Chapter 1.

Overall assessment and recommendations

This chapter presents an overall assessment of Norway's innovation system and policy, reflecting the key findings of the review. It identifies strengths and weaknesses and key issues for innovation policy, and develops specific policy recommendations for improving Norway's performance in science, technology and innovation.

Introduction

In the past century, Norway has experienced a remarkable transformation, which has reshaped the country into one of the richest in Europe. Its economy had long been dominated by agriculture, forestry, fisheries, mining and shipping, which resulted in the gradual growth of supplier firms and generated opportunities for smaller scale industrial development, for example in shipbuilding. In the first decades of the 20th century, extensive investment was made in hydropower for energy-intensive basic industries like aluminium smelters. A small number of academic innovators contributed to this development from the beginning.

From the late 1960s on, the offshore oil and gas (O&G) sector was developed by state-owned companies and other domestic and foreign companies that were awarded concessions for the exploitation of the Norwegian Continental Shelf. These concessions were coupled with specific tax and regulation instruments, notably the requirement to invest in Norwegian technological capacity. In places like Bergen, Stavanger and Trondheim, specific technological and engineering clusters emerged as a result of this voluntary policy, notably in shipbuilding and O&G.

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

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

Concerns have nevertheless been raised about persistent challenges. Several studies and evaluations, including some conducted by the OECD, have noted the limited cost-effectiveness of the research and higher education (HE) system in Norway. On the research side, the system produces "good, but not excellent," science – at a high price; on the education side, the HE pipeline has a high rate of student dropouts and overly long periods of academic studies. The performance of the HE sector, which lags behind those of the other Nordic countries on a number of key indicators, is not commensurate with the annual level of public expenditure, which is well above the OECD average.

A strong research and innovation system will be needed to transform the economy, which is still highly dependent on O&G. Despite long-standing efforts and significant success in diversifying the economy, around 7.5% of total employment in Norway was still linked to the oil industry in 2015, and the value added in oil and gas extraction (including services) accounted for 17.5% of Norway's total value added in 2015 (compared to 13.7% in 2013).While the macroeconomic performance of the country is in many respects above the OECD average, the slowdown of the oil economy has revealed the risks of the country's dependence on oil and gas. Finally, climate change is a significant challenge for Norway, as a key O&G exporter and given its relatively high and increasing CO_2 emissions.

Against a backdrop of increasing research and innovation-based global competition and mounting societal challenges, Norway is facing a "triple transition imperative". While it is clear from the most recent projections that oil and gas-related activities will decrease significantly, all the while remaining important in the Norwegian economy for many years, the first transition relates to a shift towards a more diversified and robust economy. Although the drop in the price of oil has made this imperative more acute, there is broad consensus among policy makers and stakeholders in Norway's system of innovation that the long-term need for transition will persist, even if the price of oil rises again.

Table 1.1. **SWOT (strengths, weaknesses, opportunities, threats) analysis of the Norwegian research and innovation system**

Strengths	Weaknesses
– Abundant and prudently managed natural resources – Good economic performance, above the European Union (EU) average – Several academic strongholds in specialised economic areas, such as fisheries, aquaculture and O&G – A well-equipped higher education institution (HEI) system that allows for planning and building of scientific infrastructure Continuous operational science, technology and innovation (STI) co-ordination on the government level – A rather simple institutional landscape, with strong funding actors, including the Research Council of Norway (RCN) as a central actor (but with numerous roles and instruments) – A diversified public research institutes (PRI) sector with good technological performance, well-connected to industry – International attractiveness, inflow of talent from abroad – Strong EU programmes related information, networking and advocacy infrastructure – Extensive programme evaluation, well-developed evaluation practices – Strong tradition of consensus-based decision making – Continuous incremental innovation in the public sector	– A satisfactory but less than excellent research performance, with only few "peaks of excellence" in the university system – Less return than expected from the performance-based funding and governance reform of universities in the research area – Limited fully-fledged tenure track and strategic recruitment; high average age of university professors – Persistent deficiencies in higher education in the fields of science, technology, engineering and mathematics (STEM) despite progress – High number of tertiary student dropouts and overly long academic studies – Low outward mobility in research: young researchers with little international mobility – Low levels of applications and participation in the European Union Framework Programme. – Industrial specialisation in sectors with low research and development (R&D) intensity – Limited research-industry relationships, except in O&G and aquaculture – Current setting in the Norwegian STI policy system limits effectiveness of policy advice and ability to promote structural change – Lack of a dedicated actor for renewal in the public sector (including upscaling successful solutions and approaches) – Insufficient strategic focus on key fields like health
Opportunities	**Threats**
– Evidence that diversification from O&G is already under way (e.g. in deep-water energy, mining, offshore fish farming) and industrial upgrading – Putting in place an environment (including public support instruments) conducive to the emergence of new activities/sectors – Potential that public procurement for innovation can support diversification, on the basis of existing instruments at RCN – Revision of the Long-Term Plan (wider scope integrating higher education; more precise investment and action plans, (including outside the remit of the Ministry of Research) – Reconcile Norway's egalitarian culture with the advantages of greater excellence and competition	– Little pressure for change, given the generous benefits offered by the system and the generally high level of satisfaction with it – Strong reliance on past performance, limited ability to invest in new areas – Weak strategic basis of many public research institutes (PRIs), small institutes, low basic funding – Reluctance to embrace structural change – Reduction of diversity in the system as a result of the harmonisation of universities and university colleges that may negatively affect overall performance

The second transition thus involves moving towards a more competitive, effective and efficient innovation system, with sufficient incentives and checks and balances for better performance in research and innovation.

Finally, these structural transformations must be achieved while supporting research and innovation that can confront an array of societal challenges (climate change, food security, ageing, health and so on). Several of the challenges related to the transition to a sustainable economy already affect key sectors of the Norwegian economy. Fisheries, for example, are vulnerable to the effects of climate change and food security, and the oil and gas industry is also subject to increasing environmental pressures.

Reflecting the need for this triple transition, the Norwegian government recently launched a comprehensive strategic plan to enhance the contribution of the research and HE system to these challenges. The Long-Term Plan for Research and Higher Education 2015-2024 (referred to in this report as the LTP), submitted to the Storting in 2014, is built around three overarching government objectives for science, technology and innovation (STI) policy: developing research communities of outstanding quality; enhanced competitiveness and innovation; and tackling major societal challenges. The LTP also includes six broad priority areas within a ten-year perspective, and proposals for longer term goals, as well as a few specific actions with budget commitments for the first four years (see Annex B).

The LTP will be revisited in 2018, not only to renew the budget commitments for the following four years but also to revise some of its limitations as an institutional arrangement for priority-setting, multi-year investment and interministerial co-ordination. This Review is intended to help inform this revision process.

Developing excellent academic communities

Norway has a comparatively young but sizeable public research sector consisting of public research institutes (PRIs), universities, university colleges and hospitals.[1] The country has faced long-standing concerns over the insufficient excellence of research and the quality of higher education. These concerns were recently highlighted both in the LTP and by the Productivity Commission report "At a Turning Point: From a Resource-Based Economy to a Knowledge Economy", published in 2016.

Previous attempts to address this issue have yielded mixed results. They have been hampered by some distinct features deeply entrenched in the Norwegian system of research and innovation at the level of the government and higher education institutions (HEIs). In particular, the "consensus principle", an important feature of Norwegian political culture, has tended to temper some of these initiatives, and the "sector principle," which gives individual Norwegian ministries a high degree of autonomy in their respective fields, has restricted horizontal co-ordination.

At this stage, an adapted research policy approach needs to be considered, one partly aimed at achieving critical mass in the highest-performing sector of the research system, while still ensuring sufficient relevance for competitiveness and societal challenges. Excellence and relevance are not contradictory goals in this respect. Many examples show how important top-class research is in achieving relevant objectives and new solutions for different challenges in the medium and long term, and several instruments attempt to foster both excellence and relevance.

Good, but less than excellent, research in higher education institutions

Overall, the higher education expenditure on research and development (HERD) ranks at the medium level, at 0.59% of GDP, while the share of researchers (in FTE) is high, approximately 35% of the national total (2015). The first indicator is below, and the second comparable to other successful smaller European countries.

Starting at a very low level in the 1980s, Norway's HEI research output has been on a steadily upward trend. Norway is ranked far above the world average, but below Switzerland, Denmark and Sweden in terms of the number of scientific articles published per inhabitant. While several indicators suggest that Norway is doing well, the performance and impact of its public research system is not outstanding in areas sustaining the competitiveness objective or aiming to tackle societal challenges. Various indicators show that Norway performs less well in terms of quality measures and lacks world-class environments. Its share of the top 10% most cited publications lags well behind that of the leading countries, including Denmark, Netherlands, Sweden and Switzerland. Other indicators, like Norway's low success rates at the European Research Council (ERC) and in publications in top journals, also indicate that the number of its world-class researchers and environments is still too low.

Nevertheless, Norway needs more top-performing groups and is well-equipped to support them. International experience suggests that highly rated research groups and leading scientists are critical for establishing technology clusters in a context of growing technological complexity. Examples in Norway include fields like oil and gas or marine biology, each of which faces great opportunities in future. Encouraging "peaks of excellence" will also be a critical step in taking advantage of these opportunities and helping to start new avenues for development, for example in the digital economy.

