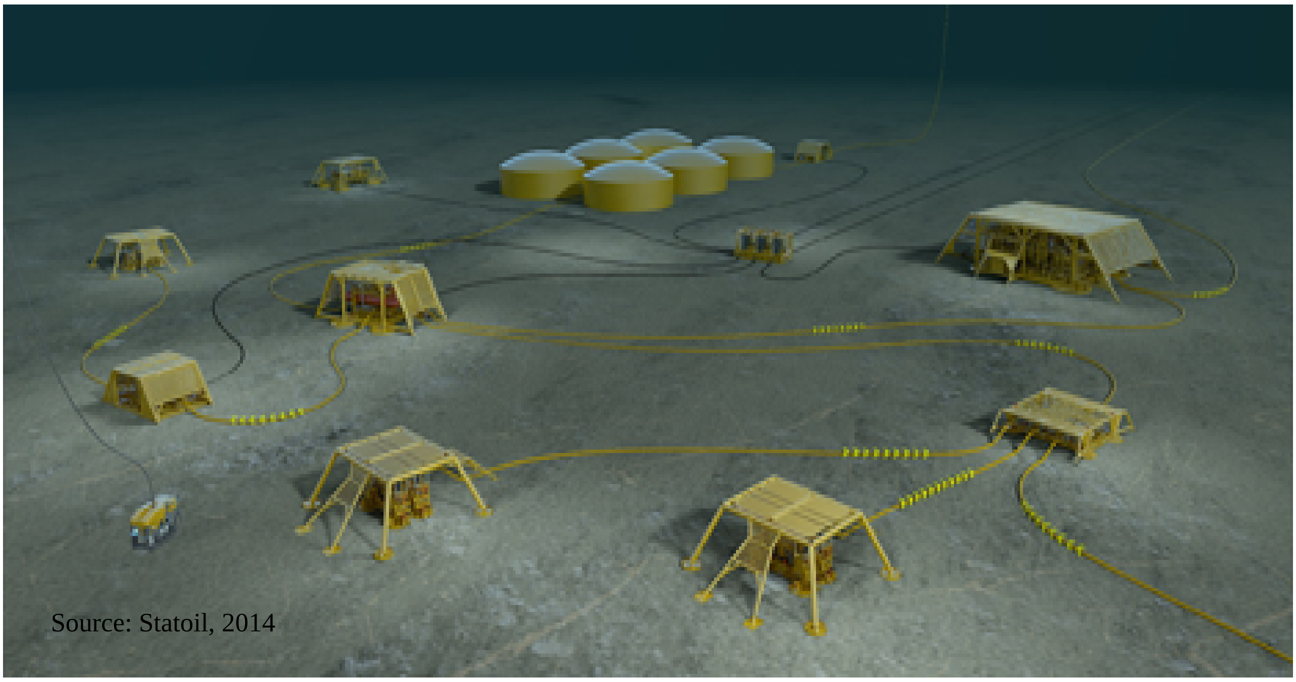
Networks and Innovation in the Subsea Industry in Rogaland

Will Position in the Network Affect a Company's Ability to Innovate?

Nina Hjertvikrem and Elisabeth Nyland
June 15, 2015


Source: Statoil, 2014

Universitetet i Stavanger

FACULTY OF SOCIAL SCIENCES,
UIS BUSINESS SCHOOL

MASTER'S THESIS

STUDY PROGRAM:	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT:
Business Administration	Economic Analysis IS THE ASSIGNMENT CONFIDENTIAL? NO

TITLE:

Networks and Innovation in the Subsea Industry in Rogaland: Will Position in the Network Affect a Company's Ability to Innovate?

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ACKNOWLEDGE RECEIPT OF 2 BOUND COPIES OF THESIS

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Abstract

Subsea is an advanced, high technology industry making oil extraction possible, simpler and safer in deep seas and rough weather conditions. Subsea is an industry where Norwegian companies have gained acknowledgment for their skills, products and services. Rogaland is the region in Norway with highest activity within the oil and gas industry. This thesis examines the structure of the network and collaboration among subsea companies in Rogaland. We examine if actors with central positions are more innovative than the less central, our research question being: Will position in the network affect a company's ability to innovate?

We present theory on clusters, regional innovation systems and knowledge bases. Four hypotheses are developed from the existing empirics. H1: A cluster needs joint action for the companies to collaborate with each other. H2: A cluster does not need joint action for the companies to collaborate with each other. H3: A central position in the network makes the company innovative. H4: A central position in the network does not affect a company's innovative ability.

Innovation in the subsea industry is usually based on a customer need. Since oil companies are the subsea companies' final customers, they are included in the second part of the analysis. We have interviewed all, but one, subsea companies in the region and 7 oil companies. We asked them questions regarding innovation and their collaborative relations to other companies. A social network analysis was applied on the interview data about collaboration. We analysed the extent of collaboration and each actor's centrality in the network. We then applied pairwise correlations and logistic regressions to see if centrality measures could explain differences in companies' ability to innovate.

We found a high degree of collaboration between the subsea companies in Rogaland, even though there are no joint actions in the form of cluster organisation. We found that position in the network, measured by in-degree centrality, can increase the likelihood that a company in the subsea industry has made use of new or significantly improved production processes, technology, components or materials, this result is supported in both populations. However, for none of the other innovation measures we found significant results using centrality as an explanatory variable.

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Preface

This thesis concludes our Master in Business Administration at the Faculty of Social Science, UiS Business School.

We want to thank our supervisor Rune Dahl Fitjar for letting us take part in the VRI synthesis project. Thank you for your concrete and constructive feedback during the entire writing process. Thank you for being helpful, accessible and supportive.

Thank you Roman Martin and Bjørn Terje Asheim for the Social Network Analysis introductory workshop. This workshop made it possible for us to do more interesting analyses with our data.

We want to thank the following people at IRIS (International Research Institute of Stavanger). Atle Blomgren for a detailed understanding of the oil and gas industry in Rogaland, providing us with list of subsea companies and oil companies in Rogaland and giving feedback during our writing process. We would like to thank Ann Karin Tennås Holmen and Anne Marthe Harstad for feedback and motivational talk. And we would like to thank Åshild Finnestad for practical help and nice morning chats.

A big thank you to all the companies that participated in the study, we are very grateful for the information you shared with us, without you we would not be able to complete our study.

Thank you to the other students at “lesesalen” for good company and good laughs during long lunches.

Thank you Aleksander.

Thank you Espen.

Stavanger, June 2015

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Networks and Innovation in the Subsea Industry in Rogaland

By Nina Hjertvikrem and Elisabeth Nyland

1.0 Introduction

Norway has developed world leading technology within the oil and gas industry, and subsea is a segment where Norway is at the top (Backe, 2015a). There is no universal definition of what it means to be a supplier company related to subsea. For this thesis, the following definition will be used: A subsea company supplies equipment to be used between seabed and surface and/or related services.

In subsea the development of new technology is of great importance in relation to cost efficiency as well as safe extraction of the oil and gas resources (Fløysand, Jakobsen, & Bjarnar, 2012). The innovative part of subsea, where subsea installations open new possibilities and allow extraction of oil from places earlier "unreachable", is of great significance. One example being the Åsgard field where it this year will be placed a subsea gas compression plant, the plant is the first of its kind in the world. This plant is an important technology innovation to develop fields in deep waters and harsh environments (Statoil, 2007). The technology advances making this possible makes subsea a very interesting object of study.

Stavanger is often referred to as the "oil capital" of Norway, and the oil and gas industry is highly visible in Stavanger and the surrounding areas. Rystad Energy (2013, p. 15)[1] explains the importance of this region as it states the following about Rogaland[2]; "In many ways, the region is a mirror of the entire supplier industry in Norway. This distinguishes the region clearly from most of the other regions that have clearer concentrations of activity within certain segments". In addition to mirror the industry, it is the region with highest activity

[1] Our translation: Original text in Norwegian.

[2] Rogaland is a county in the south west of Norway, the fourth biggest county in Norway. It has 466 302 inhabitants in the fourth quarter of 2014. Stavanger is the biggest city, followed by Sandnes, Haugesund, Egersund and Bryne.

within oil and gas, measured in both number of employed and number of companies (Rystad Energy, 2013; Blomgren, et al., 2015). It is therefore relevant analysing this region.

Even though the growth in the oil and gas industry has decreased over the last year, NCE Subsea's[3] general manager Owe Haugsæther is optimistic because opportunities for Norwegian subsea companies are large internationally (Aadland, 2015). Haugsæther is optimistic about the future and says that in the future we will see more and more subsea-installations taking platforms' place. He further states that 50% of the global subsea market can be tied to Norwegian workplaces (Haugsæther ref in: (Aadland, 2015)).

One of the more recent challenges facing the oil and gas industry is the high cost level. The costs of extracting oil have increased over the years, and seen together with the recent immense drop in oil prices, there is a risk that new projects and new field developments will be shelved or even dismissed (Norwegian Petroleum Directorate, 2014), i.e. the Johan Castberg field, the Njord field and the Snorre-extension (Lindberg, 2015; Vågen & Aadland, 2015). Over the last years, many of the new oil field findings on the Norwegian continental shelf (NCS) are smaller, and many are expected to be built with subsea installations connecting them to already existing fields. Norwegian Petroleum Directorate (2014) predicts that it is important for the players to integrate new solutions with the existing infrastructure to keep cost down.

Underwater technology opens up for great innovations and new possibilities, but cost is important for the customer when making a decision on which solution to choose. In an article presented in the online newspaper E24 (Ramsdal, 2015), oil analyst Jarand Rystad points out that as the industry is at an all-time low, it is expected that customers to the subsea industry will request cheaper solutions which just covers their needs, nothing extra. This means that it is important for the subsea companies not to overdesign their solutions, and not make them more expensive than necessary. Because the cost of subsea installations have tripled over the last decade, Statoil and its partners have chosen an unmanned wellhead platform instead of a subsea installation on their Oseberg Future development (Statoil, 2015).

Norway is known for its high competence and highly skilled labour force within the oil and gas industry (Backe, 2015a). Minister of Trade and Industry Monica Mæland says in an

[3] NCE Subsea is an industry initiative to promote further development of Norwegian subsea industry by increasing innovation, and is owned by Innovation Norway, the Research Council of Norway and SIVA (NCE Subsea, 2014).

interview by Backe (2015a) that one of our competitive advantages within the subsea (-and marine) industry is the high competence in Norway. Furthermore, she says that the high competence makes Norwegian industry work efficiently at the same time as they deliver high quality products and services. An offshore supplier said it this way[4]: "We have to produce products and services so knowledge intensive that we can claim to have the best and priciest products and services" (ref in: (Reve & Sasson, 2012, p. 21)). This means that as the products and services are relatively more expensive compared to other countries, they have to be the best on the market.

Innovation is important in the subsea industry because of the new challenges different fields will present. Being innovative means being able to find new ways to create value by developing new products and services, as well as renewing existing products and services, which means that the term "innovation" goes beyond what companies define as research and development in budgets (Reve & Sasson, 2012). In the subsea segment, innovation often takes place when finding a solution to a customer problem (Yasseri, 2015). Oil companies are the subsea companies' final customers. Both the subsea companies and oil companies contribute with their knowledge and they collaborate to find the best possible solution. Therefore it is important to keep the customers in mind when we talk about innovation in the subsea segment (Fjose, et al., 2011).

Innovation is increasingly seen as an open process where many actors cooperate. Innovation rarely happens in closed environments, and innovation knowledge is often gathered from a network of actors (Fagerberg, 2005; Isaksen, 2010). The knowledge is often exchanged between business partners, and usually not by accident but through networks that join together different organisations. Networks can be formal relationships, for example contract-based cooperation, or informal relationships such as being in the same cluster (Martin, 2013). A network can be explained as a set of relations that relate to a set of actors, in addition to other information on the actors and their relations (Prell, 2012). Guiliani (2010a) provides a suitable explanation to why it can be interesting to look at companies within a cluster, and study a company's network to say something about its ability to innovate: "(…) firms operating in clusters are likely to generate a socio-economic environment, characterised by dense inter-firm networks, which enhance their likelihood to innovate" (Guiliani, 2010b, p. 261). Clusters

[4] Our translation: Original text in Norwegian (Reve & Sasson, 2012, p. 21).

and innovation systems can therefore stimulate to learning, innovation and competitive strength for the actors involved (Isaksen, 2010).

1.1 Will position in the network affect a company's ability to innovate?

In this study we examine companies within the subsea segment of the oil and gas industry in Rogaland. Subsea has been a growing segment with considerable innovation activities, and the Norwegian subsea technology is in the world top. When it comes to oil and gas, Rogaland is the number one region in Norway. As innovation is increasingly seen as an open process, where knowledge is sourced from a network of actors, we study:

Will position in the network affect a company's ability to innovate?

We will try to answer this question by (1) describing the structure of the subsea network in Rogaland, and (2) use centrality measures to show who the central actors are.

We will present theory on innovation and then especially innovation within the subsea industry, we will then represent cluster and network theory using four hypotheses.

H1: A cluster needs joint action for the companies to collaborate with each other.
H2: A cluster does not need joint action for the companies to collaborate with each other.
H3: A central position in the network makes the company more innovative.
H4: A central position in the network does not affect a company's innovative ability.

After the theory section we will present a more detailed background about the subsea industry. To be able to answer our research questions we have interviewed 37 firms about their collaborative relations to other actors in the industry, as well as questions related to innovation. We have used a questionnaire developed by the VRI project group[5] (The Research Council of Norway, 2008). In order to find support for the hypotheses, we will apply social network analysis (SNA) on the data we collected to uncover the subsea network as well as uncovering who the central actors are. We will then apply pairwise correlations and

[5] The Research Council of Norway has implemented a program called Program for Regional R&D and Innovation (VRI). VRI is a support program to aid research and development (R&D) in Norway, where the primary focus is to encourage cooperation between industries and R&D-institutions in an attempt to develop regional innovation systems.

logistic regressions to see if it can give any insights to why some companies are more innovative.

There will be a short discussion of our findings before we present the conclusion of this thesis. Our main finding being; we find support for H2, and support for H3, regarding H4 we are left inconclusive.

2.0 Theory

In this section we will present a model of how innovation in the subsea industry usually happens. Afterward, we will present arguments in the existing literature about collaboration amongst companies in a cluster, and about the importance of position in the network.

2.1 Innovation

Innovation is an idea, a practice or an object that is seen as new (Rogers, 1995). This means that innovation does not need to be completely new, as long as someone perceives it as new. There are also many types of innovation, product-, service-, and process innovation, as well as innovation within organisational structure, organisation strategy and marketing strategy. Dillon, Lee, & Matheson (2005) explain product- and service innovation as creation of new products or services, which increases the benefits or reduces the costs of a product or service. Product innovation is often a result of technological innovation, where there is a new or significantly improved product as a result. Service innovation can be defined as an idea about a rise in the level of service that the customers see as such a radical improvement that it changes the way the customers behave in the market. Process innovation is explained as a new, or considerably improved, production technology, production method or method for delivering products or services (Statistics Norway, 2014).

