Capturing Norway's Digital Opportunity

NORWAY AS A DIGITAL HUB FOR OIL AND GAS AND OTHER ASSET-HEAVY INDUSTRIES

BCG

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CAPTURING NORWAY'S DIGITAL OPPORTUNITY

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PREFACE

The Norwegian Ministry of Trade, Industries and Fisheries; the Federation of Norwegian Industries (Oil and Gas); and Boston Consulting Group would like to thank all the international and Norwegian executives who provided their input to this report. The engagement demonstrated in the interviews clearly indicates the interest in and importance of this topic.

EXHIBIT 1 | A wide range of executives provided input to the report

DEFINITIONS AND ABBREVIATIONS

AI: Artificial intelligence

API: Application programming interface

Asset-heavy industries: Industries which generate earnings primarily by building, owning, and/or operating large assets. In this report asset-heavy industries refers to oil and gas, maritime, fishing and aquaculture, and process industries.

BCG: Boston Consulting Group

Digital hub: A location that is (a) a world leader at realizing digital productivity gains, (b) a frontrunner at driving digital innovation and growth, and (c) characterized by a rich ecosystem where innovative business models can flourish.

Digital roles: In this report, refers to emerging roles as a result of digitization. Emerging roles include positions such as data analysts and scientists, IT services and process automation specialists, but also other roles with a large technological or digital element.

Domain expertise: In this report, refers to a deep understanding/knowledge of a particular industry function, process, machine, or material. A domain expert is a person who is an authority in a particular area or topic. An example domain could be reservoir engineering.

Ecosystem: In this report, an ecosystem refers to a network of organizations—including suppliers, distributors, customers, academia, research institutions and government agencies— involved in the delivery of a specific product or service through both competition and cooperation.

Enablers: In this report, enablers refer to factors that contribute to success of an entity, program, or project.

CAGR: Compound annual growth rate

GDP: Gross domestic product

HSE: Health, safety, and environment

IMD: International Institute for Management Development

KonKraft: Abbreviation for "Competitiveness on the Norwegian Con-

tinental Shelf," a collaborative arena for Norwegian Oil and Gas, the Federation of Norwegian Industries, Norwegian Shipowners' Association, and Norwegian Confederation of Trade Unions

MIT: Massachusetts Institute of Technology

NORSOK: Norwegian Continental Shelf's competitive position ("NORsk SOkkels Konkurranseposisjon" in Norwegian). Established in 1993 by the Norwegian minister Finn Christensen to reduce execution time for projects, and capital and operating expenditures for petroleum facilities on the Norwegian continental shelf. As a result, the NORSOK standards were established; a set of technical standards of which many are referred to in the Petroleum Safety Authority Norway's regulations.

OECD: The Organization for Economic Co-operation and Development

STEM: Science, technology, engineering, and mathematics

WEF: World Economic Forum

EXECUTIVE SUMMARY

Norway has a strong starting point and positive momentum as a digital hub for oil and gas and other asset-heavy industries. Five areas emerged from 47 interviews as the basis for Norway's strong relative position: (1) high degree of domain expertise, (2) availability of vast amounts of data, (3) transparent and collaborative culture, (4) robust technological infrastructure and a high degree of technology adoption, and (5) favorable local regulations and conditions. Although primarily addressing upstream oil and gas, the conclusions of this report may apply as well for other asset-heavy industries in the country such as maritime, fishing and aquaculture, and process industries.

Enhancing attractiveness as a digital hub represents an opportunity for Norway. The strong starting point is instrumental for Norway to claim a position as a leading digital hub—characterized as being a world leader at realizing productivity gains through the application of digital technologies, being a frontrunner at driving digital innovation and growth, and possessing a rich ecosystem where innovative business models can flourish. Being a leading digital hub offers great value potential. Introducing new profit pools and removing friction across value chains represents an opportunity for step-change improvements for oil and gas. For Norway as a nation, at least 20,000 roles in oil and gas will be redefined and become more digitally oriented over the next five years. To fill these digital roles, a mix of digitizing existing domain expertise and hiring external digital talent is required. Ensuring that these high-value roles reside in Norway and do not move to other geographies could add significant value for the country.

Five priorities for Norway to further strengthen its position as a globally leading digital hub. Based on insights drawn from interviews and analysis, there are five priorities for Norway to increase global attractiveness:

1. **Digitize Norway's world-class domain expertise.** Domain expertise, specifically areas such as subsea system engineering, subsurface reservoir modeling, seismic interpretation, and leading competence within HSE, is seen as one of Norway's great assets in general, and also in the context of being a digital hub. Digital innovation more frequently happens at the intersection of domain expertise and digital competence. Defining and focusing on selected areas—building depth instead of breadth—will be the key to succeeding. Rather than competing globally on Artificial Intelligence (AI) as a topic, Norway should define specific areas

where it will merge world leading domain expertise and knowledge about data structures with new technology, for example developing next generation reservoir models with AI functionality. Norway is well positioned to digitize its world-class domain expertise due to strong industrial adaptability, a collaborative mindset, and a supporting ecosystem. The use of contract structures to accelerate merging of traditional domain expertise and digital technologies could be one way to stimulate the desired behavior.

2. **Claim global academic leadership in application and development of digital technologies.** Norway has an opportunity to claim academic leadership in applied digital innovation in areas where the country has strong domain expertise. To get there, the industry and academia have a shared role to play. One way to do this is by expanding the existing Catapult program by establishing educational hubs that train employees in how digital technologies require new ways of working; and in potential application areas of digital technologies, for example, in relation to freeform additive manufacturing. Additional potential levers include setting clear and ambitious goals for strengthening specific academic communities, further increasing the ties between academia and business, and expanding partnership with leading academic communities.

3. **Improve access to industrial venture capital.** Seed money is seen as fairly accessible through government grants, however industrial venture capital to commercialize and scale is not seen as sufficiently available. The limited industrial venture capital environment in Norway restricts access to capital for industrial scale-ups. Potential levers to increase capital access include increasing government incentives for scale-ups, liberalizing the defined contribution scheme, attracting foreign venture capital firms, and reevaluating innovation-inhibiting regulations such as wealth and option taxation.

4. **Establish new best practices for data and sharing.** The interviews highlighted a need to agree on technical definitions of data and standard interfaces for exchanging data to enable integration and better collaboration. These technical standards should be internationally compatible, leveraging international standards to the extent possible. Not surprisingly, there are different views regarding to what extent data should be shared given the commercial implications. Some companies emphasize open systems where all data is readily available to everyone, while others limit sharing to their own systems. Accelerating current initiatives, for example based on the KonKraft report, while maintaining a legal and regulatory framework protecting intellectual property rights and proprietary data was cited as important.

5. **Increase industry agility and speed.** According to BCG, digital success is 70% business transformation, 20% technology and IT, and 10% algorithms. However, current digitization efforts are limited for many companies due to lack of digital knowledge by managers. Success requires a more agile mindset, where potential

levers include government bodies promoting a digital agenda through more active ownership, boosting managers' digital knowledge, introducing senior compensation structure incentivizing a successful digital agenda, and implementing agile principles at scale.

For Norway to increase its global attractiveness as a digital hub, key stakeholders (government, academia, industry, companies) need to drive their share of the responsibility. To achieve success, companies collaborating across the industry need to be the main driver while working together with government and academia to reaffirm Norway's digital competitiveness. Efforts to increase Norway's attractiveness as a digital hub should be focused in areas with strong domain expertise. Exhibit 2 is an overview of recommended actions for the different stakeholders. Please refer to Exhibits 13A-13D for an extended list of recommended actions.

EXHIBIT 2 | Call to actions for key stakeholders

	Government	Academia & research institutions	Industry	Individual companies
Digitize Norway's world-class domain expertise	• Government-led program for digital upskilling • Tax breaks for digital training programs • Program to attract digital talent • Reduce taxation for int'l talent	• Workshops and digital training programs	• Standard contracts structures accelerating digital developments • Sessions sharing digital best practices and success stories	• Connect strong domain expertise with digital talent • Invest in employee training and adopt new work processes • Attract international talent
Claim global academic leadership in application and development of digital technologies	• Expand Catapult program to train in new ways of working • Increase research funding for user-driven research • Tax relief for investing in applied innovation research	• Set ambitious goals to build deep knowledge in specific domains • Consider cross-functional institute to address specific industry challenges • Expand partnerships with leading academic communities	• High potential collaboration topics for academia/business • Sessions to increase business / academia collaboration	• Co-fund applied research programs • Collaborate proactively with academia
Improve access to industrial venture capital	• Increase government incentives for scale-ups • Fund-in-fund investment to attract foreign venture capital • Reevaluate wealth and options taxation for startups			• Increase internal funding for venture capital investments • Expand collaboration with startup communities
Establish new best practices for data and sharing	• Regulate sharing of specific datasets • Initiate industry data workshops	• Standard contracts enabling data sharing • Regulatory framework for IP rights and data sharing • Research program to explore legal issues with data sharing	• Standard interfaces, standards for data sharing and fair contract regimes • Stimulate data sharing and remove waste between parties • Data workshops sharing best practices	• Share data with limited commercial implications
Increase industry agility and speed	• Promote digital agenda through regulations and license to operate		• Industry-wide digital training program for managers • Exemplify bonus schemes related to growth leveraging digital tech.	• Compensation structures incentivizing a successful digital agenda • Implement new ways of working

Source: Interviews, BCG analysis.