Efforts to strengthen competitive mechanisms among higher education institutions

The fragmentation and lack of critical mass in the dominant HEIs, both within the organisations and in the overall HE sector, impede the emergence of more "peaks of excellence". Norway has a considerable number of universities and university colleges, with a few traditional centres of research and higher education, including Oslo, Trondheim, Bergen and a large number of smaller regionally distributed HEIs created in the post-war era. The number of HEIs has significantly fallen in recent years, mainly due to mergers in the overpopulated University College (UC) sector. However, the significant effort expended on mergers between universities, including university colleges, has not yet borne fruit.

Various recent assessments and white papers, including the LTP, suggest that the lack of critical mass is partly the result of the clear preference of Norway's government and of universities to distribute funds equitably among HE institutions (an effect that has been reinforced by the lack of internal priority setting). These sources indicate that Norway does not favour a culture of competition or set adequate competitive mechanisms among HEIs. The structural change initiated by the government is to some extent also driven by this approach: the intent of the latest wave of mergers seems to be to level out the university colleges, which have traditionally been weaker in research, rather than to enhance excellence in leading universities.

In addition, the MER has used a performance-based funding element as part of the HEI block funding since 2002, and the Research Council of Norway (RCN) has introduced several competitive programmes to enhance research quality. The Centres of

Excellence programme (Sentre for fremragende forskning, or SFF) scheme was set up to finance the best research groups for periods of up to ten years and helped significantly to raise the level of quality in Norwegian research. The FRIPRO Toppforsk scheme also provides financing for a four-to-five-year period for research projects that have the potential of attaining the highest international standards. However, there is still room to increase the share of large, risky and more fundamental projects in the overall Norwegian (i.e. RCN) funding portfolio, as indicated by the Productivity Commission report and the recent RCN Spending Review. Competing for large external grants makes it possible to bypass internal distribution channels.

Opportunities to reinforce competitive mechanisms within higher education institutions

The LTP and the evaluations of Norway's top research performers also attribute its lacklustre scientific performance to the lack of competitive mechanisms within HEIs themselves. The recruitment, career management, priority-setting and budget allocation processes only imperfectly allow selection mechanisms to operate at the level of departments, research groups and individual researchers. The universities themselves, which have reached a significant level of autonomy, have an important role to play in enhancing research quality. The universities appear now to have a legal and structural framework that should allow the stronger HEIs to enhance their performance and achieve critical mass. Recent reforms of HE governance structures and of career paths are a step in the right direction and could now in principle be fully embraced by the HEIs. However, the results have not yet reached a satisfactory level.

For research staff, one key incentive is the career path. So far, Norway has no real tenure track system of the kind that is in place, for example, in the United States. Recruitment is described as often being based on routinely programmed promotions related to the time spent in the organisation, with little long-term strategic planning. Positions for professors are advertised internationally and promotions are merit-based and peer-reviewed. However, further efforts could be made to search for the best talent worldwide, recruiting potential applicants early on and putting them on an evaluation-based track to full professor.

It has been noted that the lack of a strategic approach underpinning human resource policies has limited the number of lifelong positions for younger top talent, due both to the small number of permanent senior positions and to how appointments are carried out. Recruitment processes appear to often satisfy local ambitions, with incumbents building their own small research fiefdoms. This does not take full advantage of the number of talented international researchers – actually and potentially – coming to Norway at all levels, from PhD students to full professors.

Change will therefore also have to come from within organisations, as external incentives and support programmes can be only part of the solution. The conditions are now conducive to such changes: universities are well funded and enjoy a high degree of autonomy; the position of university boards and rectors has been recently reinforced; new incentives for world-class recruitment have been set up; and the conditions for a tenure-track system have been put in place.

A tenure-track system, which is in principle now possible in Norway, allows for active recruitment of younger talent, mostly from outside and for the promotion of researchers to the status of full professor after a number of evaluations.

Most universities have yet to transform these opportunities into action. They will need to use part of their internal block funding in order to strategically create critical mass and attract top talent to their best departments. This will also mean shutting down departments whose performance is underperforming. The government can only carry out such changes by setting the right framework conditions, taking further legal steps and providing adequate incentives and "nudges". Another key condition for success would be to strengthen the HEIs' strategic leadership and to further incentivise HEIs to recruit and promote top people from abroad as well as from within the system.

The creation of critical mass through mergers, while preserving the dual university system

As in many other countries, the Norwegian HE system went through a major period of expansion in the post-war era. Increasing numbers of students and regional ambitions under specific geographic conditions resulted in a population of more than 100 HEIs with their own regulations and missions. Many new university colleges were based on regional upper-secondary schools that were "upgraded" to the tertiary level. Confronted with this proliferation, Norway's HE policy responded with two interrelated policy measures: on the one hand, HEI mergers have been encouraged; on the other hand, the main structural differences between universities and university colleges were gradually eroded.

Mergers typically aim to reduce the number of HEIs and decrease the fragmentation of the system, in order to enhance research and educational quality through critical mass. They have been carried out in successive waves in recent years, mainly among university colleges or between colleges and larger universities. These reforms combined successive or overlapping voluntary and mandatory measures, top down and bottom up, state control and stakeholder involvement, egalitarian and leadership visions. Although some consolidation initiatives have been watered down due to the consensus principle, and to successful – often regional – resistance, the number of university colleges has been significantly reduced in the past decade. Some new players have been created, while a few universities were merged into larger entities. The incremental, long-term Norwegian approach contrasts, for example, with Denmark's "big bang" university merger process.

In a white paper released in 2015, the government announced a new series of structural reforms in the HE sector. While in the past, reforms were usually voluntary and took a long time to take effect, the most recent mergers were strongly promoted and incentivised by the state. The Ministry of Education and Research invited all higher education institutions to discuss the issues, asking them to draw up expressions of interest in possible mergers. This resulted in several mergers, reducing the number of public HEI from 33 to 21 as of January 2017. This also shows that the step-wise, negotiation-based approach of Norwegian science, technology and industry (STI) policy can be quite effective. The reduction in the number of HEI was emphasised as a necessary means of increasing the quality of research and of teaching and learning. However, a closer look at this document reveals that it does not primarily target the larger universities or address issues of quality but serves mainly as a justification for the ongoing wave of mergers in the university college sector. It will be a while before these mergers bear fruit, since the research capacity of university colleges is far below that of universities and may ultimately result in levelling rather than raising the level of quality. However, it is too early to assess whether the recent mergers will have the desired effect on the quality of research and teaching, especially since some of them have not even been completed. One additional instrument for enhancing quality and differentiation is the individualised performance agreements, which are now in the pilot phase but will be rolled out in the coming years.

The recent trajectory of Norwegian HE policy, together with other factors, has reduced the differences between the respective missions of universities and university colleges. Both are governed by the same laws, which give them the same internal structure, tasks and prerogatives. Nearly all HEIs can grant PhDs and conduct research. The colleges were incentivised regarding both their performance and their ambitions. A number of university colleges aim to become full-scale universities, often through mergers. This should lead to a much smaller number of university colleges but a large number of universities.

International experience suggests that Norway should retain some stratification in its HE system, for two reasons. First, regionally anchored university colleges can be successful, as the Swiss, German and Austrian examples show. Second, Denmark, Germany, the Netherlands and Switzerland have in different ways shown the advantage of cultivating a few top universities able to compete in the top European or even global academic circles.

An adequate funding model to increase research quality

Norwegian HEIs are well funded. The share of block grants is high by international standards, and the same is true for the share of all public funding sources compared to the HEIs' overall budgets. The larger universities are well endowed by European standards, but budget increases are needed before a few top universities can become major European HE players at the level of the best-performing Belgian, Danish, Dutch, German and Swiss institutions.

Universities and university colleges receive part of their block funding through a performance-based budgeting system. Around 70% of the block funding is based on historical levels, while 30% of the HE funding comes through a performance-based financing (PBF) stream, mainly following an *ex post*, output-oriented approach. Two different sets of performance criteria co-exist; from 2017 onwards, the following adapted formula will be in place:

- A dominating "open budget" PBF element, where overall funding for the HE system can increase if the universities or university colleges are successful. This element concerns the HE education component in four sub-categories: The main bulk of PBF funding is measured against reported student performance (completed study credit points). This makes up for 64% of the overall 30% PBF HE block funding share. Another 15% of the overall PBF is tied to graduation rates and 5% to PhD graduates (formerly part of the "fixed-limit budget"), while 1.2% forms an incentive for student exchange. So around 85% of all PBF are in this open category; PhD graduates have been recently shifted from the "fixed-limit budget" to this category.
- A much smaller "fixed-limit budget" element for the more research-related components, where the overall amount for the HE system is fixed with a ceiling, allowing only for reallocations between HEIs. From 2017 onwards, this element accounts for a little more than 15% of the overall PBF HE block funding. This component now includes four smaller indicators – each between 2.8% and 5% – the publication credits, the funding from RCN, funding from EU and other public sources and the contract research indicator (*Bidrags og oppdragsfinansiert aktivitet*, or BOA) for private revenue, including contract research.

