Knowledge-based innovation and the benefits of clustering

A study of the Norwegian offshore industry

Date of submission:
01.09.2010

Supervisor:
Amir Sasson

Exam code and name:
GRA 19002 Master Thesis

Study programme:
Master of Science in Business and Economics

This thesis is a part of the MSc programme at BI Norwegian School of Management. The school takes no responsibility for the methods used, results found and conclusions drawn.
Innovation is fostered by information gathered from new connections; from insights gained by journeys into other disciplines or places; from active, collegial networks and fluid, open boundaries. Innovation arises from ongoing circles of exchange, where information is not just accumulated or stored, but created. Knowledge is generated anew from connections that weren’t there before.

Margaret J. Wheatley
**Acknowledgements**

This master thesis marks the accomplishment of our Master of Science in Business and Economics degree at BI Norwegian School of Management.

We have had the pleasure of writing our master thesis as part of the research project “A Knowledge Based Norway”. We are truly grateful for this opportunity. Being part of the project has been greatly informative and has given us first-hand experience in challenges and opportunities of the Norwegian business life in general and the offshore industry in particular. We would like to extend our gratitude to our fellow research assistants for making this an interesting and challenging experience.

We would also like to extend our greetings to all the company representatives that have taken part in interviews and provided us with valuable information and enhanced our knowledge about both industry and firm dynamics. In addition, we are thankful to Graham Bailey and Samantha Stephens for their helpful input and comments on our work.

Most importantly, we would like to extend our deepest gratitude to our supervisor, Associate Professor Amir Sasson for sharing his insights, and providing guidance and helpful suggestions throughout the entire process of writing this master thesis.

Oslo, September 1st 2010

Christopher Eikanger Andersen

Torleiv Opsal

Enquiries about this master thesis can be sent to chph@chph.no or torleivopsal@gmail.com.
Executive summary
Innovation is considered to be a main driver for competitiveness and economic growth. Discussions on what drives innovation are, however, more fragmented. Two advocated explanations are the effects of clustering and the importance of knowledge. Clusters are argued to have a positive impact on innovation due to among others knowledge spillovers, labor market pooling, and competitive pressure. Utilizing knowledge in new ways is considered vital for development of innovative ideas. This study examines how different measures of knowledge affect the impact of innovation in firms and to what extent this relationship is moderated by clustering.

The research context is the Norwegian Offshore industry, accounting for impressive 15.9% of GPD in 2008. This industry is especially interesting because it is internationally competitive, knowledge-intensive, clustered in a few regions of Norway, and currently faces challenges due to a maturing petroleum industry. To test our hypotheses we analyze 187 innovative offshore companies. The results show that high levels of education and mobility of employees inside the industry are likely to increase the impact of innovation in a firm. Further, mobility of employees has a greater impact on innovation in firms in clustered regions compared to firms outside such regions. Surprisingly, level of agglomeration was not alone found to significantly explain impact on innovation. Findings also show that impact of innovation and performance are affected by somewhat different factors.

Our findings have important implications for both the Norwegian government as well as business managers. A continued and strengthened focus on higher education is vital to ensure an innovative environment in the industry. There is, however, no need to build and maintain universities in all parts of the country. Instead, a few strong research environments that are provided with sufficient resources to develop into world class research institutions should be prioritized. Cooperation, both within the industry and in the intersection between firms, universities, and government, is presented as an important mechanism for sharing knowledge. Also, incentives and promotion of employee mobility is highlighted to increase knowledge sharing, likely to benefit not only individual firms, but the industry as a whole.
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1. Introduction

Innovation seems to be universally understood as one of the main drivers for a sustainable and internationally competitive business environment (Romer 1986; Nadiri 1993; Edquist 1997; Agarwal et al. 2003). Research from OECD shows a strong link between innovation activities and GDP growth (Bassanini et al. 2000; Ahn 2002). Already in 1934, Schumpeter explained innovation as principal driver for long-term economic growth. In the modern and global business world, innovation is increasingly discussed in light of clustered regions and explained by utilizing accessible knowledge, leading to economic growth.

Theories of clustering (e.g. Porter 1990; Krugman 1991; Porter 1998) have over the last 20 years emerged as a prominent explanation of economic growth and success of industrial regions (Cortright 2006). A central theme amongst these theories is that clustering gives competitive advantages to firms in geographic proximity to customers, competitors, suppliers or other pivotal industry actors. These geographical benefits are the result of knowledge spillovers, access to markets, access to job opportunities, and competitive pressure. More recent developments within cluster theory have shifted the focus towards innovation-related benefits of being located in a cluster (see e.g. Pouder & StJohn 1996; Baptista & Swann 1998; Tallman et al. 2004). Porter (1998, p.261) argues that, “the ultimate test of the health or decline of a cluster is its rate of innovation.”

Closely interrelated with the concept of clustering is the importance of knowledge. This is by many academics and practitioners seen as the most fundamental underlying driver for both cluster performance and innovation (Lawson & Lorenz 1999; Lawson 1999; Malmberg & Maskell 2002). This view on clustering advocates that clusters exist to create competitive advantages for both the collective as well as the individual firm by enhancing individual firms’ knowledge creation efforts (Lawson 1999; Arikan 2009). Recent research on clustering (e.g. Reve 2009) on clustering underscores this by defining access to talent and technology as important presumptions for the innovativeness of a cluster.
By analyzing how the relationship between knowledge and impact of innovation is moderated by clustering, this study attempt to enhance previous empirical research on the relationship between clusters, knowledge and innovation; and thus fill a gap in the existing literature. Hence, the following research question is proposed:

**TO WHAT EXTENT DOES CLUSTERING MODERATE THE RELATIONSHIP BETWEEN KNOWLEDGE AND INNOVATION?**

In light of the above discussion, the Norwegian business environment constitutes a particularly interesting empirical context. According to OECD, Norway has among the highest GDP per capita in Europe. Despite this, Norway scores relatively low on indices and scoreboards measuring levels of innovation; a phenomenon termed the “Norwegian paradox”. Academics, researchers, policy makers and business managers have proposed different hypotheses as to why this paradox exists. The Norwegian government argues that the high national productivity levels can be explained by a high overall educational level in the work force (Ministry of Education and Research 2008), hence high levels of knowledge. Acknowledging this situation, it would be highly interesting to investigate how variation in levels of- and access to knowledge influence the impact of innovation in firm both residing inside and outside of clustered regions. Increased insights related to how different types of knowledge flows, stocks of knowledge as well as access to knowledge through educational institutions influence innovation in firms are of great interest to decision makers, government, and business managers. Within the Norwegian business environment, the offshore industry appears as an especially interesting industry. The industry, accounting for an impressive 15.9% of the Norwegian GDP, is seemingly geographically located in a few clustered regions, although there is activity along the entire coast of Norway. By being a provider for the oil and gas activities on the Norwegian Continental Shelf, the industry has over the past 40 years developed into an internationally competitive industry, often providing new and innovative technology adopted throughout the world. However, it is currently facing challenges due to a maturing petroleum industry. There are industry-wide pressures for improved technology at lower cost, which again put pressure and demand for new and innovative solutions. To our knowledge, the empirical research on drivers for innovation in Norwegian industries is
limited. By analyzing the Norwegian Offshore industry this study will also contribute to the discussion on important drivers for innovation and future success of the industry.

The remainder of this paper firstly reviews literature on innovation, clusters and knowledge. Secondly, we develop hypotheses based on relevant literature, a qualitative study, and results from a survey-questionnaire. Thirdly, we introduce the research context and methodology. Thereafter results from our analysis are presented, upon which a discussion is based. Lastly, governmental- and managerial implications are presented.

2. Theoretical review
Innovation can be defined as the actual use of a nontrivial change and improvement in a process, product or system that is novel to the institution developing the change (Freeman & Soete 1997). Joseph Schumpeter (1934) is often credited as the pioneer explaining innovation as the principal driver for long-term economic growth and social change. Schumpeter defines the concept of innovation widely, and argues that it includes new products, new methods of production, new sources of supply, exploitation of new markets as well as new ways to organize businesses. Following the works of Schumpeter, most scholars and practitioners form their definitions and arguments related to innovation around these principles. The Norwegian government has adapted this definition and addresses innovation as “a new product, service, process, application or organizational structure that is introduced to the market or exploited in production to create economic value” (Ministry of Trade and Industry 2008).

Innovation is of vital importance to the value creation and development of modern societies; hence innovations are creations of economic significance (Edquist 1997, p.1). The importance of innovations for economic growth are thoroughly documented, both theoretically (e.g. Solow 1956; Romer 1986) and empirically (Mansfield 1972; Nadiri 1993; Agarwal et al. 2003). Studies show that an increase in input factors only accounts for a small share of economic growth, and that significant economic growth is only created when the factors are used in new and more efficient ways (Cameron 1996).
In recent literature, innovation is gaining increased credibility as one of the primary drivers for the development and success of clusters. The concept of ‘clusters’ is used relatively broadly in the research literature. This may be due to the fact that ‘clusters’ and ‘clustering’ encompasses a wide range of dimensions and schools of thought. Due to the long history and the wide nature of the term, it goes by different names in the literature, e.g. ‘industrial districts’, ‘agglomerations’ (Marshall 1920), ‘cities’ (Jacobs 1970), ‘learning regions’ (Florida 1995), ‘efficient locations’ (Sorenson & Audia 2000), ‘knowledge communities’ (Henry & Pinch 2000), and ‘dynamic knowledge systems’ (Reve 2009). Depending on field of interest, scholars have offered competing definitions on the concept of clustering. Cortright (2006) argues that a cluster, in the most general form, consists of firms and related economic actors and institutions that draw productive advantage from their mutual proximity and connections. This is a general definition drawing on ideas from geographic-, social- and competitive studies, and is a sound starting point for our theoretical review. In this paper we will use the term cluster when discussing firms in a region with high levels of agglomeration. Such firms can also be described as geographic proximate or co-located.

The concept of clusters can be traced back to Marshall (1920) and Weber (1929). Studying patterns of economic activities and co-location, so-called industrial agglomerations among industrial districts in England Marshall (1920) explained business prosperity through the lens of economic geography. Marshall identified three main reasons why a certain set of firms within a given industry would be more productive if located in close proximity. These reasons are often referred to as the Marshallian Trinity and include knowledge spillovers, labor market pooling, and supplier specialization.

Knowledge spillovers occur through flows of information and ideas between actors located in the same spatial grouping. Marshall (1920, p.225) argues that shared knowledge occurred in a type of “industrial atmosphere” and that “the mysteries of the trade become no mysteries; but are as it were in the air”. Hence, clustering would enable easier sharing of product and market knowledge compared to firms that were not located in geographic proximity (Gordon & McCann 2000). Knowledge spillovers have been widely discussed in research literature, and may be referred to as the positive externalities firms
receive in terms of knowledge from the environment (e.g. Furman et al. 2002; Molina-Morales 2002; Caniels & Romijn 2003; King et al. 2003), and is a result of personal contact between individuals in a specific location (Feldman 1993; Aharonson et al. 2007; Gilbert et al. 2008). The rationale behind the concept of knowledge spillovers is that the spillovers are only available to the actors within the boundaries of the cluster, and that stand-alone firms will have a disadvantage relative to the firms within the cluster (Audretsch & Feldman 1996). It is therefore often termed as localized knowledge spillovers, and may “allow companies operating nearby the knowledge sources to introduce innovations at a faster rate than rival firms located elsewhere” (Breschi & Lissoni 2001a, p.257).

Labor market pooling is another positive outcome of localized industries (Marshall 1920, p.225). A constant market for skill would make it easier for both employees and firms to match job opportunities (Simpson 1992), as well as reduce their search costs (Gordon & McCann 2000). Specialized suppliers would emerge as the number of industrial actors would enable suppliers to specialize in normally expensive niches as a result of sufficient demand (Marshall 1920).

Based on the foundational works of Marshall, and emphasizing the importance of regional industrial agglomerations, neoclassical economists developed a new genre of research from the early 1990s (Krugman 1991; Jaffe et al. 1993; Krugman 1998; Fujita & Krugman 2003). The ‘new economic geography’ distinguished itself from traditional economic geography by adopting general-equilibrium modeling (Fujita & Krugman 2003). This modeling takes a mathematical approach to why firms located in geographic agglomerations face increasing returns, imperfect competition and lower transport costs. However, limited empirical research have been undertaken to test these models (Cortright 2006). As Gupta & Subramanian (2008) have referred to, Krugman acknowledges the foundations of the Marshallian Trinity, but questioned benefits of knowledge spillovers within an industry, as he points to them being technological externalities which are international in scope; hence equal to all players in the industry.

Krugman (1991) further indicates that regional clusters often emerge from accidental reasons. Additionally, when these clusters emerge, they are sustained by external scale
economies, occurring when firms benefit from lower production costs as a result of the industry growing on the whole (Gupta & Subramanian 2008). Krugman also argues that, due to lower transaction costs, firms should locate in proximity to markets where demand is high or where the supply of input factor is favorable (Krugman 1991, p.98).

Building on the ideas and concepts from economic geography, Porter (1990; 1998) has presented some of the most influential ideas and theories within the field of clustering. However, it is of importance to note that Porter’s arguments differ from the traditional economic geography in one fundamental way. Whereas Krugman sees agglomeration as a static system and attempts to explain why firms agglomerate, Porter emphasizes that in order to be a cluster, geographic proximity is required, not yet sufficient. Continuing, Porter (1990, p.197) defines clusters as “geographical concentrations of interconnected firms, specialized suppliers, service providers, firms in related industries and associated institutions in a particular field that compete but also cooperate”. By doing so, he argues that it is the interplay and interaction between actors within the clusters that create the true value. Underpinning these arguments, Reve (2009, p.11) concludes that “agglomerations become industrial clusters or dynamic knowledge systems when industrial and knowledge actors start to interact.” Advancing this argument, Whittington et al. (2009, p.90) acknowledge the interplay between geography and sociology and argue that, “organizations are situated in both geographic- and social structural spaces”. In doing so, he builds on the concepts of how social networking affects levels of innovation and economic growth (Granovetter 1985; Burt 1992).

Contradictory to the literature of economic geography, schools of sociology and networking explain clustering dynamics and location advantages through social ties and connections (Powell & Smith-Doerr 1994; Saxenian 1996a; Sorenson & Audia 2000). Theories of sociology are therefore important to consider when focusing on knowledge and clustering as it provides a different view on knowledge dynamics and its effects on innovation. It is the social linkages that offer access to new resources and knowledge; elements crucial for innovative purposes (Gulati et al. 2000; Baum et al. 2000; Ernst 2002). Thus these linkages play out as an alternative to physical proximity as promoted by advocates of economic geography. Pushing the argument further, Gulati et al. (2000) and
Podolny (2001) claim that mere access to a social network is not sufficient; the location within the network is deterministic for accessing information and knowledge.

In response to Porter’s emphasis on the important role of regions in the face of increased globalization, Ernst (2002) claims that the spatial stickiness of innovation is reduced as information sharing and knowledge transfer in networks are simplified. Porter (1990) claims that in order to understand competition and competitive advantage in the world of globalization, one needs a good understanding of a cluster. Facing increased globalization, the importance of regional locations increases, rather than decreases. With an increased focus on globalization in the literature, it is of value to distinguish between the concept of tacit and explicit knowledge. *Explicit* knowledge is often referred to as codified knowledge, e.g. manuals and written documentation (Grant 1996). Contrary, *tacit* knowledge is often referred to as personal knowledge, rooted in individual’s experience and values and recognized as abilities, developed skills and “gut feeling” (Nonaka & Takeuchi 1995). This division has certain implications for the importance of knowledge and geographic proximity. The relative importance and value of explicit knowledge is diminishing due to its ease of copying and transferring across geographic locations, while the importance of the tacit knowledge is increasing. It is even argued that this distinction is a primary reason why distance and geographic proximity matters when discussing who will benefit from knowledge spillovers (Breschi & Lissoni 2001b).

A large portion of all knowledge in regions can be described as non-codifiable, i.e. tacit in nature (Szulanski 1996). This represents a huge challenge, but also an interesting opportunity for firms striving to improve levels of innovation. The General Manager of Hewlett Packard illustrated this challenge by stating “If only HP knows what HP knows!” (Sieloff 1999). Because tacit knowledge resides within individuals, this knowledge follows employees’ mobility patterns, and hence; knowledge becomes spatially sticky and locally embedded (Gertler 2003). This implies that the mobility of skilled employees in a certain industry has been recognized as an essential facilitator of the circulation of embodied tacit knowledge between firms in a cluster (Power & Lundmark 2004).
Bringing the discussion back to reasons for positive cluster effects, Porter argues that the competitiveness of a nation or location is measured by the level of productivity of its industries. Hence a nation depends on its industries’ ability to innovate and stay competitive. To answer questions such as why some industries are capable of consistent innovation, and why clusters are more competitive than isolated firms, Porter (1990) outlines the diamond of national advantage presented in Figure 1; four attributes that individually and as a system constitute the playing field that each nation establishes and operates for its industries.