METHODOLOGY

THIS REPORT PRESENTS OUR assessment of Norway's relative position as a digital hub for oil and gas, and a consideration of how to improve the country's attractiveness as such. Our conclusions may also be relevant for other asset-heavy industries in the country such as maritime, fishing and aquaculture, and process industries. The report consists of three main sections: an assessment of Norway's starting point as a digital hub including opportunity and value at stake; a discussion of five key focus areas to further enhance Norway's attractiveness as a digital hub; and finally, a view on the next steps and responsibilities for key stakeholders.

An important source of information for the report was the results of interviews with 47 international and Norwegian executives. They represent, among others, oil and gas operators and suppliers, large technology companies, startups, industry organizations, academia, research and government bodies, and investment companies. (See Exhibit 3.)

The purpose of the interviews was fourfold: 1) to discuss enabling factors for a digital hub,

EXHIBIT 3 | Interview approach: Feedback from interviews synthesized in heatmap of key findings

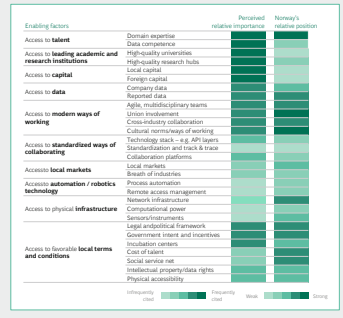
Structured interview guide followed to a create dataset…

1. **Discuss potential enabling factors**
   - Considering the definition of a digital hub, what are the potential enablers to become a digital hub?
2. **Relative importance of factors**
   - What are the two most important factors? Why?
   - What are the two next most important factors? Why?
   - What are the two least important factors? Why?
3. **Norway's relative position**
   - What two factors is Norway best positioned for? Why?
   - What are the third and fourth factors that Norway is best positioned for? Why?
   - What two factors is Norway least well positioned for? Why?
4. **Actions to improve attractiveness**
   - What actions would you prioritize and why?

… consisting of insights from 47 executives…

A wide range both local and international executives provided insights, increasing validity of interview findings

… synthesized in a heatmap highlighting key interview findings



Heatmap highlights perceived relative importance of enablers and Norway's relative position across them, illustrating both Norway's relative advantages and key focus areas to improve attractiveness

Source: BCG analysis.

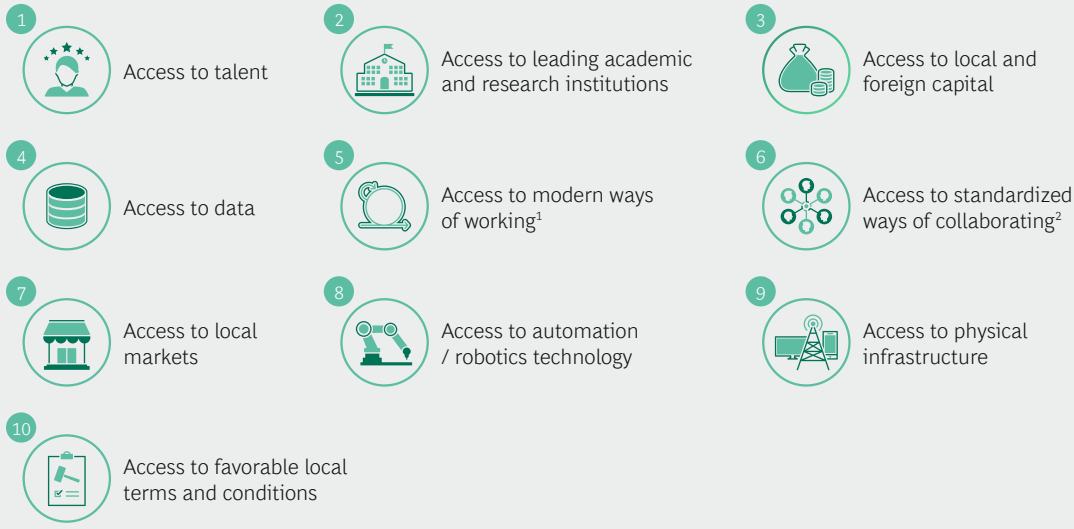
2) to establish the relative importance of those factors, 3) to define Norway's position relative to other countries, and 4) to define actions Norway should take to enhance its attractiveness. BCG has furthermore performed desktop analysis leveraging data from a broad list of external sources (OECD, Digital21, KonKraft, IMD, WEF, etc.), insights from previous BCG studies and projects, and new BCG analyses. (Refer to Appendix for a full list of sources.)

Please note that this report aims to present a range of opportunities and to prioritize initiatives for key stakeholders (including government, industry, and individual companies). Further assessment and detailed planning will be required for some of the initiatives.

Ten key enablers for a digital hub

To come up with the ten key enablers for a digital hub, a long list of factors was identified prior to the 47 interviews. The enablers were derived by BCG from the description of a digital hub outlined in the next section and adjusted based on the feedback in the interviews to arrive at the ten key enablers shown in Exhibit 4 above. See Appendix for more details on each enabler.

EXHIBIT 4 | Ten key enablers for a digital hub



Note: Numbering 1 – 10 not in a prioritized order.
Source: Interviews, BCG analysis.
[1]E.g. Attractive cultural norms, constructive union involvement, cross-industry collaboration forums, etc., 2. E.g. API-layers, track & trace.

STARTING POINT AND OPPORTUNITY

When asked to assess the relative starting point of Norway as a digital hub, the interviewees were most often positive in their response. Five main areas stand out as providing a strong competitive starting point for Norway as a digital hub for oil and gas (See Exhibit 5). In the next section, recommendations for how Norway can further enhance attractiveness as a digital hub are presented, building on these five areas:

- High degree of domain expertise
- Availability of vast amounts of data
- Transparent and collaborative culture
- Robust technological infrastructure and a high degree of technology adoption
- Favorable local regulations and conditions

High degree of domain expertise. Over decades, Norway has built deep domain expertise and a leading global position in certain domains, such as subsea system engineering, subsurface reservoir modeling, seismic interpretation, and HSE. Interviews clearly indicate that high domain expertise is Norway's strongest advantage as a digital hub.

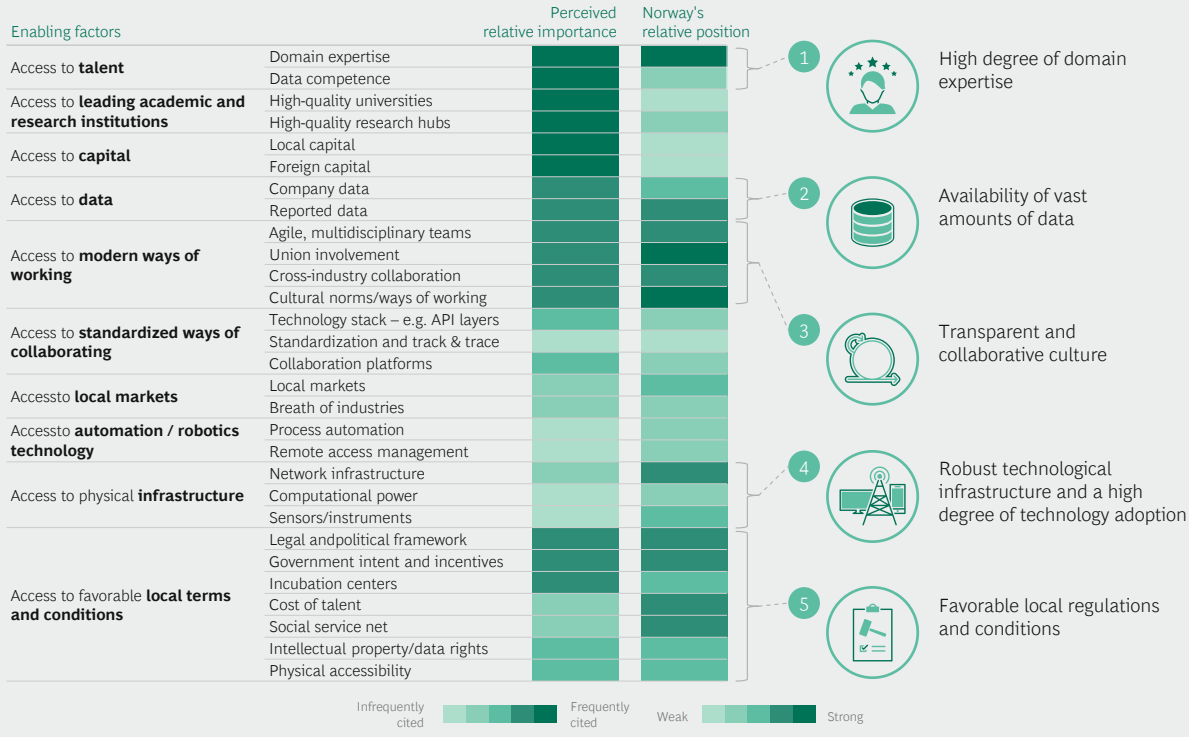
Several interviewees also highlighted the opportunity and value at the intersection of traditional domain expertise and digital expertise. Please refer to the next section for further discussion.