These recent changes were introduced on the basis of recommendations by an expert committee to fine-tune the Norwegian PBF component in HE funding. On this basis, the government adapted some elements and included revisions in its 2016 and 2017 budget proposal. The main changes include the new indicator for completed degrees, to reduce the length of time students spend on their studies. As described, greater incentives for success in the European Union Framework Programmes (EU FP) and for contract research have also been added.

Performance-based funding can come in various forms, from *ex post* peer evaluations with a strong reallocating effect (along the lines of the Research Excellence Framework, or REF, in the United Kingdom) to performance contracts mainly negotiating extra budgets for additional achievements. Norway has chosen a third path, widely applied internationally, making a certain fraction of the block grants conditional upon indicators measuring past output. Both appear to have some advantages, but it is unclear whether the research component of the performance-based funding helps create critical mass and superior performance. The teaching component will also be difficult to handle in the future, as there are still not many competitive funding elements in place in addition to PBF. Some steps, however, are planned for the coming years to introduce more competitive elements into the Norwegian HE teaching realm, based on a white paper presented to Parliament spring 2017.

There is no golden rule for university funding, either for the different forms of block grants or for the proportion of block funding and competitive funding. However, Norway's high share of block funding in its current form might have led to internal distribution patterns without strong quality signals. One option would be to combine quality-enhancing indicators with a broad discussion process and incentives for new recruitments and career standards, as well as to strengthen HE leadership.

Based on the recommendations from an expert committee, the ministry is also piloting institutional performance agreements (PAs) with a sample of five state-owned higher education institutions. The overall goal is to increase quality in education and research, and the instrument may possibly be included as an element in the funding system. PAs are expected to contribute to the achievement of the two big HE sector goals, excellence and differentiation. Until 2019, the government plans to introduce PAs across the whole HE sector.

The goal of the PAs is also to establish clearer institutional profiles and better division of labour between the institutions, with individual performance goals for each HEI. PAs are therefore also a potential response to concerns regarding the loss of diversity in the HE system, as long as they are concise, coupled to indicators and action-oriented. The pilot universities are asked to include in their performance contracts a "local development strategy" that describes how they will contribute to the economic development of their area. In addition to driving universities towards higher performance, these contracts are meant to help preserve the regional profile and particularity of universities.

Recommendations: Developing excellent academic communities

- Continue to focus on excellence and critical mass in the higher education (HE) sector. This effort need not only come from the top, a common vision, financial incentives and policy experiments will have to be developed, involving a joint, structured action like the Long-Term Plan process. In particular, the government should:
  - introduce a next step in the performance-based part of HE funding, to incentivise high-quality research and education
  - prioritise top-class recruiting and career models
  - further increase, in co-operation with other stakeholders, the capacity of HE leadership to reallocate resources towards excellence
  - discuss options to develop a few universities as top European players.
- Rapidly install a fully-fledged tenure track system in the HE sector and support its implementation in HEIs. The Norwegian HE system needs to roll out an internationally competitive career development model, and while it is already possible in principle, ways must be found to establish it as the standard way of hiring and developing talent.
- Further promote HE mergers, mainly among university colleges, without abandoning a functionally binary system. The number of smaller HEIs could still be reduced. However, merger issues and development ambitions of university colleges should not inadvertently lead to an increase in the number of universities. In the current legal framework, Norway should take care to maintain a functional stratification between regional or applied HEIs and highly visible, research-intensive universities able to compete at the highest levels in the European league.
- Continue funding centres of excellence (CoEs) as an effective external driver of change for the public research sector. CoEs cannot substitute for internal priority setting and structural reforms, but they can play a strong supportive and enabling role.

Enhancing competitiveness and innovation

The success of the transition of Norway's economy will, in the end, be assessed in the light of structural changes in the industry and service sectors. The Long-Term Plan has set ambitious goals in terms of industrial renewal and improvement of Norway's competitiveness. It relies principally on the two other pillars of the plan, i.e. innovation resulting from excellent research, as well as economic development based on major societal challenges. The plan's three overarching priorities are intended to reinforce each other systemically, with innovation as a common thread between them.

Norway's innovation performance is mixed. The EU's 2016 Innovation Union Scoreboard (IUS) classifies Norway as a moderate innovator and ranks it below the EU average. Norway performs well in terms of its research system in the IUS, but scores particularly low on indicators related to high-technology industries and innovation activities and expenditure, particularly in small and medium enterprises (SMEs). However, data from the most recent Norwegian innovation survey (conducted separately for the first time, rather than combined with R&D surveys) show strongly improved performance in these indicators, including considerably higher reported innovation activities by Norwegian firms. Using these figures for the relevant indicators in the IUS, the position of Norway would improve from 16th place to 13th in the IUS ranking.

A specialisation in sectors with lower R&D intensity

Like many other countries, Norway has set ambitious targets for levels of R&D expenditures, which, as an input in research innovation processes, will translate into improvement of innovation and economic performance. As early as 2005, Norway adopted the general target of increasing total R&D expenditure to 3% of GDP by 2010, with 1% from public R&D expenditure, in line with the original EU Lisbon strategy. The level of R&D expenditure remained stable, oscillating between 1.4% and 1.7%, no more than in the previous 20 years, and the target was not met. The Long-Term Plan reiterated these R&D intensity targets, starting from the same level (1.71% of GDP in 2014), while specifying that the 1% target should be reached in 2019/2020 and the 3% target in 2030. While the 1% public R&D expenditures' target was reached in 2016, there is broad agreement that reaching the overall 3% target would require a substantial restructuring of Norway's industry. R&D figures for 2015 indicate a considerable real increase in Norway's total R&D expenditure, of 12% from 2014, or from 1.72% to 1.93% of GDP.

Business R&D, which accounted for 54% of total R&D expenditures in 2015, is low, especially compared with figures of approximately 70% in other Nordic countries and 60% on average in the EU. This is partly attributable to the structure of the Norwegian economy, and its large share of commodity-based activity and related low share of industries with high R&D intensity, as well as the relatively large share of smaller sized companies. Moreover, Norway's high-tech industries have lower R&D intensity than the OECD average. In contrast, sectors such as fishing and aquaculture, typically classified as low-technology, have a higher R&D intensity in Norway.

Despite this relatively low business R&D intensity by international standards, Norway has recorded the highest growth in business sector expenditure on R&D (BERD), particularly due to increasing R&D in the service sector. There is also a good match between the scientific specialisations and the large Norwegian industrial clusters, in particular fisheries and aquaculture, the maritime sector, marine biology and environmental technologies. With the relevant incentives and adequate guidance, the strong positions established in these sectors could be used as a stepping stone to broaden and diversify the national economy. 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 is already occurring.

Efforts to internationalise Norwegian research and innovation will help in this respect, together with increased mobility across economic and institutional sectors and opportunities for diversification in the service sector, including in the public sector. The growing opportunities for economic diversification within the service sector, including public sector services, will have to be carefully scrutinised.

Diversified and effective public support for business innovation

Norway is among the OECD countries with the highest share of government-financed gross domestic expenditure on research and development (GERD). Public funding to support business innovation has risen substantially in recent years, in particular through the Skattefunn R&D tax incentives and RCN programmes. RCN and Innovation Norway offer a comprehensive portfolio of financial support schemes and technical services to support business innovation. Some of these are technology- or industry-neutral, while others are linked to specific industries, covering the needs of industry along the innovation life cycle and covering the research spectrum from curiosity-driven to more user-driven R&D. Geographically, funding through the RCN and Skattefunn tends to

concentrate in geographical areas with well-developed research infrastructure and a strong concentration of industrial R&D, respectively. Innovation Norway funding is distributed more widely across the regions, including in peripheral areas and those more likely to be affected by the decline in the oil and gas industry.

Norwegian industry therefore benefits from a well-developed system of R&D support. It could be argued, however, that Norway's comprehensive policy mix is better suited to support existing strengths than new sectors and new areas for diversification. The government has taken some actions, using in particular RCN strategic programmes and funding schemes, that encourage the transfer of knowledge across sectors. Finally, more use could be made of demand-side tools such as public procurement, building on the experience of the Public Research and Development contracts (or OFU, standing for *Offentlige forsknings- og utviklingskontrakter*).

Instruments undergo rigorous periodical evaluations. Evaluations of R&D and innovation support instruments generally show promising results, although most of the evaluations focus on individual instruments and few evaluations take a system perspective. In a recent evaluation of innovation support instruments, including the tax incentive scheme Skattefunn, Innovation Norway and the RCN found positive effects in sales, valued added, employment and R&D expenditure compared to a control group.

Since 2014, a comprehensive innovation cluster support programme has been in place in Norway, which adopts a cluster life cycle approach, adapted to the different stages of development of supported clusters. Some pro-active attempts are under way to promote cross-cluster collaborations, but these still need to be confirmed and scaled up. Besides the cluster programme, programmes such as the Ten-Year Programme for Regional R&D and innovation (Virkemidler for regional Forskning og Utviklingsarbeid og innovasjon, or VRI), introduced in 2007, have supported the development of 15 regional innovation initiatives across Norway and reinforced the position of regional authorities in the formulation of regional policy and setting of regional priorities based on the regions' strengths and challenges.

