UNIVERSITETET I AGDER

Open Process Innovation Practices: An Exploratory Study

Confidential

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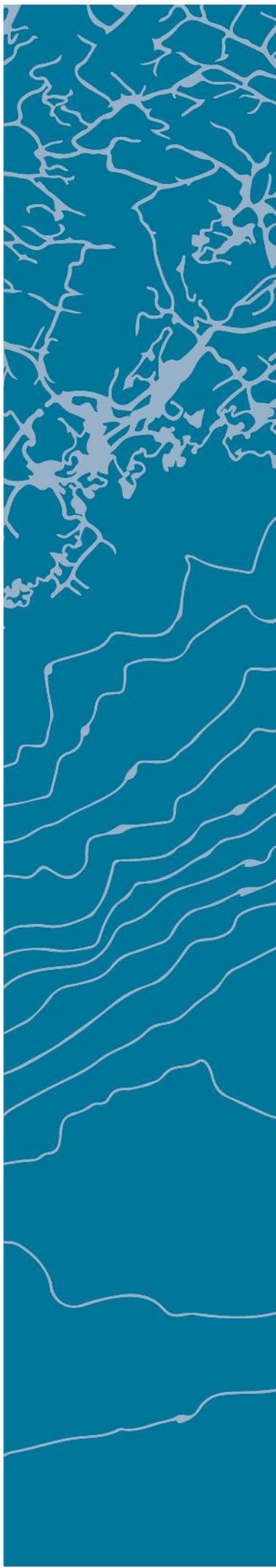

I. Preface

Before you lie the dissertation "Open Process Innovation Practices," the basis of which is a single case study of a company in the process industry. This master thesis has been written to fulfill the graduation requirements of the "Industrial Economics and Technology Management" program at the University of Agder and accounts for 30 credits. The foundation of the research stems from the curiosity we share concerning innovation mechanisms and the process industry. There is a consensus among researchers that innovations can be the origin of creating a competitive advantage. With technology breakthroughs released at a rapid pace and core competencies continuously becoming narrower and more specialized, researchers have suggested to open up the innovation process for external actors. Moreover, the research described herein presents the results of a study towards practices in open process innovation and how the characteristics of process innovation inhibit the implementation of practices derived from open product innovation. Writing this master thesis has been a challenging, yet educational and exciting journey.

We would like to thank our supervisor, Tor Helge Aas, for his excellent guidance and support during this process. We also wish to thank GE Healthcare for the opportunity, without whose cooperation we would not have been able to conduct this research. Additionally, we would like to thank all of the informants for their valuable contributions to our study. We would not have been able to conduct this case study without their cooperation.

Grimstad, 31.05.18

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II. Summary

The background for this case study is that we discovered a research gap concerning open process innovation practices. The vast majority of empirical literature addresses open product innovation, whereas conceptual literature does not distinguish between different forms of innovation. Due to the different characteristics of process and product innovation, we anticipated differing practices for open process innovation. Thus, for scientific and managerial purposes, we conducted a single case study to reveal how characteristics of process innovation affect open process innovation practices.

We would argue that our study contributes to the literature on open process innovation. Further, the study presents essential managerial implications. Our findings indicate that search breadth and depth seems to be of higher importance in radical process innovations than incremental process innovations. The study further indicates that a close collaboration between external actors and the focal firm is crucial in order to integrate external knowledge flow successfully. Additionally, we found that it seems beneficial to have an intermediary coordinating the external and internal knowledge flow. Compared to product innovation, the intermediary appears to be of higher importance in process innovation due to its obscure and systemic nature. As a consequence, it appears that including external actors in multidisciplinary meetings is a necessity in order to administer both internal and external knowledge flow.

Concerning the process innovation process, we found distinctions between the pre-project stage and the project execution. We discovered that suppliers were considered the most valuable collaborator, followed by universities. Further, it seems beneficial to engage in collaborations with suppliers throughout the process innovation process, whereas universities were only engaged in the pre-project stage. We found no implications that firms should engage in collaborations with customers or competitors. Moreover, in open process innovation, increased efficiency in the production line seems to be the primary motivation. Lastly, we found no evidence of co-creation in networks. Although, networks can be utilized to establish relationships that can be exploited in order to identify and obtain external knowledge.

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1 Introduction

«It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change. »
Charles Darwin

Nowadays companies experience an age of new realities where it is no longer feasible to build a sustainable competitive advantage based solely on static resources or products. Competitive advantages based on static resources or products quickly become obsolete if a firm is not agile enough to change in the same pace as the forces of the market (Teece, Pisano, & Shuen, 1997). Technology breakthroughs appear overnight, and no company is great enough to be sheltered from the fierce storm of competition. This is what D'Aveni (1995) refers to as hyper-competition, and for companies to survive in this environment, they need the ability to adapt to change. Moreover, to cope with hyper-competition a company needs to manage innovation efficiently. John Welch, former CEO of General Electric (Henceforth, GE) stated that "*if the rate of change inside an organization is less than the rate outside, the end is in sight*" (Smith, 1998, p. 279), implying the significance of innovation and innovation management.

Research suggests that a paradigm called *Open Innovation* (Henceforth, OI) might be the answer to stay competitive (Chesbrough, 2003; Laursen & Salter, 2006). Although the term has arisen in the last couple of decades, the concept has been present in business through all times. The OI paradigm suggests that companies should exploit external ideas and knowledge in addition to utilizing their internal knowledge base. Moreover, external channels to the market should be utilized in addition to internal channels. Further, this paradigm assumes that by doing so, the companies will generate more value and seek to advance their technology (Chesbrough, 2006, p. 1). Chesbrough (2003) stated that to successfully implement OI, firms must know how to integrate external knowledge into their existing knowledge base. Moreover, OI can be defined as "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively"* (Chesbrough, 2006, p. 1). Hence, the term refers to how companies can utilize external knowledge to enhance their internal innovation process or to commercialize their products and services through external channels.

There are various forms of openness, and the different types are characterized by whether the company seeks outside knowledge to accelerate internal innovation, or if the firm seeks to exploit internal knowledge through external channels. The former refers to inbound OI, while the latter refers to outbound OI. The different types of openness have their advantages and disadvantages and are suitable for various types of firms (Dahlander & Gann, 2010). In this thesis, inbound OI will be emphasized. The reasoning behind is that inbound OI tends to be more focused towards the company's core competencies and technologies. Gains derived from OI is often intangible and hard to observe (Sisodiya, Johnson, & Grégoire, 2013), although, West and Bogers (2014) claim that inbound OI is more easily observed and measured than outbound OI.

The conceptual literature on OI does not distinguish between different forms of innovation. Moreover, the vast majority of empirical research has focused on product innovation. However, due to the different characteristics of process and product innovation we claim that the existing literature does not necessarily apply to open process innovation. Thus, we would argue that there is a lack of research on how knowledge flows in inbound open process innovation. Therefore, for scientific and managerial purposes, we seek to examine how the characteristics of process innovation affect the practices for inbound OI.

In the research literature, two opposing views concerning the two types of innovation exists: the integrative view and the distinctive view. The integrative view considers product and process innovation as complimentary, whereas the distinctive view considers the two types of innovation as independent of each other (Damanpour, 2010). The integrative view can be based on, amongst others, the contribution of absorptive capacity (henceforth, AC). The reasoning behind is that firms need to hold a certain degree of AC, concerning both product and process innovation, in order to identify and exploit external knowledge (Guisado-González, Guisado-Tato, & Rodríguez-Domínguez, 2014). Although we acknowledge that product and process innovation might act interdependently in some contexts, we suspect that the practices for OI might differ between the two. We would claim there is a knowledge gap concerning open process innovation practices. Thus, for scientific and managerial purposes we discern the types of innovation and investigate open process innovation practices in isolation.

A combination of both product and process innovation leads to a competitive advantage, and this might be one of the reasons why firms can be reluctant to engage in open process innovation (Von Krogh, Netland, & Wörter, 2018). Thus, we seek to examine how the competitive impact of the production process affects open process innovation. Von Krogh et al. (2018) have made a six-step suggestion to successfully implement open process innovation meanwhile protecting the firm's intellectual property (Henceforth, IP). In their paper, the authors suggest further research on open process innovation because the primary focus has been openness in product innovation. Also, the authors state that for managerial purposes it is useful to examine what phases of process innovation could benefit the most from cooperation with external actors and with whom the firm should engage (Von Krogh et al., 2018).

We would argue that there is a lack of research concerning how organizations manage inbound knowledge flow throughout the phases of process innovation. Existing empirical literature concerning open process innovation, such as research conducted by Un and Asakawa (2015), focus solely on research and development (Henceforth, R&D). Moreover, Un and Asakawa (2015) investigate what external actors are beneficial in R&D collaborations in process innovation. The authors developed a theoretical framework for understanding why process innovation can benefit from external R&D collaborations and how these collaborations impact the process innovation within a firm. The authors differentiate between collaborators in two dimensions, where the first dimension is based on how close the collaborator is regarding contextual knowledge distance. Further, Un and Asakawa (2015) classify competitors and suppliers as close in contextual knowledge distance because they belong to the same business and possess a related knowledge base. The second dimension is based on where the collaborator is located in the knowledge chain. Customers and competitors are classified as downstream, while universities and suppliers are upstream of the focal company. Position in the knowledge chain refers to where the actor is located regarding the supply chain (Un & Asakawa, 2015). The contribution of this research notwithstanding, we would argue that it is useful to investigate how organizations search for, obtain and integrate external knowledge flow throughout the phases of open process innovation. Further, for scientific and managerial purposes, we claim it is useful to investigate what benefits an organization can capture from the collaboration and what mechanisms can be utilized to facilitate open process innovation.

Un and Asakawa (2015) discuss the limitations of their study and mention that they do not provide details concerning the characteristics of collaboration in process innovation. Further, the authors acknowledge that the research does not study the mechanisms facilitating open process innovation. Therefore, we seek to examine what mechanisms and instruments firms utilize to facilitate collaboration in open process innovation. Moreover, the authors limit their research to include suppliers, competitors, customers, and universities as the R&D collaborators, whereas this thesis will not be restricted to specific collaborators. We want to examine all possible external actors including but not limited to: consultants, suppliers, customers, research institutes, competitors, users, authorities, participants in clusters and universities.

Concerning inbound OI, West and Bogers (2014) introduced a framework for explaining this paradigm. The authors developed a four-phase model consisting of four dimensions, respectively: obtaining, integrating, commercializing and interaction mechanisms. The dimension of obtaining includes searching, sourcing, enabling and contracting of inbound knowledge flow. The dimension of integrating innovations concerns factors that enable integration and how the firm internalize the external knowledge. Commercializing includes creating and capturing value from the external knowledge flow. Interaction mechanisms have been added to the model in order to demonstrate that the process of innovation is nonlinear. The reciprocal interaction with external actors happens throughout the process (West & Bogers, 2014). Although, the reciprocal interaction is not always assigned to a specific phase in the innovation process. West and Bogers (2014) further address a lack of research concerning the dimensions of integrating and commercializing external knowledge flow. Thus, our study contributes to the existing literature through investigating all four dimensions. Moreover, we examine open process innovation practices and utilize West and Bogers (2014)'s four-phase model as a framework for this study, as depicted in Table 1.

Table 1: Illustration of our findings in regards to West and Bogers (2014)'s framework.

Phases of Process Innovation	Obtaining	Integrating	Commercializing	Interaction Mechanisms
Phase 1				
Phase 2				
Phase 3				
Phase 4				

It is evident that more effort should be devoted in order to reveal practices for open process innovation. Therefore, the objective of this study is to diminish the knowledge gap concerning open process innovation practices, which leads to the following research questions:

> *"How do firms search for and obtain external knowledge during process innovation processes?"*
>
> *"How do firms integrate external knowledge during process innovation processes?"*
>
> *"How do firms capture benefits from open process innovation processes?"*
>
> *"How do firms utilize various interaction mechanisms in order to facilitate open process innovation?"*

In total, the thesis consists of 5 chapters. Chapter 2 consists of a literature review where theoretical and empirical literature is addressed to construct the theoretical framework for our study. Further, in chapter 3, we explain our choice of research design and qualitative methods, as well as justifying our selection of company. In chapter 4, we present our findings followed by a discussion and conclusion in chapter 5. In the discussion and conclusion chapter, we have included theoretical implications, managerial implications, and considerations for further research.

2 Literature Review

In the literature review, we focus on relevant theory and empirical literature to address the research questions. The chapter starts with an explanation of the concept OI and a brief introduction to its history, and further, a comparison of open and closed innovation is given. Subsequently, we review the empirical literature of the dimensions within OI, where the focus is on inbound OI and West and Bogers (2014)'s four-phase model. Further, we address process innovation, and the chapter ends with a theoretical discussion concerning open process innovation. Moreover, we address the different characteristics that distinguish process innovation from product innovation and how it can affect OI practices.

2.1 Open Innovation – The Concept

Before we start elaborating on OI, it is useful to define innovation to get a better grasp of what OI concerns. Du Plessis (2007) defines innovation as follows:

> *"Innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services. Innovation encompasses both radical and incremental innovation."* (p. 21).

The term innovation has its origin from the Latin word "innovare," which means to renew or to create something new (Høyer, 2009). A distinction is often made between the term invention and innovation, where an invention is the first existent of the idea and the innovation is the first commercialization of the idea. Several types of knowledge, capabilities, resources, and skills are required of a firm to turn an invention into an innovation (Fagerberg, 2003).

2.1.1 History of Open Innovation

Although the term OI has become a hot topic the last decades, the concept is not revolutionary. Through all times, firms have been utilizing inputs from outsiders to improve their internal innovation processes or to exploit outside channels to commercialize what has been developed internally. With increasing global competition and core competencies continually becoming more specialized and narrow, the need for cooperation between firms magnifies (Huizingh, 2011). Although Chesbrough (2006)'s definition of OI is probably the most commonly used, there are various definitions of this concept, as depicted in Table 2.

Table 2: Definitions of Open Innovation.

(Chesbrough, 2003, p. xxiv)	Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology
(Gassmann & Enkel, 2004, p. 2)	Open Innovation means that the company needs to open up its solid boundaries to let valuable knowledge flow in from the outside in order to create opportunities for cooperative innovation processes with partners, customers and/or suppliers. It also includes the exploitation of ideas and IP in order to bring them to market faster than competitors can
(Chesbrough, 2006, p. 1)	Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively
(Dittrich & Duysters, 2007, p. 512)	The system is referred to as open because the boundaries of the product development funnel are permeable. Some ideas from innovation projects are initiated by other parties before entering the internal funnel: other projects leave the funnel and are further developed by other parties
(Terwiesch & Xu, 2008, p. 1529)	There exist a rapidly growing number of innovation processes that rely on the outside world to create opportunities and then select the best from among these alternative for further development. This approach is often referred to as Open Innovation
(Johannsson et al., 2015, p. 173)	The process of strategically managing the sharing of ideas and resources entities to co-create value

Opening up the innovation process for external actors is the premise of OI. Only a few differing focus areas and formulations distinguish these formulations of definitions.

2.1.2 Open Innovation vs. Closed Innovation

Chesbrough (2003) introduced the paradigm termed OI. The old paradigm is termed Closed Innovation, where the innovation process arises inside the firm through internal ideas. Moreover, the focus is solely towards internal activities, investing in internal R&D to deliver new products and services. In the course of time, companies have faced different challenges concerning delivering the products and services to market in time. Further, the shelf life of technology has become shorter. Additionally, suppliers and customers have become more knowledgeable. This is due to the accessibility of knowledge through the internet and an increase in transparency. Moreover, the paradigm OI was introduced, where it suggests that companies could utilize both external and internal ideas (Chesbrough, 2003, pp. xx - xxiv). Closed Innovation and OI is illustrated in Figure 1 and Figure 2, respectively.