> "Norway has an opportunity to take a leading position by combining its world-class domain competence with knowledge about digital technologies."
>
> — Kjerstin K. Braaten, SVP, Kongsberg Maritime Commercial Marine

Availability of vast amounts of data. This is a result of longtime oil and gas activity in Norway, for example, the seismic database Diskos operated by the Norwegian Petroleum Directorate holds approximately eight petabytes of seismic data. Effectively utilizing this data through big data analytics has been mentioned as a way to improve the success rate of exploration.

Interviewees also pointed to early adoption of technology on the Norwegian continental shelf, which resulted in well-equipped offshore installations with the necessary sensors for data collection and aggregation, providing access to both historical and real-time data. For example, real-time data on the Johan Sverdrup field is estimated to be equivalent to streaming 18,000 Netflix movies simultaneously. Leveraging historical and current data to enhance decision-making can, in the right context, generate significant value for Norway.

EXHIBIT 5 | Five main areas providing Norway with a strong competitive position as a digital hub



Source: Interviews, BCG analysis.

> "An oil platform typically has more than 100,000 sensors from a huge range of different devices, components, and systems, enabling an array of opportunities using advanced visualization and data analytics. Leading oil and gas companies are now realizing bottom line value from this."
>
> — John M. Lervik, CEO, Cognite

Access to data was highlighted as a prerequisite to developing digital solutions locally, and was cited as one of the reasons international oil and gas suppliers chose to invest in Norway.

> "Norway is a fantastic country for incubation and innovation; data access is an important enabler. Norway is also better at sharing than other countries; there are a lot of good initiatives for data sharing underway."
>
> — Dean Watson, COO, Aker Solutions

Recent cases of data sharing include data made available from operators Lundin, Aker BP, and Equinor. For example, operating data from the fields Edvard Grieg and Ivar Aasen is now shared between the operators and with relevant suppliers in the ecosystem. The data sharing is intended to allow suppliers to be better able to monitor and improve the performance of the equipment, and to adapt maintenance programs.

Please refer to the next section for recommendations related to initiatives to enhance value capture from data.

Transparent and collaborative culture is mentioned as part of the Norwegian way of working. The close and constructive three-part collaboration in oil and gas among employees, employers, and government is an example that was emphasized by the interviewees as a differentiating factor for Norway. All parties generally work toward common goals, for mutual benefit. The collaborative arena Konkraft was highlighted as an example of this unique three-part collaboration. It periodically assesses the industry's competitiveness on the Norwegian continental shelf.

Furthermore, the productive collaboration between unions and employers has been highlighted as an advantage. High involvement of unions, for example through employ-

ee representatives on the company Board of Directors, contributes to constructive discussions of how Norwegian companies should adapt to an increasingly digital world. Rather than opposing change, stakeholders work together to find solutions that benefit both employees and employers.

International executives emphasize Norway's flat organizational structure and limited bureaucracy relative to other countries as an advantage. The World Values Survey confirms this belief—Norwegian society is ranked the most trustworthy of the 60 countries included in the study, supporting close collaboration both within and across industries.

> "Norway has a flat and non-traditional way of working and high degree of trust. This enables close collaboration towards common goals."
> — Morten Jensen, Digital Innovation Director, Schlumberger

This collaborative mindset and high level of trust have historically stimulated a culture of close industry cooperation, exemplified in the NORSOK standards. More recently, this is seen as an enabler of new ways of working. Aker BP's strategic alliances with some of its contractors is one public example. The goal is, among others, to ensure predictability for suppliers and stimulate development of cost-efficient solutions, as well as to work more efficiently as one integrated team.

> "We have decided to establish a new manufacturing plant in Norway. Easy access to innovative and forward-thinking companies in the local community willing to take the newest technology and products in use, contributed to the decision."
> — Anne Marit Panengstuen, CEO, Siemens Norway

An example beyond oil and gas is the industrial cluster at Raufoss. The cluster shares best practices among its members. For example, composite technology developed by Nammo for military rocket engines was used to develop LPG gas containers by Hexagon Ragasco at Raufoss, applied today by both the oil and gas industry and the private market. This sharing culture has generated productivity gains for the cluster; a SINTEF study identified a 2.4 times higher productivity growth in the cluster compared with comparable companies outside the cluster over a ten-year period.

> "Sharing culture is the single most important factor for the success of the industrial cluster at Raufoss."
> — Morten Brandtzæg, President & CEO, Nammo

Robust technological infrastructure and a high degree of technology adoption was frequently mentioned as an advantage of Norway. For example, fiber-optic cables were installed on the Norwegian continental shelf in the late 1990s. Still emphasized by interviewees as unmatched by most countries globally, it has enabled the industry to have bandwidth and uptime superior to satellite communications, and provided a global example of new ways of working, through practices such as leveraging video communications and real-time data sharing.

Further, according to the EU's Digital Economy and Society Index, internet penetration is approaching 100%, and both internet bandwidth speed and smartphone adoption are high in Norway relative to other countries. This is seen as an advantage as it contributes to the fact that the average user in Norway is familiar with the basic digital tools and technologies, potentially reducing the need for training. Specifically, this high technology adaptation enables people across all levels of the organization, from blue collar workers to highly educated PhDs, to quickly adapt and take advantage of new digital solutions in their daily work life. Further, the strong network enables access to sufficient storage capacity and computational power, cited as a prerequisite for big data analytics.

> "Technological infrastructure in Norway is very well positioned relative to our peers."
> — Håvard Devold, Group VP and Digital Lead, ABB

Favorable local regulations and conditions provide stability and predictability for business, and are seen as strong enablers for Norway. According to Worldwide Governance In-

dicators, Norway is one of the most stable democracies in the world. For example, policies are perceived as stable independent of governing party. In addition, incentives are highlighted as good in an international context. For example, oil companies benefit from a reimbursement system for exploration costs, where companies with deficits are able to get the tax value of their exploration costs refunded the following year instead of carrying forward a loss. The OECD confirms this finding, showing that Norway is among the ten nations with the highest direct government funding and tax incentives for business enterprise research as a percentage of GDP.

In addition, interviewees emphasized that highly educated talent currently is cheaper in Norway than in certain comparable countries. OECD wage figures corroborate this statement. Senior hires are cheaper in Norway than countries such as the US and Germany. For example, according to software consultancy Daxx, senior software developers are on average 15% more expensive in the US than in Norway. The flip side is that junior hires typically are more expensive in Norway. Although an advantage for companies, this means that other factors such as quality of life, social support programs, and work culture have a bigger role in increasing Norway's attractiveness for international talent, as salaries could appear to be less competitive.

> "Norwegian core values such as equality, flat organizations, informal ways of working, strong welfare and social support, proximity to nature, environmental awareness are compatible with the value set of young global talents seeking to become business entrepreneurs. As such, the conditions are present for Norway to enhance its startup community, a prerequisite for digital innovation."

In sum, these factors represent a strong starting point for Norway as a digital hub. In fact, Norway ranks sixth out of 63 countries in IMD's 2018 digital competiveness index. The index ranks countries according to their ability to adopt and explore digital technologies leading to transformation in government practices, business models, and society in general. Norway ranks second out of 63 countries on the technology factor of the digital competitiveness index, which relates to elements such as a regulatory and technological framework that enables the development of digital technologies.

International companies already recognize Norway's competitive advantage as a digital hub, with Norway often cited as a reference point for best practice in digital value creation. For example, interviewees highlighted that Aker BP and Equinor are seen as frontrunners in the application of digital technologies within oil and gas. Further, several international executives interviewed have had a long-standing strategy to acquire Norwegian technology startups and scale the products within their ecosystems. The Schlumberger acquisition of the Norwegian software platform Petrel in 2002 is one of many examples. It is now one of the leading software platforms used in exploration and production. In addition, global industry leaders such as ABB and TechnipFMC have global digital centers of excellence in Norway.

