UNIVERSITETET I NORDLAND
HANDELSHØGSKOLEN I BODØ • HHB

MASTEROPPGAVE

Innovation in the drilling and well value chain

An ecosystem perspective

Bjørn Torstein Bruun
MBA HHB - Bodø
BE320E

Acknowledgements

I would like to thank Roger Sørheim and Vidar Hepsø for valuable help and guidance for this thesis. Further I would like to thank Erik Nyrnes for spell checking, and Steinar Strøm for making my MBA study possible. I would also like to thank my respondents for their time and willingness. Big thanks also go to Statoil for all assistance throughout my studies. Last of all I would like to thank my two sons, who have been so patient with their father for the last three years.

Summary

This is an MBA master thesis written for Business School, University of Nordland. The topic of the study is to identify barriers to innovation and examine how to build innovation capability through cooperation between the actors of the drilling and well value chain. The context of the study is drilling and well development projects run by Statoil in cooperation with external actors. The study conducted is a qualitative small-N type survey. A total of nine respondents were chosen for interviews, mainly form within the Statoil organisation. They were asked to explain their experiences with innovation activities and cooperation, both internally in Statoil and collaborations with external actors. As a theoretical foundation for the study theoretical subjects concerning organisational and dynamic capabilities, proximity theory, diffusion and translation of innovations as well as platform theory are used.

The main barriers to innovation found were divided in the categories industrial barriers and barriers to collaboration. The industrial barriers unveiled were shown to have their origin in the actors of the value chain’s incentives to innovate. Platform strategies and the use of dominant marked positions to favour own products are among the barriers discussed. Different perspectives on time, business models, and income potentials are found to be the main obstacles to innovation. Carefully selecting actors for collaborations, and also providing incentives to collaborate are important issues to overcome these barriers. Different perspectives on time, business models, and income potentials are found to be the main obstacles to innovation.

When it comes to barriers to collaboration, undetermined roles with respect to the commercialisation of end products, actors’ lack of involvement throughout the innovation process and dependency of individuals were identified as typical issues. Another issue addressed was the lack of involvement of actors throughout the innovation process. Risk averseness among actors and individuals, was also found to be a hindrance for new innovations, as well as lacking incentives for using new technology and involvement throughout the innovation process. Prioritisation of innovation related activities among actors, mainly occupied with mainstream business activities, was also found to be a hurdle for innovation.

In terms of building capability to innovate and overcome hindrances to innovation the study has a special focus on relations. Two distinct types of relations between actors are identified, which have been named the informal team relation and the pure contractual relation. The informal team relation, characterised by close relationship, involvement throughout the innovation process, openness, trust, and mutual respect among the involved actors was found to be the most fruitful for successful innovation. Social proximity was found to be vital for this relation, and temporary geographical proximity is important for building the necessary social proximity.

Another aspect discussed is the importance of aligning and creating incentives to collaborate on innovation activities. For external actors this mostly is about creating economic incentives, utilising competition, access to new markets, direct economic gains etc. to stimulate the actors' willingness to collaborate. For the internal actors prioritising, creating a culture for, and providing direct organisational and individual goals for innovation are tools to create such incentives.

The study further discusses translation processes among ecosystem actors and also the informal team, and shows how translation processes of mutual information exchange between actors affect the content of the innovation and the actors understanding of the innovation, and also their cognitive, technological, social and cultural reference frames, thus contributing with an understanding of how proximity between actors dynamically changes.

Contents

Table of tables

Table of figures

1.0 Introduction

A challenge faced by organizations is the adaption to an ever changing business environment. Due to globalisation and the progress in information and communication technology, change happens continuously and at a higher pace than ever before. For most businesses and organisations innovation is vital for sustained growth and long-time survival, the oil and gas industry being no exception. Remaining resources are getting increasingly scarce and harder to develop, and for many oil and gas companies innovation and adaption of new technology are seen as a strategic ability to secure reserve replacement and growth. For oil and gas companies there are two areas of innovation which are of particular interest. The first area is innovation which makes it possible to access resources which previously have not been technically possible to develop. The second is innovation which reduces the cost of production. Very often the two areas are linked. A rise in oil and gas prices might make technological solutions and recovery methods which were previously found to be too expensive commercially sustainable. On the contrary a drop in oil and gas prices might make established solutions and recovery methods unprofitable. Resources which were previously considered unrecoverable can also be made commercially viable by application of new and less expensive technological solutions. This is reflected in Norway's governmental commissioned national technology strategy for the oil and gas sector (OG21, 2012), which is based on the inputs of a broad selection of industry actors. The strategy includes exploration and increased recovery, and cost effective drilling and intervention as two out of its four technology target areas.

In this study the main focus is innovation and technology development within the drilling and well segment of the oil and gas industry. Although drilling operations are concerned with the seemingly simple task of drilling holes in the ground to drain oil and gas resources, the complexity of both technological solutions and actors involved are vast. Three main features typically characterises drilling operations. The first is the large investment cost. Drilling a well offshore of Norway can in total cost up to 1 billion NOK, with the main cost driver being the cost of the drilling rig, crew and related services which typically can be up to 6-7 million NOK per day. On the Norwegian continental shelf drilling and well investments exceeded 100 billion NOK in 2013, constituting approximately half of the total oil and gas related investment costs (OG21, 2014). Increased production, due to the application of new technologies has also over the history contributed to dramatic drops in the oil price, most recently seen with the rise in U.S. shale oil production (Baffes et al., 2015) due to the development of shale fracking technology (Jacobs, 2014). The second feature is the risk involved with the operations, where the extreme consequence of errors can be loss of lives, loss of the installation and huge environmental spills, as seen most recently with the Deepwater Horizon accident in the Gulf of Mexico. The safety aspect is also included in the national technology strategy (OG21, 2012). The consequences of less dramatic incidents can also be large, in terms of economic losses. The cost of delaying drilling operations must be taken into account, which typically will cost the above mentioned 6-7 million NOK per day, in addition to potential income losses due to the start production of the well. The third feature to be mentioned is the high degree of outsourcing in the drilling value chain where typically the operator company plans and oversees the operations: The drilling rig, equipment and crew being supplied by a rig company, and service companies supplying additional specialised services involved.

So how does this affect the technology development and innovation processes of the industry? Due to the high risk and cost perspective of operations, technology development and innovation processes is a thoroughly and time consuming process, not seldom the development and innovation phase spans more than ten years from the initial research phases are started until a new technology is fully qualified and successfully applied offshore for the first time. This correspondingly affects both the economic and personnel resources needed in the innovation process and constitutes a high economical risk, especially for smaller companies, and also where the total market volume consists of a relatively small number of units, such as topside drilling equipment. The structure of companies involved in the drilling value chain also affects the innovation process. For instance the main user of an innovation in terms of benefitting from the use of the innovation might not necessarily be the same company that provides the service or physically operates the new technology. This adds further complexity in the innovation process and can be a source of conflicting interests. Also the actors involved in operations typically are large organisations with their own internal complex organisational relations, making the innovation process even more complex.

This study looks from an oil and gas operator’s perspective upon the relations and interactions between the actors of the drilling and well industry. Both the relations between the actors at a company level and between the internal actors and stakeholders are subjected to study based on the experiences of senior professionals within the drilling industry and related innovation

activities. Drawing on experiences from research, development and innovation activities conducted by Statoil in cooperation with third parties as a basis, the aim of the study is to shed light on the innovation process within the drilling domain, trying to identify potential obstacles to innovation, and to contemplate on how to achieve effective and successful innovation results. Both questions are of high interest not only to oil and gas operators, but also to other actors involved in drilling and well related innovation, spanning from rig companies, established service companies and equipment manufacturers to smaller entrepreneurial companies trying to make a break in the drilling market.
To narrow down the problem setting, the following research questions have been formulated, and trying to answer them in the given context are the main objectives of the study:

- How do the established structures in the drilling industry affect innovation?
- What are typical obstacles in the innovation process?
- How can innovation capability be built in cooperation between actors?

On the theoretical side the angle of approach selected to attack the problem, is looking through the glasses of diffusion and translation theory for innovation, capability theory, platform theory and proximity theory. These theoretical perspectives are central in the further analyses.

The thesis is structured as follows:

- Chapter one gives the introduction and relevance of the problem setting
- Chapter two contains the theoretical background, with subchapters giving an introduction the relevant theoretical aspects.
    - Chapter 2.1 giving an introduction to diffusion and translation theory
    - Chapter 2.2 platform theory
    - Chapter 2.3 Organisational and dynamic capabilities
    - Chapter 2.4 Innovation capability
    - Chapter 2.5 Henderson et al. (2013)'s capability stack model
    - Chapter 2.6 Proximity theory
    - Chapter 2.7 Gives the conceptual framework for the further study
- Chapter three gives a short description of the study context, the actors involved and Statoil's technology qualification process

- Chapter four describes the methodology for the study, with subchapters covering problem analysis, research design, description of the data collection, selection of respondents, data analysis and the validity/reliability of the study
- Chapter five contains empirical findings form the study. Emphasis has been made to use quotes from the respondents as a telling part of the text. As an overall covering subchapters on barriers to innovation, cooperation issues, and proximity aspects
- Chapter six contains the analysis and discussion part covering analysis and discussion on innovation models, industrial barriers to innovation, barriers to collaboration, relations between actors, proximity and building innovation capability
- Chapter seven containing the conclusion and final remarks
- Chapter eight contains literature references for the study

2.0 Theoretical perspectives

As theoretical foundation for the study theory covering the areas of diffusion of innovation (Rogers, 2003) and innovation as translation (Hepsø, 2007; Latour, 1990), dynamic and organisational capabilities (Grant, 1996; Teece et al., 1997; Lawson and Samson, 2001; Zollo and Winter, 2002; Ambrosini and Bowman., 2009, Henderson et al., 2013) , platform constructs (Cusumano and Gawer, 2002; Eisenmann et al., 2009; Baldwin and Woodard, 2009), proximity theory (Boschma, 2005; Knoben and Oerlemans, 2006; Balland, 2012; Ben Letaifa and Robeau , 2013) are used. The following sections cover some concepts within the area.

2.1 Innovation in organisations as diffusion or translation

Rogers (2003:5) defines diffusion of innovations as "the process in which an innovation is communicated through certain channels, over time, among the members of a social system". In a diffusion view, thus the diffusion or spread of an innovation depends on four key factors: 1. the quality of the innovation, 2. the communication channels it being spread through, 3. time, and 4. the social system in which the innovation is diffused. For an innovation process to be successful, in terms of the diffusion process to be self-sustained, the innovation must be widely adopted, reaching a critical mass of adopters. Throughout the diffusion process the innovation can be seen as successively being adapted by the following adaptor groups: innovators, early adopters, early majority, late majority, and laggards. The concept of diffusion is widely adopted by several science areas, and especially within marketing theory.

For organisations Rogers (2003) proposes a model for innovation, which divides the innovation into a sequence of five stages, divided between the two broad activities initiation and implementation, see Figure 1. The initiation activity is defined as information gathering, conceptualising and planning for adoption of an innovation, ending with the decision to adopt the technology. The model divides the initiation activity into the two stages agenda setting and matching, whereas the implementation activity consists of the three stages of redefining/restructuring, clarifying and routinizing.

Agenda setting happens when a general organisational problem is defined, which creates a perceived need for an innovation. Matching is defined as the stage where an innovation is identified as matching with a problem on the organisations agenda, and where the matching of the innovation and the organisational problem is planned and designed.

Redefining/restructuring occurs when an innovation is reinvented to meet the organisation's needs and structure, and the organisation's structure is modified to fit with the innovation. Clarifying happens as the innovation is put into more widespread use within the organisation, and the meaning of the new idea gradually becomes clearer to the members of the organisation. Routinizing is when an innovation has become integrated in the regular activities of the organisation, and has lost its separate identity.

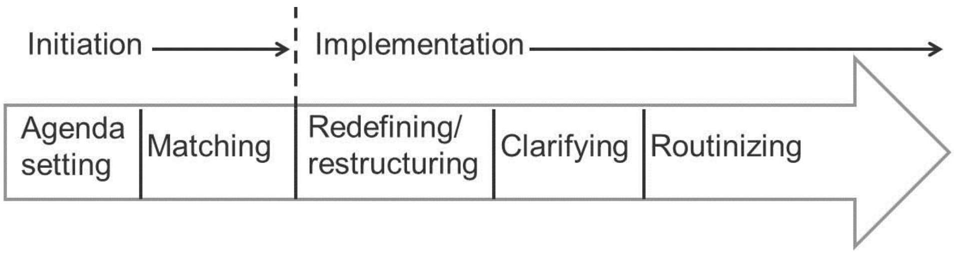

Figure 1 Innovation in organisations, ref Rogers (2003)

Hepsø (2007) offers an alternative view to seeing innovation as a diffusion process, presenting innovation as translation. The translation view differs from the traditional diffusion view through its strong focus on innovation as a relational phenomenon, whereas the diffusion view focuses on innovation as a process where the innovation follows a trajectory through a set of discrete phases from the idea phase to successful commercialisation. Hepsø (2007) argues that the diffusion view sees an innovation as having an inherent energy or quality, which for successful innovation forces the organisation and its members to adapt to the innovation. An analogy to this view is seeing an innovation as a bullet, which on impact meets more and more resistance, and its initial energy decides whether the bullet stops or in case of successful innovation penetrates the organisation. The innovation moves freely until it meets resistance and friction for instance in the form of resistance to change or competing concepts. In this view the adjustments, adaptions and organisational processes that need to be performed to get an innovation in place gets lower importance, as the inherent quality of the innovation will force them upon the organisation unless the resistance get to strong and the innovation dies.

The translation perspective presented by Hepsø (2007) focuses on the interaction between innovations and their surroundings of people, technology, organisational structures and governance. The innovation itself has little initial inherent energy, and is continuously being refuelled with energy through human and material forces surrounding it. In this perspective innovations are seen as a relational phenomenon where the actors translates the innovation to their reference frames, and through a process of meaning exchange and repeated translations adds meaning and physical content to the innovation. Through meaning exchange between actors the original content of the innovation is challenged, and both the innovation concept and the actors' understanding of the meaning content of the innovation is changed as the actors translate and adapt the meaning exchange to their own reference frames. As a result of this process the innovation concept becomes more robust and adaptable.

The effect of repeated translations between the actors can be understood through the concept of programs and antiprograms (Latour, 1990). Different actors can be seen as having different programs which governs their behaviour, the programs being defined by the individual actors' goals and perspectives. Latour (1990) in his publication focuses on programs and antiprograms opposed to each other, and focuses on enrolling support for a program by enrolling actors of the antiprogram through translation processes . However, this study has chosen to view translations done by the actors as changes of the settings of the actors' programs instead, seeing the actors' programs pulling in different directions. As a translation occurs it somewhat changes the settings of a programs, altering its actors' behaviour and direction of pull through their goal driven response to a new situation. Thus repeated translations between actors can end up in their programs converging against pulling in the same direction, or diverging, causing friction between the programs and actors. The understanding of translation processes are especially relevant to actors trying to develop new technologies, as they need to gain the support and contributions of other actors for the innovation process to succeed, as well as predict and steer the other actors' behaviour and responses. Latour (1987) gives examples of several strategies which actors can use based on translations.

2.2 Platforms constructs

The concept of platforms is of particular relevance to the oil and gas industry because of the complexity of operations and the wide spectre of vendors of technology and services being part of the business operations. Due to the vast network or ecosystem of technologies, services and vendors involved, extra complexity is added to the innovation process. One way of understanding the interaction between company and vendors, and the services and technology involved is in terms of platforms. A platform definition holds two key concepts, according to Henderson et al. (2013). It provides reusable functionality which can be used to achieve productivity gain when used in new innovations or applications. It also provides interfaces or mechanisms which enables the ecosystem actors to develop and offer distinctive functional services independent of each other. One could see a platform as a service or technology provided from one vendor, providing some interface where complimentary services or technologies can interact. Another way is to use the platform construct to generate layers of similar services or technologies in an ecosystem, providing similar interfaces to their surroundings. The layers can then be put together forming a layered or stack model of the ecology of services and technologies (Baldwin and Woodard, 2009). A broad example from drilling operations includes three layers consisting of; oil and gas companies on top, a middle layer of rig companies, and a bottom layer of service companies. The oil and gas companies plan and oversee operations. The drilling rig and its general manning are a service provided from the rig companies. Service companies provide specialised services or technology to be used in the drilling operation, often with smaller and even more specialised service companies as subcontractors, providing complimentary niche services like for instance mud-logging or directional drilling services. Each of the companies are capable of innovating or changing the contents of services they offer independently without imposing a need for vast adaptions and changes for the other companies involved in the operation. Yet they are capable to interact seamlessly, and drag benefits from innovation and development made by the other actors. The interaction is made possible due to the relatively standardised interfaces between the services and technology involved, consisting of technology interfaces, procedures, competence, governance elements and standard specifications.

For all actors in the ecosystem platform ownership, platform openness and interface control becomes important issues for competition and innovation. Platform ownership and interface control can be used for leveraging own products and be a hindrance for competitors in other areas. An example of this can be the drilling control system of the rig seen as a platform, whereas the control system provider through control over the interfaces can use this position to hinder other vendors delivering interfacing products competing with his own, and selectively chose which products from other actors to allow interfacing. On the other hand openness can open for better products and services and also be important for the demand for own product. Eisenmann et al. (2009) discusses the importance of selecting optimal levels of openness as a part of business strategy, dividing the actors interacting with a platform into the roles of; demand side platform users or end users; supply side platform users, who offers complements which can be used by demand side users together with the core platform; and platform providers which serve as user's primary contact with the platform; and platform sponsors exercising property rights, determining which actors allowed to participate in the platform-mediated network, and responsible for developing its technology. Each of these roles can be open or closed. Open meaning that no restrictions are placed on participation, development or use of the platform, and that other restrictions, like for instance license fees, are reasonable and non-discriminatory.

When choosing a horizontal platform strategy, targeting existing and prospective rivals, the sponsors especially have, according to Eisenmann et al. (2009), to take into account the benefits and drawbacks of; allowing interaction from rival platform with the focal platform's users; allowing direct participation from additional parties in commercialisation of the focal platform; allowing direct participation from additional parties in the technical development of the focal platform. When it comes to vertical strategy in addition to make-buy decisions there are according to Eisenmann et al (2009) three options sponsors have to consider; backward compatibility to complements when upgrading the platform; the advantages of granting selected complementors' exclusive access rights; and whether to absorb certain complements into the platform core.

Cusumano and Gawer (2002), discuss platform leadership, e.g. "the ability to drive innovation about a particular platform technology at the broad industry level" (Cusumano and Gawer, 2002:53). In their publication they identify four important "levers" to consider in a strategy for platform leadership. The first one, scope, comprises the amount of innovation to perform internally, and what to encourage others to do. The second product technology, comprises decisions about the architecture of the product and broader platform, e.g. the degree of openness of interfaces, the amount of modularity, and the amount of information to give outsiders about the platform and its interfaces. The third relationships with external complementors, comprises considerations about how competitive or collaborative the relationships between platform producers and complementors should be. The last one, internal organisation, comprises considerations of internal organisational structure, and how it can be used to manage internal and external conflicts of interest.

2.3 Organisational and dynamic capabilities

To get a grasp of the concept of dynamic capabilities, a god start is Grant's (1996) article about organisational capabilities. Thinking in terms of organisational capabilities instead of served markets gives an alternative basis for organisations to build their long term strategies on. In his article Grant (1996:377) states the essence of organisational capability as "the integration of specialist knowledge to perform a discrete productive task". Further Grant (1996:377) defines organisational capability as "a firm's ability to perform repeatedly a productive task which relates either directly or indirectly to a firm's capacity for creating value through effecting the transformation of inputs to outputs". An organisation's capabilities can thus be seen as specific abilities, gained through processes with individuals and their knowledge as building blocks, a view which is supported by Ambrosini and Bowman (2009). Henderson et al. (2013) through their definition of capabilities as "set of interdependent activities involving people, process, technology and governance that directly creates economic value", adds governance and technology to Grant (1996)'s definition, thus bringing in a full man, technology and organisation interaction approach to the understanding of organisational capabilities.

Building on Grant (1996), dynamic capability is defined by Teece et al. (1997:516) as "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments", bringing in operating routines to the definition, opposed to Teece et al.'s more generic use of competencies. Zollo et al. (2002:340), offers the following definition: "A dynamic capability is a learned and stable pattern of collective activity through which the organisation systematically regenerates and modifies its operating routines in pursuit of improved effectiveness". This definition is also supported by Henderson et al. (2013) who bring forward a view where dynamic capability can be understood as ability to innovate through combing resource elements involving people, process, technology and governance into new or reconfigured processes, as opposed to static capabilities like for instance the ability to mass produce a specific product through a static process. The term dynamic refers to renewal of the resource base, and renewal of resources, opposed to referring to dynamic environments or that the capabilities themselves are of a dynamic nature (Ambroisini and Bowman, 2009). Zollo et al. (2002) further arguments that integration, building and reconfiguration of a firm's competencies is not specific to firms operating in a rapidly changing environment, but also complies for firms operating in environments with slower pace of change.

Ambrosini and Bowman (2009:34) states that the role of dynamic capabilities is to "impact on the firm's extant resource base and transform it in such a way that a new bundle or configuration of resources are created so that the firm can sustain or enhance its competitive advantage", and also that dynamic capabilities comprise the four main processes; reconfiguration, leveraging, learning and creative integration. Reconfiguration is the process of transforming and recombining assets and resources. Leveraging is replication of processes or systems from one business unit to another, or deployment of a known resource into a new domain. Learning allows for a more effective and efficient performance of tasks, as a product of experimentation and subsequent reflection over failure and success. Creative integration comprises the ability to integrate assets and resources into new resource configurations.

Reegard et al. (2014), add another important aspect to the concept of dynamic capabilities, adding the issue of scalability. Scalability can be understood as how one goes from a working solution in one context or setting, to adjusting the solution for deployment in different contexts or settings, or to a larger deployment. Scalability in a dynamic capability setting then becomes an issue of "managing variations in capacity and complexity depending on contexts, by transferring, adapting and/or requiring resources and combining theses to meet the contextual demands for operations”(Reegard et al., 2014:5). Setting this into a dynamic capability context, a capability, although intended to perform the same objective everywhere it is deployed might need to inhabit different properties or configurations of resources, dependent on the specific operational setting it is deployed in. Reegard et al. (2014), also states that scalability is important to build global capability, ”understood as developing and deploying a capability that consists of the same core qualities regardless of where it is deployed” (Reegard et al.,2014:5). Pointing out that global capability doesn’t mean that the configuration of a capability is identical wherever it is deployed, but that the core of its realisation is.

Reegard et al.(2014) proposes a structure or work process for developing capability , they call the capability resource matrix. The focus of the model is the maturing of capabilities to be performed to reach a certain objective, where all people, technology, processes and governance elements building up the capability has to be matured through the levels of initial, managed, scaled, predictable and adaptable.

