  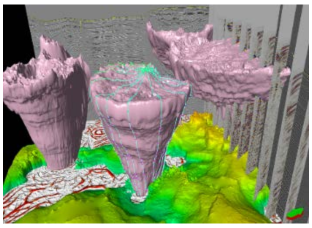 

THE INNOVATION PERFORMANCE OF THE NORWEGIAN OFFSHORE INDUSTRY

A REPORT FOR THE NORWEGIAN OIL AND GAS ASSOCIATION

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INTRODUCTION

Hardly anyone questions the role of innovation is a major driver for an economy's upgrading, productivity and prosperity in the long run. Unleashing Norway's innovation potential is a top priority on the agenda of a number of ministries from the Ministry of Education to the Ministry of Industry and Trade. A simple Google search "Erna Solberg on innovation" yielding about 890 000 results today immediately gives a sense of its importance for the nation.

The question is how we can boost Norway's innovation performance. What are the potential lever points? What industry and corporate policies are likely to be most effective in stimulating the innovation? The first challenge in addressing those questions is absence of an adequate measure of innovativeness. There is a long tradition of speaking on innovation in terms of patents. But, not all patents lead to commercially successful products, technology behind some products is better protected by trade secrets, and novel business practices are not patentable at all. The innovation survey by Statistics Norway (SSB) provides us with a richer dataset capturing many dimensions of innovation. However, effective decision-making calls for a more holistic and parsimonious measures.

We address this challenge by taking industry-level innovation data provided by SSB as an input and developing on its basis three novel innovation indices integrating the different types of innovation; measuring how effective businesses in different industries are in technological and commercial innovations given their R&D spending and other factors; as well as its impact. These measures are:

- **The innovativeness index**. It aggregates different aspects of technological and commercial innovations and allows us to map all the industries according to their current overall innovation performance as well as to statistically explore the drivers for the innovation performance.
- **The innovation effectiveness score**. We estimate the difference between the actual and predicted levels of innovativeness across the industries given their R&D-intensity, internationalization and other factors.
- **The innovation impact index**. This index indicates the extent to which innovation affects businesses across industries.

These novel measures allow us to map all the Norwegian industries by their scale and innovation capability to identify those with the highest innovation potential and assess the different aspects of their innovation performance to find the key areas to focus on.

This report particularly considers the supplier (upside) part of the offshore oil & gas industry. It appears to be as innovative as telecommunication and pharmaceutical (traditional high-tech) industries in Norway but, in addition, it is part of the cluster with most developed knowledge commons and dynamics in the country, which suggests a significant innovation potential. Our analysis suggests a number of corporate and industry policies that can help turn that potential into innovation output.

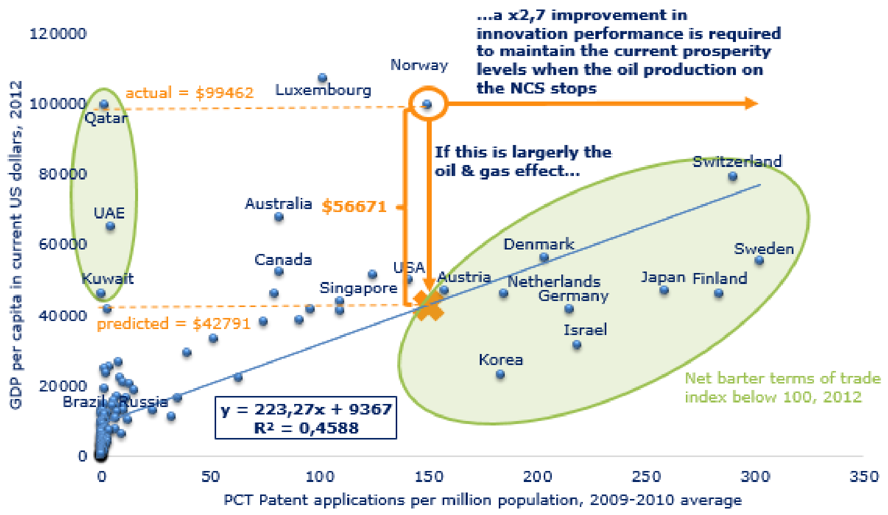
This report should not be viewed in isolation. It is a follow-up of our earlier study "Offshore Oil & Gas as Industrial Driver" (2013), focusing more on the productivity development in the offshore oil & gas supplier industry, and a larger national-level research project "Knowledge-based Norway" (2012) by Torger Reve and Amir Sasson as the theoretical and empirical background.

1. OFFSHORE INDUSTRY AS A POTENTIAL LEVER FOR INNOVATIONS

Boosting innovation performance is crucial for sustaining the current prosperity level in Norway

For a long time, researchers have viewed innovation as a major mechanism for an economy's upgrading and thus a driver for its competitiveness and prosperity[1]. Exhibit 1.1 below gives us a simplified empirical illustration for this point.

Exhibit 1.1



SOURCES: TEAM ANALYSIS. DATA: "THE GLOBAL COMPETITIVENESS REPORT 2013-2014" & WORLD BANK

We measure prosperity in 2012 as GDP per capita in current US dollars for 145 countries in "The Global Competitiveness Report 2013-2014"[2] and regress it on the average number of PCT patent applications[3] per million population in 2009-2010, a proxy for the innovation performance. The linear regression[4] presented in Exhibit 1.1 with a blue line is highly significant[5]. The R^2 of about 0,46 indicates that the innovation performance is a very good predictor of a country's prosperity in two years since the variance in PCT patent applications accounts for almost 46% of total variance in the GDP per capita levels across the countries.

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[1] Porter, M. E. 2008. *On competition*. Boston: Harvard Business Press.

[2] Schwab, Klaus and Xavier Sala-i-Martin. 2013. *The Global Competitiveness Report 2013-2014*. World Economic Forum.

[3] A PCT patent application is a international patent application filed under the Patent Cooperation Treaty (1970), which establishes a filing date in all contracting states (148 parties) and must be followed up with the step of entering into national or regional phases to proceed towards grant of one or more patents.

[4] We used an OLS regression

[5] The regression is significant at 1% level: F-statistic is 121, 24 and degrees of freedom are144 giving p-value equal to 0.00.

Particularly, this simple regression model predicts that a country with no patent applications will have a GDP per capita of 9367 US dollars and this number will grow by about 223 US dollars with each additional patent application per million population[6]. There is uncertainty associated with these regression line predictions though. The 95% confidence interval for the GDP per capita figure for a country with no patent applications ranges from 6586 to 12148 US dollars and the 95% confidence interval for the increase factor per patent application per million residents is from 183 to 263.

Table 1.1

Country	$ difference from predicted	Energy production (kt of oil equivalent) per 1000 population	Terms of trade index
Qatar	90007	103,0	217,8
Luxembourg	75199	0,2	75,8
Norway	56671	38,9	161,6
United Arab Emirates	54535	20,7	186,1
Australia	40115	13,1	184,8
Kuwait	36412	47,5	227,8
Brunei Darussalam	31644	45,4	226,5
Canada	24713	11,8	118,5
Ireland	18793	0,4	92,7
Cyprus	15213	0,1	94,2
Oman	15108	22,2	244,2
Saudi Arabia	14981	21,3	215,5
Singapore	14020	0,2	80,6
Bahrain	13686	13,7	129,0
New Zealand	12288	3,6	129,4
Italy	12227	0,5	94,8
Spain	11170	0,7	88,5
Iceland	10960	15,0	87,3
Greece	10723	0,9	87,2
Germany	-15769	1,5	95,3
Japan	-20325	0,4	60,5
Sweden	-21794	3,4	92,3
Finland	-26634	3,2	87,1
Israel	-26923	0,6	97,6
Korea, Rep	-27202	0,9	61,8

SOURCES: TEAM ANALYSIS & DATA FROM WORLD BANK

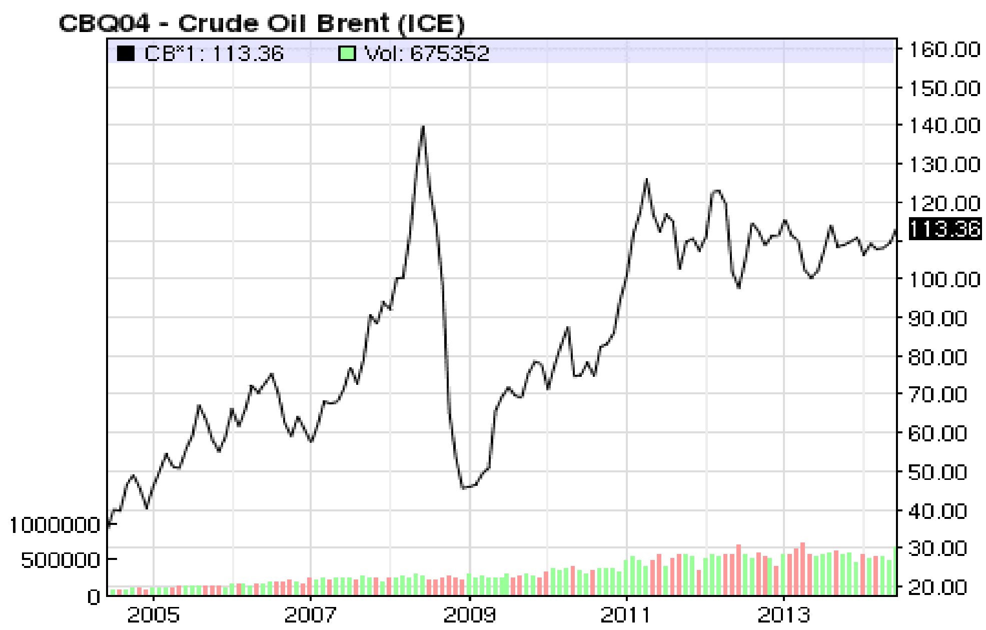
We should not forget also that the model has mainly the illustration purpose. Hence, it is very simplified and does not account for many other factors that may be relevant. A closer look at the outliers presented in Table 1.1 helps us to reveal some of them. The first column lists countries with GDP per capita levels that deviate by more than $10000 per person from the levels predicted by our regression model. The second column shows the difference in current US dollar terms between the actual and predicted GDP per capita levels in 2012. The third

[6] Both the intercept (9366.98) and slope (223.27) coefficients are significant at 1% level with the t-values of 6.66 and 11.01 correspondently.

column gives us the energy production volume in kt of oil equivalents per 1000 population in 2011 and the fourth – net barter terms of trade index 2012[7].

The last two columns present the likely variables to explain why countries with few innovations such as Qatar are doing so well in terms of prosperity while such advanced and highly innovative economies as Germany and Japan lag behind. As we can see, on the top of the list are small oil & gas – producing countries like Qatar, Norway, UAE and Kuwait together with the mining-driven Australian economy. This suggests that natural resource endowments are an important driver of prosperity, especially when the prices for raw materials increase, as evidenced by the high values of the terms of trade index. For example, the unit price of Qatar exports has more than doubled relative to the unit price of it imports since 2000. By contrast, we can see that the terms of trade has worsened for the highly innovative economies like Germany, Japan, Sweden, Finland, Israel and South Korea, which have a significantly lower than predicted GDP per capita. In short, it appears that the natural resource endowments and the terms of trade moderate the significant positive relationship between innovation and prosperity.