A shifting balance of instruments

Since its inception, innovation policy in Norway, as in many other advanced countries, has gone through a number of stages, alternating targeted measures with more neutral approaches where the emphasis is placed on areas such as recruitment of researchers, basic research and framework conditions for innovation. A budget breakdown by programmes and schemes indicates that the biggest funding category (18% of RCN funding) covers large-scale programmes, currently focusing on eight areas, such as ICT, bio- and nanotechnology, followed by non-selective user-led programmes (14% of the funding of RCN and around half of the RCN funding received by businesses), in addition to industry use of Skattefunn. This breakdown calls into question the recent efforts towards greater selectivity. Still, there is evidence of efforts towards greater signalling and steering of neutral programmes around key priorities, including those of the LTP. In addition, and in order to balance the goals of strategic prioritisation and diversity, the RCN is reorienting some of the thematic programmes to support knowledge transfer across sectors and themes.

Innovation Norway is also increasing selectivity and strategic thinking. The initiative, as part of the "Dream Commitment" activity, is seeking to reorient its activities towards opportunities seen as relevant for the Norwegian economy. This shift towards encouraging greater selectivity is driving efforts to modify existing tools, such as clusters

and other instruments (loans, financial support) to promote greater connectivity across industries to support the opportunities that have been identified.

Framework conditions for entrepreneurship and venture creation

Setting up the right conditions for entrepreneurship and creating new companies, particularly in pioneering activities, is of key importance for the long-term growth and diversification of the Norwegian economy. Analyses undertaken by the Productivity Commission and the OECD suggest that Norway is well placed to manage such restructuring, in terms of its institutions and regulatory conditions.

Ranked 6th out of 190 countries, Norway scores very well in the latest World Bank *Doing Business* report (2017). According to this metric, Norway performs better than the OECD average, ahead of countries like Sweden, Finland or Germany and the United Kingdom, but behind Denmark, (in particular with respect to the ease of starting a new business).

However, Norway has been slower to reduce barriers for business than the average OECD country, including barriers to entrepreneurship. The government recently implemented a series of reforms to reduce red tape, including, for example, simplified tax rules for business partnerships.

The number of start-ups is low compared to other countries, although they seem to be larger and their survival rate higher. At the same time, its percentage of fast-growing businesses is low, and few of them grow to become major employers. Recent efforts to address these shortcomings include increasing funds for seed capital to start-ups, start-up grants and financing of young companies through the FORNY programme, dedicated to the commercialisation of R&D results.

Improving knowledge transfer to reward excellent research

Legislation in the early 2000s in Norway gave universities a mandate to develop the incentives and framework conditions for commercialisation of academic research. 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. Arguably, the system is still immature and fragmented, but there are signs of development towards greater collaboration and critical mass, greater professionalisation and better systems for project selection.

The third mission of universities is increasingly acknowledged and supported in universities and colleges. However, Norway has no dedicated third-stream policy and funding, and commercialisation indicators such as patents, licenses and spin-offs are not included in the performance-based funding system for universities.[2] Unlike, for example, the United Kingdom, which has a well-established system of third-stream funding of universities, Norway does not have a comprehensive mechanism for reporting the knowledge-exchange activity of its universities, beyond narrow metrics such as patents and licenses. Although commercialisation has been among the priorities in MER's governance of the HEIs, the ministry has not yet set any incentives for commercialisation besides the support programme such as FORNY.

Industry funding, which currently stands at 3.1% of higher education expenditure for R&D (HERD), is moderate by international standards. A relatively small percentage of HEIs' staff reports research collaboration with industry. However, collaboration is extensive with the public sector and with health trusts.

Commercialisation activities are particularly strong in certain universities, such as the University of Oslo (UiO) and the Norwegian University of Science and Technology (NTNU), which have strong ties to industry and the public sector. Knowledge transfer is an integral part of its activities, with significant investment in infrastructure for commercialisation of research and entrepreneurship education. Universities and colleges play an important yet differentiated role in supporting commercialisation and knowledge exchange in their regions. Colleges are likely to play an important part in offering industry-oriented continuing education, which is important for Norway's economic transition.

The contribution of public research institutes to competitiveness and innovation

Distinct features of Norway's research institute sector

One of the defining features of the Norwegian innovation system is the strong research institute sector. Key R&D performers in the Norwegian system, the research institutes accounted for around 24% of R&D in the country in 2013, only slightly less than the university and the college sector. Most of the R&D performed by the institutes can be categorised as applied research, covering a range of disciplines, of which engineering and technology and natural sciences are the most important. The share of applied R&D activity undertaken by the research institutes in Norway is higher than that of comparable structures in other countries such as Denmark and Sweden. Research institutes also make a significant contribution to the volume and impact (in terms of number of citations) of scientific production.

Norway's research institutes, particularly the technical-industrial institutes, have a long history of supporting innovation in industry. Its marine and agricultural institutes were established in the nineteenth century. However, the main growth in the sector occurred during the post-World War II period. The SINTEF, now the largest Norwegian research institute, was established in 1950 by the Norwegian Institute of Technology (Norges Tekniske Høgskole, or NTH, now part of the Norwegian University of Science and Technology, or NTNU).

Compared to other countries, the institute sector in Norway is large in terms of number of institutes (over a hundred) but also more heterogeneous and fragmented in terms of the size of the average institute, ranging from large, cross-disciplinary organisations with several hundred employees, such as SINTEF, to small, specialised institutes with a few employees. Most of the institutes operate as autonomous entities at arm's length from the government, constituted as foundations or non-profit organisations.

Forty-four research institutes currently receive public funding from the state through the common block-funding system. These are divided into four arenas (technical-industrial institutes, primary industry institutes, environmental and social sciences). The fragmentation and relatively small size of many institutes is a constraint in terms of competing in international areas and developing quality and competence. A number of voluntary mergers have been undertaken 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. Few of the RCN funding instruments specify collaboration between PRIs as a criterion.

In addition to these institutes that receive core funding, some "government laboratories", such as the Institute of Marine Research (Havforskningsinstituttet) are also financed by the government, but through other channels. Norway could benefit from

broadening its PRI strategy and policy to this category of research institute, as well as to other types of institutes.

The funding of research institutes

The average percentage of the non-competitive base funding of Norwegian research institutes is relatively low, at around 11% (ranging from 6% to 15%), compared with organisations such as Finland's VTT Technical Research Centre, the Netherlands' Organisation for Applied Scientific Research, TNO, and Germany's Fraunhofer (around 30%), although the share is similar to that of the Danish GTS and Swedish RISE institutes, which receive around 10%.

RCN is in charge of the management of the block funding of research institutes, within the framework of guidelines defined by MER and following decisions by relevant funding ministries (for instance regarding the funding levels). Since 2009, the block funding of the research institutes has included a mechanism for performance-based redistribution, intended to stimulate competence building, scientific quality and collaboration. As of 2017, the performance indicators used for PRIs, as well as for higher education and regional health authorities, have been further harmonised. This performance-based system of core funding allocation has not, however, been fully rolled out across all categories of institutes. Where different ministries contribute to the core funding of the institutes, they have been reluctant in some instances to transfer their core funding to the performance-based part of their funding arrangements.

Fully harmonising performance-based funding would contribute to the objective of improving the research quality of institutes. While the current levels of direct R&D allocations in selected institutes provide them greater financial stability and resources for capacity building, it also reduces competition in the sector, rather than rewarding the institutes with the best performance.

Although the performance-based component of the core funding is a relatively small percentage of the total, evaluations have shown that it has an influence on the research institutes' priorities and strategies. However, some institutes see the performance-based system as placing conflicting demands upon the research institutes, in terms of their contribution to excellent research and innovation. For instance, the emphasis on publication may reduce engagement in innovation and commercialisation activities, such as patent, spin-off and licensing activities.

The institutes play a key role in the internationalisation of research and innovation in Norway, notably in terms of their participation in the EU Framework Programme (FP) projects and by integrating Norwegian firms into global networks. The institute sector has the highest engagement and the largest share of EU research funding, and some of the institutes do very well in the FP. Overall, the TI institutes absorb 64% of the total EU revenues for all institutes. SINTEF Foundation is the largest single actor participating in EU programmes. Financial mechanisms such as the STIM-EU scheme have been set up to boost internationalisation, somewhat offsetting the additional costs incurred by the institutes in their FP participation through an increase of the block funding proportional to the amount of EU funding received.

Research institutes' role in the transition

PRIs play an important role in the competitiveness of Norwegian industry. Surveys of innovation have shown that the research institutes are industry's most important R&D partners. Collaboration with institutes has been demonstrated to add to turnover and productivity gains as well as capacity building.

While the close interaction between industry and research institutes can be seen as a success, it is not clear how well placed the research institutes are to contribute to Norway's transition from an economy based on oil. An evaluation of the technical-industrial institutes revealed that their activities focus more on well-honed methods and activities (exploitation) than on exploring new markets and technological opportunities.