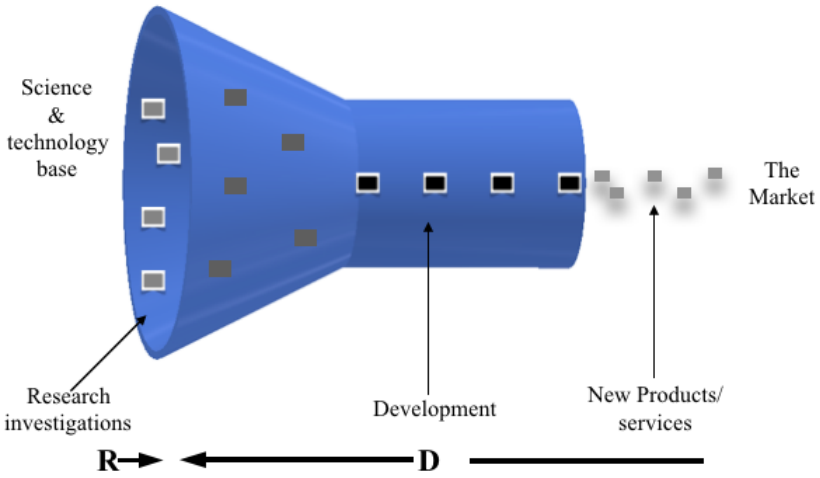

Figure 1: Closed Innovation Paradigm (Chesbrough, 2006, p. 2)

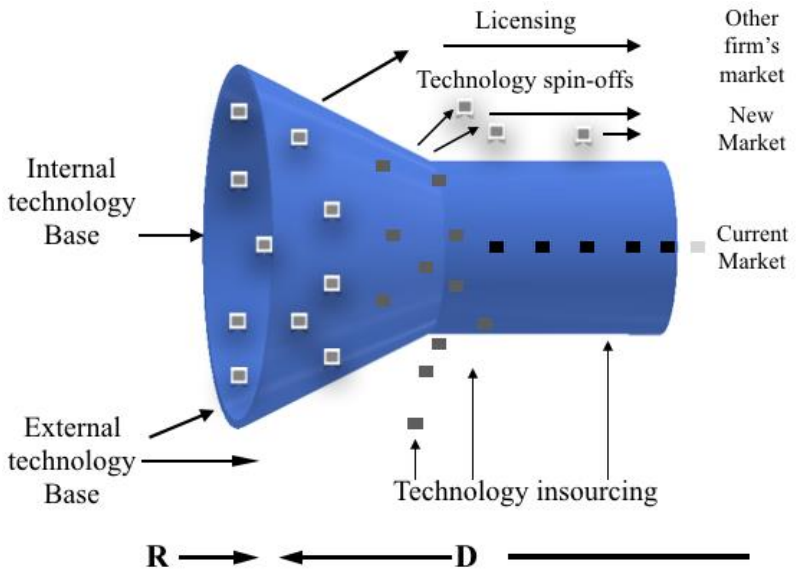

Figure 2: Open Innovation Paradigm (Chesbrough, 2006, p. 2).

The paradigm of OI focuses on the fact that knowledge flow can be managed in a way that will benefit the company through sharing knowledge and innovations, instead of excluding it from external actors. Firms benefit most through combining internal and external knowledge to create new products and services. Also, companies should make use of the technology that is available on the market, instead of waiting for internal innovations to arise. OI also shed light on the importance of firms' ability to expose their technology to an extended market through licensing out (Chesbrough, 2006, pp. 1-9).

West, Vanhaverbeke, and Chesbrough (2006) emphasize that "*Open Innovation is both a set of practices for profiting from innovation, and also a cognitive model for creating, interpreting, and researching those practices*" (p. 286). Therefore, this literature review includes different cognitive models developed in the last decade, with the focus on West and Bogers (2014)'s four-phase model.

2.2 Inbound Open Innovation

OI can be divided into two main categories: inbound OI and outbound OI. The former revolves around how external knowledge is utilized internally, while the latter concerns how internal knowledge is exploited externally (Huizingh, 2011). Inbound OI will further be elaborated as we seek to investigate how firms obtain and integrate external ideas and knowledge. Therefore, outbound OI will not be included in our discussion. The focus will further be on West and Bogers (2014)'s four-phase model, which revolves around inbound OI.

Firms must have the ability to utilize external knowledge and incorporate it into their existing knowledge base in order to benefit from OI. West and Bogers (2014), therefore, developed a four-phase model concerning how firms can leverage and profit from external sources of innovation, as illustrated in Figure 3.

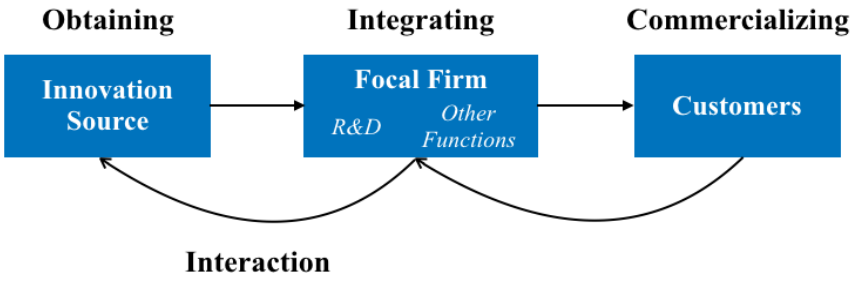

Figure 3: Four-phase Model (West & Bogers, 2014).

West and Bogers (2014)'s framework is a result of empirical research concerning open product innovation, and thus the findings might not be applicable in open process innovation. Further, in order to use the model as a framework, we will adjust the dimensions where we find it necessary to make it applicable to open process innovation.

2.2.1 Obtaining

The first dimension within this framework is obtaining external sources of innovation. Moreover, it includes acquiring new knowledge, such as new technology or market knowledge (West & Bogers, 2014). It is important that the obtained sources of innovation are valuable knowledge that can potentially enhance the firm's innovation process (Foss, Lyngsie, & Zahra, 2013). Therefore, it is essential that firms can recognize the most profitable sources of innovation efficiently (West & Bogers, 2014). This is important in order to profit from the resources invested in obtaining external actors. However, it can be challenging to identify what external knowledge is useful for the firm (West & Gallagher, 2006b, p. 84). To obtain external sources of innovation, the firm needs to expand the search strategies and scan across numerous search channels (Laursen & Salter, 2006). Concerning the search process of obtaining external knowledge, Laursen and Salter (2006) introduced two new concepts: *search breadth and depth*. The former refers to "*the number of external sources or search channels that firms rely upon in their innovative activities*," while the latter refers to "*the extent to which firms draw deeply from the different external sources or search channels*" (Laursen & Salter, 2006, p. 134). Further, the authors found that firms tend to become more innovative when having open-search strategies. In order to successfully obtain and exploit external knowledge, various routines should be established (Von Krogh et al., 2018).

2.2.1.1 Different ways to obtain knowledge

Knowledge can be obtained through both inbound closed innovation and inbound open innovation. Research conducted by Kim, Kim, and Foss (2016) emphasizes that to successfully improve the firm's innovative performance it is essential to shift between these two types of inbound innovation. Inbound closed innovation refers to the firm's internal search strategies and is defined as "*leveraging prior organizational knowledge to absorb new technological knowledge residing in other units in an organization*" (Kim et al., 2016, p. 81). Inbound OI refers to firms' external search strategies and obtaining new external knowledge (Kim et al., 2016). It is required that the company can recognize new valuable knowledge in other units within and outside the firm's boundaries.

OI allows the use of external sources of knowledge and the study conducted by Dahlander and Gann (2010) address various types of openness. Moreover, Sourcing and acquiring relates to inbound OI and will further be addressed.

Inbound OI - Sourcing (non-pecuniary):

Sourcing refers to how firms can access and utilize the external sources of innovation without involving a financial transaction. Firms must incorporate the external knowledge flow in their internal process through creating synergies between their internal and external resources (Dahlander & Gann, 2010). Within this type of openness, Laursen and Salter (2006) address the importance of not over-searching for external sources of knowledge flow as it can have a negative impact on a firm's innovation performance. Additionally, the authors indicate that firms can be too dependent on external sources of innovation, which can further lead to a decrease in the firm's internal innovation performance. This further indicates that firms must draw attention to what external sources they need and combine these with their internal resources to enhance their innovation performance.

Inbound OI-Acquiring (pecuniary):

Dahlander and Gann (2010) define acquiring as how firms can access external resources, such as expertise and licenses, through the marketplace. The authors state that there are several advantages of buying or in-sourcing external resources. However, they emphasize that expertise is required to scan and evaluate the external knowledge flow. Although, Sapienza, Parhankangas, and Autio (2004) address knowledge relatedness and discover challenges concerning integrating unrelated knowledge into the existing knowledge base of the firm. On the other hand, it is hard to arrive at novel combinations if the knowledge bases between the acquiring and the acquired actor are too similar (Sapienza et al., 2004).

2.2.2 Integrating

The second dimension within this framework is integrating external knowledge flow within the firm's R&D activities. Firms have to be able to integrate the external knowledge obtained to enhance their innovation process. West and Bogers (2014) investigate the AC perspective for integrating innovations and further examine how culture and competencies influence the integration process.

2.2.2.1 Absorptive Capacity

AC can be defined as "*the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends*" (Cohen & Levinthal, 1990, p. 128). Thus, it is an essential factor to integrate the external knowledge within the firm successfully. AC is a function of the organization's prior level of knowledge, and the AC of the firm is dependent on the absorptive capacities of its individual members. Moreover, firms need to develop both capacities and resources to attain a competitive advantage (Barney, 1991). To advance their internal innovation, companies need the capacity to integrate and exploit both internal and external knowledge flow. Additionally, it requires capacities to combine and create synergies between external and internal knowledge (Lichtenthaler & Lichtenthaler, 2009).

AC is a critical factor to increase a firm's innovative performance and more research is needed concerning the connection between integration and AC (West & Bogers, 2014). Later research conducted by Kim et al. (2016) state that AC is a critical component to organize OI activities successfully. Moreover, firms have the opportunity to achieve higher innovation performance through balancing both inbound closed innovation and inbound open innovation, and AC (Kim et al., 2016). Rosenkopf and Nerkar (2001) also underline the importance of balancing both closed innovation and OI in their study, where they state that "*gains associated with the internal development of technology are not sustainable unless the organization is able to integrate external developments*" (Rosenkopf & Nerkar, 2001, p. 292). Additionally, Lichtenthaler and Lichtenthaler (2009) underline the need for AC in the integration process. However, the authors expand the integrative perspective by merging AC with knowledge management and dynamic capabilities in their capability-based framework. Moreover, the framework focuses on increasing the firm's ability to manage internal and external knowledge in OI processes. Also, it intended to develop an

integrative perspective through merging dynamic capabilities, absorptive capacity and knowledge management. Further, it is essential to explore new knowledge internally, as well as maintaining and reactivating knowledge in interfirm relationships (Lichtenthaler & Lichtenthaler, 2009).

2.2.2.2 Organizational Culture

In order to integrate external knowledge successfully, it is required that organizations hold a compatible culture to eliminate the "not invented here" syndrome. However, more research is needed concerning the connection between integration and organizational culture (West & Bogers, 2014). Moreover, an organizational culture aiming for innovation creates an environment that facilitates the complex process of social exchange which is essential to succeed in OI activities (Chatman, Doerr, Caldwell, & O'Reilly, 2014). This is also underlined by West and Bogers (2014), which emphasize the effect organizational culture has on integrating the external knowledge flow regarding the firm's capability and willingness to attain profit from the external sources.

Companies holding a culture promoting innovation seems to have a competitive advantage on several performance indicators (Chatman et al., 2014), which indicates the importance of organizational culture to implement OI successfully. Moreover, it is imperative to create an organizational culture that appreciates external knowledge in order to benefit from OI (Naqshbandi, Kaur, & Ma, 2015). Further, Mazur and Zaborek (2016) have investigated organization culture and OI performance in Small and Medium-sized enterprises (SMEs). Their findings imply that a culture's ability to nurture innovations can be characterized by 1) creativity and risk taking, 2) internal cooperation and 3) learning focus. Additionally, their findings indicate that these characteristics lead to greater innovativeness, operational and financial performance and extent of sources to OI. This is consistent with some of the findings of Dobni (2008), which emphasize that "*a culture supporting innovation engage behaviors that would value creativity, risk taking, freedom, teamwork, be value seeking and solutions oriented, communicative, instill trust and respect, and be quick on the uptake in making decisions.*" (p. 544).

2.2.2.3 Organizational Structure

The study conducted by Menguc and Auh (2010) also shed light on how the power structure within an organization influences the innovativeness of a firm. Moreover, companies with a more rigid and bureaucratic structure might restrict exploration, experimenting, creativity, and risk taking which can further impact the culture's ability to enhance the company's innovation processes (Menguc & Auh, 2010). Further, companies have to create an organizational culture that nurtures the willingness to take risks and experiment to profit from OI (Hillestad & Yttri, 2016). However, having a rigid and formalized structure can in certain situations be appropriate. This type of structure nurtures transparency and clarity and can be appropriate when tasks are characterized by routines and a low degree of complexity (Menguc & Auh, 2010). Zheng, Yang, and McLean (2010) findings also imply that OI is affected by how centralized the power is within a firm. Having a centralized power structure is characterized by the authority being concentrated in the upper levels of the organization. This form of organizational structure may lead to more formal procedures and less flexibility. A more decentralized design of the power structure may, on the other hand, initiate flexibility and open communication between functions both vertically and horizontally (Zheng et al., 2010).

2.2.3 Commercializing

The term commercializing is often referred to as the process of bringing a new product out on the marketplace. The term is not applicable to our research as our study concerns process innovation. Moreover, West and Bogers (2014) primarily focus on product innovation and the realization of gains will be different in process innovation and product innovation. The term value creation will in process innovation mean cooperating with external actors to reduce costs or environmental impact, increase capacity or productivity and otherwise enhance the process. Value capture, on the other hand, is to reap the benefits of the value creation. In product innovation, this refers to getting the product out in the marketplace, whereas in process innovation it concerns the implementation of the process innovation. We would argue that for the four-phase model to apply in open process innovation, small adjustments need to be made. Therefore, we further choose to use the term capturing benefits instead of commercializing.

West and Bogers (2014) postulate that if the internal innovations are considered a competitive advantage for the organization, relying on external innovation may reduce the differentiation from competitors and further the competitive advantage. It is recommended to only source commodity products to eliminate the risk of reducing the competitive advantages (West & Gallagher, 2006a). Further, it is suggested to acquire the supplier (Christensen, Olesen, & Kjær, 2005), or the firm could source on an exclusive basis to avoid the problem (Chesbrough & Crowther, 2006).

West and Bogers (2014) state that the aim of commercializing innovations is to create and capture value from external knowledge. Several researchers have focused on the potential of value creation of external knowledge. However, West and Bogers (2014) shed light on a research gap concerning how firms can capture value from the external contribution. Some research has found cost reduction as a secondary motive for implementing OI (Chesbrough & Crowther, 2006). Additionally, van de Vrande, de Jong, Vanhaverbeke, and de Rochemont (2009) study of small- and medium-sized enterprises (SMEs) revealed that cost reduction as a motive was not as prominent as market-related motives for pursuing OI practices.