Exhibit 1.2



SOURCE: NASDAQ

Keeping that in mind, let us now return our attention back to Norway. Exhibit 1.1 demonstrates that the GDP per capita level in 2012 was around 99462 US dollars, i.e. the third largest in the world after Qatar and Luxembourg. The country had also a strong innovation performance in 2009-2010 with 149,7 PCT patent applications per million of population.

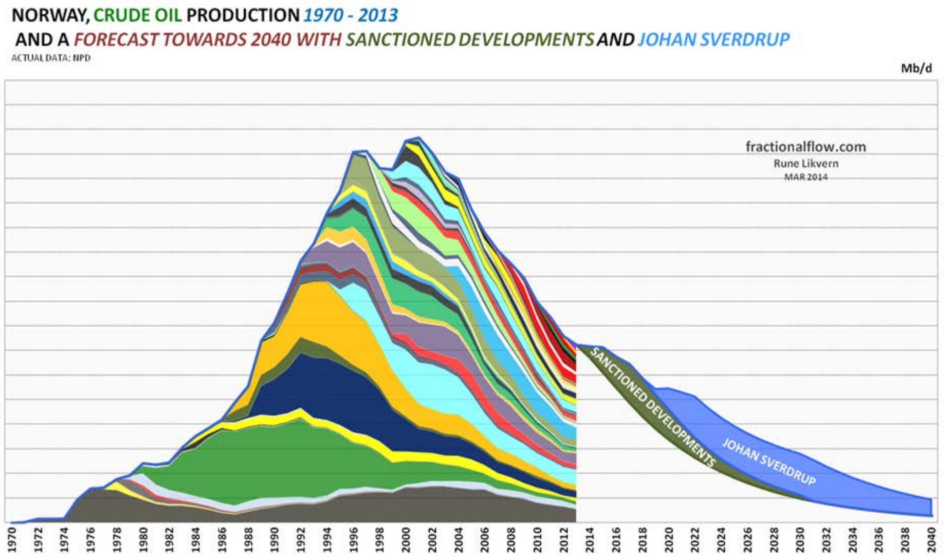
[7] The data on energy production, population and net barter terms of trade index is taken from www.data.worldbank.org. The energy production numbers are taken for 2011 since the data for 2012 is not complete. Net barter terms of trade index is measured relative to the base year 2000, i.e. the value less than 100 (base year value) means that the export unit value has decreased relatively to the import unit value since 2000.

However, our regression model suggests that the prosperity level justified by this level of innovation output should be about 57% lower. A part of this 56 671 US dollar per person difference between the predicted and actual levels of GDP per capita must be driven by the historically high prices on the crude oil (see Exhibit 1.2 below) as well as relatively high levels of crude oil production (see Exhibit 1.3).

Exhibit 1.3 suggests also a dramatic decrease in the crude oil production on the Norwegian continental shelf to 2040[8]. In addition, the World Bank Commodity Price Forecast released on April 25th, 2014 predicts the decline in the crude oil price to 96,7 US dollar per barrel until 2025[9]. The combination of these two factors are likely to push the Norwegian GDP per capita towards the predicted levels in the medium and long term.

As the model presented on Exhibit 1.1 suggests, Norway needs to improve substantially its innovation performance to compensate for these adverse forces. If we take the extreme point by assuming that the whole difference between the actual and predicted GDP per capita levels is explained by the oil production and that the prediction is correct, then Norway needs a 2,7 time increase in the number of PCT patent applications per million to sustain its GDP per capita close to 100000 in 2012 US dollars.

Exhibit 1.3



SOURCE: FRACTION FLOW

[8] Electronic article by Rune Likvern at Fractional Flow, March 2014, accessed from<http://fractionalflow.files.wordpress.com/2014/04/fig-1-norway-actual-oil-production-2013-and-forecast-to-2040.png> on June 18th, 2014.

[9] World Bank Commodity Price Forecast from April 25th, 2014 accessed from <http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1304428586133/Price_Forecast_20140425.pdf> on June 18th, 2014.

Offshore industries have the potential to leverage Norway's innovation performance

Given the pressures to improve the innovation performance of Norway described above, industrial policy makers should consider focusing on industries that are large enough to have any significant impact at the country level and have demonstrated their ability to innovate. Following this reasoning, we have mapped different sectors of the Norwegian economy according to their revenues in 2012 and innovativeness index in 2010-2012 on Exhibit 1.4. While revenues is a straightforward measure of size, the use of the innovativeness index needs to be discussed in more detail.

Though patents are commonly used as a proxy for innovation output, they are very imperfect measures of innovation performance. First, not all innovations are patentable due to the tacit knowledge component that is hardly possible to describe in a patent. Second, in many cases patents make it easier for competitors to copy the innovation rather than give protection to the proprietary knowledge[10]. This is probably why only 32% of the 3108 Norwegian companies that reported product or process innovations in 2010-2012 have applied for a patent[11]. Finally, there are many aspects of innovation performance that are not captured by patents, for example, process innovations, organizational innovations, marketing innovations, etc. Therefore, we have developed the innovativeness index a more elaborate measure of innovation performance that would account for these weaknesses (see Box 1.1 for a detailed description).

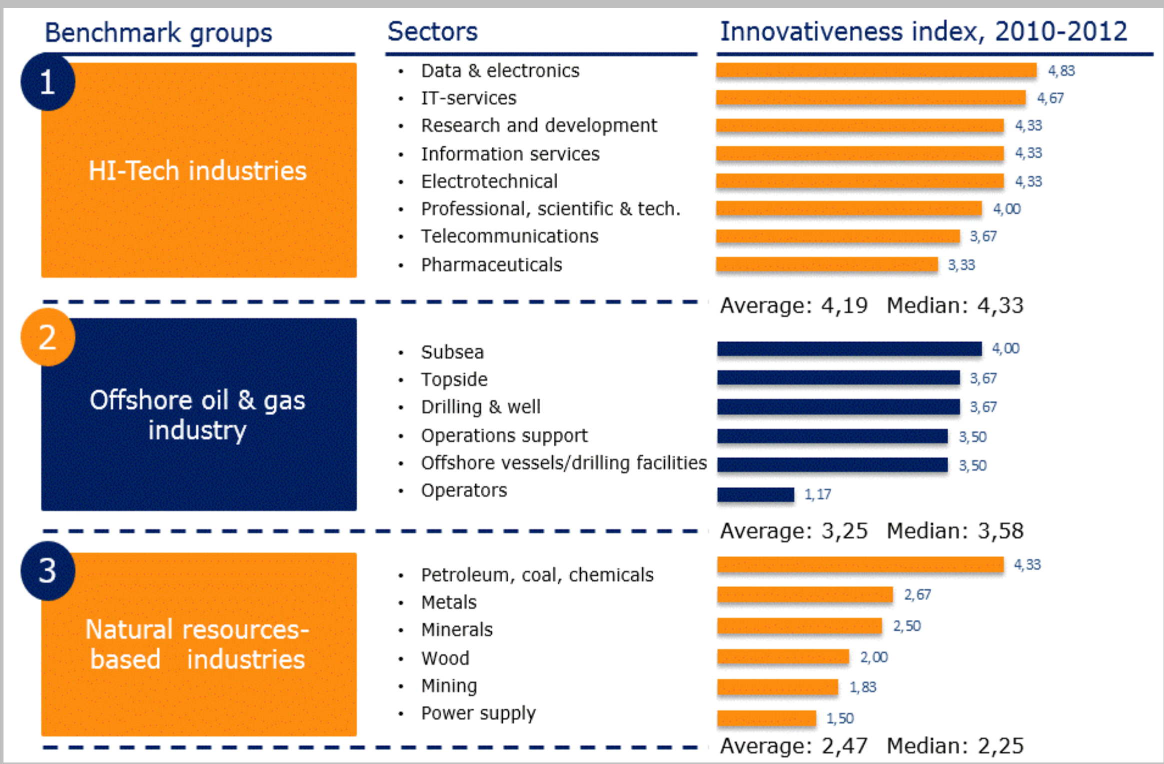
[10] For a more advanced discussion of the use of patents to measure the innovation performance see Ahuja, G. & Katila, R. 2001. Technological acquisitions and the innovation performance of the acquiring firms: A longitudinal study. ***Strategic Management Journal***, 22 (3): 197-220.

[11] Source: The innovation survey performed by Statistics Norway (SSB) for 2010-2012. The survey is conducted every two years and is obligatory for all companies that are registered in Norway and have more than 5 employees.

Box 1.1

How do we define and measure innovativeness?

Innovativeness is a multifaceted construct that is hardly possible to capture with a single variable. Hence, we have developed an aggregate measure of innovativeness based on the data from Statistics Norway (SSB) on the five major areas of innovation by all Norwegian companies with more than 5 employees in 2010-2012. These five innovation areas include product, service, process, organization and marketing innovations. Based on the % of companies in an industry that reported a given type of innovation activities in 2010-2012, we calculate the percent rank for that industry for each type of innovation. Then we convert the percent ranks into scores from 1 (for the lowest quintile) to 5 (for the highest) and take the average of these scores to obtain a measure of the overall innovativeness, which we call "Innovativeness Index, 2010-2012". The graph below illustrates the Innovativeness Index, 2010-2012 for three groups of industries in Norway: high-tech, oil & gas and other industries that are natural-resource intensive.



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

Looking at the Innovativeness index presented in Box 1.1 alone, we can make several important observations. First, the industries that are commonly viewed as high-technology[12] clearly outperform most of the other industries in terms of innovation. The median value of the Innovativeness index for this group was 4,33 in 2010-2012 compared the median value for Norway of 2,83. Second, the median innovativeness for the offshore oil & gas industry of 3,58 was somewhat lower than for the high-tech industries, but it was still very high compared to both the national median and the other natural resource intensive sectors that had the

[12] For a more detailed discussion see Kile, C. O., & Phillips, M. E. 2009. Using Industry Classification Codes to Sample High-Technology Firms: Analysis and Recommendations. ***Journal of Accounting, Auditing & Finance***, 24: 35-58.

median value of 2,25. Further, the oilfield services industries demonstrated the overall innovation performance in 2010-2012 comparable to that of such high-technology sectors as telecommunications and pharmaceuticals. Among the oilfield services industries, subsea, topside and drilling & well segments were the clear leaders in innovation. Finally, if we look at the two ends of the oil & gas value system, we can see that operator companies scored low on overall innovativeness while the petroleum refining, coal and chemicals were among the top innovators.