![Porter's diamond of national competitive advantage](image)

It is important to highlight the systemic nature of the diamond; that these attributes affect each other and are dependent on the state of the other attributes in the diamond. As can be seen in the model above, the four attributes of the model are:

- **Factor conditions** describe the nation’s position in factors of production, such as labor force, infrastructure, education and research institutions.
- **Demand conditions** are concerned with the nature of the home-market. Despite markets globalizing and worldwide customers, a demanding home-market is seen as important because it spurs innovation.
- Presence of **Related and supporting industries** affects the ability to use cost-effective inputs at the lowest possible transaction cost.
- **Firm strategy, structure, and rivalry** constitute the context for competition in the cluster, as well as how firms are created, organized and managed. Domestic rivalry is presented as most important due to its effect on firms’ need to innovate and improve.
The dynamics of these attributes constitutes a nation’s ability to create value through innovation, and is an applicable framework for governments and firms to reveal areas for future improvements. Porter (1998, p.261) pursues the importance of innovation and argues that “the ultimate test of the health or decline of a cluster is its rate of innovation.” Hence, he concludes that rates of innovation are closely interrelated the performance of a cluster. This is also supported by some of the most recent works on clusters and competitiveness. In an extension of Porter’s diamond model for global competitiveness, Reve (2009) defines innovation as the central driver for cluster competitiveness.

3. Hypotheses

3.1 Proximity to research institutions
In a knowledge-based economy, access to knowledge is a vital ingredient to any firm that seeks to sustain or improve their competitive advantage. Porter (1998) argues that an important part of the concept of clustering is proximity to research institutes and universities. Also Reve (2009), in his study of the Norwegian maritime industry, argues that world leading clusters are characterized by the presence of such institutions. Researchers further report that the location of such institutions often influences localization decisions for managers in start-ups or firms doing R&D (Furman 2003; Audretsch et al. 2004).

Research universities can be defined as institutions that “typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate” (Shulman 2000, p.11). In addition, specialized research institutes conducting primarily applied research within relevant topics are an important source of knowledge. These institutes are characterized by doing research for private and public organizations, in addition to publishing research papers.

Clusters and associated firms can benefit from the presence of research institutions in at least two ways: Firstly, as a source of expert knowledge that may be exploited through
different types of joint research projects between the industry and academia or traditional consulting, and secondly; by providing graduates with higher education through which knowledge disseminates throughout a cluster (Rothaermel & Ku 2008). The hypothesis presented in this section will focus on the first effect, whereas the second effect will be discussed as part of Hypothesis 2 in Section 3.2.

The notion that academic research and education are key contributors to innovation in firms is widely supported in the literature (Rosenberg & Nelson 1994; Feller et al. 2002). Rothaermel & Ku (2008) found that a cluster’s innovative output, as measured by number of patents, was closely correlated with the existence of a leading research university within the cluster. Building on this, Coccia (2004) underlines the importance of looking at the productivity of such research institutions.

Findings from the qualitative study also show that geographic proximity to research institutions is underlined as an important source of expert knowledge. As a general manager of a large engineering and construction firm situated in Rogaland stated:

*The close proximity to the university is of vital importance to our development and innovation activities. We have several projects going on with them, and they are a great source of knowledge.*

Another point-of-view is highlighted by a university dean:

*Several firms have tight connections with the university, not only on specific projects, but on a more general level. This link between universities and the industry enables graduates to build up networks; and through internships and part time jobs, the firms are able to recruit and retain the candidates that suit them.*

Concluding, both theory and empirical investigations suggest that the presence of research institutions is an important explanatory factor for innovation. We therefore hypothesize that:

**H1: Productive research institutions in close proximity to firms has a positive effect on impact of innovation**
3.2 Stock of human capital

Most theorists support the argument that a highly educated workforce fosters innovation. According to Schultz (1961) investments in human capital with an emphasis on formal education and training is the main explanatory factor of production efficiency in technically advanced countries. Foster (1987) builds on this argument and claims that a formal education consisting of literacy, numeracy and other general topics are likely to generate an “ability to learn” that is vital to the innovation process. Especially in industries where the technological change is rapid, like in the offshore industry, firms need to have a qualified workforce in order to be able to innovate (Layard et al. 1971; Whiston 1980). It is argued that higher levels of education may benefit firms on at least two levels: Firstly, individuals with long formal educations are responsible for the vast majority of innovations in a firm, and secondly; effective use of new technology requires high levels of education among employees (Pack 1974; Rebelo 1991). Further, it is important to underline that in knowledge-based organizations, high levels of education is important for line workers as well as managers. Nelson and Phelps (1966) argue that a manager with a university degree is better suited to quickly introduce, adopt and evaluate innovations; hence being better suited to manage a firm operating in a rapidly changing environment (Gibbons & Johnston 1974).

The importance of a skilled work-force is also stressed by the interviewees in the qualitative study. As one manager of a medium sized supplier of mechanical manufacturing to the offshore industry noted:

*We are no longer a pure manufacturer where the majority of our employees are situated along an assembly line. We deal with demanding best-in-class customers, requiring our employees to be able to do complex problem-solving and provide innovative solutions, often under time pressure. Therefore, we mostly employ workers with a higher education, as they are more suited to work under these circumstances.*

It may be plausible to assume that attained educational level is correlated with cognitive ability (Rogers & Shoemaker 1972). Therefore, higher levels of both formal education and general experience should be associated with the ability to generate and implement
creative solutions to complex problems. This aptitude may explain why people who are more educated have more receptive attitudes towards innovation (Kimberly & Evanisko 1981; Bantel & Jackson 1989). Based on the theory and empirical investigations of the issue and our qualitative study, we argue that there is a strong link between level of education in firms and the impact of innovation. Therefore, the following hypothesis is presented:

**H2: High levels of education in the firm has a positive effect on impact of innovation**

Further, we argue that the knowledge employees acquire through general working experience is of value and may influence levels of innovation in a firm. Cotlear (1986) suggests that non-formal and informal education should be included in a complete measure of level of education. Non-formal education includes different kinds of extensions and organized apprenticeships, while informal education refers to a wide definition of learning-by-doing, which may include not only direct experience in a particular job but also various learning processes that arise from being exposed to different circumstances (Masakazu Hojo 2004). We therefore hypothesize the following:

**H3: High levels of general experience in the firm has a positive effect on impact of innovation**

### 3.3 Intra- and inter-industry mobility

Earlier works on knowledge spillovers fail to provide consistent conclusions on how knowledge spillovers take effect, and falls back to relatively vague explanations on this phenomenon. Power & Lundmark (2004) argue that exchanges of knowledge occur in the workplace, specifically through labor mobility. The movement of people between labor markets, sectors and firms must therefore have important consequences for industrial functioning and innovation (Basant 2002).

Power & Lundmark (2004, p 1027) presents three ways innovation is affected by employee mobility: Firstly, it speeds up knowledge dissimilation and learning processes. Secondly, it is likely to create new combinations of knowledge (ideas, methods etc.) and finally, it creates links between employees and workplaces, and has a reinforcing effect on
clustering per se. In addition, mobility of employees may be seen as a positive sum game for firms within a cluster. Cabrera & Cabrera (2002) argue that what makes it possible for both firms and clusters to simultaneously obtain competitive advantage through knowledge spillovers, as opposed to standard economic transactions, is that its value flourishes when it is shared.

Further, it is important to note that it is not only knowledge flows within a given industry (intra-industry mobility) that are sources of knowledge leading to increased innovative capacity. There are also flows of knowledge from external sources (inter-industry mobility). Malmberg & Maskell (2002) suggests that there is a shortcoming in theory related to knowledge spillovers and argues that knowledge spillovers also occur between labor markets, industries and regions. Theoretically, it may seem problematic to combine the theories arguing that close proximity in clusters is important and theories arguing that external flows of employees foster innovation; however, it is argued that in order to be able to innovate, a combination of new and existing knowledge is preferable (Kogut & Zander 1996).

Despite an increase in both quality and quantity of articles discussing this issue (Dahl 2002), empirical tests provide mixed results as to what types of mobility and knowledge spillovers are the most important factors for levels of innovation. Rosenkopf & Almeida (2003) argue that most available research offers at best indirect evidence on the connection between employee mobility and knowledge flows. On the other hand, a study conducted by Ettlie (1985) finds a positive relationship between knowledge flows from external sources and a firm’s innovative capability. However, he found this relationship to be curvilinear; implying that the relationship is positive only up to a certain point, where the interventions from external workers resulted in high disruptive costs and diminishing returns. On the subject of to what degree mobility exists in clusters researchers present strong empirical evidence that firms in clustered locations, on average, have a higher degree of labor mobility than firms not operating within a cluster (see e.g. Almeida & Kogut 1999; Dahl & Pedersen 2004). Studying the Motor Sport Valley, Henry & Pinch (2000) underpin the importance of employee mobility among firms in order to build up a common knowledge pool, mutually beneficial for the whole industry.
Results from the initial survey confirm the importance of mobility. On a question on what recruitment sources improve the firms’ competence, recruitment from other firms within the industry scores 3.46\(^1\), followed by personnel with international experience (2.66) and personnel from direct competitors (2.31). However, managers interviewed in the qualitative study are concerned about the levels of mobility in the industry. As a vice president in a large engineering firm argues:

*One pressing challenge for the Norwegian competitiveness is its low rates of mobility, both in terms of people not changing workplace, as well as people not willing to work in different locations. Norwegian workers are creatures of habit; when they have settled down, they have a great resistance to change status quo. The problem with these low mobility rates is primarily that we get less input from our environment; from our competitors and from foreign markets. This is an impediment to our innovative capabilities.*

Another manager with experience from other international maritime clusters argues that increased mobility may be beneficial for the cluster in general:

*In other clusters, e.g. the offshore cluster in Aberdeen, the mobility between competing firms is significantly higher than in Norway. Apparently, this should be considered a problem; competitors “stealing” employees from each others. However, this is actually considered a mutual benefit, as all firms gain some new insights that foster innovation.*

Based on this review, it seems apparent that, if existing, employee mobility has a positive effect on innovation in clustering; hence the following hypotheses are suggested:

**H4: Intra-industry mobility of employees has a positive effect on impact of innovation**

**H5: Inter-industry mobility of employees has a positive effect on impact of innovation**

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\(^1\) The question was “To what degree do the following sources contribute to the enhanced company knowledge?” (Our translation). The question had a 4-point Likert scale, with 1 indicating “to a lesser degree” and 4 indicating “to a large degree”.
3.4 Geographic proximity

In the realm of clustering, geographic proximity is perhaps the most foundational characteristics of clusters. Cortright (2006, p.11) argues that virtually all academic and practitioner literature about clusters is based on geographic proximity. Simplified, the argument is that co-located firms enjoy advantages unavailable to firms in more scattered locations. These advantages can take the form of knowledge spillovers, access to markets, access to job opportunities or competitive pressure.

In the modern economy, innovation is often considered being the fundament of economic growth and competitive advantage (Ibrahim & Fallah 2005). Many theoretical works in the literature claim that innovation and productivity are higher among geographically proximate firms than geographically dispersed firms (Baptista & Swann 1998; Porter 1998; Keeble & Wilkinson 1999). The underlying logic of these claims is that knowledge and learning, fundamental drivers for innovation, increase in such locations. Vigier (2007, p.198) supports this view, and argue that proximity enables flows of tacit knowledge and unplanned interactions, elements critical for the innovation process; hence a reason for why innovation is more geographically concentrated than productivity. Porter (1998) on the other hand argues that the increased innovative ability of firms in close proximity is mainly due to competitive factors. As the competitive environment becomes denser, individual firms are forced to innovate to maintain or achieve a competitive advantage. The competitive environment is affected by the factors in the diamond model (see Section 2), and Porter emphasizes the importance of home market demand conditions, and related and supporting industries. Building on these arguments, Reve in 2009 presented the model of a global knowledge hub, a kind of super cluster. Here innovation is seen as the driver of competiveness and economic growth, dependent on a geographic proximate structure consisting of R&D institutions, access to talent and access to competent capital.

Although the theory on the issue is rather unison and conclusive, stating that geographic proximity has a positive effect on innovative ability, empirical results are somewhat mixed. In a classical work comparing the geographic location of patent citations, Jaffe et al. (1993) found positive and significant evidence for citations being geographically localized. Feldman (1993) found that certain locations facilitate innovation at a higher rate
than others due to access and localization of specialized knowledge resources. Viewing knowledge- and technology transfer as vital elements for the innovation process, a range of empirical literature finds a positive relationship between geographical proximity and faster knowledge- and technology transfer (Keilbach 2000; Meagher & Rogers 2004; Coccia 2008). Audretsch (1995) found that the propensity of innovative activity geographically tends to be greater in industries where knowledge plays a more important role. Arguing that “innovation is increasingly dependent on a geographically defined infrastructure” consisting of networks of knowledge, concentration of R&D and business services with expertise in new product commercialization, Feldman & Florida (1994) found that innovation is indeed related to the geographical infrastructure.

Other research finds weak or no ties between proximity and innovation. Testing the effect of geographical proximity on the Marshallian trinity, Porter’s diamond market conditions, and trust-based effects, Lublinski (2003, p.453) reported that: “All in all, results suggest that if agglomerative advantages are at work, they are at best operating weakly.” Further, Tallman & Phene (2007) found geographic proximity not to matter in certain instances studying knowledge flows within and across geographic clusters.

In general, the conclusions from the qualitative study were that locating in close proximity to relevant industry actors is of great importance. The HR-manager of a Norwegian seismic and geology firm headquartered in Oslo argues that:

*Despite being headquartered in Oslo, the vast majority of our customers are located elsewhere. Therefore, we are reliant on a large set of branches in other locations like Stavanger, Aberdeen and Houston. Close proximity to our customers are of vital importance in terms of collaboration on on-going projects, but just as important when it comes to sensing in the markets for new projects.*

Another manager in a large oil service firm highlighted the importance of labor market pooling:

*This cluster attracts the competent workers in Norway. Being situated here enables us to compete on employing the most attractive workers. This would have been very difficult, if not impossible, if we were located outside this region. In addition, many*
of the students that come here to study stay here after they graduate. This is also a unique source of labor that would be hard to exploit if located elsewhere.

Based on the theory, empirical findings, and results from the qualitative study, there seems to be a strong link between geographic proximity and innovation. Therefore, the following hypothesis is presented:

**H6: Geographic proximity of firms has a positive effect on impact of innovation.**

### 3.5 Clustering as a magnifier of human capital and employee mobility

As the previous discussions have shown, the theory is full of works explaining the importance of clustering and geographic proximity on innovation. There are also numerous works on knowledge spillovers, knowledge flows and social networking as underlying factors for the innovation process. Several studies show that the innovative ability of clusters varies extensively (Saxenian 1996b; Baptista & Swann 1999; Cook & Pandit 2007). Arikan (2009) argue that cluster variations are a reflection of the clusters ability of inter-firm knowledge exchange. Expanding to clusters Nonaka’s (1994) arguments that firms create new knowledge by amplifying the knowledge of its members, Arikan states that:

“Specifically, firms located inside a cluster will collectively become more innovative than the sum of individual firms had those firms been geographically scattered to the extent that knowledge exchanges take place between cluster firms, and cluster firms effectively amplify knowledge from other cluster firms through their knowledge spirals.” (Arikan 2009, p.660)

Tallman et al. (2004) distinguish between potentially transferable component knowledge, and integrated and embedded (Granovetter 1985) architectural knowledge. Based on this division, it is proposed that cluster-level architectural knowledge only is available to members of the cluster. This knowledge can provide certain clusters with sustainable competitive advantages by restricting flows of unique knowledge and know-how, thereby building an inimitable cluster-specific technology base.
Conclusively, there is theory explaining that cluster membership can provide access to certain knowledge bases that in turn has a magnifying effect on innovation. However, there is to our knowledge little or no empirical research investigating the magnifying effects of clustering on knowledge, and further, its total effect on innovation. That is, do firms in clusters innovate more than firms in areas without clustering characteristics due to access to different sources- and characteristics of knowledge?