2.2.4 Interaction Mechanisms

Berkhout, Hartmann, Van Der Duin, and Ortt (2006) highlights the cyclic nature of innovation processes and a linear model, as Chesbrough (2006) presented in his work, thus becomes idle. West and Bogers (2014) state in their research that the unidirectional three-step model was not a thorough description of how innovation is conceived in either research or practice. Hence, the interaction mechanism was added to the model, which include various interactive processes, such as feedback loops and reciprocal exchange of knowledge. Moreover, Mortara et al. (2010) have developed a framework for obtaining external knowledge through iterative feedback processes. Another example of a feedback loop is the iterative "probe and learn" model. This approach lets firms commercialize discontinuous innovations while receiving market feedback (Lynn, Morone, & Paulson, 1996). Furthermore, a firm enters the marketplace with an early version of the product, learn from the feedback they receive and modify the product before launching an improved version.

West and Bogers (2014) further highlight the reciprocal exchange of knowledge with external actors. The exchange can happen through dyadic relationships or networks and communities. These sources can also be utilized to identify relevant external sources of innovation. Many researchers have found interest in these cooperative innovation process mechanisms and have examined the relationships and why companies engage in OI (West & Bogers, 2014). As seen in West and Bogers (2014)'s four-phase model, the interaction may occur at any stage of the innovation process. A substantial body of research has examined the reciprocal exchange of knowledge, and the most common area of research is the dyadic co-creation. This type of relationship is between the focal firm and a single external actor. The collaborators are often universities, competitors, suppliers and non-profit organizations (West & Bogers, 2014). Research is repeatedly concerning the importance of these external actors as collaborators (Neyens, Faems, & Sels, 2010; Un & Asakawa, 2015). Further, technology facilitates knowledge flow in a reciprocal exchange of information and ideas. Moreover, Dodgson, Gann, and Salter (2006) introduced a new term, referred to as Innovation Technologies (Henceforth, IvT), which entails interaction enablers such as simulation, virtual reality, and rapid prototyping. These technologies affect the way knowledge is composed, shared and exploited. Further, IvT can affect what collaborations a firm engage in, where it enables visualization of the innovations for other parties, such as users (Dodgson et al., 2006).

Another type of interaction is the use of networks. Firms can engage in networks through industry relationships, geography-based networks and with public research networks (West & Bogers, 2014). West and Bogers (2014) also mention the reciprocal exchange of knowledge happening in communities. Further, communities can be described as a voluntary association of actors where the participants have group loyalty and membership (West & Lakhani, 2008). Notwithstanding the amount of research, we would argue that empirical literature is necessary to investigate how engagement in networks and communities affect open innovation practices. Moreover, being a part of communities or networks may influence the way a company interacts with external actors, although, it does not necessarily mean that the firm has implemented OI.

2.3 Process Innovation

Product innovation refers to a new product or service, while process innovation refers to how an existing product is produced. Although, a new machine can be product innovation for one company, while it incorporates in the process innovation of another. For our case study, we have chosen to focus on process innovation, and further how open process innovation is managed. We have chosen to distinguish process innovation from other forms of innovation. Furthermore, process innovation can be defined as: *"the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software). [..]"* (Union, 2006, p. 10).

The reason for desiring process innovation is often the necessity of reducing the processing time and cost or increasing the quality of a product. Decreasing the processing time can reduce costs and time to market or customer. It is possible to shred some of the costly parts of the production process, and the savings can be passed on to the customer. This way, the company can deliver a cheaper product without affecting the quality (Davenport, 1993). Moreover, a driver for innovation can be to reduce waste and environmental impact. The process innovations can be a result of regulations and legislation, although, profitability and public perception is also an incentive to improve the sustainability of the processes. Despite its reputation as a cause of environmental degradation, new technology has in recent times been recognized as a critical driver for sustainability (Jenck, Agterberg, & Droescher, 2004).

Another reason for process innovation is customer demand. For instance, if customers demand higher quality, new product specifications or faster delivery, the company has to satisfy these needs to stay competitive. Process innovation might also lead to improved management and coordination in-house. For example, better communication processes between sales and manufacturing can lead to production being in balance with customer needs (Davenport, 1993).

Davenport (1993) has created a framework for process innovation which consists of five stages. He states that the company has to start with the identification of processes for innovation. Further, the company needs to identify innovation enablers. After identifying the enablers, the development of vision concerning a new process can commence, continued by understanding and measuring the current process. Finally, the design and prototyping of the new processes can be initiated. Although sequentially presented, Davenport (1993) states that these steps are not definite and the sequence may vary.

While Davenport (1993) states that technology innovations act as process innovation enabler, other researchers claim that the relationship is of significantly higher complexity (Damanpour, 2010). Despite the discussion of distinguishing research concerning process innovation from product innovation, the characteristics of the two innovation types differ. A description of the differing characteristics of process innovation and product innovation is depicted in Table 3.

Table 3: Product vs. Process Innovation (Un & Asakawa, 2015).

Aspect	Product innovation	Process innovation
The objective of innovation	Attaining a new/improved product to gain a competitive advantage (Un & Asakawa, 2015)	Efficiency in the way the company handles its operations (Ettlie & Reza, 1992; Hatch & Mowery, 1998)
Competitive impact	Can charge the customer a higher price for a new and innovative product (Un & Asakawa, 2015)	Reducing cost of manufacturing and thereby increasing the profit (Ettlie & Reza, 1992; Reichstein & Salter, 2006)
Valuation of the innovation	The customers value how good the new/improved product is by comparing it to competitors (Damanpour, 2010)	The managers or leaders value the transformed process by measuring reduced costs and/or efficiency increase (Repenning & Sterman, 2002).
The requirement of rareness	More focus on achieving novelty products to meet new or unmet needs of markets (Danneels, 2002; Un, 2010)	More focus on improvements to reduce costs (Clark & Fujimoto, 1991; Stadler, 2011, Womack, Jones, & Roos, 1991)
Complexity of codification	Relatively easy for competitors to imitate features (Hatch & Mowery, 1998)	Difficult to copy due to tacit knowledge and it is less visible to actors outside the firm (Hatch & Mowery, 1998)
Location of knowledge	Expert teams developing new technology (Un & Asakawa, 2015)	Different departments co-operating to create the best process for all interdependent departments (Ettlie & Reza, 1992; Repenning & Sterman, 2002)

2.4 Open Process Innovation

Concerning the conceptual studies on OI, process innovation is seldom distinguished from product innovation. Further, the empirical literature often focuses on open product innovation. The research on open process innovation is limited, although this chapter concerns some of the existing literature.

Un and Asakawa (2015) claim in their study that two dimensions affects the outcome of collaborations in process innovation, as illustrated in Figure 4. The authors solely focus on R&D collaborations, and thus we seek to investigate the entire process innovation process. The two classifications of dimensions are contextual knowledge distance and position in the knowledge chain. The former is explained by how similar the industry of the R&D collaborator is to the focal firm, and the latter is related to upstream and downstream collaborators. The authors further consider universities and suppliers as upstream collaborators whereas the customers and competitors are downstream. The reasoning behind is the position in the knowledge chain of the industry, where the transformation of raw materials eventually leads to products delivered to the end customer.

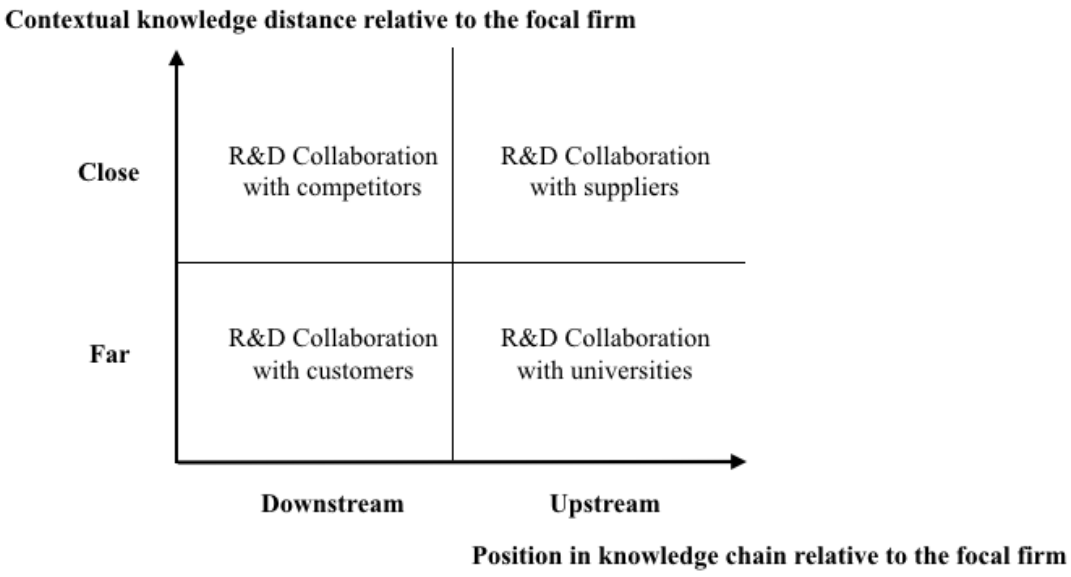

Figure 4: Illustration of the four types of R&D collaborations in regard to the contextual knowledge distance and position in the knowledge chain (Un & Asakawa, 2015).

Un and Asakawa (2015) state that contextual knowledge distance is not affecting the outcome of the collaboration in process innovation as much as position in the knowledge chain. Further, the authors emphasize that it is beneficial in product innovation to collaborate with actors downstream of the focal firm, while process innovation seems to greater benefit from upstream collaborations with suppliers and universities. The reasoning behind is that collaborators need to have interests in streamlining the process, and not solely focus on the product. Customers mainly care for the product, whereas suppliers and universities may be more interested in improving the efficiency of the production process. Un and Asakawa (2015) further reveal that the cooperation with universities and suppliers leads to enhanced process innovation. It appears that cooperation with customers has no impact, and collaboration with competitors seemingly has a negative impact (Un & Asakawa, 2015). In fact, prior studies have revealed that collaboration with competitors has a negative influence on product innovation as well. The reason for this negative influence is because firms strive to retrieve knowledge from competitors, and at the same time keeping the firm's resources and capabilities related to the competitive advantages confidential (Lhuillery & Pfister, 2009).

Midttun and Ørjasæter (2012) investigate how OI intensifies process innovation. The authors address how the multiplier effect arises when the focal firms, Statoil and Hydro, exploit the knowledge of their network, and also benefits from the knowledge of their networks' network. For Statoil and Hydro as project owners, this is a matter of process improvement regarding how to enhance the extraction and production of oil and gas (Midttun & Ørjasæter, 2012). On the other hand, we would argue that it is hard to distinguish between process and product innovation due to the size of the project. For suppliers, research departments and operators it might be a matter of product development, which is initiated due to the process innovation requested by Statoil and Hydro. Moreover, Midttun and Ørjasæter (2012) address the collaboration in systems and clusters and focus on the coordination and management of these relationships. However, the different phases of open process innovation and how the focal firm integrates external knowledge is not addressed. Therefore, we seek to contribute by developing theory concerning when firms should absorb external knowledge, and how it should be integrated into their existing knowledge base.

Salte (2007) concludes their study, concerning innovation in Norwegian industry, with a statement that firms performing either in the process or product innovation takes great advantage of cooperation with external actors. An impressive 70 percent of firms, which the author classified as cooperative innovators, considered the innovation activities as successful. Compared to independent innovators, which considered approximately half of the innovational initiatives as successful, indicating that cooperation is enhancing the innovation activities. Unlike Un and Asakawa (2015), this study reveals that firms considered customers as the most beneficial cooperator. Salte (2007) does not distinguish between open product and open process innovation, it is, therefore, difficult to say if the findings apply to both. Sandven (2007) found that most firms classified as innovative conducts both product and process innovation interchangeably. Nevertheless, we would argue the results can be distorted by merging the two types of innovation and can further present ambiguous findings. Therefore, we find it necessary to investigate open process innovation separate from product innovation.

Due to the lack of empirical research, we will highlight the characteristics that might impact open process innovation practices, as depicted in Table 4. We anticipate that the practices for open process innovation might differ from open product innovation due to different characteristics. For instance, process innovation requires more internal coordination and cooperation between departments in a firm, whereas product innovation is often led by a group of technology experts (Un & Asakawa, 2015). Moreover, we anticipate that the systemic nature of process innovation might complicate the integration of external knowledge and make the open process innovation process more complicated. The innovation will alter several departments and areas of production, and we anticipate that it is more complex to coordination the information and knowledge flow, both internally and externally.

Compared to product innovation, the processes within a company are less visible to outsiders, and thus it might be harder to implement OI and further benefit from outsiders' knowledge (Huizingh, 2011). Hatch and Mowery (1998) further state that process innovation requires a higher level of tacit knowledge than product innovation. Moreover, we anticipate that this will affect the practices for open process innovation. For this reason, we claim that empirical literature is needed to address how firms integrate external knowledge, and what external actors they choose to engage.

The competitive advantage for firms is often a result of the combination of process and product innovation (Von Krogh et al., 2018). Additionally, Grant (1996) claims that an organization's ability to keep the competitive advantage is related to how imitable the advantage is. Nevertheless, Von Krogh et al. (2018) further claims that keeping the process innovation closed deprives companies of valuable external ideas. However, the production process is harder to imitate due to being less visible to outsiders and more complicated to codify (Hatch & Mowery, 1998). Hence, we assume that it is easier to keep the competitive advantage related to process innovation confidential. Further, to attain valuable external knowledge and at the same time protect the competitive advantage, we anticipate that the practices for open process innovation might differ from open product innovation. For this reason, we would argue that empirical literature is needed to investigate how the characteristics of process innovation influence the open process innovation practices.

Further, the success factors are different in process innovation compared to product innovation (Lager & Hörte, 2002). Process innovation has its emphasis on reducing costs (Ettlie & Reza, 1992; Reichstein & Salter, 2006), tacit knowledge (Hatch & Mowery, 1998) and efficiency (Ettlie & Reza, 1992; Hatch & Mowery, 1998). In product innovation, customers value the new or improved product and compare it to the competitors' products (Repenning & Sterman, 2002). Kristensson, Matthing, and Johansson (2008) claim that even the most brilliant innovation will fail unless it meets the needs of the market, and thus customer involvement in co-creation is beneficial for open product innovation. Although, for process innovation, the valuation is considered in terms of increased efficiency or quality, and is performed by managers or leaders within the organization (Repenning & Sterman, 2002). For this reason, we assume the various collaboration partners will have a different impact on open process innovation than in open product innovation.

Releasing an immature version of a product only makes sense if the organization can develop the technology further, learn about the market and what market segments are receptive to the different features of the product (Lynn et al., 1996). For product innovation, this approach seems reasonable because one objective is to achieve a novelty product to meet new or unmet needs of markets (Danneels, 2002; Un, 2010). For process innovation, on the other hand, it is rather about improving the production process to increase efficiency or quality than commercializing innovations (Clark

& Fujimoto, 1991; Stadler, 2011; Womack, Jones, & Roos, 1991). Moreover, process innovations are not released on the market and evaluated by customers, the valuation of the innovation is performed by managers and leaders (Repenning & Sterman, 2002). The valuation is performed internally, and thus the need for the novelty to impress customers is deprived. Further, we anticipate that this might affect what collaborators an organization choose to engage in open process innovation. A presentation of the different characteristics we anticipate will affect open process innovation is depicted in Table 4.