Exhibit 1.4

Notes:

1. The graph does not include 5 outliers with low innovativeness index score but high size (presented in brackets): oil operators (1,17; 677121), mining (1,83; 786551), finance and insurance (2,17; 193271), wholesale (1,83; 146251) and food (2,33; 107314). In addition, we have dropped “other business services” (2,67; 480) and “other industry” (2,67; 2421) because of interpretation difficulties.
2. The orange lines on the graph represent the mean values for the revenues and innovativeness, calculated without the industries mentioned above

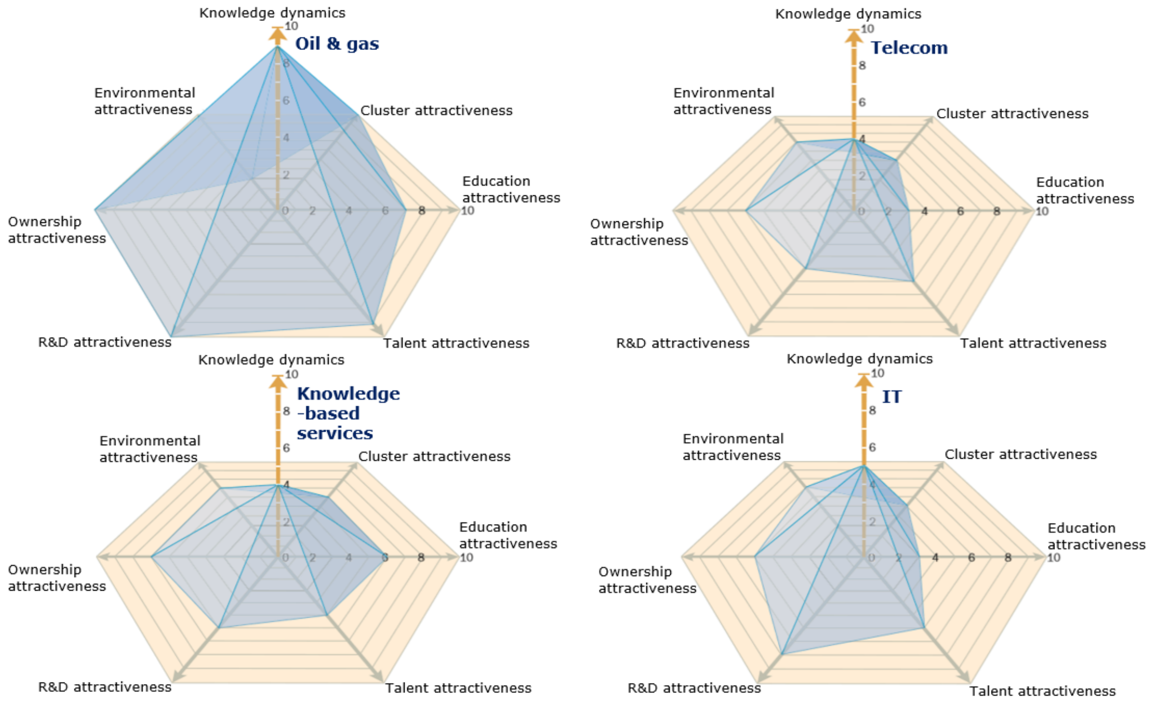
SOURCE: TEAM ANALYSIS BASED ON DATA FROM “INNOVATION SURVEY 2010-2012” BY SSB

Let us now take a closer look at our mapping of the industries in Norway according to their size and the overall innovativeness presented on Exhibit 1.4. The mean values for revenues and the innovativeness index split the graph into four areas. The industries in the upper right area have the highest potential as levers for Norway’s innovation performance as they are both large and have demonstrated the superior ability to innovate. These include: offshore vessels and drilling facilities, drilling & well, petroleum, coal and chemicals, IT-services, subsea, topside, telecommunications, machinery as well as architect-and technical consulting.

Further, a recent study “A knowledge based Norway” has shown that the ability to continuously create value through innovation depends on the knowledge commons and knowledge dynamics in the industry. The emerald model measures both knowledge dynamics and six attractiveness dimensions (cluster, education, talent, R&D, ownership and environment) that jointly define the knowledge commons[13].

Exhibit 1.5 presents the emerald models for the four clusters relevant for this analysis in 2012: oil & gas, telecommunications, knowledge-based services and IT.

Exhibit 1.5



SOURCE: REVE, T. & SASSON, A. "A KNOWLEDGE-BASED NORWAY" (2012)

As we can see, the oil & gas industry definitely has the most developed emerald, implying that the offshore vessels and drilling facilities, drilling & well, topside, subsea, and operations support have better opportunities to draw on the local environment for innovating compared to the other industries. On balance, size, innovativeness and cluster characteristics suggest that the oilfield services industries have all the prerequisites for becoming the major drivers of innovation in Norway in the coming years.

Innovations have a substantial impact on the upstream offshore oil & gas companies

For companies competing in rapidly changing environments, the ability to develop new technologies, introduce innovations to the market and adapt the organization are crucial for achieving growth, productive efficiency, competitive advantage and after all the mere survival[14]. The oilfield services industry can be characterized as such a dynamic environment

[13] Reve, T., & Sasson, A. 2012. *Et kunnskapsbasert Norge*. Oslo: Universitetsforlaget.
[14] Teece, D. J. 1986. Profiting from technological innovation – Implications for integration, collaboration, licensing and public policy. ***Research Policy***, 15 (6): 285-305; Teece, D. J., Pisano, G. & Shuen, A. 1997. Dynamic capabilities and strategic management. ***Strategic Management Journal***, 18 (7): 509-533; McEvily, S. K., Eisenhardt, K. M. & Prescott, J. E. 2004. The global acquisition, leverage and protection of technological competencies. ***Strategic Management Journal***, 25 (8): 713-722.

where "market shares may shift frequently depending on technology offerings and demand levels, price is a major factor in purchasers' decisions and…major oil companies can usually substitute with in-house services if prices are too high, innovation tends to diffuse quickly…and players must reinvest in R&D to remain competitive"[15].

Empirical evidence from the Innovation survey for 2010-2012 conducted by Statistics Norway (SSB) supports the argument and suggest that it is in the interest of both industrial policy-makers and offshore companies to work on further improving their innovation performance. Particularly, the survey allows us to evaluate the impact of product and process innovations on a given industry in the forms of percent of revenues coming from the new products, innovations in the world market that are likely to improve the competitiveness in the global arena as well as the increased likelihood of M&A, stopping the operations, and expansion in Norway, EU and outside EU. The heat diagram on Exhibit 1.6 summaries the results of such evaluation across the industries in our three benchmark groups: hi-tech, offshore oil & gas, and other resource-intensive industries.

Exhibit 1.6

The form of impact:

	Sectors:	%revenues from new products	World market innovations	On M&A likelihood	On likelihood of discontinuing some operat.	On likelihood of expansion in Norway/EU	On likelihood of int. expan. outside EU
HI-Tech	Information services	100,0	68,0	87,2	95,7	4,2	23,4
	Data & electronics	91,4	100,0	46,8	40,4	74,4	65,9
	Professional, scient. & tech.	89,3	80,8	19,1	29,7	19,1	40,4
	Electrotechnical	87,2	78,7	46,8	40,4	21,2	51,0
	Telecommunications	65,9	46,8	72,3	91,4	42,5	51,0
	IT-serives	53,1	65,9	46,8	59,5	40,4	57,4
	Research and development	40,4	63,8	31,9	63,8	80,8	74,4
	Pharmaceuticals	19,1	59,5	80,8	2,1	97,8	93,6
Oil & Gas	Topside	97,8	74,4	40,4	51,0	65,9	97,8
	Drilling & well	95,7	97,8	25,5	85,1	42,5	85,1
	Subsea	78,7	95,7	65,9	72,3	93,6	44,6
	Operations support	63,8	87,2	31,9	51,0	53,1	29,7
	Offshore vessels/drill. fac.	53,1	91,4	74,4	40,4	80,8	95,7
	Operators	0,0	44,6	63,8	80,8	2,1	78,7
Resource	Petroleum, coal & chem.	57,4	93,6	82,9	70,2	55,3	87,2
	Minerals	44,6	34,0	25,5	31,9	55,3	0,0
	Wood	42,5	10,6	14,8	25,5	4,2	0,0
	Mining	27,6	61,7	40,4	63,8	29,7	29,7
	Metals	23,4	53,1	31,9	91,4	42,5	57,4
	Power supply	2,1	27,6	4,2	97,8	42,5	29,7

Percent rank, nationally: 0 10 20 30 40 50 60 70 80 90 100

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

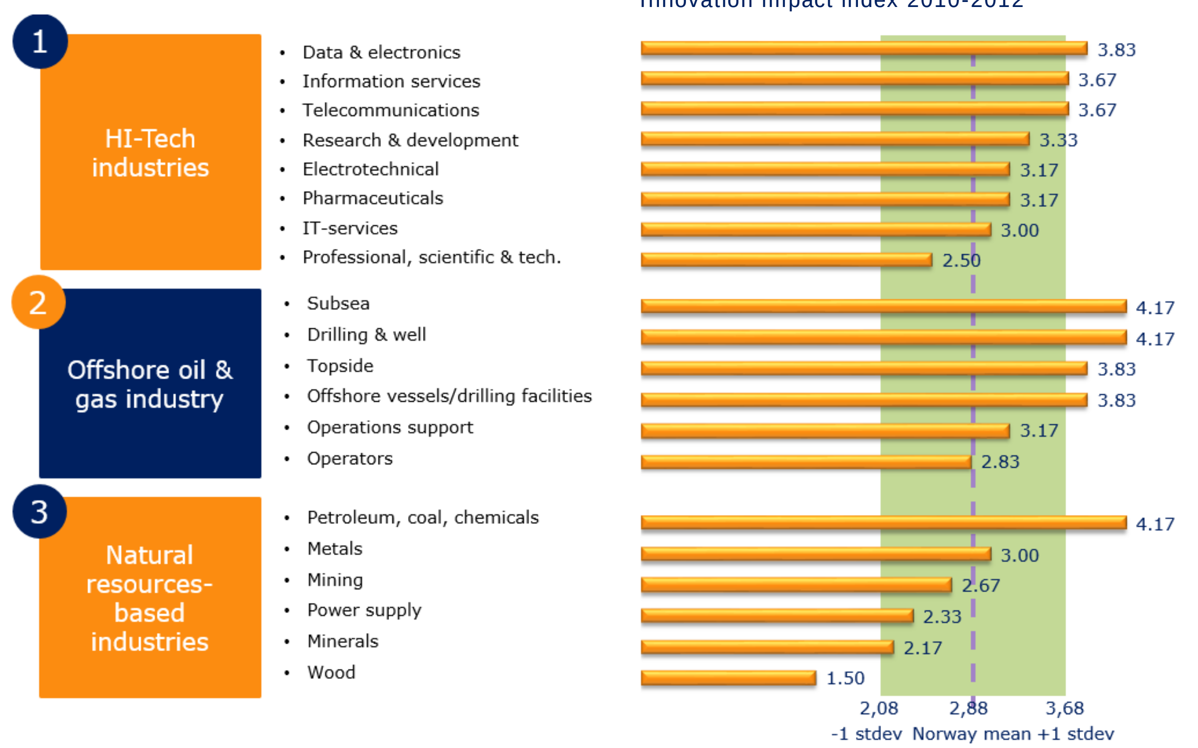
The high percent of oilfield services companies that have introduced product innovations in the world market (the second column on the heat diagram) suggest that the industry is relatively more internationalized and that innovativeness is probably a factor of its international competitiveness. Further, we can clearly see that product innovations are an important source of growth in the Norwegian oilfield services industry. First, new products account for a high percent of revenues compared to other industries (the first column on the heat diagram). Second, product and process innovations seem to significantly increase the

[15] Dorsey, P. W., Fiore, A. M. & O'Reilly, I. R. 2011. "Introduction to industry and company analysis", In *Equity and Fixed Income, CFA Program Curriculum, Volume 5*, CFA Institute.

likelihood of expansion for Norwegian oilfield services companies (the last two columns on the diagram).

