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Open Innovation and Barriers to Adoption

A Case Study in the Construction Industry

Master's thesis in the Master's Programme, Entrepreneurship and Business Design

SOFIA STENINGER

Department of Technology Management and Economics
Division of Management of Organizational Renewal and Entrepreneurship – MORE
CHALMERS UNIVERSITY OF TECHNOLOGY
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Executive Summary

The role of knowledge in driving innovation and economic growth is winning more recognition in society (OECD 1996). Firms have realized this and invest tremendous amounts in corporate Research and Development (R&D), knowledge new to the world. Despite the high investments firms are starting to face diminishing returns to R&D and as valuable knowledge is getting more dispersed, companies can't rely entirely on internal paths in bringing new innovations to the market. As a result, a new innovation paradigm called "*open innovation*" is emerging, where companies purposively strive to harness internal as well as external flows of knowledge to enhance their innovation capabilities. The phenomenon shows promising results of making the innovation process more efficient, less costly, agile and dynamic but yet it hasn't been thoroughly investigated beyond the faster moving, technology intensive industries, such as pharmaceutical, Fast Mover Consumer Goods (FMCG) and automotive.

The question motivating this research is thus whether open innovation practices also are suitable for companies in more mature and traditional industries and whether those are facing other barriers towards its adoption than those currently known. The purpose of this research is therefore to perform a case study revolving around the innovation activities at a tool and consumable manufacturer serving the global but professional construction market, specifically addressing the question "*which are the barriers for a manufacturing company, i.e., a company in a more mature industry context, to "open up" its innovation process? And will such a company benefit from doing so?*

The research question was answered by interviewing internal employees in any of the core innovation functions; Intellectual Property (IP), Research, Innovation Management and Development. The result is thus not a representation of the whole organization, neither of the industry in which the company operates. Further studies will be needed to validate the results externally.

The research could show that the company already is benefitting from open innovation concepts, using for example customers, suppliers and universities as sources of external knowledge. It will likely be beneficial for the company also in the future, as certain contextual characteristics indicate that the otherwise traditional construction industry, gradually is becoming more "*smart*", as new emerging, complex technologies are entering the field, which often increases the need of external collaboration. The research could also confirm that certain barriers towards the concept seem to prevent its extensive adoption, among the greatest count; culture, strategy and perceived risks.

Nomenclature

Capabilities A common definition of firm capabilities is the *"complex bundle of skills and accumulated knowledge, exercises through organizational process, that enable firms to coordinate activities and make use of their assets or resources"* (Day 1994, p. 38)

Information and Communication Technology (ICT) is often used as an extended synonym for Information Technology, but is a more specific term that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information. (Wikipedia 2014)

Innovation is a concept with many definitions. Typically it is defined as something new, a change in ideas, practices or objectives that to some degree involves (i) a novelty or creation build on intellectual achievements, and (ii) success in commercial application. Thus, it does not only refer to the object itself, rather also to the new idea or practice, as well as the process leading to it. Innovation is not to be confused with **invention**, which must be a novelty and a result of human ingenuity. Furthermore, the concept of invention doesn't require success in commercial application (Granstrand 2009).

Intellectual Capital comprises all intangible assets of a firm that in some way can be capitalized upon by an economic agent. For example; patents, trademarks, trade secrets copyrights (codes) and know-how but also employee skills, strategy, processes, customer and supplier relations etc. Important to note is that intangible assets neither creates value nor generates growth without being combined with means of production (Lev & Daum 2004).

Intellectual Property refers to intellectual creations of the mind: *inventions*; *literary* and *artistic works*; and *symbols, names* and *images* used in commerce. Intellectual property is divided into two categories: Industrial Property that includes patents for inventions, trademarks, and industrial designs. Copyright includes literary works such as source code, film, music, artistic work and architectural design. (WIPO 2014)

Intellectual Property Rights are best understood as a "*bundle of rights*", including special ownership concepts applicable to intellectual property and legal rights assigned to the IP owner, which he "*owns*" (Gollin 2008).

Not Invented Here syndrome (see Katz & Allen 1989) is the philosophy of social, corporate, or institutional cultures that consequently favors internally developed creations over using, licensing or buying external products, technologies, research, standards, or knowledge. The reasons for not wanting to use the work of others are varied.

Open Innovation is most commonly defined as *"the use of purposive inflows and outflows of knowledge and technology to accelerate internal innovation, and expand the markets for external use of innovation, respectively"* (Chesbrough 2003).