Table 4: Characteristics of process innovation and the anticipated impact on open process innovation practices.

Process Innovation Characteristics	**Anticipated Impact on Open Process Innovation Practices**
Systemic nature - several departments and areas of production cooperate to create the best solutions	External actors need to attain a holistic understanding • Might affect what collaborators are engaged and require more effort to coordinate internal and external knowledge flows
The requirement of tacit knowledge	• Might affect how the firm collaborate with the external actors and whom they choose to engage
The resources and capabilities related to the competitive advantage is less visible for external actors and harder to imitate	• Might affect whom they choose to engage and how they interact with the external actors
The valuation of the innovation is performed internally	• Might affect what actors are suitable for collaboration

3 Method

To ensure we would suitably approach the research questions, we used Jacobsen (2005)'s model for constructing our research. In this chapter, we will cover the choice of research design and qualitative methods. Additionally, we justify the selection of company, individuals, and secondary data. Further, we describe how the qualitative data has been collected and analyzed. Lastly, the validity and reliability of the result will be included in chapter 5.3.

The research has been conducted through an abductive approach, which is a combination of a deductive and inductive method. The abductive approach is driven by both theory and empiricism. However, the study is leaning towards an inductive method and empiricism has been collected through a qualitative method. Further, we seek to answer the research questions in light of West and Bogers (2014)'s four-phase model and examine if the framework applies to open process innovation.

3.1 Research Design

Jacobsen (2005) underlines that the choice of research design is crucial for the research' validity, as the various types are suited for specific types of research questions. A common distinction of research design is between extensive and intensive strategies, which generally illustrates the distinction between quantitative and qualitative research (Leseth & Tellmann, 2018, pp. 34-35). We have chosen an intensive design as we have conducted qualitative research with few informants and several variables. Moreover, our research is in depth and is conducted through a single case study.

A single case study is appropriate when researchers seek to explore a phenomenon while preserving the richness of the studied event and its context (Eisenhardt & Graebner, 2007). Thus, we found it appropriate for our research questions to conduct this type of study. Moreover, we wanted to attain a deep and broad understanding of how open process innovation was managed by a company. Case studies are suitable when the knowledge in a research area is scarce, and the objective of the research is to identify new phenomenon and aspects (Eisenhardt, 1989; Yin, 2003). Considering the lack of research concerning open process innovation, we found it reasonable to use case study

for our research. Larsen (2007) claims that qualitative methods are well suited when researchers seek to develop a holistic understanding of a phenomenon. Thus, we have chosen a qualitative approach as we seek to attain a comprehensive understanding of GE Healthcare's process innovation. Moreover, qualitative data has been obtained through interviews and analyzing project documents. Further, the design has been observation-based.

Qualitative data has been obtained through interviews and is considered as primary data. We have analyzed documents from various projects, which contributes as secondary data. We sought to attain sufficient and essential information from key informants, and thus in-depth interviews were conducted. Also, most of the existing empirical literature does not distinguish between process and product innovation. For this reason, we have conducted a qualitative case study to investigate process innovation in depth, separately from product innovation.

3.2 Selection of Company

To answer our research question in the best manner, we wanted to examine a highly innovative company. Therefore, we have chosen to conduct a single case study of GE Healthcare and their department located in Lindesnes. GE Healthcare has its own innovation initiative called *"Healthymagination,"* and confirms our impression of GE Healthcare as a highly innovative firm. The firm defines the initiative as an innovation catalyst and further state that the organization is "*challenging the status quo and exploring new, unexpected partnerships, technology, pilots and programs to drive better health through innovation"* (General Electric, 2018d), implying they are engaged in open innovation as well. On their homepage, GE Healthcare claims that "*Openness and collaboration are key characteristics of this new, digitally driven wave of innovation*"(Annunziata, 2018) and is a strong implication that this company is well suited for our thesis.

Further, we sought to find a company where process innovation could easily be distinguished from product innovation. GE Healthcare's department in Lindesnes mainly process chemicals into contrast medium, and thus the product development is limited. Moreover, GE Healthcare's desire to reduce the environmental impact has become a driver for innovating the production processes. In 2004, GE Healthcare Lindesnes decided that the energy consumption per produced unit was to be reduced by 70 percent by 2020. In 2015, the organization had reduced the energy consumption

by 53 percent and achieved an annual saving of 50 MNOK, indicating a lot of innovative initiatives had taken place (Delta V, 2015).

GE Healthcare focuses on innovative measures and has been honored on the list of "The World's Top Ten Most Innovative Companies of 2018 in Biotech" by *Fast Company*. On April 11th in 2018, GE Healthcare won silver for the best new product in digital imaging at the *Edison Awards* for launching new technology that helps make a mammogram more comfortable (Edison Awards, 2018). The parent company of GE Healthcare, General Electric, has developed the GE Global Innovation Barometer. This barometer measures the perception, including both business leaders and the public, of innovation and how they see the framework for innovation in their country (GE, 2016; General Electric, 2018a). Further, the firm have a daily news, video and social media hub, called GE Reports, where they write about GE's business, innovation and digital transformation (General Electric, 2018b).

Further, Ecomagination is a strategy within GE and is an initiative towards resource productivity and reducing environmental impact. This strategy involves investments in cleaner technology, business innovation, reducing the use of water and establishing strategic partnerships to solve some of the toughest challenges concerning environmental impact. These partnerships are a clear sign of OI, and the partners are innovative companies in the oil and gas industry, industrial, manufacturing, power, retail and water treatment sectors (General Electric, 2018c).

Moreover, GE Healthcare is a participant in the Eyde-cluster, a cluster for enterprises in the process industry. On the cluster's web-page, they claim that one of the objectives of the cluster is to establish well-functioning collaborative relationships and arenas for firms and their suppliers. Another is to: strengthen the competitiveness of the firms by developing complementary competencies and the firm's innovativeness (Eyde-klyngen, 2018). These objectives are interesting for our thesis, and indicates that the participants are willing and open for collaboration concerning innovation of the processes.

We have chosen to use the term units for the different division within GE Healthcare. Furthermore, we have chosen to consider the collaboration between the different units within GE Healthcare as OI. The reasoning behind is that the organization has over 50,000 employees across more than 100 countries (General Electric Company, 2018). The units also differ in the work they do. Although, some of the units seem to have a lot in common and we suspected that the firm had a lot to gain by cooperation with other units within the organization. Further, within the facility of GE Healthcare in Lindesnes they have several areas of production and departments.

3.2.1 Selection of Process Innovation Projects

To examine how different factors affect open process innovation practices, we decided to examine process innovation projects with an extensive span of size, complexity, and novelty. Our choice is based on common contingency variables in innovation management research (Aas & Breunig, 2017), and we seek to investigate these variables to reveal variations in open process innovation practices. From GE Healthcare, we received 87 project documents. The 87 projects were all initiated to improve the process, although, several of them only included replacement of old equipment, and was not relevant for our study. In cooperation with the firm, we found that 19 of the 87 projects could be of interest regarding the predefined characteristics. Furthermore, we chose projects with a varying level of complexity, size, and novelty. The reasoning behind is that we suspected that the findings might be different for the various characteristics. Additionally, we wanted to examine recent innovations to ensure that the informants remembered the process of the process innovation. Thus, we decided to choose projects from the last three years. To be able to detect patterns, we decided to probe seven projects based on the following characteristics:

- Large projects versus small projects
- High complexity versus low complexity
- Radical innovation versus incremental innovation

The size of the project was determined by the investment cost, where we distinguished between small, medium and large projects. Moreover, small projects range from $0 to $300k; medium projects range from $300k to $1M, and large projects are everything above $1M. The complexity was determined by how many different actors they had to organize and interact with. The novelty

of the project was determined by how much the actual production process would change and to what extent new technology was incorporated. The description and project goal was also of interest. An overview of the various process innovation projects is shown in Table 5 and are described in detail in Appendix 1.

3.2.2 Selection of Informants

To answer the research question and to obtain relevant knowledge and expertise, it is important to single out the right informants (Busch, 2013, p. 57). The *snowball method* was therefore utilized to identify relevant informants involved in the selected process innovation projects. We started by contacting one of the managers in GE Healthcare, department Lindesnes, and conducted interviews with two of the project managers after the conversation. Here, we asked if the informants could identify key informants on the various projects. Subsequently, we conducted interviews with the several informants, which further recommended other informants on the projects that they believed could enlighten our research question. The result of this was that ten informants were interviewed, as depicted in Table 5. We believe that this selection is relevant for our case study because they have had an essential role in the process innovation projects. Moreover, the informants were chosen based on the projects selected. The characteristics of the projects were identified by asking the informants and through analyzing the project documents provided by GE Healthcare.

Table 5: An overview of the various process innovation projects.

Projects	Characteristics	Description	Goal	Informants	Their role
Project 1	- Large project - High complexity - Radical innovation	Upgrade to change from batches to continuous production in parts of the production line	-Increase capacity -Reduce inventory	Informant 1	Project Manager
Project 2	- Large project - High complexity - Radical innovation	Reduce emissions by 70 percent from 2014 to 2020	- Reach the imposed demand to be certified to continue production	Informant 2	Project Manager
Project 3	- Large project - High complexity - Incremental innovation	Upgrade of equipment	-Avoid production failure -Increase capacity	Informant 3 Informant 5	Project Manager Discipline Manager
Project 4	- Medium sized project - Low complexity - Incremental innovation	Upgrade of old equipment	- Energy and CO2 reduction	Informant 4 Informant 6 Informant 8	Project Member Project Member Project Manager
Project 5	- Large project - High complexity - Radical innovation	Construct a pilot plant within the existing facility	- Cost and energy reduction	Informant 7	Project Manager
Project 6	- Small project -Low complexity - Incremental innovation	Process cooling	- Improving Yield	Informant 9	Project Manager
Project 7	- Large project - High complexity - Radical innovation	Insourcing the production of a raw material	- Save cost and ensure availability	- Informant 10	- Department Engineer

3.3 Data Collection

This chapter addresses how relevant data has been collected for our case study. In addition to interviews, we found it useful to collect and analyze secondary data in forms of project documents. Moreover, Jacobsen (2005) claims that analyzing secondary data is appropriate when the researcher wants to examine what has been done and how others have interpreted a situation or event.

A qualitative study is defined by the informants formulating their answer, and the interviews are more or less structured (Leseth & Tellmann, 2018, p. 71). The interview process has been conducted as semi-structured interviews. Conducting semi-structured interviews enabled the informants to talk freely and allowed them to discuss subjects that they found relevant. We have chosen to conduct the interviews in this manner because we sought to achieve a deep and broad understanding of the process of process innovation and what external actors are included in the different phases. We prepared the interview guide on the basis of West and Bogers (2014)'s four-phase model and literature addressed in chapter 2, as depicted in Appendix 3 and Appendix 4. Utilizing an interview guide enabled us to cover the foundation and various aspects of the research questions. This further allowed us to ask follow-up questions to attain more detailed information, in addition to a validation of the information. This is also underlined by Larsen (2007), which claims that a semi-structured interview ensures that all relevant questions are being answered.

The interview guide was prepared using the so-called "funnel principle" (Dalen, 2013, pp. 26-27) to ensure that the central themes and questions covered our case study. Moreover, we started with general and open questions about the more central themes to be discussed, such as "What was the background for starting this project." Further, we focused on certain topics and asked questions like "Can you elaborate on the different phases of the project?". Subsequently, we concentrated on questions around more specific conditions, like "Was it easy for the employees to collaborate with the external actors on this project? Why/why not?".

The first step of West and Bogers (2014)'s four-phase model is obtaining innovations. To depict this step of the process within GE Healthcare, we asked questions like "Who were the decision-makers concerning what collaborative relationships the company made for this project?" and "When did you decide to look for external collaborators?". To answer our research question, we

asked questions like “What type of actors did you collaborate with on this project?” and “In what phase did these actors contribute?”. Further, in coherence with the dimension of obtaining, we asked questions similar to “How did you acquire these actors?”.

In compliance with West and Bogers (2014)’s four-phase model, we wanted to examine how GE Healthcare integrated the contribution from external actors. We included questions like “What did the external actors contribute with?” and followed up with questions like “How, as a company, do you exploit these contributions from the external actors?” Additionally, West and Bogers (2014) highlights the barriers and success factors to integration, like organizational culture and AC, and therefore we asked questions like “How did you experience the cooperation?” and “Were there any problems cooperating with any of the actors? (why?)”. Further, we tried to reveal if there were any cultural barriers to integrating external knowledge by asking questions like “Did you experience that the collaborators made suggestions that were hard to implement?” and followed up by asking “Why was it hard to implement?”. These questions enabled us to discuss if there were cultural barriers and how AC influenced the integration.

The third dimension of the four-phase model is capturing benefits and concerns the value creation and value capture. In the interview, we addressed this dimension by asking questions like “How did the company benefit from the collaboration?” and “Did the collaboration lead to an increase in efficiency/profitability/capacity?”.

To examine how GE Healthcare utilized the interaction mechanisms, we tried to expose how their relationships with collaborators appear. To reveal if they engage in dyadic relationships or benefit from communities or networks, we asked them whom they cooperated with, and how they benefit from networks like the Eyde-cluster. We also asked if they had exploited their existing industry relationships or public research networks.

The interviews were conducted at the informants’ offices. Since we are two people conducting this case study, we decided that one of us had the primary responsibility to lead the interview. While the other asked more detailed follow-up questions when we found it appropriate. All interviews were recorded and transcribed.

3.4 Data Analysis

Jacobsen (2005) A-C guidelines were utilized to conduct the data analysis:

A. Describe the material we have received

All of the informants allowed us to take audio recordings of the interviews, which ensured that no details were lost. In addition, we took notes while conducting the interviews. The notes enabled us to reflect upon the interview session. Then, we were able to discuss conditions that could not be grasped by the transcribed interviews. For instance, we could discuss factors that could affect the data, as was the interview object stressed? Or did he/she seem to speak truthfully? Additionally, it was vital for us to discuss the interviews immediately after they were held, to uncover if they had inputs that were particularly interesting and should be taken into account in the upcoming interviews.

B. Systematize and categorize the information

Transcribing the interviews was very useful for this thesis, although, it led to a substantial amount of information. The data was very cluttered and unorganized, in addition to holding much unnecessary information. To analyze and interpret the data, we had to reduce and categorize the data from the interviews and project documents. To increase the efficiency of the analysis, the transcribed interviews needed to be compressed and systematized. We also made a table of what the interviewees replied to the questions we asked, to be able to compare the informants' answers. Also, we sorted the data in themes, according to each research question, as depicted in Table 6.

Table 6: Illustration of how data was sorted.

How the firm search for and obtain external knowledge	When the external actors are involved	How does the firm integrate the external knowledge	How does the firm capture benefits from open process innovation	How does the firm utilize various interaction mechanisms to facilitate open process innovation
Findings theme 1	*Findings theme 2*	*Findings theme 3*	*Findings theme 4*	*Findings theme 5*

C. Interpretation of data

During the interpretation, we looked for causes and tried to conclude based on the data we had collected. In this stage, we had to go beyond what we talked about in the interviews, to uncover patterns. Further, we tried to answer the research questions based on the findings and in light of existing literature.