By aggregating these different innovation impact measures we can construct the Innovation impact index for different Norwegian industries in 2010-2012 presented on Exhibit 1.7. The Innovation impact index values presented on Exhibit 1.7 indicate that companies in the oilfield services industries are much more affected by their innovation performance then companies in other sectors of the economy. Consequently, it is in the interests of both government and business to boost innovation performance of the industry.

Exhibit 1.7



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

2. THE CURRENT STATE OF INNOVATIVENESS IN THE OFFSHORE: LEADING TECHNOLOGIES BUT STAND-BY COMMERCIAL CHOICES

An imbalance between technological and commercial innovations in the Norwegian offshore supplier industries

> **Box 2.1**
>
> **How do we define technological and commercial innovations?**
>
> Innovation is not only about technology. Introducing new business practices, methods for organizing business relationships or significant changes in design can be legitimately called innovations as well. To distinguish these non-technological types of innovations from technological ones, we refer to them as "commercial innovations" throughout this report.
>
> This approach is consistent with the methodology applied by Statistics Norway (SSB) in their Innovation survey, which we base our Innovativeness Index on. Particularly, SSB identifies five types of innovations: product, service, process, organization and marketing. In our classification, product, service and process innovations fall into the technological innovations category while organization and marketing innovations are considered commercial innovations.

The Innovativeness Index we presented in the previous section aggregates different types of technological and commercial innovations (for definitions see Box 2.1). In order to understand which innovation areas may offer opportunities for improvement of the innovation performance in the Norwegian oilfield services industries, we need to make a step back and look at the decomposed index.

Exhibit 2.1

Group	Sectors	Product	Service	Process	Organization	Marketing
		Type of innovation				
Hi-Tech	Information services	38,2	100	100	74,4	100
Hi-Tech	Telecommunications	27,6	97,8	55,3	87,2	70,2
Hi-Tech	IT-services	55,3	95,7	89,3	82,9	87,2
Hi-Tech	Professional, scientific & tech	44,6	91,4	42,5	82,9	59,5
Hi-Tech	Research and development	65,9	82,9	95,7	74,4	48,9
Hi-Tech	Electrotechnical	89,3	68,0	70,2	95,7	78,7
Hi-Tech	Data & electronics	100	63,8	91,4	100	89,3
Hi-Tech	Pharmaceuticals	76,5	0,0	97,8	29,7	63,8
Oil & Gas	Topside	65,9	80,8	70,2	95,7	21,2
Oil & Gas	Subsea	85,1	78,7	48,9	74,4	78,7
Oil & Gas	Offshore vessels/drill. facil.	55,3	61,7	53,1	65,9	42,5
Oil & Gas	Operations support	72,3	70,2	59,5	55,3	31,9
Oil & Gas	Drilling & well	85,1	89,3	63,8	40,4	21,2
Oil & Gas	Operators	17,0	27,6	17,0	40,4	0,0
Resource	Petroleum, coal, chemicals	97,8	63,8	87,2	68,0	78,7
Resource	Metals	53,1	40,4	80,8	51,0	31,9
Resource	Minerals	48,9	0,0	59,5	68,0	44,6
Resource	Wood	51,0	27,6	40,4	40,4	31,9
Resource	Mining	27,6	51,0	17,0	55,3	6,3
Resource	Power supply	10,6	40,4	25,5	29,7	14,8

Percent rank, nationally: 0 10 20 30 40 50 60 70 80 90 100

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

The heat diagram on Exhibit 2.1 presents the relative innovation performance of the sectors (industries) in the three selected benchmark groups (hi-tech industries labeled "Hi-Tech", offshore oil & gas industries – "Oil & Gas", and other natural resources-related industries – "Resource") across the five types of innovations defined by SSB in the Innovation survey 2010-2012, namely product, service, process, organization and marketing innovations. The numbers in the diagram stand for the percentile rank among all the industries in Norway. For example, the score 85,1 for product innovations in subsea means that 85,1 % of all the sectors in Norway performed worse in terms of the product innovations than subside segment of the oil & gas industry. When we say "performed worse", we mean that a lower percentage of companies with more than 5 employees in those sectors reported any product innovations in 2010-2012. Further, we use different colors to separate performance deciles, with "colder" colors meaning weaker performance and "warmer" colors for stronger performance.

If we take a closer look on the supplier part of the oil & gas industry, we can see an interesting pattern: the companies in these sectors are generally much stronger in product and service innovations than in process, organization and marketing ones. The two exceptions worth mentioning are the top performance of the topside segment in terms of organization innovation and relatively high percentile ranks of the subsea segment in organization and marketing innovations. This pattern contrasts with that in the hi-tech industries where the companies seem to be superior innovators on both the technology and commercial sides.

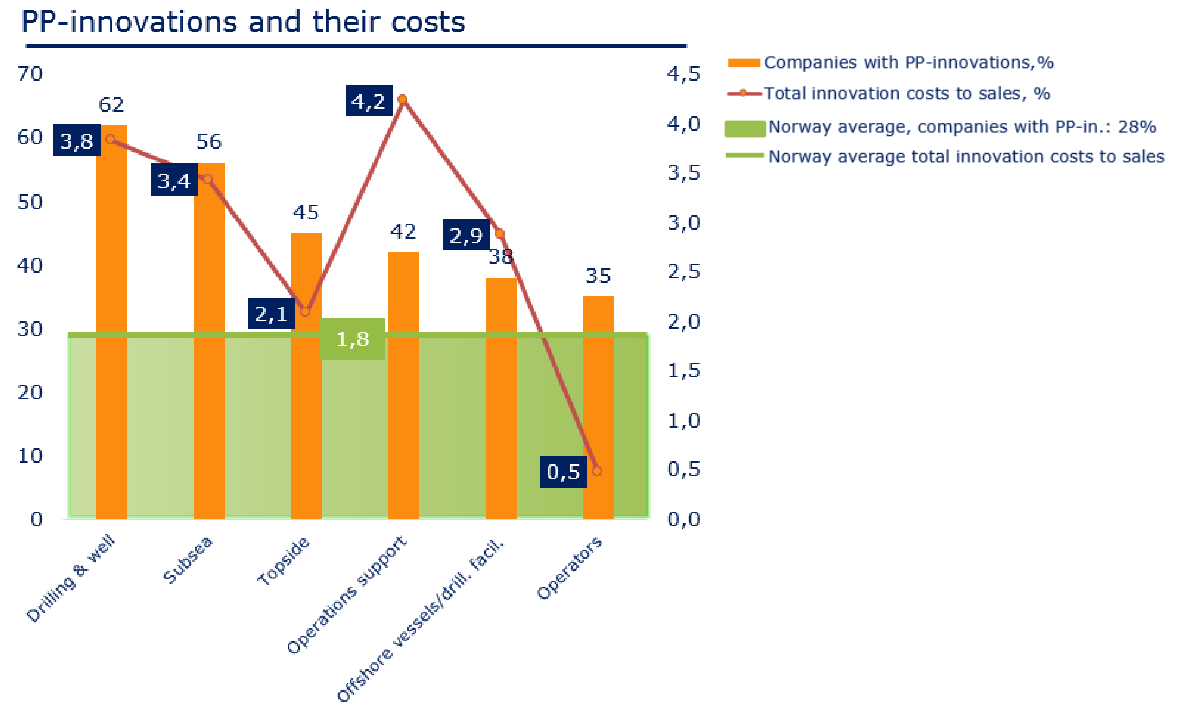
Why should we bother? An argument can be made that the imbalance between the technological and commercial innovations merely reflects the nature of the competition in the oilfield services industry. At an extreme, one may say: "Look, we are speaking of industrial goods, not consumer products. Why should we care that much about marketing innovations?"

An answer to this question is twofold. First, research in strategic management and experience from a variety of industries (medical equipment, aerospace, electronics, etc.) show that only companies that possess the complementary engineering, production, marketing and distribution capabilities are able to profit from their technological innovations and those that do not possess these complementary capabilities risk not surviving in the competition[16]. Second, price is an important factor of the purchase decision made by the oil & gas operator companies. When the cost levels are high it is not only applying world-class technologies that justify higher prices but also the ability to work smarter and find more effective ways to organize business interactions that help keeping the costs down and allow maintaining the competitive advantage[17]. From this perspective, introduction of more efficient processes, new methods to organize work and interactions within and between companies, as well as more competitive pricing methods and product designs become relevant.

Oilfield services industries have a higher technological innovation intensity and output than an average industry in Norway, but less focus on the market introduction of the innovations

Now we can consider the industries' performance in terms of technological and commercial innovations separately. We start with technological innovations. As mentioned previously, they encompass product, service and process innovations, which we will further denote PP-innovations.

Exhibit 2.2



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

[16] Teece, D. J. 1986. Profiting from technological innovation – Implications for integration, collaboration, licensing and public policy. ***Research Policy***, 15 (6): 285-305.
[17] Reve, T. 2014. *From industrial clusters to global knowledge hubs*. BI EMBA Program in Maritime and Offshore. Ålesund.