People	Technology	Process	Governance	Maturity level	
Continuous improvements and innovations to the capabilities				Adaptable	Objective
Predict and manage the future execution of capabilities				Predictable	
Scaling up the proven capabilities				Scaled	
Managing and in control of execution of capabilities				Managed	
Delivery of capabilities				Initial	

Figure 2 Capability resource matrix, ref Reegard et al. (2014)

At the initial level of maturity the main focus is removing obstacles and hindrances which might be in the way of repeating successful practises, in terms of what are the absolute minimum requirements for the capability to be successfully executed. On the managed level the main focus is to establish the necessary control and baselines for enabling the organisation to repeat successful capability execution on a regular basis. The scaling level is where the successful practices are being scaled to meet the ambitions, like for instance multiple implementations. The predictable level is where the infrastructure enables you to manage quantitatively the performance of your capability, and through the experience gained predict the capability's future performance. At the adaptable level the knowledge gathered is used to identify processes or capability elements which can be improved to provide further benefits.

2.4 Innovation capability

Lawson and Samson (2001) proposes a model for an innovation capability based in Kanter's (1989) model of "mainstream" and "newstream" processes, and dynamic capability thinking (see Figure 3). "Mainstream" activities are the ordinary business activities converting an input, like for instance raw materials, into an output, e.g. products. "Newstream" can be envisioned as business resources devoted to identifying and creating new value to customers, like for instance research activities. Kanter (1989) argued that the different resource needs for "mainstream" and "newstream" have to be recognised and their management to be largely autonomous for organisations to be at their most effective. This way of managing business units assists organisations in balancing tensions of stability and change. In this model "mainstream" activities provide funding for "newstream" activities, which in turn provide new products and processes to be assimilated back in the mainstream. Lawson and Samson (2001) raises critic against the model for not being adapted for a dynamic and turbulent operating environment, due to the independent managing of "mainstream" and "newstream" activities. They argue that successful commercialisation is threatened unless there are strong information flows and connection efforts between the two streams.

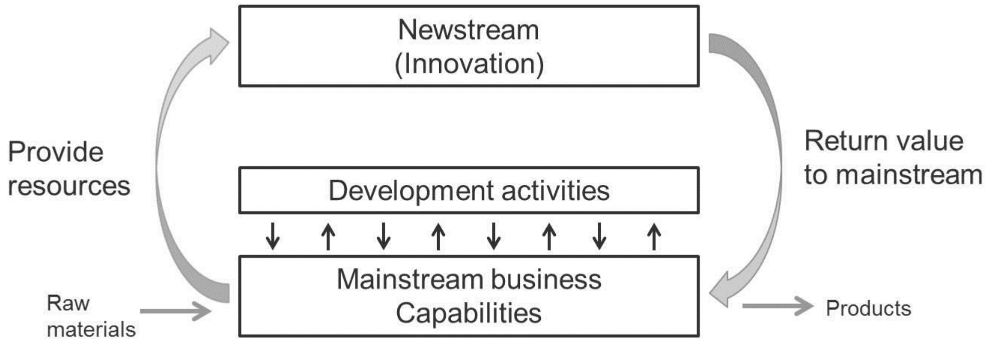

Figure 3 Kanter's model of newstream and mainstream, ref Lawson and Samson (2001)

Lawson and Samson (2001) instead propose the concept of innovation capability as a bridge between the "newstream" and "mainstream" activities, see Figure 4.

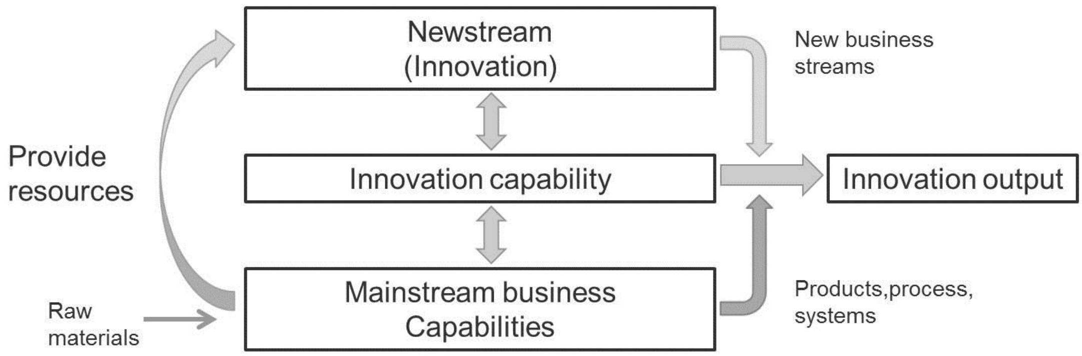

Figure 4 Integrated innovation capability model, ref Lawson and Samson (2001)

Linking the Lawson and Samson model to dynamic capabilities, their concept of an innovation capability can be seen as the process of merging resources, comprising technology, people, process and governance elements, from the "newstream" activities with activities and resources from the "mainstream" into reconfigured or new processes

2.5 Capability stack model

Henderson et al. (2013) combines the concepts of platforms and capabilities, defining the concept of a capability platform as "a set of capabilities deployed by multiple parties in a manner that: 1. Creates economic options value through design efficiency and flexibility. 2. Creates economic value through network effects generated by the ecology of organizations and individuals providing complementary goods and services. 3. Has explicit architectural control points that enable relevant stakeholders to systematically capture portions of the economic value that has been created" (Henderson et al, 2013:7-8).

Organising the ecosystem of resources available to the firm both internally and externally into a stack model, one gets a layered hierarchy of unique resources which are connected through standard interfaces, where changes or innovation in one layer are decoupled from the others as long as the information representing the change can be transferred through the standard interface. The resource stack can be seen as a foundation where organisational capabilities and capability platforms are formed through combining and integrating resource elements from the various stack layers. Due to the way capabilities are formed, the resulting capability platforms can be organised into a stack structure derived from the resource stack, where capabilities at higher levels to a large extent will be dependent on capabilities at lower levels, see Figure 5.

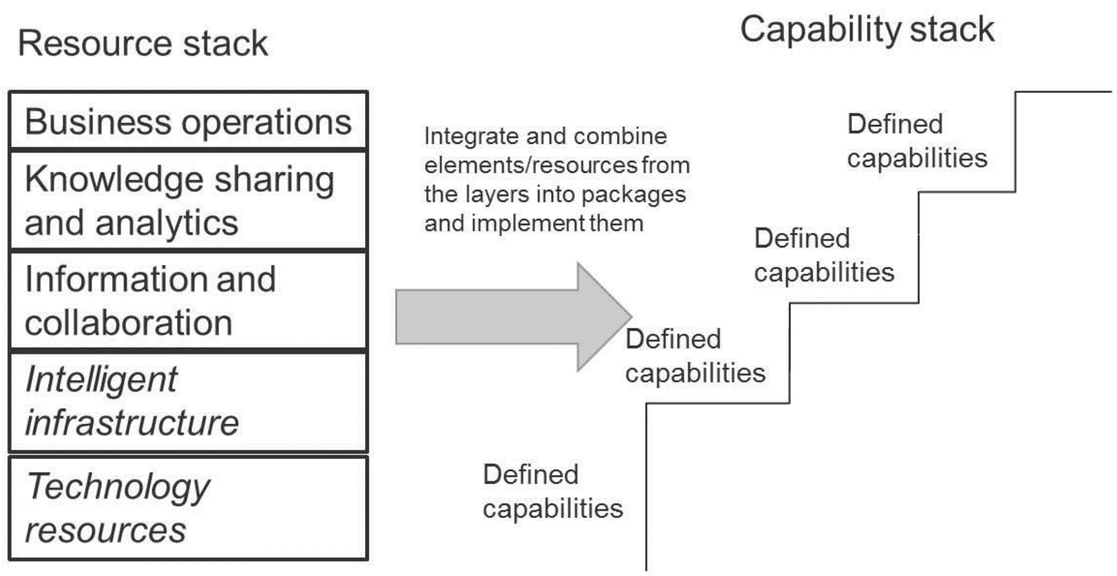

Figure 5 Example of stack model capability platform, ref Henderson et al (2013)

The capability platform concept offers a network driven innovation perspective, which emphasises the interplay between people, technology, process and governance, and provides a tool to examine and understand the way firms engage in networked relationships to develop distinct practices and impact performance.

2.6 Proximity

One important aspect for successful innovation and implementation of new technology through inter-organisational collaboration is the proximity of actors. Although often thought of as geographical proximity, other dimensions of proximity like technological or organisational proximity are just as relevant in inter-organisational collaboration (Knoben and Oerlemans, 2006).

Geographical proximity is by Boschma (2005:63) defined as "spatial distance between actors, both in absolute and relative meaning". Knoben and Oerlemans (2006) in their literature review states that literature differs slightly in their definitions of geographical proximity, some authors concerning about absolute geographical distance between actors, others concerning about distance in terms of travel times, whereas others again concern about actors perceived distance. Studies concentrate on two types of geographical proximity, dyadic distance between two interacting organisations, and clusters of organisations within the same geographical unit or area. The importance of geographical proximity lies in that small distance between actors facilitate face to face interactions, which in turn fosters knowledge transfer and innovation (Knoben and Oerlemans, 2006). The aspect of face to face interactions is also interesting due to the growth in information and communication systems such as internet-based social networks and videoconferencing systems. With this as background Torre (2008) brings in the term temporary geographical proximity, which implies that geographical proximity through short or medium term visits or meetings often are sufficient for the exchange of the information needed for cooperation between actors. Torre (2008) states that face to face interactions are only important in certain stages of the innovative process, and such interactions can be made possible through the mobility of individuals. However, small firms do not benefit from temporary geographical proximity as easily as larger due to high transport costs and insufficient human resources.

Technological proximity does not refer to technology itself, but is based in shared knowledge bases and technological experiences (Knoben and Oerlemans, 2006), thus relating to the knowledge actors possess about technologies and technological processes, and their capability for technological learning. Literature on the field divides technological proximity in two areas; the general level which concerns with a single actor's general capability for technological learning from other organisations, and the dyadic level which concerns about technological learning as an interplay between actors in some form of collaborative relation. At the general level technological proximity is based in the concept of absorptive capacity, described by Cohen and Levinthal (1990:128) as "the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends". Knoben and Oerlemans (2006:77) further states that on the general level "similarities in technological knowledge facilitate technological learning as well as the anticipation of technological developments". At this level an actor's capability to learn from other organisations is considered only to be dependent on the actor's own level of absorptive capacity, and thus the learning capability is independent of the studied organisations (Knoben and Oerlemans, 2006). For an actor's successful absorption of new external knowledge, the actor must inherit prior knowledge which on a basic level is similar to the new to facilitate knowledge assimilation. The basic knowledge will typically encompass some level of understanding of the underlying scientific discipline and techniques involved. However the actor also has to inherit an amount of specialised knowledge which has to be fairly diverse to permit for creative and effective utilisation of the new knowledge (Cohen and Levinthal, 1990; Knoben and Oerlemans, 2006)

On the dyadic level “technological proximity between actors facilitates the acquisition and development of technological knowledge and technologies” (Knoben and Oerlemans, 2006:77). Dyadic technological proximity is based in the concept of relative absorptive capacity, which implies that “the ability of a firm to learn from another firm is jointly determined by the relative characteristics of the student firm and the teacher firm” (Lane and Lubatkin, 1998:462). This is supported by Colombo (2003) emphasising that similarities in knowledge bases between actors, enhances the ability to understand and absorb partners’ knowledge, making mutual learning easier. However, the actors also need to inherit different specialised knowledge to be able to contribute with new knowledge to the inter-organisational collaboration, and also to be able to utilise the new knowledge offered by partners’ in an efficient and creative manner.

Organisational proximity is by Rallet and Torre (1999:375) defined as “the set of routines - explicit or implicit -which allows individuals of a same organisation to be co-ordinated without having to define beforehand how they must do it”, thus implying that organisational proximity encompasses both formal and informal coordination mechanisms. According to Boschma (2005:63) organisational proximity is “associated with the closeness of actors in organizational terms”, defining organisational proximity as “the extent to which relations are shared in an organizational arrangement, either within or between organizations”. Although noting that cognitive proximity can be seen as an element of organisational proximity, Boschma (2005) presents cognitive, organisational, social and institutional proximity as separate dimensions of proximity along with organisational proximity, Knoben and Oerlemans (2006) in an effort to reduce ambiguity suggest that these types of proximity are in fact elements of organisational proximity, reasoning that they are interrelated and can hardly be distinguished in practice, drawing on the Rallet and Torre (1999) definition.

Cognitive proximity refers to similarities in the way actors “perceive, interpret, understand and evaluate the world” (Wuyts et al., 2005:278). Knoben and Oerlemans (2006) states that actors need to have similar reference frames for effectively and efficiently communicate and transfer knowledge. According to Wuyts et al. (2005) a high degree of cognitive proximity leads to a high degree of mutual understanding and effectiveness of learning. However the novelty of a relation lies in diversity, thus for learning and innovation processes a high degree of cognitive proximity reduces novelty, whereas a low degree will reduce mutual understanding and the effectiveness of learning. This view is supported by Boschma

(2005:63) stating that although “cognitive proximity facilitates effective communication, too much cognitive proximity may be detrimental to learning and innovation”. Although at a glance the concept of cognitive proximity might look similar to technological proximity, technological proximity refers to what extent actors actually can learn from each other, cognitive proximity refers to what extent actors can communicate efficiently (Knoben and Oerlemans, 2006).

Institutional proximity refers to actors having a shared institutional framework, eg common “sets of common habits, routines, established practices, rules, or laws that regulate the relations between individuals and groups” (Edquist and Johnson, 1997:46). In their literature review Knoben and Oerlemans (2006) points out that institutional proximity is studied on two levels of analyses, one based in similarities of institutional frameworks of countries or regions such as legislative frameworks, business practices etc., whereas the other concerns with similarities in norms and routines present in an organisation. Institutions can be divided into formal institutions such as laws and rules, and informal institutions like cultural norms and habits (Boschma, 2005; Knoben and Oerlemans, 2006). One hand institutional proximity support learning and innovation, providing stable conditions for effective knowledge transfer and learning. On the other hand institutional proximity can be a constraining factor for innovation and new ideas, obstructing awareness of new possibilities (institutional lock-in) and hindering required changes to existing institutions (institutional inertia) (Boschma, 2006). Knoben and Oerlemans (2006) argues that institutional proximity is almost identical to cultural proximity, and in practice are so interrelated that they are hard to separate,

Social proximity refers to the degree of common social relationships shared between actors (Balland, 2012). To clarify Knoben and Oerlemans (2006), state that social proximity refers to actors belonging to the same space of relations. Boschma (2005) defines relations to be socially embedded when they involve trust, based in friendship, kinship, and shared experiences. Ben Letaifa and Robeau (2013) emphasise that social proximity facilitates communication, knowledge transfer and collaboration due to relationships based in trust and mutual commitment. However, to much social proximity could lead to a closed or locked community (Ben Letaifa and Robeau , 2013), where members are locked into established ways of doing things, hampering own innovation and learning capacity, and denying new entrants with new ideas(Boschma, 2005). On the other hand Boschma (2005) emphasises that too little social proximity can be harmful to interactive learning and innovation due to lack of trust and commitment. In their literature review Knoben and Oerlemans (2006) mentions two common categories of social proximity studies, one where one looks upon to what extent actors belong to the same ‘community of practice’ or occupy structurally equivalent network positions, the other determining similarities in collaborations between actors and third party organisations.

Cultural proximity refers to similarities in patterns of thoughts, feelings, behaviour, symbols etc., which give meaning to actions and behaviour, and influence people’s interpretations of situations (Knoben and Oerlemans, 2006). Knoben and Oerlemans (2006), state that there are two levels of analysis common in literature. The first concerns geographically conditioned cultural differences between continents, nations or regions. The second concerns with differences in organisational culture between collaborating actors. Organisations with similar organisational cultures are expected to interact more easily due to common interpretations and routines, making it possible to give meaning to and interpret actions without making interpretations explicit (Knoben and Oerlemans, 2006).

2.7 Conceptual framework

The Statoil technology qualification process, with its technology readiness levels and decision gates give starting point for categorising the innovation process. The process’ categories span a timeline of steps, giving the ability of questioning at what points or steps in the process the innovation is hampered or meet problems, and also to what extent the innovation process flow well and are easily progressing from one phase to another. The decision gates are becoming important meeting points between actors, and also marking formal transitions of responsibilities between actors. The view of innovation as translation as described by Hepsø (2007) versus traditional diffusion theory as fronted by Rogers (2003), is a starting point for further analysis of what goes wrong and what works fine at a process level. However seeing it from a medical perspective this first level of analysis can be seen as an identification of symptoms, with the study looking for symptoms of good health as well as symptoms of disease.

For identifying the root causes of good health/disease the study looks into the world of capabilities and how the actors work together in inter-organisational collaboration to form the required capabilities for successful diffusion of innovation. Building on Henderson et al.

(2013) the study sees capabilities needed for the innovation process in an ecosystem perspective, where both sub-organisations within the implementing organisation and external vendors are seen as ecosystem actors collaborating to form the capabilities needed to drive the innovation process. At this level of diagnostics it is appropriate to ask what capabilities are needed for a successful diffusion process and what actors have key roles in building these capabilities, and how can the actors be categorised.

To complete the diagnostics the collaboration between the actors needs to be addressed. Proximity theory give a tool for analysis of theses interactions, making it possible to address the health and effectiveness of inter-organisational collaborations between actors, using dimensions of cultural, cognitive, geographical, institutional, social, organisational and technological distance proposed by Knoben and Oerlemans (2006) to analyse the effectiveness and effect of collaborations. Translations can be seen as the driving mechanism of the innovation process. Understanding of the interactions among actors in the form of translations gives another tool for examining the collaboration between actors, and how it affects the necessary innovation capabilities and process.

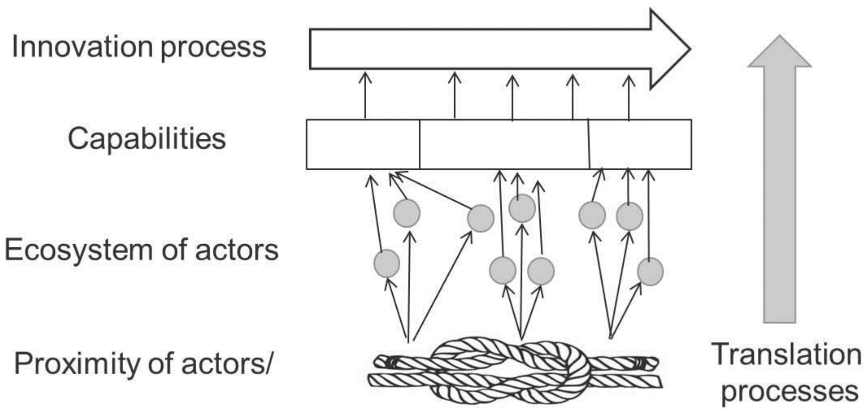

Figure 6 Conceptual model

3.0 Context

3.1 The ecosystem of actors

The drilling and well industry can be considered as an ecosystem of actors, where both the involved companies and their internal organisation elements can be seen as ecosystem actors. The actors are jointly making up the drilling and well value chain, while they individually represent niches and company roles. The following sections summarises the most important actors.

3.1.1 Industrial actors

The actors of the drilling and well value chain which are covered in this study are operator companies, service companies, rig companies and equipment manufacturers. Operator companies are oil and gas companies appointed as responsible for the development and production of oil and gas fields, serving as overall managers and decision makers on behalf of the partner companies holding financial interests in the field. Service companies contracted by the operator, provide specialised services including technology needed in the oil field operations. The technologic solutions applied by the service companies are to a large extent developed and manufactured in-house. The rig owners rent out drilling rigs including topside drilling equipment and the general rig crew, and are typically not directly involved in the development or manufacturing of drilling equipment other than in the role as a customer of technology. Among equipment manufacturers this study focuses on topside drilling equipment manufacturers who provide drilling machinery to the rig companies and also to the operator companies where they own their own installations, which for Statoil is the case for a smaller number of solid installations, like for instance the concrete platforms on the Troll and Statfjord fields in the North Sea.

Smaller and entrepreneurial companies, providing and developing technologies and services on a smaller scale supplied to the above mentioned actors will also be a topic of this study. Research institutions are not covered in this study, although they hold an important role in industry related research activities. However, development and sales of commercial products based on their research is typically not done by themselves, but most often done through smaller spin-off companies, or through license agreements with other industrial actors.

In the drilling and well domain Statoil typically don't develop and manufacture own equipment, with the exception of a small number of drilling support related software products. Innovation is thus performed in cooperation with other industry actors, Statoil contributing with ideas, concepts, personnel and financial resources to development activities either initiated by Statoil or external companies, where the resulting innovation products are commercialised and supplied by the external companies.

3.1.2 Actors internally in Statoil

Internally in Statoil three organisational units are being focused on in this study, RDI (Research Development and Innovation), the professional ladder and the operative units (assets or licences). RDI provides research, development and innovation activities aimed at covering Statoil's short and long term needs. Within the drilling and well domain this study especially focuses on the activities and organisation of the Drilling and Well Solutions (DWS) portfolio, within the Mature Area and Developments and IOR (MADI) program.

The professional or discipline ladder organisation are responsible for providing competency and technology solutions to the Statoil operative units. Among their tasks are providing advice and specialist support for Statoil operations, developing and maintain technical standards and governing documentation, improvement projects and technical contract work and supplier follow up. This study is particularly focused on the Drilling and Well Engineering unit (ENG), and their role as qualifier of technology and facilitator for technology implementation within the drilling and well area.

The operative licenses or assets are the operative units responsible for the development and production of individual oil and gas recovery licenses. For this study their roles as end users implementing new technology are the main focus.

3.2 Statoil's technology qualification process

Statoil's technology development and implementation work process utilises the concepts of technology readiness levels (TRL) to assess the maturity of technology as a base for technology development and innovation management. The concept of technology readiness levels was first developed by NASA, and has since been widely adopted as a part of technology development management in several industries. The NASA definition (Mankins, 1995) consists of nine technology readiness levels, whereas the Statoil adaption consists of eight levels, see Figure 7 Statoil TRL levels.