3.5 Ethics

Leseth and Tellmann (2018) underline that to conduct data collection, both formal approval from an ethics committee and informal approval from the informants is required. We have decided to conduct the interviews anonymously, were the informants' names are not used to categorize data. However, since we have conducted a single case study, we found it necessary to apply for permission from "Norsk samfunnsvitenskapelig datatjeneste (NSD)." Furthermore, the interview guide was submitted to NSD and approved.

Ethical issues have to be considered when conducting interviews with informants in qualitative research. Dalen (2013) addressed the following ethical guidelines, which have been taken into consideration when conducting our research:

- The requirement of informed and voluntary consent
- The requirement to inform those who are being interviewed
- Requirement of confidentiality

All of the informants were informed about why we wanted to conduct the interviews and what part they played in our research. The informants gave us consent to tape the interviews and to use their statements. We had to consider that the vast majority of employees have a duty of confidentiality, which could probably inhibit them in the interviews. To get them to talk about topics without feeling restrained, we tried to let them lead the interview and point them in the right direction. To ensure the informants that the information was treated with confidentiality, we saved all of the audio recordings on a memory chip that no one else could access. These audio recordings were deleted after the interviews were transcribed. Additionally, the information has been anonymized in the best manner when the results are presented.

4 Findings

This chapter is structured on the basis of the four-phase model. Firstly, we start by presenting the findings for obtaining, where we describe how the firm search for and obtain external knowledge flow. Secondly, we present the findings for the dimension of integrating, where we describe how the organization implements the external knowledge. Thirdly, a presentation of the findings of how the firm capture benefits from the collaborations. Lastly, we present the findings regarding interaction mechanisms. A summary of the findings will also be presented at the end of each section.

4.1 Obtaining

The first dimension of the four-phase model revolves around how firms identify the need for knowledge from external actors and how companies search for and obtain external knowledge flow. Concerning the process innovation phases, we found that GE Healthcare divides their process innovation processes into seven phases, respectively: Conceptual Study, Pre-project, Design Qualification, Installation Qualification, Operational Qualifications, Performance Qualifications and Process Validation. Further elaboration and description of all phases are shown in Appendix 2. Through our study, we discover differentiation in open process innovation practices between the pre-project stage and project execution. We consider all activities conducted before the project execution as a part of the pre-project stage.

Concerning the idea generation, we found that the ideas have arisen internally and the firm was not influenced by external knowledge flow. This practice may be illustrated by the following statement from informant 9:

> *"It was entirely our idea, we have accumulated a massive amount of knowledge concerning the production process over the years and know when we need to upgrade. So, you can say the ideas mostly come from us."* - Informant 9

Further, in the pre-project stage and project execution, we found that the firm often obtains knowledge from suppliers in radical innovations to enhance the solutions. This practice may be outlined by the following statement from informant 2:

> *"We often start by doing a literature search, and ask ourselves: "what kind of solutions is there?". After the search, we often realize whom we can start asking for help. We ask open questions to suppliers. Sometimes they can help us, and sometimes they put us in contact with someone else. We often use people we know due to several reasons. They know us, and they know what we need. Often they know whom we should work with and they are familiar with the industry."* - Informant 2

In addition to collaborating with suppliers, the firm also cooperates with universities. The collaboration involves both students and researchers from institutes. Several of the informants mention the collaborative relationship with students in the pre-project stage, although, they told us that they are not involved in the project execution. This practice may be outlined by the following statement from informant 8:

> *"We have students here relatively often. To a greater extent nowadays, compared to before. They are often here as a part of a master's degree or Ph.D. Although when conducting the projects, I have not experienced collaboration with students, it is more in the conceptual and design phase."* - Informant 8

Concerning the pre-project stage in the radical innovations, we found that the process of obtaining collaborators is more systematic and time-consuming than in the incremental innovations. This practice may be illustrated by the following statement from informant 1:

> *"When it involves this type of equipment, it is normally our process and development department or the process engineers that scan the market. We have plans for how we search. It depends on the novelty of the project. They investigate what is needed for the project and scan the market for potential external actors."* - Informant 1

Through our study, we found that the organization conducts broad searches. Our findings indicate that the organization utilized the internet, their industry network and development department for obtaining external knowledge flow. It seems to be particularly important when working with technology that is new to the firm. Although, we found no distinction between radical and incremental innovations. This practice may be described by the following statement from informant 5:

> *"We need to retrieve the competence where we can find it. For instance, we use our development department. The way we think is like 'where the competence and knowledge is, that is where we need to retrieve it.' When we are working with new technology within process industry, we will most likely not find it in the south of Norway. Most likely not even in Norway."* - Informant 5

For the radical innovations, we found that the organization also found it necessary to conduct a more in-depth search. For instance, we found that a cross-functional team had traveled around Europe to obtain external knowledge. Our findings revealed that this search process took six months. We also uncovered that in the radical innovations the project manager was sometimes included in the search for external knowledge in the pre-project stage, and not merely in the execution of the project. This practice may be outlined by the following statement from informant 7:

> *"We were going to implement a new technology that the development department had investigated in cell number 14, to increase the capacity. We were a group of five, three from cell number 14 and two from the development department. We visited various suppliers and factories all over Europe to see the equipment in motion. After six months, an external supplier was chosen."* - Informant 7

Our findings revealed that GE Healthcare had engaged a technology scout on a temporary basis in some of the radical process innovation projects. One of the informants was hired on a temporary basis for this reason and said the following:

> *"They needed help with their BAT (Best Available Technology) review, so they hired me on a temporary basis to search for the best technology and collaborators."* - Informant 2

We found that the company often utilized familiar external actors on several projects. Our findings imply that the reasoning behind is that these actors have established a profound knowledge about the production processes. This practice may be illustrated by the following statement from informant 1:

> *"We often use the same external actors because they have high efficiency. They know us, and they know the production process well."* - Informant 1

Concerning the incremental innovations, we wanted to reveal how the process of obtaining external knowledge was in the pre-project stage. Our findings indicate that the acquirement of collaborators often happened through project team members who knew someone they could contact, or by using a vendors list. This practice may be described by the following statement from informant 3:

> *"It depends on the project. We have a vendors list where the pre-approved suppliers are listed. In several contexts, we prefer to use local suppliers because it is often more practical and economical. Additionally, in the short and long term, we are dependent on having local suppliers that can deliver services to the facility. Concerning technical support, we mostly use the local suppliers. Although, when it comes to more complex deliveries, we have to look further to find collaborators. It depends on what we need. Some of them we search for online, even though we have many employees with a lot of experience that has many contacts in the industry. We often exploit these relationships. We are located in Lindesnes, and of course, not everything is possible to source locally."* - Informant 3

Our findings revealed that GE Healthcare engaged external actors in the pre-project stage to help them with drawings, modeling, and programming. We found that the firm brings competence and knowledge to the firm. This practice may be outlined by the following statement from informant 2:

> *"Sometimes we just give them drawings and ask them to convert them into 3D models. They sometimes give us some inputs, and we have to change something, you can say they help us with the engineering as well. We need the externals to contribute with the knowledge that we do not have here. For instance, when we use solutions that we do not have experience with. Then, we have to use suppliers that can deliver parts or complete facilities and teach us how to use it."* - Informant 2

In the pre-project stage, GE Healthcare worked on the 3D drawings received from a consultancy firm. Our findings revealed that the organization conducted meetings with all disciplines to ensure the drawings were correct and that all necessary details were taken into consideration. Further, our findings indicate that the firm often obtained the same external actors in the project execution to conduct the installation. These actors, such as plumbers and electricians, are involved in the meetings to contribute with valuable knowledge regarding relevant changes or other inputs before the drawings are finalized. This practice may be illustrated by the following statement from informant 9:

> *"The external actors collaborate with us and are involved in finding better solutions. They come up with very useful inputs because they have more knowledge about this than we do. Sometimes they say: 'Are you sure you want to build it like that because that is not the most optimal solution.' "* - Informant 9

In the project execution, our findings revealed that GE Healthcare Lindesnes hired electricians, plumbers, and installers on temporary contracts to conduct the installation. These collaborators know the facility well and provide useful inputs, especially when problems have arisen during installation. This practice may be described by the following statement from informant 9:

> *"When a mistake is found during installation, they are especially good at finding solutions for how we can solve the problem. They are good at noticing other options, and sometimes they just say, 'we can just put it over there.' "* - Informant 9

We followed up this statement and asked who decided which external actor to cooperate with. In addition to which role the purchasing department has in this process, and the informant replied:

> *"We recommend the choice of external actor to the purchasing department, and they often agree with the choice. Purchasing is with us throughout the process and negotiate the commercial terms."* - Informant 9

In compliance with the four-phase model, we wanted to examine how GE Healthcare incentivizes the external collaborations. Our findings revealed that it is mainly through monetary incentives, although, it appears that some of the incentives are non-monetary as well. This may be outlined by the following statement from informant 2:

> *"[..] And if it is a new process, it is a win-win situation. It will look good on the suppliers' resume that they have been a part of the innovation within GE Healthcare."* - Informant 2

We have chosen to call collaboration across units within the company OI. Concerning collaboration between the units, our findings imply that their collaboration is very limited. Some of the informants mention the collaboration of central deals as canteen services and transporting goods. Although, one of the informants stated the following:

> *"Historically speaking, we have not been collaborating with different units as much as we should. Although, in the recent years, we have become better at it. We are more into knowledge-sharing now. For instance, representatives from Uppsala have been here to learn how we recycle solvent. We have been to their plant as well, to learn from them. We try to cooperate where the processes are alike, where we have the same needs and the same challenges. I think we can become better at the collaboration between units, but we are on the right path."* - Informant 9

We also wanted to uncover if they collaborate with the department in Oslo concerning process innovation. Our findings indicate that the collaboration between the units mainly concerns product innovation, testing, and HSE. Some of the informants stated that the department in Oslo is not

interested in the process, the end product is the only interest. One of the informants stated that if they were to change the last step of the process, the department in Oslo wanted to be involved. This may be outlined by the following statement from informant 9:

> *"What they are interested in is the quality of the chemicals and how easily it dissolves, if it is easy to handle and so on. The things they are interested in happens in the last phases of the production process. They are not interested in what happens before that, nor should they be. So, if we are to do changes in the last steps, they want to be involved."* - Informant 9

4.1.1 Summary Concerning the Dimension of Obtaining

Through our study, we discovered that search breadth and depth seems to be of higher importance in the radical and complex process innovations, as opposed to the process innovations of a more incremental character. In the incremental innovations, it seems as though search breadth is of importance to obtain external knowledge. Regarding the size, the only difference between small process innovation projects and larger process innovation projects was how many external actors they engaged, not the type of externals. Further, the more radical and complex the projects were, the harder the informants found it to identify the most appropriate collaborators. Through the interviews, we revealed a pattern for how formal the search process for external knowledge was. It seems as though the more radical and complex the projects were, the more systematic the search was. For the radical projects, we discovered that they often collaborated in multidisciplinary teams to identify suitable collaborators. In the radical innovations, we also found that the firm utilized a technology scout. Further, we found that their collaboration with other units within GE Healthcare is limited. We found that the collaboration with the department in Uppsala has been limited, but fruitful. Further, the collaboration with the department in Oslo only concerns the last step of the process as it affects the end product. A summary of the findings is depicted in Table 7.

Table 7: Summary of the findings concerning obtaining.

Obtaining		
	Pre-project Stage	*Project Execution*
Radical Process Innovation Projects	- Systematized - Thorough search breadth and depth - Technology scouts - Multidisciplinary teams searching for external knowledge - Often through industry relationships	- The same collaborators often follow the entire process innovation process - Often installers from suppliers' list
Incremental Process Innovation Projects	- Less time spent searching - Less systematized search process - Often through the network of project members - Familiar suppliers	- Often installers from suppliers' list - Frequent use of local suppliers

4.2 Integrating

The framework of West and Bogers (2014) highlights the importance of being capable of integrating the knowledge from external actors to profit from collaborations. We wanted to reveal how GE Healthcare integrated the contribution from external actors and if there were any barriers to integration. West and Bogers (2014) discuss the importance of AC, and therefore we wanted to examine how GE Healthcare assimilates the external knowledge. Furthermore, in compliance with the four-phase model, we wanted to reveal if the company had a compatible culture to integrate the external knowledge flow successfully.

Our findings revealed that different measures are implemented in order to integrate the external knowledge within the different phases. In the pre-project stage, we found that GE Healthcare collaborates closely with the external actors in the radical and complex projects to assimilate the external knowledge. This practice may be illustrated by the following statement from informant 10:

> *" [..]. If it is something new to us, we have to collaborate more actively with the supplier."*
> - Informant 10

In the pre-project stage, the consultancy firm delivered 3D drawings, and the firm performed a design review. It is a consensus among the informants that it is an essential phase as the drawings are qualified and carried out in the installation phase. They emphasized the need for well-functioning information flow between all disciplines, both internally and externally. Therefore, one initiative to integrate the external knowledge was to conduct joint meetings with all of the disciplines, including both internal and external actors, throughout the pre-project stage. Our findings revealed that in radical and complex projects, the meetings were frequently conducted and often once a week. One of the informants underlined the importance of information flow and stated the following:

> *"The most important thing is the information flow within the project, and that is always challenging. We are almost twenty people who attend the project meetings to ensure that the information flow is equal between the disciplines, and further communicated to all*

> *workers on the project. The attendees of the meetings can be both temporary employees, internal and external actors."* - Informant 3

We revealed that the organizational culture supports open process innovation and does not suffer from the "not invented here" syndrome. It further became clear that the firm focus on learning and building competencies. This may be outlined by the following statement from informant 2:

> *"We have to be careful about thinking that we know best. The best solutions are not always clear to us, and we need help from others sometimes. We often learn a lot from collaborating with other firms."* - Informant 2

To integrate the external knowledge, we reveal varying practices. In all process innovation projects, it seems as though they conduct multidisciplinary meetings and include the external actors if possible. Although, in the radical innovations some of them mentions that the project manager conducts meetings with the various disciplines in isolation as well. One of the informants stated the following:

> *"It is more about getting every actor on board, even though they are not included in the pre-project. I have been on this project from the start; you can say I am both the customer and the project leader of this project. There are many opinions from various disciplines that you have to take into consideration, such as regulatory and safety issues and at some point, you have to gather the expertise. In the past, we have conducted meetings with all the disciplines over 2-3 days were the process and details are discussed. However, on this project, we decided to have separate meetings with the various disciplines and external actors. The reasoning behind was due to some people taking control over the meetings."* - Informant 1

Our findings revealed that the collaboration within the project groups was considered successful. It seems to be benefical to hire an intermediary to integrate the external knowledge. In the project execution, our findings revealed that GE Healthcare had implemented some measures to ensure that the information flow is well-functioning between the various disciplines. Moreover, we found

that a construction manager was hired. This practice may be illustrated by the following statement from informant 3:

> *"In the installation phase, we have hired a construction manager to avoid misunderstandings between the disciplines. This is important to ensure that the implementation of the external and internal contributions is successful."* - Informant 3

Further, we found that the majority of people employed in GE Healthcare holds a high level of competence and tacit knowledge about the production process. This may be outlined by the following statement from informant 9:

> *"Through the years we have established profound knowledge about our processes, which is crucial in order to improve parts of it."* - Informant 9

GE Healthcare often utilized familiar external actors in the project execution due to various reasons. Our findings indicate that the reasoning behind was due to these actors knowing the facility very well. In addition to having established a significant high efficiency and licenses needed to conduct the work. Several of the informants revealed that it is challenging to have new external actors in the project execution. This may be described by the following statement from informant 9:

> *"When we have a new external actor, the work efficiency is low in the beginning. They have to learn how it works out here and have the certificate in place. In addition to getting to know our people and the culture here."* - Informant 9

In resemblance with the pre-project stage, we reveal the importance of close collaboration with the external supplier at the facility in the project execution as well. This may be underlined by the following statement from informant 1:

> *"The supplier come to the facility and test the system to see if it works as it should. Sometimes they can say ´you have to change the set point or it has to be tuned down a little*

bit. ´ After the evaluation, the program is qualified, and the final test run is conducted in collaboration with the external supplier." - Informant 1

Our findings revealed that it was easy to collaborate with the local external actors that frequently came to GE Healthcare's facility in Lindesnes. Therefore, we wanted to expose the differences when collaborating with external actors outside of Norway. Moreover, we wanted to reveal if there were difficulties communicating or cultural problems when collaborating with foreign companies. Although, our findings indicate that the reason for choosing local actors is that the firm often attains a closer relationship, not because it is difficult to cooperate with different nationalities. Moreover, it is easier for the local actors to come to the facility in order to attain a profound understanding of the production process. Further, our findings imply the importance of this in terms of having a successful integration of the external contribution. This may be illustrated by the following statement from informant 1:

" [..]. It is challenging to be located in different places, even though you have Skype. However, Skype meetings are better than communicating through emails. Therefore, it is better to have local suppliers because you meet up and work on the project together. When you meet people face to face, it is more interactive than if you just communicate through mail or Skype." - Informant 1

We also found that in the radical innovations, GE Healthcare often visits the supplier to ensure that there were no misunderstandings. Moreover, the firm highlighted the importance of having a close collaboration throughout the process innovation processes. This may be described by the following statement from informant 10:

"The supplier has been very helpful, and we have had a good experience working with them. We have visited the suppliers and conducted several test rounds. It is important to be present at the supplier location and have a close collaboration with them. Particularly in the beginning to ensure that there are no misunderstandings. Additionally, we can ensure that the supplier conducts the testing correctly. Therefore, we have visited the supplier a couple of times." – Informant 10

4.2.1 Summary Concerning the Dimension of Integrating

Through the interviews, we found that GE Healthcare relies on a close collaboration with the external actors to successfully integrate external knowledge flow. However, it is dependent on the novelty of the innovations, and it appears to be more critical in radical and complex innovations than in incremental and less complex innovations. It also seems crucial that the external actors can participate in the multidisciplinary meetings to understand the entire process and how the various departments and areas of production interact. Additionally, it seems beneficial to hire an intermediary to ensure that the external contribution is successfully integrated. We also reveal varying practices as to how the project managers chose to conduct the meetings. Some of them had meetings in isolation with each discipline, in addition to the multidisciplinary meetings. Further, it seems like the culture within GE Healthcare welcomes the contribution of external actors, and the informants express their willingness and openness towards cooperation. A summary of the findings is depicted in Table 8.

Table 8: Summary of the findings concerning integrating.

Integrating		
	Pre-project Stage	*Project Execution*
Radical Process Innovation Projects	- Close collaboration happens both on the facility and at the suppliers' location - Project leader involved in the pre-project stage - Frequent multidisciplinary meetings	- Close collaboration happens at the facility - Frequent meetings, varying practices (multidisciplinary teams and/or meeting the disciplines separately) - Intermediary (construction manager) - Often familiar suppliers/installers - The external actors are often involved in previous phases
Incremental Process Innovation Projects	- Close collaboration happens at the facility	- Collaboration happens at the facility - Often familiar suppliers/installers - Less defined roles and responsibilities of the project members
Incremental and Complex Process Innovation Projects	- Close collaboration happens at the facility - Frequent multidisciplinary meetings	- Collaboration happens at the facility - Often familiar suppliers/installers - Intermediary (construction manager) - Frequent multidisciplinary meetings - Well defined roles and responsibilities of project members

4.3 Capturing Benefits

Throughout the interviews, we wanted to uncover what the drivers for utilizing external knowledge were and what they expected to gain through these collaborations. West and Bogers (2014) addressed a lack of research on how firms can capture value from these external actors, and thus we wanted to uncover how GE Healthcare captured value. Collaborating with external actors is often a part of the strategy for companies. In some cases, it might be due to competence, and sometimes to reduce time or costs.

For the radical and complex innovations, we found that GE Healthcare engaged external actors to a higher degree in the pre-project stage. Several of the informants' state that in order to form the framework of the project, they need help from external actors. Some of them mention that they are dependent on new technology in many of the innovation projects, and it is not profitable to do research and development of it all in-house. This may be outlined by the following statement from informant 2:

> *"In developing the concept and engineering, that is where we get the most bang for the buck. If it is possible to gain more profit from the collaboration we have to do it. We are obliged to profit the utmost from the external actors. [..] We know the functional specifications, although, how we can accomplish the requirements is not always clear to us."* - Informant 2

Concerning the incremental innovations, we found that the firm receives useful inputs from suppliers. GE Healthcare has often done most of the engineering, and the suppliers can help the firm improve the solution, making it even more effective. This may be described by the following statement from informant 9:

> *"One of our competitive advantages is that we have much competence concerning technology and equipment. Although, we do not have specialists in every single field. We often have an idea for a solution, and then we approach the suppliers and ask "we have worked on an idea, what do you think? Is there a better solution for solving this?". They*

are the experts, and often they work up a solution that makes it even more effective." - Informant 9

We wanted to uncover how GE Healthcare made sure the collaborations were worthwhile and the informants stated that they tried to engage in collaborative relationships with suppliers they can benefit from also in the future. Several of them implied that they see the time spent working closely with the suppliers as an investment. This may be outlined by the following statement from informant 2:

"We invest time in suppliers and hope it will pay off in the current project and the future as well. We often turn to suppliers we have had a successful collaboration in the past. If they cannot help us, they are often willing to refer us to someone else." - Informant 2

Our findings revealed that by collaborating with external actors holding expertise in a specific field of interest reduced both time and costs in the pre-project stage, as well as in the execution of the project. We also found that GE Healthcare does not have the capacity needed for all of the process innovation projects. Further, we found that the collaborators often enhanced their competence when the external actors came to the facility for cooperation. To capture value from the collaboration, our findings revealed the importance of working closely together, and preferably at the plant in Lindesnes. This may be illustrated by the following statement from informant 2:

"We try to outsource what we call "volume work," while we try to keep the competence building tasks in-house. That is, sometimes they come here and help us, and then we learn something." - Informant 2

We found that the external actors are contributing with useful inputs and solutions. We also discovered that the collaborations often led to an expansion of the knowledge base within the firm. This may be described by the following statement from informant 6:

"Our collaborators do a great job, and the competence of our employees grow as we continuously receive inputs from outsiders." - Informant 6

Our findings revealed that time, cost and competence were drivers for cooperation. In the incremental innovations, GE Healthcare was more concerned about reducing time and cost of conducting the innovations, whereas in the radical innovations the company often sought external actors with cutting-edge technology and expertise to increase the efficiency in the production process. This may be outlined by the following statement from informant 3:

> *"It depends on the project. Although, time and cost are most important in this type of project. In the radical projects, we are more concerned about expertise in state-of-the-art technology in order to achieve the best solutions."* - Informant 3

Our findings indicate that GE Healthcare also engages in collaborations with universities to become a well-known firm among the students. This way, they become an attractive workplace for future job seekers. This may be illustrated by the following statement from informant 5:

> *"Mostly due to capacity and we experience that the students find it educational as well. I guess we feel some social responsibility. It is important that companies engage in the education of students. We will rely on some of them in the future, so it is also beneficial for us if they see us as an attractive place to work. [..] Not all student projects are equally fruitful, although, some of them lead to spin-offs."* - Informant 5

4.3.1 Summary Concerning the Dimension of Capturing Benefits

Our findings revealed that for radical innovations, GE Healthcare had the most to gain by including external actors in the pre-project stage. Moreover, it was important that the suppliers were a partaker in both pre-project stage and project execution to profit the utmost from the investments in collaboration. We revealed that GE Healthcare need suppliers, with in-depth expertise, in the pre-project stage to make sure they attain the most efficient solutions. In the project execution, the company needs help from the external actors to implement the solutions in a well-suited manner, regarding testing and teaching GE Healthcare how to operate and maintain the equipment. Concerning the incremental innovations, they engaged external collaborators to reduce the time spent on engineering and installation. It was more a matter of reducing time and costs of the process innovation, rather than expecting novel ideas and solutions. Another incentive GE Healthcare

emphasized was that the firm learned from the external actors and considered it as an investment to spend time on collaboration. Additionally, the company emphasizes the mutual benefits when collaborating with students. The students and universities get an insight into what the process industry needs and the firm can get ideas from the student as well as promoting GE Healthcare for future job seekers. A summary of the findings is depicted in Table 9.

Table 9: Summary of the findings concerning capturing benefits.

Capturing Benefits		
	Pre-project Stage	*Project Execution*
Radical Process Innovation Projects	- Expanding internal knowledge base - Expertise concerning state of the art technology - Making the innovation possible - Promoting GE Healthcare for future job seekers	- Expanding internal knowledge base - Smart solutions - More efficient execution of the project
Incremental Process Innovation Projects	- Expanding internal knowledge base - Improve the solution - Reduce the time spent on engineering - Promoting GE Healthcare for future job seekers	- Expanding internal knowledge base - More efficient execution of the project - Reduce the time spent on installation

4.4 Interaction Mechanisms

Interaction is what ties the three dimensions in the four-phase model together. We wanted to investigate how GE Healthcare utilizes the interaction mechanisms in open process innovation. Through the interviews, we wanted to reveal if the firm engage in dyadic relationships or exploit external knowledge through networks and communities.

Although GE Healthcare emphasizes the use of networks and industry relationships to identify and obtain external knowledge; our findings indicate that the firm does not co-create innovation in network activities. Moreover, our findings revealed that GE Healthcare mostly engaged in dyadic relationships with universities and external suppliers. Further, we found that the firm established relationships with suppliers and universities, which the firm continuously exchanged knowledge with. This may be described by the following statement from informant 9:

> *"We mostly collaborate with suppliers, but we also have a lot of collaboration with universities. It is important that universities and the process industry have a close cooperation. This is essential to nurture a future relationship regarding knowledge sharing."* - Informant 9

We found that GE Healthcare is engaged in two networks, one of them is through Ecomagination and is in cooperation with, among others, Walmart, Statoil, and Intel. The other network is through the Eyde-cluster, a cluster for companies in the process industry. We tried to reveal how the organization utilized the Eyde-cluster as a mechanism to enable open process innovation. Further, we found that the participation in clusters can lead to valuable insight concerning future collaborators and for creating ideas and brainstorming. One of the informants stated:

> *"Yes, maybe indirect. We recognize things that they do and see that it could be wise to implement here. The more you are around, the more experience you obtain. We have been around on the various companies and shared experiences with each other. This has been very fruitful. [..]. We have also had co-meetings with various suppliers."* - Informant 4

Thus, our findings indicate that GE Healthcare does not collaborate directly on innovating the processes, due to the different characteristic of the processes. Moreover, the majority of the companies in the Eyde-cluster is in the smelting business and does not have much competence concerning pharmaceuticals. However, we reveal a collaboration concerning support activities. This may be illustrated by the following statement from informant 9:

> *"It is not a focus on the processing of the chemicals; it rather concerns organizational processes, maintenance and a large focus on lean. The other companies focus on metals, and we cannot spend time on things that do not concern us."* - Informant 9

Some of the informants mentioned the Eyde-cluster, although, no one mentioned the network they are engaged in through Ecomagination. Several of the informants were unaware of the network they had through Ecomagination. Moreover, it may be on a higher level in the organization or not applicable to the selected process innovation projects. Thus, we have chosen not to focus on this network. Instead, we focused on their use of networks to come in contact with the external actors. One of the informants said the following:

> *"We have many employees that have worked here for many years and therefore have many contacts."* - Informant 3

Our findings revealed that for GE Healthcare it is easy to establish a collaborative relationship with other participants in the Eyde-cluster. We uncovered that the firm is an attractive collaborator in the process industry due to being innovative and having a lot of resources. Informant 4 underlines this finding with the following statement:

> *"GE Healthcare is a company with many resources, so we often feel that they gain more from the collaboration than we do. On the other hand, having a lot to offer makes it easier for us to attain collaborators."* - Informant 4

Furthermore, we reveal that the firm participates in conferences to establish relationships, which can be exploited in open process innovation later on. One of the informants stated the following:

> *"We participate in various conferences and fairs to establish a network with other companies in the process industry. We try to retrieve as much knowledge as we can through these arrangements and seek to use the connection we obtain here if we acknowledge a need for these firm's knowledge in the future."* - Informant 10

4.4.1 Summary Concerning the Dimension of Interaction Mechanisms

Our findings indicate that GE Healthcare mostly engages in dyadic relationships with suppliers and universities. The firm is also engaged in networks through the Eyde-cluster and Ecomagination. The Eyde-cluster seems to be a platform for sharing ideas and building competence in the process supporting activities, and not directly related to the innovation of the processing of the chemicals. The firm emphasize that they have accumulated many collaborators through their industry relationships and networks. Moreover, our findings revealed that the company participated in various conferences in order to establish relationships with other firms in the process industry.

5 Discussion and Conclusion

Through discussing the findings in light of the literature, we wish to answer the research questions for this thesis. The research questions we want to answer are as follows:

> *"How do firms search for and obtain external knowledge during process innovation processes?"*
>
> *"How do firms integrate external knowledge during process innovation processes?"*
>
> *"How do firms capture benefits from open process innovation processes?"*
>
> *"How do firms utilize various interaction mechanisms in order to facilitate open process innovation?"*

The discussion is structured in accordance with the findings chapter, and thus on the basis of West and Bogers (2014)'s four-phase model.

5.1 Theoretical Implications

In this chapter, the essential findings of each dimension will be discussed in light of existing literature. Several propositions will also be outlined in the four dimensions.

5.1.1 Obtaining

We found that idea generation mostly took place internally without any influence of external knowledge flow. However, literature concerning product innovation often emphasize the positive effects of involving external actors in idea generation. Moreover, Bergendahl and Magnusson (2015) claim in their research that idea generation seems to benefit from external knowledge flow and can lead to valuable ideas. We suspect that the nature of process innovation diminishes the benefits of co-creating ideas for innovation. Thus, an organization cannot just replicate a successful process innovation from another firm, because process innovation is more context-specific than product innovation.

Further, we would argue that for process innovation, the benefits of collaboration with customers in idea generation is not as significant as for product innovation. The reasoning behind this statement is that the customer mainly cares about the end product, and not the process (Un & Asakawa, 2015). Further, Frow, Nenonen, Payne, and Storbacka (2015) claim in their research that customer engagement concerning idea generation leads to a higher valuation of the brand. We would argue that process innovation is not affected by the valuation of the customers as profoundly as in product innovation. Moreover, Repenning and Sterman (2002) state in their research that leaders or managers value the transformed process and not customers, as in product innovation. Hence, we do not consider customers as appropriate collaborators for co-creation ideas in open process innovation.