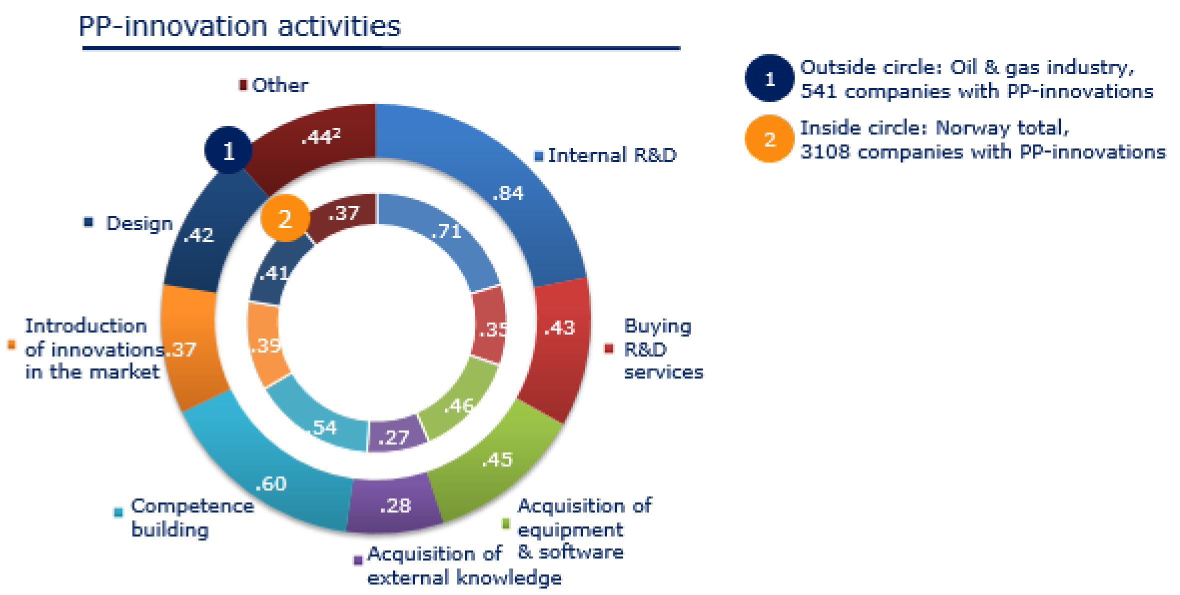
Exhibit 2.2 presents the innovation inputs measured as the total innovation costs to sales ratio and the PP-innovation output measured as percentage of companies in the industry that reported any PP-innovations in 2010-2012 for the six segments of the offshore oil & gas industry, namely drilling & well, subsea, topside, operations support, offshore vessels and drilling facilities, and operators. Further, we benchmark these measures against the mean levels in Norway.

On average, companies in Norway spent about 1,8 % of their 1 945 billion NOK in total revenues in 2012 on innovation activities including internal R&D, buying R&D services from other companies, acquisitions of machines, equipment and software, acquisition of external knowledge and other. This number is lower than the average innovation intensities across the oilfield services industries that ranged from 4,2 % in the operations support to 2,1 % in the topside segment. Operators had the total innovation intensity of 0,5 % in 2012, which primarily explained by the magnitude of revenues rather than lower absolute innovation spending relative to the oilfield services.

All the segments of the offshore oil & gas industry significantly outperform Norway's average numbers in PP-innovation output. The percent of companies with PP-innovations across the segments of the offshore oil & gas industry ranged from 62 % for drilling & well to 35% for operators, which is significantly higher than the 28% for an average Norwegian industry.

The priority of PP-innovation activities differs also between the offshore oil & gas and other industries in Norway. SSB identifies eight types of PP-innovation activities: internal R&D, buying R&D services, acquisition of machines, equipment and software, acquisition of other external knowledge, competence building, introduction of innovations in the market, design and other.

Exhibit 2.3



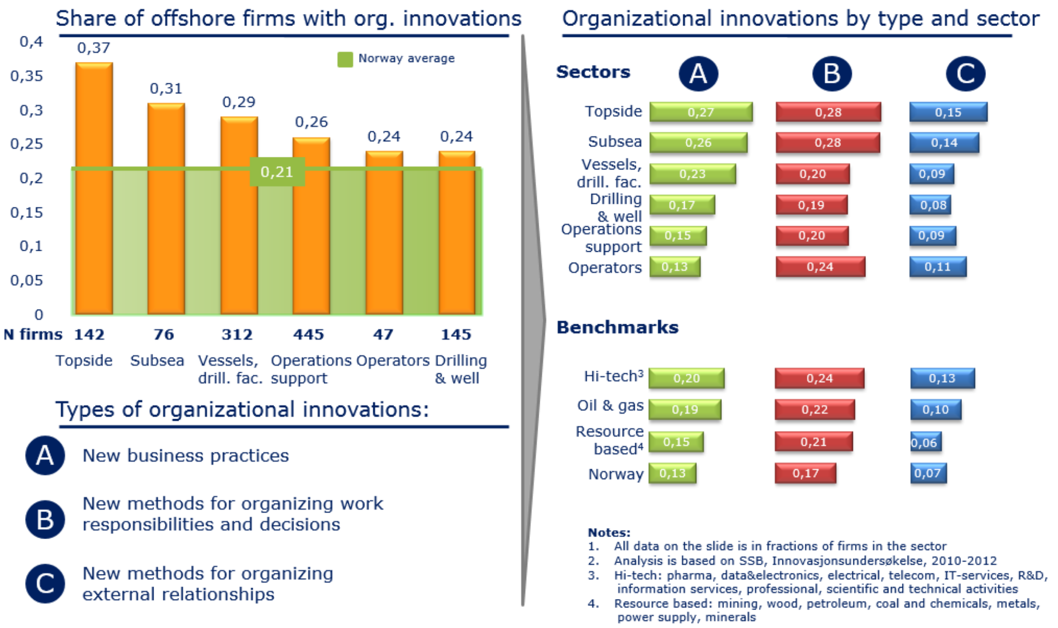
SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

Exhibit 2.3 demonstrates percentages of companies that reported a given type of PP-innovation activity in 2010-2012 in both the offshore oil & gas industry (outside circle) and Norway in total (inside circle). The offshore companies seem to have focused more R&D, acquisition of external knowledge, competence building and design, but less on the introduction of innovations in the market. While 84 % of the offshore oil & gas companies with PP-innovations in 2010-2012 engaged in internal research and development, only 37 % of them introduced their innovations to the market. This is a negative signal because innovations that are not eventually commercialized add no value.

Subsea and topside segments lead in commercial innovations

We consider two types of commercial innovations that in our view are complementary for technological ones: organization innovations and marketing innovations.

Exhibit 2.4



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

Organization innovations include new business practices, methods for organizing work responsibilities and decisions and new methods for organizing external relationships[18]. As Exhibit 2.4 shows, topside, subsea and offshore vessels and drilling facilities segment had strong performance in terms of organization innovations relative both to the national average and the three benchmark groups (hi-tech industries, oil & gas industry on average, and other industries related to natural resources). Drilling & well and operations support segments performed on par with the benchmarks. It seems also that searching for new ways of organizing external relationships has not been a priority for the industry.

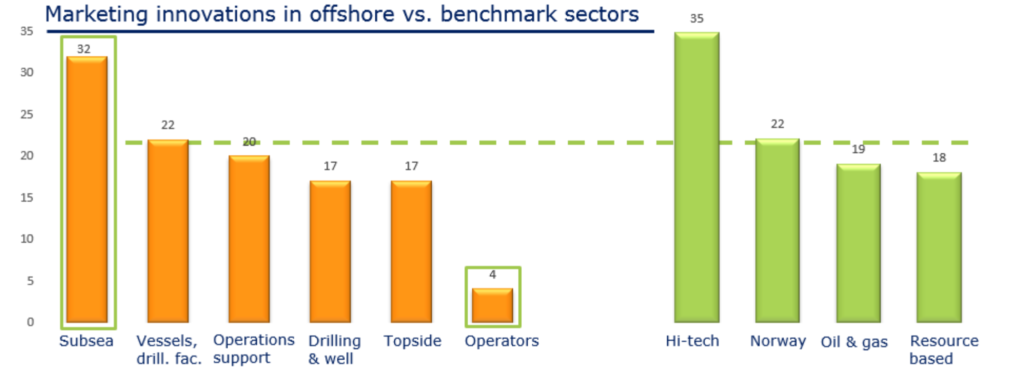
Marketing innovations encompass significant changes in design, new promotion methods, channels, and pricing methods. All the segments of the offshore oil & gas industry except for the subsea and offshore vessels and drilling facilities underperform the average Norwegian industry in these types of commercial innovations (see Exhibit 2.5). The contrast with the

[18] SSB. 2012. *Innovation survey*.

high tech industries is more pronounced. There are a few exceptions though. Drilling & well segment is relatively strong in pricing innovations and operations support and topside – in the new methods for product placement and distribution. While the need to rethink the marketing strategies can be more easily overlooked in this industry compared to, for example, consumer electronics because of the nature of competition, we still believe that given the high innovation costs finding new ways to sell the already developed technology is not less essential than investing in new technologies.

Exhibit 2.5

Marketing innovations in offshore vs. benchmark sectors



Types of marketing innovations:

- **A** Significant changes in design and packaging
- **B** New media and promotion methods
- **C** New methods for product placement or distribution channels
- **D** New pricing methods

Marketing innovations by type & sector

	A Design & packaging	B Media & promotions	C Placement & channels	D Pricing methods
Subsea	0,60	0,57	0,64	0,55
Vessels, drill. fac.	0,43	0,49	0,30	0,40
Operations support	0,57	0,34	0,60	0,19
Drilling & well	0,23	0,28	0,13	0,68
Topside	0,13	0,21	0,57	0,53
Operators	0,06	0,00	0,00	0,02