Opportunity and value at stake

The strong starting point is instrumental for Norway to claim a position as a leading digital hub, characterized as:

- A world leader at realizing productivity gains through the application of digital technologies
- A frontrunner at driving digital innovation and growth
- A country possessing a rich ecosystem where innovative business models can flourish

In such a digital hub, companies, both local and international, would choose to increase their investments and digital workforce in Norway relative to other countries.

A world leader at realizing productivity gains through the application of digital technologies. There is a strong correlation between a country's productivity and its digital competitiveness. (See Exhibit 6.) To succeed, however, is difficult. Too many digital initiatives fail to deliver on the promised value potential. For

example, BCG estimates that 50% to 70% of change programs fall short of targets. The ability to realize true productivity gains, eliminate inefficiencies and frictions in the value chain, or create new sources of revenue, is a proof point of successful digital initiatives. If Norway succeeds, countries and companies will look to Norway as a pioneer in digitally enabled operations, which could stimulate the inflow of international talent and companies to learn and deploy best practices.

For oil and gas, BCG estimates indicate a significant opportunity for all parts of the value chain. (See Exhibit 7.) Taking a leading role in realizing this potential, Norway could increase the competiveness of the Norwegian continental shelf and help secure activity and employment while reducing the environmental footprint of the industry.

A frontrunner at driving digital innovation and growth. There is a strong correlation between level of innovation and digital competitiveness. (See Exhibit 8.) A leading digital hub is at the forefront in driving digital innovation and growth, as it fosters top talent creating new and innovative ideas and applying digital technologies. This implies, among other things, short lead-time from ideation to commercialization of new ideas, an innovative culture, and a collaborative mindset. Furthermore, a strong link between industry and academia is important for providing academic leadership in applied innovation.

A country with a rich ecosystem where innovative business models can flourish. This is due to favorable local regulations and conditions that incentivize innovation. The ecosystem will include a balance of large corporations with deep domain expertise and a rich startup community. Large international companies will opt to use Norway as a strategic "test laboratory" for new digital solutions, investing in and building expertise locally. The startup community would also drive innovation, attracting global talent and venture capital.

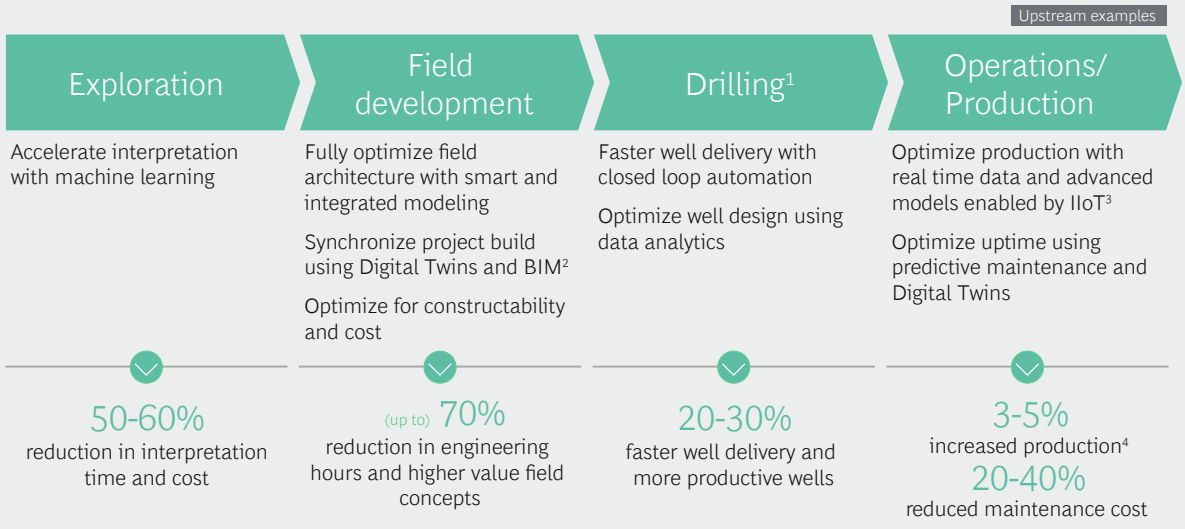
"Success requires active participation and cooperation among academia, the large system suppliers, technology suppliers, technology startups, oil and gas companies, and the government, where domain expertise is fundamental to asking the right questions."

— Roy Ruså, CDO, Petoro

EXHIBIT 6 | Strong correlation between high productivity and digital competitiveness

Note: PPP = Purchasing power parity.
Source: IMD Digital Competitiveness Ranking 2018.

EXHIBIT 7 | Digital can unlock significant value in upstream oil and gas



Source: BCG project experience, BCG analysis.
[1]Drilling covers E&A and Development/Infill drilling 2. Building Information Modeling 3. Industrial internet of things 4. Assuming marginal value of US$50 per additional bbl.

EXHIBIT 8 | Countries that perform well on innovation also have high degree of digital competitiveness

Source: IMD Digital Competitiveness Ranking 2018, Global Innovation Index 2018, BCG analysis.

Enhancing attractiveness as a digital hub offers great potential value for Norway, increasing competitiveness of its industries. Introducing new profit pools and removing friction along the value chains represents an opportunity for step-change improvements in oil and gas. There are several recent public examples from the oil and gas industry in Norway demonstrating the value potential enabled by application of digital technologies:

- *Equinor* recently opened two digital centers in Bergen. The integrated operations center enables more proactive support to its offshore installations, resulting in reduced downtime. The Geo Operations Center will offer more cost-effective and better-controlled geoscience support for drilling operations. These centers are already contributing to improved performance and are expected to increase earnings by NOK 2 billion from 2020 to 2025.

- In January 2019, *Aker BP* went live with the onshore control room in Trondheim, operating the offshore field Ivar Aasen. Remote operations represent considerable potential value by bringing experts closer to the control room, accelerating decisions that avoid incidents, and detecting opportunities to improve production.

- *Aker Solutions* will develop a digital twin of Wintershall's Nova field. The digital twin will make possible live data streaming from the subsea production system, enabling easy access to real time subsea condition monitoring and predictive analytics for the field.

There are also good examples from other asset-heavy industries demonstrating value potential:

- *Yara Birkeland* is the world's first fully electric and autonomous ship with zero emissions. The vessel will reduce diesel-powered truck haulage by 40,000 journeys a year, reducing both emissions and costs.

- NCE Raufoss reports that automation allows *Kongsberg automotive* to produce automotive parts 30% faster and more cheaply in Raufoss than in China.

For Norway as a nation, increasing use of new digital technologies brings a shift in workforce requirements and capabilities. Today, according to the Federation of Norwegian Industries (Oil and Gas) and Menon Economics, there are around 225,000 people employed in the oil and gas industry in Norway. Conservative estimates from the World Economic Forum's Future of Jobs survey indicate that the share of digital roles in oil and gas will increase over the next five years. Specifically for Norway, at least 20,000 roles in oil and gas will be redefined and become more digitally oriented over the next five years, assuming a similar absolute employment level. To fill these digital roles, a mix of digitizing existing domain expertise and hiring external digital talent is required. Ensuring that these high-value roles reside in Norway and do not move to other geographies could add significant value for the country

An interesting case which was highlighted in several of the interviews is Tel Aviv, currently a leading technology hub. Israel, like Norway, has a small home market compared with other digital hubs such as California and London. According to Israel's Start-up Nation Central, an independent non-profit that builds connections for Israeli innovation, the tech sector in Israel accounts for about 8% of the workforce, 17% of GDP, and 45% of industrial exports. Several factors have been credited with Israel's success, such as the Israeli defense forces tech programs (a source of innovation and high quality talent), high level of state initiatives and incentives, and strong public academic institutions.

ACCELERATING NORWAY

Five recommendations for how to further enhance Norway's attractiveness as a digital hub for oil and gas are presented. They are the result of feedback from the interviews on the key enablers, and represent a combination of the relative importance and Norway's relative position on the enablers. (See Exhibit 9.)

