Knowledge networks and innovation among subsea firms

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Abstract

The chapter discusses innovation of firms (30) operating in the subsea industry in Rogaland in 2015. The subsea industry is a high technology industry making oil extraction possible and safer in deep seas and rough weather conditions. Norway is in the front in subsea technology, and Norwegian firms have gained acknowledgment for their skills, products and services. Since mid-2014, oil prices had been fallen dramatically, and the data collected therefore reflects activity in this specific sub-sector of the supply industry during an early phase of the industry crisis.

The data used are from personal interviews and a questionnaire on company innovation and knowledge exchanges between the subsea firms and external firms and organisations. A main finding is that subsea is a highly innovative industry, with a very high share of firms reporting innovation and even radical innovation. We discuss how this finding relates to companies' participation in a collaboration knowledge network using social network analysis.

The analysis uses the linkages to different types of actors through these networks inside and outside the petroleum industry as an indication of the potential for loosening its ties to upstream petroleum. An average subsea firm collaborates with seven other firms in the local subsea industry. Projects often involve various subsea firms, and firms frequently supply components for each other's products. This creates fertile conditions for knowledge exchange in the industry, but also carries a risk of lock-in.

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1. Introduction

Oil and gas on the Norwegian Continental Shelf involves deep waters, and the use of traditional platforms and divers is challenging because of depths and the rough seas. Equipment installed on the seabed therefore improves the opportunities to search for and produce oil and gas safely. The natural conditions of oil production in the North Sea has presented companies with enormous technological challenges, as described in chapter 2. One important challenge pertains to the installation, maintenance and operation of equipment on the seabed. In the early stages of the Norwegian offshore industry, divers conducted most such operations. However, this was associated with safety issues and both short-term and long-term health risks. Many resources were therefore devoted to the development of subsea technology commencing in the 1980s.

In the 1990s, breakthroughs occurred in subsea technology making it possible to extract oil more safely and in deeper seas. Partly as a result of this, the number of fatal work accidents declined. Most subsea accidents between 1980 and 1990 involved divers (Ryggvik, 2017), but relatively few during the last ten years (Petroleumstilsynet, 2016). By reducing the need for divers, the automation of subsea production made offshore oil production safer. One of the big steps forward for the subsea sector was an innovation, 'Clamp Connector', which made it possible to connect installations on the seabed without the use of divers. This innovation has been taken up globally (Aker Solutions, 2017). Some of the firms in the subsea sector started as providers of divers. Today, remotely operated vehicles (ROVs) and other equipment that can be operated from shore or from ships have largely replaced the need for divers. Due to these developments, Norwegian suppliers is today seen as world-leading in subsea technologies.

In this chapter, we examine innovation processes and knowledge networks in the subsea industry in Norway's oil capital, Stavanger, and its surrounding region, Rogaland. Being located in a region with a high density of competitors, suppliers and other interrelated industries, is said to be conducive to 'localized knowledge spillovers'. These may materialise

from collaboration between firms (Bathelt & Turi, 2011; Storper & Venables, 2004), labour mobility (Timmermans & Boschma, 2014) and the opportunity to constantly monitor and compare with other firms (Bathelt, Malmberg, & Maskell, 2004). The subsea sector in Rogaland is located in a region with many competitors and many interrelated industries. Subsea firms have the opportunity to collaborate with, recruit from, and monitor other firms in their industry, as well as firms in related industries.

In 2015, we interviewed 30 of 31 firms operating in the subsea industry in Rogaland – the region in which Stavanger is located – collecting data on their innovation output and innovation processes. This included collecting full network data on their collaboration networks.

We find that subsea is a highly innovative industry. In total, 83 per cent of firms report product innovations in the last three years, and 63 per cent report new-to-market innovations. Innovation is mainly a result of problem-solving in response to customer needs, and is heavily engineering-based. Subsea firms typically make tailor-made products for their customers, and compete on performance and problem-solving ability more so than cost. This makes collaboration with oil operators paramount, and all subsea companies have multiple connections with oil operators. However, the collaboration network within the subsea industry is also very dense. An average subsea firm collaborates with seven other firms in the local subsea industry. Projects often involve various subsea firms, and firms frequently supply components for each other's products. This creates fertile conditions for knowledge exchange in the industry, but also carries a risk of lock-in.