Percent rank, nationally: 0 10 20 30 40 50 60 70 80 90 100

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

3. THE POTENTIAL TO INCREASE THE INNOVATIVENESS IN THE NORWEGIAN OFFSHORE INDUSTRIES

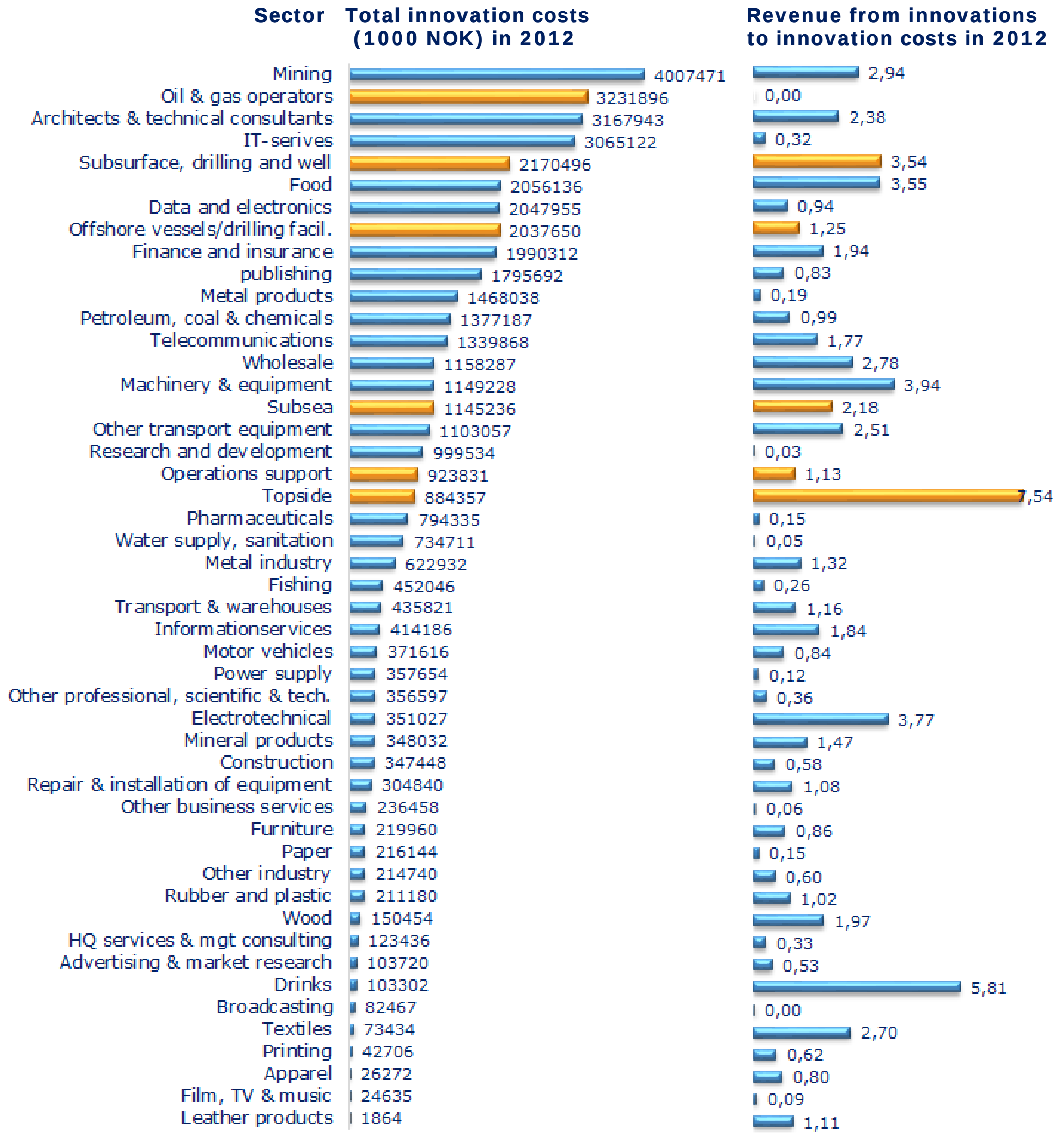
There are substantial cross-sector differences both in the amounts spent on innovation activities and returns on that spending

We have so far examined the innovation performance of the Norwegian oilfield services industries relative to other sectors of the Norwegian economy and have generally concluded that the industry is very innovative. Another important question is whether it is innovative enough given the level of investments in innovation activities in the industry and other industry characteristics that may affect innovation performance. Can the innovation budgets be used more effectively?

We begin this analysis by considering the total innovation costs and the incremental revenues generated by a krone invested in innovation. Exhibit 3.1 shows 48 sectors of the Norwegian economy, their total innovation costs in thousand NOK in 2012 and the ratio of the total revenues attributed to products new for the firm's market in 2012 to the total innovation costs in 2012. The data suggests that the total innovation spending by an average Norwegian industry was around 934 million NOK in 2012 and each krone invested in the innovation activities generated approximately 1,47 krone in revenue from the new products. There is a significant variation though. The total innovation costs ranged from 1,8 million NOK for leather products to more than 4 billion NOK in the mining industry. The revenues from innovations to innovation costs ratio ranged from 0 for the oil & gas operator companies to 7,54 for the topside segment.

We should also keep in mind the limitations of the revenue form innovations to innovation costs ratio as a proxy for the innovation effectiveness. First, not all innovation activities have the ultimate goal to generate new products. For example, the oil & gas operator companies sell a commodity and thus may focus their innovation efforts primarily on improving safety and environmental friendliness of their operations. Therefore, the zero ratio does not indicate complete innovation ineffectiveness in this case. It mere suggests that it does not capture another relevant dimension of the innovation activities. We generally expect the ratio to be lower for industries selling standardized products. Further, the ratio implicitly assumes that the innovation expenditures made in 2012 resulted in new products in the same year, which may be unrealistic. Finally, it does not control for other variables that may affect innovation performance. In our further analysis, we will present the innovation effectiveness score, which accounts for most of these limitations, but for now we will use this ratio as a simple yet very intuitive and reasonably good measure of the innovation effectiveness for the industries selling technology intensive products.

Exhibit 3.1



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

Exhibit 3.1 shows also a substantial variance in the total innovation expenditures and the ratios of the revenue from innovation to innovation costs across the segments of the oilfield services industry. The total innovation costs were the lowest in the topside segment at approximately 884 million NOK and the highest in the drilling and well – 2 170 million NOK. By contrast, the ratio of revenues from innovations to innovation costs were the highest in the topside segment at 7,54 and the lowest in the operations support - 1,13 NOK in revenues from new products per 1 NOK spent on innovation. Considered together, these two indicators suggest that:

- Given the significantly higher than average "returns" on innovation expenditures in the topside, drilling & well and subsea segments, there exist opportunities to improve the innovation performance in these segments by increasing the innovation budgets;

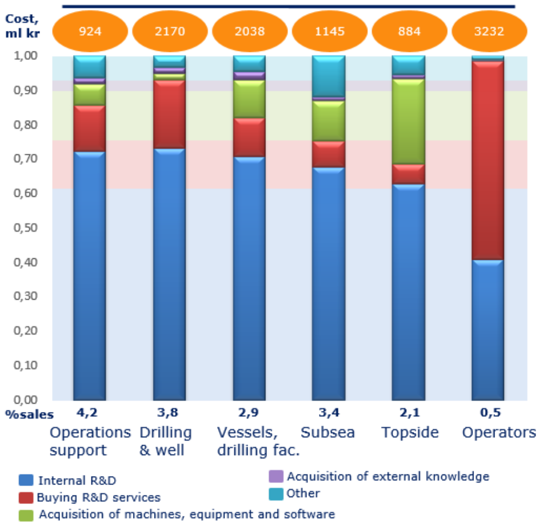
- Given the significantly lower than average "returns" on innovation expenditures in the offshore vessels and drilling facilities and operations support segments, improving the innovation effectiveness rather than increasing the innovation budgets should be prioritized.

Investments in internal R&D have a more significant impact on the product and process (PP) innovations than other innovation expenditures

The total innovation costs consist of costs on: internal R&D, buying R&D services from other companies, acquisition of machines, equipment and software, acquisition of other external knowledge and other innovation costs[19]. The left hand side figure on Exhibit 3.2 shows the distribution of the total innovation costs in 2012 into these five categories for the segments of the offshore oil and gas industry as well as their average distribution in Norway.

Exhibit 3.2

Distribution of total innovation costs, 2012



Notes:
1. Based on data from SSB, Innovasjonsundersøkelsen, 2010-2012
2. The background colouring reflects the average distribution of innovation costs for all industries in Norway

Spending that drives most PP-innovations

Predictor	Coefficients		R^2	p(F)
	Intercept	Slope		
LN(Total innovation costs to sales)	0,57***	0,06**	0,13	0,01***
LN(Internal R&D costs to sales)	0,63***	0,06***	0,21	0,00***
LN(External R&D costs to sales)	0,61***	0,04*	0,12	0,02**
LN(Machines, equip. & soft to sales)	0,40***	0,00	0,00	0,81
LN(Acquis. of external know. to sales)	0,45***	0,01	0,01	0,49
LN(Other innovation costs to sales)	0,51***	0,02	0,03	0,25

- Positive but non-linear relationship between PP innovation spending and output
- Expenditures on internal R&D and buying external R&D services are significant predictors of PP-innovations
- Buying machines, equipment and software does not have a significant impact on innovativeness

Notes:
1. Results of OLS regressions across Norwegain industries with the percent of companies with PP-innovations in 2010-2012 as the dependent variable
2. *** - significant at 1% level, ** - significant at 5%, * - significant at 10%
3. N=48 observations
4. White heteroskedasticity-corrected standard errors were used

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

We can see that expenditures on internal R&D constituted on average in Norway the largest part of the total R&D costs, about 62%, and were followed by expenditures on external R&D (13%), acquisitions of machines, equipment and software (15%), other innovation costs (8%) and acquisition of other external knowledge (2%). The distribution of the total innovation costs in the offshore oil & gas industry differs from the average in the country. It also differs substantially between the operator and supplier companies. Around only 40% of the total innovation costs are attributed to the internal R&D activities and almost 59% were spent the external R&D. By contrast, in the supplier segments, the expenditures on internal R&D varied from 63% for the topside to 72% of the total innovation budget in the drilling and well, the share of the expenditures on external R&D services ranged from around 4% in the topside to about 20% in the drilling and well, and the share of the spending on machines, equipment and software ranged from around 1% in the drilling and well to around 25% in the top. Observing

[19] Statistics Norway. 2012. *Innovation Survey 2010-2012*.

these differences, one may wonder whether the allocation of the total innovation costs between the alternative activities impact the innovation performance. Alternatively, one may ask spending on which innovation activities leads to higher innovation output.

To answer these question, we measure the innovation output of an industry as the share of firms in the industry that reported any product or process (PP) innovations in 2010-2012, and regress it on one of the innovation intensity measures, each representing a particular part of the total innovation costs. We use six innovation intensity measures: total innovation costs to sales, internal R&D costs to sales, external R&D costs to sales, expenditure on machines, equipment and software to sales, spending on acquisition of other external knowledge to sales, and other innovation costs to sales. We use the innovation costs scaled by sales for comparability across the industries. Further analysis has revealed that the relationship between the innovation intensity and the PP-innovations is better described by the logarithmic than linear functions. Therefore, we regress the share of companies with PP-innovations in 2010-2012 on the natural logarithm of a given type of innovation costs to sales in 2012. We have 48 observations and use simple OLS regressions with White heteroskedasticity-corrected standard errors. The results of the regression analysis are shown on the right hand side figure on Exhibit 3.2.

The column "Predictor" lists the explanatory variables we use in the regressions. The two "Coefficients" columns list the intercept and slope coefficient values together with the significance. Notice that only the slope coefficients for the total innovation costs to sales, internal R&D costs to sales and external R&D costs to sales are significant, meaning that the other types of innovation costs are not significantly related to the innovation output. All the slope coefficients are positive which is consistent with the prediction that increase in the innovation expenditures has a positive impact on the innovation performance. The R-squared values show us the proportion of the variance in the innovation performance explained by a given measure of the innovation intensity, i.e. the variance in the total innovation costs to sales ratio explains about 13% of the variance in the share of companies with PP-innovations, the internal R&D to sales ratio explains about 21%, the external R&D costs to sales – about 12%, and the other – 3% and less. The p-value of the F-statistic (presented in the last column) with the values 0,05 or less indicate that the regressions are significant.

This analysis suggests that:

- Increasing expenditures on the internal and external R&D per krone of sales in an industry will have a positive impact on product and process innovations in that industry
- The magnitude of that positive impact is likely to be lower in the industries that have more innovators and larger in the industries with few companies with product and process innovations
- Expenditures on other innovation activities, now representing from 8% to 32% of the total innovation budget in the oilfield services industries, do not facilitate product and process innovations.