When we examine if the companies in this study are innovative, we do not only include whether they have introduced new products or services to the market, but also if they have taken new technology, materials or production processes in use, as well as introduced new or improved organisational structure, business strategy or marketing strategy. Innovation is therefore broadly defined, as the ability to come up with new and better ways of organising the production and marketing of new and better products.

To be able to prosper on a long-term basis in today’s knowledge-based economy, the ability to innovate is of greater importance then cost efficiency. Cost considerations are not unimportant, but in today's global market it is difficult to compete solely on cost advantages (Malmberg & Power, 2003). However, with Norway's current cost level and with current oil price, it is important to have focus on innovation and high technology solutions together with lowering costs.

2.1.1 Innovation in the subsea industry

The innovation system in the oil and gas industry is centred round the oil companies, where they get the suppliers competing over delivering the best solutions to satisfy the oil companies' practical challenges (Reve & Sasson, 2012), consequently innovation within subsea technology often start with a customer need, see Figure 1 below. Gertler (1995) points out that demanding and technologically advanced customers can represent a dynamic source of creative stimulus for the suppliers when they attempt to meet their customers' needs. Innovation based on customer need do not only help suppliers compete more successfully, "(…) but also bring obvious benefits to users who are fortunate enough to enjoy a close relationship with producers" (Gertler, 1995, p. 3).

The development of new subsea equipment and installation builds on experience gained from past projects. One of the reasons being that subsea technology is increasingly requiring engineers to make judgement calls about situations where sufficient data is not available. Hence, the developing process often takes many years in order to ensure all required testing and risk evaluations (Yasseri, 2015). One example of how time-consuming the process of developing subsea equipment can be, is the subsea gas compression plant to be placed on the Åsgård field. Aker Solutions started working on the solution in 1985, and it is scheduled this year 2015, 30 years later (AkerSolutions, 2015). In addition, as large investments are needed, the cost is very high if equipment does not work as intended (Yasseri, 2015).

The incremental field development model (Yasseri, 2015) below shows that risk assessment will be done after each part of the innovation process, called gates. They have to consider risk of malfunctioning, risk of leakage of oil into the sea and the cost of not being able to produce. Risk needs to be considered when a decision on continuing, amending scope, prioritise differently or abandon a project is made (Yasseri, 2015).

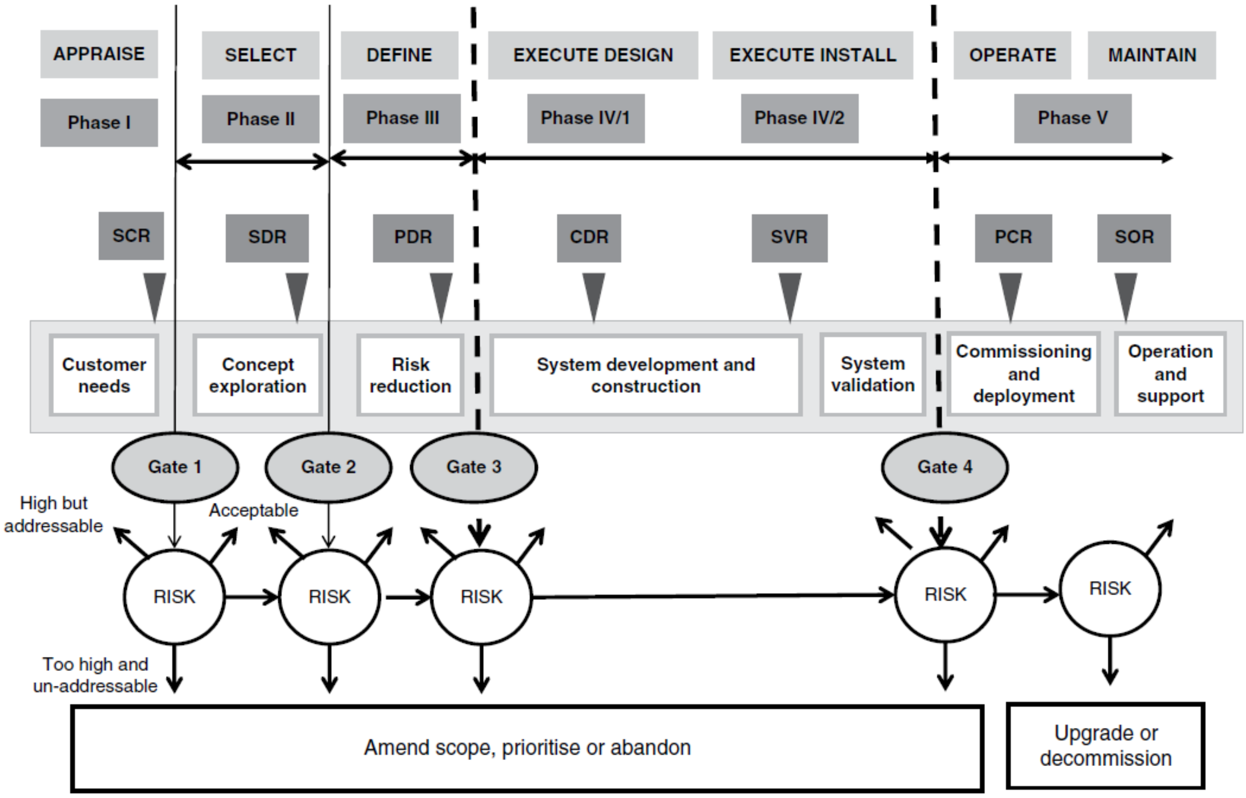

Figure 1 Incremental field development model (Yasseri, 2015)

The figure shows the innovation process in the subsea industry from beginning to end. It usually starts with a customer need, then the supplier has to consider whether this need involves a risk that is addressable or if the risk is too high and un-addressable, if it involves the latter then they must abandon project. If the risk is addressable they have to develop solutions with the best features profitable and possible. At each stage of the process there is a decision whether to continue or not, a process known as stage-gate. After each phase of the process an evaluation is made, if the stakeholders find the project feasible and risk are acceptable they move on to the next phase. If not, the project extends its current phase; find better solutions or they re-scope or terminate project to avoid low-return resource commitments.

The gates are to make sure that money is not tied up in something not worth the investments, with every decision of going forward based on feasible evidence. In addition, the gates are there to make sure that nothing goes wrong, as the cost will be very high. They have to be certain that the equipment will function properly when they take it in use, which is a reason why it takes a long time from when an idea occurs to when the idea is realised (Yasseri, 2015). Decisions made on gut-feeling and experience only does not always lead to ideal decisions. In complex situations, like those in subsea development, it is therefore best to make decisions based on a comprehensive list of questions, which needs to be proved with evidence in order to proceed (Yasseri, 2015).

2.2 Clusters, regional innovation systems and knowledge bases

In this section we give a brief introduction to some of the terms we will use in later sections. These terms are clusters, regional innovation systems (RIS) and knowledge bases.

The term clusters is often used to describe a concentration of actors in close proximity that have something in common. Companies in a cluster can be in the same industry, or they are related in some other way in the form of mutual dependence; they exist in the same value-chain or in the same regional innovation system. It is recognised that regional clusters can enable innovation and economic performance (Guiliani, 2010b). Successful clusters have the ability to reinforce themselves; competition, cooperation, innovation pressure and knowledge exchange pushes the cluster to do better (Porter, 1998).

Cluster theory has roots back to Alfred Marshalls «Principles of Economics» from 1890. There it was shown that companies located in the same area benefitted from a specialised market of workers, as well as knowledge spillovers and lower transportation costs. These location externalities could be especially beneficial for small firms as they could make use of the external economies of scale.

Michael Porter has in the last decades influenced the understanding of cluster and cluster effects, he is one of the most cited persons on this subject. Porter defines a cluster as: "…geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (Porter, 2000, p. 16).

How clusters originate remains unclear, and it is almost impossible to determine where and how this happens. Literature is repeatedly arguing whether local conditions, e.g. suppliers, local policies, qualified labour etc., determine the emergence of clusters, and if clusters can arise in areas where fewer conditions are met. More often clusters starts out in a specific area more or less by chance (Perez-Aleman, 2005).

Porter's work on how clusters generate competitive advantage based on exploitation of unique resources and competences in interconnected firms within close proximity, leads us to the concept of Regional Innovation Systems (RIS). This theory seeks to investigate different regional conditions that can enhance or inhibit innovation at the regional level (Asheim & Coenen, 2006) .

An innovation system is an arena where central actors for innovation and development are located. Actors can be everything from research institutions and government, to companies and universities (The Research Council of Norway, 2003). RIS are "places where close inter-firm communication, socio-cultural structures and institutional environment may stimulate socially and territorially embedded collective learning and continuous innovation" (Asheim & Isaksen, 2002, p. 83). The interaction for knowledge creation is emphasised, meaning that the innovation comes from a flow of shared practices, attitudes, expectations, norms and values (OECD, 2008).

Innovation-related knowledge is often sourced externally from defined networks of actors, and there has been an increasing focus on industry-specific differences of knowledge in literature on RIS (Martin, 2013). One can differentiate industries based on their type of knowledge bases, which three are distinguished: analytical, synthetic or symbolic. The different types indicate different mixes of tacit and codified knowledge (Asheim, Coenen, Moodysson, & Vang-Lauridsen, 2005).

Synthetic knowledge is knowledge to design something that works as a solution to a practical problem. A synthetic knowledge base refers to industrial setting, however, the innovation happens through the application of existing knowledge or through new ways of combining knowledge. This type of knowledge creation will usually take place in a setting where a client has a specific problem, and the suppliers aim to solve the problem (Asheim & Coenen, 2006), which is how innovation in the subsea industry usually happens, showed in 2.1.1. Typical industries are plant engineering, specialized industrial machinery, production systems, and shipbuilding. The subsea industry is clearly drawing more towards this knowledge base. More characteristics of companies based on synthetic knowledge are presented in 2.2.1.

Analytical knowledge is knowledge to understand and explain features of the universe. It is also often found in industrial settings where the creation of knowledge is based on cognitive and rational processes or formal models. Companies usually have their own R&D-departments, and university-industry links are important. The knowledge inputs and outputs are usually more codified than in the other knowledge bases, because the knowledge creation is based on the application of scientific principles and methods, the knowledge processes are more formally organized, and outcomes are often documented in reports or patent descriptions (Asheim & Coenen, 2006). Typical industries are biotechnology, genetics and information technology; in the oil and gas industry this can be a geologist who investigates reservoir seismic.

Symbolic knowledge is knowledge to create cultural meaning through transmission in affecting sensuous medium. A symbolic knowledge base exists in industries that are innovation- and design intensive as work is devoted to creation of new ideas and images, and less to physical production processes. The knowledge creation is related to the aesthetic attributes of products, as well as the creation of designs and images. This type of knowledge base has a strong tacit component, because the knowledge is related to a profound understanding of norms and habits of specific social groupings (Asheim & Coenen, 2006).

2.2.1 Characteristics of industries based on synthetic knowledge

In synthetic knowledge bases, R&D is often less important than in the analytical knowledge base, and if it occurs it is usually in the form of product or process development. Products from synthetic knowledge base are often tailored or produced in small scale, which is characteristic for the subsea industry. The networks often involve a small number of actors, and they collaborate and exchange knowledge along the supply chain (Martin, 2013). We therefore expect to find these characteristics in our network analysis.

The knowledge creation occurs through testing, experimentation or through practical work, and tacit knowledge is more important than in the analytical knowledge base, especially because the knowledge often comes from experience gained at the workplace. The learning comes from doing, using and interacting, and compared to the analytical knowledge base, there is more know-how and practical skills required in the knowledge production (Asheim & Coenen, 2006).

In synthetic knowledge bases, the innovation process is often focused on how to make products or processes extra efficient, or user-friendlier from the customers' perspective. The innovation process is incremental, as products and processes are changed and modified (Martin, 2013), which fits well with the subsea innovation process described in 2.1.1.

Industries that are based on different knowledge bases will have different structural, relational, and geographical dimensions of their innovation networks (Martin, 2013), see Table 1. From the table we see that industries based on synthetic knowledge are located in specialised clusters or close to the lead-users, usually in nationally or regionally configured networks. In Rogaland, the subsea companies are located close to many of the oil companies, more detailed description under 3.0. Industries based on analytical knowledge are based close to universities and research institutions and there are often a small number of actors with strong collaboration. Symbolic knowledge (i.e. creative industries) are based in urban areas (Asheim & Coenen, 2006). There are often numerous actors and they do not tend to collaborate to a great extent (Martin, 2013).

	Analytical	Synthetic	Symbolic
Structural dimension	Small number of actors; high network density	Small number of actors; low network density	Numerous actors; low network density
Relational dimension	Knowledge exchange in epistemic communities; long-term cooperation between research units	Knowledge exchange in communities of practice; cooperation along supply chain	Knowledge exchange in interpretive communities; cooperation in short-term projects between companies
Geographical dimension	Knowledge exchange in globally configured networks	Collaboration in nationally and regionally configured networks	Prevalence of regionalized/localized networks

Table 1 Innovation and network with different knowledge bases (Martin, 2013).

The table shows three dimensions of the analytical, synthetic and symbolic knowledge bases. The structural dimension refers to the density of the network. Density measures how many connections are present divided by number of possible connections. The relational dimension refers to how knowledge exchange happens within different knowledge bases and lastly the geographical dimension refers to how close you find collaboration organisations.

The different types of knowledge bases will have an impact on the nature of how firms innovate and its network. As the subsea industry is drawing mostly on a synthetic knowledge base, we should expect to find a small number of actors and a network with low density. We expect that the subsea industry will have cooperation along the entire supply chain, and that knowledge will be exchanged in groups of practice, e.g. RIS or clusters.

2.3 Collaboration amongst companies in a cluster

Clusters can increase the productivity of the companies based in the same area by giving better access to employees and suppliers, as they are part of the same industry, and the cluster itself can attract talented people from other regions because it signals opportunity. The proximity of the cluster also eases communication between the firms and their suppliers. Personal relationships facilitate information flow and knowledge flow, as well as developing new knowledge. Knowledge flow promotes innovation and occurs when labour switches employer, when companies cooperate, when companies use the same consultants or the same suppliers (Porter, 1998).

Clusters can influence a company's continuing ability to innovate by driving the pace and direction of innovation. Innovation pressure will become more apparent when there are several customers and several suppliers, as there will be in a cluster. The customers can allow themselves to be demanding and require constant communication with the suppliers. The competition of winning customers among the suppliers will push for innovation. The face-to-face contact and site visits between the actors in the cluster also make it easier for them to learn about new technology development, and more quickly understand needs in the market (Porter, 1998). In section 2.1.1 we showed how innovation in the subsea industry often is based on a customer need and how the customers actually influence innovation in the subsea industry in Rogaland.