2. Norwegian subsea industry clusters

The subsea industry supplies products and services for use between the seabed and the surface in offshore oil and gas production. The industry includes firms which produce subsea equipment, firms which install equipment, and firms which maintain existing subsea equipment. As such, the industry includes firms engaged in various different types of activity and which supply goods and/or services to other subsea firms, to general oil service companies, or directly to the oil operator companies.

Norway has a large share of the subsea market, accounting for around half of the global market. The firms can be divided into two types, one specialising in technology and development, and the other specialising in planning and installation offshore (Reve & Sasson, 2012). The firms in the Norwegian subsea sector are mainly located in three regions: Buskerud, Hordaland and Rogaland. Hordaland and Rogaland are both located on the west coast, close to the offshore activity on the Norwegian Continental Shelf. The main cluster of subsea firms in Norway is found in the axis from Kongsberg (in Buskerud county) to Oslo, known as Subsea Valley. This includes four of the five largest Norwegian subsea companies. This cluster mainly specialises in development of subsea technology. Another important cluster is in Hordaland county, world-leading in operating, maintaining and modifying subsea equipment. This cluster was awarded Global Centre of Expertise status (GCE Subsea) by the Norwegian cluster programme in 2015. The cluster organisation GCE Subsea consists of more than 100 companies and organisations. The subsea industry in Rogaland is also substantial, accounting for around 10 per cent of oil service employment in the most oil-intensive region of Norway (Blomgren et al., 2015; see chapter 10). While Buskerud and Hordaland export more subsea equipment, the subsea firms in Rogaland (especially compared to Buskerud) are more hands-on and involved in practical planning and installation of subsea operations. The Stavanger region houses the biggest petroleum cluster in Norway, including all parts of the oil industry value chain with its various oil service and supply sectors (see chapter 10).

3. The subsea industry in Rogaland

The chapter is based on a population study of all firms specialising in subsea technology in Rogaland, which was conducted in early 2015. In order to identify subsea firms, we used a population database of all oil-related firms in Norway compiled by the International Research Institute of Stavanger (IRIS) (Blomgren et al., 2015). The database included all unique subsea firms registered in Rogaland county with five employees or more. This resulted in a population of 31 firms active in the region's subsea industry. These were all contacted for interviews, and we conducted interviews in 30 firms, a response rate of 96.8 per cent. Data collection was based on personal interviews lasting for around 45 minutes in each case. The interviews were structured around a questionnaire with a combination of closed- and open-ended questions, including network data on the firm's collaboration partners, recruitment and

inspiration sources. In half of the cases, we interviewed the CEO of the firm. The other respondents comprised regional branch managers, technical managers or others in managerial positions. Data collection was undertaken shortly before the fall in oil prices which caused economic turmoil in the Norwegian oil industry, including the subsea industry in Rogaland. The years prior to the study were characterised by high oil prices and an unprecedented period of growth in the industry. As such, the data represents the innovation activities and processes at the height of the oil boom in the Stavanger region.

<Table 4.1 about here>

Table 4.1 Characteristics of the firms in the subsea sector in Rogaland (based on interviews)

Table 4.1 shows characteristics of the interviewed firms. There is wide variation in the size, age and ownership structure of the firms, ranging from small local workshops to large multinational enterprises. Smaller firms frequently offer a specific high-technology product and typically employ a high proportion of engineers. Some of the subsea firms are fairly old, predating the era of oil and gas exploitation in Norway. One firm started as a small family business renovating cars, another was a local workshop, and a third used to make and repair agricultural equipment. Some of the firms offered diving services and seized the opportunity to move into a new market in the oil and gas industry, changing from divers to ROVs and related services in the process. Some firms mention their experience from diving as a strength even though they have now replaced divers with ROVs. Two multinational firms in Stavanger still offer diving services.

3.1 Innovation in the Rogaland subsea industry

A large share of firms in the subsea industry in Rogaland report innovation in terms of new products or processes as shown in Table 4.2. In total, 25 of 30 firms (83 per cent) report having introduced new products or services during the three years preceding the survey. Nineteen of these also report new-to-market innovations which we use as an indicator for radical innovation.