An industry's innovation performance improves as the relative R&D expenditures grow and the industry becomes more internationalized and decreases as the incumbent firms become larger

In order to measure the innovation performance that we can expect in an industry, the internal benchmark needed to assess the innovation effectiveness, we should first identify a set of measurable factors that may significantly impact the innovation performance. We suggest using four major factors to predict the innovation performance: R&D intensity, internationalization, the size of the average firm and public procurement.

R&D intensity is R&D costs relative to sales. We have already shown that R&D intensity has a strong positive impact on the innovation performance. The upper graph on Exhibit 3.3 illustrates the finding. There we regress the natural logarithm of R&D to sales ratio on the share of firms in an industry that had product innovations in 2010-2012. The green dotted line is the predicted relationship, the orange dots are the actual observations. The R-squared shown on the top of the graph suggests that R&D intensity explains about 35% of the variance in the product innovations.

Exhibit 3.3

1 R&D intensity

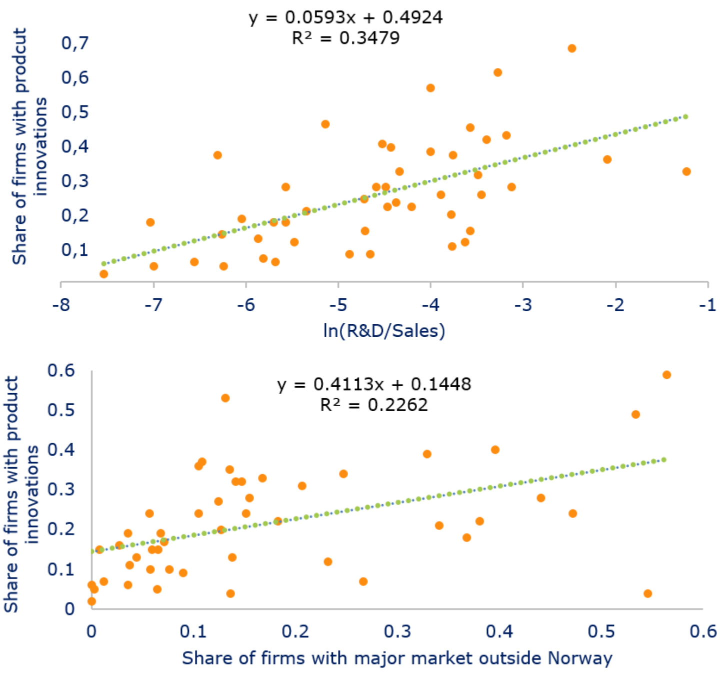
- Larger expenses on internal R&D relative to the sales are associated with significantly better innovation performance
- Other innovation expenses don't exhibit a significant relationship to innovation output

2 Internationalization

- Industries with more exposure to international competition perform significantly better in terms of innovation output, including: product, process, organizational and marketing innovations

3 Other

- Other important drivers include the size of the average firm and contracts from the public sector



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

Internationalization can be measured as the proportion of firms in the industry that have their major market outside Norway. As the lower graph on Exhibit 3.3 shows, internationalization also has a significant positive impact on the product innovations. The R-squared indicates that the variance in the degree of the internationalization explains about 23% of the total variance in the share of firms with product innovations in 2010-2014. The reason is likely to be the exposure to more intensive competition in the international markets and more demanding customers.

Public procurement can be measured as the percent of companies in the industry that received contracts from the public sector. Prior research shows that public procurement is an effective policy tool to stimulate innovations[20]. The results of the multivariate regression analysis we do in this study and presented on Exhibit 3.4 show that public procurement ("Govt. contracts" line) have a significant positive impact on process innovations, but not on the other types of innovations.

Exhibit 3.4

Innovation measure	Product innovations	Process innovations	Organizational innovations	Marketing innovations
Intercept	0,32***	0,14***	0,34***	0,30***
ln (R&D/Sales)	0,04***	0,01	0,02***	0,02
Internationalization	0,40***	0,29***	0,12**	0,05
Size	-0,00***	-0,00***	-0,00	-0,00***
Govt. contracts	0,04	0,15**	0,07	0,11
Adjusted R-squared	0,44	0,40	0,23	0,13
p (F-statistic)	0,00***	0,00***	0,00***	0,04**
N	47	47	47	47

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

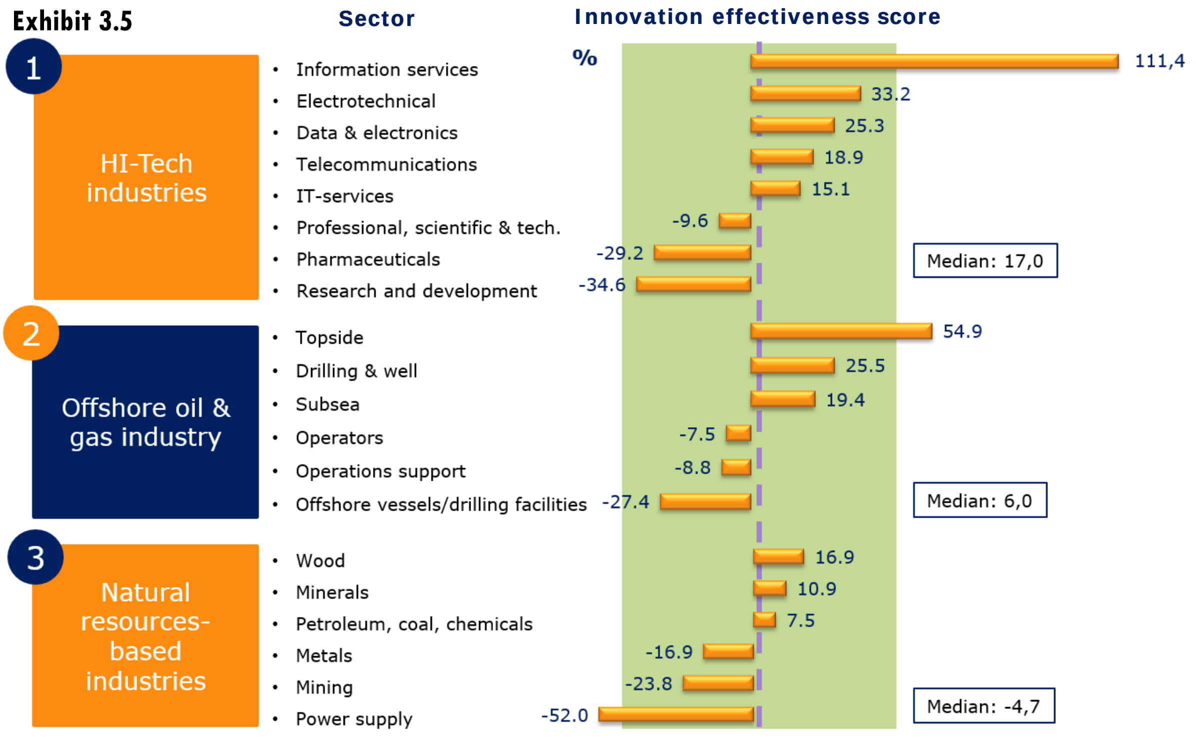
The size of the average firm is measured in this report as the ratio of the total industry sales in 2012 to the number of firms in the industry. Exhibit 3.4 shows that it has a statistically significant (but small) negative impact on product, process and marketing innovations. The two factors that may explain the relationship are that smaller firms are better positioned to innovate and that the competition in the industries where the average firm is smaller may be more intense.

There is a significant potential to improve the innovation effectiveness in the offshore vessels and drilling facilities as well as in the operations support segments

Having identified the major factors affecting the innovation performance at the industry level, we can now use the regressions presented on Exhibit 3.4 to estimate the predicted levels of the innovation performance for different innovation measures and find the average percentage difference between the actual and predicted innovation performance, which we call the innovation effectiveness score. If the value of the innovation effectiveness score is zero, there

[20] "Using public procurement to stimulate innovation and SME access to public contracts". Report of Procurement Innovation Group. 2009. Accessed on 09.07.2014 from <http://etenders.gov.ie/Media/Default/SiteContent/LegislationGuides/Report%20of%20the%20Procurement%20Innovation%20Group.pdf>

is no gap on average between the predicted and actual innovation performance of the given industry. If it is negative, then the overall innovation performance is below the expected levels, and if positive – above the expectations given the relative R&D expenditures and the other important industry characteristics.



SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

In Exhibit 3.5 we summarize the innovation effectiveness scores for different sectors in the three benchmark groups (hi-tech, offshore oil & gas, and other natural resources related industries) together with the average score and its standard deviation for Norway, which are 2,3% and 40,7 % correspondently and indicate that the average Norwegian industry has the overall innovation performance 2,3 % higher than expected but there are huge differences between industries. The median values of the score for the three benchmark group show that hi-tech industries generally have the overall innovation performance 17% higher than the predicted one and 11% higher than the offshore oil & gas industry, which in turn outperforms the other natural resource intensive industries by 10,7%. The three largest outliers among the presented industries are the information services with the innovation effectiveness score of 111,4, the topside – 54,9 and power supply – negative 52%.

Among the sectors of the oilfield services, the topside, drilling & well and subsea are much more effective innovators that one could expect given the industry characteristics, while the operations support and offshore vessels and drilling facilities significantly underperform with the innovation effectiveness scores of -8,8% and – 27,4 % respectively. This suggests the potential to improve the innovation performance in the operations support and offshore vessels and drilling facilities segments by focusing on improving the innovation effectiveness, i.e. innovation output per krone invested in innovations.

Strategic expansion was a major stimulus to innovate in the offshore industry in 2012 and few companies considered innovations as a strategy to reduce their operating costs

Designing effective policies to boost the innovation performance requires an understanding of what stimulates and hinders innovation activities at the corporate level. Statistics Norway surveyed companies with product and process innovations in 2010-2012 regarding the major reasons why they engaged in the innovation activities. We summarize the results for the offshore oil & gas industry on Exhibit 4.1. The numbers in the heat diagram stand for the % of companies with PP-innovations in 2010-2012 that named a given reason for innovating as a very important one. The colors rank the reasons from 1 (dark green) to 10 (dark red) according to the percentage of respondents that named a given factor.

Exhibit 4.1

Rank 10 9 8 7 6 5 4 3 2 1

The need to ...	Operators	Drilling & well	Vessels/ dril. facil.	Subsea	Topside	Operations support
• Broaden product scope	6	59	56	64	29	53
• Enter new markets/increase the market share	6	55	52	64	48	41
• Increase product quality	23	52	54	64	43	40
• Subsitute outdated products/processes	34	25	42	35	28	31
• Improve production flexibility	6	17	26	23	13	23
• Increase production capacity	34	15	22	31	23	26
• Reduce labor costs per unit	23	10	29	31	17	30
• Reduce average material/enegry costs	23	11	29	27	7	19
• Decrease environmental effects	46	11	32	19	17	18
• Improve health & security for employees	40	22	28	41	27	23
n firms with PP innovations	**17**	**108**	**129**	**43**	**82**	**245**
of total N	**34%**	**62%**	**38%**	**57%**	**45%**	**42%**

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

According to the data presented in Exhibit 4.1, the most often cited reasons why operators engaged in product and process innovations in 2010-2012 were the pressures to decrease environmental effects and improve health and security for employees. In the supplier industries the most common motivations were related to strategic growth and only up to 25% of the offshore supplier companies reported the need to reduce operating costs as a an important incentive to innovate, which is somewhat unexpected given the high costs levels that may potentially impair the competitiveness of the Norwegian oilfield services industries. We believe that the need to reduce the operating costs may become an important additional incentive to innovate in these industries in the coming years.