As follows from the above discussion, it is clear that both stock of human capital and mobility are elements needed for clustering to have a magnifying effect on innovation. The former, taking the form of either level of education or general experience, makes for the knowledge to be shared. Combining the empirical findings of the positive effects of knowledge level on innovation in clusters with a marginal increase in clustering, should result in a larger than marginal increased effect on innovation. Therefore the following hypotheses are presented:

**H7**: Clustering magnifies the effect of higher education level on impact of innovation.

**H8**: Clustering magnifies the effect of general experience on impact of innovation.

Knowledge flows in terms of mobility is the second necessity for magnifying effects of clustering on innovation to take place. As previously discussed, employee mobility positively affects innovation by speeding up knowledge dissemination, and increasing learning processes. In locations characterized as clusters, barriers for mobility, such as need to move and schooling, are minimized (Aho 2006). Knowledge through employee mobility can therefore disseminate at a higher marginal level than in non-clustered locations; this is also supported in a report on the NODE-cluster\(^2\) by European Cluster Mapping Project (2008). As earlier, we distinguish between intra-industry mobility- and inter-industry mobility, and present the following hypotheses:

**H9**: Clustering magnifies the effect of intra-industry mobility on impact of innovation.

**H10**: Clustering magnifies the effect of inter-industry mobility on impact of innovation.

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\(^2\) For more information about NODE, see [http://www.nodeproject.no/](http://www.nodeproject.no/)
4. Methodology
This study takes a mixed method approach, implying that both qualitative and quantitative data has been collected and analyzed. In order to form the basis for the development of hypotheses, an exploratory qualitative study was conducted in order to seek industry insights and to understand the present situation in the offshore industry. Based on the findings from the preparatory study, a quantitative study was conducted. This study has been based on analyses of data from a set of databases from Statistics Norway and Brønnøysundregistrene. As this part of the study seeks to explore the causal relationship between concepts, the study will be explanatory in nature (Saunders et al. 2009).

The remainder of this chapter firstly describes the defined research context; the offshore industry. Highlighted will be its history, its importance for Norway, and future key challenges that constitutes an interesting framing for a discussion on clustering, knowledge and innovation. Secondly, a presentation of the qualitative and quantitative studies and the related data material is presented. Thirdly, we provide suggestions for operationalizations of the selected theoretical constructs.

4.1 Context: The Norwegian offshore industry
Norway has a long tradition of creating value through activities related to the ocean. According to Reve (2009), Norway has developed into a unique global position in the maritime sector by combining three major factors: ocean, technology and knowledge. The geographical placement in the Northern part of the world, with extensive exposure to the ocean through a 2500 km long coastline provide the basis for employment and value creation across the country. Both historically and present, Norway holds the position as one of the world’s dominating maritime nations within shipping and other maritime services. In addition, Norway controls one of the largest maritime zones in the world. These enormous areas also include extensive oil and gas reserves, founding the basis for what has been termed an industrial adventure occurring in Norway over the last 40 years.
Firms started to show interest in offshore oil production on the North Sea Shelf in the 1960s. As a result, the Norwegian government established guidelines for exploration of oil on the Norwegian Continental Shelf, as well as claiming all resources public property (Bjørnstad 2009). The first commercial oil field on the Norwegian Continental Shelf, Ekofisk, was discovered by ConocoPhillips in 1969, with commissioning starting in 1971. The next few years, several major discoveries were made and the Norwegian oil adventure became a reality (Ministry of Petroleum and Energy 2007).

Building up Norwegian expertise was an important element in Norwegian petroleum policy, and in the beginning this expertise was obtained from foreign oil- and supplier firms (NPD 2009a, p. 56). A government white paper (Norwegian Government 1970) was issued and suggested to create the oil company Statoil in order to “ensure the role of the industry in the North Sea” (Bjørnstad 2009). Empowered by advantageous privileges given by the government, Statoil arose as a significant and powerful player that had the means to orchestrate a supplier industry based on its needs. In doing so, Statoil accelerated the emergence of the offshore industry. Numerous specialized suppliers, often directly or indirectly controlled by Statoil, were established. By providing resources and demand, Statoil has helped the offshore industry to develop into a highly competent knowledge-based industry. Today, the entire Norwegian petroleum industry has developed into a strong cluster (Reve 2009) where Norwegian oil firms, the offshore industry and research institutions are highly developed and internationally competitive (NPD 2009a, p. 56).

The Norwegian offshore industry is an essential service- and product provider for the petroleum activity in Norway. The next sections are devoted to a more detailed presentation of key data and activities in the offshore industry. As it is vital to have a clear-cut definition of which firms to include, we first present our classification of the industry.

In 2009, Ernst & Young presented The 2009 Norwegian Oilfield Service Analysis (OFS). The analysis included firms with at least 50% of turnover generated in the oil and gas sector, above 20 MNOK (2008) in revenues, and with legal entity address in Norway. These criteria captured 600 firms employing 80,000 people with combined revenues of 280
BNOK. In our classification, we used the logic from OFS as a platform. However, a disadvantage with OFS is that it does not capture small and medium sized enterprises (SME) with turnover lower than 20 MNOK; which in effect excludes quite a substantial number of industry-relevant firms. We have therefore combined the logic of the OFS classification with industry classification NACE codes (Statistics Norway 2008) as the foundation for our classification. However, even at a 5-digit classification level, there can be possible inaccuracies with classification codes as NACE (Power 2002), and such should hence be used with caution. Also, Statistics Norway (2007) warns that NACE codes can contain categorization errors due to seldom updates and self-reporting. In order to avoid these inaccuracies, a comprehensive and manual classification, including an individual assessment of each firm, was undertaken in order to assure that every firm included was a part of the industry. In this analysis, criteria for being defined as a Norwegian offshore firm are:

• The majority of turnover is generated in the oil and gas sector
• Revenues exceed 3 MNOK (2008)
• The legal entity has its address in Norway

Using this classification and data from Statistics Norway (SSB) and Brønnøysundregistrene (see Section 4.3), key figures for the industry from 2005 to 2008 is presented in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Key figures for the offshore industry, 2005-2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Firms</td>
<td>1 869</td>
</tr>
<tr>
<td>Employees</td>
<td>78 773</td>
</tr>
<tr>
<td>Revenues 1</td>
<td>198.2</td>
</tr>
<tr>
<td>Net income 1</td>
<td>31.7</td>
</tr>
<tr>
<td>Margin</td>
<td>16.0 %</td>
</tr>
<tr>
<td>% of Norwegian GDP</td>
<td>10.2 %</td>
</tr>
</tbody>
</table>

Note that firms classified as licensee operators, such as Statoil, are not included in the study.

Table 1 show that the offshore industry employed almost 113,000 persons in 2008, spread across 2214 firms. The industry generated revenues of almost 405 billion NOK, thereby accounting for 15.9% of the Norwegian GDP. Over the last few years, the industry...
has grown substantially. The number of employees has increased 40% from 2005 to 2008. Total revenues have experienced an astonishing doubling of revenues in the same period, and the percentage of GDP has increased from 10.2% in 2005 to 15.9% in 2008.

However positive these trends are, the profit margin has not seen an equally positive development. Despite having a positive profitability trend, the offshore industry is cyclical, and highly dependent upon the oil price. Hence, the profit margin has varied considerably the last few years, see Figure 3. From being negative in 2002-2003, the profit margin peaked at almost 20% in 2007 before plummeting in 2008. Major reasons for this are the international financial crisis and a low and fluctuating oil price.

Figure 4 illustrates how levels of innovation in the industry have developed from 2003 to 2008, as measured by percentage share of “innovative firms”\(^4\). The figure also compares how the offshore industry performs compared to the national average including all industries. As observed, the offshore industry innovates close to twice as much as the

\[^4\] Firms that has either introduced or significantly improved their products/services or implemented new or significantly improved processes during the last three years are defined as an "innovative firm" by SSB. Firms that only have ongoing innovation activity that is yet to be completed or has been cancelled are excluded from the definition.
national average in Norway. However, the rates of innovative firms are slightly declining, in line with the national trend.

![FIGURE 4](image)

**FIGURE 4**
Development in levels of innovation - average for the offshore industry vs. average of all industries

It is argued that the offshore industry is increasing its knowledge intensity; hence that knowledge and competence is becoming increasingly important for the value-creation in the industry. Figure 5 shows proportions of different levels of education from 2000 to 2008. Our findings show that not only has the number of employees increased over the last 8 years, but also the average education level of the workforce is increasing. The proportion of employees with higher education (Bachelor-, Master-, or PhD degree) increased from 23% in 2000 to 29% in 2008.

![FIGURE 5](image)
Figure 6 presents the geographic distribution of firms in the offshore industry. The red dots represent locations with more than 100 firms located in close proximity. As observable, the vast majority of activity is located along the Norwegian east and west coast. The major agglomerations include Rogaland (664 firms), Oslo/Akershus (498), Bergen (358), Haugesund (163), Agder (134) and Trøndelag (122). Please refer to Appendix 8 for a full-size overview.

4.1.1 Activities in the offshore industry
The offshore industry comprises a wide set of activities, ranging from firms specializing in initial geologic and seismic services, all the way through decommissioning of platforms and other offshore installations.

All firms within the Norwegian offshore industry, as defined in Section 4.1, are classified in a category according to their main activities. It is worth noting that many firms are engaged in activities spreading over more than one category. Such firms are classified in
the category that corresponds best with the primary focus (i.e. majority of turnover) of the firm. The categories of firms in the offshore industry in Norway include:

- **Geology, seismic and reservoir service.** Firms in this category are involved in activities that are carried out prior to engineering and production. This includes seismic surveys of the seabed and initial works on reservoirs. This part of the activity chain enjoys among the highest margins across the industry.

- **Drill and well services and equipment.** These firms are involved in exploratory drilling and preparation and maintenance of wells.

- **Engineering, fabrication and maintenance.** Firms in this category specialize in designing and constructing high technological and complex installations for the offshore industry. This category is divided in two sub-categories: *topside installations* and *subsea systems*. The former category includes firms working with installations on oil rigs and other installations above sea level, while the latter engages in installations on the seabed. As can be seen in Table 2, the topside part of the industry is by far the larger of the two, however it is not profitable. The subsea firms, on the other hand, are enjoying a healthier margin.

- **Production of products and services, including maritime operations.** The firms include small, specialized suppliers that produce parts and products for other firms in the activity chain. In addition, suppliers of services like welding, diving, operation of remote operated underwater vehicles (ROV) and similar services are located in this group. This is the largest category of firms, both as measured by turnover and number of firms. As much as 60% of the firms in the industry are classified into this group.

- **Decommissioning.** A growing, yet relatively small business component in the offshore industry is the presence of firms engaged in decommissioning of abandoned oil rigs and equipment. This is the most emerging part of the activity chain, as platforms and installations on the Norwegian shelf are maturing.

- **Refineries, transport and marketing.** These are downstream activities in the offshore activity chain. Firms in this category are engaged in activities subsequent to oil and gas extraction.
• *Education, research and consulting.* Actors in this category are sources of expert knowledge such as research institutions, universities and consulting firms.

The following table presents key information on size and profitability of the different parts of the activity chain:

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Key figures for activities in the Norwegian offshore industry in 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firms</td>
<td>151 211 390 87 1 311 6 34 24</td>
</tr>
<tr>
<td>Employees</td>
<td>3 952 19 685 41 591 12 576 33 279 547 343 860</td>
</tr>
<tr>
<td>Revenue 1</td>
<td>28 447 81 150 137 714 46 477 101 360 689 7 209 1 535</td>
</tr>
<tr>
<td>Net Income 1</td>
<td>5 346 6 573 -14 269 3 765 5 700 2 1 900 105</td>
</tr>
<tr>
<td>Profit margin</td>
<td>18.8 % 8.1 % -10.4 % 8.1 % 5.6 % 0.4 % 26.3 % 6.9 % 2.3 %</td>
</tr>
</tbody>
</table>

1) All numbers in MNOK

In the 41 years since the discovery of Ekofisk field in 1969, the Norwegian petroleum industry has evolved from being a promising prospect to a maturing industry. The industry now faces new challenges in order to stay competitive and remain an international leading cluster. These include, but are not limited to, declining production, smaller discoveries of new fields, political uncertainty regarding opening of new fields, fluctuating profit margins as well as significant technological challenges (Norwegian Petroleum Directorate 2009). In addition, increased demand and requirements for environmentally friendly and sustainable processes of extractions and increased pressure for focus on renewable energy are important challenges.
No new acreage has been made available for petroleum activity on the Norwegian continental shelf since 1994 (Norwegian Petroleum Directorate 2009), and the last major discovery was the Ormen Lange field in 1997 (Norwegian Petroleum Directorate 2010). Oil and gas production was rising until the record year 2001, and have been on a steady, slight decline since. As can be seen in Figure 7, oil production is declining, whereas gas is accounting for and increasingly bigger share of total petroleum production.

![Figure 7](image)

Even with declining production there are still vast amounts of oil and gas in and around existing oil fields, representing interesting opportunities for the petroleum industry. According to the Norwegian Petroleum Directorate (NPD) (2009) there are still numerous amounts of oil fields that have yet to be discovered and exploited. To extract these reserves, new technology regarding increased field lifetime, increased recovery rates, as well as technology for extracting and connecting smaller fields to existing infrastructure, all at a lower cost than today, is needed. NPD emphasizes the importance of expertise, research and technological advances to facilitate this development, and highlights that “the next few years are critical for making important choices that can enable the recovery of significantly more oil and gas” (Norwegian Petroleum Directorate 2009, p.16). The Norwegian Offshore industry plays a crucial role in this process. Industry actors have, through the qualitative study, highlighted
that knowledge and the ability to innovate are key factors in solving these challenges. This will further ensure sustained activity, economic growth and increased competitiveness for the industry.

4.2 Qualitative preparatory study
As part of the preparatory study, in-depth interviews with 27 relevant industry actors have been undertaken. A complete list of interviewees is provided in Appendix 2. The in-depth interviews have been standardized and semi-structured (Cassell & Symon 2004), enabling us to gather targeted and case-relevant information containing perceived causal inferences (Yin 1994). By following the principles presented by Silverman (2005), the interviews have been conducted by using a pre-defined list of topics for the interview. However, as the interviewees have business representatives from small companies to multinational enterprises as well as politicians and representatives from NGOs, the list of topics have been slightly modified and adapted to the situation in each and every interview. In order to collect the best possible information from each interview, the key informant technique has been adapted in order to ensure that the most knowledgeable individual in each situation has been interviewed (Burgess 1986). On average the interviews lasted between 75 and 120 minutes, and provided constructive dialogue and discussion on topics as knowledge, innovation and competitiveness. The findings and conclusions from these interviews have formed an understanding of industry challenges and dynamics, and thereby functioned as a base for the quantitative study.

4.3 Quantitative study
This paper has made use of several data sources in order to support and sufficiently test our hypotheses. The primary data sources consist of a survey sent to relevantly classified industry actors, as well as the preparatory qualitative study. The secondary sources include ownership information from The Register of Business Enterprises, complete business enterprise financial information from The Register of Company Accounts, and an extensive dataset from Statistics Norway, encompassing data from “Innovation in the Norwegian business enterprise sector” and a dataset of employee-employer information based on the register-based employment data files.
4.3.1 The Register of Business Enterprises (Foretaksregisteret)
The Register of Business Enterprises is responsible for registering all Norwegian and foreign business enterprises in Norway. All enterprises operating business activities - both those with unlimited as well as limited responsibilities - are obliged to register. The register provides correct and up-to-date information about board members, general manager/management, auditors, changes to share capital, financial overviews, eventual bankruptcies, and several other official matters (Brønnøysund Register Centre 2010a). Further, registration provides each business enterprise with a unique organization number. As most of the information is available to the public, the Register of Business Enterprises is a highly reliable source of facts and key information about Norwegian registered enterprises. Updated data from the register provides a solid and trustworthy foundation for the quantitative data collection.

4.3.2 The Register of Company Accounts (Regnskapsregisteret)
Information from The Register of Company Accounts is used in order to produce measurements of financial performance and development of both Norwegian and foreign business enterprises located in Norway. “Pursuant to the Act relating to Company Accounts, all limited companies and public limited companies, savings banks, mutual insurance companies and petroleum enterprises are obliged to submit their annual accounts, including the auditor’s report, to the Register of Company Accounts” (Brønnøysund Register Centre 2010b). The register only contains annual accounts for single legal entities, hereby excluding corporation annual accounts. The longitudinal dataset used for this paper is collected through use of relevant organization number, and includes all available financial information from the period 2000 – 2008.

4.3.3 Datasets from Statistics Norway (Statistisk Sentralbyrå)
The Norwegian Innovation Survey is undertaken every second year by Statistics Norway. It is part of the Eurostat Community Innovation Survey (CIS), and is based on guidelines defined by OECD and the so-called “Oslo Manual” (OECD 2005). The survey encompasses the entire manufacturing sector and parts of the services sector, and also covers extraction of oil and gas, fish hatcheries and fish farms.
Observed units in the survey are business enterprises based on organization number from the Register of Business Enterprises. An advantage with this unit of observation is that it often leads to correct decision-makers as respondents. A disadvantage occurs if registered businesses have innovation activity in several unit and locations. Innovation activity will then be reported at HQ and its location, even if it were undertaken somewhere else. The most recent survey was sent June 2009, as a mandatory filing requirement with statutory authority in the Act of Statistics. The survey was sent to 6300 firms across all industries, and the final response rate reached 95% (Statistics Norway 2009). In total, the innovation study provided a solid and reliable basis for studying the innovation activity in the Norwegian business life.