Level	Development stage	TRL description
TRL 0	**Unproven idea/proposal**	Paper concept. No analysis or testing has been performed
TRL 1	**Concept demonstrated**.	Basic functionality demonstrated by analysis, reference to features shared with existing technology or through testing on individual subcomponents/subsystems. Shall show that the technology is likely to meet specified objectives with additional testing
TRL 2	**Concept validated**.	Concept design or novel features of design validated through model or small scale testing in laboratory environment. Shall show that the technology can meet specified acceptance criteria with additional testing
TRL 3	**New technology tested**	First version of technology built and functionality demonstrated through testing over a limited range of operating conditions. These tests can be done on a scaled version if scalable. If the technology is tested as a small scale version, the scale effects compared to a large-scale version must be sufficiently well understood and predicted
TRL 4	**Technology qualified for first use**	Large scale version of technology built and technology qualified through testing in intended environment, simulated or actual. The new technology is now ready for first use. If the technology is qualified as a large scale version, the scale effects compared to a full-scale version must be sufficiently well understood and predicted
TRL 5	**Technology integration tested**	Full-scale technology built and integrated into the environment where it is intended to operate, with full interface and functionality tests
TRL 6	**Technology in operation**	Full-scale technology built and integrated into the environment where it is intended to operate, with full interface and functionality tests. The technology has operated in accordance with predefined performance criteria over a limited period of time.
TRL 7	**Proven technology**	The technology has operated in accordance with predefined performance and reliability criteria, over a period of time sufficient to reveal time-related effects. Required duration of operation is one of the pre-defined criteria

Figure 7 Statoil TRL levels. Source Statoil

The assessment of technology maturity through technology readiness levels, are accompanied by a set of six decision gates, TDG 0 to TDG 5, see Figure 8:

- TDG 0 – Approve start of technology planning
- TDG 1 – Approve start of technology development
- TDG 2 – Approve first use planning
- TDG 3 - Approve start first use
- TDG 4 – Approve implementation in individual assets
- TDG 5 – Approve completion of “Multi-use”

,where typically TRL2 has to be met before TDG2 can take place, TRL4 before TDG3, and TRL7 before TDG4.

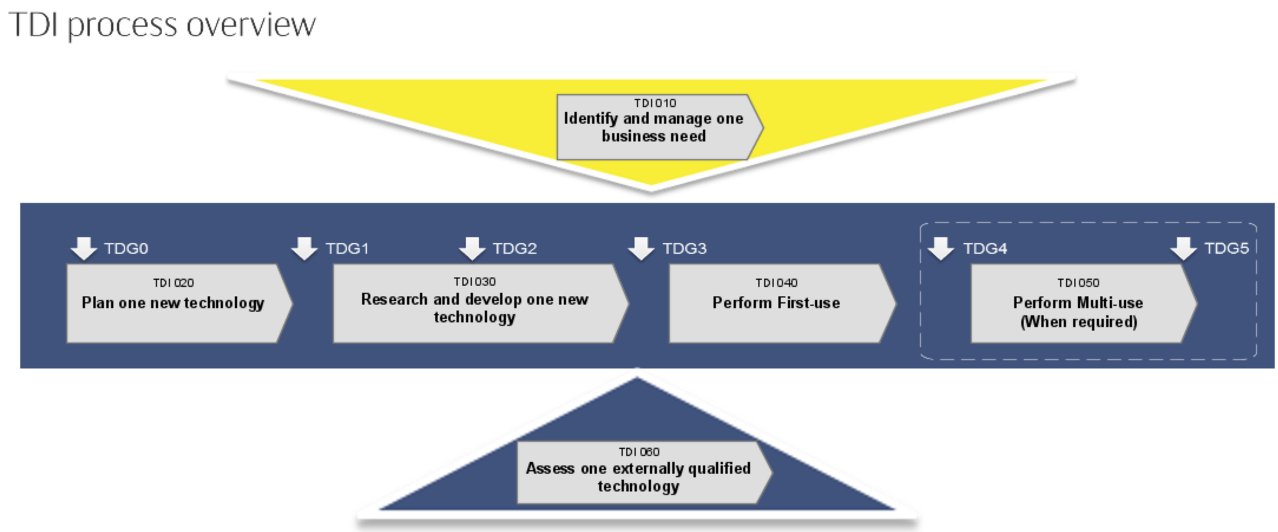

Figure 8 Technology development and implementation process in Statoil. Source Statoil.

The decision gates also marks the start and accept for the internal actors formal responsibilities within the innovation process. The "plan one new technology" and the "research and develop one new technology" activities are the responsibility of the technology owner development, typically located within the R&D organisation. TDG2 involving the pre-sanction of first use by the implementing asset, marks the start of the planning of the first use of the technology in question. TDG3 includes the final approval for first use of the technology from the implementing asset owner, and also marks handover of technology ownership from the technology owner development to the technology owner implementation, which typically will be the professional ladder represented by a chief engineer, accepting the responsibility of ensuring support for the technology in the operational phase, maturing technology to TRL7 and ensuring broad implementation where applicable. The final approval for starting multiuse is at TDG4 given by the individual implementing assets. Finally TDG 5 is the approval of completed broad implementation by the technology owner implementation.

4.0 Method

4.1 Analysis of the problem

The topic of the study is to reveal hindrances to innovation and examine how innovation capability can be built in cooperation between internal and external actors. The identified theory however brings little concrete identifications of particular hindrances or elements particularly important in building capability for innovation, but instead offers more general frameworks and descriptions useful for understanding the innovation process. The particular hindrances and innovation context can of course vary with the context in terms of for example organisation type, industry and type of innovation studied. Given the primarily context of technology innovation within the realm of drilling related technologies seen from the perspective of Statoil, a major oil and gas operator, an empiric approach to the study was chosen, using observations to gain knowledge and build theory, in contrast to an approach testing the validity of theoretical hypotheses through observations. The theory is serving primarily as a context or framework for understanding the problem. As follows the purpose of the study is of an explorative nature trying to reveal new relatively unknown knowledge. The intention of exploratory research can be described as, a) to reveal new knowledge of a phenomenon, through b) finding out what the phenomena consists of, to c) develop a theory about the phenomenon, which can exit into d) a set of hypotheses that can be tested (Jacobsen, 2005). Although variables, like for instance obstacles to innovation, established structures of the industry and innovation capability are used in the problem definition, the problem setting is vague and one aim of the study is to concretise them, finding relevant sets of concrete variables and values.

As the research topic of the study is mainly of an exploratory and theory extending nature, trying to find hindrances to innovation and gain understanding for how innovation capability can be built in cooperation between actors. Although the research objective of gaining understanding of how the established structures in the drilling industry affect innovation seemingly has an explanatory element in it implying a causal relationship between established structures and innovation, the problem setting still is exploratory and vague and at the starting point little were known about what the relevant established structures are and how they possibly connect with innovation. This leans against a more descriptive approach, trying to identify possible variables and elements that affect innovation, rather than a more casual approach upfront setting up a set of hypotheses to be tested.

As the context for the study is limited to drilling technology related innovation in Statoil, the study results are not automatically suited for broad generalisation of the research topics, revealing a fundamental structure valid for all organisations. However the broad context and problem setting of the study of effective innovation in capital-demanding and high risk environments, and innovation in complex value chains with a large extent of outsourcing are relevant for other organisations as well, first of all for other oil and gas operators, and the companies within drilling industry, but also other industries will have similar problem settings.

4.2 Research design

As the intention of the study was to take a deep dive into the topic of innovation, within a context limited to drilling technology innovation conducted by Statoil in cooperation with others, an intensive research design was chosen, with a small number of respondents or units used as subjects for the study. In the this text the Jacobsen (2005) definition of intensive designs, as depth designs typically with many variables and few research units/objects is used. The goal of an intensive research design according to Jacobsen (2005) is to seek in depth understanding and nuances of a phenomenon studying relatively few units, rather than the broad generalisations of more extensive designs. Choosing an intensive design thus can give limitations to directly transferring findings into a broader context. However this type of design is useful for in-depth examination of a phenomenon within a limited context, and for examining a large number of variables which potentially could be the outcome from data collection. A weakness with this choice is the ability to generalise findings into general theory according to Jacobsen (2005), however Flyvbjerg (2010) gives several examples of how intensive studies can be used both for generalisation purposes and broader theory development. For this purpose studies of more extensive design will be needed, but is considered outside the scope of this study. An ideal research design would have been the ideal choice for the study, potentially studying many variables using many respondents or units. In practice an ideal approach would be hard to conduct due to the restrictions in time and resources available for a master's degree study, and also because it would be hard to identify a large number of relevant respondents in terms of possessing a broad knowledge and experience with relevant innovation. Given the limited context of drilling related innovation within the Statoil value chain, it also would be a consideration whether a large number of respondents within the same professional environments would add significant value to the study in terms of broadening findings.

Jacobsen (2005) mentions two types of intensive research designs, case studies, and small N studies, where a small N study design is chosen for this study. The small N study design is well suited for studies with focus on a specific phenomenon trying to enlighten it from different perspectives, as in this case studying drilling technology innovation related to the

Statoil organisation. An alternative approach could have been to select a case study design, using the implementation of one or a few specific technologies as case. The case study being concerned with specific cases or incidents limited in time and place. However the small N study design focusing on a relatively few respondents and their experiences instead of specific cases, is in this context considered a better approach as the study will benefit from respondents broader knowledge and experience gained from the implementation of a vast number of technologies within the context.

4.3 Data collection

To conduct data acquisition, a qualitative approach was selected as the most appropriate choice. Basically because the data desired to collect had the form of words and meanings, and not data in the form of numbers, figures or statistics. The fact that the study conducted is empiric, of an exploratory nature, and that an intensive research design was chosen leaned against a rather pure qualitative approach, with an open dialogue as ideal, rather than using quantitative elements with closed questions.

A total of nine interviews were conducted, each lasting for approximately one hour. The interviews were recorded on tape and later transcribed in full, totalling 63 pages. Anonymity for the respondents was granted, as it didn't seem to be of big relevance to the study, and was considered to assist in making the respondents talk more openly. As the ideal for the interviews were open dialogue, no detailed questions were made upfront, but instead an interview guide containing a list of topics to talk about was made, including comments about important aspects to cover. The topics included; industry structures and how they affect innovation, cooperation internally in Statoil on innovation, cooperation on innovation with external organisations, business opportunities for entrepreneurial and smaller companies within the drilling industry, hindrances to innovation, conflicting interests and the importance of proximity.

Of the nine interviews, 6 were held face to face at the offices of either the respondent or the interviewer in Trondheim, two were conducted using telephone and one through video conference. Although not preferable, the use of video and telephone was necessary due to the respondents working in other cities in Norway. With two of the respondents working at other geographical locations, interviews were conducted during respondents work related stays in Trondheim.

4.4 Respondents

The respondents were selected based on their experience within the drilling industry and related innovation efforts. All of the respondents were having more than ten years of relevant experience. That the respondents had experience from more than one innovation related role was also important for the selection, to make sure that the data obtained, contained several perspectives. The main perspectives which the study tried to cover where the perspectives of the industrial actors, Statoil as an operator company, service companies, rig owners, equipment manufacturers, and smaller and entrepreneurial companies. We also sought to cover the perspectives of the internal actors within Statoil, RDI, the professional ladder and the operational assets as well as experience from concrete research and development projects conducted as collaborations between the industrial actors. The table below shows the perspectives introduced by the individual respondents.

Respondent	Main perspectives introduced to the study
R1(RD,SC,RO)	RDI perspective, equipment manufacturer perspective, rig owner perspective
R2(RD,DP)	RDI perspective, development project experience
R3(RD,SC,DP)	RDI perspective, service company perspective, development project experience
R4(EC,DP)	entrepreneurial company perspective, development project experience
R5(PL,DP)	professional ladder perspective, development project experience
R6(RD,OA)	RDI perspective, operational asset perspective
R7(RD,OA,PL,DP)	RDI perspective, operational asset perspective, professional ladder perspective, development project experience
R8(VI,OA)	venture investment perspective, operational asset perspective
R9(PL,SC,DP)	professional ladder perspective , service company perspective, development project experience

Table 1: Respondent perspectives

To easier to keep track of the respondents throughout the text, the identified perspectives they bring in have been given the following letter codes in parenthesis behind the respondent numbers, signalling the perspectives brought in by the respondents.

Letter code	Perspective
DP	development project experience
EC	entrepreneurial company perspective
EM	equipment manufacturer perspective
OA	operational asset perspective
PL	professional ladder perspective
RD	RDI perspective
RO	rig owner perspective
SC	service company perspective

Table 2: Respondent perspectives, letter codes

The following table shows an overview of the respondents main experience backgrounds, interview lengths and observation contexts.

Respondent	Background	Interview length	Observation Context
R1(RD,EM,RO)	leader in Statoil Research Development and Innovation, earlier leading positions within technology development for drilling equipment manufacturer	50:02	interview at meeting room
R2(RD,DP)	researcher in Statoil, previous experience from service company and research institute	1:39:46	interview at the respondents office
R3(RD,SC,DP)	researcher in Statoil, previous experience from service company	38:48	interview at the respondents office
R4(EC,DP)	leader in start-up company, previous experience from several other start-up companies	57:50	telephone interview
R5(PL,DP)	discipline advisor in Statoil, previous experience from research institute	1:01:27	telephone interview
R6(RD,OA)	leading role within Statoil Research Development and Innovation, previously various leader positions within Statoil operational units	53:50	interview at the respondents office
R7(RD,OA,PL,DP)	researcher in Statoil, previous experience from operational and operational support units in Statoil	1:11:37	interview at the respondents office
R8(VI,OA)	venture investment, previous several positions within operational units within Statoil and other operator companies	1:03:08	interview at the respondents office
R9(PL,SC,DP)	discipline leader in Statoil, previous experience from positions within service companies	53:21	video meeting

Table 3: Overview of respondents, backgrounds and interview contexts

4.5 Data analysis

As analysis method of the transcribed interviews content analysis was chosen, first coding the entire content of the interviews into broad categories. Based on these categories an iterative process of organising and structuring the data within the categories was made, leading to the larger categories of data being further divided into subclasses, the process also included the removal of data found irrelevant to the problem setting, resulting in data being organised by the following coding scheme.

Coarse categories	**Subclasses**
industry structure	general structure, small companies, innovation in small vs larger companies
internal structure in Statoil	
industry barriers	
conflicting interests	
cooperation with external vendors	cooperation between Statoil and external vendors, cooperation between external actors, small companies, specific cases
cooperation internally in Statoil	RDI, professional ladder, operational assets, first use, broad implementation, conflicting interests
barriers to implementation	
proximity related	geographic proximity, technologic proximity, cognitive proximity, organisational proximity, institutional proximity, social proximity, cultural proximity

Table 4 Initial coding scheme guide for categorising data

Further an iterative process of grouping, selection and initial analysis of the data were done directly in the working text of this document, resulting in the Empirical findings chapter, where instead of grouping data in tables it was focused on creating a good case history using the most relevant data quotes as an integrated part of the text trying to create a story built on the basis of the respondents stories and my initial analysis instead of focusing strict on findings and theoretical generalisations. Both due to the dialogic nature of the interviews and the rich detailed stories of the respondents, this was considered a good choice, not to lose detail due to generalisation of the findings. A good case story according to Flyvbjerg (2010), allowing for diversity through it being built by the histories of the faceted and complex stories of the involved actors, allowing the reader to hold his own interpretations up against the interpretations of the respondents as well as the authors. In the process of creating this story the selected respondent quotes was translated from Norwegian as the language used for interviews and transcription to English. Although striving to give as accurate translations as possible, there is a possibility that some details of the quotes have got lost in translation. The Analysis and discussions chapter covers further interpretation, analysis against theory, and discussion based on the initial case story.

4.6 Validity/reliability

To stay in line with Jacobsen (2005) the terms validity and reliability, which are normally associated with quality assessment of quantitative studies, are used in the following despite the qualitative nature of the proposed study. However it is important to note that whereas one in quantitative studies concerns about reliability and validity referring to the correctness and the replicability of statistical results, results in qualitative studies will be dependent of the context and study subjects, and thus neither are 100 percent replicable nor can be defined as general valid truths. The term validity used in a qualitative setting thus can be understood to relate to the transferability and credibility of the results, and the term reliability to transparency, e.g. to openness about the research methods used and how they can affect the results.

For internal validity of the study the selection of respondents are of importance. Although limited to respondents within the Statoil organisation with the exception of R4(EC,DP), the selection of respondents were made trying to make their backgrounds reflect the perspectives of all of the ecosystem actors. This strategy seems to have been successful, with the exception of finding someone with a direct background as employee from a rig company. However R1(RD,EM,RO) with a background from an equipment manufacturer being a supplier to rig owner, also brought in a rig owner perspective to the study. Although it would have been preferable to include respondents currently working in innovation roles within service companies, rig owners and equipment manufacturers, it was considered hard to identify the right persons with the right backgrounds to be respondents within these often multinational companies. It is also reasonable to believe that company policies and the interviewer’s role working for an operator company could severely limit the respondents, and also impact the sincerity and correctness of statements from respondents from external supplier companies, due to the customer supplier relation.

The respondents were chosen due to long experience and diverse backgrounds from different roles within innovation within the drilling and well value chain ensuring their in-depth specialist knowledge and closeness to the topic. In few cases it is reason to believe that respondents were limiting their answers due to confidentiality restrictions, however this was not considered as particularly important for the study results, and the answers given from all the respondents are considered to be truthful and reliable. This belief was also supported by the coherency of the respondents' answers.

Validation of the study was done through triangulation. One of the respondents within a leading role within Statoil RDI went through and confirmed the face validity of the study. The study was in addition presented to anther independent Statoil professional with long experience within innovation, also confirming the study and conclusions as authentic, i.e. that the results seem realistic and true, and that findings seems relevant. The study has also been found to be in accordance with secondary information available both internally in Statoil, and externally in the form of available reports and writings.

The interviewer's role in the interview situation was not found to have any negative impact or constraints to the respondents' answers. On the contrary it is reason to believe that the interviewer's prior relation to the respondents has contributed to an informal setting where the respondents have talked willingly and freely, substantiated by the respondents' long and detailed answers. In the interview situations focus was also put on letting the respondents talk freely, following up on the topics they brought up rather than going through a fixed questionnaire, trying to shape the interview situation more like an informal dialogue, and also omitting leading questions. The topics of the interviews were defined as broad categories, and emphasis was also put on making the respondents give examples from own experiences. The use of telephone and videoconference to conduct some of the interviews is not considered as having an impact on the respondents' answers, due to the use of this type of communication aids common and familiar in the daily work of the respondents, and also due to the respondents' familiarity to the interviewer. All interviews were recorded, the accurately transcribed. As the interviews were conducted and transcribed in Norwegian it is a chance that some of the detail or meaning of from the selected respondent quotes has got lost in their translation to English, although effort has been made translating the quotes as accurate and precise as possible. To ensure openness and reliability of the findings and analysis, quotes from the respondents has to a large extent been used as part of the text when reporting empirical findings, thus giving the reader a chance to verify and make up his own opinion about the accuracy of the findings and analysis.

The external validity of the study can be argued for as limited by the focus only on drilling and well innovation and implementation related to the Statoil organisation using only a few respondents mostly from within the Statoil organisation. Thus to create generalised theory and direct transfer the results and findings they have to be followed up by further research of a more extensive design. However it can also be argued that Statoil as an oil company in an innovation setting is not unlike other oil and gas operator companies, using similar standardised development and innovation processes. The other industrial actors within the drilling and well value chain, such as service companies, rig owner, equipment manufacturers and smaller and entrepreneurial companies is the same actors making up the drilling and well value chains of other oil and gas operator companies as well. Also within other industries similar actors and processes will be found, illustrated by the Statoil technology development and implementation process being adapted from a NASA developed concept (Mankins, 1995) adapted by actors of several other industries. Thus if not directly possible to generalise the findings based on this limited study alone, the study results and context should be comparable to other actors both within the drilling and well industry, and also to other industries.

When it comes to the selection of respondents, the study is made up of only a few respondents mostly from within the Statoil organisation, thus giving the study a limited width not necessarily giving a good overall picture of a population. It is however not the aim of the study to reveal new information of a phenomenon, and as such it is not a broad meaning of a population that is most interesting, but rather to get a grasp of the deeper understanding of the phenomenon gained through the knowledge and experience of the respondents. And as earlier argued the phenomenon itself of innovation within the drilling and well value chain if not identical, at least is of similarity to innovation as phenomenon also among other actors. The respondents of the survey also must be considered as experts within innovation related activities within the drilling and well domain, due to their long experience from a variety of roles both internally in Statoil and also for other industrial actors. Thus through the choice of using a small-N study design one does not only drag on their experience from a single case of innovation, but their total experience from numerous innovation processes, from several roles and several actors, thus not only contributes with an in-depth understanding of the expanding the phenomenon, but also contribute to giving the study a broader validity.

However, to generalise findings and make them valid in terms of broad theory, they should be followed up through studies of more extensive designs, using a broader population both including more respondents and more organisations, according to the views presented in Jacobsen (2005). However this type of analysis is outside the scope of this particular study, leaving theoretical generalisation from empiric data using theory the primary form of generalisation possible. If findings are to be subject for probable generalisation they thus should be supported by existing theory. Flyvbjerg (2010) however points out that selecting cases carefully, also intensive designs can be used for generalisation purposes and theory development.

It can also be questioned whether context independent generalisation and broad theories necessarily is the ultimate measure of external value of research, Flyvbjerg (2010) argues the importance and value of context-dependent studies such as case studies and small N studies, due their detail richness, variation and nuanced views which tends get lost in quantitative research and broad generalisation.

5.0 Empirical findings

5.1 Barriers to innovation

5.1.1 Industry Barriers

Between the industry actors in the drilling industry there are some underlying differences which affect their perspectives and their willingness to innovate. The first of these differences is the differences in income sources. Whereas it for the operator companies can be said, that their business is to get as much production from the drilled wells to as low cost as possible, the rig companies are concerned with the performance of their equipment as their main source of income is the rental of equipment only paid for when it is operating.

R9(PL,SC,DP): "To us it is simple, the two things that affect us is production and time. How much we can get out of a well is the main priority, and the second is how fast we can make it. Due to the rates, speed is a dominant feature of the cost picture. A rig company however, is not interested in finishing as fast as possible. No matter which incentives we make, we don't manage to make them good enough for it to be economical for the rig companies to do it in fewer days. They make money per day."

The service companies which are delivering technology based services mainly related to the downhole drilling process in their contract paid for per day used or per meter drilled.

R9(PL,SC,DP): "When it comes to the service companies, Schlumberger, Halliburton and Baker, they make money on equipment rental, either accounted for in meters drilled or days used. We try to orient it against meters drilled, to make it in our interest, but we never fully manage to align it against what is beneficiary for them. So you won't have the same goals no matter, you just don't manage."

The topside drilling equipment manufacturers deliver topside drilling equipment mainly to the rig companies, but also in smaller scale directly to the operator companies in those cases where they own installation (fixed installations), and within their contracts get paid per sale and for maintenance of equipment. Whereas the service companies to a large extent develop and manufacture the equipment they use to deliver their services, the rig-companies don't do own equipment development. When it comes to innovation the operator perspective of lowering the cost of the operation is in direct conflict with the rig- and service-companies income potential.

R7(RD,OA,PL,DP):" We often have totally different interests. Statoil wants to do things faster, better or more efficient, which normally is not in the interest of the service companies because it will take away some of their income. It might be they have to change their routines, or start doing something else. Maybe they got a product they won't be able to sell anymore. They often have a direct economic interest in us not developing further."

R1(RD,EM,RO):"Of course every link of the business chain tries to maximise its own profit. So if there is a wish from the oil companies that threatens a revenue source with the suppliers, one fights like dogs to prevent it."