One can separate clusters that are self-organised clusters and intentional clusters/cluster organisations, where the first has originated from classic agglomeration and cluster effects such as knowledge spillovers, complementary, rivalry etc., while the latter is linked to policy strategies and government support programs (Fløysand, Jakobsen, & Bjarnar, 2012; Mytelka & Farinelli, 2000). Many governments and industry organisations have used cluster theory as basis for cluster initiatives, which now can be seen in most countries, including Norway. Cluster initiatives are partnerships projects, which have the intention to promote cluster competitiveness and growth. It is usually a collaboration between cluster companies and the government, and can also include universities or other research institutions (Sölvell, Lindqvist, & Ketels, 2002).

Knowledge spillovers and other external effects can explain why a cluster is attractive for a company (Perez-Aleman, 2005). However, there are different views on how successful, meaning being both innovative and competitive, a cluster can remain without joint action. In their paper "The New "Cluster Moment": How Regional Innovation Clusters Can Foster the Next Economy," Muro and Katz (2010) argument that one should be careful trying to create a cluster, one should make sure to only start an initiative where a cluster already exists. The existence of the cluster is a proof that the cluster has passed the "market test". When it has passed the market test it can also still succeed without interfering.

Isaksen (2010) argues that the term cluster is used without any restrictions and that often any area with a concentration of an industry is called a cluster. According to Malmberg and Powers (2006; ref in (Isaksen, 2010, p. 46)) there are four criteria's which all have to be fulfilled in order to be entitled a cluster:

1. Geographic concentration of the same or closely related businesses. This means firms in the same industry; supply chain; technological area or similarly related.
2. The businesses are linked together through different forms of local cooperation, knowledge flow and competition.
3. The actors in the cluster acknowledge that they are part of a cluster and have developed a mutual understanding, which leads to joint actions to strengthen the cluster.
4. The cluster is successful, meaning it is innovative and competitive.

This definition is defined as strict both from its authors as well as from Isaksen (2010). However, Isaksen also says that the Porter definition, see section 2.2, should be used with caution, because the criteria to be a cluster allow many areas to be defined as a cluster, and they might not have any potential to become successful in the sense being innovative and competitive. We have earlier described that innovation is an open process, where cooperation is important for interactive learning and exchange of knowledge (Guiliani, 2010b; Fagerberg, 2005), hence cooperation is important for the cluster to be successful.

One of the cluster criteria above say that the actors acknowledge that they are part of a cluster which leads them in taking joint action to further strengthen the cluster. Joint action[6] is an unclear concept, but in this context joint action aims to improve or encourage innovation. There are several different ways to encourage a company to innovate, it can be through awareness, advising, expertise, support or training in a specific area. For joint actions to develop within the cluster there must exists networks in the form of collaboration, trust among actors and effective sanctions (Gutiérrez-Martínez, Duhamel, Luna-Reyes, Picazo-Vela, & Huerta-Carvajal, 2015).

However, firms rarely cooperate and exchange knowledge on their own initiative, and cooperation between competitors will therefore call for joint action in order to be initiated (Gutiérrez-Martínez, Duhamel, Luna-Reyes, Picazo-Vela, & Huerta-Carvajal, 2015; Bessant, Alexander, Tsekouras, Rush, & Lamming, 2012). The reason companies do not collaborate is often a question of trust. Imagine a typical “prisoner’s dilemma”, both risk losing more if they choose to collaborate and the other chooses to not collaborate. Joint action initiatives in form

[6] Joint action could also mean SME going together when advertising themselves, hiring consultants, doing quality testing, or building test laboratories and so forth. This is a way for small business to reduce costs (UNIDO).

of a cluster organisation can help accelerate innovation by building bridges where there are structural holes or weak links in the network, and through this help knowledge exchange between companies (Howells & Bessant, 2012). A tool that can be used for building bridges between two companies, or a company and a R&D institution, is specialist consultants or competence brokers (Jakobsen, Fosse, Slinning, & Våge, 2012). Building bridges is done because cooperation is vital in an interactive innovation process.

In Norway, NCE Subsea and Subsea Valley are examples of cluster initiative organisations trying to improve innovation in existing clusters. Both NCE Subsea and Subsea Valley arrange conferences and run different innovation projects, giving companies the opportunity to collaborate with other companies at the same time as they face reduced cost. The cluster organisations are funded by The Research Council of Norway, Innovation Norway and SIVA and are part of policy programmes trying to improve innovation in Norway (NCE Subsea, 2014; arena, 2015).

Strong competition and rivalry between companies that produce similar goods are important incentives for innovation and product differentiation. When closely located, i.e. in the same cluster or network, the companies can benefit from constant monitoring and comparing. Companies are able to make comparisons because conditions in the business environment are practically the same when they are co-located (Bathelt, Malmberg, & Maskell, 2004).

From the theory and empirics presented above we have seen that it is important for firms within a cluster to collaborate. Do companies start collaborating by themselves or do they need an organisation to make it happen, we have developed two hypotheses:

H1: A cluster needs a joint action for the companies to collaborate with each other.

H2: A cluster does not need a joint action for the companies to collaborate with each other.

2.4 Position in the network and ability to innovate

Several studies have shown that a company's position in a network can influence the company's behaviour and outcome (Ouimet, Landry, & Amara, 2004; Powell, Koput, & Smith-Doerr, 1996; Tsai, 2001). However, the exact effects of different positional measures are still unclear (Ahuja, 2000).

Some actors in the network are more central than others. Central actors are expected to be more influential because they collaborate with more actors in the network. Reve & Sasson

(2012) explain how the oil companies drive innovation and technological progress in the segment we study. They point out the following:

> The innovation system in the oil and gas industry is centred round the operators, by different suppliers competing in finding the best technical solutions that satisfy the operators' needs in solving practical challenges… … The interaction between the operators and the suppliers on the Norwegian continental shelf has made Norwegian based suppliers world leading within oil technology[7] (Reve & Sasson, 2012, p. 70).

Because the oil companies, and the interaction between them and the subsea companies, are so important for innovation in the subsea industry, we expect oil companies to hold central positions in the network where they are included. Reve and Sasson (2012) say that the oil companies in many ways are the reason for the world leading technology developed in the Norwegian oil and gas supplier industry.

In ”Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology”, Powell, Koput and Smith-Doerr (1996) argue that the place of innovation is found in networks of inter-firm relations because this provides knowledge and resources which otherwise would be unavailable. They further claim that companies placed more centrally, and with more experience in managing the links in a network, will have more access to new ventures and ideas, and be more able to exploit them. Centrality in a network will also facilitate a common understanding of the principles of collaboration, and with that increase the knowledge exchange among the actors (Powell, Koput, & Smith-Doerr, 1996).

The idea that position in the network matters is also shown in a paper by Schilling and Phelps (2007), where they examine two network properties, clustering and reach, to see if these properties have an impact on innovation, which the study reveals they have. This is further supported by a study conducted by Wenpin Tsai (2001), where it was shown that having a central network position, a company is more likely to obtain useful knowledge, information and learning from other actors in the network, thus increasing that company's innovative capability.

[7] Our translation: Original text in Norwegian.

In his study of direct links, indirect links[8] and structural holes, Ahuja shows that indirect links have a positive impact on innovation. Seeing that indirect links have relatively low maintenance costs compared to direct links, he said that this should be acknowledged (Ahuja, 2000). In a study of Quebec optics and photonics cluster, it is shown that the cluster's effective network is largely made up of weak links[9], which is opposite to a popular assumption that the stronger the links are, the better it is for innovation (Ouimet, Landry, & Amara, 2004). The study also shows that measures of betweenness are not significantly associated with radical innovation, demonstrating that betweenness centrality does not matter greatly for innovation.

Another point of view is connected to what we said in 2.2, where it was shown that being part of a cluster will provide several spillover effects, which in itself will increase productivity and innovation for all companies in a cluster or a network. "In a nutshell, the cluster literature claimed that regions are drivers of innovation and economic development: firms in clusters benefit almost automatically from knowledge externalities that are 'in the air', as Marshall once put it" (Ter Wal & Boschma, 2009, p. 741). According to this quote all companies will benefit and be more innovative, not only those holding central positions.

Porter (2000) points out that clusters might retard innovation. This can happen if the cluster starts thinking uniformly. If the members start thinking alike, new radical innovation can be suppressed. This is also shown in an article by Van Rijnsoever, Van den Berg, Koch and Hekkert (2015), where they show that in dense network there is less technological diversification.

The risk of uniformly thinking is greater if a dominant actor has a lot of power within the cluster; in the position to influence other actors' innovation activity. Being dependent on one customer raises concern that long-term relationships, or too much commitment between actors in a network, can establish ways of doing things that can be harmful for innovation (Boschma & Koen, 2010).

The above examples and empirics gives two different views on the effect of being a central actor. According to one view central actors in the subsea network in Rogaland are more

[8] Indirect links means that you are linked to another actor in the network, however, the link to the actor goes via another actor (hence indirect links) (Prell, 2012).
[9] The strength of an interpersonal link can be explained by the following: "The strength of a link is a (probably linear) combination of the amount of time, the emotional intensity, the mutual confiding, and the reciprocal services which characterises a link" (Granovetter, 1973, p. 1361).

innovative then the less central, whereas the other view says the position in the network does not matter to any great extent in explaining their ability to innovative, though the latter argument lacks solid empiric results. Based on this we have developed two hypotheses that we will test later in our analysis.

H3: A central position in the network makes the company innovative.

H4: A central position in the network does not affect a company's ability to innovate.

3.0 The subsea industry in Rogaland

Initially we said that there is no clear-cut definition of what it means to be a supplier company related to subsea. In addition to the definition we have chosen: A subsea company supplies equipment to be used between seabed and surface and/or related services, there are several others similar ways to define subsea. EY (2014) says that the subsea segment: "comprises companies that engineer and fabricate subsea equipment and companies with subsea umbilicals, risers and flowlines, and inspection, maintenance and repair". And Subsea 7 explains their operations as follows: "seabed to surface engineering, construction and services" (Subsea 7, 2015). These definition are similar, and they explain the subsea industry in only slightly different ways.

Subsea is often split into three sub-segments, which are distinguished; installation, production and maintenance. The first is SURF (Subsea Umbilicals, Risers and Flowlines) market, which involves everything concerning installation of equipment; umbilicals, risers leading the oil and gas from the wellhead to the production unit, and flowlines that transport the oil and gas to a production unit based onshore. The second sub-segment is development and production of subsea equipment, where advanced equipment is needed because of the demanding surroundings from which oil and gas is extracted. The third sub-segment is the subsea services, which covers inspection and maintenance of the existing subsea equipment (UTF, 2014).

One aspect that have pushed Norwegian subsea innovation forward, is that the oil and gas in the North Sea is found below deep sea and in rough weather conditions, making it challenging to extract the oil. Subsea technology offers great advantages over fixed production platforms as well as allowing extraction more cost efficiently, especially in the more challenging settings (EY, 2015). This is part in explaining why Norwegian companies have developed world leading technology and attractive solutions.

The subsea companies in Rogaland operate in a wide range of activities, in many ways there exists a value chain of its own within this industry. The subsea industry contains subcontractors, suppliers and customers. Some are local workshops producing smaller part, like screws and pipes, with mostly skilled trades people employed. Others are high technology companies providing technological solutions with only engineers employed. In addition, there are companies that tailor products and services other companies need, and others still that install subsea equipment, or provide vessels with ROVs and other subsea equipment. We find companies working in all the three sub-segments in Rogaland (Blomgren, et al., 2015). The subsea companies in the region have different origin, some have always been located in Rogaland, and seized the opportunity to supply the oil and gas industry by adapting their products and services when the chance arose as there was a great potential to earn good profits (Reve & Sasson, 2012).

Half of the global subsea market can be tied to Norwegian workplaces, and in total there are about 800 subsea installations in Norway and roughly 5 000 internationally (Haugsæther ref in: (Aadland, 2015)). This gives a good indication of how much the international market means for the subsea companies in Norway, as well as showing how important the Norwegian market is, with 16% of the world's subsea installations.

According to Rystad Energy (2013) about 3 000 of the jobs in Rogaland are within the subsea segment. In the region a total of 30 000 people are employed in the oil and gas service industry, offshore not included (Blomgren, et al., 2015), showing that roughly 10% of onshore oil service employees are employed in subsea.

The oil and gas industry in Rogaland is substantial. In Stavanger and the surrounding areas more than 40% of the labour force are employed in this industry (Norwegian Petroleum Directorate, 2014). However, in the last 15-18 months, thousands have lost their jobs in this industry. Stavanger's local newspaper "Stavanger Aftenblad" has weekly news about people who have lost their jobs in the oil and gas industry (Stavanger Aftenblad, 2015).

An additional reason for why it is interesting to study the subsea segment in Rogaland is that it lacks formal clusters initiatives within the oil and gas industry despite this is where the activity is biggest (Blomgren, et al., 2015; Rystad Energy, 2013). Two other regions, Hordaland and the eastern region in Norway, have cluster organisations to support and develop subsea knowledge, but in Rogaland a cluster has evolved without any formal initiatives. Furthermore, network and innovation in the subsea industry in Rogaland has not, to our knowledge, been the subject of study before, further motivating our study.

3.1 Subsea in other parts of Norway

Four out of the five largest companies in the subsea segment, i.e. FMC Kongsberg Subsea AS, Aker Subsea AS, Subsea 7 Norway, Technip Norge As and GE Oil & Gas (Vetco Gray Scandinavia AS), have their head office and R&D departments in the eastern region of Norway, although several of them have subsidiary entities in Rogaland (EY, 2014; Blomgren, et al., 2015). In addition, Subsea Valley is located in the eastern region. Subsea Valley is a cluster organisation with the vision to be "the world leading subsea engineering and technology cluster." Hordaland is another region with substantial subsea activity, where you can find NCE Subsea (Rystad Energy, 2013). NCE Subsea is a cluster organisation that consists of roughly 100 companies and organisations, and their goal is "to promote further development of the Norwegian subsea industry by increasing innovation" (NCE Subsea, 2014). Giving support to our arguments that Rogaland gives significant contributions to Norway's influence in the subsea industry, is the fact that NCE Subsea is expanding their geographic area to include Haugesund this year, and they plan to include Stavanger next year (Myset, 2014).

3.2 Oil companies' position

Oil companies are the subsea companies' customers, and in the end, the reason for the subsea industry's existence. To completely understand innovation in the subsea industry we therefore need to take the oil companies into account.