The Employee/employer - match data from Statistics Norway consists of the Central Register on Employers and Employees, End of the Year Certificate Register, The Registers of Conscripts and of Conscientious Objectors, The Central Coordinating Register for Legal Entities, The Central Register of Establishments and Enterprises, The Register of Job Seekers, Several registers of government employers and employees of local and regional authorities, Wage statistics for employees in the private sector, The Sick Leave Register and The Register for Personal Tax Payers. The dataset has several advantages. Individual persons are connected to business enterprises (selected by organization number) by employment. Holding information for the period 2000-2008, the dataset is longitudinal, making persons and firms traceable from year to year. Also, holding information on the total working population between ages 16 and 74 residing in Norway, the database has 100% coverage. The entire labor market and all private and public firms are present in the database. Containing vast information about employees and business enterprises, the dataset is the most complete and reliable source of information available in Norway on this topic.

4.3.4 Survey questionnaire

The theoretical base for the self-administered survey questionnaire is Porter’s (1990) diamond model and Reve’s (2009) model for Global Knowledge Hubs. The purpose of the survey is to complement the other sources of data, and gain access to first hand

\[ \text{For more information about the dataset, consult: http://www.ssb.no/english/mikrodata_en/} \]
information regarding each respondent firm’s knowledge development, innovation, competitiveness and part in industry dynamics. Survey research is a great way of collecting original data for describing a population too large to observe directly (Babbie 2004), and provides an opportunity to access attitudes and opinions otherwise not possible to obtain. As observations represent a single point in time, the survey is cross sectional. Babbie (2004, p.102) argues that a problem with explanatory cross-sectional studies is that they often attempt to answer causal processes that occur over time. However, as the survey is one of several data sources, complementing longitudinal data sources, the problem is minimized for this study.

The survey consists of 36 closed-ended questions\(^6\). Such questions are preferred as they provide a greater uniformity of response, and are more easily processed than open-ended questions. Respondents chosen to receive the survey are part of top management, hence reliable and qualified to answer. The survey population was 2416 companies based on the classification described. Upon collection of e-mail addresses, the survey was distributed to 1649 respondents. After one email invitation, two reminders, and a manual follow up, 298 respondents completed the survey, resulting in an overall response rate 18.07%.

4.4 Operationalization of variables

4.4.1 Dependent variable: Impact of innovation

The Innovation Survey from Statistics Norway will be used in order to provide a reliable measure of innovation. In accordance with the Oslo manual, SSB defines *innovative companies* as “companies that has introduced a new or significantly improved service or product or implemented significantly improved processes in the period”. The operationalization of innovation in this paper is based on a question in the survey asking, “What percentage of your turnover in 2008 originates from significantly improved services or products?” This provides a reliable and detailed measure on the innovative activity in the surveyed companies. By using this measure, we are able to capture not only innovation activities (e.g. like a count of patents would do), but also

\(^6\) For an online preview of the complete survey, see: https://web.questback.com/isa/qbv.dll/ShowQuest?Preview=True&QuestID=3915959&sid=Yrxc8SuyR0
capture impact of the innovations, as we only measure innovations that actually provide a revenue stream to the firm.

In 2008, the Innovation survey received response from 614 firms within the offshore industry. The number of respondents answering the question relating to what percentage of turnover originates from new innovations was 215.

### 4.4.2 Independent variable: Academic publications

This variable aims at measuring to what degree impact of innovation in firms benefit from being located in close proximity to research institutions. Using a broad definition, there are educational institutions providing relevant education for the offshore industry in 18 of 19 counties in Norway (Oljeindustriens Landsforening 2008). This includes all relevant educations equal to and higher than bachelor level. However, following Rothaermel & Ku’s (2008) reasoning, an educational institution (e.g. a University College) is not sufficient for intellectual capital to benefit innovation. They argue that research needs to be undertaken; hence there is an important difference between an educational institution and a research institution.

![FIGURE 8 Academic publications](image)

The relevant research institutions are selected by a review of published articles within relevant fields in academic journals. For a detailed summary on this process, see Appendix 2. After manual corrections (merging equal research institutions and removing publications written by firms), seven research institutes and universities with
ten published articles or more, are listed. Subsequently, a variable consisting of the number of articles published in each county was computed. By doing so, we are able to capture not only the existence of research institutions in proximity to the firms, but also the level of productivity. This is important, as it is plausible to assume that research institutions with a higher number of publications contribute more to innovation than an institution with fewer publications.

4.4.3 Independent variables: Higher education and general experience

The two hypotheses proposed in relation to the stock of human capital investigate the relationship between level of formal- and informal education and its effect on impact of innovation.

Level of education is reported through the employee-employer dataset from SSB. By looking at the highest completed level of higher education for all registered employees within the industry, detailed reports on individual educational level can be aggregated to firm-level variables. Other studies on this topic have often been survey based and used ordinal scale variables (Nås et al. 1998; Dahl 2002; Graversen et al. 2002) and grouped levels of education. We will, however, use the exact number of years of higher education that the firm has accumulated divided by number of employees to calculate the average level of higher education for each firm. The numbers of years are calculated based on Norwegian Standard for grouping of Education Levels\(^7\).

As discussed previously, general experience covers informal and non-formal ways of acquiring knowledge. Therefore, it is of value to capture the total knowledge base of employees that a firm has accumulated through present and previous working experience. We chose not to limit this to knowledge acquired through work within the offshore industry, but claim that knowledge gained through experience in other industries also may be of value for the current employer and its ability to innovate. As the formal education is captured by the measurement presented above, we calculate the general experience by subtracting years used in formal education from each person’s age. As the average years of completed education in the offshore industry are

\(^7\) Please consult http://www.ssb.no/vis/04/90/nos_c617/art-2001-01-25-01.html for more information.
14 years and the vast majority of employees started at school when they were 7 years old\(^8\), 21 years is subtracted in the computation.

Further, we need to consider that experience may not follow a linear growth curve. By applying a logarithmic function we acknowledge that there is a diminishing marginal effect of gaining experience. Hence, the following equation is applied:

\[
\text{General experience} = \ln(\text{workers' age} - 21)
\]

### 4.4.4 Independent variables: Intra- and inter industry mobility

These constructs aim at measuring the mobility of employees within the offshore industry as well as mobility from other industries into the offshore industry. The employer-employee database from Statistics Norway provides a detailed overview on all employer-employee connections in Norway, as well as changes in these connections. We use this database to compute firm-level mobility rates.

When looking at the relationship between employee mobility and impact of innovation, we need to consider that it may exist a delay in the effect on the impact of innovation due adjustments to a new working environment, training and other initial activities. When computing these variables, we have introduced a two-year lag, implying that the mobility-rates from 2006 have been used to measure *Impact of innovation* in 2008.

For intra-industry mobility, an employee who has moved within the industry the last 12 months is coded as an ‘Intra-industry mover’. For inter-industry mobility, an individual that either has been unemployed, is a graduate, is coming from other industries, or comes from the public sector the last 12 months is coded as an ‘Inter-industry mover’. Based on this codification, the intra- and inter-mobility rates per firm are computed from the number of new employees as a percentage share of the total workforce in each firm.

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\(^8\) Norwegian children start at school at the age of 6 today, but as this has only had effect since an education reform in 1997; the vast majority of workers today started at school when they were 7 years old.
4.4.5 Independent variable: Geographic proximity
A main problem of empirical studies on geographic proximity is to find a reliable operationalization of geographic proximity. Various methods have been used in the research. A few recent studies have asked respondents in surveys to identify important knowledge providers in close proximity as a measure (Lublinski 2003; Ganesan et al. 2005). A problem with this approach is that firms themselves decide which industry actors to include. Hence, a list can be insufficient and not necessarily provide a complete overview over localization of industry actors. However, the majority of research conducted uses level of agglomeration within certain geographic units, such as states or counties, as a measure of degree of geographic proximity (e.g. Jaffe et al. 1993; Audretsch & Feldman 1996). A high level of agglomeration indicates geographic proximity, which again is foundational for being considered a clustered region. An advantage with data on e.g. county level is that it can provide complete and clear-cut measures of relevant business activity within the county. A disadvantage with such a measure is that agglomerations may span across county borders, and certain firms or locations can hence be omitted from the measure.

Based on the data available for this paper, geographic proximity will be measured by level of agglomeration on county level. This will be operationalized using Balassa's (1965) index of revealed comparative advantage. Both revenues and number of firms can be utilized as measures for this purpose. However, we consider number of firms to be a better measure for geographic proximity as a high number of firms in the same location indirectly imply close proximity.

Employing data from The Register of Business Enterprises, the average level of agglomeration for the entire country will be estimated as number of business enterprises in the offshore industry over the number of enterprises in all industries. Next, using county (Norwegian: ‘fylke’) as the geographic unit, a measure of agglomeration for each county will be estimated in relation to the level of agglomeration for the whole country. In total, this provides an index where the level of agglomeration for each county, comparable to the natural value of 1, will be the result.
Example for the level of agglomeration for the county Rogaland:

\[
Level\ of\ agglomeration = \frac{\left( \frac{\text{# of offshore firms in Rogaland}}{\text{# of all firms in Rogaland}} \right)}{\left( \frac{\text{# of offshore firms in Norway}}{\text{# of all firms in Norway}} \right)}
\]

The natural value of the index is 1, indicating that the level of agglomeration of the county is equal to the average level of agglomeration of the country, hence no distinct proximity. Thus, interpreting the Balassa-values, counties can obtain levels lower than average (< Average – 1 standard deviation), at average (Average +/- 1 standard deviation), and above average (>Average + 1 standard deviation), only the latter indicating that the region is characterized by geographically proximate firms, and hence can be classified as a clustered region.

4.4.6 Moderator variable: Clustering as a magnifier of stock of human capital and mobility

As previously mentioned, there are few, if any, empirical works studying clustering as a magnifier of knowledge on innovation. Therefore, it is difficult to find good theoretical support for our operationalization of these constructs. The relationship between the dependent variable impact of Innovation and the independent variables are hypothesized to be affected by level of agglomeration. As the level of agglomeration changes the form of the relationship between the knowledge constructs (human capital and employee mobility) and impact of innovation, moderating effects occur (Hair et al. 2010).

This paper has suggested two constructs measuring stock of human capital, two constructs measuring access to knowledge through mobility, and one independent construct for geographic proximity. The latter is measured by level of agglomeration, and used as a moderator variable for the four former. Founded on these, constructs for the moderating effect of level of agglomeration are created as products of the mean centered observations of each knowledge construct, and the mean centered observations of level of agglomeration. Mean centered scores are used to avoid
problems with multicollinearity and make coefficients more interpretable (Jaccard & Turrisi 2003, p.29). An example is

$$\left( \frac{\text{Intra-industry mobility}}{\text{Intra-industry mobility}} - \frac{\text{Intra-industry mobility}}{\text{Intra-industry mobility}} \right) \times \left( \frac{\text{Level of agglomeration}}{\text{Level of agglomeration}} - \frac{\text{Level of agglomeration}}{\text{Level of agglomeration}} \right)$$

where the product is the moderating construct of intra-industry mobility and level of agglomeration. As mentioned earlier, high levels of agglomeration indicate clustering, which moderated on the knowledge constructs, should result in magnifying effect on impact of innovation.

4.4.7 Control variables
A control variable is a variable that is held constant and whose impact is removed in order to analyze the relationship between other variables without interference. Firm size, firm age, competition as well as R&D investment have been controlled for in this study.

Firm size was measured by the number of employees in the firm. Prior studies have identified a significant positive relationship between firm size and innovativeness. This is also documented by the innovation survey performed by Statistics Norway.

Firm age was measured by the number of years since the founding of the firm. Prior studies have identified a significant negative relationship between firm age and innovativeness. Due to a new form of registration introduced in 1988, all firms established before this date are coded with 1988 as their registration date in our dataset. We have minimized this bias by applying a logarithmic transformation; hence the relative importance of each year increased age is diminishing.

Competition follows a standard measurement used by Norwegian Competition Authority. It is measured as the proportion of each firms’ revenue for its county, squared and aggregated to county level, resulting in a scale ranging from 0 – 1. A low number indicates high competition, and a high number indicates low competition.
R&D investment is measured by a survey question, asking respondents to report how much they invest in R&D. The amount is normalized against the firms’ total turnover. Most previous studies have found a positive relationship between R&D Investment and innovative performance.

A measure to control for tenure, i.e. the average number of years workers have been employed in the firm was also created. However, introducing this control variable led to signs of multicollinearity in the data set as this variable had high correlations with other measures, especially firm age and general experience. This implies that tenure to a large degree is overlapping with the other constructs presented, and therefore not included in the final analysis.

In sum, the list of variables used in the regression analysis is as follows:

<table>
<thead>
<tr>
<th>Concept</th>
<th>Operationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of Innovation</td>
<td>Share of turnover originating from significantly improved products or services</td>
</tr>
<tr>
<td>Firm size</td>
<td>Firm size measured as number of employees in the firm</td>
</tr>
<tr>
<td>Firm age</td>
<td>Age of firm (years from registration date)</td>
</tr>
<tr>
<td>R&amp;D investment</td>
<td>Total firm R&amp;D spending normalized by firm turnover</td>
</tr>
<tr>
<td>Competition</td>
<td>Proportion of each firms’ revenue for its county, squared and aggregated to county level</td>
</tr>
<tr>
<td>Academic publications</td>
<td>Number of relevant research publications published from research institutions within a county.</td>
</tr>
<tr>
<td>Higher education</td>
<td>Average number of years of higher education in the firm</td>
</tr>
<tr>
<td>General experience</td>
<td>Average number of years with general experience in the firm</td>
</tr>
<tr>
<td>Intra-industry mobility</td>
<td>Percentage of intra mobility in the firm</td>
</tr>
<tr>
<td>Inter-industry mobility</td>
<td>Percentage of inter mobility in the firm</td>
</tr>
<tr>
<td>Level of agglomeration</td>
<td>Lever of agglomeration as measured by the Balassa-index</td>
</tr>
</tbody>
</table>

4.4.8 Data screening and transformations
Initial screening of the dataset shows that the dataset had characteristics of homoscedasticity, and no problems with autocorrelation. However, the screening revealed that the residuals had a slight left skewness. After analyzing the variables individually, we applied a square root-transformation on the dependent variable to
normalize the residuals in the regression, in accordance with suggestions from the literature (DeCoster 2001, p.10; Field 2009, p.220; Hair et al. 2010, p.80). In addition to this, an analysis of the outliers in the dataset was performed, and non-normal observations were deleted.

5. Results

5.1 Descriptive statistics

Table 4 presents the descriptive statistics. Despite having 2214 companies in the offshore industry, our sample size is limited to N=187. This is due to our selection of the dependent variable that is based on a survey question from The Innovation survey. The response rate on this particular question is less than 15%. In addition, the dataset has been corrected for incorrect data, other missing variables and outliers. The sample size is sufficient in order to complete reliable regression analysis (Green 1991; Field 2009; Hair et al. 2010).

<table>
<thead>
<tr>
<th>TABLE 4</th>
<th>Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Minimum</td>
</tr>
<tr>
<td>1. Impact of innovation</td>
<td>199</td>
</tr>
<tr>
<td>2. Firm size</td>
<td>199</td>
</tr>
<tr>
<td>3. Firm age</td>
<td>199</td>
</tr>
<tr>
<td>4. Competition</td>
<td>199</td>
</tr>
<tr>
<td>5. R&amp;D investment</td>
<td>155</td>
</tr>
<tr>
<td>6. Academic publications</td>
<td>199</td>
</tr>
<tr>
<td>7. Higher education</td>
<td>197</td>
</tr>
<tr>
<td>8. General experience</td>
<td>199</td>
</tr>
<tr>
<td>9. Intra-industry mobility</td>
<td>189</td>
</tr>
<tr>
<td>10. Inter-industry mobility</td>
<td>189</td>
</tr>
<tr>
<td>11. Level of agglomeration</td>
<td>199</td>
</tr>
</tbody>
</table>

N = 187

The dependent variable, *impact of innovation* has a mean of 0.50, implying that a mean firm has a turnover where 50% is generated from innovative products or services. However, the standard deviation is high (0.28), implying that within ± a standard deviation, we find companies with values as low as 22% and as high as 78% of
their turnover originating from innovative products. The mean of higher education is 3.71, implying that the average firm has a workforce holding more than a Bachelors degree. Even one standard deviation below the mean, we find that the value is above a Bachelors degree, implying that the workforce in general is highly educated. Intra-industry mobility ranges from 0% up to 63%, with a mean of 10% and a low standard deviation of only 0.08. Finally, level of agglomeration, has a relatively high mean of 1.70. This can be explained as some regions (e.g. Rogaland) are densely agglomerated, while the high standard deviation of 1.26 indicates that that there are many regions characterized by low agglomeration as well.

Table 5 presents the 2-tailed Pearson Correlation coefficients. No correlations higher than recommended values are observed, hence there is no sign of multicollinearity in the dataset. Furthermore, all VIF values are within the recommended limit of 10, of the maximum value being 1.464.