The five key recommendations are:

- Digitize Norway's world-class domain expertise
- Claim global academic leadership in application and development of digital technologies
- Improve access to industrial venture capital
- Establish new best practices for data and sharing
- Increase industry agility and speed

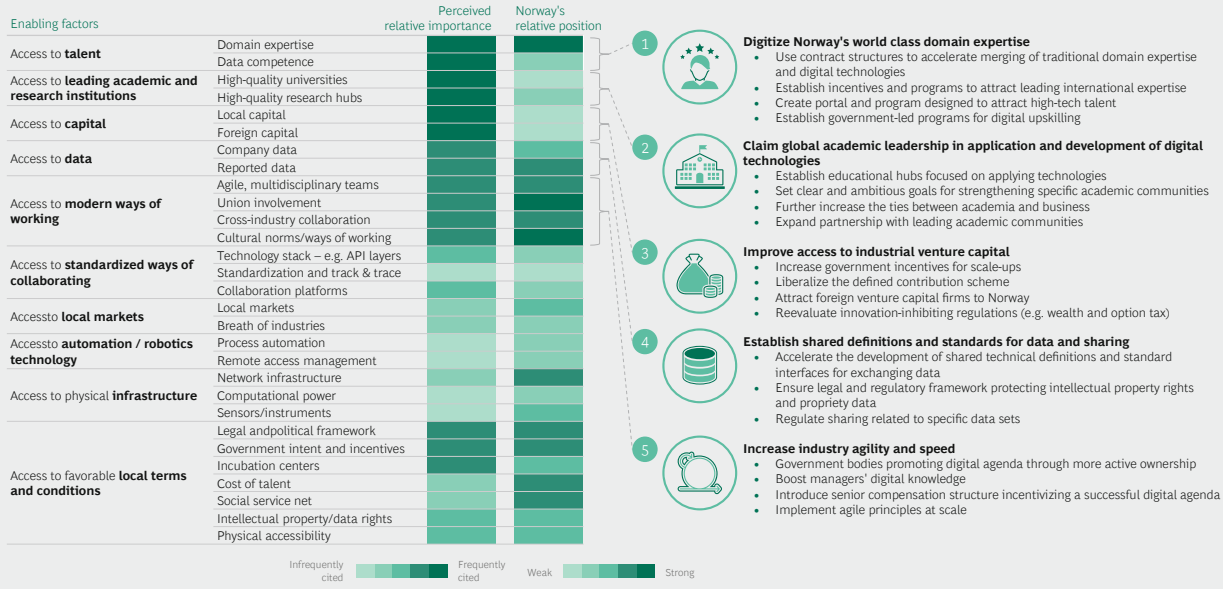
Digitize Norway's world-class domain expertise

Specific domain expertise, such as subsea system engineering, subsurface reservoir modeling, seismic interpretation, and leading competence within HSE, is seen as one of Norway's great assets in general, and also in the context of being a digital hub. Interviewees highlight that Norway is well positioned to digitize its world-class domain expertise due to strong industrial adaptability, a collaborative mindset, and a supporting ecosystem. For example, Norway has been at the forefront of subsea developments since the 1990s, moving from more manual operations to a high degree of automation.

> "The cluster embedded in a strong ecosystem and our operational domain expertise provide a good foundation for digitization and development project with the companies to develop new business models and convert operational data to services."
>
> — Anne-Grete Ellingsen, CEO, GCE NODE

Digital innovation more frequently happens at the intersection of domain expertise and digital competence. Asset-heavy industries may require more domain expertise relative to digital competence to drive innovation than other industries, according to several interviewees. To illustrate, oil and gas today, with relatively high complexity, require about 80% domain expertise and about 20% digital competence to realize digital value potential. On the other hand, for industries with lower complexity and high digital maturity the underlying problem might be easier to define, as such, companies may rely on a much higher weight of digital competence to domain expertise.

EXHIBIT 9 | Five main paths to addressing opportunity areas to increase attractiveness (some already in progress)



Source: Interviews, BCG analysis.

> "The most advanced search engines in the world mainly rely on a handful of data tags, such as number of clicks and consumer purchase events. An oil and gas installation typically has hundreds of thousands of data tags."
>
> — Karl Johnny Hersvik, CEO, Aker BP

The importance of understanding the physical installations along with the associated data models and IT structures is key to accelerating the impact of digital initiatives. To be able to make meaningful interpretations of the data and to direct the new data analytics models to solve the right problems, domain expertise is required.

> "You need those people with an in-depth understanding of the business and operations working effectively together with software engineers and data scientists to develop digital solutions."
>
> — Hege Kverneland, CTO, National Oilwell Varco

Strengthening the digital competence of the domain engineers who already have the necessary understanding of the data structures and the physical systems could be more fruitful than relying purely on new hires with digital competence. Competing globally on a topic such as artificial intelligence comes with significant challenges—some of the largest companies in the world spend billions of dollars on research every year. For Norway however, the opportunity could lie at the intersection of this technology and areas where there already is strong domain expertise.

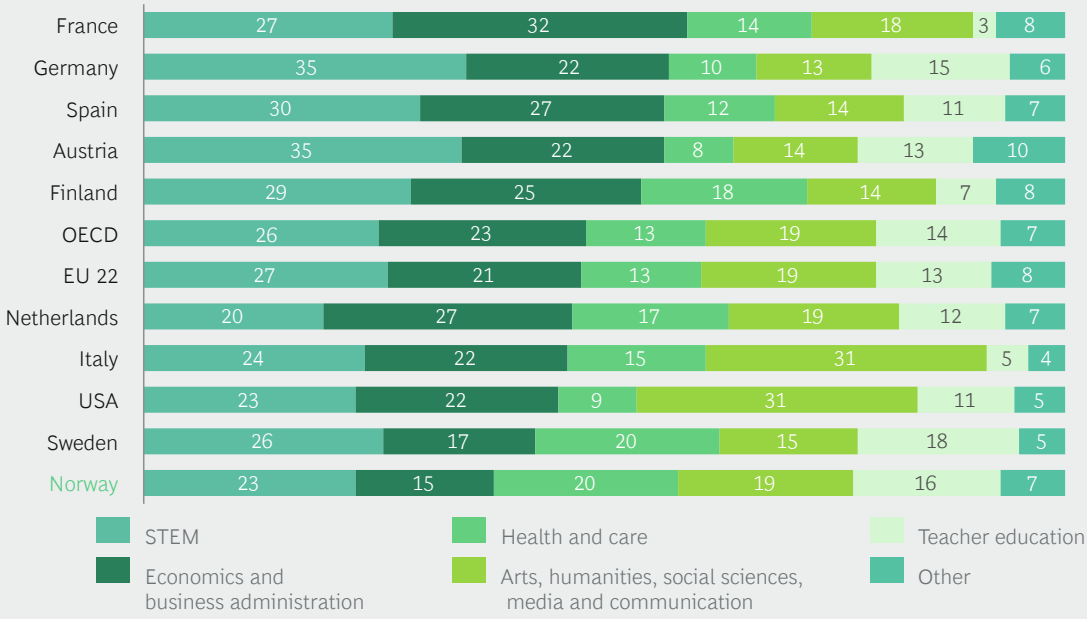
> "I think Norway could take a leading position in applying AI in reservoir modeling to perform predictive analysis of reservoir performance."
>
> — Karl Johnny Hersvik, CEO, Aker BP

Although basic digital skills are strong in Norway, the potential to raise general digital expertise and increase access to specialized digital competence was frequently cited in the interviews. In fact, Norway trails behind the OECD average in terms of number of graduates in STEM subjects and economics and business administration. (See Exhibit 10.) Lack of access to expertise in these areas could limit Norway's attractiveness as a digital hub.

Several additional potential levers to digitize Norway's world-class domain expertise were mentioned in the interviews:

EXHIBIT 10 | Norway has fewer graduates in STEM subjects and economics and business administration than the OECD average

DISTRIBUTION BY SUBJECT AREA AMONG PERSONS WITH HIGHER EDUCATION (25–64 YEARS, 2016)



Source: OECD (2017b). Education at a Glance 2017.

- **Use contract structures to accelerate merging of traditional domain expertise and digital technologies.** This can be done by building on Norway's strong track record in establishing fair standard contracts, for example, the NTK/NF standard contracts for greenfield, brownfield, and fabrication. Further, the strict requirements for HSE and the NORSOK standards provide updated standards for all disciplines when operating on the Norwegian continental shelf. Industry standards, or regulation by the Ministry of Petroleum and Energy, could be one way to stimulate this behavior.

- **Establish incentives and programs to attract leading international expertise.** Establishing short-term incentives such as reduced taxation for a certain number of years has been emphasized as a way to increase access to the international talent pool.

- **Create a portal and program designed to attract high-tech talent to Norway.** Portals and programs targeted to international talent at leading universities in the US, UK, and Asia have been mentioned as a way to attract high-tech talent. Highlighting Norway's attractiveness in terms of work-life balance and social support programs is important. This could be an industry- or government-led initiative.

- **Establish government-led programs for digital upskilling.** Promote lifelong learning by establishing a national incentive scheme to raise the digital expertise of the general population. For example, by offering tax breaks to companies for sending employees to digital training programs (for example, deduct course fees from taxes). This is particularly relevant for smaller companies that lack the resources to train employees internally.

Claim global academic leadership in application and development of digital technologies

Norway has an opportunity to claim academic leadership in applied digital innovation in areas where the country has strong domain

expertise. Research institutions such as SINTEF and NORCE, both focused on applied industry research, are good examples of institutions with favorable industry connections and international reputations.