The oil and gas industry can be divided into smaller parts. There are two main groups, the license holders/operators[10] and suppliers. License holders/operators are often referred to as "oil companies" and are the companies given permission to search for and extract oil (hydrocarbons) from a field (a production license). The oil companies compete against each other when it comes to "winning" a field, but when the license is awarded the companies see each other as collaborators and not competitors. One reason for the collaboration is that a production license is often given to several companies with a share to each company. The

[10] The operator is the company responsible for all operation/activities necessary to uphold the partnership's obligations towards the authorities.

process of attaining a production licence has changed over the years. In the beginning the ministry would, for each license, form a group from the companies applying for the licence, and the government even appointed the operator. Today, the companies are allowed to form partnerships themselves, which allows them to prioritise the partners they want to share a licence with, when they apply for the licence to search and operate on a field on the NCS (Lerøen, 2012).

Oil companies are found at the end of the value chain in the oil and gas industry, and their field of work includes all the different aspects of the entire oil extraction process (Blomgren, et al., 2015), from searching and developing a field, to extracting and closing the field – the decommissioning. With a few exceptions all the larger oil companies operating on the NCS have offices in Rogaland.

The cooperation going through the value chain can partly be explained by an increasing interdependence between companies, to meet the demands of new global competition. To meet these demands it is vital that the whole value chain responds, as a company alone cannot attain better product quality and delivery (Schmitz, 2000).

There are 34 oil companies in Rogaland, and more than 11 000 people work for an oil company in this region (Blomgren, et al., 2015). More than 300 different suppliers offer products or services to the oil companies directly or indirectly, and in the end most of these companies only exist because of the oil companies who buy their products and services (Rystad Energy, 2013).

3.3 Government's influence

”50 years as an oil nation - a honour to the bureaucrats who made it possible” is the title of a chronicle written by Head of Department of Political Science, Dag Harald Claes, at the University of Oslo, where he describes that one reason for the successful development within the oil and gas industry might be strict regulations by the government (Claes, 2015). Strict regulations have affected the way operators and the whole industry handle people, health and safety. In addition, the government has made it clear that it is important to extract as much oil out of every field as possible (Fjose, et al., 2011). “The Skuld project” is a good example of the governments influence, and the homepage of the Frigg field explains how the government influenced the beginning of subsea in Norway:

> Following the discovery of Frigg in 1971, Elf/Petronord found a number of marginal fields in the immediate vicinity of this major gas field. These deposits were regarded by the operator as too small, and thereby unprofitable to develop. For its part, however, the Norwegian government wanted all discoveries to be exploited. The Ministry of Industry and the Norwegian Petroleum Directorate (NPD) urged Elf to consider unconventional production solutions for the satellite fields (Meland, 2015).

Government regulation might be one reason for success; others are government incentives and government programmes[11]. The government gives incentives to work together and there has been a willingness to try new solutions, therefore Norway has been able to produce more advanced technology (Lorentzen, 2014). There are also projects involving customers, suppliers and authorities working together in order to find ways that enables them to extract more oil out of every field in operation, one being Demo 2000[12], which is a project with government participation that has successfully led to new technology within subsea (Fjose, et al., 2011).

In Norway there has been a large focus on using networks in forms of clusters to enhance innovation and economic growth. One objective set by the government is that Norway will become one of Europe’s most innovative countries (Government.no, 2014). International research show that new product-, service-, or process innovation more often comes from industrial clusters, rather than single companies outside clusters (Backe, 2014).

In Norway, government supported cluster initiatives have given rise to the Arena-, GCE and NCE programmes. The programmes are directed towards regional clusters and seek to enhance the interaction between actors in industries, knowledge institutions and the public, with the objective to increase innovation and strengthen the regions international competitiveness (Government.no, 2014).

[11] Examples of government programs and incentives: SkatteFUNN is a tax incentive scheme, where companies are subject to tax relief, designed to stimulate R&D in Norwegian trade and industry. Innovation Norway is an instrument for the Norwegian government which offers subsidies, grants and loans to aid companies in the innovation process. VRI is a program with the purpose to strengthen innovation and interactions among actors within the same region (The Research Council of Norway, 2008) (The Research Council of Norway, 2014).

[12] Demo 2000 helps pilot new technology that will contribute in reducing costs, increase efficiency and improve performance on the NCS (The Research Council of Norway, 2010).

4.0 Data and method

This study, aiming to uncover characteristics of the subsea network in Rogaland, is based on data collected at company level, on the basis of face-to-face interviews carried out in January through March of 2015. 37 companies participated in the study, of which 30 are subsea companies and 7 are oil companies.

4.1 Population

Our focus group is the subsea segment of the oil and gas industry in Rogaland. The subsea companies are gathered from IRIS' categorisation of corporates into populations[13]. We have divided our analysis in two main parts. The first part of the analysis consists of the subsea population, which is followed by an extended analysis where we have included the oil companies to the initial population. The reason for including the oil companies is, as mentioned earlier, that innovation in the subsea segment often start with a customer need, and a subsea customer is, if not another subsea company, an oil company.

3.1.1 Subsea population

There are 54 subsea corporates registered in Rogaland according to IRIS' categorising, in which some are head office entities, others are subsidiary entities

31 companies met our requirements and we contacted these to request participation in our study. Of these 31 companies, only 1 did not wish to participate in this study, participation rate is therefore 96.8%. 23 entities were eliminated from this study, either because they had too few employees (0-4), or they were entities of the "same" company but located at several locations within the region, which were treated as the same company if they had the same general manager.

3.1.2 Subsea and oil companies population

IRIS' categorisation presents 34 operators, which we refer to as oil companies. Not all of these companies have subsea activity in a strict interpretation, and are therefore not of interest as the focus was to examine the subsea segment of the oil and gas industry. We used data on

[13] IRIS has a database with all corporates operating in the oil and gas industry and all companies has been sorted into one population, e.g. subsea, operator. More about the way they have prepared this population is found in Industribyggerne 2015, p. 199 (Blomgren, et al., 2015).

active fields in Norway to see who operates oil fields on the NCS. In addition, we used the roster recall[14] answers from the subsea companies' responses.

We identified 20 oil companies with subsea activities located in Rogaland, which we contacted with positive response from only 7. The other 13 oil companies did not participate for different reasons, some were not allowed to participate from their head office, some did not have the time, others did not respond to our requests at all. Even though 35% participation rate is less than hoped for, we can still use data to indicate the collaboration between customer and supplier.

4.2 Interview and questionnaire

4.2.1 Arranging interview appointments

First we identified the person in the companies who was most appropriate to interview for this study. If the headquarter was located in Rogaland, our preferred interviewee was the General Manager or CEO. We found this information at the web pages for The Brønnøysund Register Centre[15]. In the subsea population, the respondents held the following positions; 15 general managers or CEOs, 7 "head of Stavanger region", 5 "technical manager" and the rest held other managing positions.

When we contacted the oil companies for the extended network, we tried to get hold of the person in charge of the subsea activity of the company. In the oil companies, the 7 respondents were either "chief engineer" or "subsea manager".

4.2.2 Collecting data

The interview always took place at the respondents' office. Most interviews lasted roughly 45 minutes. We used a questionnaire developed by the VRI project team[16], which is found in the Appendix 1 Questionnaire. During the interviews, two interviewers were always present.

The questionnaire used is extensive, and in our analysis we do not utilize the full set of questions. The question being the background for our network analyses and centrality measures is:

[14] A roster recall is a list of all actors in the network in question, where the respondents is asked to recall other actors as well (Prell, 2012).
[15] The Brønnøysund Register Centre develops and operates several of Norway's most important registers, and is government body under The Ministry of Trade, Industry and Fisheries (Brønnøysund Register Centre).
[16] The questionnaire has been used in studies of other regions in Norway, as well as in Sweden.

- *Question 12: Please name all organisations your firm collaborates and exchanges knowledge with in the last three years[17]. These may be firms, universities, research organisations, public agencies etc., and no matter where these are located. (The respondents were given a list of organisations, the roster recall, and had the opportunity to add others as well).*

This question is the one that gives relational links between the companies in the network, where 1 indicates that a collaborative relationship exists between two actors in the population, and 0 indicates that no collaborative relationship exists.

The questions giving data considering if the company is innovative are:

- *Question 8a: Has the firm introduced new or significantly improved products/services in the market in the last three years?*
- *Question 8b: Has the firm made important discoveries or breakthroughs in the last three years that would hopefully lead to new products?*
- *Question 8c: Has the firm made use of new or significantly improved production processes, technology, components or materials in the last three years?*
- *Question 8d: Has the firm introduced a new or significantly improved business strategy in the last three years?*
- *Question 8e: Has the firm introduced a new or significantly improved business structure in the last three years?*
- *Question 8f: Has the firm introduced a new or significantly improved marketing strategy in the last three years?*

Questions 8a through 8f give answers to whether the companies are innovative or not. If the respondent answered yes, they are coded as innovative, if the respondent answered no, the company is coded as not innovative.

For the discussion in section 7.0 we have used general comments and other information provided by the respondents during the interview.

[17] The respondents were asked to indicate from 1 to 5 how important the collaboration is/was for innovation activities, we converted these values to binary, leaving the answers being collaboration and exchange of knowledge in general.

4.3 Social network analysis

To study if a company's position in a network has an impact on its ability to innovate, we first describe the structure of the subsea network in Rogaland by looking at collaborative relations, then analyse who the central actors in the network are. This means that we will first examine the network at the network level, then at the actor level.

Network data differs from conventional data by displaying the relationship between different actors in the study, rather than comparing the actors based on their attributes. SNA is a mathematical and visual tool to analyse network data (Prell, 2012; Hanneman & Riddle, 2011b).

Recently, social network analysis methods have been used when analysing what geographical clusters looks like and how the interactions in regions are structured. It is becoming more recognised that SNA is a suitable method when conceptualising interactions and knowledge flows between companies within a region (Ter Wal & Boschma, 2009). SNA has emerged as a set of methods for analysing the relationships between social entities, as well as the patterns and consequences of these relationships (Marin & Wellman, 2011; Prell, 2012), and is a popular approach when studying social relations and networks.

When analysing social networks researchers can use two tools from mathematics to represent information about the patterns in the network – graphs and matrices (Prell, 2012). In this study we will use graphs to display the networks, which are drawn in NetDraw. NetDraw is part of UCINET software (Borgatti, Everett, & Freeman, 2002). We have used UCINET to find other measures on the networks and the networks' actors, which will be explained in detail in 5.2.1. UCINET is commonly applied when analysing social networks (Hanneman & Riddle, 2011b; Prell, 2012).

4.3.1 Analysing network data

In SNA, researchers start by defining which nodes to include in the network. In our case it is the actors in the subsea industry in Rogaland, which later will be extended to include their customers, namely the oil companies. After identifying the nodes, we identify the relations between these nodes (Marin & Wellman, 2011).

According to Guiliani and Pietrobelli (2014) if the population has less than hundred actors the best way is to interview them all by using roster recall, which is what we have done. Using a roster recall the respondent is given a list of all other actors in the population, and is asked to recall other actors (whom they have the relationship with) and list them on the roster. This is to ensure that the complete network will be identified (Prell, 2012).

When the network data has been collected, by observation, interviews or collecting secondary data, it is used to calculate different properties of the network. We did face-to-face interviews, which is the preferred method when you have a relatively small network to analyse. We study two network structures; one consisting of 30 nodes and the other of 57 nodes.

4.4 Differences between the companies' ability to innovate

We will apply pairwise correlation of centrality measures and innovation measures, followed by logistic regressions in order to be able to give more insights to whether a company's position in a network affects its ability to innovate. We use Pearson's R correlation coefficient, which is widely used as a measure of linear dependence between two variables. Pearson's R measures the linear correlation between two variables X and Y, giving values between +1 and -1, where +1 is total positive correlation, 0 is no correlation and -1 is total negative correlation (Anderson, Sweeney, & Williams, 2002).

For the logistic regression the following model was applied:

$$logit(\pi_i) = \alpha + \beta_i \, Centrality_i + \gamma_2 \, Controls_i + \varepsilon_i,$$

where π refers to six different dependent variables; (1) introduction of new or significantly improved products or services the last three years, (2) discoveries/breakthroughs in the last three years that might lead to new products or services, (3) made use of new or significantly improved production processes, technology, components or materials in the last three years, (4) introduced new or significantly improved business strategy in the last three years, (5) introduced new or significantly improved business structure in the last three years, and (6) introduced new or significantly improved marketing strategy in the last three years. The interesting variable is *Centrality*, which involves three centrality measures; (1) in-degree centrality, (2) out-degree centrality and (3) betweenness centrality.

We will test the robustness of our results by adding different controls[18]. We will check if controlling for number of employees, share of employees with higher education, share of employees in R&D, number of government incentives used to promote innovation, will

[18] See Appendix 1 Questionnaire, we have used answers to questions: 5a, 6a, 10 and 16

change the results from the simple logit model. Because of the small population size we do not include several control variables in one regression.

5.0 Analysis of subsea population

5.1 Central concepts

Before we present the findings of our analysis of the subsea segment, we will present some central concepts when using SNA in an analysis (Wasserman & Faust, 1994; Prell, 2012):

- Actors and their actions are seen as interdependent rather than independent, this is important to keep in mind, the subsea companies has been picked because they are in the same industry, and we assume that they are interdependent.
- The relational links between the actors are channels for transferring resources. In this analysis we have asked if there is collaboration and exchange of knowledge, therefore the links will represent a collaborative and knowledge exchanging relationships.
- Graphs are undirected lines among a set of nodes. The graphs are visual illustrations of networks connections in this study of collaboration between the companies. If there is a connection, at least one of the two connected actors have reported to collaborate with the other actor.
- Binary graphs, where the links have the values 0 or 1, are used in this study.

In the analysis the subsea companies interviewed are named SF, followed by a suffix consisting of a number from 1 – 30, which was randomly selected.

5.2 Network in subsea population

In Figure 2, the companies are sorted by their place in the value chain within the subsea industry. There are many ways to sort networks in graphs; we have placed the companies according to their main activities. The workshops are placed furthest to the left, and moving towards the right you find the companies that perform installation, maintenance and repair of subsea equipment. Some of the companies are hard to place as they perform all activities. In the network graph these are placed to the right.