<Table 4.2 about here>

Table 4.2 Results for the different type if innovation activity in the subsea firms, based on interviews

Innovation in the subsea industry is typically based on customers' needs and problem-solving where the customer (typically oil operators) presents problems for which subsea firms develop solutions. Innovation is mainly incremental, typically in the form of small scale tailor-made products at a high cost. Some problems might force firms to find completely new solutions by using new technology or new materials in the product, resulting in a product or services new to the market. Product development is based on close contact between suppliers and customers throughout the development phase. Several subsea firms stated that their main reason for being located in Rogaland was the need for communication with customers, sometimes 24/7. Others maintained that their customers (operators) demanded their presence in Stavanger because of a need for daily face-to face dialogue and discussion on how to solve problems and to be able to react at short notice.

Innovation processes in the subsea sector have a strong element of learning-by-doing. As product development mainly takes the form of problem-solving, it is often not reported as R&D activity in tax returns. Consequently, R&D activity in this sector is probably higher than reported in official statistics (see also chapter 3). The industry has also taken advantage of competence from other sectors in the oil and gas industry with deeper knowledge on specific challenges (like pressure and temperature), through recruitment from other sectors like seismic services, drilling, and measurement (Reve & Sasson, 2012).

Among the interviewed firms, 23 have employees devoted to product development. However, the proportion of employees working specifically on product development varies greatly. In one of the larger firms, just one employee was engaged in product development while in some of the smaller firms a majority of employees were engaged in this activity. Most firms state that they do not have the resources to enable their employees to do research only. This is too

costly, and R&D is mostly undertaken as part of problem-solving for a customer. The case study in chapter 6 finds similar results, saying that when activity in the oil industry is high the supplier is busy selling their services and undertaking only incremental changes to their products. However, some companies in our case do have research departments, often focussing on problems which are likely to occur in the future, with the aim of getting one step ahead of competitors.

Successful solutions to customers' problems often provide the reference for future customers. Indeed, several firms said they did not pay for marketing since reputation within the industry is all that matters. However, half of the companies had introduced a new marketing strategy in the period 2012–2014. Several managers stressed the importance of being able to deliver on time and to be flexible should a customer require modifications to the product as the driver of competitiveness. The aim for many firms is to provide a solution which is unique, and where the firm will therefore have a monopoly on future projects.

When the respondents are asked what kind of knowledge is important to stay innovative, most firms regard both engineering and analytical skills as very important (a score of 4 or 5 out of 5). However, only a few firms value creativity. Engineering skills are considered most important followed by experience and practice and analytical skills while creativity is considered less important. Most managers added that the most important skill their employees can have is curiosity and the ability to work hard to finish a project. Even though they have several collaboration partners, very few explicitly mentioned being able to collaborate and communicate as an important skill. Firm managers tended to emphasize in-house knowledge as most important for being able to come up with new solutions. Approximately 95 per cent of the firms say that the mix is 65 per cent or more in-house knowledge and 35 per cent or less from outside. We also interviewed some oil operator companies, most of which answered the exact opposite: between 15 and 35 per cent internal knowledge and the rest as external knowledge. Several of the subsea firms are part of multinational organisations which means they might also have a lot of resources and in-house competence. The firms depend on collaboration, but they also want to protect their knowledge and technology. Several firms said that the most important way to protect their intellectual property was through contracts with their customers (and in some cases suppliers). Several firms also used other ways of

protecting their intellectual property such as patents (11 firms), industrial design (5 firms), trademark (8 firms) and claimed copyright (6 firms).

Standardisation and the availability of technology are becoming increasingly important, and there has recently been a change in competition within the industry from performance towards cost. Following the fall in oil prices commencing in 2014, cost and cheaper solutions have received much more attention. Several firms mention the positive role of specifications. In particular, governmental safety and environmental regulations have been highlighted as important for innovation and development throughout the whole oil industry in Norway. Some firms say that safety and environmental regulations are the reasons why the Norwegian subsea sector is so competitive on the international market.