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 locking 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. This systemic co-dependency may also make it difficult to build up internal R&D capacity in firms.

Norwegian research institutes have traditionally maintained close connections with the university sector. They co-operate on joint projects, co-publications, doctoral projects and joint affiliations, and contribute in other formal and informal ways. To some degree, there is increasing overlap and competition between the two sectors: HEIs are becoming more involved in contract research in real terms (although the HERD financed by industry as a share of total HERD has decreased almost constantly since the 1990s), and institutes are increasingly expected to deliver doctoral training. Good examples of collaborative work between universities and research institutes can be found, and there is no evidence that this overlap is significant and problematic at present. However, funding mechanisms, and particularly the harmonised system performance indicators coming into force in 2017, may encourage further overlap of the roles of research institutes and universities, rather than complementing each other.

RCN also fulfils other missions, such as the development of a strategy for the sector and the periodic evaluation of the centres. However, the low share of base funding, as well as the multiple ownership and independent legal status of the institutes, has limited the RCN's capacity to steer the institutes towards particular policy goals, and in particular, to prepare for the major transition ahead. Instead, the RCN and its principals have taken a piecemeal approach to such guidance, 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 Long-Term Plan's support of the innovation-based transition

The LTP emphasises the need to diversify and increase the absorptive capacity of industry, to prepare for the transition to a low-emission society. Clear long-term priorities for government support are required.

Since the early 2000s, policy efforts to support R&D have identified a number of key priorities. These have remained more or less stable, and the LTP does not represent a break with the past. Priorities are consensus-based and uncontroversial, reflecting the composition of the Norwegian economy. They reflect the strategic advantages of Norway around natural resources and strong industrial clusters. As such, they could be considered

rather conservative, raising questions as to whether they are ambitious enough to support Norway's transition from an oil economy.

While the Norwegian policy mix for R&D is comprehensive, more efforts towards greater selectivity and co-ordination are needed. As the LTP notes, this requires that the agencies involved (RCN, Innovation Norway and the Industrial Development Corporation of Norway, or Siva) adopt a "co-ordinated and cohesive commitment to prioritised areas".

There is strong overlap between the research priorities identified in the LTP and the opportunity areas identified by Innovation Norway's "Dream Commitment" strategy (e.g. bio-economy, ocean space, clean energy). However, a more co-ordinated commitment to the priority areas requires better cross-ministry and cross-agency co-ordination. The "21-Forums" (see below), could be instrumental in supporting this co-ordinated work if they are constituted as permanent advisory bodies, and monitor the implementation of their proposed strategy in close co-operation with the public authorities. The proposed attention to collaboration arenas for co-ordination and implementation included in the follow-up plan of the LTP will require greater examination of potential missing linkages in the innovation system, as well as co-ordination failures.

The LTP does not address the spatial dimension of economic transition and diversification. The decline of the oil industry and related activities is expected to have an uneven impact on the regions. At the same time, economic diversification through spin-offs, product diversification and mobility is likely to be supported by dynamic regional ecosystems.

To support the innovation-based diversification of Norway's industry effectively, the LTP will need to involve stronger forms of priority setting, including in emerging areas, in addition to formal horizontal co-ordination mechanisms.

Recommendations: Enhancing competitiveness and innovation

Innovation policy

- Strengthen targeting and reorientation of innovation support funding, towards identified priorities. For instance, cluster policies could be amended to increase their selectivity.
- Develop a holistic system of enterprise support that focuses both on R&D of established firms and renewal through start-up development.
- Reinforce collaboration across agencies and ministries around key priorities and opportunity-driven innovation policies.

Public research institutes

- Increase the block funding for the institutes showing good performance and a low share of block funding. These additional funds should be linked to the institutes that demonstrate their ability to contribute to the industrial transition. A more strategic approach based on dialogue (including in the context of possible mergers) and the use of performance agreements (e.g. using indicators associated with knowledge transfer and industrial diversification activities) would help advance this agenda.
- Ensure that the funds distributed directly by ministries to the research institutes are related to strategic projects, in line with the government's defined priorities.
- Continue the structural reform of research institutes, including mergers across institutes and with universities, to increase critical mass and international competitiveness.

Recommendations: Enhancing competitiveness and innovation (*continued*)

- Encourage collaboration across institutes, stipulating that collaboration across institutes will be a criterion assessed in funding programmes.
- Encourage knowledge-transfer activities of research institutes. Consider additional funding streams, including dedicated commercialisation funds, and/or the inclusion of knowledge-transfer indicators, in the performance-based funding system (including, but not limited to, commercialisation).
- Reduce the mutual dependencies between RCN and the PRI sector. Increase block funding for PRIs and link it to incentives to start mergers and employ longer term planning and research cycles.

Knowledge transfer

- Provide more diversified support to the "third mission" in universities, in addition to increasing the budget of the FORNY programme, as suggested by the LTP. This should include a broader range of technology transfer mechanisms than commercialisation activities.
- Increase incentives for external engagement of academics with industry, and also broader stakeholders such as hospitals and the public and voluntary sector. Improve data collection on third-mission activities.

Tackling major societal challenges

Societal challenges already have concrete economic and social implications, which call for action. For instance, health security and climate change requirements have affected fisheries. The ageing of the population translates into increasing public expenditures for pensions, healthcare and the elderly.

Norway is among the European countries that have taken up the challenge to address the "grand" societal challenges with elaborate instruments at the national level, rather than only at subnational or European levels. Since the mid-1980s, important government documents on future research policy orientations presented regularly to the Storting as white papers (the *Stortingsmeldinger*) have had dedicated priority areas focusing on societal challenges.

The Long-Term Plan also assigns a prominent place to societal challenges, not only as one of the three overarching priorities, but also in the four thematic priorities that incorporate many of these challenges. The Long-Term Plan also includes the new insight that finding new solutions to address societal challenges is not only important for overcoming future threats for society but for providing important opportunities for economic development. However, it stops short of proposing the systemic new policy approach and instruments that such bold ambitions call for.

The "21-Forums" are set up in certain key areas relevant to societal challenges. They provide a valuable complement to the LTP in bringing together stakeholders within thematic areas to agree upon, co-ordinate and advance efforts to strengthen prioritised sectors and areas. They are, however, at the same time, strongly sector-driven and consensus-oriented processes, often lacking a broader and more visionary or forward-looking perspective. They have not demonstrated the ability to accommodate and drive the

transformative (and often disruptive) change that is likely to be necessary to address the grand challenges our societies face today.

A disproportionate focus on developing the knowledge base in addressing societal challenges

Norway has a strong tradition of investing in research areas regarded as relevant for societal challenges. Health, for instance, is by far the largest thematic research area in terms of R&D expenditure, ahead of petroleum. Significant investments have resulted in strong scientific performance, as measured by citation impact (for example in marine technology, global and planetary change). The fact that RCN, the main research funder, has set up a division dedicated to "society and health" is an important indication of the importance assigned to societal challenges in the research system.

The focus on societal challenges was open to criticism in the recent report of the Productivity Commission. This argued that excessive consideration of societal challenges as a criterion for allocating public research funding has undermined research excellence in Norway. The commission argues that as a result, too few research groups or institutions score high on research excellence, negatively affecting their total relevance and impact. However, an evaluation of the engineering sciences commissioned by the RCN in 2015 showed that research groups or institutions that scored high on research excellence also scored high in societal relevance and impact, calling into question the premise that excellence and relevance are mutually exclusive

Norway's focus on the development of the basic knowledge base underpinning societal challenges has two main limitations. First, inadequate investment has been made in other elements that could ensure the changes in socio-technical regimes that are necessary for systemic change. Overall, the tendency has been to address problems by designing a research and innovation programme, with too little focus on the framework conditions for innovation and systemic change, and on regulatory barriers that might hold change back. This attention to societal challenges is a recent phenomenon, but it has been widely documented that this linear approach is not well suited to tackling societal challenges. What was considered adequate in earlier decades for supporting the traditional "mission-oriented" research, and also, more recently, innovation for competitive purposes, has been called into question by the systemic and cross-sectoral dimension of societal challenges (including the fact that they transcend sectors and disciplines). An in-depth examination of research and innovation in health also revealed significant co-ordination and governance challenges. Systemic change is needed to promote better, more economically sustainable healthcare and for a thriving health industry. Second, most funding has been focused on areas often associated with societal challenges (climate, energy, medicine, biotech), but ground-breaking solutions to societal challenges might arise in other areas. For example, better health and healthcare are typically not the result of medical breakthroughs, but of organisational and behavioural changes that rely heavily on social sciences rather than technical solutions.

A specific action framework is needed to support transformative, systemic change

Policies should be implemented not only at the level of individual areas but also at the systemic level. The former, often referred to as the "niche level", requires measures to support experimentation and learning in a given area, most often with a strong involvement from users and a wide array of stakeholders. At the system level, where these niches compete

and are combined, large-scale transformations require an interdisciplinary and intersectoral interaction framework, in the form of wide-ranging strategies, roadmaps and platforms.