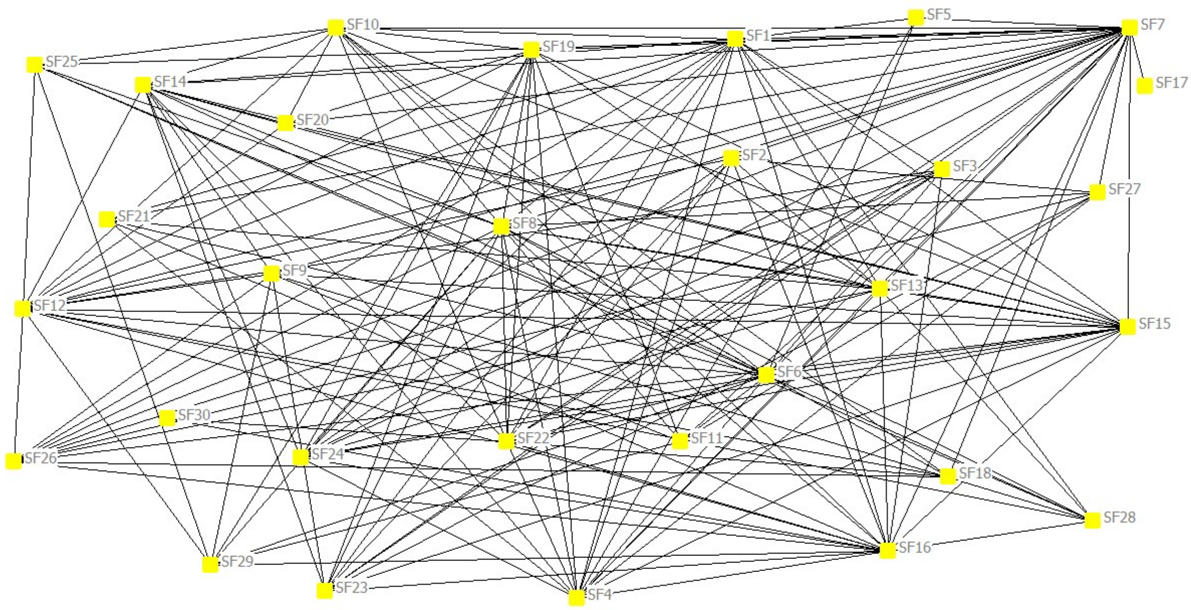

Figure 2 Network in the subsea segment.

The nodes represent the 30 actors in the subsea network, and the links between them represent the collaboration among them. Companies placed furthest to the left are workshops and manufacturers, and companies to the far right do maintenance and repairs. In the middle but slightly to the left are companies with mainly engineering, and the companies in the middle, but slightly to the right, do everything within the subsea value chain described earlier.

Figure 2 provides a visual representation of the subsea network and it shows the direct links between the actors in the subsea population in Rogaland. By visual inspection, we can see that the network consists of 30 nodes (actors), and a large number of links between the nodes. The figure shows that there are more horizontal than vertical links in the network, which indicates that most links are going up and down the value chain in the subsea segment, as is expected from theory presented in 2.2.1. However, the figure also indicates that collaboration exists among those at the same place in the value chain, which is shown by the vertical lines in the network. Another observation to be made is that all actors are connected to at least one other actor in the network, meaning that there are no isolates[19] in the network. The graph also shows that some actors have considerably more links than others, e.g. the actor in the top right corner, SF 7. Examining the actor in the top right corner, SF 7, we see that it has a link to actor SF 17 who is not linked to anyone else in the network. This means that SF 17 is dependent of SF 7 to interact with the rest of the subsea network.

[19] An isolate is a node with no links to other nodes in the graph (Prell, 2012).

5.2.1 Measures of the network in the subsea segment

The size of a network is often important because of the limited resources an actor has for building and maintaining links in the network. The larger the social network is, the more difficult it becomes making and maintaining relational links (Hanneman & Riddle, 2011a; Prell, 2012).

We start analysing the network by calculating the network density, which is the sum of present links in the network divided by the total number of possible links in the network (Prell, 2012). The density measure indicates how quickly information travels among nodes; the more links there are, the easier and quicker information can be spread. The formula for network density looks like this:

$$d = \frac{L}{n(n-1)/_2},$$

where L equals the number of links and n equals the number of nodes in the network.

The density coefficient for the subsea network is 0.246, meaning that 24.6 % of all possible links are present in the subsea population. Even though density measures cannot be directly compared to other network analyses with different numbers of actors, it can still indicate differences. The density coefficient of 0.246 is larger than in other literature, e.g. Andrea Morrison (2004)[20] and Cantner and Grafs (2006)[21], suggesting that information travels quickly between the actors in the subsea network. From the density calculations we find that an average actor has 7 links, which means that actors in the network, on average, communicates and shares knowledge with 7 other actors in the network.

In addition to the density measure, we calculate the number of cliques in the network to investigate the network's substructures. These substructures will appear in the graph as locally dense areas, which are to some extent separated from the rest of the graph (Hanneman & Riddle, 2011b). A clique can be defined as a maximal complete subgraph of three or more nodes that are all connected to each other. This means that no other actor can be included in the clique without making it less connected (Prell, 2012).

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[20] In *"Gatekeepers of knowledge" within industrial districts: who they are, how they interact* Morrison shows density scores of 0.1126 and 0.0315, with 37 nodes in both networks.

[21] Cantner and Grafs find density scores of 0.151 and 0.165, with 159 and 205 nodes respectively, in their paper; *The network of innovators in Jena: An application of social network analysis.*

In the subsea network, 70 cliques are identified and the largest clique consists of 8 actors. We find three cliques with 8 actors involved. In addition, there are 8 cliques with 7 actors involved, and a large number of cliques with 6 and 5 actors involved. In addition to the high density score suggesting that information travels quickly, these large and numerous cliques suggests that there is considerable collaboration among most actors in this network, which is depicted by the great number of link seen in Figure 2.

Since the results above show high degree of collaboration and Rogaland do not have any cluster initiative making sure there are joint actions, the hypothesis H2 is supported, thus there can be collaboration between companies without joint action.

5.3 Actors in the subsea population

When analysing who is important in the network, we calculate centrality measures, which shows which actors who have central positions in the network. There are several measures for centrality, we will calculate in-degree and out-degree centrality, and betweenness centrality.

5.3.1 In-degree and out-degree centrality

In-degree centrality tells us which actor has the most links coming in from the other actors in the network, and actors with a high in-degree usually have high rank in the network (Hanneman & Riddle, 2011a). The formula for in-degree centrality for actor *i* is:

$$C_1\,(i) = \sum_{j=1}^{n} x_{ji}$$

where x_{ji} equals the binary value from actor j to actor i, and n equals the number of nodes in the network.

Calculating in-degree centrality we find that actor SF 16 has the highest in-degree score, with 18 other actors saying they have direct collaborative links to this particular actor. SF 1 has 15 other actors reporting to collaborate with them. SF 6, SF 8, SF 14 and SF 15 all have 14 other actors reporting to collaborate with them. This means that these actors are seen as prominent (Hanneman & Riddle, 2011a), and they (potentially) receive information and knowledge from half of the actors in the network. Following the companies with the highest scores, the values decrease evenly. All in-degree measures are found in Table 2 below.

Out-degree tells us how many links an actor has going out, or said differently; how many collaborators a specific actor says it has. Actors with a high out-degree are seen as actors who are very capable to share knowledge and information with others, thus being very influential (Hanneman & Riddle, 2011a). The formula for out-degree centrality for actor *i* is:

$$C_0\,(i) = \sum_{j=1}^{n} x_{ij}$$

where x_{ij} equals the binary value from actor *i* to actor *j*, and *n* equals the number of nodes in the network.

SF 7 has an out-degree of 25, meaning that SF 7 reports to be collaborate and share knowledge, in a direct link, with 25 out of the 30 other actors. There is a jump down to SF 4 and SF 8, which all reports to collaborate with 15 of the other actors in the network. An interesting observation is that SF 16, which had the highest in-degree, has the lowest out-degree of only 2. There could be several reasons for this. First, the respondent, SF 16, may not have the knowledge about whom they collaborate with. Although we did not speak to the general manager in SF 16, the respondent was a regional director and it is therefore expected that he has knowledge on this subject. Second, when other companies have said that they collaborate with this company, they might collaborate with an entity placed outside Rogaland. Third, the respondent could have a different definition of "collaboration" and "exchange of knowledge." Fourth, it can be a combination two or more of the other reasons.

5.3.2 Betweenness centrality

In order to measure actors' centrality, taking the entire network into account, we use betweenness centrality. Betweenness centrality measures how many times an actor lies on the geodesic distance[22] between two disconnected actors in the network. The idea with betweenness is that you are placed between two disconnected actors, which place you in a position to play an intermediary role within the network, which can further give you certain advantages (Prell, 2012). Betweenness centrality tells us how much an actor has opportunity to control the flow of communication and information in the network, which puts the actor in a position to choose what information he or she wants to share with other actors. This centrality measure is best in capturing the most important actors in the network (Prell, 2012). The formula for betweenness centrality is shown in (Prell, 2012) as:

[22] The geodesic distance is the shortest path between two nodes. A path is a sequence of nodes in which all nodes and links are different (Prell, 2012).

$$C_B\,(k) = {\sum \partial_{ikj}} \Big/ {\partial_{ij}}\ , i\ \neq j\ \neq k$$

and *dij* equals the number of geodesic linking actors *i* and *j*. To calculate the normalised betweenness score (enabling us to compare the measures to other networks) the formula is:

$$C'_B = {C_B(k)} \Big/ {[\frac{(n-1)(n-2)}{2}]}$$

The betweenness centrality for the subsea network shows that SF 7 is very important to the network, with a normalised betweenness score of 18.41%, which means that actor SF 7 is involved in linking other pairs in the network 18.41% of what is possible. SF 7's betweenness centrality is nearly three times bigger than the subsequent actor, SF 8 (6.2 %). Other actors with high betweenness centrality are SF 12 (5.1%), SF 6 (4.82%) and SF 22 (4.14%). Several actors have betweenness centrality of zero. We will continue in the following section to compare the companies with the highest betweenness centrality to those with no betweenness centrality to see if there are any differences in their innovative ability.

The results shown in Table 2 are only descriptive data, showing whether the company has introduced a new product or service, as well as the three different centrality measures for all companies in the subsea network. By just looking at these figures, a simple comparison of the most central companies and the least central companies suggests some characteristics. Three companies have in-degree of zero (SF 3, SF 28 and SF 29) and two companies have an out-degree of zero (SF 11 and SF 17). The results shown in Table 2 also show that most actors in the subsea network are innovative, only 5 out of 30 companies have not introduced a new product or service during the last three years, indicating that having a central position in the network does not necessarily impact a company's innovative ability. Two of the companies with lowest betweenness centrality are newly start-ups.

Company	New product/service	Out-degree	In-degree	Betweenness
SF1	1	7	15	3.4
SF2	1	7	5	0.64
SF3	1	8	0	0.4
SF4	0	15	5	2.44
SF5	1	2	2	0.02
SF6	1	4	14	4.82
SF7	1	25	12	18.41
SF8	1	15	14	6.2
SF9	0	4	6	1.01
SF10	1	12	6	1.41
SF11	0	0	7	0.49
SF12	1	11	13	5.1
SF13	1	9	7	1.34
SF14	1	7	14	1.6
SF15	1	8	14	2.3
SF16	1	2	18	7.2
SF17	1	0	1	0
SF18	1	3	6	0.11
SF19	1	7	9	2.04
SF20	1	6	2	0.02
SF21	1	4	2	0.07
SF22	1	12	8	4.14
SF23	1	7	6	1.33
SF24	1	8	8	0.79
SF25	0	4	6	0.27
SF26	1	7	8	1.42
SF27	1	1	6	0.46
SF28	0	8	0	0.59
SF29	1	8	0	0.66
SF30	1	2	1	0

Table 2 Centrality measures and innovation. New product/service are shown with binary values (1=yes and 0= no). Out- and in-degree shows the number of links going out and in, respectively, from an actor. Betweenness is the normalized score of betweenness.

5.4 Position and innovation in subsea population

In Table 2 we showed the different centrality measures together with introduction of new products and/or services. All top seven companies had introduced a new product or service in the last three years, and six out of seven non-central companies had done the same. We will in the following section look at correlation between the answers between the innovation questions, 8a – 8f and the centrality measures. We will then run logistic regressions.

5.4.1 Are central actors more innovative?

	Out - degree	In - degree	Betweenness
New product/service	0.08	0.21	0.17
Ideas	0.09	0.10	0.07
New process	0.18	0.56***	0.34*
New strategy	0.22	0.01	0.15
New structure	0.11	0.05	0.11
New marketing	0.19	0.23	-0.08

Table 3 Correlation between the innovation and centrality.

***** = significant at the 99% level, ** = significant at the 95% level, * = significant at the 90% level**

Table 3 is a correlation matrix, showing correlation between the centrality measures, in-degree, out-degree and betweenness, and the questions related to innovation. From Table 3 we find that all, but one, correlations are positive. Many of the correlations are close to zero, some are practically zero and indicates that there are no correlation. We have included correlations at the 90% significance level as we only have 30 observations.

When first considering the correlation between centrality variables and innovation variables, all centrality variables are positively correlated with new product/service but none of them were significant, the same is true for centrality variables and idea even though we finds less correlation here (closer to zero). Betweenness and new marketing strategy is negatively correlated, but the correlation is very close to zero. It is only the innovation variable concerning; made use of new process that is significantly correlated with any centrality measures. New process and the centrality variable in-degree have a correlation coefficient of 0.56, which is significant at 99% level. This innovation variable is also correlated the betweenness centrality, with a correlation coefficient of 0.34 significant at 90% level. From this we see that there is a positive correlation being a central actor and the company answering yes to the question: Has the firm made use of new, or significantly improved, production processes, technology, components or materials in the last three years?

Further, we ran logistic regression using the innovation questions as dependent variable one at the time. With this we only found significant coefficients when using the question regarding whether the company has made use of new production process as dependent variable. When it comes to using centrality measures to explain the innovation variable, only in-degree centrality was significant, results are seen in Table 4 below.

Coefficient	*Logistic regression with new production process, new technology, components or materials as the dependent variable*				
In-degree[23]	0.36** (0.14)	0.30** (0.13)	0.37** (0.17)	0.36** (0.14)	0.40** (0.16)
Number of employees		0.01 (0.01)			
With higher degree			-2.57 (1.77)		
Employees in R&D				0.24 (5.45)	
Number of incentives					1.09** (0.53)
Constant	-1.64* (0.88)	-2.90** (1.33)	-0.61 (1.08)	-1.64* (0.90)	-3.80** (2.03)
Log likelihood	-13.85	-10.62	-12.65	-13.85	-10.45

Table 4 Central position effects on process innovation. In the table there are five regressions, and all has process innovation as the dependent variable. We see that higher in-degree will have a positive effect on the whether the company has process innovation or not. In the first regression there are none control variables, but in the four other regression different controls have been added, and the effect of in-degree does not changes dramatically. It has significant positive effect.

***** = significant at the 99% level, ** = significant at the 95% level, * = significant at the 90% level**

We ran five different regression. First, a simple one using new process as variable of interest, and using in-degree as explanatory variable, then we added a different control variable to the simple model in the next four regression. Concerning in-degree centrality, we can see that the effect is positive and significant at the 95% level, on the likelihood of introducing new, or significantly improved, production process, components, materials or technology, regardless of which control variable that is included. The in-degree coefficient of 0.36 does not change notably either, reduced to 0.30 when we added number of employees, and increased to 0.40 when we added number of incentives. When we add either employees with higher degree or

[23] We also ran logistic regression using Betweenness and Out-degree as centrality measure, however, we did not find any significant results, and they are therefore omitted from the analysis. We did not find significant results using them as explanatory variable on any of the other innovation variables either.

employees in R&D in the regression, the results are practically the same. This suggests that central actors, measured by in-degree, are more likely innovative regarding making use of new, or significantly improved, production process, technology, components or materials.