R1(RD,EM,RO):" Those who are suppliers to the drilling contractors deliver after the hotdog principle. "You get the hotdog, I get the money". All revenues on the job have to come up-front and on after-sales, in the form of margins on the product you sell and service on the product after the sale. But you have to be careful about making products that needs too much service, because that intervenes directly in the revenue flow of the customer since he is selling operational time on the same machines. So he doesn't care how fast things go as long as the machines are reliable. The next customer again, the operator, is very concerned with things going fast and effective, and that he gets few downhole-related incidents, but who cares? He is the only one concerned about those things. So I would say that there are fundamental, not only contradictions but giant gorges between sharing incentives."

The main driver for innovation within service companies and equipment manufacturers are their competitor positions, closing gaps to their competitors or delivering a product or service which will give a competitive advantage.

R1(RD,EM,RO):" The priority of innovation tasks only depends on the gap to the competitors and the importance of what must be obtained. And this leads it sometimes being an extreme pressure to come up with new products, services or whatever it should be

to close the gap to the competitors, or satisfy an important customer asking for something special, given that it is a sale with an income margin within reach."

The limited number of competitors in the marked for drilling related services also is a concern, with only two suppliers MH Wirth and National Oilwell Varco dominating the world marked for topside drilling equipment, and the three service companies Halliburton, Baker Hughes and Schlumberger traditionally holding a similar position for offshore downhole drilling services, and the concern is not being reduced by the ongoing merger between Halliburton and Baker Hughes.

R7(RD,OA,PL,DP):" It reduces the possibilities for innovation, it becomes less competition, and the risk of cartel activity is also there."

However, despite low number of actors, the main impression is that technology driven competition is substantial, especially amongst the service companies

R9(PL,SC,DP):" They have a pretty strong technology drive, especially Baker and Schlumberger. Halliburton has been a little weaker, at least within drilling. But they have been quite technology-driving those two, to get competitive advantages."

Another trait both with the service companies and the drilling equipment manufacturers is bundling of technology into packages or services, leveraging their own technology by controlling the interfaces to the individual technology and service elements, thus creating closed platforms as discussed in Eisenmann et al (2009). This creates a hindrance especially for new entrants in the market, as they cannot compete on individual components but have to be capable of offering products competing with the entire range of the bundled packages or services.

R3(RD,SC,DP): "I don't think we could have developed it with anyone else, because it is the supplier's technology, their drilling tools and their gear which is used, and it needs to fit with the rest of their technology portfolio. If anyone else is going to run this type of system they will have to develop it themselves, because it will only work with the suppliers gear"

R1(RD,EM,RO): "One example is the drilling control system, which without too much hackle could have been made relatively open, based upon open standards, and as such

could have been a configurable control room like most other control rooms. Instead one has consciously chosen the opposite direction, solidifying the control system with the machinery and made it a proprietary product, to protect one's own business. And this is done by all the actors in this market."

An important aspect to understanding differences between operator, rig companies, service companies and equipment manufacturers when it comes to innovation priorities, is their different perspectives formed by how they make an income. One of these differences is the different perspectives on time. The operator companies have a planning perspective related to field development. The service companies and the rig companies work in contract perspectives, where getting the contracts and then trying to get most income out of their contracts is the most important to sustain business and secure income. The equipment manufacturers have a sales perspective, depending on the individual sales of equipment and components as income source. To make it short operators have a long term perspective, rig companies and service companies have a medium term perspective, whereas equipment manufacturers have a short term perspective.

R1(RD,EM,RO): "Operators, drilling contractors and suppliers work on three different time scales. The operators often work in a five-year perspective. The drilling contractors in contract perspective, which can be everything from 8 to 80 months, while the supplier industry often tend to work from quarter to quarter."

A related difference in perspectives affecting their innovation priorities is the focus on their internal value chains, and how their income is created. Thus operator companies interests lies mainly in innovation related to securing production and reducing production costs. For rig companies one of their main focuses is operation stability of equipment securing that they don't lose money due to downtime of their equipment. For the service companies, their ability compete on service contracts and to increase income by offering and selling additional services to the operator companies is a key driver to innovation. For the equipment manufacturers securing the individual sales has main focus.

R1(RD,EM,RO):"All companies prioritises the biggest money-makers. For the operator it is the production, and it overrules all their prioritisation. With the drilling contractors it is of course the drilling process which overrules everything. To keep the machinery running, to

keep the wheels turning, steers all their priorities. While for the equipment manufacturer it is often the salesperson, and what is necessary to make the salesforce and the following deliveries work which is important."

5.1.2 Small companies

As mentioned earlier, the platform strategies of the big suppliers and service companies are a hindrance to new entrants as competitors. The oil companies also tend to prefer large integrated contracts on bundles of services and technologies, making it hard for new entrants to compete on these without providing the full spectre of relevant products.

R1(RD,EM,RO):" Twenty years ago one bought drilling-packages machine by machine, now they are being bought as systems instead. All the vendors acts the same, they define their deliveries into systems, so they can get more of their own products into the same system delivery. This makes it very hard for a vendor which has only one product, which by all means can be similar to the system suppliers, and often even better. He still won't get a place at the table."

Building up a portfolio is cost and resource demanding, and acts as a barrier for new entrants in the marked.

R1(RD,EM,RO):"In addition the basis investment to develop a product-portfolio large enough for one to be a player to reckon with, has become a very costly admission ticket. So high, that it is just other big companies that have a chance of making an entry."

This leads to a shift down the value chain, effectively forcing small and niche companies to be suppliers to the service companies and the big equipment manufacturers instead of the oil- and rig- companies, possibly shifting the innovation focus more towards the perspectives of the service companies and the big equipment manufacturers.

R9(PL,SC,DP): "What you do when you make these big integrated contracts, is that you move the customer relationship, in such a way that we are not the customer to the small niche companies any more. It is Baker, Schlumberger and Halliburton which become the

customer. So then things are changed a bit, and they don't necessary have the same goals as us. We try to align goals, but their task is to make money just as us, and they do it in a somewhat different way than us"

However, in the large integrated contracts with service and rig companies Statoil and other oil and gas operators often make openings for third party equipment and services to be used, leaving the operator company the possibility to force the providers to take in third party technology and services. Both service companies and the big equipment manufacturers commonly uses technology and services from third party suppliers in their product packages through licencing/branding agreements or through company acquisitions.

R8(VI,OA):" So in our contract structures against the big service providers, we have made opportunities for forcing in technology we want. You don't motivate the service companies to do it, but if the operator specifies that he shall have it so and so, then he gets it. But the demand has to come from the oil company."

R1(RD,EM,RO). "For instance 60% of one of the major equipment suppliers value creation comes from purchased products and services. But then there is a branding agreement so you can't see from the outside what is external and internal technology."

Another hurdle for smaller and entrepreneurial companies is the time and resources needed to develop a commercial product. Seen from some of the examples mentioned by the respondents the time from starting up with a new idea until having a commercial product often can be up to ten years.

R8(VI,OA):" The main challenge is to get to the finish line, securing a robust enough funding and holding the cost base low enough that you manage to get to the point where you either are bought or at some point get to the point where you manage to get positive numbers on the bottom line."

R1(RD,EM,RO):" If small companies are trying to make large products, with little copying effect one should be on the alert. As an example one often sees a one or two man company setting out to make a new drilling machine. What these optimists don't realise is that it takes around 50.000 engineering hours with all contributions to get to the finish line. And

of course if two persons shall manage this, it would take them around 25 years which of course isn't feasible. So very often one underestimates the hour intensity, and there are too low volumes of sale for one to finance it through borrowing money and still getting an acceptable return on the investment capital."

Still there are niches which are easier for smaller companies to enter which aren't that cost and resource demanding, software and downhole tools mentioned as examples.

R1(RD,EM,RO):" The easiest business model for very small companies are products with a relatively low entrance fee and a high copy value, traits that typically defines software which in practice has no copy cost. Also downhole products can be a niche, often having a much simpler interface, less mechanical constructions, and a small company can make a difference, due to it being lower physical volumse and less work involved. Besides, the interface often is a threaded connection in each end, so you don't have to negotiate peace with half the world to get to the table."

5.1.3 Innovation from small vs established actors

When it comes to innovation there is consensus among the recipients that the most radical ideas mostly comes from small and entrepreneurial companies, whereas the bigger companies tend to make smaller steps building upon their existing technology. However it seems that the bigger vendors seem more likely to manage to realise the ideas into commercial products. There can be several reasons for this. One reason can be the previous mentioned industry barriers, where companies are not eager to develop new things which can reduce their income potential from existing products. Companies also might want to take out the full revenue potential from existing products before introducing new and better ones. Existing technology and marked positions can also be used as an effective hindrance to new competing entrants. Besides this, another reason is simply that the more radical an idea is the harder it is to realise, also in terms of compatibility with existing equipment/services. The big established companies also have the advantage of having established organisations to bring their products into the marked, and they can use their experience and existing products as a leverage to get new products implemented with their customers.

R8(VI,OA): "The innovative ideas might come both from the small and the big companies, but what one sees historically is that it is very hard to develop radical new things that are destructive to convention in a big established organisation, they do it better in small companies."

R6(RD,OA):" "It comes more good ideas from the smaller companies than from the big established companies. It has always been argued, and more and more we see, that it is little ground-breaking news that comes from the big suppliers, unless we specifically ask them to run a project."

R7(RD,OA,PL,DP): "It is often so that small companies innovate without boundaries. That will not happen in the big companies because they always have an object clause to their innovation. So the most radical ideas very often come from the smaller companies. But if you see opportunism and realism as two independent graphs and take their product it gets harder, because what in the end creates value is what gets realised and spread throughout the market. And the most extreme entrepreneurial ideas have an ugly tendency not to be realised. Of course there are exceptions, but as a main rule I will say that there is a relatively dead run on what is being realised, clearly favouring the small ones when it comes to the idea generation itself, and the freedom to think outside existing solutions. However, in practice you always, always, always are bound by solutions already existing, in form of backward compatibility."

5.1.4 Incentives

It seems that an important factor in creating successful innovation partnerships is the selection of suppliers/partners for the innovation task. Not only technology excellence, but also the collaboration willingness of the selected supplier/partner is important for successful innovative partnerships.

R7(RD,OA,PL,DP): "Normally we chose a vendor among several, and choosing the right one can be a challenge. I think the vendor's willingness to collaborate is more important than that they are the very best at that specific technology at that instant in time. In principle of course, we should always work together with the best to push the industry

forward, but it is also important that they are interested in the collaboration, and not just tells us that they want to do something as a duty in hope of getting the next contract."

Another important aspect when it comes to collaboration willingness is the ability to create win-win situations for all involved parties, rather than trying to force third parties. Having or creating aligned incentives for doing an innovation task, where all parties has something to gain from collaborating in terms of monetary advantage, market and competitor positions seem to be an important factor for success.

R3(RD,SC,DP): "In addition to the service being more expensive than usual, they also get market shares they normally don't have. It is often so that they have a contract on drilling, and another vendor normally has the completion contract. And now they get the completion work to, where this technology is used."

R7(RD,OA,PL,DP)." They want to get a new product in their portfolio, and make money out of it. Profit, profit and more profit, that's the driving force of our suppliers, and we need to have that clearly in mind when we do technology development."

R3(RD,SC,DP):"Statoil wants to be seen as a pioneer on this, to be seen as sitting in the lead seat driving technology forward is very important when we try to get into new areas, fields and partnerships. And of course that the supplier suddenly has a technology which no one else have put them in a bright spot, which can be decisive in bidding rounds with other operators than Statoil. Again it is positive to be seen as a pioneer, both as an oil company, an operator, and a service provider. So, in that respect the incentives are common, even though the revenue arguments are different. They are to make money on the service, and we are to make money from the upside we get by buying the service"

As mentioned, failing to find aligned incentives often leads to resistance against innovation from the suppliers.

R1(RD,EM,RO):"Of course every link of the business chain tries to maximise its own profit. So if there is a wish from the oil companies that threatens a revenue source with the suppliers, one fights like dogs to prevent it."

R6(RD,OA):" On one side they want to be in front of their competitors, but on the other hand they want a good turnover on the products they already have. So we've seen some cases where niche companies have been bought up, primarily with the purpose of putting their technology dead for a period, as it has been seen as a threat to the overtaking company's business model."

The ability the operators have in their integrated contracts to force the service providers to take in new technology provides an opportunity to get in technology not necessarily wanted by the providers. But one operator forcing in one product in a delivery here and there, does not necessarily make the big marked breakthrough for entrepreneurial companies, and seldom is a sustainable market model in the long run. However it can be used as leverage for technology from smaller third party suppliers and giving the smaller companies an opportunity to sell in their products to the established companies.

R4(EC,DP):" We will deliver our product through the service companies to Statoil, but that is because it has been a demand from Statoil, but we will try hard to convince the service companies how they can utilise our technology. Especially where they have contracts which are not paid by daily rates but in meters drilled, they can use our technology to streamline their own operations, to get more money out of the contract than they do today."

R8(VI,OA):" The demand has to come from the oil company, and then if it is technology that one of the big companies wants, they might try to buy the company. For us as venture investors, that is an important part of our aims, to eventually get the companies in under a bigger umbrella."

5.1.5 Internal barriers

One of the main barriers found internally in Statoil is to get new technology put to use in the operative units. First to get the technology implemented for the first time and then to get the technology rolled out for broad implementation. One of the causes found for this is the incentives for starting to use new technologies in the licenses. The operating licences of course steer after operational and often short term targets, which within drilling are related to cost, operational efficiency and HSE, and using new technology can often be seen as risky, and endangering the local operational goals.

R7(RD,OA,PL,DP):”They steer after other goals than implementing new technologies, and bringing in in new technology can of course affect the KPI of the well.”

In the decision to start using new technology in the operating units, three factors are identified as especially important; the benefits of using the new technology, the perceived risk of using new and unproven technology, and the cost of using it. And even with big potential gains on a company or long term level, it often for the individual license or operation is considered as a safer path using traditional methods, than introducing new technology even if the new technology might have benefits and a large upside. The cost of using new technology can also be high both in terms of modifications to allow for the technology to be used, but also in terms of costs of errors with and due to new technology. With rig rates for floating vessels of up to 6-7 MNOK per day, errors or problems leading to downtime of the operation soon become very costly.

R8(VI,OA): “It comes down to three factors, how attractive it is for them to start using it, and the perceived risk with implementation. The third one is cost. It is a giant challenge, the threshold to start using things for the first time.”

R9(PL,SC,DP):”It is a challenge we got as a company. With new technology there are no incentives to start using it. If you develop a technology there is always a risk, it has to mature before it gets as reliable as a system widely in use. And for an engineer in the licences, it is all right if he does thing “the old way”, and it goes wrong “the old way”, due to formation collapse or whatever it should be. It is just “though shit”, he did the best he could and it was no obvious mistake. It was a known problem and it went down the drain. He won’t get a pat on the shoulder, but he won’t get scolded either. If he instead has taken on a new technology, he has put himself right at the edge, risking criticism. “

R8(VI,OA):” One example are this technology we are working with, where the starting costs are 75 million NOK just to upgrade the rig before you are able to start using the technology. Even though the business case for using the technology is rocket high, they don’t have the motivation to start using it as long as they somehow manage to drill their wells without it. “Why is it so many people who live in bad marriages?” The answer is “They simply aren’t bad enough.” And that is the way it is with the methods and

technology we are using too, if things go fairly well and things aren't problematic enough, the motivation for doing things differently isn't big enough either."

Especially to get technology from the stage where it has been run for a first time in a single asset until being broad implemented or routinized (Rogers, 2003), pose a challenge. Whereas there for the first use in the company might be incentives to test and try out new technology like for instance high management focus and being renowned for being the first to use new technology, the same incentives are not in place for the next users. And even though a technology has been run one time in one license it has to be run several times with success in several assets before it can be considered a mature technology.

R9(PL,SC,DP): "Multiuse, to get the technology spread is a lot worse, but for the pilot and first use we have incentives in the company which makes it easier to get going."

R9(PL,SC,DP):" We struggle with the implementation because there are not enough experiences. It is the conservatism of our industry. As long as it isn't totally developed and well proven by experience we are sceptical to using it."

R4(EC,DP):" When Statoil has used a lot of money on development and has qualified a product they think can bring value to the operations they should have better ability for doing a broad scale implementation, to ensure they extract the value of the technology. Seen from our side it is one of the things that can break a company like ours is that it takes too long time to get things out."

One type of technologies which often is problematic to get matured enough to be routinized are technologies which might give substantial savings for the company as a whole through repeated or widespread use, but not necessarily shows direct benefits on each individual well, such as technology which to alarm an avoid downhole problems during drilling. Technology which actual gains only can be evaluated statistically over the use on multiple wells and a longer period of time, poses problems because it can be hard prove or see the gains for an individual asset or well in a short term perspective.

R2(RD,DP):" Take for instance technical side-tracks, you can't show that you have less technical side-tracks in one well, it takes at least three or four wells to get an indication that we have reduced the risk and saved money."

R4(EC,DP):" One well can go well, and the next not. So if you use our technology on the well that went well, you say that everything went well and we didn't need this tool. But then again it might be that in the next well the technology would have given a warning of something about to go wrong, and you could have saved really big values."

Another hindrance identified is decentralisation of decisions and the decisions dependency of individuals. Especially for multiuse of technology the decentralisation of implementation decisions down to the individual assets can create hindrances in implementing company level technology implementation strategies, especially where benefits of the technology is best measured at a company level. The willingness to take on new technology varies from asset to assets and two factors which seems to contribute to their willingness is economy and culture.

R9(PL,SC,DP):" It varies widely between the licenses how risk willing, technology eager and conservative they are. It is very much governed by individuals. Some organisations are very adept, and striving for new technology. I also think this is related to economy as well. The licenses making the most money are often the ones most willing to take their chances on new technology to do even better, whereas those struggling with margins have very little willingness to take any chances on anything at all."

R6(RD,OA):" If it is strategically important technology, which might involve some amount of risk to the first, second and third user, I think it is important to anchor the strategy high up in the organisation, in such a way that the leader levels in the operative units almost gets it imposed, that they shall contribute to the implementation on the behalf of the company."

Internally in the assets the role of individuals in decisions and recommendations is also pointed out as a source of problems when it comes to carrying out strategies for broad implementation of technology. Even if there is a strategy at a company level for broad implementation of specific technologies, the decision of whether or not to implement them are left up to the asset itself, and ultimately the recommendations of individuals in the asset and their positivity or lack of such have large impact on decisions.

R4(EC,DP):" The decision-making is extremely decentralised and not necessary at the asset level. It is to a large extent the individual feedback of John, Peter and Gretchen, and how positive and eager they are which makes significance for the way forward. It is one of our biggest challenges, that it is down to the level of individuals whether you manage to achieve a broad implementation or not."

R7(RD,OA,PL,DP):"The sale of new technology goes from the bottom and up. Of course there are presentations of new technologies at a management level as well, but there has been a tradition in Statoil that the engineer level has had a relatively big influence. If the engineer level is against something it is very hard to get things in even if it comes from above."

R5(PL,DP):"There came in a new leader in the license, and he sanctioned and said he didn't want it. Eventually he got forced to approve it, but even then he tried to draw things out. And as a consequence we got delayed by several months."

R2(RD,DP):"When a change of positions occur, and suddenly a person who is responsible for a delivery or a unit is replaced, and his personal attitude, and whether he hates or loves something is allowed to govern, it has big consequences. It would have been a shame if the project had to be stopped, not due to the lack of interest from the licenses, but due one single person's personal interest of "No, this isn't that exciting." "

The incentives of individuals is also a factor which might be a hindrance to broad implementation, whereas for company level first use of technology recognition is made for the involved parties, this is to a lesser degree the case for the next users in other assets, and due to the dependency of individual recommendations individuals recommending new solutions also putting themselves in an exposed positon if something go wrong.

R9(PL,SC,DP):"The incentives for using new technology are non-existing, and instead you might expose yourself to risk as an engineer if you chose new solutions, which has not been proven. It makes one very conservative and reluctant to using anything which has not proven over and over again that it works. Unless you don't have any other options, then you cringe to new technology."

Time is also an aspect to take into account on the individual level. In the assets there is a high workload and high focus on efficiency, leaving little time for individuals to spend on new solutions, making well know solutions and proven technology an easier choice.

R7(RD,OA,PL,DP):" Often the people working at the licenses have more than enough with the well they are working with, and then they have to plan the next well simultaneously. Thus they don't have the time to be creative and find new solutions. So they'd rather copy and paste what has been done before because that is easiest."

5.2 Cooperation

5.2.1 Cooperation with external vendors

In general there seems to be two distinct types of cooperation with the external vendors during the technology development and qualification processes, differing in the relations between the developing company and the customer representatives responsible following up the external development and qualification runs. In the first type, which I have chosen to call the pure contractual relation, is characterised by a distanced relationship, and little degree of openness from the vendor and little involvement of customer representatives in the development and in-house qualification process of the vendor. The involvement of customer representatives is restricted to a controlling function to oversee that the vendor is satisfying specifications and contractual terms at scheduled milestones, much in the same way as in engineering projects. Respondent 9 comments on this type of relation as an ***"I will pay out the money, and you shall deliver me a product"-relationship."***

The other type of cooperation, which I have chosen to call the informal team relation is characterised by a close relation, with a high degree of openness from the vendor and a high degree of involvement by Statoil personnel in the executing vendors development and qualification process, to an extent were you can say that the Statoil personnel and the vendors project team are working together as one informal but unified team. An example from such a relation was given by respondent 7:

R7(RD,OA,PL,DP):"We were a part of the project team, and we used a lot of resources on it. We were participating actively in the project. In technical matters we were a part of most

things, and generally we set the premises for almost everything. What to develop, how to develop it, and the order in which to develop it."

One of the main differences found between the two approaches are the customer representatives ownership to the external development and qualification activities and the willingness and possibility to give guidance and participate in finding solutions to problems and adaptions that fit the customer needs. The following quote from respondent 9 illustrates this.

R9(PL,SC,DP): "When problems occur where we have a close cooperation and work as a team, then it is the team who fails, and the team that looks for solutions. In contrast to projects where you don't have that openness and cooperation, then it is the partner that runs the project who fails, and you as a customer are sitting there with a critical eye asking "Why haven't you?" and "Why aren't you on track?", you are not solution minded at all , you are just being plain out demanding."

To the vendor the informal team relation is beneficiary in terms of getting help and guidance on how to deliver a product best suited to the operational environment and customer needs, which of course also benefits the customer.

R4(EC,DP): "To us it has been alpha and omega, to have the possibility to have people from the customer that uses time to really understand what we shall deliver and understands the value of it and can guide us with respect to what is the optimal way of delivering this type of service."

On the contrary not meeting expectations and specifications in the distanced pure contractual relation lead to criticism and resistance.

R9(PL,SC,DP): "If it is me and you, and you are supposed to make something for me, and you don't involve me along the way, you better have everything in place and don't mess up anything at all, because if you do you'll have an opponent at the other side of the table."

Besides personal chemistry, three key characteristics are mentioned as important in the informal team relationship, openness, trust and mutual respect, whereas the pure contractual relationship often are characterised by opposite characteristics. The following three quotes are descriptions illustrating the openness, trust and mutual respect perspectives of relations leaning towards the informal team relation.