Open Innovation Barriers are in this research referring to any obstacle, risk or hinder that may prevent or limit a company or an individual employee from conforming to, or practicing open innovation activities, i.e., "*innovation efforts that leverage external parties' knowledge and/or ideas, or individual problem solvers, to contribute to the internal innovation process"* (InnoCentive, 2013).

Technical, Commercial and Economic Success is often mentioned in relation to innovation. In this research technical success means that technical specifications have been met, or that an invention was achieved. Commercial success means that the invention has found a commercial application. Economic success is when acceptable returns on the investment can be collected (ROI)[1].

Technology is per definition a body of technical information and/or knowledge, that can appear in a market transaction embodied in people, products and/or companies, or even as disembodied (Granstrand 2009). I may still have physical properties, eg., as paper, tapes, discs etc.

Technology Trade i.e., buying and selling of technology on some kind of market can take many forms. Technology trade isn't new but until now it didn't play a significant role compared to traditional trade, which partly can be explained through the inherent difficulties in trading with intangibles, such as knowledge and information (Gollin 2008). Licensing is a common means to trade technology, based on a contractual relationship between a minimum of two parties, where at least one owns IP. A license enables the owner of IP to transfer certain IP rights (IPRs) to the licensee, normally in exchange for compensation. As licensor you can choose to transfer all IPRs to an IP asset, including the ownership, it is then referred to as "assignment". As a rule of thumb, as soon as less than the full set of IPRs to an asset is transferred, we call it a license.

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[1] Economic success (or break–even) occurs when total revenues exceed total spending, compounded with the relevant rate of interest (Granstrand 2009)

List of abbreviations

BU	Business Unit
IA	Intellectual Assets
ICT	Information and Communication Technology
IP	Intellectual Property
IPR	Intellectual Property Right
MMC	Multinational Manufacturing Corporation
NIH	Not Invented Here syndrome
PLS	Product Leadership Strategy
PPM	Portfolio Management Process
R&D	Research and Development

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Sofia Steninger

1 Introduction

Industrial firms are under pressure. R&D costs are growing faster than sales as innovation productivity flatters and customer demand increases (Huston and Sakkab 2006; Schilling 2010). To stay competitive, companies have to re-invent their business- and innovation models (Chesbrough 2006) and look for alternative approaches to value creation (Huston & Sakkab 2006). In the new society where Intellectual Capital (IC) will become dominant (Granstrand 1999; Wurzer 2009), the role of knowledge and technology to economic growth will increase in importance (OECD 1996). Human inputs in the innovation process, i.e., individual skills, knowledge and competence are all representations of IC that is put to work through research, development and commercialization activities (Wurzer 2009). IC can be sourced either from inside or outside corporate boundaries but the innovation processes that follows a linear R&D model, where ideas are sourced, developed, financed and supported to market through internal channels, is about to become obsolete (Gassman 2006). In the linear, also called *"closed"* innovation system, R&D activities were concentrated to big research labs (Mowery 2009) where profits yielding from high-margin products were reinvested in the system, providing barriers to entry (Cohen & Levinthal 1990). Firms absent these massive R&D capacities were traditionally at a strong competitive disadvantage (Teece 1998).

Today, the mode of competition has changed and collaborative efforts continuously connect innovative capabilities of small companies, to the market reach of large corporations. Thus, we are in a shift towards a more *"open"* innovation paradigm (Chesbrough 2003; Gassman 2006; Granstrand 2009), where companies strive to accelerate their internal innovation processes by purposively harnessing flows of both internal and external knowledge, establishing new links and possibly also new paths for product and service commercialization (Chesbrough 2003; Sarkar & Costa 2008). The new phenomenon have however until recently mostly been investigated among successful *"early adopters"* (Huizing 2011), mainly within fast-growing, technology intensive industries like pharmaceutical (See InnoCentive founder Eli Lilly) and Fast Mover Consumer Goods (FMCG) like Proctor and Gamble (See Huston & Sakkab 2006). The interesting question motivating this research is whether those practices also are suitable for the more mature industries and whether the obstacles to its implementation is the same. Why haven't for example more companies in the mature industry opened up their innovation process? Are there perhaps sound reasons not to, or is it particularly difficult? The objective of this research is therefore to shed light over the open innovation concept, in the context of a late-adopter in a more mature industry.