Hypothesis H3, a central position in the network makes the company more innovative, is supported by finding a significant positive effect on the centrality variable in-degree on the likelihood that the company has made use of new or significantly improved production processes, technology, components or materials in the last three years. However, the two other centrality measures do not show significant results, thus leaving us inconclusive regarding H4.

6.0 Analysis of the population with subsea and oil companies

In the previous chapter we showed that the subsea population has a high density network with a great deal of collaboration and knowledge exchange. One reason that might explain the dense network we observe is the subsea companies' dependence of the oil companies.

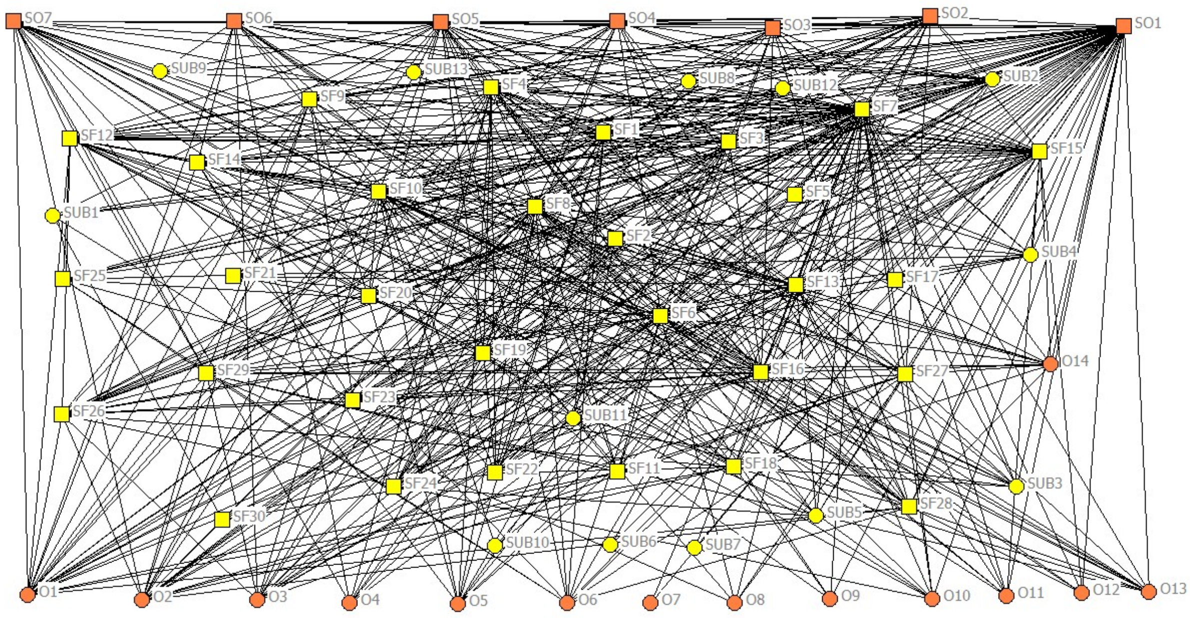

Figure 3 Network in population extended to include oil companies.

The nodes represent the 57 actors in the subsea and oil companies' network, and the links between the nodes represent the collaboration among the actors in the network. The colour of the nodes represents what type of company it is, yellow denotes subsea companies while orange denotes oil companies. SF denotes subsea companies that are interviewed, SUB denotes subsea companies not interviewed, SO denotes oil companies that are interviewed and O denotes oil companies not interviewed. The round nodes represent subsea and oil companies we have interviewed, and the square nodes represent subsea and oil companies we have not interviewed. We have used Figure 2 - Network in the subsea segment as a base, where the subsea companies are placed according to their place in the value chain, and the oil companies we have interviewed are placed above the subsea base, while the oil companies not interviewed are placed below the subsea base.

In the next part of our analysis we have included oil companies as well as the subsea companies. Regarding the subsea companies, this population includes all the companies we interviewed and 13 additional subsea companies. The subsea companies included in Figure 3 but not interviewed are named SUB, and numbered from 1 – 13. These were excluded from the original subsea population as 11 of these are subsea companies located outside the region, and 2 are located in the region but do not have subsea as their main activity. They are included in the extended population because they were mentioned on the roster recall by at least one interviewed subsea company.

The interviewed oil companies are named SO, and are randomly numbered 1 – 7. The oil companies not interviewed are named O and are randomly numbered 1 – 14.

In Figure 3 we used Figure 2 as base, which we have extended with the additional subsea companies placed roughly where they are placed in the subsea value chain. The oil companies are placed in a circle round the subsea companies to display all the connections between the subsea companies and the oil companies. In the figure we have denoted interviewed oil companies by squared nodes placed at the top of the figure, and companies not interviewed denoted by circled nodes placed at the bottom. In this figure, there are no links between the companies that were not interviewed, which is a weakness because the network is expected to consist of even more links than the ones displayed. We expect there are links between the non-interviewed oil companies and the interviewed oil companies and subsea companies. However, the main objective of this study is the subsea industry in Rogaland, and we have the links concerning the subsea actors in Rogaland.

6.1 Network in population extended to include oil companies

The extended network consists of 57 actors, and from Figure 3 we can see that this network, similarly to the subsea network, is quite dense. The large number of links shows the high network density. There are no isolates in this network either, all actors are connected to one or more actors in the network. We can also observe that there are a few actors who have considerably more links than others, the most obvious ones being SO 1, SO 7 and O 1. We will measure this further in the following.

In this network we have not interviewed all companies, but we have interviewed more than half of the entire network (37 of 57). Because we have gathered data from more than half of the network size, we will symmetrize the data and make the assumption that if one actor has stated a collaborative relationship, then the relationship exists. This is not the best option but a second best. Our main concern regarding this is that we have interviewed less than half of the oil companies, which mean that the links between non-interviewed actors are not measured, and subsequently underrepresented. And as we have described earlier, the oil companies are important in this network and for the innovation process in subsea companies. We need therefore keep in mind that central views and collaboration links might be absent in this part of our analysis. This will naturally affect the results presented, however, the findings will be able to indicate some tendencies.

We find a density of 0.154[24], which is lower than the subsea network with a fewer actors. This is expected as a larger number of actors in the network leads to a larger number of links, which makes it difficult to achieve high density scores (Prell, 2012). However, there are a number of links missing from the analysis because the low response rate from the oil companies. A density score of 0.154 means that 15.4% of the possible links in the network are present, showing a high density when taking the networks size into account. An actor will on average have 10 links to other actors in this network, which means that information travels quickly in this extended sample.

There are 328 cliques in this network, meaning that several actors will be part of many cliques and that several cliques will overlap. The largest clique size consists of 9 actors, and we find 7 cliques of this size. In addition, there are more than 20 cliques with 8 actors involved and more than 20 cliques with 7 actors involved. The large cliques, together with the amount of cliques found, imply that there is a lot of collaboration between most actors in this network, explaining all the links seen in Figure 3.

From this extended population we can see that there is lots of collaboration between the companies, even when some links are missing. We can therefore with more certainty support H2, there is collaboration between companies in the subsea industry in Rogaland without a cluster organisation making sure of joint actions.

6.2 Actors in the population extended to include oil companies

In the following section we will present the centrality measures of the extended network, uncovering which actors hold central positions. We will use the same measures for centrality as in the subsea network, which are in-degree and out-degree centrality; explained in detail

[24] Density would be higher if all links between not interviewed actors were present.

5.3.1, and betweenness centrality; explained in detail in 5.3.2. The measures of all actors are listed in Table 5.

6.2.1 In-degree and out-degree centrality

Actor SO 1 has the highest in-degree centrality in the network, with a score of 34, which is matchless, suggesting that this actor is much more influential in the network than others. Actor SF 16 has the second highest in-degree, with 25 links, followed by SF 6 (20 links) and SF 1 (19 links).

The actors with the highest out-degree are SF 7 and SO 1, which have the same number of links going out; 56. There is a drop of 20 links before we reach the actor with the third highest out-degree, SF 8. With such a high out-degree, SO 1 and SF 7 are able to communicate their views to several actors in the network, and are therefore highly influential actors.

An interesting discovery when studying the in- and out-degree scores, is that actor SO 1 has the highest score in both. This indicate that SO 1 is perceived as both having high prestige, as well as being very influential, and capable of sharing knowledge and information to a large part of the network. Furthermore, this shows that actor SO 1 is frequently used as a partner.

Another interesting observation we make in the extended population, is that actor SF 7 holds a highly central position, with the highest score of out-degree (together with SO 1) and the second highest betweenness centrality score. This actor held a central position in the subsea population as well, where it had highest out-degree and betweenness centrality.

6.2.2 Betweenness centrality

Examining the betweenness measures we can see that actor SO 1 has a normalised betweenness centrality score of 20.61%. This means that SO 1 is placed on 20.61% of all links between other pairs of actors in the network. An actor with a high betweenness centrality has a lot of power as it can choose which information to share and which to withhold or distort to other actors. It is not always important how many actors you are connected to in the network, but rather where you are placed in the network (Prell, 2012). The actor with the second highest betweenness centrality is SF 7 (16.03%). Following a substantial drop to third place, where we find actor SF 15 with a betweenness centrality score of 5.04%. In this extended population, only SF 17 has zero betweenness centrality. Seeing that actors SO 1 and SF 7 also had the highest out-degree centrality, in addition to the highest betweenness, these are very central actors in the extended network.

Company	New product/service	Out-degree	In-degree	Betweenness
SF1	1	16	19	4,65
SF2	1	15	7	1,3
SF3	1	18	0	2,3
SF4	0	26	6	1,4
SF5	1	3	4	0,01
SF6	1	22	20	3,4
SF7	1	56	16	16,03
SF8	1	36	18	3,9
SF9	0	13	11	0,54
SF10	1	33	7	3,07
SF11	0	5	10	0,06
SF12	1	19	14	1,09
SF13	1	19	9	1,23
SF14	1	10	16	0,33
SF15	1	23	16	5,04
SF16	1	4	25	1,46
SF17	1	0	3	0
SF18	1	14	8	0,46
SF19	1	14	12	0,6
SF20	1	11	3	0,1
SF21	1	7	3	0,03
SF22	1	14	9	0,54
SF23	1	11	7	0,51
SF24	1	12	9	0,46
SF25	0	7	7	0,08
SF26	1	17	9	0,66
SF27	1	14	7	0,83
SF28	0	19	0	0,64
SF29	1	19	0	0,58
SF30	1	4	1	0,02
SO1	1	56	34	20,61
SO2	1	14	13	1,01
SO3	1	9	16	0,36
SO4	1	8	17	0,48
SO5	0	23	14	2,82
SO6	1	11	10	0,63
SO7	0	19	11	1,05

Table 5 Centrality measures and innovation. New product/service are shown with binary values (1=yes and 0= no). Out- and in-degree shows the number of links going out and in, respectively, from an actor. Betweenness shows the normalized score of betweenness (shown in percentage), which makes it possible to compare to other networks.

The results shown in Table 5 are only descriptive data, and as in Table 2, it is showing whether the company has introduced a new product or service and the three different centrality measures for all companies in the extended network of subsea and oil companies.

We can observe that 30 of 37 companies have introduced new products/services, showing that the extended network also has a high degree of innovation. And of the 7 companies that did not introduce new products/services, actor SF 28 is the only one with an in-degree of zero.

Seeing that 30 out of 37 companies show innovative abilities, the results seen in Table 5 indicate that companies' innovative abilities are not influenced by their centrality measures in the network, giving support to H4. We will analyse how, and if, position can affect ability to innovate further in the following section.

6.3 Position and innovation in the subsea and oil companies population

In Table 5 we showed whether a company has introduced new products/services as well as the centrality measures. To see if central actors are more innovative, we will in the following section look at correlation between the answers of the innovation questions, 8a – 8f and the centrality measures.

6.3.1 Are central actors more innovative?

	Out - degree	In – degree	Betweenness
New product/service	0.03	0.14	0.14
Ideas	0.14	-0.01	0.18
New process	0.22	0.50***	0.25
New strategy	-0.02	-0.28*	-0.16
New structure	0.04	0.03	0.12
New marketing	0.10	0.12	0.10

Table 6 Correlation between the innovation and centrality. The correlation measure we have used is the Pearson's R and has been calculated using STATA.

***** = significant at the 99% level, ** = significant at the 95% level, * = significant at the 90% level**

From the correlation matrix in Table 6 we can see that most correlations are positive, suggesting that answering yes to the innovation questions are positively correlated with centrality. We have interviewed 37 actors in this populatin, we will therefore still include correlations at the 90% level. Regarding the centrality measures we now find four negative correlation coefficients. The only negative and significant correlation we find is between in-degree and the likelihood of introducing a new business strategy, with a correlation coefficient of -0.28.

We find that in-degree is the only significant centrality variable. In-degree and the innovation question: made use of new production processes has a correlation coefficient of 0.50 and is significant at the 99%. We see that new production processes is positively correlated with the other two centrality variables as well, though not significant. In-degree correlation with both ideas and new structure are close to zero and there seems to be no correlation at all. We see that most correlations are weak, meaning too close to zero to find significant correlations. Contrary to the subsea population, the betweenness centrality variable is not significantly correlated to any of the innovation measures.

Coefficient	*Logistic regression with new production process, new technology, components or materials as the dependent variable*				
In-degree[25]	0.25*** (0.09)	0.30** (0.13)	0.33*** (0.13)	0.25*** (0.09)	0.33*** (0.12)
Number of employees		0.01 (0.01)			
With higher degree			-3.12** (1.55)		
Employees in R&D				2.04 (5.40)	
Number of incentives					1.37** (0.55)
Constant	-1.62* (0.84)	-3.11** (1.29)	-0.71 (1.02)	-1.70** (0.86)	-4.54*** (1.71)
Log likelihood	-17.79	-13.58	-15.21	-17.71	-12.34

Table 7 Central position effects on process innovation. In the table there are five regressions, and all has process innovation as the dependent variable. We see that higher in-degree will have a positive effect on the whether the company has process innovation or not. In the first regression there are no control variables, but in the four other regression different controls have been added, and the effect of in-degree does not changes dramatically. It has significant positive effect.