R3(RD,SC,DP): "They have been very open to us, very honest and very direct. So when there have been delays or anything, we've always been informed straight away. It has a great value, and is a part of what has made the project go so well, that it has been 100% openness."

R9(PL,SC,DP): "It is a long term thing. You build up a trust relationship with all parties involved. You know they don't lie to you. They can disagree with you, but then you argue on a professional foundation, a strategic foundation or whatever it should be. But there are no hidden agendas, and it makes it incredibly much easier to cooperate, and concentrate on the development they are doing. "

R9(PL,SC,DP): "What really has worked in that particular project is that you have people that respect each other, you have people that are being mighty open and don't look for excuses and distribution of fault"

When openness and trust is lacking in the relations, the relation quickly end up as a pure contractual relation, being found little constructive, and focused on control of deliveries.

R9(PL,SC,DP): " I am working with this operation where a guy from a service company keeps sending me information which I all the time have to quality assure, just because I keep finding faults his claims, and such cases turns out to be very little constructive and effective to put it that way."

R9(PL,SC,DP): "The times you end up with problems collaboration-wise, is when the supplier hides facts along the way, when you get surprises. You can say it is twofold, if you don't have trust in the supplier you end up as a controller, checking up on and ticking of what he does compared to expectations and contractual demands. That is the trust part of it. And what builds or removes the trust is these surprises, where things are not brought to the table soon enough."

Seemingly the type of relation, affect the personal engagement of the customer representatives in the innovation effort, and their positivity to the vendor and the innovation efforts.

R9(PL,SC,DP): "It is much more satisfactory and constructive to concentrate on working together against a solution, opposed to other times when you are sitting there interpreting and wondering about the things not said, and the reasons why certain things were said."

The informal team relationship besides building engagement, over time also seems to assist in building an in-depth understanding of the innovation to the extent that customer representatives can become technology champions and ambassadors for the technology in their own organisation.

R3(RD,SC,DP): "Well, we've been working on it for a long time, and know it inside out, to the point where we probably know it better than 95% of the vendors people. "

R3(RD,SC,DP): "And that support, that we can step in and do things for the licenses, or just be sitting in the chair beside them, has been very important."

Another important aspect is that in the informal team relation, the customer and its representatives tend to participate in reshaping, adapting and forming the innovation to their needs.

R3(RD,SC,DP): "To a large extent we are the ones who have come up with the innovative elements of some of the solutions that have been chosen. So it has absolutely been a form of collaboration where we on equal terms as the vendor, have contributed to problem solving and the innovative of the solutions, coming up with how to do things."

R3(RD,SC,DP): "It is due to us seeing that if you had this you could have done that, and if you had that you could have done this. It is merely that we see that the technology opens some doors for new thinking. And if you combine the technology with other things, it opens even more doors. So it is just about looking for the potentials for getting the most out of the technology."

5.2.2 Cooperation internally in Statoil

Also when it comes to collaboration between the actors internally in Statoil, one sees traits of the same type of relationships as with the external vendors. Following the Statoil technology development and qualification process the process often turns into a form of relay race, where R&D, the discipline ladder and the operating units has little participation in the activities of the other parties except filling their own distinct roles, and the process pays resemblance with the pure contractual relationship, with handovers and quality control at decision gates and handovers primary focus for interaction:

R6(RD,OA): "It sort of becomes a relay race. I think we would have a better implementation of technology if there was better contact between our operative and technology units. And having a closer relation would also strengthen innovation. There are many good suggestions and ideas to be found in the operative units as well."

The pure contractual relationship traits are especially is evident in the interaction with the operative units.

R3(RD,SC,DP): "But of course it is hard to get representatives from them to participate in for instance meetings. They don't have the time, and it is not prioritized even if we offer for them to travel on our budget."

R9(PL,SC,DP):"Before we can start a project we have to find a first user, we then involve and convince a license that this is something which could be useful to them. But during development they don't find it purposeful, or don't get authorisation to use resources to follow it up. Their attitude is that this is something that research and the discipline ladder should fix, and then you can come back and sell it in, so they to a very small extent participate and influence the development."

R8(VI,OA):" Of course the operative units have a whole to consider, and they can't prioritize everything. So if the job isn't important enough for them you won't get priority, even if it is a technology that would have been nice to have but is not strictly necessary for them to be able drill a well."

In cooperation between the disciplinary ladder and R&D units the level of involvement from the disciplinary ladder varies, often depending on the individuals involved. Their ability to use time on participating in the development process is named as one limiting factor.

R9(PL,SC,DP):" In the disciplinary ladder it is much up to individuals how they focus and aims. There are no policies on implementation of new technology."

R7(RD,OA,PL,DP):" I think most of the discipline leaders are very interested in and wish to use new technology, but it demands additional work and effort to be a pioneer for new things. I think the limitations lies more in it being made a bit difficult for them. They might not get to use the necessary time participating in the development of new technology, for them to see the benefit of it. So I think it is time pressure which contributes on the negative side, rather than the attitudes. "

Where one has managed to get involvement and interaction between the disciplinary ladder and the R&D organisation, resembling an informal team relationship it has been considered beneficial to both development and implementation activities, improving the follow up of activities and giving better experience transfer. This form of collaboration is considered to benefit in improving the technology and further development as experience from use and implementation is successfully being transferred back into development activities.

R9(PL,SC,DP):" It is not usual, but due to the high degree of support from the managerial level, it has been accepted that I as representative from the disciplinary ladder is more involved with the research and development activities than in most other projects, and research has been more involved in the implementation than in other projects. It gives us more resources, it increases our follow-up capability, and we get better experience transfer."

R9(PL,SC,DP):" When it comes to the normal technology scheme, research would have let go of it when the pilot was finished. We are very lucky that the research personnel is participating in the continuation, and it helps the both the implementation of the existing system, and it helps in transferring the experiences from the use of the existing technology into the development of the next generation."

It is considered beneficiary for the quality of technology if the operative units could have been more involved in the developing activities, getting products more adapted to the actual needs of the end customer.

R9(PL,SC,DP):" I believe you get a better and more suitable product if the customer participates. It is fair enough that we have good people working in research and the discipline ladder, but if you could bring in a first user specifically working against the field you are developing for, you would get a product more adapted to their needs."

5.2.3 Cooperative barriers

In collaborations between Statoil and more than one external partner, one area identified as causing hindrance to collaboration between the parties in innovation projects is un-clarity about the roles of the collaborating parties in the commercialisation of the end product. This often is the case in collaborations with more than one party, where commercialisation agreements are left to the third parties to work out, and often are being left unfinished during development process. Another case is where commercialisation agreements are not being long term enough, and thus expiring before the product reaches the commercialisation phase. One reason for the operator company in these cases not being stronger involved at an early stage, can be that the operator has no direct commercial interest in the sales of the product, having the use of the commercial product as a service or technology available from a third party as main objective.

R1(RD,EM,RO):"What really, really torpedoed the project was when they brought their commercialisation plans out in the open, and lifted the all their technology rights over in a company we saw as a direct competitor in an area we considered strategically important. Then everything fell to pieces. After that it was just to the extent possible, to try to keep a straight face towards Statoil, so we wouldn't get caught in a direct breach of contract."

R2(RD,DP):" Everything was easy until they reached the point where the product should be ready, and they should start making money. Between them they had a deal where the product was to be commercialised through one of them. The details they should clarify themselves. But due to it taking longer time than expected to have a product ready, the deal

expired, leaving the commercialisation part unclear. They've got along so far, but there are some underlying conflicts there. "

It seems that to avoid disagreement about commercialisation roles, it is beneficial to establish an agreement about roles and commercialisation prior to starting collaborative activities, and that one part, typically the operator company, has a leading role with an established mandate to cut through if disagreements occur.

R1(RD,EM,RO):" It was not expressed any clear ambition from us where we wanted it to lead, it was not expressed any clear ambition from the research institute what path they wanted to go, nor what should be the role of us and what should be the role of the research institute. And it was also unclear from Statoil's side what would be the total market for this type of technology."

Although operator companies have a strong position and often can force parties to cooperate either through established delivery contracts and or their customer position. It seems that this is not necessarily an optimal solution for forming a good collaborative environment, and often creates resistance in the further work.

R2(RD,DP):" On the other hand they still got a commitment. When Statoil have a well where their equipment is used, and we want to operate a different way, they have to cooperate."

R4(EC,DP):" We experienced a good deal of resistance, and also Statoil which coordinated the collaboration at the time experienced resistance, and little willingness to get things in place."

R5(PL,DP):"The disagreement between them makes things hard. Every time we bring in their management and need new negotiations it is tricky."

5.3 The importance of proximity

5.3.1 Geographic proximity

Geographic proximity seems to be most important in terms of being located in an area which has a professional environment or cluster of companies within the same discipline. Important factors are to have easy access of competent personnel and suppliers. This also related to social proximity, that there is an existing competence environment or network where ideas can be exchanged, picked up and developed, which is especially important for small and entrepreneurial companies. To have geographic proximity to the end customer is mentioned as less important.

R1(RD,EM,RO); "Talking from own experience, geographic proximity to others who are working within the same area is very important. No business is one-dimensional, so you always have to relate to someone else. It could be suppliers of concrete technologies you need to have near you to integrate closely, it could be to have access to qualified personnel for hire, or it could be to have access to competent suppliers of standard products that knows your application so you save time on adult education. I would say it is much more important to be close to those who are doing the same as you, than the end customer. To be close to the customer is in no way essential."

R8(VI,OA):"You see that the start-up companies often derives from the technology-community related to Sintef/NTNU here in Trondheim, from the industry and business community in Stavanger, some from Bergen and some from "subsea valley" around Kongsberg. Then of course they are in an environment where also others are working with related things, seeming to be beneficiary."

The growth in use of internet technology and telecommunication technology such as video and web conferencing seems to have made geographic proximity less important for successful collaboration activities. However the success of using these aids seems to be closely related to social proximity, and that the involved parties has established individual social relations, as touched upon by Torre (2008) in his definition of temporary geographical proximity.

R6(RD,OA):"I think it can be a constraint, but much less than it used to be. Now you have communication aids like video conferences and such. But of course it is much easier to get involved with one another, if you have some form of physical contact or are sitting in the same room."

R9(PL,SC,DP):" We are so well coordinated that it works well discussing things using web-conferences and telephone. But of course we have worked together for a long time and know each other well, making it easier using phone and web to sort things out."

Internet and telecommunications technology also seems to have made it easier to pick up new technology and finding and establishing contact between potential suppliers, customers or innovation partners across geographical distances. Although not direct mentioned it is reasonable to believe that internet and telecommunication technology also has had an effect on the ability to sustain professional networks regardless of physical distance.

R6(RD,OA)." I think we have quite a good record on managing to pick up things that are happening elsewhere in the world. The threshold is getting to know that something exists. You have to get aware that the businesses exist and get to know them. But it is easier nowadays since nearly everyone has some kind of web pages or something, making them searchable."

However, geographical proximity seems to makes informal contact easier although it has become a far less important factor in collaborative efforts.

R7(RD,OA,PL,DP):" If you have a company located nearby, and they have a laboratory nearby where some laboratory work is to be conducted, it is much easier to just drop by and have some informal contact. If the same thing is run somewhere far away it often ends up with just more formal contact. The informal contact is much easier with smaller distances."

5.3.2 Social proximity

As touched upon previously social proximity and temporary geographical proximity is closely related. It seems that physical interaction is important in building the necessary social proximity to facilitate fruitful collaboration efforts, and especially for distanced collaborations. Socially embedded relations (Boschma, 2005), is found to be of especially importance for distanced communication and collaboration, in line with Ben Latifa and Robeau (2013)'s view on social proximity as a facilitator for communication, knowledge transfer and communication, and at least in the start of collaboration activities efforts should be made to build such relations.

R6(RD,OA): "It means a lot for the outcome of the project, or at least the start-up of it. If you meet people you have met before and have some previous relation to, it makes things a lot easier. It might be you have met someone at a dinner or taken a cup of coffee discussing things informally, and when you later meet them in a more formalised setting things become much easier."

R4(EC,DP).: "To have a good chemistry is very important to be able to talk the same language and communicate effectively together . If you have to do things too formal all the way you'll spend a lot of time, but if you instead can pick up the phone and quickly give a message, and that you have worked together with the person at the other end that he understands the message clearly I think is important."

R9(PL,SC,DP):" One of the main reasons that it works so fine is that we know each other so well. We have worked enough together, met each other often enough, eaten enough dinners and done enough small talk for it to work over the telephone. I think you have to have built up quite a bit of confidence in each other to have effective web or phone conferences."

R9(PL,SC,DP):" It is interesting, the thing about trust and cooperation. You need to make an effort at least in the start of a project when people are new to one another to meet, sit together, and go out and dine together. That you know a person, understands him and that you dear to joke because you are confident that he knows your humour. That makes the collaboration much easier. It also makes you understand how they think and how they react, and make it much easier just to pick up the phone and ask about things. But in my opinion you have to make an effort in the beginning of a project to create that confidence between the parties working in a project."

Another aspect related to social proximity and innovation mentioned is informal meeting spaces and professional networks, which is found to be of importance to innovation as arenas or communication platforms for informal information exchanges. However, some of the respondents also points out that too close social relations also can be of concern regarding the loyalty of individuals.

R1(RD,EM,RO):" You need effective communication platforms, where concerns, ideas and problems are exchanged. I have not found any IT- based forum that compensates or makes the need of human presence disappear. Good meeting places without agendas are, in my opinion, crucial to get the good innovation processes started."

R6(RD,OA):" There can be some conflicting interests to social interaction, you should not know people too well either if you know what I mean. But I think it is important to have some contact, at least in professional networks like for instance SPE or the petroleum society. You need to have a meeting arena to pick up thoughts and ideas and to share challenges and problems."

5.3.3 Technologic proximity

On among established companies one see that it is harder for companies rooted in other industries to establish themselves in the drilling market. One reason for this appears to be the previous mentioned barriers to entrance set up by the established actors in the drilling marked previously discussed. But lack of technologic proximity can also be an issue, both in terms of operators and established companies openness to new solutions from other industries, and also for other industries proximity in terms of being able to take into account the complexity and demands from the drilling industry.

R1(RD,EM,RO):" There are relatively few examples, at least within drilling technology, that totally different industries has come in and made a big difference. I would say that they have been far more important through the impulses they have given the traditional actors, rather than managing to break through the wall the system integrators have built. There are only a few examples of the opposite. The best one is probably the Dutch company Huisman, which started out with cranes, and from there evolved into making complete drilling packages. But except from that, the examples of someone which has begun in a completely different industry and been successful in introducing themselves into the

drilling marked are few. But as impulse providers and guides other industries has been very important, and there are also individual innovations which have been picked up by the established companies, and even been bought up.”

R7(RD,OA,PL,DP):”We had one study we ordered some years ago, where a contractor who earlier mainly had been working onshore on land rigs, lacking offshore experience should do a theoretical study for a task on a floating drilling vessel. To make a long story short, if they’d been allowed implement their solution the rig would have sunk.”

For entrepreneurial and smaller suppliers it seems to be a common starting problem that they often don’t have the technological proximity in terms of customer perspectives and customer needs, not understanding the context where their product shall fit in. Although learning by doing might work to gain this type of proximity, it can be a costly process both in money and resource usage. The experience background of individuals is also mentioned as a an important factor when it comes to technological proximity and understanding of the customer needs.

R8(VI,OA):” A recurring problem among start-up companies is that they pay to little regards to the customer perspective, and what job it actually is to find the customers, engage them and make sure that what they develop matches the needs of the customer and what the customers are willing to buy and pay for.”

R8(VI,OA):” If the technology companies early enough had gained a sufficient understanding of for their customers and the context the product should work within, they would probably have saved both time and money, and avoided coming in situations where they’ve invested a lot and still don’t manage to sell the resulting product.”

R8(VI,OA):” It depends on the experience background of the entrepreneurs. Some have experience backgrounds from companies and the industry which make them understand the landscape, whereas others haven’t. And then we have to help them understand.

Openness and dialogue seems to be the best way of overcoming lacking technological proximity, and the informal team type collaboration discussed earlier can be of relevance to gain technological proximity. By the respondents is seems that the venture industry has become more and more aware of problem with lacking technological proximity, and there are also possibilities for entrepreneurial companies to get assistance in such matters both from third party advisory companies, and through venture capital organisations.

R6(RD,OA):"It is often that the innovators haven't understood the real problem setting well enough, and I think it is important that there is openness to discuss and see what we can do to make them understand the real nature of the problem. Sometimes the way they ask questions also can give us a different picture of the real nature of the problem, making it a two way opportunity to evolve."

R6(RD,OA):" There are quite a few companies which business is to advice entrepreneurial companies in these matters. I think it is important that start-up companies use this type of aid. Also finance institutions and venture companies which entrepreneurial companies are dependent on getting in contact with have quite a good competence on this. "

When it comes to technical proximity in collaborations and teams it seems that mixing disciplines and people with different backgrounds are a good for innovation, whereas it is noted that having only people with the same background makes innovation level out. However to be able to benefit from mixing people with different backgrounds one needs to have relatively strong teams upfront to integrate the new knowledge. Openness to and some prior knowledge in the new area is also mentioned as factors important for the ability to integrate and develop new ideas.

R6(RD,OA):" I am a supporter of mixing disciplines, and get in people with other experiences and backgrounds from other disciplines. I think that if you only have people which have experience and are experts within the discipline in question, the innovation level soon will flatten out. To generalise, you often become better at seeing limitations than opportunities when everybody has the same background. So I am a supporter of mixing people, and get in someone who isn't that experienced within the discipline one is working with. But it requires that one has relatively strong teams and enough people working with a given problem, for a newcomer to be integrated and managing to understand the true nature of the problem."

R6(RD,OA):" If someone comes with a new idea or a new approach, it is easy to think of, or making explanations, why it won't work, rather than looking at what has to be done to

make it work. I think it is important to have the ability to listen and be curious about it. That said it will always be an advantage to have people within a similar discipline which can assist, at least at the idea stage in telling whether this is something which can be realised. If you don't have any experience within a given area, it can be you take too easy upon the complications involved with new technology. But then again the danger is that experts often can become a limiting factor, depending much about the attitudes of the individual expert. But clearly it is an advantage to at least to some extent have knowledge about the technology proposed."

5.3.4 Cognitive proximity

One finding regarding cognitive proximity of importance is that the perspectives, in terms of how of the actors "perceive, interpret, understand and evaluate the world" (Wuyts et al. 2005:278), are to a large extent shaped by their role in the industrial value chain, and the goals and priorities of the organisations, organisational elements and individuals involved. Knoben and Oerlemans(2006) states in their definition of cognitive proximity that actors need to have similar reference frames to effectively and efficiently communicate and transfer knowledge. However, based in the findings it seems that an important aspect of cognitive proximity and similarities in reference frames underlying the ability to communicate and transfer knowledge, is the individual actor's willingness to collaborate and their ability to pull in the same direction in collaborations based on having aligned incentives, goals and priorities, and thus are closely related to previous mentioned industrial barriers and incentives. Besides that the actors in the drilling value chain has different perspectives due to how they make an income, one also sees that the more distanced actors are in the value chain the more distant their reference frames are. This is found to be due to the suppliers sales focus leading to a closer cognitive proximity to their direct customers' perspectives and needs, rather than priorities more distant in the value chain.

R1(RD,EM,RO):" Of course collaborations are affected by the actors' differences in perspective. One's expense is the other's income, and that is a fundamental barrier. The best way of overcoming it is to convince the customer or the supplier that they generate more value by using their money or resources in a certain way."

R1(RD,EM,RO):" It also has to do with what is seen as problems. The things operators see as particularly problematic, one are quite unsuccessful in turning into sub-suppliers problems. And so it goes successively down the value chain. What is the drilling contractor's problem the drilling contractor is not very successful in transferring further. And I think one of the reasons is that one makes money in different ways."

Closing gaps due to lacking cognitive proximity thus becomes a matter of understanding the perspectives and reference frames of the involved actors and trying to generate aligned incentives and win-win situations.

R1(RD,EM,RO):" To overcome such problems you need to have insight in how those who are underneath you in the value chain are thinking. In the abundance of incentives in this value chain, you need to make some artificial ones, making some kind of reward system for the functions, technologies and systems which makes most value to you, and thus win the internal prioritisation struggle which goes on in all companies. As a result one instead of running reengineering project aiming at producing a given machine cheaper might prioritising using the same investment funds on making something the oil companies are asking for."

R6(RD,OA):" We don't share the same goal. They have an objective of getting as much money as they can out of us, while our objective is to use as little as possible on them, like it always is in sales situations. But their motivation should be to increase their sales because they have better products than the competitors. But then again they have demands from the owners that what they spend on developing new technology shall be returned from the sales with as high profit as possible, which can be a hindrance for adopting new technology. So to collaborate as good as possible, we have to try to understand how they think, and they to try to understand how we think to be able to make win-win situations for both parties."

Also internally within organisations having shared reference frames between organisational parts and internal actors appears to be relevant, and alignment of incentives and goal can be a contributor to improve collaboration.

R6(RD,OA):" To some extent I think we are being pulled in different directions, because we have different objectives. And I think we would have been better at implementing technology if there had been better contact between researchers and users. The research and discipline ladder, the technology community I think looks much at the same things, but to get better contact between the technology community and the end user I think would contribute to increased innovation."

5.3.5 Cultural proximity

Geographical culture in terms of culture differences between individuals was not identified as being of particular importance to the respondents. One thing mentioned was difference in politeness, where politeness can be a hindrance for asking for clarifications, and sorting out misunderstandings. Another thing mentioned is culture for openness, where Norwegian culture seems to have a larger room for openness, criticism and discussion between actors, than common in many other countries. Varying degree of openness is also found as a difference in corporate cultures. One of the reasons for not finding bigger geographical cultural differences might the global nature of the drilling and gas industry, another might be that most of the main actors involved with the drilling industry in Norway are companies from countries within the western world Europe and Northern America, and bigger differences can probably be expected to be found with company actors rooted in other parts of the world.

R7(RD,OA,PL,DP):"Language misunderstandings can occur, and sometimes they can be so polite, that instead of saying they don't understand what you say, they just ignore it and continue with "OK! Shure.""

R6(RD,OA): "There are examples where cultural differences are making things harder. It may for instance be differences on how openly you discuss new technologies and results. In some cultures for instance it is totally unthinkable to criticise a customer, or to have objections to results. One of the benefits of the Norwegian model is that we have a high degree of openness, and I think one of the reasons that we have had as much successful technology development in Norway is that there are some room for discussion , both internally in the projects and between vendor and customer."

Differences in corporate culture was found to be of more importance than geographical, especially differences in openness towards customers and collaboration partners was mentioned as a restricting factor for knowledge transfer, learning and collaboration. Also internally in companies and among individuals cultures of varying degrees of openness was found. Especially American companies were mentioned as being less open in innovation collaborations. Other cultural differences rooted in corporate culture and strategies, were differences in risk aversion or risk willingness, and differences in their willingness to involve and engage in innovation activities

R9(PL,SC,DP):"The American companies have much more of a culture for not being so open against their customers, because of some reason they think it will fall back on them. We have seen several times that they struggle being open, and prefer to keep all problems internally, because they think it can be used against them."