> "Norwegian research institutes, such as SINTEF and NORCE, are unique in an international context, providing leading applied research for specific industry domains. They are very important for the [Norwegian] industries."
> — Gunnar H. Lille, Managing Director, OG21

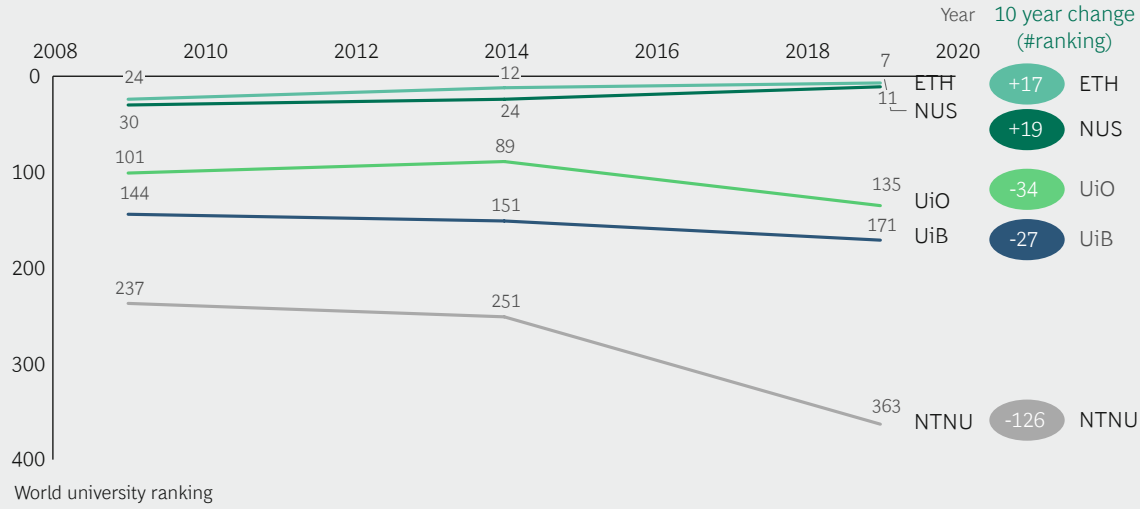
According to OECD, Norway is one of the top five nations in the world in terms of spend in higher education per student. Although research institutions such as SINTEF are favorably perceived, Norwegian universities appear to be falling behind universities from comparable countries (such as Switzerland). While school rankings (See Exhibit 11) do not present the full picture, this trend, combined with feedback gathered from the interviews, indicates that there is potential and desire to enhance the competitiveness of Norwegian universities.

Although some actions have been taken in recent years, several additional potential levers were mentioned in interviews that could further build internationally recognized academic communities:

- **Establish educational hubs focused on application of digital technologies.** Building on the existing Norwegian Catapult Programs, interviews highlighted that these educational hubs could train employees in how digital technologies require new ways of working and the application potential in specific industry domains. The goal would be to stimulate increased adoption of digital technologies by creating "playgrounds" where companies can come with their ideas and pilot new ways of getting to output. Freeform additive manufacturing represents one of many such potential areas, as engineers need to focus on the functionality of the resulting product – not how it used to be manufactured. New digital technologies could form output in a different way.

- **Set clear and ambitious goals for strengthening specific academic communities.** Success was seen as dependent on highly motivated people who can drive the agenda to build deep academic knowledge in specific domains, as well as government commitment. Further, creating an ecosystem of young talent, innovative startups, and industry and academic partnerships in specific areas was perceived as important. EPFL (Ecole polytechnique fédérale de Lausanne) is an example of what can be achieved with an ambi-

EXHIBIT 11 | Norwegian universities are falling behind on the QS rankings



Note: NTNU ranking 2009 relates to 2010 figures due to missing numbers.
Source: THE QS and QS World University Ranking.

tious goal targeted to specific research areas. EPFL has over the last 15 years built leading global medical expertise by working with hospitals, pharmaceuticals companies, and startups—and by creating partnerships with international academic communities. Attracting young talent to stimulate innovation has been a key factor in its success.

- **Further increase the ties between academia and business.** Interviewees pointed to the opportunity for increasing industry-oriented research and collaboration. Increasing the share of research funding for user-driven research (for example, industry applicability) in the national budget could be one way to drive this change, though this has increased recently. Another way could be for businesses to co-fund applied research programs with the Research Council of Norway to close potential technology gaps, or for the government to provide tax relief (similar to "skattefunn") for investing in Norwegian based academic research focused on applied innovation. Further, cross-discipline institutions focused on specific industry challenges could be developed. Teams could tackle specific industry challenges beyond the focus of their current institutions. SIRIUS, a Norwegian center for research-driven innovation, is a recent example of close collaboration between academia and business. The project was established in 2015 and will run for eight years. SIRIUS is a consortium of leading industrial organizations, as well as academia and research institutions, which address the problems of scalable data access in oil and gas. Educating businesses and academia on the potential ways to collaborate, for mutual benefit, could stimulate increased collaboration. Both universities and industry organizations have a role to play here.

"Combining simulation expertise from the Institute for Energy Technology, leading mathematicians from the University of Stavanger/Bergen, and modeling expertise from SINTEF into one institute focused on oil and gas industry challenges represents an opportunity."
— Karl Johnny Hersvik, CEO, Aker BP

- **Expand partnership with leading academic communities.** Partnerships in many forms were emphasized in the interviews: from professors and students on exchange, to developing a physical campus presence. Increasing basic partnerships, for example by further attracting world-leading professors to spend time at Norwegian Universities, could be a start. In turn, this could attract more talent. Second, there is an opportunity to further tap into academic networks outside of Norway. Leading universities such as the Massachusetts Institute of Technology (MIT) and the National University of Singapore collaborate with industry outside of their home markets. By further investing in these academic communities, it would be possible to access their strong ecosystems and build lasting relationships. Finally, attracting a leading university to establish a physical satellite campus in Norway is a possibility that could provide a brand and value proposition for Norway.

Improve access to industrial venture capital

The current funding landscape in Norway has been noted to have these characteristics:

- Early seed money is considered fairly accessible through government grants provided through entities such as Innovation Norway.

- Industrial venture capital, on the other hand, is seen as insufficient. The most recent Capital Access Commission, led by Aksel Mjøs, pointed out that capital up to NOK 20 million is particularly challenging to find in Norway. Further, access to investors with relevant experience and networks was cited as one of the main limitations for growth for Norwegian scale-ups in a recent survey conducted by Menon Economics.

- Private equity capital is considered fairly accessible for larger, more mature, entities.

The limited industrial venture capital environment in Norway limits access to capital for industrial scale-ups. In fact, according to

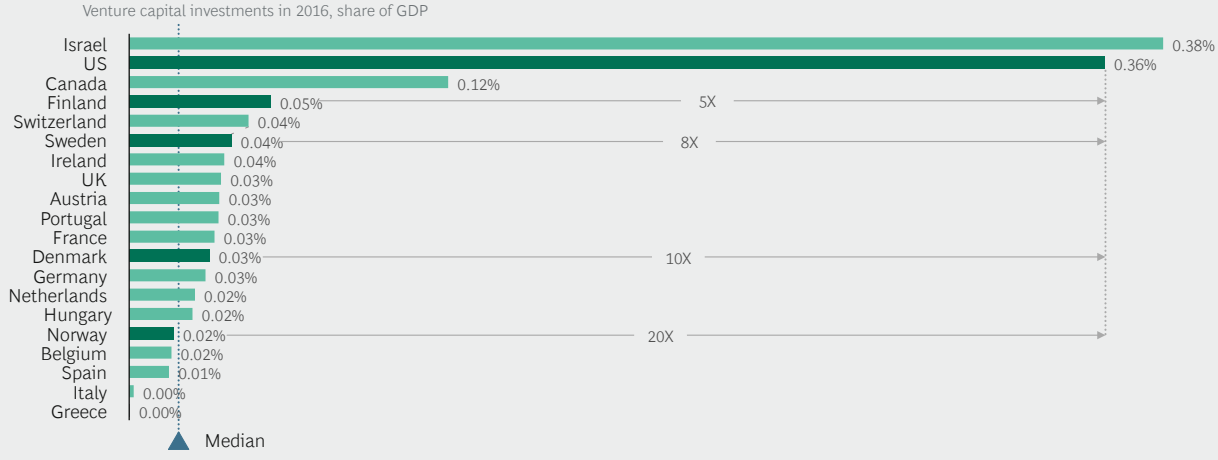
OECD, venture capital investments in Norway were a mere 0.02% of GDP compared with 0.03% in Denmark, and 0.04% in Sweden in 2016. (See Exhibit 12.) This is below the OECD median. The US and Israel were best-in-class with investments of 0.36% and 0.38%, respectively.