<table>
<thead>
<tr>
<th>Correlations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Impact of innovation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Firm size</td>
<td>-.111</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Firm age</td>
<td>-.114</td>
<td>.017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Competition</td>
<td>-.086</td>
<td>-.230</td>
<td>-.136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. R&amp;D investment</td>
<td>.325</td>
<td>-.179</td>
<td>-.690</td>
<td>.119</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Academic publications</td>
<td>.134</td>
<td>-.151</td>
<td>-.040</td>
<td>.360</td>
<td>.443</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Higher education</td>
<td>.273</td>
<td>-.062</td>
<td>-.095</td>
<td>.081</td>
<td>-.097</td>
<td>.297</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. General experience</td>
<td>-.073</td>
<td>.011</td>
<td>.172</td>
<td>-.234</td>
<td>-.098</td>
<td>-.249</td>
<td>.012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Intra-industry mobility</td>
<td>.243</td>
<td>-.095</td>
<td>-.399</td>
<td>.103</td>
<td>-.109</td>
<td>-.071</td>
<td>-.042</td>
<td>-.202</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Inter-industry mobility</td>
<td>-.037</td>
<td>-.028</td>
<td>-.034</td>
<td>.015</td>
<td>.231</td>
<td>.087</td>
<td>.058</td>
<td>-.238</td>
<td>.024</td>
<td></td>
</tr>
<tr>
<td>11. Level of agglomeration</td>
<td>-.058</td>
<td>-.073</td>
<td>-.114</td>
<td>.538</td>
<td>-.057</td>
<td>.128</td>
<td>-.107</td>
<td>-.437</td>
<td>.201</td>
<td>.020</td>
</tr>
</tbody>
</table>

† p < .1 * p < .05 ** p < .01 *** p < .001

As might be expected, the strongest correlation for the dependent variable (impact of innovation) is R&D investment. In addition to this, higher education and intra-industry mobility are positively and significantly correlated with impact of innovation. Further, competition, academic publications and level of agglomeration are positively, however not significantly, correlated with impact of innovation. Finally, both firm age and firm
size are negatively correlated to the dependent variable. This indicates that the larger and older the firm is, the less percent of the total turnover originates from products based on firm innovations.

5.2 Multivariate analyses

Variables have been entered stepwise as to investigate the effect of each independent variable on the dependent variable and the model as a whole. When conducting the regression, the following regression model was applied:

\[
\text{Impact of innovation} = \beta_0 + \beta_1 \text{Academic publications} + \beta_2 \text{Higher education} + \beta_3 \text{General experience} + \beta_4 \text{Intra-industry mobility} + \beta_5 \text{Inter-industry mobility} + \beta_6 \text{Level of agglomeration} + \beta_7 (\text{Level of agglomeration} \times \text{Higher education}) + \beta_8 (\text{Level of agglomeration} \times \text{General experience}) + \beta_9 (\text{Level of agglomeration} \times \text{Intra-industry mobility}) + \beta_{10} (\text{Level of agglomeration} \times \text{Inter-industry mobility}) + \epsilon
\]

Model 1 of Table 6 presents the results from the regression with the control variables only. The results show that only firm age is significantly and negatively correlated with impact of innovation. Neither firm size nor level of competition is significantly affecting impact of innovation. R&D investment was found significant and positive. The control variables have a total Adjusted R^2 of 2.3% and when including R&D investment the overall explanatory power increases to 5.8%.

Hypothesis 1 stated that proximity to research institutions positively affects impact of innovation. In Model 2 of Table 6 we can see that the relationship between academic publications and impact of innovation is not statistically significant, hence we find no support for Hypothesis 1.

Hypotheses 2 and 3 are related to stocks of human capital. Hypothesis 2 states that a high average education level in a firm has a positive impact on innovation. Hypothesis
3 states that *general experience* has a positive effect on *impact of innovation*. The results are reported in Model 3 and 4 of Table 6, and shows that *higher education* is positively and significantly affecting *impact of innovation*. Model 4 reports that the *general experience* is negatively, however not significantly, related with the dependent variable.

Further, Hypotheses 4 and 5 look at employee mobility. Hypothesis 4 proposes that higher rates of intra-industry mobility have a positive effect on impact of innovation, while Hypothesis 5 suggests that inter-industry mobility also should have the same effect. As can be seen in Model 5, the *intra-industry mobility* is reported to significantly and positively affect *impact of innovation*. This implies that intra-industry employment have a positive effect on the share of turnover that originates from innovations; hence Hypothesis 4 is supported. When introducing *inter-industry mobility* in Model 6 of Table 6, we find this variable to be not significant; hence we find no support for Hypothesis 5. Hypothesis 6 states that *geographic proximity* is positively associated with *impact of innovation*. In Model 7 of Table 6, we introduce *level of agglomeration* as an independent variable. As can be seen, this variable is not significantly related with *impact of innovation*.

Hypotheses 7-10 are related to testing the moderating effects of agglomerations on relevant constructs from the other hypotheses. The four hypotheses suggest that if clustering (high level of agglomeration) occurs, this will have a magnifying effect on certain knowledge constructs; *education level* (Hypothesis 7), *general experience* (Hypothesis 8), *intra-industry mobility* (Hypothesis 9) and *inter-industry mobility* (Hypothesis 10). The moderating variables are added sequentially in Model 8-11 of Table 6. From these models, we can conclude that the only significant magnifying effect is *intra-industry mobility*. The positive magnifying effect of this variable is seen as the Adjusted R² increase from 0.105 (Model 2) to 0.114 (Model 10). This represents a significant change (p < 0.05) in the Adjusted R², and implies that the effect of intra-industry mobility has a positive and magnifying effect as the level of agglomeration increases in a region. As magnifying effects occur, the slope of intra-industry mobility on innovation increases as the level of agglomeration increases.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.693 (.237)</td>
<td>.761 (.241)</td>
<td>-.847 (.576)</td>
<td>-.667 (.725)</td>
<td>-1.194 (.728)</td>
<td>-1.080 (.739)</td>
<td>-1.186 (.769)</td>
</tr>
<tr>
<td>Firm size (in thousands)</td>
<td>-.073 (.000)</td>
<td>-.066 (.000)</td>
<td>-.062 (.000)</td>
<td>-.061 (.000)</td>
<td>-.045 (.000)</td>
<td>-.045 (.000)</td>
<td>-.049 (.000)</td>
</tr>
<tr>
<td>Firm age</td>
<td>-.102 * (.048)</td>
<td>-.104 * (.048)</td>
<td>-.084 † (.048)</td>
<td>-.080 (.049)</td>
<td>-.020 (.051)</td>
<td>-.019 (.051)</td>
<td>-.021 (.052)</td>
</tr>
<tr>
<td>Competition</td>
<td>.106 (.198)</td>
<td>.006 (.209)</td>
<td>.041 (.205)</td>
<td>.030 (.207)</td>
<td>.005 (.202)</td>
<td>-.005 (.202)</td>
<td>-.069 (.238)</td>
</tr>
<tr>
<td>Academic publications</td>
<td>.001 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
</tr>
<tr>
<td>Higher education</td>
<td>.092 ** (.030)</td>
<td>.094 ** (.030)</td>
<td>.100 *** (.030)</td>
<td>.101 *** (.030)</td>
<td>.103 *** (.030)</td>
<td>.103 *** (.030)</td>
<td>.103 *** (.030)</td>
</tr>
<tr>
<td>General experience</td>
<td>-.152 (.369)</td>
<td>.002 (.364)</td>
<td>-.081 (.375)</td>
<td>.000 (.408)</td>
<td>.000 (.408)</td>
<td>.000 (.408)</td>
<td>.000 (.408)</td>
</tr>
<tr>
<td>Intra-industry mobility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.361 ** (.116)</td>
<td>.360 ** (.116)</td>
<td>.353 ** (.117)</td>
</tr>
<tr>
<td>Inter-industry mobility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.226 (.242)</td>
<td>-.217 (.243)</td>
<td>-.217 (.243)</td>
</tr>
<tr>
<td>Level of agglomeration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.011 (.021)</td>
</tr>
</tbody>
</table>

Adjusted R²
- Model 1: .023
- Model 2: .028
- Model 3: .071
- Model 4: .067
- Model 5: .110
- Model 6: .109
- Model 7: .105

N
- Model 1: 187
- Model 2: 187
- Model 3: 187
- Model 4: 187
- Model 5: 187
- Model 6: 187
- Model 7: 187

df
- Model 1: 3
- Model 2: 4
- Model 3: 5
- Model 4: 6
- Model 5: 7
- Model 6: 8
- Model 7: 9

F-statistics
- Model 1: 2.434†
- Model 2: 2.363†
- Model 3: 3.853**
- Model 4: 3.225**
- Model 5: 4.272***
- Model 6: 3.845***
- Model 7: 3.432***

† p < .1   * p < .05   ** p < .01   *** p < .001
<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 8</th>
<th>Model 9</th>
<th>Model 10</th>
<th>Model 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.043 (.783)</td>
<td>-1.154 (.772)</td>
<td>-1.246 (.766)</td>
<td>-1.164 (.780)</td>
</tr>
<tr>
<td>Firm Size (in thousands)</td>
<td>-.048 (.000)</td>
<td>-.050 (.000)</td>
<td>-.040 (.000)</td>
<td>-.049 (.000)</td>
</tr>
<tr>
<td>Firm Age</td>
<td>-.017 (.052)</td>
<td>-.021 (.052)</td>
<td>-.009 (.052)</td>
<td>-.021 (.052)</td>
</tr>
<tr>
<td>Competition</td>
<td>-.043 (.240)</td>
<td>-.075 (.239)</td>
<td>-.007 (.240)</td>
<td>-.072 (.239)</td>
</tr>
<tr>
<td>Academic publications</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
</tr>
<tr>
<td>Higher education</td>
<td>.096 ** (.031)</td>
<td>.103 *** (.030)</td>
<td>.095 ** (.030)</td>
<td>.103 *** (.030)</td>
</tr>
<tr>
<td>General experience</td>
<td>-.040 (.410)</td>
<td>-.007 (.409)</td>
<td>.076 (.408)</td>
<td>-.010 (.413)</td>
</tr>
<tr>
<td>Intra-industry mobility</td>
<td>.343 ** (.118)</td>
<td>.346 ** (.118)</td>
<td>.390 ** (.119)</td>
<td>.350 ** (.119)</td>
</tr>
<tr>
<td>Inter-industry mobility</td>
<td>-.190 (.245)</td>
<td>-.225 (.244)</td>
<td>-.169 (.243)</td>
<td>-.219 (.244)</td>
</tr>
<tr>
<td>Level of agglomoration</td>
<td>.009 (.021)</td>
<td>.014 (.022)</td>
<td>.010 (.021)</td>
<td>.011 (.021)</td>
</tr>
<tr>
<td>[Level of agglomeration] x [Higher education]</td>
<td>.020 (.022)</td>
<td>.042 (.076)</td>
<td>.177 † (.105)</td>
<td>.053 (.302)</td>
</tr>
<tr>
<td>[Level of agglomeration] x [Relevant experience]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Level of agglomeration] x [Intra-industry mobility]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Level of agglomeration] x [Inter-industry mobility]</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.105</td>
<td>.102</td>
<td>.114</td>
<td>.100</td>
</tr>
<tr>
<td>N</td>
<td>187</td>
<td>187</td>
<td>187</td>
<td>187</td>
</tr>
<tr>
<td>df</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>F-statistics</td>
<td>3.178***</td>
<td>3.108**</td>
<td>3.402***</td>
<td>3.075**</td>
</tr>
</tbody>
</table>

† p < .1   * p < .05   ** p < .01   *** p < .001

To better show this effect, we will calculate three levels of agglomerations based on the Balassa-index: ‘non-clustering’, ‘neutral’, and ‘clustering’. ‘Non-clustering’ is represented by agglomeration level 1 standard deviation below the mean; ‘neutral’ is represented by agglomeration level at the mean; and ‘clustering’ is represented by agglomeration level 1 standard deviation above the mean. The magnifying effect can be observed graphically in Figure 9 where the slope of knowledge is steeper for ‘neutral’ than ‘non-clustering’, and steeper again for ‘clustering’ than the previous two.
To build more confidence in the presented results, we have undertaken several analyses in order to test the robustness of our model. Firstly, because the *level of agglomeration* is our moderator variable, we operationalized this concept in four various ways (Absolute employee count, the Balassa-index as a dummy variable, as well as two Balassa-measures across categories), all in which have been used as measures of agglomeration in previous literature. Analysis showed consistent findings across the differing measures, and we argue that our initial presentation of relationships between our constructs is robust.

Secondly, we have tested the model using data from 2006 and 2003. These years were selected based on access to data for the dependent variable. The sample size for 2006 were somewhat lower than the original dataset of 2008, whereas the size of the 2003-dataset were similar to that of 2008. All in all, the findings give mostly similar results, both in terms of beta values and significant variables, underpinning that the original model is robust over time.

Lastly, and presented more in-depth, we also tested our model using financial performance as the dependent variable. The positive relationship between
innovation and performance have been documented both theoretically (Porter 1998; Chandler et al. 1999) and empirically (Tsai 2001; OECD 2007b). From a business perspective it is highly valuable to also test our model on performance. We calculated the average EBIT for the years 2006-2008 as a measure for financial performance. The sample size for performance is considerably higher than for impact of innovation mainly due to the latter being measured through a survey, whereas performance is measured using data from The Register of Company Accounts (see Section 4.3.2). Table 8 shows our findings on performance. We note that although the overall model is significant, it has a low explanatory power.

As seen in Model 1 in Table 8, the results on performance differ somewhat from the analysis using impact of innovation as the dependent variable. We observe that higher education is positively and significantly affecting also performance. Contradictory to the findings on impact on innovation, general experience and level of agglomeration is found to have positive and significant effect of performance. As seen in Model 2 of Table 8, the moderator variable for intra-industry mobility is

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.014 (.150)</td>
<td>-.032 (.150)</td>
</tr>
<tr>
<td>Firm Size (in thousands)</td>
<td>-.086 ** (.000)</td>
<td>-.086 ** (.000)</td>
</tr>
<tr>
<td>Firm Age</td>
<td>.006 (.016)</td>
<td>.008 (.016)</td>
</tr>
<tr>
<td>Competition</td>
<td>-.058 (.075)</td>
<td>-.058 (.074)</td>
</tr>
<tr>
<td>Academic publications</td>
<td>.000 (.000)</td>
<td>.000 (.000)</td>
</tr>
<tr>
<td>Higher education</td>
<td>.031 ** (.009)</td>
<td>.030 ** (.009)</td>
</tr>
<tr>
<td>Relevant experience</td>
<td>.186 † (.092)</td>
<td>.197 * (.092)</td>
</tr>
<tr>
<td>Intra-industry mobility</td>
<td>.027 (.032)</td>
<td>.030 (.032)</td>
</tr>
<tr>
<td>Inter-industry mobility</td>
<td>-.085 (.054)</td>
<td>-.088 (.054)</td>
</tr>
<tr>
<td>Level of agglomeration</td>
<td>.015 ** (.006)</td>
<td>.016 ** (.006)</td>
</tr>
<tr>
<td>[Level of agglomeration] x [Intra-industry mobility]</td>
<td></td>
<td>-.047 * (.021)</td>
</tr>
</tbody>
</table>

Adjusted R² | .025 | .029 |
N | 187 | 187 |
df | 9 | 10 |
F-statistics | 3.705*** | 3.838*** |

† p < .1  * p < .05  ** p < .01  *** p < .001
found significant, however negative, an effect opposite of that found on *impact of innovation*. In total, the results indicate that there are different explanatory factors affects respectively *impact on innovation* and *performance*. See Table 9 for a comparison of constructs affecting the two dependent variables.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Impact of Innovation</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic publications</td>
<td>Insignificant</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Higher education</td>
<td>Significant and positive</td>
<td>Significant and positive</td>
</tr>
<tr>
<td>General experience</td>
<td>Insignificant</td>
<td>Significant and positive</td>
</tr>
<tr>
<td>Intra-industry mobility</td>
<td>Significant and positive</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Inter-industry mobility</td>
<td>Insignificant</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Level of agglomeration</td>
<td>Insignificant</td>
<td>Significant and positive</td>
</tr>
<tr>
<td>[Level of agglomeration] x [Higher education]</td>
<td>Insignificant</td>
<td>Insignificant</td>
</tr>
<tr>
<td>[Level of agglomeration] x [General experience]</td>
<td>Insignificant</td>
<td>Insignificant</td>
</tr>
<tr>
<td>[Level of agglomeration] x [Intra-industry mobility]</td>
<td>Significant and positive</td>
<td>Significant and negative</td>
</tr>
<tr>
<td>[Level of agglomeration] x [Inter-industry mobility]</td>
<td>Insignificant</td>
<td>Insignificant</td>
</tr>
</tbody>
</table>

### 6. Discussion

In this study we have found that higher education and intra-industry mobility are likely to increase the impact of innovation in a firm. Further, intra-industry mobility has a greater impact on innovation in firms in clustered regions compared to firms outside such regions. Surprisingly, level of agglomeration was not alone found to significantly explain impact on innovation.