1.2 The role of collaboration in product development

As in other parts of the petroleum industry, the development of new products in the subsea industry is often undertaken in collaboration with other actors (see also chapters 2 and 3). Fløysand, Jakobsen and Bjarnar (2012) have previously found widespread collaboration in their survey of subsea firms in Hordaland county. The subsea sector in Rogaland is also highly collaborative. This is reflected in how contracts are set up. Licences for oilfields are typically awarded to groups of multiple oil operator companies. Operators needing subsea services tend to contract with a single subsea firm, but this firm in turn collaborates with other subsea firms during product (and service) development. Quite often, according to the subsea firms, operators pressure for this. Oil operator companies may contract with one firm for equipment on the condition that it uses another firm's component as part of the final product. One informant explained: 'This is how this industry works; you make a product and the customer tells other suppliers they have to use it'. A key to long-term success for a firm is to achieve this position of having a product or component which operators require other (subsea) firms to use. Others say that this drives up costs. Before a product ends up with an operator, three or more other subsea companies have often been involved. Most firms are occasionally direct suppliers to the oil companies and at other times sub-suppliers through other firms' contracts. The firms report a high number of collaborations both vertically along the internal supply-chain of the subsea industry, also horizontally between competitors.

<Figure 4.1 about here>

Figure 4.1: Collaboration within the subsea sector in Rogaland.

Note: Size of node refers to the size of the firm. Box nodes are firms without innovation. Diamonds nodes are firms with innovation, and the triangle nodes are firms with new-to-market innovation. (Graph made in Ucinet (Borgatti et al., 2002))

Figure 4.1 presents the collaboration network between firms in the subsea industry in Rogaland. The density of the network is 0.246, i.e. 24.6 per cent of all possible links in this network are present. The average firm collaborates with seven other firms. The five most central firms in terms of degree centrality are all large firms with more than 200 employees. All have had innovations, and four of five have radical innovations. Firms without innovations are clearly on the periphery of the network. They are all multinationals with headquarters abroad. However, if we also consider linkages outside the subsea sector in Rogaland, two of the top five firms in terms of degree centrality are replaced by other firms, both headquartered in the region.

<Figure 4.2 about here>

Figure 4.2: Linkages from subsea firms to oil supplier (top left).

Note: Linkages from subsea firms to other oil operator (top right). Linkages from subsea firms to other firms (bottom left). Linkages from subsea firms to universities, research institutes and other organisations (bottom right)

Figure 4.2 presents the collaboration which subsea firms have with oil operators (top right) and with other oil suppliers outside subsea (top left), to universities and research institutes (bottom right), and to other firms in the subsea collaboration network (bottom left). Most collaboration linkages are with other oil firms while there are fewer linkages to organisations outside the oil and gas industry, indicating that knowledge is mostly sourced from within the oil industry. The firms that most subsea firms collaborate with outside the Rogaland subsea

industry itself are local operator firms (Statoil, Norske Shell, BP) or subsea firms located elsewhere in Norway (Aker Solutions and FMC Kongsberg).

<Table 4.3 about here>

Table 4.3 Collaboration links within and outside the subsea sector.

Table 4.3 shows all collaboration partners reported by the interviewed firms in the subsea industry, including links to partners outside the subsea industry. In total, 20 of the firms in the Rogaland subsea industry are part of multinational corporations, and it is likely that they will therefore have links to mother or sister plants elsewhere in Norway and abroad. Several of these firms are international and most state that within-organisation collaboration and resources are very important. Collaboration with actors outside the Rogaland subsea industry is mostly with multinational companies. However, many of these linkages are also to firms in the subsea industry. There are 76 linkages to 21 different subsea firms elsewhere in Norway and abroad. There are more linkages to oil operators than the total number of internal linkages, indicating the dependence on supplier–customer relationships. A substantial portion of other linkages is also to other oil suppliers. Most of the operators and other oil suppliers are also multinational enterprises with offices in Rogaland which are particularly closely involved in the collaboration. Even though subsea firms in Rogaland have several linkages outside the cluster itself, these are mostly to similar industries and their customers, mainly within the region, suggesting that there is a risk of lock-in.

Oil operator companies are the most common collaboration partners. In total, 28 of the firms report collaboration with Statoil. Several of the subsea firms said that Statoil is the driver of innovation in this industry because it provides funding for several development projects. Concerning other large oil companies such as Exxon, Norske Shell, and BP, more than half the subsea firms report collaboration with these. In addition, all the subsea firms said that they monitor the oil companies, and that this gives them inspiration and new ideas.