While incremental innovation in niche areas appears to be accepted and facilitated in Norway, transformative change at the systemic level may require new instruments, organisation and co-ordination. Solutions for societal challenges often require a multidisciplinary approach. Furthermore, they require translational activities in which different solutions are first developed in close co-operation with users and then tested in different contexts. Much bottom-up experimentation and incremental innovation is under way, for example, in municipalities and in education, healthcare and in the provision of public services, one of the great strengths of the Norwegian public sector. However, there is little systematic policy experimentation and learning with a focus on disseminating, scaling up and incentivising the wider implementation of successful initiatives and approaches. Incentives, mechanisms and structures for scaling good practices are often lacking in the public sector, an area that merits closer scrutiny.

Public sector innovations are key to tackle the "grand challenges"

The Ministry of Local Government and Modernisation has the formal responsibility for innovation in the public sector. The Agency for Public Management and e-Government (Difi), under the Ministry of Local Government and Modernisation, appears to have some responsibilities in this respect. However, its main focus is digitisation, which, while important, relatively neglects other factors driving innovation in the public sector. Organisational issues, regulatory changes (for example regarding public procurement), incentives and disincentives for innovation and the diffusion of innovation, experimentation and learning, public-private partnerships, leadership and other aspects are also crucial for increasing the efficiency and effectiveness of the public sector.

A further challenge is that social innovations in areas such as integration, healthcare, green growth, social mobility and cohesion are often interrelated and require systemic change and horizontal policy co-ordination. There is thus a need for a co-ordinating function for innovation in the public sector or an architecture for ensuring structured learning and driving systemic change (see, for example, the experience of Mindlab in Denmark, the Government Policy Analysis Unit of the Prime Minister's Office in Finland or the United Kingdom's Prime Minister's Delivery Unit).

The Long-Term Plan has not yet provided a new policy approach to address societal challenges

The LTP singles out societal challenges as one of the core priority themes and acknowledges their specificity, calling for actors and ministries to work across sectoral divides. However, it falls short of providing a road map or a tool box for the task.

In general, the plan approaches this task in a rather conventional way. The range of issues identified is relatively narrow (health, education, climate change, ageing) and the main strategy proposed is still a science-push approach. Other important societal challenges, such as social cohesion, integration, security and safety (in a broader sense) get scant attention. Regulatory changes, leadership and change management – essential in handling the kind of disruptive transitions that might be required – are not discussed.

Moreover, the LTP has so far mobilised little new funding for this purpose, and there has been little change in the origin and destination of the limited funds. Although the LTP aims to provide an overarching, interministerial framework for research and higher education, most of its research funding comes from the Ministry for Education and

Research (MER) and the Ministry of Trade, Industries and Fisheries (MTIF). Some ministries allocate little funding to research and innovation, even though their portfolio is associated with important societal challenges. The Ministry of Justice, for example, has a large budget for fighting crime and policing, but only limited funds for knowledge creation and innovation in these arenas.

Furthermore, the formulation of the LTP does not appear to have included a systematic process for identifying the "challenges within the societal challenges", that is, a foresight process or stakeholder consultation that could identify bottlenecks and institutional or systemic failures, as well as potential conflicts and resistance to change that might stand in the way of developing solutions.

The revision of the LTP should focus on "translational", systemic issues focusing on turning good research into practical solutions, but also on acknowledging the importance of user and demand-driven innovation. Greater emphasis on the demand side for innovation will be needed, focusing on experimentation, learning and orchestrating systemic change. This will require mechanisms and structures for horizontal policy co-ordination and governance, for addressing framework conditions for innovation (including the regulatory aspects), organisational issues, public procurement, policy labs, demonstration and testing facilities and upscaling of successful solutions.

Further work is needed to assess whether the higher education system can not only meet the need for translational capacities but also cultivate the interdisciplinary and multidisciplinary skill sets and approaches that are often necessary to tackle societal challenges. The LTP does not address the critical long-term question of building the competence and skill base needed to address its priorities. Failing to address the mismatch between LTP priorities and the education services provided by the tertiary education and Technical and Vocational and Educational Training (TVET) system could have adverse consequences. This particularly affects the priority of tackling social challenges, which will require questioning established structures and capabilities, redefining learning outcomes and strengthening systems and structures for lifelong learning.

The renewal of the public sector is one of six key pillars of the LTP, and social innovation is cited as a clear priority for ensuring an adequate, effective and efficient public sector. The LTP places great emphasis on healthcare, education and social services, but little on other areas, some of which urgently require systematic renewal and innovation. These include policing and security, labour market services and integration.

"21-Forum" processes complement the Long-Term Plan, but do not take systemic change far enough

The "21-Forum" processes are actor-driven strategy initiatives commissioned by the government or a ministry to promote research-based value creation and development. Based on broad interactions between industry, research and other actors, these platforms, which have developed sectoral R&D strategies, serve as advisory bodies and stakeholder forums.[3] In a few cases, such as OG21 (oil and gas), these initiatives function as a permanent advisory body that advises the government on implementing the strategic recommendations. The permanent 21-Forum revise their strategy documents at regular intervals, whereas the non-permanent 21-Forum have been finalised with the launching of their main strategic document.

These initiatives represent a significant effort towards mobilising stakeholders beyond public R&D funding. However, they do not offer a holistic approach to addressing societal challenges (e.g. health), since they are limited by sectorial boundaries. According

to an evaluation that the Norwegian Board of Technology (*Teknologirådet*) and the RCN conducted in 2015, the "21-Forum" focus primarily on co-ordinating activities, supporting political priorities and on creating consensus among the participants in their respective areas. The forums tend to promote dialogue between actors within, rather than across, sectors or areas. The evaluation concludes that the "21 processes" are expected to co-ordinate and optimise – not to question – the direction of adopted (existing) policies. They could have benefited from involving more actors who could have contributed outside perspectives and anchored the initiative in a broader societal context. Furthermore, they often lack a forward-looking vision or perspective, and many could have a stronger international perspective and context.

In common with other initiatives in Norway, "21-Forum" adopt a strongly consensus-based approach. They could benefit from a broader and more visionary perspective and the ability to accommodate and drive the transformative (and often disruptive) change likely to be necessary to address the challenges our societies face today.

Recommendations: Tackling major societal challenges

- Devise broad integrated programmes that prioritise addressing societal challenges. These programmes should include features that directly take account of the specificities of societal challenges. They should:
  - be based on inclusive processes that engage a broad array of stakeholders, including users, concerned parties and experts, entrepreneurs, local public authorities (and even, for example, artists and immigrants)
  - launch studies and initiatives to examine regulatory frameworks, legislation and standards that could facilitate the widespread implementation of solutions to tackle societal challenges
  - promote interdisciplinary and multidisciplinary research
  - access a wide range of instruments, from specific research and innovation projects (including social innovation) to experimentation and public procurement
  - include foresight exercises and agree on strategies/visions that transcend sectoral boundaries and include education, innovation and upscaling.
- Align the higher education and technical and vocational and educational training (TVET) system with the competence and skill base needed to address societal challenges.
- Invest in translational activities and establish structures for experimentation (including radical/disruptive innovations), as well as for learning and upscaling solutions. This could take the form of policy labs, experimental regulation-free zones, and also assigning selected actors (agencies, ministries, commissions) the responsibility for broader implementation.
- Strengthen public procurement for innovation, aiming to address societal challenges and considering other forms of support to demand relevant solutions.
- Address governance issues to improve co-ordination across ministries and policy domains of efforts towards solving societal challenges (for example in healthcare innovation).

Improving the governance of Norwegian national system of innovation

The triple transition imperative requires Norway to improve its capacity for priority setting and horizontal co-ordination in the context of highly sectorial policy. Although it falls short of fully achieving initial expectations, the LTP is a significant first step in this direction and is expected to advance further in its 2018 (and subsequent) revisions.

A highly sectoral governance structure

Norway has a stable and functional policy framework that strongly shapes science, technology and innovation (STI) policy. The Norwegian set-up requires that ministries independently formulate and execute policy measures in this regard. This so-called "sector principle" gives no less than 15 ministries strong prerogatives in all research and innovation matters in their respective policy areas. The principle is observed in many countries – without necessarily being conceptualised or explicitly acknowledged in most cases – but it appears particularly strong in Norway. In the past, it may have been advantageous to sequester research in various fields throughout the policy spectrum, but Norway's imperative for an economic transition has increased the need for horizontal, cross-silo co-ordination and a more active and integrated setting of strategic priorities. This approach can help support the transformation of the system that is needed to address societal challenges and to encourage emerging areas.

The Ministry for Education and Research (MER) has by far the largest budget and is well positioned to lead the co-ordination effort within the confines of the sector principle. Of the other ministries, the Ministry of Trade, Industries and Fisheries (MTIF) and the Ministry for Health and Care Services stand out, the first being responsible for industry-oriented research and innovation policy and the second for health research funding. Health research is a world of its own, with competitive funds deployed mainly through distinct allocation mechanisms outside the RCN. The three ministries account for more than 75% of government allocations for R&D.