***** = significant at the 99% level, ** = significant at the 95% level, * = significant at the 90% level**

As with the subsea population we ran five regressions, first, the simplest one only including in-degree as explanatory variable, then we ran four new regressions. Each regression with a

[25] We ran logistic regression using Betweenness and Out-degree as centrality measure, however, we did not find any significant results, and they are therefore omitted from the analysis.

different control variable, to see if result stay the same. It is only regarding the innovation question; made use of new production processes, technology, components and materials that we find any significant coefficient, not any of the other innovation questions gave significant results using them as independent variable. The coefficient for in-degree is positive, which means that in-degree has a positive effect on the likelihood that the company has made use of new production processes. We further see that the coefficient does not change considerably even if we include a control variable. In addition, we see that the coefficient now is significant at 99% level compared to the subsea population where the significance level was 95%, thus increasing population size gave more significant findings.

As in the subsea population, we find that in-degree centrality has a significant effect on the likelihood for a company to have made use of new or significantly improved production processes, technology, components or materials. This supports H3, however, we are still inconclusive when it comes to H4, as the two other centrality measures to not affect the likelihood of innovation. We will discuss our result further in the next section.

7.0 Discussion

We have organised the discussion of our results according to the presentation of theory. We will first discuss the finding that there is high degree of collaboration in the subsea industry despite it missing a cluster initiative. We will then discuss the results that having a central position affect the likelihood of being process innovative, and that we are left inconclusive regarding centrality and other innovation measures.

7.1 Collaboration in the subsea industry

In the analyses of the subsea population and the extended population presented above in section 5.0 and 6.0, we found dense networks with high degree of collaboration. These results are interesting as there are no cluster organisations facilitating this collaboration or helping to build trust between the actors.

If we look at Table 1 in 2.2.1, we expect the network in an industry with a synthetic knowledge base to consist of few actors and have low density. We found a network with high density, however we also found collaboration within the value chain, which was characteristic of synthetic knowledge base industries. The value chain within the subsea industry could therefore partly explain the dense network we observe. One of the actors we interviewed said that before their product ended up at an oil company it had “visited” three other companies in the subsea network displayed in 5.0. We do, however, also observe several vertical links in Figure 2, showing high degree of collaboration among actors who “should be rivals”.

We described in theory section 2.1.1, that innovation is based on a customer need, and often the customer tells the suppliers what they need and ask them to provide a solution. Some of the actors in the subsea population have said that they are sometimes the supplier and other times the customer, it depends who has a contract with an oil company. We also know that oil companies collaborate with each other, because it is possible to find out which companies share a licence on a field[26], in addition to this, all oil companies told us during the interviews that they look at other oil companies more as collaborator than competitors. This collaboration, between the subsea companies’ customers, could be one reason for the high collaboration between the subsea companies, the reasoning for this will be discussed below.

When the customer is part of a developing project, they select the suppliers they expect to be able to help them with a solution. During such a process, relations between the suppliers occur, and this can then help suppliers in later collaborations as the actors now know and trust each other. If a supplier has made a positive impression on an oil company, it is more likely that the oil company wishes to use that particular supplier in new projects and recommend them to partners.

Most of the subsea companies we interviewed said that their performances was their main activity for achieving competitiveness. Their performance gave them a good name and a solid reputation, and they often used successful projects as reference. Some examples of what subsea company respondents said: “Our reputations is the most important”, “We are not better than our most recent project”, “We do not use marketing because it is only project completion that matters”, “Customers know that we deliver as agreed; on time and at the right price, this is why we succeed”. All these quotes demonstrate that the subsea companies put a lot of effort in making a good impression, because they know that the relationship with the customer is important for future work.

According to the stricter definition of a cluster we presented in 2.3, the subsea network in Rogaland cannot be defined as a cluster because they do not have joint action. However, despite the lack of formal cluster initiative, there is still a great deal of collaboration among the companies, and the actors themselves look at Stavanger as a large oil and gas cluster.

[26] This is public information made available by the Norwegian Petroleum Directorate, see www.npd.no

Actor SF 15 believed that the other subsea cluster initiatives in Norway[27] were established in order to compete with the strong cluster in Rogaland. Another reason why there are no cluster organisations here might be that just being close and having a strong dependency to the customer stimulates collaboration, knowledge exchange and innovation, which keeps the cluster successful.

7.1.1 Government collaboration

Some projects are supported by the government, e.g. Demo2000, where the government, customers and suppliers try to solve challenges together. The numerous government supported developing projects that the subsea companies are involved in, can therefore substitute the cluster organisation as joint actions in the subsea industry in Rogaland. The reasoning for this will be discussed further in this section.

The Norwegian government has been mentioned as essential for the innovation development in the subsea industry by many of the respondents, both subsea and oil companies. One respondent said that maintaining contact with the government is crucial, as they are the ones who make the framework and set the limitations of which the oil and gas industry has to operate within. However, the importance of government collaboration, and to what extent it is a collaboration, varies between the different actors, because they have no other choice but to collaborate with the authorities. Some respondents point out that Norwegian authorities are so successful because they listen to what the industry says. Most actors mention the Petroleum Safety Authority Norway as important and some mention the Norwegian Petroleum Directorate, which are both located in Rogaland. For a graphic view of the collaboration between the industry and government, see graph in Appendix 2 Network including all RIS organisations.

In 3.3 we explained government influence and gave the example of the Skuld project. Regulations have therefore been a driver for innovation in the subsea industry by highlighting to the oil companies what is expected of them, thus oil companies need the suppliers to deliver satisfying solutions. Several respondents, who have participated in projects with government said, however, that the most important return from this was that it helped increase the company's network. The majority of the respondents stressed the importance of building and maintaining networks as a reason for success. Respondent SF 8 said: "it is little help in

[27] Recall NCE Subsea and Subsea Valley.

just throwing money at a problem, alliances and networks are vital when developing plans and projects."

We believe that the answers we got from the industry and the theory presented, suggest that the government funded projects can be part of building bridges and necessary trust between the companies in the subsea industry in Rogaland, which could lay the foundation for joint actions in the next step.

Not all companies have been only satisfied with the outcomes of projects like SkatteFUNN, Demo2000 and others involving suppliers, customers, competitors and authorities. One said that in these types of projects, everyone gets a clear picture of what the customers are requesting, however, it gives too much transparency in what the competitors are doing. The development of ideas is run by the ones who shouts the loudest, which directs the innovation development in a negative way.

7.1.2 Collaboration with universities

In 7.1.1, we showed that government collaboration is important for both collaboration and innovation activity in the subsea industry. RIS literature mention that having a relationship with educational facilities is important for innovation, however, the synthetic knowledge base is not characterised by a strong university – industry link like an industry based on analytical knowledge. This is strongly supported by the answers from the industry we have examined. According to the answers from our respondents, technology development in collaboration with universities and research institutes takes too long because they lack incentives to earn money. Company, SF 22, who said that they were collaborating with UiS (University of Stavanger) stated the following: "the challenge with this collaboration is that UiS is seeking to find new technology and does not care if it takes a month or a few years, in the meantime our customer wishes to commercialise the innovation as soon as possible."

Even though universities and university colleges are not the preferred collaborator in innovation products, the industry say that the university still is important. A couple of respondents said that they collaborate with universities, even though there is usually little knowledge to gain from that type of collaboration. The companies say collaborate with the universities because it helps them with their reputation, and they actively use universities to recruit people to their companies. It is striking how few respondents mention UiS[28] as important seeing that it is the only university in the region, and some theory suggests that the innovation process is harmed when relations to complementary educational facilities are not well developed.

7.2 Centrality in the network and innovation ability

All respondents in the subsea population said that it was important to collaborate with their customers, and the majority said that they had to have a strong relationship with their final customer, the oil companies. It is therefore not surprising that we find an oil company to be most central in the extended social network analysis.

Finding that centrality is important in a company's process innovation might not be surprising. Not everyone are able to take the risk of applying "new" technology, use new components or materials because they cannot afford not succeeding. This because large investments are needed and it can harm their reputation, thus leaving them without new assignments. Being central and having several links to the network, the actor is more likely to obtain useful knowledge, see page 20, and can learn from other actors, thus in a better position to evaluate the risk. Some confirm this by saying that they only use existing materials, components and technology and put it together in new ways because they cannot risk being left out of the competition because they have used an untested component. Part of the reason for the extensive testing, some respondents said, is the major loss of revenue if production has to stop, and under 2.1.1 we explained that risk is one of the main concerns when developing new products and services in the subsea industry. Therefore many actors call the oil and gas industry conservative despite there being considerable innovation activity.

The answers we got from the actors we interviewed suggest that being a central actors might not only influence innovation within the company, but being central also influence innovation in its collaborative companies. This is confirmed by the following statements: SF 12, said that "our dream is to make a product no one can be without, and therefore make sure that oil companies require other suppliers to use exactly our product in a particular solutions." He continued, "this is how this industry works; you make a product and the customer tell other suppliers they have to use it." This shows how important the customer can be for the supplier as well as giving a good example of a situation where central actors can lead to less

[28] Many engineers have a preference for NTNU in Trondheim, because of this university's strong tradition and reputation educating engineers.

diversification. When the oil companies tell the suppliers what kind of solution they should use, the suppliers will not be inspired to develop better solutions or better technology. However, SF 30 said that “it is inspiring making a product someone just need to have, so if you succeed making that product or service the customer need, you will earn lots of money.” Furthermore, some subsea respondents said that in order for them to be innovative, the outcome of an innovation project needs to be purchased before they begin the developing because it is too expensive developing it on their own.

High developing cost might enhance the customers’ position and power by them controlling the development. But without a strong customer, prices of the products and services delivered by the subsea companies might have been even higher, and the engineers might lose focus of cost, thus overdesigning and overdeveloping products. SF 24 said that engineers in this industry need someone with a business administration background making sure that their inventions actually can be sold and not only be bragged about. “Engineers sometimes just want to make something cooler than their mates in a competing company.” This might not be innovation in a positive matter.

When we see it from the customer perspective, and we know that the customers want high quality products at the lowest price possible, the oil companies have strong incentives to take part in innovation projects and to finance the suppliers in their innovation activities. Because when taking part in this, the oil companies are able to make sure they have rights to new discoveries and new technology or any patents taken.

Innovation in the subsea industry is incremental, and often tailored or produced in small scale. This might be changing as all oil companies we interviewed mentioned standardisation and availability of technology as important to them. The reason for wanting more standard products is the simple fact that the oil companies then can pick and choose whichever supplier they want during the entire oil and gas production process, and no longer be stuck with the one chosen at the starting point. Further on, this flexibility will increase the competition between their suppliers, thus lowering prices and increasing the quality of products and services. Some suppliers have seen this coming, which has materialised in a joint venture between two leading subsea companies, FMC Technologies and Technip, called Forsys Subsea. The aim of the joint venture is to reduce the cost of subsea field development and provide technology to maximise the well performance on fields (Technip, 2015).

Some suppliers' replied to the statements above that the wishes of standardisation and availability of technology from the oil companies are two faced: The oil companies are the ones demanding a specialised or tailored product, they are the one needing the specification and so forth. Thus, in many ways the suppliers feel that the oil companies blame the suppliers for the high cost, and the suppliers blame the customers because they constantly demand something different. However, at the same time, the suppliers want to make sure that they are the preferred supplier for years to come. If a supplier manage to sell a solution they are the sole supplier of, they have managed to keep that oil company as customer for a long time, which also gives the supplier some influence. Suppliers with a long-term contract with an oil company will therefore be the customer to many of the other subsea companies in the network, as we said earlier there are sometimes another subsea company being the customer.

In 2.3 we also explained that when there are several customers and suppliers located in close proximity, the customers can allow themselves to be demanding, and require constant communication with suppliers. This is confirmed from several of the respondents during the interviews. One said that they have contact with their customer 24 hours a day, 7 days a week and others have said that being close to the customer is the reason they are located in Rogaland. The close communication helps build personal relationships that facilitates information and knowledge sharing. Also, the close contact push the subsea companies to perform better than their competitors, which can increase innovation.

One concern raised in the extended population is that there are two actors who hold much more central positions than other central actors in the network. We have above given reasoning for finding an oil company to be the most central. We did however find a subsea company to be considerably more central than any other of the subsea companies. SF 7, who has very high betweenness, average in-degree and highest out-degree. This high out-degree might be overestimated, because the actor spoke on behalf of the whole company and not only the entity in Stavanger. However, the reason for having entities in different regions is because being close to the market is important for the understanding of culture, norms and collaborating companies. Most companies with entities in other parts of Norway and abroad have said that close collaboration within their own corporation is important to the companies' success and innovation.

We have mentioned above when central actors are dominant, it can retard innovation as the dominant actors have too much influence over other actors and can control the innovation.

Respondent SF 23 said, "The problem with someone being big is that they look for the solution that they like, which is not necessarily the best solution. And when suppliers are dependent on them, they end up not delivering the best possible solution but the solution that the customer demands". The same respondent said that he was concerned that the large companies did not listen to the smaller, even if they had the best solution, because the large ones were afraid to lose face.

For the actors that are central in a network, it can facilitate a common understanding of the principles of collaboration and with that increase the knowledge exchange among the actors. We have shown that the central actors have to be aware of their influence and use it with caution, making sure they do not retard the innovation process in this industry, some of the smaller companies might have ideas worth a life.

7.3 Limitation

Some of the questions were difficult for the respondents to answer, which might give a variation in the answers that could have been avoided, as the respondents seemed to answer differently depending on their position in the company, as well as their educational background. In the oil companies all respondents held similar position, however, there were big differences in the size of the subsea departments in the companies, varying from a couple employees to hundreds of employees. In the subsea companies our preferred choice was the general manager or CEO. If that person was unavailable, he[29] would delegate to answer to another person in the company he saw fit.

During the interviews it became apparent that different professions have different interpretations of certain words, e.g. collaboration and innovation. To minimise the variation in how the respondents interpret the question, we always answered the same if they asked, "What do you mean by collaborating?" Our answer would be "Who do you collaborate and exchange knowledge with; this can be your customers, suppliers, competitors or others", and added that he was the one to best decide if they had collaborative relationship or only had a customer – supplier relationship. Some then said they had to collaborate with everyone because all their products or services are tailored. And some, even though they had mostly tailored products said that they only had customers, saying "they say what they need and we provide them with it".

[29] In the subsea population we only interviewed one woman, being the only woman holding a leading position of the subsea companies in Rogaland.

With SNA the issue of reliability appears in whether the questions we ask to measure the network and its actors are accurate. Therefore the variation in how the respondents interpret the questions affects the reliability of the findings. However, as we only use binary data and not valued data, thus ruling out the strength or importance of the collaboration. This gives more valid data according to our research question, and we feel confident that all respondents had good knowledge about whom they collaborate with.

Also, when using the roster recall methodology in research, it will only be successful if we have a very high response rate (Ter Wal & Boschma, 2009). This is true for the subsea population, but not in the extended population. Therefore, there will be shortcomings in that part of the analysis. The low response rate will also affect the analysis in a way where key actors might be missing from the network analysis, and we will not obtain innovation measures from those.