1.1 Background

The opening up of the innovation process starts with a "*mindset*" (Gassman, Enkel & Chesbrough 2010). In other words, to implement open innovation practices, a company must be willing to acknowledge the value of external competence and know-how, and purposively choose to both exploit internal as well as external ideas. Competitive advantages that once were gained through the access and control of physical capital, cheap material and labor in a material value chain (Heiden & Petrusson 2009), is no longer enough to create competitive outcomes in a society where intangible assets such as knowledge, technology and intellectual property are the new sources of sustainable competitive advantage (United Nations 2011; Wurzer 2009). There is yet thin, but growing evidence that open innovation concepts start to spread within more traditional and mature industries (Chesbrough & Brunsvinkler 2013; Sarkar & Costa 2008), particular under certain circumstances, such as when firms develop high dependence on other entities, e.g., end-users, research institutions, suppliers or even competitors (Chesbrough & Crowther 2006).

According to Gassman & Enkel (2004) the phenomenon *open source* started the discussion on opening up a firm's innovation process. Across the globe, there were several thousand programmers, who successfully developed highly sophisticated software that could compete with that of Microsoft's! Open innovation is however not to be confused or equalized with open source, which is one but prominent example of the new innovation process. It is a co-operative development of independent programmers, who on demand develop new lines of codes, adding to the initial source code which is "*freely*" accessible in exchange for new knowledge. The result is astonishing, increased program applicability and complete new applications (Gassman & Enkel 2004).

Chesbrough (2003) takes a broader perspective and explains that the "*open*" paradigm mainly is driven by four factors, eroding the "*closed*" model; (i) the increased availability and mobility of skilled "knowledge-workers" (see also Drucker, 1973), (ii) the new external options available for unused ideas, (iii) external suppliers increasing capability and finally, (iiii) the emerging venture capital markets that created new strategic opportunities for companies (Chesbrough 2003). Worth adding to this reasoning is the development of the emerging "*markets for technologies*" (Arora, Fosfuri & Gambardella

2001), which likely is another important factor compelling companies into open collaboration modes.

The next blossoming trend is observed by Jeff Howe (2006), who wrote in the Wired Magazine that the new pool of cheap labor is *"everyday people using their spare cycles to create content, solve problems, and even doing corporate R&D"* (Howe 2006, p1). Cost barriers that once separated professionals from amateurs are tearing down as technology advances while people at the same time gets wider access to internet and other Information and Communication Technologies (ICTs) (Howe 2006). Smart companies in disparate industries like pharmaceutical and FMCG have already discovered this valuable source of knowledge and have found ways to access and tap talent from "intellectual crowds". Researchers have interestingly also found that the strength of such a network lies in the "diversity of the background" (Lakhani, see Hower 2006 p.4) and the likelihood of success actually increases in fields where problem solvers have no formal expertise. Mark Granovetter (1973) has previously described this phenomenon as "the strength of weak ties". Thus, *"it is not outsourcing, but crowdsourcing"* (Howe 2006 p.1), that is the outmost innovative way of performing corporate R&D.

1.2 Prior Research

There is currently a big interest in open innovation and in its relevance to corporate R&D (Enkel, Gassman & Chesbrough 2010). The open innovation model, coined by Chesbrough (2003), draws upon previous research in related fields, like strategic alliances (Gulati 1998; see Holmström & Westergren 2012) and open source software (Von Hippel & Von Krogh 2003). As the "*open*" approach shows promising potential of making the innovation process more effective, less costly, more agile and dynamic, the interest among practitioners and academics alike in its adoption process is growing (Huston & Sakkab, 2006; Chesbrough & Crowther 2006; Lichtenhaler & Lichtenhaler, 2009; Mortara, Napp, Slacik, & Minshall 2009).

Scholars have previously focused on different aspects of open innovation, identifying effective open innovation processes by distinguishing between *inbound*, *outbound* and *coupled* activities (Gassman & Enkel 2004) and defined various practices for each (Huston & Sakkab, 2006; Dittrich & Duijsters 2007).

Despite the growing body of knowledge, there is still poor evidence of successful open innovation adoption beyond the high-tech context (Chesbrough & Crowther 2006; Huizing 2011; Westergren & Holmström, 2012). Huizing (2011) suggest that more research is needed to determine whether the current best practices are suitable for the late adopters, or whether there are sound reasons not to implement open innovation.

Hurdles and enablers to the implementation of open innovation were investigated by Mortara et al., (2009) and Golightly et al., (2012). Mortara et al (2009) concluded in their study of 144 European companies (all industries) that common barriers to implementation were related to organizational *culture* (see also Lichtenhaler & Ernst 2006; Golightly et al., 2012), employee *motivation*, *procedures and structures* and finally to the blend of necessary open innovation *skills*. Other researchers have investigated the preconditions for the establishment of "*networked innovation models*" particular in mature industries and indeed concluded that organizational culture but also *trust*, i.e., trust among people as well as in technologies, are important preconditions for open innovation implementation (Holmström & Westergren 2012).