> "We do not have sufficient access to venture capital in Norway, and if we combine this with the lack of private capital and business angels, scaling startups is very difficult."
>
> — Preben Strøm, Managing Director, Energy Valley

As part of an ongoing public discussion, several options to improve access to industrial venture capital regularly surface. Opportunities mentioned include:

- **Increase government incentives for scale-ups.** Increasing incentives for scale-ups (growing from 5 to 50 employees and beyond) could have a high value creation potential for Norway, and was frequently highlighted in the interviews. The most recent Capital Access Commission's report supports this assertion.
- **Liberalize the defined contribution scheme.** Allow a small share to be invested in venture capital.
- **Attract foreign venture capital firms to Norway.** Funding the future industry of Norway, for example by allocating a percentage of oil and gas earnings to venture capital, represents an opportunity, according to the interviews. In practice, this could happen by allocating funds to international recognized players, but with physical presence in Norway required, and with a certain percentage of the funds invested in Norwegian firms. Attracting players like this would help build Norwegian venture capital as a whole, bring strategic connections and knowledge, and possibly open global doors more quickly. Additional funds could also be allocated to Norwegian entities such as Argentum or Investinor, however the knock-on effect of having foreign entities present, providing valuable market access abroad, should not be underestimated.
- **Reevaluate innovation-inhibiting regulations, such as wealth and option taxation.** From an innovation perspective, a need to reevaluate taxes inhibiting innovation, such as a wealth and option tax, was frequently mentioned. One avenue could be to introduce a capital tax on realized option gains for qualified startups (for example, related to valuation) with taxation at the point of sale, rather than the current model based on the difference between price paid and market value of the options. For several comparable nations, options and equity are important levers used to attract top global talent.

EXHIBIT 12 | Norway has a venture capital market below OECD average in terms of percentage of GDP



Note: VC investment data for Israel is from 2014.
Source: OECD Entrepreneurship at a Glance 2017.

The current Norwegian regulations do not accommodate this to the same extent as other countries, with the result that several investment classes, such as real estate, are more attractive for investors.

Establish new best practices for data and sharing

Standards for data and sharing are seen as the foundation of big data analytics and digital technologies that leverage data. The interviews highlighted a need to agree on technical definitions of data and standard interfaces for exchanging data to enable integration and better collaboration. Not surprisingly, there are different views regarding the extent to which data should be shared given the commercial implications. Some companies emphasize open systems where all data is readily available to everyone, while others limit sharing to their own systems. Yet all industry players agree that standardized data formats will enable data sharing, providing a good foundation for future discussions on data sharing.

> "We need to sort out the commercial aspect for sharing data, including a fair allocation of profits. Once we solve this, a shared technical definition and regulatory framework will fall into place. We are already well underway."
> — Ann-Christin Andersen, CDO, TechnipFMC

Interviewees also emphasized that many companies are building their own data platforms, and that there is a risk that some of these efforts are done in silos and lack an interoperability that would benefit the industry. Incompatible and heterogeneous data formats make it challenging to capture industry value. As such, there is a need to coordinate efforts in order to ensure the industry is moving in a single direction.

To this end, there are several ongoing initiatives to facilitate collaboration across both value chains and industries. DataLink is one example of a joint industry project that was frequently mentioned in the interviews. The project aims to develop standards for data exchange and to identify use cases to enhance collaboration in the ecosystem. Examples of collaboration cases include sharing of HSE data and best practices for common APIs.

Several focus areas to effectively leverage data were mentioned:

- **Accelerate the development of shared technical definitions and standard interfaces for exchanging data.** The industry urgently needs to agree on shared technical definitions of data in order to enhance data quality and make sure it is in a comprehensible format across companies. These technical standards should be internationally compatible, leveraging international standards to the extent possible. Further, the need to incentivize the establishment of standard interfaces and NORSOK/ISO standards for data sharing (API and Ontology) was cited as important. To this end, Konkraft should tighten governance to ensure progress of their key recommendations that stimulate data sharing and remove waste between the parties.

> "Standardized APIs are critical to enable data sharing at scale. We need to have interfaces that can talk to each other across companies and industries. Enabling sharing is not difficult, our intern developed an open interface over the summer."
> — Karl Johnny Hersvik, CEO, Aker BP

- **Ensure a legal and regulatory framework protecting intellectual property rights and proprietary data.** For example, industry organizations could work to ensure that the contract regimes used benefit both operators and suppliers.

- **Regulate sharing related to specific datasets.** Determining which data could add value to the industry as a whole, and regulating sharing of such data has been highlighted as an important lever. For example, data related to HSE covering existing developments with a defined remaining lifetime could be shared, based on recommendations from the Petroleum Safety Authority in Norway and industry organizations. Further, the Research Council of Norway could initiate a research program to explore legal issues with regard to sharing of HSE and environmental data. In addition, the sharing of subsurface data from Norwegian Petro-

leum Directorate was cited as a good starting point.

Increase industry agility and speed

According to BCG, digital success requires a more agile mindset and adapting traditional ways of working; it is 70% business transformation, 20% technology and IT, and 10% algorithms. Digitization has become a larger part of the corporate agenda over the last few years, however the perceived sense of urgency and the anticipated degree of disruption varies among companies interviewed.

Current digitization efforts are limited for many companies due to lack of digital knowledge. Interviews frequently cite a lack of digital knowledge to drive and implement digitization among managers. This lack of digital knowledge could reduce management's ability to realize digital value and likelihood to invest in larger scale digitization programs.

> "The biggest challenge for oil and gas is the lack of sense of urgency; we need forward-leaning companies that drive development and testing of new digital solutions."
>
> — Roy Rusås, CDO, Petoro

Norway's collective understanding of risk and strong track record in risk management has been cited as an enabler of increasing industry agility and speed. Trial and error is encouraged, and could stimulate digital developments.

To improve industry agility and speed there are several potential levers that have been mentioned. Some would have to be enforced by companies, some by industries, and others by government:

- **Government bodies promoting digital agenda through more active ownership.** The Ministry of Petroleum and Energy could motivate oil and gas companies to add digital technologies to existing developments and to leverage data sharing on its licenses, for example, through a license to operate. Recently Petoro collaborated with Equinor on the Johan Sverdrup project, which is considered a frontrunner in digitization. Petoro was part of the decision to include full coverage of the field with seismic cables for reservoir monitoring, implementation of fiber optics in wells, and installation of equipment for injection of water and gas. The decisions are, according to Petoro, expected to contribute to significantly increased oil recovery.

- **Boost managers' digital knowledge.** Invest in digital training programs and host training sessions for managers in collaboration with industry organizations and universities. Industry organizations such as the Federation of Norwegian Industries (Oil and Gas) could host sessions focused on sharing success stories, increasing data competence, and discussing best practices to raise awareness, increase understanding, and transfer learning of applications of digital technologies.

- **Introduce senior compensation structure incentivizing a successful digital agenda.** For example, KPIs related to business value/growth that leverage digital technology or the progress of digital initiatives has been cited. The Confederation of Norwegian Enterprise ("NHO") could play a role in increasing awareness and exemplifying bonus schemes for its members.

- **Implement agile principles at scale.** New digital technologies require new ways of working. Moving from a step-wise waterfall approach across siloed disciplines to working iteratively in multidisciplinary teams has the potential to drive significant value across organizations, and could be an accelerator to fuse domain expertise with digital competence. Empowering teams with end-to-end responsibility could increase customer focus and value, by adopting a more output-oriented approach to digital developments. Sharing success stories within the industry and through media has been highlighted as a way to increase industry adoption.

THE JOURNEY AHEAD

For Norway to further enhance its attractiveness as a global digital hub, multiple stakeholders are required to take action. Government, academia and research labs, industry associations, national and international corporations, and the startup community all have a role to play. Evoking the Norwegian collective spirit will be essential to successfully increasing Norway's attractiveness as a digital hub for oil and gas.

Roles of key stakeholders

The five key recommendations covered in the previous section all have clear implications for the different stakeholders. Exhibits 13A-D include an overview of recommended actions for the government, academia and research institutions, the industry, and individual companies.

To achieve success, companies collaborating across the industry need to be the main driver while working together with government and academia to reaffirm Norway's digital competitiveness. Efforts to increase Norway's attractiveness as a digital hub should be focused in areas with strong domain expertise.

Concluding words

Initial efforts should be focused in areas where Norway can maximize value. The biggest potential is at the intersection of specific technologies and specific industry domains. Focusing only on generalized technologies (such as AI, big data, the internet of things) without defining the intersection, does not leverage Norway's significant competitive advantage in certain industries. Defining and focusing on selected areas—building depth instead of breadth—will be the key to succeeding.