R6(RD,OA):"My experience is that most of the time cultural differences are not due to different nationalities, but more due to different corporate cultures which have developed over time. Some operator companies might for instance always be user number two or three when it comes to new technology, while others very often are first users of new technology. I think the management is important, and their attitudes. When it comes to use of new technology it comes down to the degree of risk aversion or risk willingness."

R6(RD,OA):" You see some recurring cultural differences internally in the companies as well. Some places people are very restrictive. You shall not say anything, and it is very important that the idea you have come up with, only you shall work with, so that no one will steal your idea and take it further. Whereas other parts of the same company there can be very open and trustful. I think the open model is what works when it comes to innovation."

Also between bigger and smaller companies some cultural differences was found. Larger companies mentioned to being more laidback in their approach to innovation, whereas smaller companies more eager to innovate. One reasons for the differences might be that for the big companies their main activities are selling the products from their existing portfolio, and as such innovation and development activities are a smaller part of their business. It is also reasonable to believe that there are big differences between the large companies.

R8(VI,OA):"In a big service company doing well on selling the products they already have, development might not become such a central part of their business as for the small ones. It might not be unimportant, but it definitely not what matters the most, which is to sell and deliver the products they already have."

R4(EC,DP):" The main difference is probably that we as an entrepreneurial company are more impatient on getting decisions made and getting progress in what we are doing than a big company like Statoil is capable of. I don't think it is a matter of will, but rather due to the decision processes of a big company like Statoil."

An explanation to the smaller and entrepreneurial companies being found more eager can lie in the fact that they are dependant of innovation success to succeed, and that they are more transparent in terms of each employee having and knowing that their role is vital for the success and survival of the companies, making also individual employees more eager to perform.

R8(VI,OA)." I think that in the small companies everything is more transparent, and everyone knows that their role is very central, and everyone must invest energy and motivation to succeed. Whereas in a big company everybody hopefully feel that they are doing something useful, but you don't feel that the company will go under if you are not there."

As mentioned before with regards to industry barriers, the different perspectives of the actors in the value chain also contributes to forming corporate cultures and is source of differences in terms of what is prioritised and what is seen as important.

R1(RD,EM,RO):"All companies prioritises the biggest money-makers. For the operator it is the production, and it overrules all their prioritisation. With the drilling contractors it is of course the drilling process which overrules everything. To keep the machinery running, to keep the wheels turning, steers all their priorities. While for the equipment manufacturer it is often the salesperson, and what is necessary to make the salesforce and the following deliveries work which is important."

Overall the aspect of cultural proximity found to be of importance to innovation is the varying degrees of openness between organisations, which can be a source of hindrances to success in innovation partnerships.

5.3.6 Organisational proximity

From the respondents lacking organisational proximity is not a problematic hindrance to innovation. Mostly this is due to the fact that most of the major actors work along technology qualification processes which are fairly standardised throughout the industry.

R3(RD,SC,DP):"They only use our definitions, and have adapted to our milestones as well, so we share the same milestones. They shall achieve something before they move on to the next step and that is basically the same as we do with our TRL and TDG levels, it looks much the same."

R9(PL,SC,DP):" Their technology qualification process is quite similar to ours. They spend longer time than us before they regard the technology as being finalised, trying out the technology. But to a large extent they adapt to the steps we demand along our qualification process. And that goes for most of that technology, we still are still in charge although we work as a team, and we set the requirements."

For entrepreneurial companies this is not always the case, and established companies are seen as easier to work with than entrepreneurial due to them not having in place or the understanding of the qualification processes demanded.

R7(RD,OA,PL,DP):" We often see that companies that have worked with us over a longer period of time, which know and have accepted our routines, are easier to work with than new ones that are coming in."

Another aspect related to organisational proximity reported is the difference between entrepreneurial and large companies such as operator companies when it comes to decision making. Due to the size of organisations and the number of actors involved decision making in the large companies is a more tedious and time consuming process, than in the smaller companies. This can be seen as problematic for entrepreneurial companies with shorter decision paths, who often are more eager to progress and having more pressure on securing income flows.

R4(EC,DP):" The main difference is probably that we as an entrepreneurial company are more impatient on getting decisions made and getting progress in what we are doing than a big company like Statoil is capable of. I don't think it is a matter of will, but rather due to the decision processes of a big company like Statoil."

5.3.7 Institutional proximity

As with organisational proximity, institutional proximity is not considered to be problematic either. Most of the established big suppliers and service companies are reported to have a good understanding of rules and regulations, often having big units placed in Norway and countries they operate in. For smaller companies and foreign companies new to the Norwegian market, this seems to be more problematic, and their knowledge and ability to adapt often are dependent on individuals and their competence and attention.

R6(RD,OA):" Today I think the service companies have a good overview of Norwegian regulations, but it has not always been that way. They have big units in Norway with good knowledge of specific regulations, and also company-specific regulations. Often they know the regulations even better than we do."

R9(PL,SC,DP):"The big companies have a very good understanding of the requirements in the Norwegian sector, they are well incorporated in the companies, but of course we need to follow up along the way and supplement. When it comes to smaller companies, which might not be integrated in the drilling industry they often have less knowledge and understanding."

R7(RD,OA,PL,DP):"For foreign companies it varies a lot, some companies have a good understanding of rules and regulations, and some companies just have an understanding for their own little or big world outside. The big suppliers normally have more experience with small countries like Norway, but also here it is very dependent on individuals. I don't see it as a big challenge, normally it works out fine."

R6(RD,OA):" For start-up companies starting from scratch, I believe laws and regulations might pose a challenge, unless they have some previous experience of working with the drilling industry or that people involved have a background from within the industry, like for instance a driller or maintenance worker with a good idea he want to start a company from."

6.0 Analysis and discussion

6.1 Innovation models

Lawson and Samson (2001)'s model for innovation strikes an important point, which is that important for forming innovation capability is the ability to merge mainstream business capabilities and activities with "newstream" or innovation activities into an innovation output in the form of a new product or altered business capabilities. However the model from Lawson and Samson (2001) seem to be more suitable for inhouse research and development activities rather than the collaborations with industrial actors seen in the drilling and well industry. One of the aspects with both the Lawson and Samson (2001) model and the original Kanter (1989) model is that it does not take into account the more complex relations seen in the drilling value chain, with a variety of actors which not only contribute with human and technology resources, but also funding for innovation activities. Thus these models do not account for an ecosystem perspective where innovation is the result of the interplay between several detached actors. In this aspect the model presented by Henderson et al. (2013) is more suitable merging resources to create define capabilities without concerning where the resources come from. This model thus don't restrict innovation capability to the merging between the distinct "newstream" and "mainstream" activities or capabilities as a source of innovation capability turning into an innovation output as in the model presented by Lawson and Samson (2001). Instead Henderson et al. (2013) states that dynamic capability is focused around the merging of resources of various nature forming new defined capabilities, thus making innovation efforts a matter of integrating elements and resources from the resource stack into capabilities which in turn can form new innovations. However the model relies to a large extent on the layers of the resource stack having clear interfaces in between them, which not necessarily is present in the drilling and well industry, or the interfaces being controlled and their access restricted by individual actors. This results of this study show that the creation of such interfaces, both of technical, organisational, governmental and relational between the elements of the resource stack is a main challenge when integrating and combining elements to form new capabilities. Whereas Henderson et al. (2013)'s model supported by Ambroisini & Bowman (2009) and others implies that a firm holds resource base of internal and external resources readily available to integrate and combine into new capabilities, this study shows that the creation of interfaces between resources often owned by independent actors is an important and dynamic part of creating constructive innovation activities, and not necessarily a prerequisite of the available resource base. In other words, to constructively combine resources from different actors, they must be or be persuaded to willingly collaborate throughout the innovation process.

Another interesting and complicating aspect of the drilling and well industry is the large degree of outsourcing from the operator or the end user side. The outsourcing leads to collaborative innovation efforts having to result in both a supplier capability to sell the innovation as a product or service, and an end user capability of utilising the innovation sold. It is important to bear in mind that the user or organisation which physically implements and operates the innovation not necessarily is the same as the end user in terms of utilisation of the innovation, which further complicates the picture. Hence, an innovation model for the drilling and well value chain based on the model introduce by Henderson et al.(2013) thus can be defined as in Figure 9.

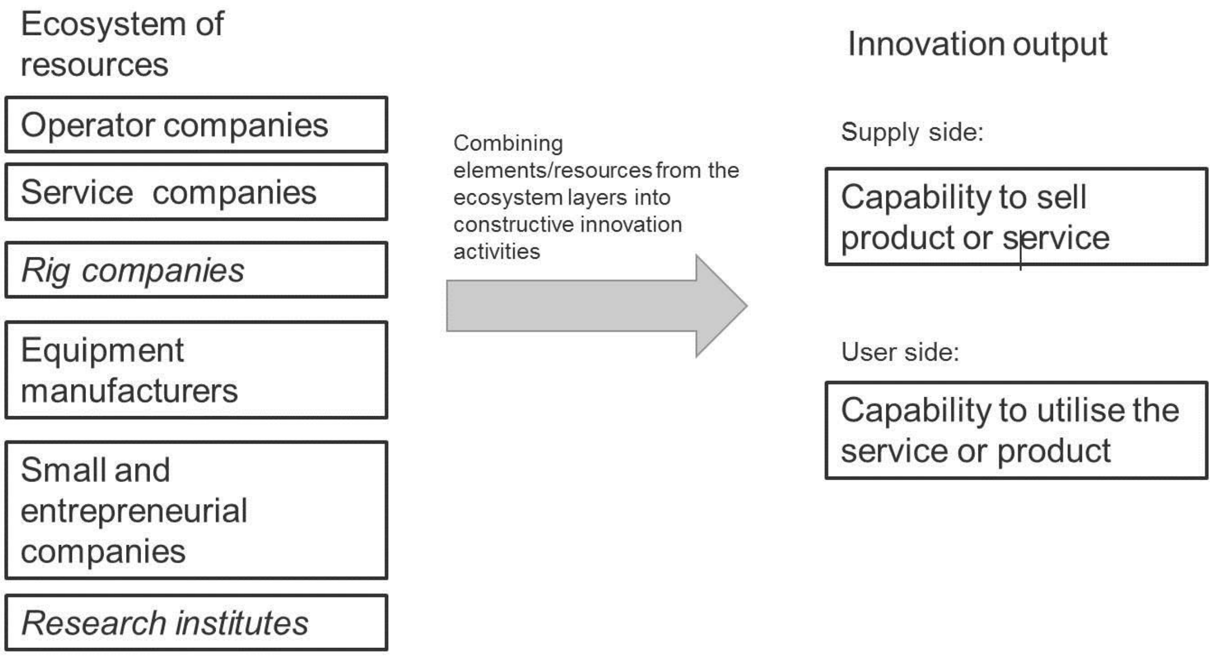

Figure 9 Innovation model for the drilling and well value chain

The principle of having a supply side and a user side perspective to innovation, where innovation often is done in collaboration with one (or more) suppliers and user(s) often on equal terms, brings in an extra element to the traditional definitions of dynamic capability, such as the ones found in Teece et al. (1997), Zollo et al. (2002), Ambroisini and Bowman (2009) and also Henderson et al. (2013). Their definitions of dynamic capability are being rooted in one single firm's or an organisation's capability to integrate, build and reconfigure internal and external competencies and resources, whereas the collaborative nature of innovation in the drilling and well value chain make the dynamic capability to innovate not a matter only of a single firm's or an organisation's capability, but the symbiosis of multiple organisation's capabilities to both internally and in collaboration integrate, build and reconfigure internal and external competencies and resources into successful innovation.

6.1.1 Key points

- Innovation in the drilling and well value chain is best seen from an ecosystem perspective where innovation is the result of the interplay between several often independent actors
- The drilling and well ecosystem resources and actors have not necessarily any clear interfaces for collaboration or combining resources into innovation efforts, thus the creation of sustainable technological, organisational, governmental and relational interfaces between resources and actors involved become an integrated part of collaborative innovation efforts
- Innovation output must end up in both supply side capability to deliver a product or service and a user side capability to utilise the product or service
- Innovation in the drilling and well ecosystem is often the result of a symbiosis of multiple organisation's capabilities to both internally and in collaboration integrate, build and reconfigure internal and external competencies and resources into successful innovation, opposed to being the result of the innovation capability of single actors

6.2 Industrial barriers to innovation

The different perspectives of the actors in the drilling and well value chain, has been identified as the main industrial barrier to innovation. The perspectives was found to be formed by the nature of how the individual actors generate profit, each actor's willingness to innovate and their innovation focus steered towards improving own cash flows and protecting their business models. Between the operator companies as customers, and the service companies and rig companies the perspectives often were found to be in direct conflict, an example being the operators' incentive of reducing costs by doing operations more cost-efficient, which is a threat to the income potential for the service companies which are often being paid by time rates for the services they provide. This finding can be understood through proximity theory as gaps in cognitive proximity (Knoben and Oerlemans, 2006), between the levels of the drilling and well value chain, with the reference frames of the actors being shaped by the individual actors business models, rather than the value chain actor sharing a shared reference frame. The difference in perspectives can also be explained through Latour (1990)'s programs and antiprograms. The behaviour of the actors at the different levels of the value chain is being explained by their organisations running conflicting programs defined by their individual goals. Bringing in the actors perspectives to Latour (1990)'s theory thus link together proximity theory and the understanding of innovation from a translation perspective.

The limited competition between the service companies, and also between equipment manufacturers are not making the barriers in incentives smaller, often having only two or three companies competing over a certain range of services or products. The companies often using platform ownership (Cusumano and Gawer, 2002; Eisenmann et al.,2009) as successful strategies to obtain platform leadership through closed platforms. Through bundling and leveraging own products, service and equipment manufacturers have successfully expanded the platforms they control and created effective barriers of entry for new competitors. This makes it extremely capital demanding for newcomers to establish themselves as competitors, thus smaller companies have to establish themselves as suppliers rather than competitors to the large service companies and equipment manufacturers. Controlling their platform interfaces the service companies and equipment manufacturers selectively can control which actors are allowed to interface their controlled platforms and at what terms.

Despite there being more competition between the rig companies in terms of the increased number of suppliers, they are by far the largest customer of the topside drilling equipment manufacturers. The rig companies' perspectives were found to be more influential on the equipment manufacturers' innovation than the operator companies. This was found to be caused by the operator companies mostly being only indirect customers through the rig companies. The equipment manufacturers thus make the operators innovation wishes less influential than those of their direct customers. The drilling companies are getting paid by the operator companies for the operational time their rig and equipment are used, thus reliability of equipment is the main driver for their choices when buying equipment. As indirect customer of topside drilling equipment, operator companies are not able to provide incentives in terms of higher prices or market shares for the equipment manufacturers, and thus their innovation needs are not prioritised unless they coincide with the rig companies´ priorities. Elaborating on this it is reasonable to say that the more distant actors are in the value chain, the larger the gap in cognitive proximity is between them. Actors in direct customer-supplier relations are having a higher degree of cognitive proximity than actors which are more distant in the value chain.

Another dominant feature of the operator, rig company, equipment manufacturer value chain is the actors perspectives on time. Whereas the operator companies operate with a long term perspective of production from oilfields during over a fields lifetime, rig companies and equipment manufacturers operate with a more short term contract perspective, directing their view on innovation towards innovation gaining leverage for securing the next contracts rather than the operators focus on innovation to optimise production over a the lifetime of a field. Understanding these findings in terms of cognitive proximity, one can say that the actors' different perspectives on time contribute to gaps in cognitive proximity between them.

Service companies and equipment manufacturers' willingness to innovate can also be hampered by their wish of maximising profits on existing products, especially in areas with little competition, and rather focus on harvesting profits of existing products than creating new and improved products, where the gains in terms of competitor positions or the potential form gained income from improved products are relatively low. Competitor positions were found to be the largest driver for innovation among the larger companies. The cost of development and qualification, also impacts on the willingness to innovate, especially where the potential in terms of number of sales are few with large development costs. In terms of perspectives, the operators wish to innovate can be in conflict with the suppliers wishes to maximise profit on existing products, or innovate through smaller increments to increase the numbers of sales through regularly providing new updates with only smaller innovative content. This is again an example where the value chain actors' business perspectives lead to gaps in cognitive proximity, or rather that their cognitive perspectives collide in the form of having conflicting interests. However, the behaviour can also be understood in the terms translation theory and Latour (1990)'s programs and antiprograms, with the opposed interests of the actors with manifesting themselves through different programs or behaviour patterns.

In this environment smaller and entrepreneurial companies seem to have limited possibilities to establish themselves over time as direct suppliers to the operator companies, not only due to the barriers set up by the large service providers and equipment manufacturers, but also due to the contractual strategies of operators where large integrated contracts are preferred. These mechanisms are pushing the smaller vendors a step down the value chain, turning the service companies and large equipment manufacturers the main customer group for these companies. Cf. the earlier discussed cognitive distance between actors increasing along with their distance in the value chain. It is however, reason to suspect that such a shift down the value chain might affect the innovation perspectives of smaller vendors, making the equipment manufacturers' and service companies' perspectives becoming dominant for the innovations which are successfully established in the marked. This could especially be an issue where there are differences in incentives between the service or rig companies on one side and the operator companies on the other. Another hindrance to especially entrepreneurial companies' success is found to be the resources and the long term capital needed to get their products commercially available. Although this is a common problem setting for most of the small and entrepreneurial companies, the complexity of the technology within the drilling and well area, especially in terms of interfacing other systems, and the lengthy qualification processes needed for new technology to be accepted as commercial by the operator companies' makes the duration and resource needs of the innovation run especially long within the drilling and well industry.

Overall it seems that small and entrepreneurial companies have an important role to play as challengers to the established marked leaders among service companies and equipment manufacturers. This is especially the case in areas where their incentives are low for innovating and where competition is low. Operator companies however seems to be participating in creating barriers to newcomers in the market due to their preference for large integrated contracts, which only the biggest established players are able to bid on. Another aspect is also that by funding and collaborating with the marked leaders research and development activities the operators indirectly contributes to creating monopolists, and sustain the existing marked structures. Transferring this to translation theory and Latour (1990)'s theory of programs and antiprograms, it is interesting to see the dynamics of translation between the programs of the operator and service companies have contributed to create marked barriers for newcomers in the marked, through the bundling of packages from service companies and the operators preferences for large integrated contracts. From an innovation and a marked perspective however, it is reason to question whether these dynamics have been in favour of the long term interests of operator companies. Although the operators' have possibilities to force technology and services from smaller companies to be taken on by the rig and service companies, this study suggests that this might better serve as an opportunity to sell oneself in to the service and rig companies, rather than being a fruitful long term strategy for smaller vendors to capture significant marked positions.

One could argue that from an operator perspective the key to overcome these barriers could be to integrate backwards themselves, or support backwards integrations in the value chain, for instance building themselves up as rig owners or service suppliers, or backing up other actors in doing so either through acquisitions or organic development. However, this study would argue that such approaches must be applied with care, as such strategies could affect the willingness of external actors to collaborate on innovation efforts. This is due to operators could be seen as taking biased or competitor positions, which easily could lead to less openness and suppliers being more restricted regarding collaboration efforts. Another aspect to be considered supporting backwards integration among actors is the risk of backward integration leading to market dominance or building bigger barriers for newcomers to establish themselves in the marked.

What seems to be the most fruitful way to deal with these industrial barriers seems to be to understand and play on aligning the incentives for actors involved in innovation efforts. This could for instance be done through carefully selecting innovation participants which are in a challenging position in a specific marked area. These companies thus having an incentive of gaining new market shares or enter new markets through the specific innovation. Other possibilities lie in finding financial win-win situations, where there are financial incentives both for the suppliers and operators of participating in the innovation effort through for instance suppliers get more paid for newer products giving even higher reductions in operating costs for the operators. Yet another approach could be to systematically support smaller vendors in building themselves up to a size and product range where they are able to compete with the large service and equipment manufacturers on the full scope of the contracts set out by the operator companies. This will however require a long term strategy and resources being made available to support smaller vendors in building up a product range, and not only specific innovations, and probably would require a joint effort among operator companies. However, all the above mentioned strategies require careful consideration in the selection of actors and the incentives given to collaborate, in which analysis of cognitive proximity, effects in terms of marked positions and platform leadership could play an important role. Also translation theory in terms of understanding the dynamics between actors, and of the established actors' responses to strategies should be considered. A question to be raised is whether the use of large integrated contracts by the operator companies and also funding and collaboration of innovation efforts with the large service providers is a good long term strategy. Whereas being beneficiary in themselves reducing the operator companies' internal handling costs, workloads, coordination and integration efforts compared to handling and coordinating a larger amount of suppliers, This study argues that the use of integrated contracts over broad service ranges are resulting in reduced competition, as only the largest service providers are able to participate in bidding rounds. The study also argues that funding and collaborating on innovation efforts with the large service providers and equipment manufacturers are contributing to solidifying and creating monopolist marked positions for the largest suppliers.

6.2.1 Theoretical implications

Going back to Henderson et al. (2013)'s model the analysis of industrial barriers introduces some theoretical implications. As earlier mentioned, if we see the external resource base available to integrate and combine into innovation efforts as the ecosystem of resources lying in the drilling and well value chain, there are few open interfaces between the resource platforms, both due to the service companies' and equipment manufacturers strategies of platform leadership through controlling their platform interfaces, and also due to the ecosystem actors different perspectives and varying incentives to collaborate. An important feature of the drilling and well ecosystem is that the resources are controlled by independent actors, thus creating interfaces both through selecting actors willing to collaborate and providing incentives for actors' stable collaboration becomes an important part of the dynamic capability to innovate.

Proximity theory and especially cognitive proximity, here understood in terms of the extent to which the involved actors' share common perspectives and incentives for collaborating, is a measure which can be used to understand the actors' willingness and ability to collaborate. However, proximity theory gives a static measure not necessarily suited to understand dynamic behaviour. In a strict interpretation, cognitive proximity refers to what extent the actors have similar cognitive reference frames, according to Knoben and Oerlemans (2006). However, is the extent to which actors share an optimum level of similarities in reference frames or world views, in terms of business perspectives, always a good measure for ecosystem actors' ability to effectively collaborate? The traditional view is being based on high cognitive proximity between actors leading to a high degree of mutual understanding. Based on the findings of this study one could questions to what extent mutual understanding being achieved through similar reference frames, always is a necessary attribute for innovation collaborations. The study thus introduces the terms aligned incentives and aligned reference frames, rather than using shared incentives or reference frames when discussing the actors' cognitive references, adopting a translation approach. Through the translation process an actor translates meaning content from the surroundings to his own references, thus giving it a new meaning. Thus an innovation or innovation effort can be given different meanings to different actors due to their differences in reference frames, illustrated by Latour (1990)'s example of programs and antiprograms. Based on this, this study argues that more important than the degree of similarities in reference frames for constructive innovation efforts is the alignment of the involved actors reference frames, in the meaning of to what extent the different reference frames allows for collaborating actors to pull in the same direction.