From the presented results, the insignificance of *level of agglomeration* as an explanatory factor for *impact of innovation* was most surprising. These findings contradict a wide stream of theoretical literature, and do not support one of the most fundamental cluster arguments; that geographic proximity is a fundamental driver of innovation. Though contradictory, our findings are in line with a few other studies questioning the effect of geographic proximity (Lubinski 2003; Tallman & Phene 2007). Another effect of geographic proximate clustered firms is increased
competition, which by advocates of the Porter-school of clustering is viewed as a self-reinforcing driver for innovation, constantly pushing the industry to innovate. Our proxy for competition was found neither positive nor significant, further supporting the fact that geographic proximity to industry actors is not alone enough to have a positive effect on impact of innovation.

We argued earlier that geographic proximity to other industry actors facilitate communication. This again, we argue, would lead to increased knowledge sharing, and in turn more innovation. Investigating geographic proximity and new product development, Ganesan et al. (2005) found that proximity indeed increased face-to-face communication; but that this communication had little effect of the kind of knowledge that lead to enhanced innovation. That is, the mechanism for sharing knowledge is not in place from the presence of other actors alone. However, an outcome of being located in proximity to each other, as also found by Ganesan, is increasing communication. This again leads to the establishment social linkages and informal networks. Geographers have had a tendency to minimize or neglect the impact of such factors on innovation. Our findings might have told another story if networks as a mechanism for knowledge sharing were included. As a manager of a major oil-service company located in Stavanger stated:

“\textit{In addition to most of the new development undertaken in the Stavanger-region, we also cooperate with both SINTEF and NTNU (both located in Trondheim) on several projects. Even though not located in Stavanger, these organizations are brilliant sparring-partners for developing new solutions, as they simply are best-in-class at what they do.}”

This supports the argument put forth by Malmberg & Power (2005) claiming that in the area of innovation, firms seek the best possible partner wherever this partner is located. Studying patterns of innovation in knowledge intensive industries, Whittington et al. (2009) found that both geographic proximity and network centrality in combination were necessary and crucial for innovation. Interestingly,
network centrality, not geographic proximity was deemed primary. Although beyond the scope of this study, we argue that the combination of geographic proximity and networks may have a positive effect on innovation. This makes for a very exciting subject for future studies.

Although we find no support for the effect of level of agglomeration on impact of innovation, we find a positive and significant effect on performance. In other words, we have indications that the drivers for innovation and performance are different. This is not necessarily surprising. Whereas impact of innovation is a top-line measure for turnover, performance measures effects on the bottom-line profitability. Proximity to customers, suppliers, and employees reduce transaction- and transportation costs (e.g. Krugman 1991), positively affecting performance, not necessarily innovation.

Level of agglomeration may have magnifying effects on stock of human capital and mobility, even though it was not found significant as a stand-alone measure. Our findings show that intra-industry mobility has an increasingly impact of innovation as level of agglomeration increases. We interpret that the industry enjoys characteristics that facilitate an enhanced effect of employee mobility on innovation. Due to the nature and difference of cluster-specific knowledge and individual-specific knowledge (Tallman et al. 2004), we argue that cluster-specific knowledge is known within the industry, and that individual-specific knowledge hence can be utilized in new settings immediately. The majority of companies in the Norwegian offshore industry is engaged in production of non-standardized products and solutions, and is hence dependent on a complementary set of highly specialized knowledge bases in daily operations. Interpreting our results, we therefore argue that the companies are particularly reliant on intra-industry movements, and clusters act as a catalyst in that regard. In addition, intra-industry mobility is easier facilitated within clusters, as the barriers to relocate are lower than outside clusters (Aho 2006). Hence, this study fills a gap in the empirical literature by showing that level of agglomeration indeed can have a magnifying effect on impact of innovation. Further, it may be appropriate to assume that the higher the level of education among employees that move within the industry, the higher would be the
magnifying effect on *impact of innovation*. This is beyond the scope of this study, but provides an interesting issue for future studies to look into.

The effects of mobility on innovation have been tested in a variety of studies, but results are not conclusive as to what degree mobility impacts innovation in firms. Whereas many empirical works are limited to investigating mobility within a given industry (Almeida & Kogut 1999; Dahl 2002; Malmberg & Power 2005), our study provides new insights and results for both employees moving within the industry (*intra-industry mobility*) and employees moving into the industry from other industries (*inter-industry mobility*). We also show that the two types of mobility affect *impact of innovation* differently.

Our findings show that employees moving within the industry (*intra-industry mobility*) are positively affecting *impact of innovation* within two years after the movement. We interpret this positive relationship to be a result of employees with industry-specific experience bringing new knowledge and know-how, in turn contributing to problem solving and innovation. However, the two-year lag may be due to the need to adapt to new circumstances and working environments. The findings in our study partially support previous research (e.g. Cabrera & Cabrera 2002; Power & Lundmark 2004).

On the other hand, our analysis shows that employees that are coming from other industries, being recent graduates, or coming from public sector (*inter-industry mobility*), are not contributing to *impact of innovation*. On the short term, high rates of inter-industry mobility may actually hamper innovation processes. Employing workers from outside the industry needs to be seen as a long-term investment. Substantial training and experience might be needed before positive associations with *impact of innovation* may be found. Although not part of the main analysis in this paper, results indicate that testing for 4 or 5 years lagged *inter-industry mobility* patterns has a more positive effect on *impact of innovation*.

Further, it is interesting to note that both types of mobility fail to significantly explain *performance*. This may be related to the fact that *intra- and inter-industry*
mobility increases number of new employees, again increasing transaction costs (like contract negotiations), switching and incorporation costs, i.e. costs related to training and general human resource management.

Our results show that level of Higher education is significantly important in explaining impact of innovation in the offshore industry. They further indicate that the average education level in the industry is increasing, a sign that the industry itself already has picked up on the importance of education in its workforce. This supports previous research that relatively universally supports the notion that a highly educated workforce is important for innovation. We also find higher education to be positive and significant on performance. This implies that a high level of education is not only of important for creativity and problem solving, but is also important for financial success.

Our findings are interesting contributions in the ongoing debate on whether a higher education is of value for success in business. In an interview in the newspaper Dagens Næringsliv on June 4th 2010, multimillionaire and ship owner John Fredriksen remarked that “students should consider skipping higher education, especially if they want to create something themselves”. In the same newspaper on August 10th 2010, principal of BI Norwegian School of Management, Tom Colbjørnsen, remarked that “an increasingly bureaucratic education system is accused of wiping away students’ ability to innovate”. Our results contradict both of these remarks, and suggest that students that want to contribute to both innovation and good financial performance at their working place should prioritize higher education.

Our findings related to the value of general experience tell a slightly different story. As presented, we find general experience not to affect impact of innovation significantly. On the other hand, it has a positive and significant effect on performance. Interpreting these results, it seems like employees with high general experience are either situated in positions less engaged in innovation, or fails to contribute to innovative processes. The former claim is not tested in this study, while the latter may explained as longer general experience might be associated
with gaining a particular way of thinking, as a kind of inertia that may be an obstacle to innovation. Further, due to the significant effect on performance, our findings may imply that employees with longer general experience often are involved in, and positively influencing, decisions on firm-level that increases the financial performance.

When testing hypothesis 1, we failed to gain significant support for academic publications to be positively related to impact of innovation. This implies that knowledge generated in research institutions in the form of publications may not improve innovation within the county boundaries. This may be due to the fact that a substantial portion of the knowledge generated by research papers, articles and other publications can be characterized as explicit knowledge. This knowledge is easily accessible through journals and other written sources; hence knowledge spillovers are not location bound and easily facilitated across geographic boundaries. Although we find no support for the importance of proximity to research institutions on innovation, we have not tested flows of graduates and the access to expert knowledge (e.g. through joint research projects) facilitated by such institutions. We acknowledge that this may change the impact of being located in close proximity to these institutions, and make for an interesting future study on the topic of knowledge spillovers.

7. Implications

7.1 Governmental implications
Firstly, as previously described, the offshore industry is one of Norway’s most important industries. In 2008 the industry employs almost 113,000 people, generated revenues of 405 BNOK and accounted for 15.9% of GDP. The last few years it has increased its importance on all these measures. There is little doubt that it is crucial for the government to present stable framework conditions for the industry to continue its growth. In such a setting, continued activity on the Norwegian Continental Shelf is vital. A clear conclusion from both the initial survey and the qualitative study is that an opening of the oil and gas fields in the disputed
areas of Lofoten, Vesterålen and Senja determine the future competitiveness of the offshore industry in Norway.

Secondly, the importance of higher education has found strong support in our results, both in terms of innovation and performance. Paradoxically, Norway scores very low on rankings of top universities in the world (ARWU 2010; QS World University Rankings 2010; U.S.News 2010). Our findings that proximity to research institutions is not significant support the argument that there is no need for higher education-institutions on every corner, as much of the knowledge is available across geographic locations. The governmental focus should therefore rather be to build up world-class universities and strong research environments in the already established institutions in order to promote further research.

Further, a continued and sharpened focus to promote relevant higher education is of essence for the competitiveness of the industry. From the qualitative study we learned that a primary concern of the industry is the future access of sufficient number of highly educated engineers. Statistics indicate that there are a dropping number of students opting for mathematical, scientific and technological studies (OECD 2007a). The government should address this challenge by increasing the focus and pursue incentives for students to engage in such studies. It is of importance that this focus should encompass the period all the way from primary school up to higher education.

There is a need for knowledge sharing mechanisms in order for geographic proximity to have a significant impact on innovation. Our results show that mobility of employees within the industry is one such mechanism. Another knowledge sharing mechanism is regional and national joint projects for industry research, cooperation and discussions. By promoting, supporting, and facilitating such projects, the government can directly help knowledge sharing in the industry. KonKraft\(^9\) and OG21\(^10\) are examples of such national initiatives that are already established. More focus on such initiatives, where the government can act as a catalyst for cooperative

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\(^9\) For more information about KonKraft, see http://www.olf.no/konkraft/

\(^10\) For more information about OG21, see http://www.og21.org/
efforts between and the industry, research universities, and private research institutions, is important. However, also more specialized initiatives, either by industry category (e.g. subsea) or localization, can function as facilitators of improved knowledge sharing and in turn higher rates of innovation and increased performance. An example of a successful local initiative is NODE, a cluster organization for the drilling-, mooring- and loading cluster in-and-around Agder. This initiative has proven highly successful, and has established the cluster as world leading in its genre (NODE 2010). Despite Rogaland being the oil and gas hub in Norway by having the majority of offshore companies located there, there is no offshore-related Norwegian Centers of Expertise (NCE) located in the county. We find it remarkable that this region lack a more structured approach to creating cluster-initiatives promoting and improving the overall presence and performance of the firms located in the region.

7.2 Managerial implications
In line with the previous discussion on the importance of higher education, managers should strive to recruit candidates with relevant, higher education. In addition, firms should also invest in knowledge-enhancing activities for their employees. Degree-oriented post-qualifying educations like Master of Management programs and bachelor educations for apprentices are examples of initiatives that increase employees’ educational level, and hence should be promoted. Despite the proven importance of such initiatives, our initial survey shows that they are used to a lesser degree by managers. Even though not tested in this study, it is likely that in-house training and upgrading courses will contribute to positive effect as well. Related, more active and collaborative efforts towards universities should be pursued in order to develop a mutual understanding on industry needs how this can be adapted in an academic setting.

11 “Post-school training through universities or academies” has a rating of 1.84 on the question “To what extent do the following sources contribute to the enhancement of knowledge in your company?” The question on was a 4-point Likert scale, where 1 indicates “to a lesser degree” and 4 indicating “to a large degree”.

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Secondly, mobility within the industry is of great importance, and managers have a responsibility to facilitate such movements. Managers should promote systems and introduce incentives for employee exchanges across firm divisions as well as in joint collaboration projects across firms and countries. It is important that firms do not counteract with flows of employees across firms and regions. However, in the short term, mobility incentives may be met with resistance as they imply changes. Despite, the mobility is likely to be beneficial for all firms within the cluster in the long term.

Finally, we also suggest that managers should be actively contributing to knowledge sharing through engaging in industry-collaborations, like the already mentioned NODE and KonKraft projects. Such collaborations facilitate knowledge transfers and promote a sense of belonging. Lessons learned from NODE point specifically at cooperating for the common good or working towards a common strategy as a central factor for success (European Cluster Mapping Project 2008). Related, valuable collaborative efforts can also be found in the intersection between higher education and mobility; that is, firms are likely to benefit from more extensive industry-academia collaboration. Our results suggest that mobility is of importance for innovation. Such mobility may also take the form of knowledge exchanges between firms and research institutions, e.g. professors as consultants in industry projects, or industry employees participating as lecturers or research associates.

8. Limitations
Although the research presented contributes to both theory and practice, it is not without limitations that the reader should be aware of. Firstly, the dependent variable, *impact of innovation*, is based on a self-reporting survey question that may provide a potential threat to the reliability of the results. A successful conduction of the Innovation survey assumes that all respondents are familiar with the definitions and terms used in the survey, and that the respondents possess reliable information about the share of turnover that originates from firm innovations. In this regard, it is important to note that the dispatcher, Statistics Norway, is considered highly
credible, ensuring that the respondents provide reliable responses. In addition, the results from the survey have undergone thorough revision and controlling at Statistics Norway before published. We therefore maintain that the results of our study are not strongly affected by response biases.

Secondly, a limitation of this study is the operationalization of the agglomeration measurement. A general problem with studies of clustering is that there is a significant methodological diversity when it comes to this measure (Rocha 2004; Globerman et al. 2005; Pe'er & Vertinsky 2006). Taken the available data into consideration, the Balassa-measure described in Section 4.4.5 was considered the most appropriate measurement. The Balassa measure has earlier been criticized for being an inaccurate measure for agglomeration. We have sought to minimize the impact of this limitation by with testing different measurements (see robustness tests in Section 5.2). While these tests have shown robustness of the measure selected, we acknowledge that if other geographical subdivisions were used, e.g. regions or cities, this might have had a different impact on our results.

Finally, we need to consider the generalizability of the findings in our study by assessing the external validity of the results (Pedhazur & Schmelkin 1991). In doing so, we are concerned with identifying threats to external validity. This study is limited to analyzing one specific industry in Norway. In sum, there are several characteristics of our sample that may threat the external validity and make it difficult to generalize our findings industries and/or geographic locations.

It is important to underline that cluster dynamics varies substantially. Other case studies reviewed as part of the work with this thesis show that the characteristics of clusters and agglomerations are diverse, both in terms of geographical boundaries and industries. Therefore, it might not be advisable to transfer the findings in this study to other clusters and use this as a basis for policy making. This is important to note, and is supported by other researchers; e.g. Simmie (2004) arguing that there is not much empirical evidence to suggest what the dynamics of clustering have

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12 For more information on this process, please consult http://www.ssb.no/innov/om.html
achieved across different circumstances and locations; hence policy-making often exceeds what can be supported empirically.

Further, statistics presented in this thesis indicates that the offshore industry is about twice as innovative as the national average in Norway. The differences in level of innovation may imply that our findings are non-transferable to other industries. Also, knowledge intensity differs across industries and locations. The Norwegian offshore industry, being highly knowledge intensive as well as being part in an increasingly globalized competition have unique characteristics making it difficult to blueprint the suggested implications from this paper.

In sum, generalizing the findings from this research without accounting for context and distinctive industry- and clustering characteristics may not be reliable. That being said, it has not been a goal of this study to present findings that are applicable across other industries or locations. However, the methods and operationalizations presented in this paper can easily be adapted for research in other industries, thus providing reliable results for that given industry.

9. Conclusion
The Norwegian offshore industry is in need of overcoming important challenges the next few years. Maturing oil fields, more focus on environmentally friendly solutions and a political uncertainty regarding the opening of new oil fields are among the most pressing. In order to meet these challenges, the industry’s innovative capabilities need to be addressed. Based on a theoretical foundation of the interplay between clustering, knowledge and innovation, this paper has investigated how different functions of knowledge affect firm-level impact of innovation, and to what extent these relationships are moderated by levels of agglomeration. We found that mobility of employees from inside the industry is important in terms of facilitating knowledge spillovers between firms. In addition, results show that higher levels of formal education lead to greater impact of innovation. Furthermore, we have found support suggesting that employees from within the industry moving to new firms
have a greater effect on impact of innovation in localizations with clustering characteristics than locations without such characteristics.

These results provide important implications for both the Norwegian government and firms within the industry. Increased focus on the importance of higher education, cross-firm cooperation and knowledge exchanges as well as focus on mobility of employees are important factors to consider when assessing the competitiveness and the future of the Norwegian offshore industry. It is imperative that collective action is soon undertaken so that the industry can sustain and develop its strong position and value creation for Norway, and also in the future provide new products and technologies to be adopted throughout the world.
References


Gertler, M.S., 2003. Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). *Journal of economic geography*, 3(1), 75.