Norway's sectoral approach is paired with a strongly consensus-oriented policy-making style. As has been demonstrated in the past, this combination allows for constant improvements. Norway has a good track record of making most of the opportunities it encounters. Its hydropower, raw materials, fishing/fish farming and oil and gas industries grew out of a combination of smart regulations, bold investments and clustered technological expertise. Some of its dominant sectors grew from modest incremental steps long ago, after acquiring foreign technology or hands-on experience. Part of the next wave of innovation, e.g. in raw materials from the seabed, could evolve in the same way. However, a number of new opportunities will be linked to cross-sectorial innovation, to fields with societal issues like health, and to new challenges, for example the digital economy and fully digitised "Industry 4.0", which would benefit from an approach that transcends conventional silos and boundaries.

Limited orientation and priority setting at the highest levels of policy making

Norway's governance structure does not favour co-ordination and agenda setting. Since World War II, and particularly in recent decades, some institutional arrangements of this kind have been set up, but they only allowed for weak co-ordination and have since been abandoned. At least since the 1970s, the Cabinet Research Committee (RFU) was used as a co-ordinating forum within the government for policy and budget questions. Without the formal powers to counterbalance the strong sectorial interests, it was abolished in 2014 in favour of more intensive Cabinet discussions.

Most key policy decisions, including budgeting and priority setting, are taken at the (sector) ministerial level, but some interministerial co-ordination processes "soften" the practice of the sector principle. The first main instrument is an extensive weekly Cabinet meeting dedicated to the discussion of substantial ministry initiatives and white paper drafts. The second is a well-structured annual process to draw up the national budget, with two large budget conferences and negotiation rounds in between. These negotiations

address both the overall ministry budgets and, depending on the year, smaller "common pots", respectively for research and for innovation. An interministerial negotiation process leads to a commonly agreed upon distribution process across ministries. With respect to the research pot, the MER has a distinct but soft co-ordination function, including the civil service research committee (departementenes forskningsutvalg or DFU) for day-to-day government research policy co-ordination and a considerable role in the "common pot" distribution.

In this setting, government actors can co-ordinate specific operational issues to ensure continuous incremental progress. This is coupled with agenda-setting mechanisms like the high-level meetings around and after the formulation of the LTP, dealing with such topics as top-tier research or entrepreneurship. Some actors have objected that these initiatives are no substitute for a holistic innovation policy. Funding programmes (mainly by RCN) and individual budget items tend to be the unit of analysis and negotiation. This often replaces the discussion of whole portfolios and strategic approaches in the interaction between the many principals and the agent. Steering by ministries appears to be operational rather than strategic. In addition, the sector principle negatively affects Norway's ability to mobilise other resources from various sectors to provide for successful cross-departmental policy delivery, for example in health, transport or other public sector innovations.

Broader strategic issues are not as well covered, including long-term options with alternative paths, possible directions of which priorities to choose, or larger initiatives combining funding with regulatory issues and cross-policy approaches.

Norway has no provision for long-term foresight, and optimising the existing sectors dominates policy discourse. In recent decades, thematic priorities have been remarkably stable, and the number of such priorities running in parallel has been large relative to the size of the country. While this configuration can have its advantages, an explicit foresight mechanism could help define desirable policy orientations.

Alternatives to the status quo do not originate only in *ad hoc* and sometimes one-off events like evaluations, spending reviews and productivity commission reports. Compared with other countries, Norway has fewer independent voices and organisational settings that come forward with strategic advice pro-actively. Elsewhere, high-level advisory and planning bodies are often used. Norway should find its own way to incorporate such a function into its STI system. The country has no high-level advisory body acting as a kind of referee, and before the LTP was launched, only the traditional white papers on research existed as formal and integrated cross-government STI strategies; however, with a different scope and with no multiannual financial commitments. Policy co-ordination generally follows the "consensus principle", depending on lengthy negotiations to reach common ground.

A more structured approach might be worth considering. Policy areas like health and other public sector innovation policies are not particularly well suited to Norway's current approach for developing a policy field. The cross-sectorial dimension of these area calls for more dedicated and co-ordinated policy action. New developments in the digital economy have been overturning established business models and transforming whole sectors. Given its abundant financial resources and regulatory know-how, Norway could become a good proving ground for experimentation in such new technology-based business models.

The Norwegian model also has considerable strengths, since it allows for long-term sectorial activities and actor mobilisation once consensus has been achieved. The various "21" thematic strategies, and to a lesser extent some government R&D strategies, e.g. for enabling technologies, play an important role in this context, as they constitute stable platforms for mid-term developmental paths, including funding instruments and some interministerial co-ordination. RCN plays a strong role in many of these sectorial strategies. The resources available allow Norway to follow a number of priorities and developmental paths simultaneously. This is an advantage as long as these resources continue to flow and policy arrangements allow informed, forward-looking and tough decisions on given options.

A costly research policy co-ordination model at lower levels

The absence of a top-level referee or central priority-setting mechanism at the top government level shifts the task of co-ordination to the "ground floor", i.e. the agency level. This puts RCN under pressure to fulfil a wide range of demands from the different ministries and assigns a number of roles to a single agency that do not necessarily amount to the broad remit of RCN as intended. The Council is a unique public body, combining funding tasks for academic and applied research and research-based innovation activities with the government STI advisory function and the role of the main commissioner of evaluations, among other tasks.

In this setting, RCN has to work hard to co-ordinate operational STI policy issues. If Norway is to introduce disruptive, new and step-change initiatives, an appropriate actor and voice is needed. The role of RCN as a "policy advisor from below" does not resolve this issue, given its position in the system and its linkages with its many "principals". RCN, which is not an independent or high-level body, strives to balance the demands of the various ministries and to obtain sufficient funding without too much earmarking. The task of giving strategic advice to the government is necessarily subordinated to this and may be influenced by RCN's immediate needs. As a whole, the structure of Norway's STI policy governance implies that research policy is guided not *ex ante* by strategic decision making, but is the *ex post* result of the balance between the different elements of the system. Elements of stronger forward planning are more typical *within* the individual priorities, as some of the "21" strategies show, rather than at the higher, overall, level.

RCN is limited not only in its ability to devise an integrated strategy but also to implement it. Although its wide scope puts it in a strong position in the research and innovation system, it has no autonomous central budget and cannot reallocate resources from different ministries for any set of priorities that might be agreed upon. RCN programmes have "ministry-earmarked" budgets, many of which are ordered by a single ministry. The number of principals and the number of funding activities put RCN in a difficult position. Although the MER and MITF account for half of the Council's funds, the imperative for RCN is to co-ordinate the requests from the 15 principals, which are conveyed through annual allocation letters (*tildelingsbrev*). This makes for a complex annual budgeting process. All the sectorial interests and the requirements of the consensus principle must be integrated every year into the RCN portfolio. There have been recent efforts to harmonise the allocation letters, partly in relation to references to the Long-Term Plan priorities.

RCN thus mainly relies upon soft co-ordination mechanisms, which ultimately results in time-consuming bilateral negotiations. Evidence shows that the (numerous) RCN staff devote much time to creating and sharing strategic intelligence and similar activities, and

in co-ordination groups and public meetings. Despite its apparent simplicity, this apparatus has to deal with a lot of complexity to preserve the highly valued stability and consensus of the Norwegian policy system. The extent of the co-ordination workload is at odds with Norway's aim to adopt New Public Management and management by objectives. Both the ministries and the RCN apparently strive for detailed, operational instructions, a play-safe approach implied by the sectorial and the consensus principles.

The RCN runs around 100 instruments (including more than 30 major programmes), a large portfolio for a small country and a single council. The number of instruments has decreased considerably in recent years, but is still sizeable. This process of compartmentalisation can be an advantage in policy fields with favourable regulations, strong actor settings and clusters like oil and gas. Other activities, like healthcare, for example, seem to fare less well under these conditions. Moreover, this system makes it difficult to discuss overarching strategic questions (for example, oil and gas vs. climate and environment).

More fundamentally, this extensive model of co-ordination may leave only limited room for policy innovations, unconventional approaches and cross-cutting activities. Policy makers are possibly overly preoccupied with establishing consensus, and fine-tuning and funding activities.

The RCN has not only to balance a broad funding instrument portfolio but must harmonise it with its other roles, including government advisor, evaluation co-ordinator or the remarkably extensive interface with the Norwegian PRI sector, it must apparently devote more attention to juggling all these functions and programmes rather than building portfolios or helping whole sectors grow.

An interesting case is the public research institutes (PRI) sector. The RCN distributes their comparatively modest block funds, checks the performance criteria of this funding stream and has a strategic responsibility for this large sector. Its functions include performance discussions plus a *de facto* decision-making power through which PRIs can obtain block funds. Nevertheless, the RCN still has the right to decide on some of the PRI board memberships. RCN funds the PRIs through various competitive programmes, as well as indirectly through industry subsidies that are used to pay for contracts with PRIs. As a result, the PRI sector is the ultimate beneficiary of nearly half of the RCN's overall spending budget.

