in recent years, which favours relationships between strong incumbents in existing supply chains.
Long-Term Plan for Research and Higher Education	
– Acknowledgement in the Long-Term Plan (LTP) of the need for better co-ordination of innovation support provided by RCN, Innovation Norway and Siva	– Overlap between the research priorities identified in the LTP and Innovation Norway's "Dream Commitment" report – Limited focus on the spatial dimension of the need for economic transition and diversification

Notes

1. Comparison with other countries is difficult, since comparative international statistics do not use the term "institute sector". In international statistics, the industry-oriented research institutes are included in the business enterprise sector, and the remaining units are included in the government sector.
2. Such as for instance, VTT in Finland, the Fraunhofer Society in Germany, TNO in the Netherlands and the RISE institutes in Sweden.
3. However, industry income is somewhat inflated by the fact that some of the revenues originating from commissioned research from industry are derived from RCN funding allocated to companies.
4. Åström et al. (2015) estimated that collaboration with TI institutes had an effect on the turnover of user firms of around 28% compared to non-users, and that the effect remained positive up to four years after the collaboration.
5. Awarded doctoral degrees with an institute contribution of at least 50% (PRIs under block funding only).
6. Regulated by Royal Decree of 19 December 2008.

7. Strategic institute initiatives (SIS) are relatively large, multi-year projects defined with and funded by the ministry in charge of the institute. The projects are intended to develop long-term expertise in the institute fields of research that cannot be realised by other means. The funding for the initiatives is added to the envelope of the block grant.

8. In Denmark, for instance, the GTS institutes merged, halving their number in the last decade. In Sweden, the Ministry of Enterprise and Innovation encouraged mergers among the institutes and created a structure of four large technology-based institutes. In the Basque Country region in Spain, the integration of several PRIs to form Tecnalia in 2001 was initially motivated by the centres involved, but due to delays and co-ordination difficulties, the regional government eventually drove the merger from the top down (Shapira et al., 2015).

9. The last few years have witnessed a number of mergers involving universities and independent and public research institutes. For instance, the Norwegian Institute for Agricultural and Environmental Research (Bioforsk), the Norwegian Agricultural Economics Research Institute and the Norwegian Forestry and Landscape Institute merged in 2016 to create the Norwegian Institute of Bioeconomy Research (Nibio).

10. Applying the sectoral share of OECD value added for a given year rather than each country’s actual sector shares.

11. R&D investment in Norway sloweddown in 2009 and 2010 after the financial crisis, as in many other countries, but to a lesser extent.

12. Following some of the same (regional) indicators, the EU Innovation Regional Scoreboard 2016 identifies only two regional strong innovator regions in Norway, Oslo and Akershus and Trøndelag, while the rest are included as regional moderate innovators.

13. The survey conducted in 2013 was the first exercise that was not combined with the R&D survey, in order to avoid a “science bias”.

14. If the tax credit for the R&D costs is greater than the amount that the firm is liable to pay in tax, the remainder is paid in cash to the firm, in connection with the tax settlement the year after the tax year. Nearly 80% of the total Skattefunn support is paid out in this way.

15. www.innovasjonnorge.no/no/Bygg-en-bedrift/klynger-og-bedriftsutvikling-2/klynger-og-bedriftsnettverk/utlysning-2017.

16. An increase of R&D may also reflect changes in input prices, particularly the wages of scientists and engineers. Impacts may also be moderated by firm and project heterogeneity, as additional projects financed through R&D tax incentives are sometimes those with the lowest marginal productivity (Appelt et al., 2016).

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