A translation approach is beneficiary also through offering a dynamic measure to understand the actors' behaviour over time, repeated translations between actors as resulting in changes in settings of their respective programs. One can argue that through the process of repeated translations between actors, their cognitive reference frames, and thus also their cognitive proximity is changed. Taking the argument one step further, one can argue that changes in proximity, as well as their behaviour, can be interpreted as the result of the translation of actors' inputs from their surroundings, and the their responses based on the translations of these inputs. Repeated translations between actors can be seen as dynamically changing not only their cognitive proximity, but also their technological, social and cultural proximity, and maybe also in the long run their organisational, institutional and perhaps even geographic proximity. This study thus finds that understanding of translation processes between actors' can be used to understand how the proximity between actors' dynamically changes over time.

6.2.2 Key points

- The main industrial barriers to innovation are formed by the conflicting interests of the actors of the value chain based in differences in their business perspectives
- The operator companies, service companies and rig companies business models often are direct conflicting
- The competition between the service companies, and also between the equipment manufacturers, are limited
- Through strategies of platform ownership service and equipment manufacturers have successfully expanded the platforms they control and created effective barriers of entry for new competitors.
- Service companies and equipment manufacturers' willingness to innovate are influenced by wishes of maximising profits on existing products
- Competitor positions the largest driver for innovation among the larger companies.
- The cognitive proximity of actors increased with their distance in the value chain and also as an effect of their value chain actors' different perspectives on time
- Smaller and entrepreneurial companies have limited possibilities to establish themselves as direct suppliers to the operator companies, although having an important role in innovation challenging the established actors
- Overcoming industrial barriers to innovation is a matter of playing on aligned incentives among the involved actors
- Aligned reference frames of actors are more important than similarity of the actors reference frames in terms of incentives to collaborate
- Understanding of translation processes between actors can be used to understand how the proximity between actors dynamically changes over time

6.3 "Collaborational" barriers to innovation

When it comes to "collaborational" barriers and resistance to innovation between the industrial actors in the drilling and well value chain, many of them are prolongations of the previously mentioned industrial barriers. Thus for a collaboration to be fruitful a prerequisite is that the actors involved have aligned incentives for succeeding with the innovation, basically coming down to the actors seeing an economical benefit of their own from the innovation. A typical problem to collaboration which was identified is the undetermined roles with respect to the commercialisation of products. This typically was found to occur in situations where two or more companies besides the operator company should collaborate on an innovation effort, and the roles in commercialisation of resulting products had not been firmly agreed upon early enough in the innovation process. This resulted in actors acting independently pursuing their own economic interests, causing conflicts as the actors' individual actions to commercialise the innovation were in contradiction to the other actors' incentives for participating in the innovation effort. Such unsolved issues were found to lead to an environment of mutual distrust and resistance, and in some cases ended up as complete showstoppers to the innovation efforts. In terms of Latour (1990)'s concept of programs and antiprograms, the actors individual translations of the innovation and the adaption of it into their own programs cause the actors programs to diverge more and more over time, due to the lack of communication and agreement about roles. The farther the programs diverge the more likely the programs of the actors are to translate initiatives as hostile acts and responding thereafter, and the larger the divergence the harder it is to reset the programs. In terms of cognitive proximity one can say that unless calibrated and aligned, the actors' reference frames can be seen to diverge over time.

Another barrier that sometimes occurs in the supplier operator relation in innovation is the lack of involvement from the involved actors throughout the innovation process. The innovation process thus becomes sort of a relay race where operator company representatives initiate innovation, and take delivery of the product without engaging or being allowed to engage in the supplier development process. Thus the delivery transfer between the supplier and the operator company becomes a hurdle where the operator in the handover process seeks for faults with the innovation, and either disqualifies it or leaves it up to the supplier to on their own to redesign the innovation, if it is not completely matching the operator needs. Whereas with involvement from both parties in the development process, the innovation would have been more adapted for the customer needs though translations and meaning exchange during the development process, and also giving the operator company better chances of adapting to the innovation. The results of this study shows that close relations both in terms of social proximity and involvement throughout the innovation process gives a better process of meaning exchange leading to a series of smaller and more accurate translations to both actors programs and a higher chance of the actors programs to converge around a unified understanding of the innovation. On the contrary handovers or decision points with little prior involvement from the receiving actor become hurdles, where the divergence in meaning of the innovation between the actors possibly diverging to an extent where the innovation fails to be adopted, or large corrective actions are needed.

Also in the operator companies' internal innovation processes the same effect can be seen with handovers between R&D, the disciplinary ladder and the operating licenses. The study finds that without involvement throughout the innovation process, with actors only focusing on their roles, each handover between actors becomes a barrier which has to be broken by the strength of the innovation, whereas involvement adds content to the innovation, and gives the actors the possibility to adapt with the innovation to create smoother handovers where all parties contribute to the success and adaption of the innovation.

The willingness and involvement from the internal actors were, like the suppliers, found to be rooted in their incentives to collaborate and involve. For instance operating units were found to have little incentives to use new technology unless it was absolutely necessary to get a particular job done. The reason for this was found to be that using new technology was considered to be both an economical and technical risk, possibly affecting the business units' key performance indicators primarily targeting efficient operations. Especially for the second, third etc. users there were found no particular incentives in terms of organisational rewards, such as recognition and goal achievement using new technology outweighing the perceived risks. Interestingly enough it was found to be considered less problematic getting in to problems using well proven technology, than when using new technology. Also it was found that even when there was a substantial economical upside by introducing new technology to the operations, it was a tendency to rather use old proven solutions with lower economic potential than risking to get into problems with new solutions. Licenses with high cash flows and operational margins were found more willing to accept the risk of testing out new technology in order to raise margins even further results than licenses more struggling to get a positive cash flow.

It was further shown that it was little willingness from the operational licenses to have personnel resources spending time participating in research and development activities due to it being considered less valuable use of time than the day to day operational activities. As this study finds this is creating a barrier to the innovation process as first use activities thus become subject to an abrupt handover of responsibilities between R&D and the disciplinary ladder on one side to the operational license, rather than being the result of a joint effort. This will be further discussed later as the pure contractual relation.

Another hindrance to innovation and implementation of technology which was identified in this study was the dependency of individuals. Both in the disciplinary ladder and in the licenses it was found that implementation of new technology often depended on individuals' attitudes and positivity to the particular technologies, rather than being a direct result of company strategy. Also on a licence level, the individual licenses are independent decision-makers regarding use of new innovations, not necessarily supporting overall company technology strategies. Especially where technologies were found to have an overall positive impact for the company through broad implementation although the first users might not have a direct benefit from it company level and license level incentives were found to be conflicting. Examples are situations where new technologies will help solving problems which are statistically significant for the company as a whole, whereas the same problem is considered to occur seldom in the individual licenses.

The positivity of individuals to prioritise and involve in the innovation activities was also found to indirectly reflecting organisational incentives. In a busy everyday environment with a limited amount of available time, individuals' prioritisation of time follows what are considered the most important organisational priorities, for instance for the licences governed by the day to day operations. Thus, lacking incentives at the organisational level become reflected in the individuals' prioritisation of innovation related tasks. The risk willingness of individuals was also found to be of importance to their recommendations for use of new technology. Personal incentives for innovation activities are often lacking, with individuals risking to be linked to potential failures using new innovations, whereas failures using proven technology was identified as less likely to be identified with personal reputation.

As with industrial barriers discussed in the previous section, I will argue that the key to overcoming collaboration hindrances to innovation lies in the understanding of and to create aligned incentives for the actors to innovate and collaboratively engage in the innovation process. For external actors the study implies that commercial incentives and incentives encouraging openness seem to be most important for fruitful collaborations, whereas for the internal actors incentives for using new technology and involvement throughout the innovation process seem to be the most important, both at an individual level and an organisational level.

6.3.1 Theoretical implications

The “collaborational” barriers found could explained through translation processes and the concept of actor programs (Latour, 1990), saying that both internal and external actors, organisations and individuals are running by their own programs. This study finds that inputs from actors are being translated into other actors’ programs as meaning content. In addition the programs themselves restrict and filter the communication flow and meaning exchange with its surroundings according to what is found relevant to the program, both in terms of what is communicated and what inputs are being picked up and translated. The individual actors’ incentives and cognitive reference frames in terms of formally defined roles, individual and organisational goals, become important creators of such filtering mechanisms. In this setting, involvement and social proximity can be seen as catalysts, which stimulate meaning exchange and translation process, but only to the extent allowed by the filtering mechanisms of the actors’ programs. If the communication flow and meaning exchange between actors are restricted by their programs, it results in gaps and divergence of the alignment of their programs, and the actors’ mutual understanding. On the contrary unrestricted communication flows between the actors through the repeated process of translations lead to convergence and higher degree of mutual understanding. The view of aligning programs is slightly differing from the original view Latour (1990), whose focus is on gaining support for own programs rather than opposed antiprograms. As a result of this, handovers between actors and decision points with little prior involvement between actors become hurdles or barriers due to gaps in their mutual understanding.

6.3.2 Key points

- Identified barriers to collaboration between actors
    - Undetermined roles with respect to the commercialisation of products
    - Lack of involvement of the involved actors throughout the innovation process
    - Handover or decision points with little prior involvement between actors becomes hurdles or barriers in the innovation process
    - Innovation processes' dependency of individuals
    - Risk averseness
    - Lacking incentives for using new technology and involvement throughout the innovation process
    - Prioritisation of innovation related activities/tasks
- Social proximity and involvement throughout the innovation process lower barriers and reduces hindrances to innovation
- Trust and openness between actors important pre-requisite for fruitful collaborations

6.4 The pure contractual and the informal team relationships

Hepsø (2007) argues for a translation perspective where innovations gain energy and content throughout the innovation process by their interaction with the environment surrounding it. This is, as he sees it, opposed to a diffusion view where innovation has an inherent energy or quality from the start and loses energy through friction and resistance throughout the innovation process until the innovation attempt either fails or the innovation succeeds due to its initial quality or energy forcing the organisation to adapt to the innovation. Based on the findings in this study it seems that none of the two views are wrong or right, but rather that whether an innovation happens to fall under one or the other category is dependent of the type of involvement, communication and collaboration between surrounding actors. Two types of innovation processes were identified. The first one which I have chosen to call a pure contractual relationship is characterised by handovers between actors and quality control at each handover. The actors involved are focused on fulfilling only their designated roles in the process, and have little involvement in the innovation activities which lies outside their specific roles, leading to each handover or meeting-points between the actors becoming points of friction or resistance, where the innovation either breaks the resistance or fails coherent with the diffusion view. The other type identified, which has been chosen to call the informal team relationship, is characterised by a high degree of involvement from the surrounding actors. Thus the actors work much more as an informal team throughout the entire innovation process adapting and refuelling the innovation to the organisation's needs, rather than just controlling and verifying that the innovation meets the organisational needs and requirements at their designated checkpoints and handovers. This type of innovation process is very much in line with the translation view proposed by Hepsø (2007). The difference between the two can be illustrated as the difference between a sales situation, where the seller tries to convince the customer that his product meets the customer's needs and the customer tries to determine whether the product meets his requirements, and a collaborative effort where both parties contribute to solving a problem in cooperation. The table below shows characteristics describing the two types of relations:

pure contractual relation	**informal team relation**
distant relationship	close relationship
involvement only according to formal role	involvement throughout innovation process
restrictiveness	openness
distrust	trust
scepticism	mutual respect

Table 5 Characteristics of actors relations in the pure contractual and the informal team relationships

Breaches of trust and openness in the relations between the actors are found to turn relations into the pure contractual relation, focusing on controlling deliverables. This type of relation in itself increases the resistance to the innovation process with the controlling actor sceptically focusing on checking the work done against expectations and contractual demands, without actually contributing to solving problems or adapting the innovation to the user needs whereas all actors of the informal team relations tend to participate in reshaping, adapting and forming the innovation to meet the organisations' needs. Another important prerequisite for the informal team relation is that actors are allowed spending time and resources to involve themselves throughout the innovation process, and not only by their function in for instance qualifying or implementing the innovation. Although this can be resource demanding, this study finds that the extra resources spent would lead to a more efficient innovation process and a higher quality of the innovation and innovation process outweighing the extra resources spent in terms of value. One could argue that informal team relations could be leading the individuals' loyalty to be towards the informal team rather than to the company itself. This study finds no such evidence, and thus would argue that the informal team relation is of a temporary nature with most of the actors involved having their day to day work within the organisation employed, thus minimising the chances of unhealthy loyalty relations. However, due to the high degree of involvement actors feel more ownership to the innovation, and are likely to function as knowledge carriers, ambassadors and champions for the innovation within their own organisations.

6.4.1 Theoretical implications

From a translation perspective the informal team relation functions like an effective arena for meaning exchange between the actors involved in the innovation process, whereas the pure contractual relationship puts constraints on the meaning exchange. As seen the types of relations between the actors also affect the actors' translation of meaning content, being more sceptical and distrusting in the pure contractual relation than found in the informal team relation. An important aspect is the importance of trust, openness and mutual respect in the informal team relation, thus making social proximity and interpersonal relations important factors for an effective meaning exchange and successful translation processes between actors to take place, whereas distrust, scepticism and restrictiveness restrict the communication and translation processes between the actors. Breaches of trust and openness are also found to have a negative impact on the translation and communication processes, turning the type of relation into more of a pure contractual relation. Another important aspect of the findings is the impact of close relations between actors and involvement of the actors throughout the innovation process, giving a running meaning exchange and translation process which allows the innovation to be reshaped, adapted and formed to the receiving organisation, as well as the organisation to adapt to the innovation. Whereas the informal team relation, with its distant relations and involvement only according to formal roles, limits the meaning exchange between actors to handovers and quality control situations and gives little room for the innovation and receiving organisation to adapt. Due to this the pure contractual relation can lead to severe mistranslations and gaps in cognitive alignment and understanding of the innovation between the actors which can turn into barriers for the innovation process. Also important is the role of the individuals involved in the informal team relations as champions and knowledge carriers into their own organisations, thus making the translation processes between organisations more effective.

This study argues that the informal team type of relation between the actors, through its function as an arena for effective meaning exchange and translation processes, is crucial for ecosystem actors ability to build dynamic innovation capability through collaboration, Dynamic innovation capability, understood as the ability to innovate through combining internal and external resource elements involving people, process, technology and governance elements into new and reconfigured processes (Henderson et al., 2013). The relation being especially important due to the ecosystem approach, where successful innovation processes have to be built up not only by one actors dynamic capability to utilise and reconfigure internal and external resources, but by the symbiosis of several actors' dynamic capabilities. The symbiosis of capabilities needs to end up in both a supply side capability to sell a product or service, and also a user side capability to utilise the product or service. In this ecosystem perspective, scaling of technology into broad use at multiple installations and in different environments becomes particularly important.

6.4.2 Key points

- To types of innovation processes are identified; the pure contractual and the informal team relationships
- The informal team relationship is characterised by close relationship, involvement throughout the innovation process, openness, trust and mutual respect
- The pure contractual relationship is characterised by distant relationship, involvement only according to formal roles, restrictiveness, distrust and scepticism
- Breaches of trust and openness in the relation between actors changes relations from informal team relationships into pure contractual types of relationships
- Important for the informal team relationships to function is that actors are given the opportunity to spend time and resources to involve themselves throughout the innovation process
- The actors of the informal team become knowledge carriers, ambassadors and champions for the innovation within their own organisations
- The informal team relation functions like an effective arena for meaning exchange leading to effective translation processes
- The informal team type of relation is important for ecosystem actors capability to efficiently collaborate

6.5 The relevance of proximity

The concept of proximity is a rather static concept, and analysis of the proximity of two or more organisations says little more than what the situation is at the moment, and can serve as a guidance for what partnerships might work or not. This study finds that the informal team relation can serve as a bridge over gaps in many of the dimensions of proximity stated in Knoben and Oerlemans (2006), leaving social proximity as the most important dimension of proximity for efficient innovation collaborations between actors, with openness, trust and mutual respect as important factors in building and maintaining good relations or social proximity. The study further finds that the informal team relation serves as an arena for mutual learning and exchange of knowledge, where proximity is being built and evolves through the cross-organisational interactions of the persons involved, turning proximity into a dynamic feature. This is opposed to the pure contractual relation, where proximity remains a static concept, with a restricted level of involvement and mutual learning between organisations. Thus in the pure contractual relationship selecting actors which upfront have a “right” level of proximity to be involved in the innovation effort becomes much more important, as proximity to a much lesser extent is dynamically evolving as a result of the innovation process.

Whereas geographic proximity was found important to businesses in terms of being located close to other businesses engaged in similar things, of reasons like easy access to qualified personnel, easy access to suppliers, and being in an environment where new ideas emerge etc., it was not found to be of particular importance for inter-organisational collaboration and innovation efforts. More important is the concept of temporary geographical proximity (Torre, 2008), which was found important for actors to build social proximity. Temporary geographical proximity through short or medium term visits and meetings are by Torre (2008) considered sufficient for the exchange of information needed between the actors. Temporary geographical proximity was in this study found to be important to build social embedded relations between actors. Temporarily physical social interaction was also found to be an important factor contributing to build environments of openness and confidence between the actors vital to informal team relations, and also a necessary prerequisite for successful use of telephone, web and videoconferencing as effective communication channels, in line with Torre (2008). Indications were also given that too much social proximity or too close relations between actors might be questionable in terms of individuals' loyalty. This study argues that informal team relations set up for specific innovation efforts, both due to their temporary nature and due to the individual participants spending most of their time serving wider roles within their own organisations, are less prone to build unhealthy loyalty bonds between the involved actors and individuals than could be the case in more stable long term social relations.

Cognitive proximity or cognitive alignment also seems to be an important dimension in enabling fruitful collaborations in informal team relations. The cognitive views of the actors were in this study found to be shaped by their roles in the value chain and the goals and prioritisations of actors and individuals. Important for building fruitful innovation collaborations and establishing informal team relations seems to be the actors having aligned incentives, goals and priorities thus shaping aligned cognitive views based in the innovation effort creating win-win situations for the organisations involved.

The actors' technological proximity is found to be important to succeed with innovation within the drilling and well industry. Also related to industrial barriers it seems that very few companies with no background from the drilling and well industry manage to succeed in establishing themselves within the drilling and well industry. However, other industries are mentioned as important impulse providers to the established actors within the drilling and well industry, and also to some extent as providers of individual innovations picked up by the established suppliers. For smaller and entrepreneurial companies the importance of individuals having an background from the oil and gas industry is stressed as an important factor for technological proximity and understanding customer needs. Openness and dialogue seems to be key factors in overcoming technological proximity barriers. This study also finds that within the informal team relation technological proximity of the actors is gained due to the close relation, interaction and collaboration between all actors innovation process. On the team or individual level mixing of disciplines is also named to be of important to innovation as long as the teams have a solid foundation in the problem area, so that new competencies can be integrated. Also found is that having teams with the same backgrounds the innovation level is said to be flatting out. These finding are in accordance with Knoben and Oerlemans (2006), Colombo (2003) and Cohen and Levinthal (1999), stating that actors need to have a basic common knowledge base but also inherit different specialised knowledge to contribute with new knowledge to collaborations.

From the findings gaps in cultural proximity were often related to different corporate cultures for openness. Openness found to be of particular importance for the informal team relationship. Especially American organisations were mentioned to be prone to have a culture for being less open in innovation partnerships leaving less room for discussion and criticism, than for instance Norwegian corporate culture. However the differences seems to be more related to the individual organisations than strict geographical divides. Varying corporate culture was also found to be related to the previously discussed industrial barriers, as the perspectives of the actors and their role in the value chain affect the priorities of the organisations. Also differences in risk willingness and risk aversion were mentioned to vary between corporate cultures. Geographical cultural differences between individuals was not found to be of particular important in the relations between actors, this might however be due to the global nature of the drilling and well industry and due to the main actors involved typically being companies rooted in Europe or USA. Among individuals and within the organisations there were also found differences in the levels of openness, often related to the protection of own work. There were identified culture differences between smaller and larger companies, which also are related to organisational proximities. Smaller companies were reported often to be more eager to innovate due to innovation being a more important part of their value creation, whereas larger organisations, where innovation is a smaller part of their total business, have higher focus on sales and production of established product lines.

Institutional an organisational proximity was not found to be problematic areas by the respondents, at least not for the larger companies within the drilling and well value chain. This can be due to several factors, most of the larger companies have years of experience working as a part the value chain of Statoil and other companies within the Norway oil and gas industry, and under Norwegian regulations. Most of them also have Norwegian subdivisions supplying their Norwegian customers. Another point of consideration is that most of the bigger companies works following international standards for research and development, and thus have quite similar procedures conducting research and development activities. However it is reason to believe that for completely new entrants in the Norwegian marked there could be a bigger proximity gap, as well as for smaller and entrepreneurial companies with less experience within the Norwegian oil and gas value chain. It is also worth notifying that for research and development work within the industry institutional proximity falls close to technological proximity, as the rules and regulations most important are regulations such as the NORSOK standards[1], with technical requirements for equipment and safe operations. For smaller and entrepreneurial companies it is found that gaps in organisational proximity also might be a problem, due to the scale differences in organisational complexity and command chains leading to decision processes taking longer time within the bigger companies, putting strain on the smaller companies' capital and personnel resources.

6.5.1 Theoretical implications

Seeing the proximity in relation to translation processes, the study has earlier found social and cognitive proximity to be important factors for successful translation processes. Social proximity and social relations between actors is found to be a catalyst for meaning exchange and translation processes between actors. The degree of cognitive proximity or cognitive alignment between actors is found to impact on the actors' communication and translation processes, where the actors' cognitive reference frames in terms of business perspective and goals acts as filtering mechanisms to the communication exchange between actors, as well as impacting on the translation of communication to meaning content and the actors responses to external inputs.

This study finds that proximity can be seen in terms of programs, where the individual programs of actors represents their cognitive, social, technical, cultural, organisational and institutional reference frames. Through their meaning exchange with the environment and subsequent translation of inputs to meaning content, the settings of their internal programs or reference frames is changed. Thus translation processes can be found to explain the development of proximity between actors over time.

The informal team relation with high degree of openness, trust and mutual respect between actors, as well as high degree of involvement throughout the innovation process between the actors', is found to be an effective communication arena, through which the actors in terms of proximities can adapt or converge their reference frames, whereas in the pure contractual relation gaps in proximity has a tendency to remain, leading to conflicts and friction between the actors.

[1] The NORSOK (Norsk sokkels konkurranseposisjon) standards are published by Standard Norge, and are a series of documents containing detailed technical requirements encompassing all technical demands for the petroleum industry in Norway.