Concerning collaboration with universities, most firms did not value such collaboration very highly for their innovation ability. They collaborate with universities because they see it as part of their responsibility, also to recruit graduates. Some firms also said that collaborating with universities makes the universities more aware of the particular skills required by the industry. The firms that had formally collaborated with universities in development projects were often frustrated with the time spent on projects, and that they were not allowed to sell or use the product until it was ready and patented. About half of the firms had collaboration with the University of Stavanger and 40 per cent with the Norwegian University of Science and Technology (NTNU).

4. Challenges for the subsea industry

The period prior to the interviews was characterised by high oil prices and an unprecedented period of growth in the industry. Respondents report that competitiveness is mainly a function of performance and the ability to solve problems rather than of cost. However, after the fall in oil prices, customers and the industry have started paying more attention to costs. This has required subsea firms to cut costs. From 2014 to 2016, most firms have cut wages and laid off employees. It is hard to find exact numbers for how many employees subsea firms in Rogaland have laid off because accounts data are typically reported at the main office. One firm has closed down its plant in Rogaland, although remains active in Norway, and one firm went bankrupt in 2015. Based on official firm accounts, three quarters of the firms have lost revenue and reduced wage expenses between 2014 and 2016, almost two thirds of the firms had a decrease in revenue of more than 20 per cent, indicating that the subsea industry went through a challenging period due to the fall in the oil prices.

The downturn has also resulted in a consolidation of firms within the industry. Many firms have entered into more formal collaboration with other oil firms, either in subsea or other parts of the oil service industry. There has always been mergers, acquisitions and joint ventures in the subsea industry. However, this intensified in 2015–2016 when a quarter of the firms merged, allied or launched a joint venture. This reflects that many firms struggle to

remain competitive on their own. For some of these alliances the aim is to reach new markets either by entering the global market, or by entering a new industry.

5. Discussion and Conclusion

This chapter has discussed innovation in the Rogaland subsea industry, focussing in particular on the role of collaboration. Joint projects and other types of collaboration between firms are important for innovation in this industry, as it is in the oil industry overall as described in chapter 2 and 3. Innovation processes are characterised by close collaboration between subsea firms, and between subsea firms and oil operators and other oil suppliers. The average subsea firm has an extensive network, being linked to seven other subsea firms and to several other oil companies. Large networks are generally assumed to be beneficial in the innovation literature. Even though transaction and communication costs increase, the benefits from interactive learning may more than compensate for these costs (Lundvall, 2013). However, if the networks are too close and rigid, these learning effects may disappear since the network contacts provide too few new insights and ideas.

A potential concern for the subsea sector in Rogaland is that the region has become too specialised and therefore has lost some of its dynamism and flexibility (Martin & Sunley, 2006). There is a risk that 'the local connectedness may become so excessive that fundamental renewal is not on the mind-set and is even heavily contested by local network players' (Boschma, 2015). Furthermore, the industry is heavily dependent on a few central customers, i.e. the oil operator companies. Large firms, like Statoil, have a lot of power. Statoil has been mentioned by several of the firms as important for innovation in the industry. At the same time, the industry is risk averse with strict regulations. With lower oil prices, the oil companies are cutting costs and some of the subsea firms will need to make changes in order to survive. One of the advantages of the subsea sector is their fairly high proportion of engineers whose skills might be relevant in other sectors/industries. This is further discussed in chapter 11 in this book.

Within a region, the internal network structure is important for knowledge diffusion (Giuliani & Bell, 2005). One strength of the Rogaland subsea network is that the central actors are also innovative firms. This can potentially enable them to share information with actors who are less connected. The potential for information and knowledge flow is high within the network because most actors are connected to more than one other actor. Overall, this is also a highly innovative industry with most firms reporting innovation during the last three years. However, linkages outside the internal network are mostly with firms in the oil and gas industry. The knowledge that comes from outside, both from outside the subsea sector and outside the region, is mostly from within the oil industry. This carries a risk of bringing little new knowledge into the network. Consequently, few firms in the Rogaland subsea industry have successfully managed to move into new markets, and many were heavily affected by the fall in oil prices after 2014. As a result, firms lost revenue and had to downsize; many entered into mergers, alliances or joint ventures with other firms. The future will reveal whether this is an industry that can manage the transition towards new markets in the context of a permanent reduction of activities on the Norwegian continental shelf, or whether its high innovation output is mainly geared towards maintaining competitiveness within current markets.

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