Jaffe, A.B., Trajtenberg, M. & Henderson, R., 1993. Geographic Localization of


Layard, R. et al., 1971. Qualified manpower and economic performance: an inter-plant study in the electrical engineering industry.


Organization Science, 5(1), 14-37.


Norwegian Petroleum Directorate, 2009. FACTS - The Norwegian Petroleum Sector 
2009, Oslo: The Norwegian Petroleum Directorate. Available at: 
2010].

Norwegian Petroleum Directorate, 2010. The NPD's fact-pages: Discovery 6305/5-1 
ORMEN LANGE. Available at: 
13, 2010].

Norwegian Petroleum Directorate. Available at: 
August 1, 2010].

innovation systems of the Nordic countries: An analysis based on register 
data. STEP Report series.


Data, 3rd Edition. Available at: 
http://www.oecd.org/document/33/0,3343,en_2649_34451_35595607_1_1_1_1,00.html [Accessed June 24, 2010].

Oljeindustriens Landsforening, 2008. UTOG2008 - Utdanningssteder for Olje og gass- 
industrien. Available at: http://www.utog.no/utdanningssteder.asp?id=615 
[Accessed July 1, 2010].

Paper No. 196. Yale University, Economic Growth Center.

integrated approach, Lawrence Erlbaum.

Pe'er, A. & Vertinsky, I., 2006. Determinants of Survival of De Novo Entrants in


Sorenson, O. & Audia, P.G., 2000. The social structure of entrepreneurial activity: Geographic concentration of footwear production in the United States,


## Appendix 1: List of companies interviewed for the qualitative study

<table>
<thead>
<tr>
<th>Firm size</th>
<th>County</th>
<th>Industry</th>
<th>Position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Oslo</td>
<td>Refineries, transport and marketing</td>
<td>General Manager</td>
<td>23.02.2010</td>
</tr>
<tr>
<td>Medium</td>
<td>Rogaland</td>
<td>Production - Products and services including maritime operations</td>
<td>CEO</td>
<td>15.04.2010</td>
</tr>
<tr>
<td>Large</td>
<td>Oslo</td>
<td>Engineering, fabrication and maintenance/ modification of subsea systems</td>
<td>Vice President, Finance</td>
<td>16.04.2010</td>
</tr>
<tr>
<td>Large</td>
<td>Rogaland</td>
<td>Drill and well - Equipment, services and drilling rigs</td>
<td>Technical Support Director</td>
<td>15.02.2010</td>
</tr>
<tr>
<td>Medium</td>
<td>Oslo</td>
<td>Engineering, fabrication and maintenance/ modification of topside installations</td>
<td>CEO</td>
<td>24.03.2010</td>
</tr>
<tr>
<td>Large</td>
<td>Abroad</td>
<td>Shipbuilding</td>
<td>General Manager of Export Department</td>
<td>24.02.2010</td>
</tr>
<tr>
<td>Large</td>
<td>Oslo</td>
<td>Financing</td>
<td>General Manager</td>
<td>19.03.2010</td>
</tr>
<tr>
<td>Small</td>
<td>Oslo</td>
<td>Shipping</td>
<td>CEO</td>
<td>19.03.2010</td>
</tr>
<tr>
<td>Medium</td>
<td>Abroad</td>
<td>Production - Products and services including maritime operations</td>
<td>General Manager</td>
<td>22.02.2010</td>
</tr>
<tr>
<td>Small</td>
<td>Rogaland</td>
<td>Education, research and consulting</td>
<td>Manager Opportunity Development</td>
<td>14.03.2010</td>
</tr>
<tr>
<td>Medium</td>
<td>Oslo/Abroad</td>
<td>Engineering, fabrication and maintenance/ modification of subsea systems</td>
<td>General Manager</td>
<td>27.03.2010</td>
</tr>
<tr>
<td>Large</td>
<td>Rogaland</td>
<td>Drill and well - Equipment, services and drilling rigs</td>
<td>HR Manager</td>
<td>18.03.2010</td>
</tr>
<tr>
<td>Small</td>
<td>Oslo</td>
<td>Production - Products and services including maritime operations</td>
<td>General Manager</td>
<td>15.03.2010</td>
</tr>
<tr>
<td>Medium</td>
<td>Vestfold</td>
<td>Production - Products and services including maritime operations</td>
<td>Sales Director</td>
<td>22.02.2010</td>
</tr>
<tr>
<td>N/A</td>
<td>Rogaland</td>
<td>Education, research and consulting</td>
<td>Technical director</td>
<td>18.03.2010</td>
</tr>
<tr>
<td>N/A</td>
<td>Rogaland</td>
<td>Education, research and consulting</td>
<td>Engineering and Management Consultant</td>
<td>24.03.2010</td>
</tr>
<tr>
<td>Medium</td>
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<td>General Manager</td>
<td>22.02.2010</td>
</tr>
<tr>
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<td>08.04.2010</td>
</tr>
<tr>
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<tr>
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<td>Vice President, Norway</td>
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<tr>
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<td>Rogaland</td>
<td>Drill and well - Equipment, services and drilling rigs</td>
<td>CEO</td>
<td>18.03.2010</td>
</tr>
</tbody>
</table>

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13 The firms are categorized according to turnover. Companies marked N/A are NGOs, universities and organizing entities with no turnover registered.

14 Norway constitutes of 19 counties in total. Please refer to Appendix 3 for a more detailed overview.
Appendix 2: Selection of research institutions

In order to define what universities and research institutes that should be included as main contributors of knowledge and graduates to the offshore industry, it was decided to use an overview of publications from ISI Web of Knowledge. This was done by searching for and reviewing articles within the relevant topics that were published by Norwegian research institutes and universities. The following search phrase was used:

TS=(oil) AND CU=Norway

Refined by: Subject Areas=ENGINEERING, PETROLEUM OR ENGINEERING, ELECTRICAL & ELECTRONIC OR GEOSCIENCES, MULTIDISCIPLINARY OR ENGINEERING, INDUSTRIAL OR MARINE & FRESHWATER BIOLOGY OR MECHANICS OR ENVIRONMENTAL SCIENCES OR ENERGY & FUELS OR CHEMISTRY, PHYSICAL OR ENGINEERING, GEOLOGICAL OR BIOCHEMISTRY & MOLECULAR BIOLOGY OR COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS OR ENGINEERING, CHEMICAL OR ENGINEERING, CIVIL OR GEOGRAPHY OR NUTRITION & DIETETICS OR ENGINEERING, MECHANICAL OR GEOCHEMISTRY & GEOPHYSICS OR AUTOMATION & CONTROL SYSTEMS OR FOOD SCIENCE & TECHNOLOGY OR METEOROLOGY & ATMOSPHERIC SCIENCES OR PHYSICS, APPLIED OR TOXICOLOGY OR MATHEMATICS, INTERDISCIPLINARY APPLICATIONS OR ENGINEERING, ENVIRONMENTAL OR CHEMISTRY, APPLIED OR ECOLOGY OR CHEMISTRY, ANALYTICAL OR ECONOMICS OR OPERATIONS RESEARCH & MANAGEMENT SCIENCE OR INTERNATIONAL RELATIONS OR OCEANOGRAPHY OR POLITICAL SCIENCE OR ENVIRONMENTAL STUDIES OR INSTRUMENTS & INSTRUMENTATION OR BIOTECHNOLOGY & APPLIED MICROBIOLOGY OR CHEMISTRY, MULTIDISCIPLINARY OR PERIPHERAL VASCULAR DISEASE) AND Document Type=(ARTICLE OR PROCEEDINGS PAPER OR REVIEW) AND [excluding] Subject Areas=(MARINE & FRESHWATER BIOLOGY OR NUTRITION & DIETETICS OR FISHERIES)

Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.

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<tr>
<th>Number</th>
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<td>7</td>
<td>IRIS</td>
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</table>
Appendix 3: Geographic distribution of firms

Compiled using www.batchgeo.com based on industry classification.
The development and future of the Norwegian Offshore Cluster

A potential Global Knowledge Hub?

Date of submission: 15.01.10

Supervisor: Amir Sasson

Exam code and name: GRA 19002 Preliminary Master Thesis

Study programme: Master of Science in Business and Economics
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Abstract

This preliminary thesis, as part of the project “A Knowledge Based Norway,” focus on the development and future of the Norwegian offshore cluster. Initially, research questions are presented, followed by a definition of the term ‘cluster’. Controlling one of the largest maritime zones in the world, Norway has historically always had a strong presence on the ocean. After the discovery of oil on the Norwegian continental shelf, a brand new industry arose around the government controlled company Statoil. Consequently, the related maritime and offshore industries emerged as technological world-class industries. Employing around 80,000 people and accounting for 11% of the national value creation, the offshore cluster is without doubt of great importance to Norway, but is also considered to be a driver of innovative technology worldwide. The majority of activities conducted in the cluster are related to engineering services, typically belonging to the value-shop logic of value creation.

Reviewing the literature on clusters, Porter’s theories are seen as a natural starting point. The main idea is that regions are becoming increasingly important even in times of globalization. Regions’ ability to innovate will ensure competitiveness. Porter’s Diamond is a systemic framework outlining four forces crucial for the innovativeness of a nation. Porter’s theories spring from ‘economic geography’: a theory emphasizing the positive effects of physical proximity to related companies. Contrary to ‘economic geography’ are theories of sociology or social networks. This stream of research argues that networks are crucial for understanding why some industrial regions perform better than others. Recent research has attempted to reconcile these streams of research, highlighting the importance of them both in a mutual relationship.

Building on Porter’s theories, Reve developed the concept of ‘Global Knowledge Hubs’ – so-called super clusters – where the importance of knowledge networks, research institutions, access to talent and venture capitalists with the ability to commercialize innovations in total make a model for an internationally competitive advantageous cluster. Finally, a critical view on the cluster theory is presented; emphasizing the fuzziness of the term ‘cluster’ and critique of Porter’s theories.
Introduction

This preliminary thesis report will make the foundation for the Master Thesis to be written under the working title “The development and future of the Norwegian Offshore Cluster – a potential Global Knowledge Hub?” The thesis is written as a part of “A Knowledge Based Norway”, an extensive research project initiated and administered by BI Norwegian School of Management. The project aims at understanding how competitive and successful Norwegian industries and clusters will look like in the future through means of innovation, adaption and value creation, as well as considering strategic challenges facing these clusters.

The remainder of this paper will encompass three main parts. Firstly, we will present the research questions and define the term ‘cluster’. Secondly, the Norwegian maritime industry and particularly the offshore cluster, is described. Finally, a literature review of cluster theory is undertaken.

Research questions

Based on the initial phases of work in the project, as well as the stated research goals, the following research questions are suggested:

Q1 Which drivers have been crucial for the development of the Norwegian offshore cluster the past 20 years?
Q2 What are the characteristics of the Norwegian offshore cluster today?
Q3 For the future, which drivers and policy changes will be crucial in transforming the Norwegian offshore cluster to an independent Global Knowledge Hub?

For Q1, quantitative time-series data provided from the previous projects “Et konkurransedyktig Norge” (1992) and “Et verdiskapende Norge” (2001), as well as statistics from Statistics Norway will be used. For Q2, a national survey, in-depth interviews and case studies will provide the data to be analyzed. Q3 will draw on all previously mentioned data and develop policy implications for both the government and companies.
Cluster definition
The concept of a ‘cluster’ is used relatively broadly in the research literature. This may be due to the fact that ‘clusters’ and ‘clustering’ encompasses a wide range of dimensions and schools of thought. The concept of clusters can be traced all the way back to Marshall (1920), and goes by different names in the literature, e.g. ‘learning regions’ (Florida 1995), ‘agglomerations’ and ‘cities’. Numerous applications and names for the concept result in a wide range of definitions. Cortright (2006) argues that a cluster, in the most general form, consists of firms and related economic actors and institutions that draw productive advantage from their mutual proximity and connections. Depending on field of interest, scholars have offered competing definitions on the concept of clustering. For instance, Nobel Prize Laureate Paul Krugman (1993) refers to clusters as agglomerations and knowledge linkages. Contrary to this, business-strategist Michael Porter (1990, p.197) defines clusters as “geographical concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions in a particular field that compete but also cooperate”. This is a broadly credited definition, and has been used as a starting point for an extensive stream of research. In addition, the concept of Global Knowledge Hubs introduced by Reve (2009), as will be discussed, is based on Porter’s reasoning. Consequently, this paper will use Porter’s definition as basis for further discussions.

The history of the Norwegian offshore industry
According to Reve (2009), Norway has developed into a unique global position in the maritime sector by combining three major factors: Ocean, technology and knowledge. What are the antecedents that have put Norway in this unique position?

Norway has a long tradition of creating value through activities related to the ocean. Both historically and present, Norway holds the position as one of the world’s dominating maritime nations within shipping and other maritime services, as flag for one of the world’s largest commercial fleets. In addition, Norway controls one of the
largest maritime zones in the world. These enormous areas also include extensive oil and gas reserves.

The offshore industry in Norway started its emergence in the 1960s when companies started to show interest for offshore oil production on the North Sea shelf. As a result, the Norwegian government established guidelines for exploration of oil on the Norwegian continental shelf, as well as claiming all resources public property (Bjørnstad 2009). A government white paper (Norwegian Government 1970) was issued and suggested to create the company Statoil in order to “ensure the role of the industry in the North Sea” (Bjørnstad 2009).

Empowered by advantageous privileges given by the government, Statoil arose as a significant and powerful player that had the means to orchestrate a supplier industry based on its needs. In doing so, Statoil accelerated the emergence of the offshore industry, and numerous specialized suppliers (often directly or indirectly controlled by Statoil) were established. By providing resources and demand, Statoil has helped this industry to develop into a highly competent knowledge-based industry now enjoying a leading global position. It is important to note that a majority of the suppliers in the offshore industry today still is reliant on key players like Statoil in order to secure sufficient demand for their products and services.

**The Norwegian Offshore Cluster**

More than 250,000 people are directly or indirectly employed in what is termed the oil industry (Statoil 2009). 80,000 of these are employed directly in the offshore cluster (Ernst & Young 2009). The 600 companies in Ernst & Young’s analysis of the Oil Field Services (OFS) industry showed a clustering on the Norwegian West-coast, with a strong presence especially in the Rogaland- and Møre-regions. The combined revenues of the cluster were approximately 280 BNOK in 2008, a significant 41% growth from 2006 (Ernst & Young 2009). Based on the GNP numbers for 2008 (Statistics Norway 2008), the offshore cluster thereby accounts for 11% of value creation in Norway, activities on the continental shelf excluded.
The Norwegian offshore cluster is evidently also strong internationally. Reve (2009) argues that “there is one industrial cluster that stands out if we analyze the industrial sectors where Norway has its global competitive strength, and that is the maritime and offshore sector”. Noticeably, Reve mentions offshore and maritime as one sector. However, the Norwegian offshore cluster alone maintains a strong international presence. As Jerman (2009, p.22) summarizes: “At astonishing speed, shipyards and other maritime companies in Norway came up with technical innovations which literally took the world’s offshore industry into entirely new waters... Norway is today a world leader in seabed technology.”

**Activities in the offshore cluster**

The offshore cluster encompasses a wide range of activities. There are, however, no given boundaries defining which activities and companies to include. Therefore, it is harder to compare reports, studies and information regarding the offshore cluster.

During the preparatory work on this thesis, a project has been conducted to classify and map a set of Norwegian companies based on the maritime NACE-codes. The classification is based on a set of categories proposed by Reve & Jakobsen (2001, p.40).

In addition, Ernst & Young conducted a mapping of Norwegian offshore companies in 2009. So far, the categories to a certain extent match, but as the project classification is not yet completed, this paper will use the categories suggested by Ernst & Young when discussing activities in the offshore cluster.

The majority of companies in the offshore industry are engaged in activities related to *engineering, fabrication and installation*. This part of the industry consists of mostly smaller companies that provide highly specialized services for both surface and subsea installations. According to Ernst & Young (2009), this part of the offshore industry accounts for approximately 50% of the number of companies, revenues generated, and the number of people employed in the offshore industry.

The second largest part of the industry is companies related to *operations*, including operating drilling rigs, (e.g. SeaDrill and Ocean Rig) as well as services related to maintenance of offshore installations. As this part of the industry is more capital
intensive and has got higher barriers to entry, the companies operating rigs are fewer, but larger. However, there is still a numerous of product- and service suppliers in this part of the industry.

In addition, companies in the offshore industry are also present in activities that are carried out prior to the engineering and production previously mentioned. This includes companies engaged in seismic and reservoir services, like Halliburton and Schlumberger. Further, about 15% of the companies engage in exploration and production drilling. The vast majority of companies engaged in this part of the industry also have activities within operations, as mentioned earlier. To bridge the exploration and engineering and construction activities, a set of companies has also specialized in providing project development-services. It is also worth noting that there are a few companies in the industry engaged in decommissioning.