> "Sharing best practices and applications of digital technology within value chains and industries, as well as across industries, is the most important element to capture value and become a digital hub"
>
> — Per Arne Henæs, CEO, Vissim

Furthermore, sharing best practice technological applications across industries could provide the necessary scale and help solve common challenges, which could increase the competitiveness of Norwegian industries as a whole.

EXHIBIT 13A | Call to action for the government

Government

Digitize Norway's world-class domain expertise	• Establish **government-led program for digital upskilling** • **Offer tax breaks to companies** for sending employees to digital training programs (e.g. deduct course fees from taxes) • Establish a **portal and program designed to attract digital talent** to Norway, for example through Innovation Norway in collaboration with the industry • Reduce taxation for a certain number of years as a way to **increase access to international talent pool**
Claim global academic leadership in application and development of digital technologies	• Expand the Catapult program by **establishing educational hubs** that train employees in how digital technologies require new ways of working and potential application areas, freeform additive manufacturing represents one potential area • Increase share of **research funding for user-driven research** in national budget • Provide **tax relief** (e.g. similarly to "skattefunn") for investing in Norwegian based academic research focused on applied innovation
Improve access to industrial venture capital	• Increase **government incentives for scale-ups**, for example by establishing government fund for investments specifically in scale-ups • Perform **fund-in-fund investment** through entities such as Investinor or Argentum in foreign venture capital firms requiring physical presence in Norway • **Reevaluate wealth and option taxation** related to startups, for example by delaying capital tax on realized option gains to the point of sale for qualified startups
Establish new best practices for data and sharing	• **Regulate sharing of specific datasets**, for example related to HSE data covering existing developments with a defined remaining lifetime based on recommendations from the Petroleum Safety Authority in Norway and industry organizations • Initiate a series of **data workshops** for the industry through for example Petroleum Safety Authority in Norway
Increase industry agility and speed	• **Stimulate digital technology adoption and data sharing** through regulations and license to operate, Petoro could play an active role similarly to its involvement for the oil field Johan Sverdrup

Source: Interviews, BCG analysis.

EXHIBIT 13B | Call to action for academia and research institutions

Academia and research institutions

Digitize Norway's world-class domain expertise	• Re-skilling in collaboration with the industry by developing and **hosting workshops and digital training programs** together with industry organizations such as the Federation of Norwegian Industries
Claim global academic leadership in application and development of digital technologies	• Set **clear and ambitious goals for strengthening specific academic communities**, building deep expertise • Consider creating a **cross-functional institute to address specific oil and has industry challenges**, such as by combining simulation expertise from the Institute for Energy Technology, leading mathematicians from the University of Stavanger/Bergen, and modeling expertise from SINTEF • Expand **partnerships with leading academic communities**, ranging from increasing student exchange, attracting world-leading professors to spend time in Norway to fostering physical satellite campuses
Improve access to industrial venture capital	
Establish new best practices for data and sharing	• Develop **standard contracts enabling data sharing**, and **explore regulatory framework** protecting intellectual property rights and proprietary data, in collaboration with industry organizations • Initiate a **research program to explore legal issues** with regard to sharing of HSE and environmental data, for example through the Research Council of Norway
Increase industry agility and speed	

Source: Interviews, BCG analysis.

EXHIBIT 13C | Call to action for the industry

Industry

Digitize Norway's world-class domain expertise	• Establish **standard contract structures** to accelerate merging of traditional domain expertise and digital technologies • Host sessions **sharing best practice for application of digital technologies and success stories** through industry organizations such as the Federation of Norwegian Industries
Claim global academic leadership in application and development of digital technologies	• Identify **high potential collaboration topics** to expand work between academia and business, such as SIRIUS • Host sessions, in collaboration with academia, **sharing success stories and opportunities** for business/academia collaboration, potentially led by the Federation of Norwegian Industries
Improve access to industrial venture capital	
Establish new best practices for data and sharing	• Accelerate **establishment of standard interfaces** (e.g. APIs), NORSOK/ISO standards for data sharing, and work to ensure **fair contract regimes** • **Stimulate to data sharing and remove waste** between parties, for example by tightening the governance of Konkraft's key recommendations • Host data workshops to **discuss new best practices for data and sharing**, potentially led by the Federation of Norwegian Industries
Increase industry agility and speed	• Establish **industry-wide digital training program for managers** focused on showcasing opportunities related to application of digital technologies • Exemplify **bonus schemes related to growth leveraging digital technologies**, potentially developed by the Confederation of Norwegian Enterprises

Source: Interviews, BCG analysis.

EXHIBIT 13D | Call to action for individual companies

Individual companies

Digitize Norway's world-class domain expertise	• **Connect strong domain expertise with digital talent** • Invest in **training of employees**, for example strengthen digital competence of domain engineers, and **adopt new work processes** • **Attract international talent** by selling the Norwegian way of life
Claim global academic leadership in application and development of digital technologies	• Co-fund **applied research programs to close potential technology gaps**, potentially in collaboration with the Research Council of Norway • **Collaborate proactively with academia**, for example through funding PhD's to research industry and company challenges
Improve access to industrial venture capital	• Increase **internal funding for venture capital investments**, for example through establishing designated venture capital investment program • Expand **collaboration with startup communities** through for example accelerator programs such as Equinor's Techstars
Establish new best practices for data and sharing	• Increase **data sharing**, for example by assessing which data can be shared without significant commercial implications
Increase industry agility and speed	• Introduce senior **compensation structures incentivizing a successful digital agenda** and new business models, for example through KPIs related to progress of digital initiatives • **Implement new ways of working**, for example agile principles working iteratively in multidisciplinary teams and share success stories within the industry and through media

Source: Interviews, BCG analysis.

APPENDIX

To come up with the key enablers for a digital hub a long list of factors was identified prior to the interviews. The enablers were derived by BCG from the description of a digital hub and adjusted based on the feedback in the interviews to arrive at the ten key enablers shown below (in random order):

1. *Access to talent* with domain expertise (such as an understanding of both the opportunity and limitations of the physical models for oil and gas), as well as talent that has the data competence required to extract knowledge and insights from data in various format.

2. *Access to leading academic and research institutions,* including leading academic communities, universities, institutions, and research hubs, as well as the ecosystem that follows.

3. *Access to capital,* both local and foreign capital investments.

4. *Access to data* such as company-specific data like seismic and drilling data for oil and gas. This could also be data reported to regulators that is available in a consumable format.

5. *Access to modern ways of working* including enabling factors such as attractive cultural norms and ways of working, constructive union involvement in decision-making, cross-industry collaboration forums, and high level of senior stakeholder accessibility.

6. *Access to standardized ways of collaborating* such as standardization of the technology stack (for example, API-layers), track and trace of the material flow, and availability of collaboration platforms (supply chain market place, etc.).

7. *Access to local markets* and assets to pilot and sell solutions, as well as breadth of industries with significant presence in the country.

8. *Access to automation/robotics technology* enabling a high level of process automation across the value chain and remote access management.

9. *Access to physical technological infrastructure* enabling stable and secure networks, access to great computational power, and assets with a strong presence of sensors/measurement instruments.

10. *Access to favorable local terms and conditions*, including a stable and transparent legal and political framework, strong government intent, and incentives to foster innovation, as well as incubation centers to support innovation. Further elements include strong and effectively enforced intellectual property/data rights, favorable cost of talent, high quality social service nets, and general physical accessibility.

Sources

This report would not have been possible without the participation of the following companies and experts:

Companies interviewed[1] (in alphabetical order):

ABB

Aker BP

Aker Scholarship

Aker Solutions

Anonymous companies

Arundo Analytics

Boston Consulting Group (BCG)

Cognite

ConocoPhillips

DNV GL

Energy Valley

EQT

Equinor

Federation of Norwegian Industries

GCE Node

Google

HitecVision

Hydro

International Institute for Management Development (IMD Business School)

Kongsberg Maritime

Lundin Norway

Microsoft

Massachusetts Institute of Technology (MIT)

Nammo

National Oilwell Varco

Norwegian Petroleum Directorate

Norwegian Venture Capital & Private Equity Association

Optimar

Petoro

The Research Council of Norway

Rolls-Royce Marine

Schlumberger

Siemens

SINTEF

TechnipFMC

University of Oslo

Vissim

Yara

BCG global experts who provided input:

- Global leader of BCG's Center for Digital in Oil and Gas
- Global leader of Development and Operations topics of BCG's Center for Digital in Oil and Gas
- Global sector leader of BCG's Energy practice for Commodity Trading and Risk Management
- Global leader of BCG's work in Shipping
- Global expert in Aquaculture
- Global topic expert in Large Capital Management
- Leader of BCG's Energy practice in the Nordics
- Leader of BCG's Corporate Finance & Strategy practice in the CEMA region

- Leader of BCG's Operations practice in the CEMA region
- Co-leader of BCG's Fintech Control Tower

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NOTES
1. For some companies, multiple executives were interviewed.

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