The relatively small number of actors in the subsea network (as well as the subsea and oil companies' network) gives limitation when running logistic regression, but still it could provide useful insights since we spoke to all but one company.

In total we believe that the results will be both valid and reliable for the subsea population in Rogaland.

8.0 Conclusion

In this study we have examined companies within the subsea segment of the oil and gas industry in Rogaland. Innovation in the subsea industry is often based on a customer need. Very often innovation is a tailored product or service. Several innovations happens in projects, and many of the actors are dependent on the costumer to be willing to create new products or services.

We have studied if a company's position in a collaborative network can affect a company's innovative ability, with the following research question:

Will a company's position in a network affect its ability to innovate?

To be able to answer this question, we have (1) described how the subsea network in Rogaland looks like, and we have (2) used centrality measures to show who the central actors are.

We have presented theory on innovation and then especially innovation within the subsea industry. The cluster and network theory was presented using four hypotheses. The two first hypotheses regarding collaboration between companies in a cluster are: (H1) A cluster needs joint action for the companies to collaborate with each other. (H2) A cluster does not need joint action for the companies to collaborate with each other. The latter two hypotheses regarding central position in the network and innovation ability are: (H3) A central position in the network makes the company more innovative. (H4) A central position in the network does not affect a company's innovative ability.

We have found that the subsea network in Rogaland is very dense, with nearly a ¼ of the possible links in the network actually existing. Furthermore, the analysis shows a large number of cliques in the network, both measures suggesting a high degree of collaboration and knowledge sharing. The results from this study show that in the subsea cluster in Rogaland there is high degree of collaboration without a joint action, this supports H2. There does not exist any official cluster initiative/organisation in the region, and actors in the networks say that there are no joint actions to make them cooperate and strengthen the cluster. However, many actors do take part in projects, financed both by government and customers, thus projects can lay foundation for building bridges and trust between companies which is a prerequisite for joint actions.

Most actors in the subsea and the extended network are innovative, having answered yes to one or more of the questions regarding innovation. In the highly collaborative network, there are a few actors who hold central position, in the extended network we find similar results, however, there are two actors who stands out as very central actors, SF 7 and SO 1, a subsea company and an oil company respectively. When it comes to offering new products or services or having ideas, we do not find any significant effects of being a central actor. However, the hypothesis that network position can explain a company's ability to innovate, (H3), is strongly supported when using the centrality measure of in-degree to explain a company's likelihood to be process innovative, the effect of in-degree is even more significant in the extended population than the subsea population. We do not find significant results using neither out-degree nor betweenness centrality measure as explanatory variables on any of the innovation measures. H3 is therefore partially supported, and we are left inconclusive when it comes to H4.

During and after the months of our data collection, the employment in Rogaland has changed drastically. As we said in the introduction, thousands have lost their jobs in the oil and gas industry. The drastic change means that some of the data, and therefore parts of the analyses, might not reflect todays' picture even though the data was collected a couple of months ago.

At the same time, the subsea cluster in Rogaland will now meet their largest challenge as of yet. Are they a cluster with the ability to reinforce and renew itself? Does the cluster have the ability to stay competitive and innovative, and meet the "low cost" demand from the rest of the industry? Because of these challenges the industry currently is facing, it would be interesting to do a similar study with the same companies in a couple of years. We could then explore if the cluster has managed without joint action, we can also say more about possible advantages the central actors have if we could measure them in two different time periods.

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Appendix 1 Questionnaire

VRI synthesis project: A novel innovation program but how successful? VRI’s capacity of regional innovation system formation and new path development

Questionnaire version 2015-02-24

General Information:

All information is treated confidentially, i.e. it will not be possible for anyone to identify your firm and name. Moreover, no individual firm or organization will be mentioned in any publications based on these interviews. If such a need should arise, we will contact you again and ask for permission. If you then say no, we will respect that.

Name of interviewer: ______________________________

Date of interview: ______________________________

Name of firm: ______________________________

Address of firm:

____
____
____

Bransje/næringssektor: ______________________________

VRI region: ______________________________

Name of respondent: ______________________________

Function of the respondent:

- o CEO
- o Entrepreneur
- o head of technical department / R&D department
- o head of commercial / marketing department
- o other, please specify: ______________________________

Part 1: Introduction

This part of the interview aims at capturing general information about the firm, including size, age, main activities and skills available in the firm.

1) Is your firm part of a larger enterprise/group?
   a) If yes, in which region is the head office of the enterprise/group located?

   If your firm is part of a larger enterprise or enterprise group, please answer the following questions only for your firm in [region]. Do not include results for subsidiaries or parental organisations outside [region].

2) In which year was your firm established? In case of merger or acquisition, indicate also the year in which the most recent merger or acquisition took place.

3) Has your firm always been located in [region]?
   a) If no,
      i) Where was it located before?
      ii) When did your firm move to [region]?
      iii) What was the main reason for moving your firm to [region]?

4) What are the main activities for achieving competitiveness of your firm? (multiple selections possible)
   a) Production of tailor made products / processes for individual customers
   b) Production of standardised products / processes
   c) Product/process development
   d) Design
   e) Marketing
   f) Other, please specify

5) Could you please indicate how many employees (full-time equivalents) are working in your firm? What was this number 3 years ago?

6) What is the educational background of the employees? Please indicate the share (%) of the following areas of education (adding up to 100%):
   a) Total number with university or university college degree
   b) Natural and formal sciences (e.g. physics, chemistry, or mathematics)
   c) Engineering and technical studies (e.g. mechanical engineering, electrical engineering, etc.)
   d) Creative studies (e.g. arts, design, media, advertisement, etc.)
   e) Other, please specify

7) Please indicate which of the following skills and competencies are key for achieving competitiveness of your firm. Please indicate their relative importance from 1 (not important) to 5 (very important).
   a) Scientific skills (e.g. physics, chemistry, or mathematics)
   b) Engineering skills (e.g. mechanical engineering, electrical engineering, etc.)
   c) Creative skills (e.g. arts, design, media, advertisement, etc.)
   d) Other, please specify

Part 2: Innovation Performance

This part of the interview concerns the innovation performance of the firm.

8) Has the firm carried out the following changes in the last three years? (Yes/No)
   a) Introduced new or significantly improved products/services on the market
      i) If yes, how many?
      ii) If yes, is the (most important) products/services also new to the firm's market (and not just new for the firm)?
      iii) If yes, was the (most important) product/service developed primarily by the company itself and not external actors?
   b) Made important discoveries or breakthroughs that would hopefully lead to new products
   c) Made use of new or significantly improved production processes, technology, components or materials
   d) Introduced a new or significantly improved business strategy
   e) Introduced a new or significantly improved organisational structure
   f) Introduced a new or significantly improved marketing concept

9) Has your firm used one of the following intellectual property rights in the last three years? (Yes/No)
   a) Applied for a patent
   b) Registered an industrial design
   c) Registered a trademark
   d) Claimed a copyright
   e) Other, please specify

10) Has the firm employees that are most of their time occupied with the development of new products/services/solutions?
   a) If yes, how many (full-time equivalents)?

11) Please indicate in terms of percentage the relative importance of firm-internal and firm-external knowledge for the development of new products /services/ solutions (adding up to 100%):
   a) Knowledge generated inside the firm (closed innovation)
   b) Knowledge generated outside the firm (open innovation)

Part 3: Knowledge networks

This part of the interview deals with knowledge relations between the firm and the external environment. Different channels of knowledge are captured, including monitoring without direct interaction, recruitment of skilled employees, and interactive collaboration for innovation. This is meant to collect data for Social Networks Analysis (SNA)

12) Please name all organizations your firm **collaborates** and exchanges knowledge with (in the last 3 years). These may be firms, universities, research organizations, public agencies etc., and no matter whether these are located.
    [Provide here a list with all possible RIS organisation, but leave space for additional names]
    a) Please indicate the companies and importance for own innovation (importance 1..5)
    b) Please list other organisations that you collaborate and exchanges knowledge with, and indicate importance.

13) Please name all organizations from which your firm **recruits** highly skilled employees (in the last 3 years). These may be other firms, universities, technical colleges, etc., and no matter whether these are located.
    [Provide here a list with all possible RIS organisation, but leave space for additional names]
    a) Please indicate the companies your firm has recruited from and importance for own innovation (importance 1..5)
    b) Please list other organisations that you have recruited from, and indicate importance.

14) Please name all organizations your firm is **monitoring** in order to receive inspiration for its own innovation activities. These may be competitors, collaborators, universities, research organizations, public agencies etc., and no matter whether these are located.
    [Provide here a list with all possible RIS organisation, but leave space for additional names]

    a) Please indicate the companies and importance for own innovation (importance 1..5)
    b) Please list other organisations that you receive inspiration from, and indicate importance.

Part 4: Policy Initiatives

The last part of the interview concerns the firms' awareness of existing policy initiatives and explores their value for the firm.

15) Have you heard of the following policy initiatives and support measures for innovation? (if the interviewee has not heard of a single support measure continue with question 21)
    a) Funding through the skatteFUNN (tax deduction) scheme
    b) Activities (grants and beyond) associated with VRI (competence brokering program, mobility program, "bedriftsprosjekt")
    c) Project grants from regional research funds
    d) Project grants from Research Council of Norway
    e) Industry PhDs funded by Research Council of Norway
    f) Grants from Innovation Norway
    g) Loans from Innovation Norway
    h) Programs managed by SIVA (incubators)
    i) Participation in EU-funded research (CIP, FP, Horizon2020)
    j) Others, please specify

16) Which of the above mentioned initiatives have you used? (if the interviewee has not used a single support measure continue with question 19)
    a) Funding through the skatteFUNN (tax deduction) scheme
    b) Activities (grants and beyond) associated with VRI (competence brokering program, mobility program, "bedriftsprosjekt")
    c) Project grants from regional research funds
    d) Project grants from Research Council of Norway
    e) Industry PhDs funded by Research Council of Norway
    f) Grants from Innovation Norway
    g) Loans from Innovation Norway
    h) Programs managed by SIVA (incubators)
    i) Participation in EU-funded research (CIP, FP, Horizon2020)
    j) Others, please specify type

17) Specify for the above mentioned policy initiative the way in which you benefited. This question is repeated for each mentioned policy initiative. Policy initiatives enabled you to:
    a) strengthened core competences and organisational routines
    b) develop capabilities in new areas
    c) access to market knowledge
    d) access to technological knowledge
    e) access to management knowledge
    f) access to risk capital
    g) access to infrastructure (e.g. laboratories)
    h) direct financial support
    i) networking with customers
    j) networking with suppliers
    k) networking with universities / research institutes
    l) human resource development (e.g. training)
    m) Other, please specify

18) Which policy initiatives supporting innovation has been the most important for the firm?

19) Why have you not received support of any of the named initiatives? (multiple answers possible)
   a) Project was turned down
   b) Lack of information about support programmes
   c) Complicated structure of support system
   d) Lack of time
   e) Supporting instruments do not fit for the company
   f) Other, please specify

20) What support would your firm need?
   a) Support for development work conducted by the firm itself
   b) Support for collaborative development work involving other firms
   c) Support for collaborative development work involving universities or research institutes
   d) Education and training of employees
   e) Information about markets
   f) Information about new technologies
   g) Consultancy
   h) Help to find partners
   i) Other, please specify

Thank you for the interview. If you would like to receive a copy of the final research report, please indicate here. YES/NO.

Appendix 2 Network including all RIS organisations

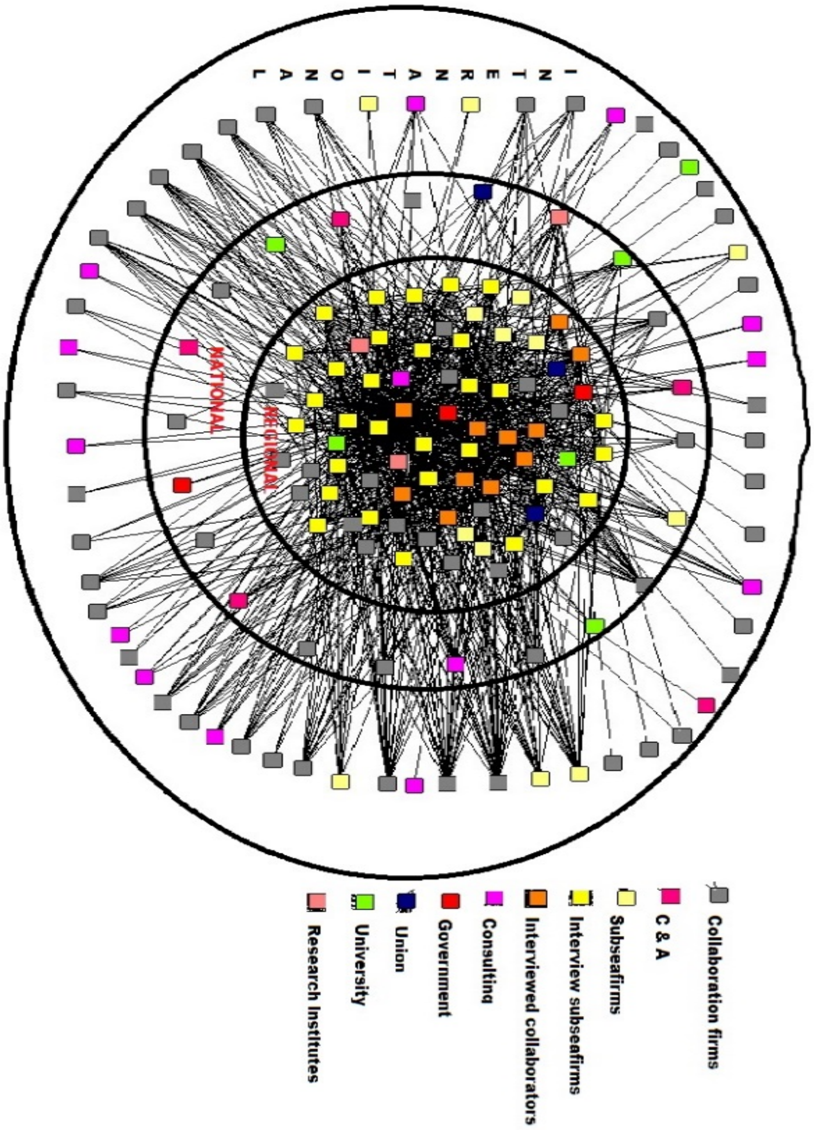

Figure 4 Collaboration between all RIS organisations. This figure shows all the companies and organisations mentioned by interviewed companies on the roster recall. In this figure all the companies we have interviewed are denoted by yellow and orange nodes placed in the middle (the regional level), all other companies have been placed according to where their head offices are located, on a regional, national or international level. The colour of the node denotes what type of organisation it is, and a description of the colour scheme is found next to the graph. As one can see there are many connections telling us that the subsea companies have many collaborators.