The oilfield service companies report that high innovation costs, the lack of financing, and access to qualified personnel remain the major factors limiting innovation activities

Statistics Norway also asked the companies with PP-innovations in 2010-2012 to identify the major factors that limit their innovation activities. Exhibit 4.2 presents the findings for the offshore oil & gas industry.

Exhibit 4.2

The innovation is limited by…	Operators	Drilling & well	Vessels/ dril. facil.	Subsea	Topside	Operations support
• Too high innovation costs	53	55	67	62	72	64
• Lack of internal financing	29	44	55	74	52	49
• Lack of external financing	6	50	50	51	47	50
• Difficulties with retaining/recruiting qual. staff	41	56	66	57	43	60
• Lack of technological information	23	19	29	29	40	34
• Lack of market information	17	24	33	39	45	39
• Problems with finding a partner	17	26	27	29	21	35
• The dominance of established companies	17	36	35	55	45	46
• Uncertain demand for new products	6	43	46	48	43	51
• No need because of earlier innovations	6	10	14	12	6	15
• Insufficient market demand	6	16	14	17	12	21
% firms with PP innovations in 2010-2012	34%	62%	38%	57%	45%	42%

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

As the heat diagram shows, the factors most commonly cited by Norwegian oil & gas companies in all the industry segments as major obstacles for innovation include high innovation costs, the lack of external and internal financing and challenges relating hiring and retaining qualified staff. In the subsea and topside segments the market dominance of established firms also discourages innovations in about half of all the innovating companies while uncertain demand is the 3rd most common factor limiting product and process innovations in the operations support segment.

The similar "cost/financing/people" challenges as well as the competitive advantage of the established firms, demand uncertainty and some unidentified reasons prevent some firm from innovating at all

Similar barriers related to high innovation costs, the lack of financing and qualified employees together with the dominance of the established firms and demand uncertainty prevented many offshore oil & gas companies from making product and process innovations at all in 2010-2012 (see Exhibit 4.3).

Exhibit 4.3

Rank 10 9 8 7 6 5 4 3 2 1

Why don't firms innovate?...

Why don't firms innovate?...	Operators	Drilling & well	Vessels/ dril. facil.	Subsea	Topside	Operations support
Too high innovation costs	6	30	17	9	35	22
Lack of internal financing	23	27	18	3	29	18
Lack of external financing	6	29	15	3	29	17
Difficulties with retaining/recruiting qual. staff	10	23	18	6	20	27
Lack of technological information	3	4	12	6	15	17
Lack of market information	3	3	12	6	18	12
Problems with finding a partner	3	12	14	3	20	18
The dominance of established companies	13	15	18	12	30	21
Uncertain demand for new products	6	16	22	9	30	24
No need because of earlier innovations	4	11	14	9	19	15
Insufficient market demand	6	3	14	6	30	17
% firms without PP innovations in 2010-2012	**66%**	**38%**	**62%**	**43%**	**55%**	**58%**

SOURCE: TEAM ANALYSIS BASED ON DATA FROM "INNOVATION SURVEY 2010-2012" BY SSB

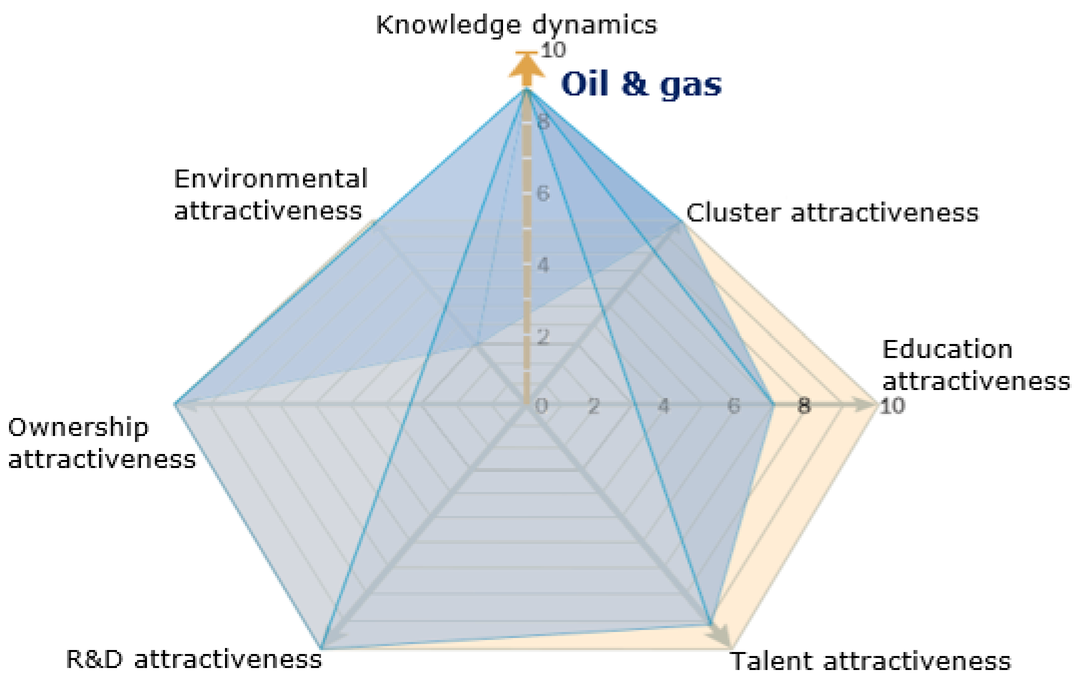
The dominance of the established companies and uncertain demand typically present more significant problems for small young companies, which indicates that it may be such companies that did not report any PP-innovations in 2010-2012. Interestingly, the list of factors suggested by Statistics Norway seems not to cover all major obstacles faced by companies without PP-innovations in 2010-2012 as 54% of them consider all the suggested factors not relevant while only 8% of the companies with innovations consider them not relevant as innovation barriers.

Improving the knowledge commons and maintaining the high knowledge dynamics are prerequisites for the strong innovation performance in the offshore oil and gas industry

As we have already mentioned, knowledge commons and knowledge dynamics, which jointly define an industry's emerald, are key industry-level factors impacting the innovation performance. Knowledge commons include cluster attractiveness, educational attractiveness, talent attractiveness, R&D attractiveness, ownership attractiveness, and environmental robustness. Industries with high cluster attractiveness have the critical mass of companies in all the parts of the value system that provide easier access to the factors of production, complementary assets and competencies, which make the innovation process much more efficient. In order to innovate, companies need talents. As the prior analysis shows, many companies in the oil & gas industry in Norway name problems with hiring and retaining the qualified personnel as a very important barrier for innovation activities. An industry that scores high on the educational attractiveness is able to bring new talents into the industry through the education system and one which has high talent attractiveness is able to recruit competent people that already work somewhere in the industry. R&D attractiveness captures the intensity of the current innovation activity in the industry, which creates the foundation for future innovations. Another commonly mentioned obstacle for innovating in the oil & gas industry is the lack of financing. An industry that has high ownership attractiveness can bring in both the financial capital and competence needed to profit from the innovations. Oil operators mention the needs to decrease the environmental impact and improve the safety for employees as a major driver for innovating. In this respect, the environmental attractiveness becomes also an important factor stimulating innovations. Finally, knowledge dynamics measured through linkages between the industry actors and knowledge sharing greatly facilitates the innovation process.

"A knowledge-based Norway" study shows that the oil & gas industry had the most developed emerald among all the industries in Norway in 2012 (see Exhibit 4.4), which certainly facilitates innovations. However, there exist a number of challenges that need to be addressed in the industry-level policy in order to maintain and further improve the cluster's emerald and in this way its innovation performance. The major ones are: talent recruitment, maintaining the R&D expenditure levels, attracting competent capital and improving the industry's environmental attractiveness.

Exhibit 4.4



SOURCE: REVE, T. & SASSON, A. "A KNOWLEDGE-BASED NORWAY" (2012)

Talent attractiveness. According to NAV, Norway currently lacks 4500 engineers[21]. An earlier BCG study predicts that the gap between the demand and supply of engineers in the oil & gas related supplier industry in Norway will increase to 8000 by 2016[22]. Though the number of applications for engineering-related programs has increased in 2014 to 5411 compared to 5054 in 2013[23], this increase is far from enough to bridge the gap.

R&D costs. Given the increased international competition in the oilfield services industries and disadvantages created by high cost levels, it may be tempting to cut costs by decreasing expenditures on R&D. A danger of this strategy is that it may undermine the innovativeness and longer term competitiveness.

[21] Ammari, S. and Sørgård, K. O. 2014. «Studentleder: – Vi trenger flere ingeniørstudier i nord». NRK
[22] «Kapasitet i den norskbaserte petroleumsrettede leverandørindustrien». 2012. BCG.
[23] Ramsdal, R. 2014. Stor vekst I søkniner til ingeniør studier. ***TU Karriere***.

Attracting capital. Although the value of the OAX 10 Energy GI index has grown from 24 in 2012 to 28 in 2013[24], which indicates that the industry is attractive for investors, the intensity of the M&A activity has decreased from 53 deals in 2012 to 43 in 2013[25].

Environmental challenges. The oil & gas industry by definition faces substantial environmental challenges. Recently, these have increased as the result of the growing concerns about the oil & gas activity in the Arctic.

[24] Oslo Stock Exchange
[25] SDC Platinum

5. IMPLICATIONS FOR INDUSTRIAL AND CORPORATE POLICY

Implications for industrial policy

- Innovation is key for sustaining the current productivity and prosperity levels in Norway
- Given its size and innovativeness, offshore supplier industry can be a good leverage point
- Oil & gas production on the NCS is particularly important for innovations in operations support
- Possible to leverage innovation through small young companies that currently do not innovate
- Internationalization and internal R&D spending play major roles in boosting innovations
- Reducing R&D risks and attracting talents should be prioritized

Implications for corporate policy

- In the offshore supplier industry more focus is needed on bringing new products to the market
- Possible to consider innovations not merely as means for expansion but also for cost cutting through, for example, improved processes and organizational changes
- R&D expenditures, both internal and external, facilitate innovations more than other categories of spending on innovation
- Innovations affect significantly financial performance, growth and business survival
- Operators, operations support and offshore vessels/drilling facilities segments should consider opportunities to improve on innovation effectiveness

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