Further, we found no collaboration with suppliers or universities in the idea generation. Hatch and Mowery (1998) characterized process innovation as complex to codify and influenced by tacit knowledge. Hence, the process is harder for outsiders to understand and it may be challenging to contribute with external knowledge. This might be one of the reasons as to why firms in the process industry often generate ideas without being influenced by external knowledge flow. Even though

actors such as suppliers or universities might hold the knowledge needed to contribute, it can be difficult for outsiders to recognize what the organization needs.

Lastly, our findings revealed no collaboration concerning idea generation with competitors. Un and Asakawa (2015) propose in their research that collaborators with a small contextual knowledge distance are preferable. The researchers build this on the nature of process innovation and claim that it is context-specific. Thus, we assume that it is easier for competitors to understand the needs and challenges to contribute to idea generation. Although, Von Krogh et al. (2018) implied in their research that the production process might be a competitive advantage for the firm. We suspect that this is the reason organizations are reluctant to co-create ideas with competitors.

The above discussion leads to the following proposition:

> P1: *Concerning idea generation, the nature of process innovation inhibits the influence of external knowledge flow.*

Through our study, we discovered that search breadth and depth seems to be of higher importance in the radical and complex process innovations, as opposed to the process innovations of incremental character. However, we revealed that concerning the incremental process innovations only search breadth seems to be of high importance. It seems as though firms can benefit from searching broadly to attain suitable collaborators. Although, it seems to be less critical to conduct a more in-depth search because it appears to be clear what the organization is looking for. We reveal that for process innovations, firms benefit from having a systematized search strategy and use several channels for searching and obtaining external knowledge. This complies with the existing literature concerning open product innovation (Laursen & Salter, 2006). Von Krogh et al. (2018) underlines that routines need to be established to successfully obtain suitable collaborators and for being able to integrate the external contribution. Furthermore, Laursen and Salter (2006) claim that firms should scan across several channels to ensure that suitable collaborators are obtained. For radical process innovations, our findings suggest that it is beneficial to hire a technology scout to gain several search channels. Additionally, we discovered that the project leader was often the internal customer of the process innovation and involved in the search process.

West and Bogers (2014) also mention the possibility of facilitating searches for external collaborators through technology scouts or intermediaries.

The above discussion leads to the following proposition:

> P2: *Search breadth and depth seems to be of higher importance in the radical and complex process innovations than in the incremental process innovations.*

Our findings indicate that for the process industry one way of obtaining external knowledge flow is to hire employees on a temporary basis. It appears that firms can hire professionals with a high degree of knowledge concerning the industry and further benefit from the industry network of the employees. Sapienza et al. (2004) reveal that engaging in collaborations with external actors holding an unrelated knowledge base hinders the integration. However, the authors discover that if the acquired collaborator holds a too similar knowledge base it makes it harder to arrive at novel combinations. Therefore, we would argue that one way of obtaining knowledge flow is through hiring individuals on a temporary basis. For instance, consultants or professionals holding a related knowledge base.

The above discussion leads to the following proposition:

> P3: *In open process innovation, attaining external knowledge flow can occur through hiring temporary employees holding a related knowledge base.*

Through our study, we revealed that a firm has to take customers perception into consideration, as well as other actors in the industry. Researchers claim that in process development, the innovation is less visible to outsiders and will not be as dependent on the valuation of outsiders (Repenning & Sterman, 2002). However, if a firm changes a process in a way that arises ethical or environmental questions, the impact can be considerable. Despite the importance of perception, we reveal through our study that customers are not well suited for open process innovation. In our opinion, it is not merely the lack of interest that make customers less suitable for cooperation. For instance, if a company improves a process to reduce costs, the savings can be passed on to the customer

(Davenport, 1993). Un and Asakawa (2015) indicate in their research that position in the knowledge chain is more important than the contextual knowledge distance. Further, processes are often distinguished by a more considerable amount of tacit knowledge and company-specific know-how (Von Krogh et al., 2018).

Our findings imply that dyadic relationships with suppliers and universities are most common for obtaining external knowledge in process innovation. Un and Asakawa (2015) also revealed dyadic relationship in the R&D phase with universities and suppliers. We found that collaboration with universities seems to bring valuable foundation for further development within the firm. This can be associated with what Dahlander and Gann (2010) referred to as sourcing. Sourcing concerns how firm obtains external knowledge without involving a financial transaction. Also, collaboration with universities can be seen as a way of promoting the firm for future job seekers. Further, we found that collaboration with suppliers does not only occur in the pre-project stage, it also occurs in the project execution. Additionally, we found that for open process innovation, it seems to be the supplier who is the most valuable collaborator. This might be due to small contextual knowledge distance and located upstream of the focal firm (Un & Asakawa, 2015). In compliance with Un and Asakawa (2015), collaboration with suppliers seems to be more beneficial than customers and competitors because the external actors need to have interests in the process.

The above discussion leads to the following propositions:

> P4: *In open process innovation, collaboration with universities in the pre-project stage seems to be preferable.*

> P5: *In open process innovation, collaboration with suppliers in the pre-project stage and project execution seems to be preferable.*

Through the interviews, we discovered that it is vital for an organization to withhold knowledge about the process that leads to a competitive advantage. We assume that firms might be reluctant to engage in open process innovation with competitors because they fear competitors can capture value from the firm's internal value creation. It is easier to protect products by patenting than it is

to get patents for processes (Arundel & Kabla, 1998). Thus, companies might be more willing to engage in open product innovation with competitors.

Our findings imply that for the process industry, it might be even more important to leverage from innovations and knowledge from different units within a firm. In their research, Kim et al. (2016) also discuss the importance of obtaining sources of innovation from both outside and inside the company. The processing of products is often seen as a competitive advantage that a firm should keep confidential (Von Krogh et al., 2018). Thus, it might be even more important to involve different units within a firm in the process industry to build competence without sharing competitive advantages with outsiders. In fact, Sapienza et al. (2004) claim that relatedness concerning knowledge bases is of high importance in OI. Hence, the units within an organization might benefit from each other if they have compatible knowledge bases. Additionally, it might be a more secure way of implementing OI. This way, they can keep the confidential information within the company borders and still enhance the competence within the different units. Hatch and Mowery (1998) accentuate the complexity of codification, and in light of our findings, we would argue it is even more critical with relatedness in knowledge bases in open process innovation, compared to product innovation.

The above discussion leads to the following proposition:

> P6: *In process innovation, it seems beneficial to open up internally due to knowledge relatedness and to keep the competitive advantage within company borders.*

5.1.2 Integrating

Our findings revealed that in process innovation, a close relationship with the collaborator is required to integrate the external knowledge successfully. We found that it is imperative for the external actors to come to the plant for cooperation for them to acquire knowledge about the production processes. Further, our findings indicate that in open process innovation, the external actors have to provide external knowledge flow that is customized for the organization. Moreover, this will make the incorporation of the external contribution more manageable. The need for close collaboration can be explained by the complexity of codification in process innovation, because it requires tacit knowledge and is less visible for external actors (Hatch & Mowery, 1998). Thus, in open process innovation, the external actors should be included in such a way that they attain a holistic understanding of the production process and further be able to identify the required knowledge. This is very different from the practices found in product innovation regarding the interaction with external actors. Moreover, (West & Bogers, 2014) emphasize that for organizations to fully integrate the external knowledge flow, the focal firm needs technical capabilities and avoid the "not invented here" syndrome. Further, the authors claim that in some cases, firms should remove the external interactions by fully internalize the external knowledge. Hence, it is evident that close cooperation is significantly more crucial in open process innovation than in open product innovation.

In coherence with Mazur and Zaborek (2016)'s study, our findings highlight the importance of internal cooperation to enable process innovation. In process innovation, it seems to be of higher importance for firms to possess the capability of managing the internal knowledge as several departments are involved in the innovation. The capability-based framework by Lichtenthaler and Lichtenthaler (2009) address various dynamic capabilities to increase the firm's ability to manage both internal and external knowledge. We also found that the process innovation processes are dependent on conducting multidisciplinary meetings throughout the process of innovation processes. We suspect that this could be explained by the nature of process innovation, where different departments and areas of production have to cooperate to create the best process for all affected departments (Ettlie & Reza, 1992; Repenning & Sterman, 2002). Our findings indicate that all affected areas of production are included in the decision making because process innovation is systemic, where changes in one part alter the interaction with other phases of the production line

(Ettlie & Reza, 1992; Gopalakrishnan, Bierly, & Kessler, 1999). Whereas location of knowledge in product innovation is in quasi-independent teams that focus solely on generating new products and make decisions in isolation (Benner & Tushman, 2003; Pisano & Shih, 2012; Un & Asakawa, 2015). It appears that conducting multidisciplinary meetings is a necessity in order to coordinate both internal and external knowledge flow. Hence, in contrast to product innovation, we would argue that external actors participating in process innovation activities have to be more involved in the firm's internal innovation processes. Thus, in process innovation, external actors must closely collaborate with the project group and participate in internal meetings with the focal firm.

The above discussion leads to the following proposition:

> P7: *In open process innovation processes, a close collaboration with the external actors is crucial for an organization to integrate the external knowledge flow.*

Through our study, we found that in open process innovation it seems to be of higher importance that the employees attain tacit knowledge rather than having a high level of education. We would argue that this is due to the systemic and complex nature of process innovation. This is in contrast with existing literature on open product innovation. Moreover, both Grimpe and Sofka (2009), and Tether and Tajar (2008) address the impact of educational level among the employees and how it affects the integration process of the external knowledge. However, the codification of process innovation is characterized as of high complexity and requires more tacit knowledge than in product development (Hatch & Mowery, 1998). It appears that this is one of the reasons why the internal customer often was the project leader.

We would argue that in open process innovation, it may be desirable to utilize familiar external actors that have knowledge about the processes. We suspect the reasoning behind this is the strong ties between the existing process and the new process. This is one of the peculiarities that makes collaboration more complicated than in product innovation. Further, we assume that the nature of process innovation leads to the requirement that external collaborators attain a level of tacit knowledge concerning the production process. One of the steps in the framework of Davenport

(1993) also highlights the importance of measuring and understanding the existing process in order to enable process innovation.

The above discussion leads to the following proposition:

> P8: *In open process innovation, both internal and external actors need tacit knowledge concerning the production processes.*

We found that for firms to absorb the external knowledge, it is essential to have a compatible culture that promotes innovation and avoid the "not invented here" syndrome. This complies with existing literature concerning open product innovation. Further, West and Bogers (2014) highlight the importance of having a compatible culture in open product innovation to integrate external knowledge successfully. Although, this seems to have a more significant impact on open process innovation because there is a greater need for collaboration between interdependent department as there is extensive involvement of all affected departments and areas of production. In contrast, open product development involves expert teams working on the innovation (Un & Asakawa, 2015). The authors Naqshbandi et al. (2015) also emphasize the importance of creating an organizational culture that appreciates external knowledge in order to benefit from OI. In light of our findings, we would argue that this type of culture is crucial in open process innovation due to the interaction between several departments and external actors.

The above discussion leads to the following proposition:

> P9: *In open process innovation, it is essential to attain a culture that appreciates the contribution of both internal and external actors due to the systemic nature of process innovation.*

Our findings indicate that familiar external actors were frequently utilized in open process innovation to diminish the risk of endangering the entire production line. We would argue that the reasoning behind is due to the affect a change in one part of the process can have on the entire production process. This is in contrast with product innovation, where the product innovation can

be separated from the existing product (Gopalakrishnan et al., 1999). According to Mazur and Zaborek (2016), the willingness to take risks is an essential factor in nurturing innovation processes. Moreover, we would argue that in open process innovation, it seems to be crucial to diminish the risks by choosing a familiar external actor. This way, the firm secure that the collaborator holds the required tacit knowledge about the production processes.

The above discussion leads to the following proposition:

> P10: *In open process innovation, familiar external actors are preferred collaborators in order to diminish the risks of endangering the entire production line when implementing radical innovations.*

In the complex process innovation projects, we found that a construction manager was acquired to coordinate the information flow between all disciplines and integration of the external knowledge flow. Having an intermediary seems to be essential in process innovation due to the nature of process innovation where the innovation has to be managed in regard to all affected departments and areas of production. Moreover, in comparison to product development, process innovation is more interdependent and systemic (Gopalakrishnan et al., 1999). The more complex the characteristics of the process innovation is, the harder it is to integrate (Un & Asakawa, 2015). Thus, we would argue that to ensure successful integration concerning all affected areas of production and departments, an intermediary should be hired for the complex process innovations.

The above discussion leads to the following proposition:

> P11: *In complex open process innovation processes, it seems beneficial to have an intermediary administering the external and internal knowledge flow.*

5.1.3 Capturing Benefits

Through our study, we found that in process innovation it is common to externally source technology and knowledge in the value creation of the innovation process. Further, it appears to be important in process innovation to assess external knowledge to realize process innovation. Our findings are in coherence with existing literature on open product innovation, where Chesbrough (2003) emphasize that firms rely on external sourcing of technology. Researchers also provide evidence on how organizations obtain external ideas, knowledge, market needs or other value-creating information (Dodgson et al., 2006; Lau, Tang, & Yam, 2010; van de Vrande et al., 2009).

Concerning value capture, we uncovered that utilizing external sources of knowledge flow to reduce costs is the primary motivation for open process innovation. It appears that in open process innovation, firms also appreciate external knowledge flows due to expanding the knowledge base of the firm, reducing time spent on realizing innovations and attaining novelty solutions and technology. The motivation for process innovation itself is improving efficiency in the way an organization handles its operations (Ettlie & Reza, 1992; Hatch & Mowery, 1998). Thus, it makes sense that it is the primary motivation for open process innovation as well. Chesbrough and Crowther (2006), on the other hand, found that cost reduction was a secondary driver for open product innovation. Other researchers found that cost reduction was an even less significant driver, compared to achieving novelty innovations, tracking market needs and absorbing external knowledge (van de Vrande et al., 2009). Since the objective of product innovation usually is to attain a new or improved product to gain a competitive advantage, we suspected the motivation for open innovation would differ between the two types of innovation.

The above discussion leads to the following proposition:

> P12: *The primary motivation for open process innovation is increased efficiency in the production line.*

5.1.4 Interaction Mechanisms

It seems as though being a large and well-respected firm leads to many channels for collaboration through their relations. Further, we reveal through our study that the participation in clusters does not directly lead to collaborations concerning process innovation. Although, the participation in clusters and conferences leads to valuable industry networks and nurture potential relationships. In fact, Dittrich and Duysters (2007) findings indicate that firms should utilize interfirm networks as it seems to enable open innovation. In compliance with existing literature and in light of our findings, we would argue that it is important in the process industry to actively engage in forums like clusters and conferences to establish relationships. Our findings also revealed that the participation in clusters often included cooperation regarding building competence in the process supporting activities. This is also underlined by Dittrich and Duysters (2007) research of Nokia, emphasizing that strategic technology networks are essential to sustain the position under change of conditions.

The above discussion leads to the following proposition:

> P13: *Engagement in networks can lead to valuable relationships that can be exploited in open process innovation.*

Through our study, we found that in the process industry, networks are actively used to obtain external knowledge. Furthermore, the industry network is utilized to identify external actors holding the required knowledge. We would argue that this is particularly important in open process innovation because the external actors in the process industry have a smaller contextual knowledge distance. This is of higher importance in process innovation compared to product innovation as the process is more obscure and thereby harder to codify (Hatch & Mowery, 1998). In addition, our findings revealed that it was reasonable to exploit previous collaboration in such a way that the external actors recommend other relevant firms with the required knowledge. Moreover, the previous collaborator has tacit knowledge about the processes, and thus it is easier for them to recommend an external actor. We would argue that this results in a more efficient search process.