In theory, the RCN thus has considerable leeway to steer the large but rather fragmented PRI sector, but it apparently does not exercise that authority. On the contrary, different and legally independent institute populations are affiliated with different ministries, and many PRIs depend on all kinds of RCN programmes to survive financially. RCN assumes the workload and the responsibilities, but it cannot help lift the PRI sector to the next level: first, RCN has many tools, but cannot help restructure a small sector that has to deal with short planning cycles, due to the low degree of basic funding. Second, the constant needs of many small (and a few larger) PRIs might have some feedback on how the RCN programmes and its other actions are decided on. The PRI sector accounts for nearly 50% of all RCN funding and requires constant attention to its short- and medium-term needs in a given setting. It could therefore be beneficial from a governance perspective to review how the PRIs could obtain more basic funding (like most of their counterparts abroad) and to give them incentives to formulate long-term planning cycles. This could be accompanied by stronger incentives for the PRIs to merge, as the university colleges did.

The Long-Term Plan as a co-ordination and steering mechanism

The LTP is an attempt to encourage a more strategic and co-ordinated policy approach. It can be traced back to the previous (a coalition including the Social Democratic Party, the Socialist Left Party and the Centre Party) government, which tried to build stronger consensus around long-term planning in Norwegian research policy. The MER, in its 2013 white paper "Long-term perspectives: knowledge provides opportunity," launched the idea of taking a ten-year perspective on research and higher education priorities. The successor government (a coalition including the Conservative Party and the Progress Party) followed up on some of these ideas and presented a "Long-Term Plan for Research and Higher Education 2015-2024" in October 2014.

The MER, which led the process, managed in a remarkably short time to accomplish the first such exercise in Norwegian STI policy, involving a wide array of stakeholders.

Against the backdrop of an institutional setting that enshrines the sectorial and consensus principles, the main expected added value of the LTP lies in its long-term perspective, its authoritative status, its interministerial scope and strategic approach. In each of these four dimensions, it has achieved noticeable progress, but several limitations persist.

Despite its original intent and formal title, the LTP is not a ten-year planning document. It has a ten-year perspective for designing longer term avenues, but is in practice conceived on a four-year rolling basis, with the first revision of the plan to come in 2018.

Although the LTP was presented to the Storting, like any white paper, it is not a binding multiannual research bill of the kind Sweden and Switzerland have put in place. Formally, it is a government strategy document. It does not enforce priorities or set radically new forms of government co-ordination. Its implementation still involves voluntary common negotiation and planning procedures.

The wide scope of the consultations during its development phase has resulted in the formulation of a single common, interministerial document, accepted across the government, covering such topics as upstream research, business innovation support and competitiveness. However, when it comes to concrete financial commitments and actions, the LTP does not have the same status in the different policy fields. While all ministries have contributed thematic or structural priorities to the plan, only some of MER's actions and programmes have earmarked budgets. Under this "asymmetric budgeting" process, the closer the actions to MER's core policy field, the firmer are the commitments. The only three concrete funding activities involve the field of research (junior university positions, appropriations to research infrastructure, etc.). In other areas, actions are more broadly defined and do not benefit from any financial commitment. The strongest limitation of its horizontal scope belies its very title, the "Long-Term Plan for Research and Higher Education". The fact that higher education issues are not covered in detail has raised some criticism. MER launched a white paper dedicated to HE policy issues in January 2017, which many see as compensation for the missed opportunity of the Plan.

The LTP initiative is a strategic initiative by nature. The plan establishes six priorities, building on ideas, proposals and plans from different ministries, agencies and stakeholders. However, these are wide-ranging priority areas. Despite the original intent, the approach of the LTP appears to be agglutinative rather than selective. Moreover, the topics covered in the LTP nearly all represent established thematic or structured priorities. Some even date back decades, either because of the long trajectories and path dependencies of sectors like oil and gas and marine/fish farming, or because of the slow progress and areas of conflict, like governance and high-level research issues in the HE sector. The

design of the priorities seems to reflect a somewhat weak strategic approach. While the four first priorities are thematic, the last two are horizontal, with a clear correspondence with the two overarching objectives, "enhanced competitiveness and innovation" and "developing research communities of outstanding quality". This structure does not favour a matrix in which research and innovation policies cut across the four thematic priorities.

However, the plan has succeeded in establishing a new approach that makes prioritisation politically more acceptable and in increasing commitment for some priorities across the whole government. It is a step in the direction of more ambitious quantitative goals, like the 3% research intensity goal envisioned for 2030. The LTP had some effects on horizontal co-ordination, including the high-level meetings chaired by the prime minister, Cabinet discussions on STI issues, the establishment of some interdepartmental steering groups at administrative and political level, alignment work in RCN and other soft co-ordination questions. The discussion and drafting of the LTP have already contributed to closer government co-operation, since it was a government-wide activity.

The LTP has also made a first step away from the "ground-floor" co-ordination model. The government seems willing to do more co-ordination work at its level. However, this structuring effect seems still superficial at this stage, even with respect to the operation of the RCN, the key LTP implementation body. Its Research Strategy for Innovation and Sustainability 2015-2020, launched in 2015 after the LTP, lists many goals and activities in lofty language and appears to be an effort to harmonise the LTP structure with the RCN's many ongoing activities. The strategy mentions the LTP only once, stating that the RCN "will help to follow (it) up".

Science, technology and innovation governance at the crossroads – options for the revision of the Long-Term Plan

While the plan is well articulated, it is long and not as precise as it might be. It intentionally contains only few concrete action points and does not set "hard" priorities, apart from the few initiatives announced for the period 2014-18. Most of these initiatives were already in the policy pipeline, and the LTP only conveys and concretises them. In a sense, the LTP is a mirror of Norwegian STI policy making, reflecting both its strengths and weaknesses.

The LTP assimilated many strategies, interests, viewpoints and policy options in an attempt to include every major actor. Getting beyond the strong sector principle and the current "ground-floor" co-ordination model will necessarily mean persuading all major Norwegian policy actors to take this step simultaneously, under the consensus principle. In this first edition of the LTP, the long and not very precise text of the document could help to initiate new policy practices. All the parties involved can assemble around the LTP to take the next step together. This might work out even better with the next LTP, because many government organisations, such as sector ministries or funding organisations, consider the plan a useful tool for streamlining and co-ordinating thematic priorities.

The LTP's strongest asset is the revolving nature of the planning process. Its four-year cycle offers the opportunity to start a next planning stage soon, since the ten-year plan has to be reworked every four years. This gives the MER and other ministries the opportunity to add more concrete structural and programme-style policy activities to the LTP from 2018 onwards, without changing the plan's general orientation. A gradual adjustment over the next LTP periods would allow more policy actors to work on this policy-negotiating instrument, without giving up the sectorial and the consensus principles.

Recommendation: Improving the governance of Norwegian national system of innovation

- Use the LTP process and its regular revisions to gradually enhance the level of multiannual financial commitment and STI priority setting

  The LTP has a ten-year perspective for its main priorities and a four-year perspective for concrete programmatic action. It is thus well suited to align sectorial interests periodically and to reach consensus on the next wave of STI priorities at government level. Its revision every four years also allows for a gradual enhancement of multiannual financial commitment in these priorities, including in emerging areas. The next four-year perspective, from 2018 onwards, might include additional and bolder policy actions, programmes and initiatives from other ministries, as well as MER.

- Build upon the LTP process and institutional infrastructure to improve strategic and operational interministerial co-ordination

  Norway's STI policy needs advisory and planning capacities at the top government level to help develop long-term views, alternative paths and strategic options. If a high-level advisory council is not considered a viable option, this role should go to a specific adapted instrument or body. This might be serviced by or linked to a permanent inter-ministerial group tasked with monitoring the progress of the LTP and preparing the next revision. This could replace the RCN's central role, while enlisting the support of the RCN, which should retain its advisory role given its unique relationship with the research actors and its privileged access to relevant data. In each current LTP thematic priority, the interdepartmental groups mobilised for the budget conference could also be made permanent.

- Prepare the ground for long-term foresight activity

  Norwegian STI policy and future revisions of the LTP should be informed by dedicated foresight initiatives. These should help to gradually identify and discuss long-term STI options for Norway.

- Provide RCN with a more independent budget to run inter-ministerial strategic programmes

  RCN follows the sector principle and receives earmarked funds from 15 ministries. The decommissioned Fund for Research and Innovation (FFN), although it was formally not an independent budget and showed its limitations in some regards, seemed to have provided RCN with some room for manoeuvre to introduce new, cross-sectorial activities. In the future, the RCN should be granted more independent budgetary authority.

- Incentivise RCN to further reduce the number of funding programmes

  RCN should run a less fine-structured and (over-)determined funding portfolio.

Notes

1. Although usually accounted for in the public research sector in Norway, hospitals are presented as a distinct category here.
2. A new indicator taking into account external income (contract research and grants other than those supported by the RCN and EC programmes) was introduced in 2017.
3. Starting from 2001, the "21-Forums" have been: OG21 (oil and gas), Energi21 (energy), Klima21 (climate), Maritim21 (maritime), Hav21 (marine), Bygg21 (construction), HelseOmsorg21 (health and care), Skog22 (forestry). A recent white paper on industry (Meld. St. 27 (2016–2017)) announced that a new 21-Forum for digitalisation of trade and industry as well as for the processing industry will be initiated.