**Value Creation**

An important aspect of the cluster theory is development, innovation and value creation (Porter 1990; Porter 1998a; Cortright 2006). Crucial for the understanding of industry dynamics is a discussion of the logic behind the value creation. Based on the major activities outlined above, one can argued that the value shop (Stabell & Fjeldstad 1998), rather than the value chain (Porter 1985) is most suitable for the offshore cluster. Whereas the logic behind the traditional value chain is transforming input to output, adding value at each level of the chain, the logic of the value shop is solving complex problems. From the Ernst & Young (2009) analysis it is observed that half of the companies perform main activities related to engineering, a typical shop-activity. Further, companies involved in exploration and project development, mostly solving unique tasks, also hold characteristics of the value shop. Nevertheless, it is impossible to generalize an entire cluster into one value creation logic. As Stabell & Fjeldstad (1998) argues, “a single firm may employ more than one technology and hence have more than one configuration”. It seems clear that some of the activities (e.g production) performed by actors in the cluster obviously can be classified as value chains. However, on a general basis, and with a majority of service- and support activities in the cluster, the value shop configuration seems fitting.
The cluster seems to be driven by a few large actors encompassing many of the most important activities (Ernst & Young 2009), as Aker Solutions, Acergy Norway, Seadrill Offshore and Subsea 7. Not surprisingly, and supported by ecology-theory (Carroll 1985; Carroll & Swaminathan 1992), also smaller niche actors especially seems to play an important role in the cluster. 2/3 of the companies are grouped as smallest (of 5 groups) in terms of revenue (see Appendix 1). Further, both the Ernst & Young report as well as the preliminary findings from the mentioned company-classification-project shows that smaller niche players often are to be found in upstream activities (service- and product supply) whereas the major actors dominate downstream activities (contracting).

**Literature Review**

**The Porter “school” of clustering**

Porter’s (1990; 1998) cluster theories are of the most influential work in this branch of research. In order to understand competition and competitive advantage in the world of globalization, Porter (1990) claims one need a good understanding of a cluster. Facing increased globalization, the importance of regional locations increases, rather than decreases. Porter argues that the competitiveness of a nation is measured by the level of productivity of its industries. Hence a nation depends on its industries’ ability to innovate and stay competitive. To answer questions such as why some companies in some countries are capable of consistent innovation, Porter (1990) outlines the diamond of national advantage; four attributes that individually and as a system constitute the playing field that each nation establishes and operates for its industries. It is important to highlight the systemic nature of the diamond; that these attributes affects each other and is dependent on the state of the other attributes in the diamond. The four attributes proposed by Porter is:

*Factor conditions* describe the nation’s position in factors of production, such as labor force, infrastructure, education and research institutions.
Demand conditions are concerned with the nature of the home-market. Despite markets globalizing and world-wide customers, a demanding home-market is seen as important because it spurs innovation.

Presence of Related and supporting industries affects the ability to use cost-effective inputs at the lowest possible transaction cost.

Firm strategy, structure and rivalry constitute the context for competition in the cluster, as well as how companies are created, organized and managed. Domestic rivalry is presented as most important due to its effect on companies’ need to innovate and improve.

The dynamics of these attributes constitutes a nation’s ability to create value through innovation, and is an applicable framework for governments and companies to reveal areas for future improvements.

Economic geography
The first definition of clustering dates back to the works of Alfred Marshall (1920), an economist that studied patterns of economic activities and co-location – so-called industrial agglomerations - among industrial districts in England (Cortright 2006). Marshall identified three main reasons why a certain set of companies within a given industry would be more productive if located in close proximity. These reasons are often referred to as the Marshallian Trinity and include knowledge spillovers, labor market pooling, and supplier specialization.

From early 1990s, a new genre of research emerged, called “new economic geography,” (Krugman 1991; Jaffe et al. 1993; Krugman 1998; Fujita & Krugman 2003). Krugman is perhaps the most prominent advocate of this stream of research, and bases his work on the foundations of Marshall emphasizes on the importance of regional industrial agglomerations. He acknowledges the foundations of the Marshallian Trinity, but as Gupta & Subramanian (2008) refers to, he questioned benefits of knowledge spillovers within an industry, as he points at them being
technological externalities international in scope, hence equal to all players in the industry.

Krugman (1991) argues that regional clusters emerge mainly from accidental reasons. Further, when these clusters emerge, they are sustained by external scale economies, occurring when firms benefit from lower production cost as a result of the whole industry growing (Gupta & Subramanian 2008). Krugman also argues that, due to lower transaction costs, companies should locate in proximity to markets where demand is high or where the supply of input factor is favorable (Krugman 1991, p.98).

**Sociology – network theory**

Early influential research in sociology was not focused on the economic aspect of networking (Powell & Smith-Doerr 1994), but rather structure, ties and constraints. However, from the mid 1970s a wave of research contributed to the economic effects of networking (Granovetter 1985; Burt 1992), providing a foundation of social networking effects on innovation and economic growth.

Numerous studies in the ‘sociology- and network theory’, contradictory to the literature of economic geography, explain clustering dynamics and locational advantages through social ties and connections (Powell & Smith-Doerr 1994; Saxenian 1996; Sorenson & Audia 2000). Social linkages offer access to new resources and knowledge; elements crucial for innovative purposes (Gulati et al. 2000; Baum et al. 2000; Ernst 2002). Thus these linkages play out as an alternative to physical proximity. Gulati et al. (2000) and Podolny (2001) argue that merely access to the network is not sufficient; the location within the network is deterministic for accessing information and knowledge. In response to Porter’s focus on globalization, Ernst (2002) claim that the spatial stickiness of innovation is reduced as globalization increases and information- and knowledge transfer in networks is simplified.

In an innovative research paper Whittington et al. (2009) attempts to merge the economic geography- and sociology theory on clusters, claiming that “Organizations are situated in both geographic and social structural spaces” (Whittington et al. 2009: 90). Their findings suggest that both types of location, geographic and social; in a
mutual relationship matter for innovation. Studying the biotechnology industry, networks were deemed primary, giving support to the importance of social linkages for innovation in clusters.

**Comparison of theories to Porter’s school of thought**

This paper makes Porter’s ideas its starting point. However, it is of value to consider both ‘economic geography’ and ‘sociology’ when discussing clusters. While Porter’s arguments build on the ideas of ‘economic geography’, these two schools of research differ in one fundamental way. Krugman sees agglomeration as a static set of linkages, whereas Porter emphasizes that in order to be a cluster geographic proximity is required, not yet sufficient. Based on Porter’s arguments, Reve (2009, p.11) explains that “agglomerations become industrial clusters or dynamic knowledge systems when industrial and knowledge actors start to interact.”

The main outcome of both Porter’s work and the sociology theories is innovation. However, whereas Porter speaks of geographic location and interaction among actors as basis for innovation, sociology explains innovation as a result of access to- and location within a network of social linkages. As mentioned, Whittington et al. (2009) found both these types of location not only important for innovation, but also in a mutual relationship with each other.

**Cluster drivers**

To gain a stronger understanding of clusters it is imperative to understand the underlying driving mechanisms crucial to the birth, sustainability and development of clusters. Marshall (1920) initially proposed three key drivers in industrial agglomerations: knowledge spillovers, labor market pooling and supplier specialization and. These drivers have since gained strong support in the research. Naturally, many others (e.g. Rosenthal & Strange 2001; Cortright 2006; Gupta & Subramanian 2008) also have defined new deterministic drivers for the cluster life cycle. Based on these
fundamental works, in combination with a literature mapping\textsuperscript{15}, five crucial cluster drivers will in the following be presented.

1 Knowledge Spillovers

Knowledge spillovers is today referred to as the positive externalities that firms receive in terms of knowledge from the environment (e.g. Caniels & Romijn 2003; King et al. 2003; Molina-Morales 2002; Furman et al. 2002).

Growing out of the geography-literature, knowledge spillovers is a result of personal contact between individuals in a specific location (Feldman 1993; Aharonson et al. 2007; Gilbert et al. 2008), which in turn contributes to economic growth and innovation (Romer 1990; Audretsch & Feldman 1995; Baptista & Swann 1998; Porter 1998b). Feldman (1993), emphasizing the importance of location on innovation, stated that “Geographic concentration of knowledge and knowledge spillovers are likely to promote innovation rates higher than those in geographic areas lacking a concentration of firms”. In greater degree than labor pooling and supplier specialization, knowledge spillovers are highly dependent on location, as the positive effects tend to decay with distance (Jaffe et al. 1993; Rosenthal & Strange 2001; Surico et al. 2003). Rothaermel & Ku (2008) and Reve (2009) argue that research universities play a particular critical role for the innovative performance of a cluster by serving as a source of knowledge spillovers and producing graduates who disseminate tacit knowledge. Numerous empirical studies support the positive performance effects on clusters by knowledge spillovers.

New entrants both benefit from the knowledge spillovers in a given location (Aharonson et al. 2007), as well as contribute to continued economic growth in the cluster (Acs & Varga 2005). However, Pe'er & Vertinsky (2008) argue that new entrants face a tradeoff between knowledge spillovers and the cost of locating within the cluster.

\textsuperscript{15} Review of all articles containing the term “cluster” found in ISI Web of Knowledge (published up to 2008). A mapping of drivers discussed in these articles provided consistent results supporting the selection of drivers presented in this section.
2 Labor market pooling
The existence of labor market pooling as a driver for clustering is founded on the premise that clustering of companies create a strong market for certain type(s) of labor needed in that specific area (Cortright 2006). This mechanism affects both employers and employees in a positive way; workers are attracted to areas where their specialized knowledge is needed, and companies strive to locate in areas where they gain access to specialized labor (Marshall 1920). This effect is also tested by Francis (2009), arguing that in-migration of workers resulting from agglomeration leads to higher rates of both job destruction and creation; in turn providing a foundation for labor market pooling.

Several studies underline the importance of labor market pooling. Dumais et al. (2002) underlines the significant impact of labor market pooling by showing that industries with similar labor mixes enjoys large benefits from proximity. Rosenthal & Strange (2001) tested a set of determinants for agglomeration and found that labor market pooling had the most robust effects on the creation and sustainability of agglomerations. Building on this, they also found that the effects of labor market pooling were less influenced by distance than knowledge spillovers, because they “rely more on the ability of agents to conveniently drive from one location to another” (Rosenthal & Strange 2003, p.20).

3 Path dependence and lock-in
Advocates of path-dependence argue that economic development is limited by a set of constraints appearing when the role of history, institutions and networks are taken into account. Boschma (2005) argues that path dependence arises by the inheritance of local structural characteristics from past knowledge accumulation and learning. He further adds that these characteristics may often be geographically determined. Such long-lasting dependences are termed “lock-in”; an extreme version of path dependence (Karlsen 2005). This theory is often labeled as “positive feedback” or “increasing returns” (e.g. David 1985; Arthur 1989). The foundation of the theory is that in the early stages of a technology or a cluster it is possible to create powerful incentives for future growth, and that this creates a positive feedback loop that
consolidates an established early advantage. Arthur (1994) argues that this theory is more suitable when describing today’s technology-intensive industries. Such industries are characterized by high up-front costs and low marginal costs, and together with network externalities constitute a different market place than known in traditional diminishing-return industries.

A growing number of scholars advocate that path dependency should not only be considered a constraint. Karlsen (2005) argues for a more dynamic view, and consider the past not only as a constraint, but also a heritage. Campbell (1997) argues that actors are not constrained by institutional structures, but are also engaged in shaping them. The existence of path dependence has been studied and confirmed in several studies (e.g. Karlsen 2005; Britton 2007). In his concluding thoughts, Krugman (1991, p.100) argues that the idea of an economy being shaped by historical contingency is not merely a hypothesis, it is the obvious truth.

4 Entrepreneurship

Much theory developed on clustering considers the initial creation of a cluster as given, and disregards the importance of entrepreneurship in the first phase of cluster development. However, how firms are formed is critical to economic growth (Cortright 2006).

The role of entrepreneurs in economic development is underpinned in the works by Schumpeter (1934); describing entrepreneurs as primary movers of economic change. Pe'er & Vertinsky (2008) builds on Schumpeter’s (1942) concept of creative destruction and find evidence that exit of old firms increase entry rates and that new entrants are more productive.

Central to the literature on entrepreneurship is evaluation of, and suggestions for, governmental policy making for fostering entrepreneurship in given locations. While some (e.g. Perez-Aleman 2005; Koh et al. 2005) underpin the importance of governmental policy making, others (see e.g. Jenkins et al. 2006; McDonald et al. 2006) question whether governmental policies have impact on clustering. Related, many scholars are also concerned with national and regional variations in entrepreneurial
activity. Acs & Varga (2005) argue that these discrepancies are a potential source of different efficiencies in knowledge spillovers, hence economic activity.

Gilbert et al. (2008) conclude that the importance of observing the conditions in the founding location when deciding where to start the venture. However, there is mixed evidence of whether entrepreneurs do think strategically about where they locate their business; e.g. Shane (2002) argues that entrepreneurs do not choose where to locate, but establish where they happen to be at time of founding.

5 Supplier specialization
Supplier specialization is the third point in the Marshallian Trinity. Marshall (1920) argued that the number of industrial actors would enable suppliers to specialize in normally expensive niches as a result of sufficient demand. This view have been supported and developed by Porter (1998) and Reve (2009). The latter highlighted the importance of specialized suppliers related to innovation and innovation commercialization:

“Impirical evidence supports the positive effects on cluster performance by supplier specialization. Studying the Faisalabad textile cluster, Khan & Ghani (2004) found specialized suppliers important for diffusing new technology in the cluster as well as reducing risks for bigger actors that outsourced the specialized activities. In another study of The Sialkot cluster, Nadvi & Halder (2005) documented the importance of specialized suppliers as 300 final manufacturers heavily relied on the services of no less than 1500 specialized subcontractors.

From industrial clusters to global knowledge hubs
As mentioned, Reve (2009) developed the Porter-school of cluster theory into what is termed Global Knowledge Hubs, a kind of super cluster. These hubs differ from
clusters in several aspects. Similar to Whittington et al. (2009), Reve introduces the importance of knowledge networks for industrial innovation. Further, a hub differs from a cluster in terms of its knowledge content and its knowledge investments. Characterizing a Global Knowledge Hub, Reve accentuate the concentration of (1) first class educational and research institutions with international knowledge workers; (2) international companies with specialized centers of excellence for research, development and innovation; and (3) venture capitalists and investors with the means and ability to commercialize innovations. Further, competing research institutions with international networks and business linkages, international innovative knowledge networks and an entrepreneurial knowledge culture are outlined as important ingredients, ending up in a model of the Global Knowledge Hub illustrated in Figure 1.

![Figure 1: Elements in a Global Knowledge Hub](image)

Applying this framework to the Norwegian Offshore Cluster changes the logic of industrial development from an engineering logic to a knowledge logic, implying that research and innovation are the central components of value creation and economic prosperity.
Critique of cluster theory

The most fundamental debate regarding clusters related to the term itself. As discussed earlier, clustering is a concept used by a wide range of scholars within many academic disciplines. These scholars emphasize different measurements of clustering, like density of network ties (e.g. Powell & Smith-Doerr 1994; Gulati et al. 2000; Podolny 2001) or geographic proximity (Krugman 1991; Porter 1998a). In addition, the cluster-term is often confused with other terms like “agglomerations”, “cities” and “industrial regions (See Martin & Sunley (2003, p. 12, Table 1) for a table of competing definitions).

Due to the “fuzziness” (Desrochers & Sautet 2004, p.233) of the cluster term, researchers may encounter problems when operationalizing constructs that measure clustering in a proper way. This may in turn have implications for the ability to generalize and provide policy implications (Cortright 2006). Simmie (2004) argue that there is not much empirical evidence to suggest what the dynamics of clustering have achieved across different circumstances and locations; hence policy-making often exceeds what can be supported empirically.

Being the most prominent advocate of clustering, Porter’s work is also subject to critique. Martin & Sunley (2003, p.28) argue that a concept as elastic as clustering cannot “provide a universal and deterministic model on how agglomeration is related to regional and local economic growth”. They further question the assumption that economic growth and success can be credited to an association between high-growth industries and some form of geographic concentration.

Based on case studies, several reviews of Porter’s work have fueled the critics’ voice as little or no support was found. McDonald et al. (2007) finds no strong support for Porter’s way of viewing cluster policy making and growth. Blundel & Thatcher (2005) argues that other models (in this case Best's (2001) “cluster dynamics model”) provide more sophisticated explanations of responses and outcome in their case study of volume yacht manufacturing in Europe.
References


of economic sociology, 368–402.


Appendix 1: Offshore companies grouped by turnover

This graph shows the distribution of offshore companies as mapped by Ernst & Young (2009). As one can observe, there is a relatively small number of companies with more than 1.000 MNOK in annual turnover. In the other end of the scale, as much as 413 companies out of the total of 558 (74%) are grouped in the smallest segment (20-250 MNOK in annual turnover).