Knoben and Oerlemans (2006), divides technological proximity into to levels the general and dyadic, where the general level is understood as the general capability for learning from other organisations, and the dyadic level concerning technological learning as an interplay of actors in some form of collaborative relation. This study finds that this division also can be used for the other types of proximity, thus the general level concerns the actors reference frames symbolised with their programs, whereas the dyadic level concerns the interaction or meaning exchange between actors. Though the informal team and pure contractual relations constitutes arenas for meaning exchange between the individuals and actors involved, they have different characteristics in terms of involvement and communication exchange among the involved actors. This study proposes a model where within these arenas the involved individuals from all actors to an extent dependent on their level of involvement with each other, creates shared cognitive, social, technical, cultural, organisational and institutional reference frames on a dyadic level. Thus the informal team relation dynamically builds a high level of shared reference frames on a dyadic level, which remains relatively unchanged in the pure contractual relation. The involved individuals of the meaning exchange thus becomes carriers not only of communication exchange, but also of the shared reference frames from which contents through translation is given meaning to by the actors at a general level , altering their reference frames and thus also the general level proximity between actors.. Individuals involved thus become important as translators or innovation champions within their own organisations.

6.5.2 Key points

- Social proximity and cognitive alignment the most important dimensions of proximity for efficient innovation collaborations
- Temporary geographical proximity important to build social proximity between actors
- Gaps in cultural proximity often related to different corporate cultures for openness
- The informal team relation in function of arena for mutual learning and exchange of knowledge builds proximity between actors
- In the pure contractual relation gaps in proximity has a tendency to lead conflicts and friction between the actors.
- Social proximity and social relations between actors catalyst for meaning exchange and translation processes

- The actors' cognitive reference frames acts as filtering mechanisms to communication exchange and impacts on the translation of communication to meaning content and the response to external inputs.
- Translation model
    - Division in a general level of proximity concerning the actors reference frames symbolised by their programs, and a dyadic level concerning proximity in the interaction or meaning exchange between actors
    - Individuals an extent dependent on their level of involvement with each other, creates shared cognitive, social, technical, cultural, organisational and institutional reference frames
    - The informal team relation dynamically builds shared reference frames between actors on a dyadic level, opposed to the pure contractual relation
    - Involved individuals becomes carriers of shared reference frames which through translation is transferred from the actors dyadic to the actors general level

6.6 Building innovation capability in an ecosystem of actors

The results of the study have so far most its focus on barriers and relations. However, what can the study tell us about building innovation capability within the drilling and well ecosystem? Reegard et al. (2014)'s capability resource matrix gives a framework for how to deploy and mature a capability, stressing the importance of focus on both people, technology, process and governance elements when building and maturing a capability. Compared to the diffusion model presented by Rogers (2003), model focusing on innovation as a spreading process among users, the capability resource matrix gives a more flexible model for innovation where the build-up and contents of capabilities needed to meet an objective is modified and changed as a part of the maturing process. A capability based model as such thus seems better suited for the needs of the drilling and well industry, where both the actors involved in operations and the operational environment can vary a lot from context to context, emphasising the importance of scaling of the innovation as a crucial part of the innovation process. An important factor for the drilling and well value chain is that it is an ecosystem of actors, each with its own individual interests and goals. The large degree of outsourcing also leads to the need for innovations to result in both a supply side capability to offer an innovation as a product or service, and a user side capability to utilise the resulting product or service, where the two capabilities are being controlled by different organisations. The resource base for building capabilities thus consist of resources controlled by many actors, building block on block with lesser capabilities to form a wanted end capability in line with Henderson et al. (2013). The Henderson et al. (2013) model however indirectly assumes that that the resources needed, both internally and externally, are under the control of a single firm or a single actor, whereas this study finds that making the necessary resources available through actors having or creating aligned incentives to collaborate is a vital part of the process of building innovation capability. This aspect is to a large degree not accounted for in capability literature, which mostly focus on one organisation's capability to drag on internal and external resources, without accounting for innovation as a result of the interplay between independent ecosystem actors.

From the findings on industrial barriers especially the different incentives or perspectives of the actors to collaborate were identified as barriers, showing the importance of actors having aligned incentives in terms of business outlooks. Selecting the right combinations of actors based on their incentives to collaborate, as well as the ability to align the actors' incentives and cognitive reference frames thus become important foundations to build any innovation capability, and also the ability to settle the involved actors' commercialisation roles at an early stage. However, it is important to be aware that in innovation collaborations, and especially with the larger vendors, the oil and gas companies often contribute to build and strengthen the participating suppliers' dominance on a given range of products and services. Thus they also contribute to build barriers for new entrants in the respective markets, which not necessarily is in the best interests of the oil and gas companies in the long run. Smaller and entrepreneurial actors can be used actively in innovation efforts to achieve innovations the larger companies are reluctant to pursue, due to lacking incentives. However, the small actors can be both resource and economically demanding for the operator companies, and as shown in this study often will require clear long term strategies from the operators not only for the innovation itself to be applied, but also from a business development and commercialisation perspective. Scaling of the technologies of small vendors, become an especially important issue to address, due to the industrial barriers which can be effective hindrances for putting technologies from small vendors into wide use. This is due to the larger suppliers' platform strategies and the usage of integrated contracts from the oil and gas companies. To overcome these barriers one needs partnerships based on aligned incentives to widely commercialise the innovation.

The study further identified relations between actors both internally and externally as an especially important issue to address, building capabilities leading to successful innovations. Social proximity between actors, and border-spanning involvement of the actors throughout the innovation process, and not only due to their formal roles was found to be important to build down barriers in innovation collaborations. In addition trust, openness and mutual respect between actors were found to be important prerequisites for creating and maintaining border-spanning collaborations between actors.

Two types of relations between actors have been identified in this study. These have been called the informal team relation and the pure contractual relation. The informal team relation is found by the study to be the preferable relation to strive for between both external and internal actors when building innovation capability, characterised by the relations between the actors to be based on close relationships, involvement throughout the innovation process, openness, trust and mutual respect. This is in opposition to the pure contractual relation where relations are distant, and involvement is more according to formal roles without overlapping involvement. The study finds that the relations between organisations and also internally within the organisations involved must be based on mutual respect, openness, trust and involvement to be at its most effective. The lack or presence of these three parameters has been found to be a key difference between innovation processes characterised by Hepsø (2007) as the diffusion and translation views on innovation. In the diffusion view the innovation has an inherent energy which either is strong enough to break the resistance met in the innovation process by the strength of the innovation itself or succumbs to resistance met in the innovation process being stronger than the strength of the innovation. The translation view sees innovation as a relational phenomenon, where the innovation gains energy and content throughout the process by its interaction with the environment and actors surrounding it.

The informal team serves as an arena for translation, mutual learning and knowledge transfer between actors, borders-spanning formal roles and formally defined individual areas of responsibility in the innovation process. Through this type of relation the innovation is found to be refuelled, shaped and adapted to fit the needs of all parties involved, as well as preparing and adapting the involved actors' organisations for the innovation, in line with the view of innovation processes as translation (Hepsø, 2007). The close relationships and involvement of all actors throughout the innovation process serve as a communication link between the involved actors. The individuals involved potentially serving as champions or ambassadors for the innovation in own organisations, efficiently fuelling the translation processes in their own organisations as well as in the informal team itself.

The investigation shows that the informal team relation serves to reduce and eliminate proximity barriers between organisations, by building proximity between the members of the informal team. Through temporary geographical proximity a high level of social proximity can be built, which is shown to contribute to overcome gaps in cognitive, technical, cultural, organisational and institutional proximity between the individuals and the organisations involved. Social proximity and the involvement of the informal team actors constitute knowledge transfer and learning between the actors involved. This ensures the necessary technological and institutional proximity, playing on the exchange of the diverse knowledge possessed by the actors involved, through effective translation processes. Cognitive proximity through aligned perspectives and incentives for the organisations involved can be seen as a prerequisite to establish informal team relations, but the study finds that these perspectives also are being shaped through the interaction of the informal team members. For organisational proximity, the informal team relation is also found to reduce gaps due to the involvement of all actors, both contributing with content and reshaping the innovation process to match the organisational requirements of their respective organisations, and also contributing to prepare their own organisations for the innovation.

The concept of translation is an important aspect when building capabilities block by block in an ecosystem with many actors. The study proposes a model to understand how the informal team relationship through translation processes affects both the innovation process and the organisations of the involved actors. The model offers a concept to understand how the reference frames of the actors as well as the informal team, are changed through the individuals involved in the informal team relationship, functioning as information carriers between their organisations. In this model both the actors on one side, and the informal team running the innovation process translates the information into their own reference frames. The model thus gives an understanding not only of how the informal team relationship affects both the innovation process and the involved actors, but also gives a dynamic understanding to how proximity between actors changes as a result of translation processes between the informal team and their respective organisations. The cognitive, social, technical, cultural, organisational and institutional reference frames of the actors and the informal team change as a result of the interactions between the individuals involved.

When it comes to proximity among actors especially cognitive and social proximity were found to be necessary for good innovation collaborations. For cognitive proximity the study has introduced the term cognitive alignment. This term refers to the importance of the cognitive reference frames of the ecosystem actors involved to be aligned rather than having a high degree of similarity in terms of business perspectives and incentives. A high level of social proximity was also found to be important for building capabilities in collaborations between actors. An important factor for building good relations and a high level of social proximity is to facilitate for this through temporary geographical proximity. Social proximity was found to be a catalyst for effective translation processes between actors.

6.6.1 Key points

- The drilling and well resource base for building capabilities consist of resources controlled by many actors, building block on block with lesser capabilities to form a wanted end capability
- Making the necessary internal and external resources available through actors having or creating aligned incentives to collaborate is important for building innovation capability
- Scaling of the innovation is a crucial part of the innovation process, especially for smaller companies
- It is important that actors have aligned incentives and cognitive reference frames in terms of business outlooks
- Collaborations can often, and especially with the larger vendors, contribute to build and strengthen the participating suppliers dominance on a given range of products and services
- Smaller and entrepreneurial actors can be used to achieve innovations the larger companies are reluctant to pursue, due to lacking incentives
- Social proximity and border-spanning involvement of the actors are important to build down barriers in innovation collaborations

- Trust, openness and mutual respect are important prerequisites for creating and maintaining border-spanning collaborations
- The informal team relation is found to be the preferable relation between both external and internal actors for building innovation capability
- The informal team serves as an arena for translation, mutual learning and knowledge transfer between actors
- The informal team relation serves to reduce and eliminate proximity barriers between organisations
- Social proximity and involvement constitute knowledge transfer and learning between the actors involved, ensuring necessary technological and institutional proximity through effective translation processes
- Temporary geographical proximity is an important factor building social proximity
- Translation processes affect both the innovation process and the organisations of the involved actors, as well as the actors cognitive, social, technical, cultural, organisational and institutional reference frames
- It is important that the actors cognitive reference frames are aligned in terms of business perspectives and incentives for effectively building capabilities

7.0 Conclusion

In the beginning of this study, three research questions were formulated. The first was how the established structures in the drilling industry affect innovation. The results of the study study have identified several obstacles and hindrances to innovation, especially due to the structure of the drilling and well value chain, preventing actors from having aligned incentives and business perspectives when it comes to innovation. One of the key issues is the dominant positions of the large service companies and equipment manufacturers serving as barriers to new entrants and smaller companies in their respective markets, using closed platform constructs to exclude minor competitors. Competitor positions are seen to be the largest driver for innovation among the large companies. The exclusion of minor competitors is strengthened by the oil and gas companies’ preference for large integrated contracts spanning over large areas of services and products. The results of the study further concluded that the innovation incentives of the oil and gas companies, service companies and equipment manufacturers, shaped by their roles in the value chain, are diverging and in some cases direct conflicting. Different perspectives on time, business models and income potentials are found to be the main obstacles to innovation. Distance in the value chain is also a hindrance for new innovations, as the innovation perspective of the actors are formed mostly by the business potentials lying with their direct customers. Thus innovation needs are not pursued by the actors further down the value chain, unless the incentives for the innovation effort are aligned among the involved actors.

The second of the research questions was to identify typical obstacles in the innovation process. One of the items identified was the undetermined roles with respect to the commercialisation of end products, which when unaccounted for at an early stage in the innovation process tended to give reason for conflict at later stages of the innovation process. Another issue addressed was the lack of involvement of involved actors throughout the innovation process. When actors' involvement was only according to formal roles, handovers and decision points were met with little prior involvement between the actors, these tended to become hurdles or barriers to the innovation process. The innovation process' dependency of individuals, especially when it comes to implementation in operational assets, also was also found to in some cases cause hindrances to the process, where individuals in stakeholder roles, regardless of corporate initiatives could stop or hamper the innovation process based on their individual opinions or incentives. Risk averseness among actors and individuals, especially in the operational units, were also identified as a hindrance for new innovations. The lack of incentives for using new technology and involvement throughout the innovation process were identified as another obstacle, along with lack of prioritisation of innovation related activities among actors mainly occupied with mainstream business activities.

The last research question was how innovation capability can be built in cooperation between actors. The findings showed that aligning incentives to collaborate among both internal and external actors was a key issue for building innovation capability among ecosystem actors. One issue to address for external actors is how to align business perspectives, whereas for the internal actors having goals that prioritise innovation activities and involvement in these are important to make the necessary ecosystem resources available. Careful selection of external actors for collaborations and providing initiatives for actors to collaborate, aligning their incentives and cognitive reference frames thus becomes an important part of building ecosystem capabilities. Competitive advantages, marked shares and direct economic benefits are the main drivers for external actors to collaborate. Small and entrepreneurial companies can be used to drive forward innovations that the larger vendors will not pursue, but this requires serious efforts, especially in terms of scaling the inventions, to omit the industrial hindrances present in the value chain. Also important to notice is that by supporting innovation collaborations, especially with the larger vendors, this might contribute to strengthen external partners' market dominance on the given range of products.

When it comes to relations between actors, both externally and internally two distinct types of relations were identified, the pure contractual relationship and the informal team relationship. The pure contractual relation characterised by its distant relationships, involvement only according to formal roles, restrictiveness, distrust and scepticism were identified as raising barriers to the innovation process. The informal team relationship on the opposite, with its close relationships between actors, border-spanning involvement throughout the innovation process, openness, trust and mutual respect among the actors was found to be lowering the barriers. Besides border-spanning involvement between the actors, social proximity was found to be vital to establish informal team relations. Temporary geographical proximity was identified as important for building the necessary social proximity, and to make the informal team relationship to function properly. The study further proposed a model based on translation processes to how the informal team relationship with its individuals function as information carriers of the innovation between the informal team and the actors' organisations. In this model the informal team members also carry information content altering the actor organisations cognitive, technological, social and cultural reference frames. The actors existing reference frames serving as filtering mechanisms for the information exchange and translation processes. The information carried thus become translated and given meaning by both the informal team and the actor organisations. Through this meaning exchange not only the innovation content changes and the actors' organisations adapt to the innovation, but also the cognitive, technological, social and cultural reference frames of the actors' organisations are changing, thus dynamically changing the respective proximity between actors.

The results of the investigation performed in this study can be useful for innovation activities through incorporating in corporate strategies careful selection of actors for collaboration activities, always having end commercialisation in mind, also at the early stages of the innovation process. Accounting for the actors incentives to collaborate and possibly creating new incentives. Among internal actors, goals and key performance indicators must be set allowing for border-spanning involvement of all actors in the innovation process. Prioritising innovation activities, allowing individuals to and recognising them for spending time building relations and participating in innovation activities is another important learning. Finding the right balance between innovation-related activities and operational activities for non R&D units is another important issue. Last and finally creating corporate cultures for innovation, participation and engagement, without making problems with new innovations stigmas of individuals or organisational parts are important. After all innovation is doing things in new ways, both troubles and failures will occur, and allowing room for these events are vital to succeed in the long run.

7.1 Further research

Although this study particularly looks upon innovation in the drilling industry, the general problem setting of innovation in capital-demanding and high risk environments, and innovation in complex value chains with a large extent of outsourcing should also be of interest to several other industries. Similar contexts can for instance to a larger or lesser extent be found in the aviation, defence, shipping, mining, paper and metal industries. Also some of the theoretical findings should be of interest for a more academic audience. Especially the aspect of proximity between actors dynamically changing as the result of translation processes between actors should be of interest.

As topics for further research the results of this study should be verified by other studies, to verify the use of the results beyond the context of the drilling and well ecosystem. It would also be interesting to examine the informal team relationship and its implications in more detail, preferably seeing it from a principal agent perspective. How the close relations between individuals in the informal team relationships affect their loyalty to the informal team versus their own organisations could also be topic for a study. In addition scaling of innovations from smaller companies into broad commercial products is a topic which should be further examined. Border spanning activities between actors is also a topic for more thorough examination, and especially how such activities can be implemented through formal processes. Already mentioned the findings on proximity between actors changing as a result of translation processes, should also be a topic for further research gaining more understanding and expanding theory, as well as the understanding of cognitive proximity as alignment of reference frames between actors rather than the actors having similar reference frames, which probably also could be expanded to other categories of proximity. Looking into capability theory further studies could be done trying to make a new model with an ecosystem approach for how to build innovation capability, accounting for the interplay of the entire ecosystem of actors, possibly building on the Henderson et al.(2013) model. At last further work could be done trying figure out how the results of this study regarding both barriers to innovation, collaboration between actors, and relations could be accounted for in terms of strategies, process models and organisational structures.

8.0 References

Ambrosini, V., Bowman, C. (2009), What are dynamic capabilities and are they a useful construct in strategic management?, *International Journal of Management Reviews,* 11(1), 29-49

Baffes, J., Kose, A.,, Ohnsorge, F., Stocker,. M.,Chen, d., Cosic, D., Gong X., Huidrom, R., Vashakmadze, E., Zhang, J., Zhao, T.. (2015), Understanding the Plunge in Oil Prices: Sources and Implications, *Global Economic Prospects, January 2015: Having Fiscal Space and using It*, Washington DC: World Bank (155-168)

Baldwin, C. Y., Woodard, C. J. (2009), The architecture of platforms; a unified view, Gawer, A., ed, *Platforms, Markets and Innovation*, Edward Elgar Publishing, 19-44

Balland, P. A. (2012), Proximity and the Evolution of Collaboration Networks: Evidence from Research and Development Projects within the Global Navigation Satellite System (GNSS) Industry, *Regional Studies,* 46(6), 741-756

Ben Letaifa, S., Rabeau, Y. (2013), Thos close to collaborate? How geographic proximity could impede entrepreneurship and innovation, *Journal of Business Research*, 66(10), 2071-2078

Boschma, R. (2005), Proximity and Innovation: A Critical Assessment, *Regional Studies*, 39 (1), 61-74

Cohen W. M., Levinthal, D. A. (1990), Absorptive Capacity: A New Perspective on Learning and innovation, *Administrative Science Quarterly,* 35(1), 128-152

Colombo, M. G. (2003), Alliance form: A test of the contractual and competence perspectives, *Strategic management Journal*, 24(12), 1209-1229

Cusumano, M. A., Gawer, A. (2002), The elements of platform leadership, *MIT Sloan management review,* 43(3), 51-58

Edquist, C., Johnson, B. (1997), Institutions and organisations in systems of innovation, Edquist, C., ed, *Systems of Innovation: Technologies, Institutions and Organizations,* Pinter: London, 41-63

Eisenmann, T. R., Parker G., Alstyne M. V. (2009), Opening platforms; how, when and why?, Gawyer, A., ed, *Platforms, Markets and Innovation*, Edward Elgar Publishing, 131-162

Flyvbjerg, B. (2010), Fem misforståelser om casestudiet, Brinkmann, S. and Tanggard, L., ed, *Kvalitative metoder*, Hans Reitzels Forlag: København, 463-487

Grant, R. M. (1996), Prospering in Dynamically-Competitive Environments: Organizational Capability as Knowledge Integration, *Organization Science*, 7(4), 375-387

Henderson, J., Hepsø, V., Mydland, Ø. (2013), What is a capability platform approach to integrated operations, Rosendahl, T. and Hepsø, V.,ed, *Integrated Operations in the Oil and Gas Industry: Sustainability and Capability Development*, Business Science Reference,1-19

Hepsø V. (2007), Organisatorisk innovasjon som oversettelse, Hernes T. and Koefoed A. L. ed., *Innovasjonsprosesser om innovasjoners odysse*, Fagbokforlaget, 223-242

Jacobs. T. (2014), The Shale Evolution: Zipper Fracture Takes Hold, *Journal of Petroleum Technology*, 66(10), 60-67

Jacobsen, D. I. (2005), *Hvordan gjennomføre undersøkelser*, 2nd Edition, Høyskoleforlaget

Kanter, R. M. (1989), Swimming in newstreams: Mastering innovation dilemmas. *California Management Review*, 40(3), 45-69

Knoben, J., Oerlemans, L. A. G. (2006), Proximity and inter-organizational collaboration: A literature review, *International Journal of Management Reviews*, 8(2), 71-89

Lane, P.J., Lubatkin, M. (1998), Relative absorptive capacity and interorganizational learning, *Strategic Management Journal*,19(5), 461-467

Latour, B. (1987), *Science in action: How to follow scientists and engineers through society*, Harvard university press

Latour, B. (1990), Technology is society made durable, *The Sociological Review*, 38(S1), 103-131.

Lawson, B., Samson, D. (2001), Developing innovation capability in organisations: A dynamic capabilities approach, *International Journal of Innovation Management*, 5(3), 377-400

Mankins, J. C. (1995), Technology Readiness Levels A White Paper, NASA Downloaded the 10th of June 2015 from: http://www.hq.nasa.gov/office/codeq/trl/trl.pdf

OG21 (2012), OG21- Oil and gas in the 21st century - Norway's technology strategy for the 21st century, Norwegian Ministry *of* Petroleum and Energy Downloaded the 1oth of June 2015 from : http://www.force.org/Global/AboutFORCE/OG21_strategi.pdf

OG21 (2014), *Technologies to improve drilling efficiency and reduce costs*, OG21 Downloaded 10th of June 2015 from: http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3D%22OG21TTA3Report-ImproveDrillingefficiencyandreduceCosts-15Oct2014.pdf%22&blobkey=id&blobtable=MungoBlobs&blobwhere=1274505749123&ssbinary=true

Rallet, A., Torre, A. (1999), Is geographical proximity necessary in the innovation networks in the area of global economy?, *GeoJournal*, 49(4), 373-380

Reegård, K., Drøivoldsmo, A.,Rindahl, G., Fernandes, A. (2014), Handbook – The Capability Approach to Integrated Operations, Center for Integrated Operations in the Petroleum Industry

Rogers, E. M. (2003). *Diffusion of innovation*, 5th Edition , Free Press.

Teece, D. J., Pisano, G., Shuen, A. (1997), Dynamic Capabilities and Strategic Management, *Strategic Management Journal*, 18(7), 509-533

Torre, A. (2008), On the role played by temporary geographical proximity in knowledge transmission, *Regional Studies*, 42(06), 869-889

Wuyts, S., Colombo, M. G., Dutta, S., Nooteboom, B. (2005), Empirical tests of optimal cognitive distance, *Journal of Economic Behaviour &Organisation*, 58(2), 277-302

Zollo, M., Winter, S. G. (2002), Deliberate learning and the Evolution of Dynamic Capabilities, *Organization Science*, 13(3), 339-351