The above discussion leads to the following proposition:

> P14: *Due to a small contextual knowledge distance, it seems beneficial to utilize industry networks to identify and obtain external knowledge flow in open process innovation.*

We found that in open process innovation the reciprocal exchange of knowledge often occurred through dyadic relationships with universities and external suppliers. This is consistent with existing literature, including West and Bogers (2014) who point to dyadic relationships, networks, and communities. Further, we revealed that the collaboration through the dyadic relationships was recognized as a learning arena in the process industry as their competence in-house was continuously expanded through the collaboration.

The above discussion leads to the following proposition:

> P15: *In open process innovation, the reciprocal exchange of knowledge mostly occurs through dyadic relationships with universities and suppliers.*

5.2 Managerial Implications

To obtain external knowledge, search breadth and depth seems to be of higher importance in radical process innovations than incremental process innovations. Further, it seems beneficial to hire a technology scout to search for external innovations. Additionally, firms can benefit from their established industry networks to identify and obtain external knowledge. Obtaining external knowledge can also happen through hiring experts on a temporary basis. Although, it seems as though these employees need to hold a related knowledge base, and at the same time complement the existing knowledge base within the firm.

Further, our findings imply that it is beneficial to engage universities in the pre-project stage. Whereas, it seems beneficial to collaborate with suppliers in the pre-project stage and through project execution. It appears that suppliers are the preferred collaborators, due to understanding the systemic nature and being able to attain tacit knowledge about the production process. We found no implications that would suggest companies should engage customers or competitors in open process innovation. The production process is often seen as a competitive advantage that firms should keep confidential (Von Krogh et al., 2018). Thus, in the process industry, it might be even more critical to benefit from innovations and knowledge from the different units within a firm. This is also underlined by Kim et al. (2016), which discuss the importance of obtaining sources of innovation from both outside and inside the company. We would recommend starting by opening up the innovation process within the firm's boundaries. Moreover, the units might have a lot to learn from each other, and it might be a more secure way of implementing OI. This way, they can keep the confidential information within the company borders and still expand the knowledge bases within the different units.

To integrate external knowledge successfully, we found that it is crucial to have a close collaboration with the external actors due to the obscure and systemic nature of process innovation. We would advise managers to frequently conduct multidisciplinary meetings to coordinate both internal and external contributions. Additionally, we also found that some of these meetings were held separately with each discipline to ensure that all inputs were brought to light, which further led to a close interaction with each discipline. Moreover, we would advise managers to hire an intermediary to coordinate and integrate the external knowledge flow successfully.

5.3 Limitations and Further Research

We would argue that our research is contributing to the existing literature on open process innovation and can be used for scientific and managerial purposes as well. The suggested propositions may be considered as tentative recommendations. However, some limitations have to be considered to guide further research.

The limitations and quality of the study need to be examined to suggest further research. Yin (1994) accentuate that the criteria to qualify the qualitative study are reliability and validity. According to Yin (2009), reliability refers to the repeatability of the study and researchers should aim to eliminate the possibility of misinterpretations and errors. The transparency of the study is essential to enable another researcher to conduct the same survey and achieve the same findings and conclusions. Further, Jacobsen (2005) claims that one of the limitations by performing a qualitative study is that the findings are dependent on the context in which they are retrieved and can be ambiguous. The way we interpret the information we received will also influence the outcome of the study. To avoid biased interpretation of the information, we transcribed all the interviews and systematized our findings based on the different dimensions of the four-phase model. Further, we have tried to make the interpretation and discussion as transparent as possible. Moreover, we have utilized West and Bogers (2014)'s framework and existing literature on open product innovation and process innovation to explain the findings we have attained. Additionally, we have used the framework of open process innovation provided by Un and Asakawa (2015).

The validity of the research can be divided into internal and external validity (Johannessen, Christoffersen, & Tufte, 2004) In qualitative research, the internal validity revolves around the extent to which the researcher's findings correctly reflects the purpose of the study (Johannessen et al., 2004, p. 228). To ensure internal validity, we have conducted qualitative research with in-depth interviews. Additionally, the process innovation projects analyzed were carefully selected to ensure findings that would address the research questions. Further, we sent the quotations to each informant to ensure that our interpretation of the information was correct. However, we acknowledge that one of the limitations of our study is the fact that we have not utilized mixed methods.

In qualitative research, the external validity refers to the transfer of knowledge instead of generalization (Johannessen et al., 2004, p. 229). The ambition of our study was not to generalize; we sought to contribute by developing theory concerning open process innovation. A limitation to our research is that we have conducted a single case study and thus the practices we have found for open process innovation may not be applicable for other firms. Additionally, GE Healthcare is considered a large organization, and by limiting ourselves to one unit, we only achieve a profound knowledge about this particular unit. Therefore, the practice we have identified may not apply to all units.

Another potential limitation of our study is the use of the snowball method, as Grønmo (2004) pointed out, this method is limited due to the possibility of sampling bias. Moreover, we had limited control over the informant's evaluation of criteria and referrals. However, we would argue that utilizing this method ensured that we attained suitable informants to represented the firm as a whole. The sample of informants included different roles in the various process innovation projects, such as project managers, project member, discipline leader and department engineer. Although, we acknowledge that the majority of the informants are project managers and the result may be influenced by their position. The findings also indicated that due to the systemic nature of process innovation, it is a necessity that the focal firm and external actors attain a close collaboration. To further investigate this interaction, we would suggest interviewing the external actors.

Our findings are tentative due to the exploratory nature of the study, and thus it requires confirmation by other researchers in other settings. However, for future research, it could be beneficial to replicate this research in several companies across industries to reveal varying open process innovation practices. Process innovation is context-dependent, and thus we would argue it is essential to conduct qualitative research in other companies. This could further form the foundation for developing a more refined theory of open process innovation practices. Process innovation might be harder to separate from product and service innovations in other sectors, and thus practices may differ. Additionally, we recommend other researchers to probe and measure the contingency factors we have identified to reveal if it is a matter of correlation or causation. Additionally, it can be reasonable to investigate different contingency factors of the process innovation projects to reveal differentiation in open process innovation practices. For further

research, it could also be beneficial to conduct both qualitative and quantitative studies to assess our study's external validity. Also, it would be of great value to conduct a deductive approach to confirm or invalidate the theoretical propositions presented in chapter 5.1.

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Appendix

Appendix 1

Project Description

Project 1

This project concerns changing parts of the process to go from batch production to continuous production. This will not make the entire process continuous, only parts of the production line. This is considered a large and radical project with high complexity. There are many actors involved, both in numbers of employees and actors involved and it includes new technology and is classified as of high risk. The primary goal of the project is to increase capacity and reduce inventory.

Project 2

This project is an umbrella project, covering many initiatives to reach the goal of reduced emissions by 2020. The European Industrial Emissions Directive commits national legislators to implement new standards regarding emission levels and emission controls. GE Healthcare is required to reduce their emissions by more than 95% by 2020. This portfolio of projects is classified as radical and with high complexity. It is a massive project, and new technology is crucial.

Project 3

This project concerns an upgrade of old equipment to avoid failure in production. Another incentive is increasing the capability of the process. The project is of incremental character with new equipment and familiar technology. GE Healthcare considers the project as of high complexity.

Project 4

This project is a part of the Ecomagination program and concerns the installation of a mechanical vapor recompression system. It was an initiative to reduce energy consumption and CO2 emissions from the production process. GE Healthcare classified this as an incremental innovation with familiar technology, and it is considered a small project with low complexity.

Project 5

This project concerns the construction of a pilot plant within existing building at Lindesnes. The project is conducted to be able to verify an upgraded process of a new process. Enabling this new process will lead to significant reduction in both cost and CO2 emissions. The future value of this test line will be the small-scale production of products, and testing of novel process technology and process improvements or new large-scale productions. This is considered a large project, with high novelty. It is also complex and includes new technology.

Project 6

GE Healthcare initiated this project to improve the yield of one of the products. It involved installation of a new heat exchanger, including pipework and instrumentation to cool process solution. This is classified as a small, incremental project with low complexity. It involves new equipment, although, the technology is familiar to GE Healthcare.

Project 7

This project is still in the conceptual phase. Due to failing deliveries in the past and high price from the supplier, GE Healthcare now wishes to insource the production of raw material. It is a project classified as of high complexity as well as novelty. It includes unfamiliar technology and is considered a large project.

Appendix 2

Project phases

Project Phases	Description
Feasibility study	• Evaluating and analyzing the potential of the project
Conceptual phase	• Investigate several concepts and choose the best concept suited to satisfy the defined need
Pre-project	• The concept is decided with the intention to provide a framework for the scope of work (SoW)/ User requirement specification (URS), completion, resources/organizing, finance, and risks, for stakeholders to decide final completion (go/no go)
Project	• Conduct the agreed change in the pre-project with the purpose of giving the firm the opportunity to extract the expected value
Design Qualification (DQ)	• Review of design documents in order to verify that the projected design will meet the requirements of the URS
Installation Qualification (IQ)	• Ensure that the processing equipment and auxiliary systems are in proper condition, properly constructed and installed based on approved design and the sellers' recommendation and requirements specification (URS)
Operational Qualification (OQ)	• Ensure that the processing equipment and auxiliary systems are operational/functioning, as it is designed for, based on sellers' and design specifications
Performance Qualification (PQ)	• Ensure that the processing equipment and auxiliary systems can perform the process (-es) efficiently and reproducibly, based on the approved methods, specifications and URS
Cleaning Qualification (CV)	• Establish a validated cleaning and documenting that the product, in general, is not contaminated in any way that poses a danger to the product quality
Process Validation (PV)	• Ensure that the process, repeatedly and reliably, can manufacture the product according to the predetermined and approved requirements

Appendix 3

Interview Guide (Norwegian)

Hovedspørsmål	Oppfølgingsspørsmål
Kan du fortelle litt om prosjektet?	• Hensikt? • Størrelse? • Radikal/inkrementell? • Kompleksitet? • Risiko? gjennomfører dere ofte prosjekter med høy risiko? • Når kom du inn i prosjektet? Hva var din rolle?
Hvordan har samarbeidet fungert innad i prosjektgruppen?	• Tok dere beslutninger i fellesskap eller er det du som leder som har tatt de fleste beslutningene? • Har det vært et godt samarbeid i gruppa?
Hva var bakgrunnen for å starte prosjektet?	• Hva er driveren? miljøtiltak, effektivisere, redusere kost etc? • Hvem kom med ideen? • Eksterne involvert i tidligfasen, før prosjektet er definert?
Kan du fortelle litt om de forskjellige fasene av prosjektet?	• Kan du definere disse fasene? • Hva inngår i de ulike fasene? • Vi har sett i prosjektbeskrivelsene at dere ofte deler inn i conceptual study engineering, testing og hand over to operation. Vil dere si at dette stemmer?
Har det vært noen eksterne aktører involvert i disse fasene?	• Hvilke aktører har blitt involvert? • Har dere betalt de for å hjelpe dere? • Burde de eksterne aktørene blitt involvert på et annet tidspunkt? Isåfall, hvilken fase?
Hva har de eksterne aktørene bidratt med i de ulike fasene?	• Hvilke kunnskapshull har de dekket? • Ny teknologi/kunnskap?
Hvordan har den eksterne kunnskapen blitt integrert i prosjektet?	• Utfordringer? • Var det enkelt for de ansatte å samarbeide med de eksterne? hvorfor/hvorfor ikke? • Hadde dere kompetansen til å implementere ny teknologi? Eller var det behov for å ha innleide personer til å utføre dette? • Hva er årsaken til at dere har valgt å ha innleide personer?
Hva fikk dere ut av dette?	• Økte det effektiviteten?

	• Førte det til reduserte kostnader? • Økt kvalitet? • Ble prosjektet levert tidligere fordi dere fikk hjelp?
Har samarbeidet vært vellykket?	• Hva var grunnen til dette? • Har dere opplevd at det er vanskelig å bruke det de eksterne kommer med? hvorfor?
Hvordan identifiserer dere behovet for ekstern hjelp?	• Hvorfor har de blitt spurt? Kan de gjøre det raskere/bedre/kan ikke GE dette i det hele tatt osv? • Hvem tar beslutningene om hvem dere skal samarbeide med? • Har dere oversikt over ulike eksterne aktører dere kan kontakte for å hente inn nyttig kunnskap? • Benytter dere ofte eksterne aktører som dere tidligere har hatt et samarbeid med? • Er det rutiner på hvordan dere skal gå frem for å samle inn eksterne ressurser?
Hvordan tilegnes disse eksterne aktørene?	• Er det gjennom Eyde? • Samarbeider dere med andre bedrifter i prosessindustrien? • Hender det at dere tar med studenter på prosjekter? • Er det dyadisk forhold, altså en-til-en? (konsulenter eller leverandør osv) eller network eller communities?
Har andre avdelinger i GE vært involvert?	• Hvilken avdeling? • Hvilken kunnskap/teknologi har de bidratt med? • Ny teknologi som er utviklet i en annen avdeling? • Hvorfor henter dere hjelp internt og ikke eksternt?

Appendix 4

Interview Guide (English)

The interview guide has been translated from Norwegian to English.

Main Questions	Follow-up Questions
Can you tell us about the background of this project?	• Purpose? • Size? • Radical/incremental? • Complexity? • When were you first engaged in this project? what has been your role in the project?
What was the intention of the process innovation?	• What was the driver? environmental issues? reduce costs? increase capacity/efficiency? • Whose idea was it? • Do you often conduct high-risk projects? • Were external actors involved the in idea generation? Did you get any ideas that led to the innovation?
How has the cooperation been within the project team?	• Who took the decisions of whom to engage in collaborations? • How was the cooperation within the project group?
Can you tell us about the different phases of the project innovation process?	• Can you define the phases? • What is included in the different phases? • Who are involved in the different phases?
Have any external actors been involved in any of these phases?	• What external actors are involved? (universities? suppliers? competitors? clusters? industry networks? customers/users?) • In what phases were they involved? • How did the external actors contribute? • How did they enhance your innovation/solutions?
How do you obtain external knowledge?	• How do you identify the need for external knowledge? • How do you search for external knowledge? (internet? cross functional teams?) • Do you have an established routine for how to obtain external knowledge? • Do you have a vendor list over various external actors that you can utilize? • Do you often use a familiar external actor? • Do you hire professionals to search for external knowledge?

	• How do you incentives these collaborations? • Is it through the Eyde-cluster? • Do you cooperate with other firms in the process industry?
How did the external actors contribute?	• Are you dependent on external knowledge? • Do the external actors hold knowledge you do not have? • Do the external actors have a knowledge base that is distant to your internal knowledge base? • What are your incentives to engage in collaborations?
How did you make sure the external knowledge was integrated successfully?	• Were there any challenges? • Is it easy to collaborate with external actors? Why/why not? How did you solve this problem? • Did you have the competence to integrate the external contributions? • Are intermediaries utilized in order to integrate the external knowledge flow? Are the intermediaries' internal employees or hired to help implement the external knowledge?
What did you gain from the collaboration?	• Efficiency? • Reduced costs? • Increased quality? • Earlier delivery of project?
Was the collaboration successful?	• What was the reason for being successful/unsuccessful? • Have you experienced difficulties utilizing the external knowledge for the intended purpose?
Have other units in GE Healthcare been involved?	• Which unit? • What knowledge have they contribute with? • Why do you choose to obtain knowledge within GE Healthcare?