Potential risks associated with open innovation were investigated by Liechtenhaler and Ernst (2006), who argues that potential risks are the reason why companies fear to open up their innovation practices extensively. In other words, companies limit their external exposure in light of associated risks and so many negative effects haven't yet materialized. He continues to argue that associated risks can be managed and that the well-known Not Invented Here (NIH) syndrome, see Katz and Allen (1982), which is a common response to embryonic open innovation initiatives (Golightly et al.., 2012), actually rather is a consequence of the underlying potential risks, than a negative attitude as such.

Prerequisites for, or success factors to, open innovation adoption were investigated by Chesbrough & Crowther (2006) who asked 40 companies about their already running open innovation practices and concluded that important dimensions to consider were; *organizational structure*, *metric systems* and/or *measurement systems* (see also Golightly et al., 2012), *strategy and goals* for open innovation, which have to be focused and in line with overall business objectives. They also found that the effective *integration and management* of knowledge, technology and information was another important prerequisite for success.

1.3 Objective and Purpose

As we may understand, the emulation of open innovation requires more than a few changes in a company's innovation paradigm. The purpose of this research is therefore to empirically investigate open innovation practices in a more mature industry context, by analyzing innovation activities at the company which in this report will be referred to as Multinational Manufacturing Corporation (MMC), who provides the global construction industry with tools-, consumables- and service innovations. The objective of this research is twofold; (i) the first is to highlight potential hurdles and risks preventing or hindering the "*opening up*" of the innovation processes, which before were more "closed" and (ii) secondly, provide suggestions on managerial countermeasures to overcome those barriers, thus contribute with knowledge relevant for open innovation practitioners, decision makers and researches interested in open innovation and its adoption in the more mature industry.

1.4 Research Questions

The main question to be investigated is:

Which are the barriers for a manufacturing company, i.e., a company in a more mature industry context, to "open up" its innovation process[2]*? And will such a company benefit from doing so?*

The following sub-questions will be answered in course of the research:

- *What does open innovation really mean and why do companies open up their innovation process?*
- *What are the potential hurdles and risks opening up the innovation process?*
- *Are there any managerial countermeasures to reduce or even overcome those hurdles and risks?*

1.5 Scope and Limitations

The research follows a case study design, focusing on one single organization, where the investigation in turn revolves around selected employees working close to the innovation mechanism, e.g., within any of the selected departments; Corporate Intellectual Property (IP), Corporate Research, Corporate Innovation Management and Development in any of the company's seven business units (BU's). This leads to the limitation of only getting the view from those particular departments and their perspectives on open innovation, whereas the concept encourages involvement of all corporate functions (Chesbrough 2003; Enkel & Gassman 2004). The limited amount of empirical evidence resulting from only investigating one organization also leads to the limitation that results aren't externally verified.

Focusing on the single organization and its employees also means that certain environmental conditions that may be required for open innovation activities to diffuse,

[2] Innovation process specifically refers to the *outside-in* innovation process, i.e., the sourcing of external knowledge, technology, information and IP to enhance internal innovation capabilities.

such as liquid private equity markets, markets for intellectual property or the strength of the local IP regime (Chesbrough 2006) won't be investigated.

Furthermore the study is restricted to one of the three "*core-innovation-processes*" (Enkel & Gassman 2004) where the "*outside-in*" innovation process, also called "*inbound open innovation*" will be investigated. The results of the research are henceforth applicable to this particular process and the researcher makes no claims to cover the whole concept of open innovation in this regard.

1.6 Thesis Outline

After the current introduction in chapter one, chapter two will describe the research methodology, i.e., the research- strategy, design and data gathering methods, which have been used in this study. Chapter three sets forth the theoretical framework; starting with a short introduction to the current innovation climate and moves on by describing the concept of open innovation, its prospects and finally it presents the identified barriers to open innovation adoption. Chapter four outlines the result from the empirical investigation, starting with an objective description of the industry and the company, followed by the results from the employee interviews. The identified barriers in the theory chapter are then addressed one by one. Chapter five provides an analysis of the results, comparing the empirical evidence to the previously known literature while chapter six discusses the implications of the results and provides suggestions for managerial action. Chapter seven concludes the final thesis and presents a recommendation for further research. The thesis ouline is presented in *Figure 1.1*.

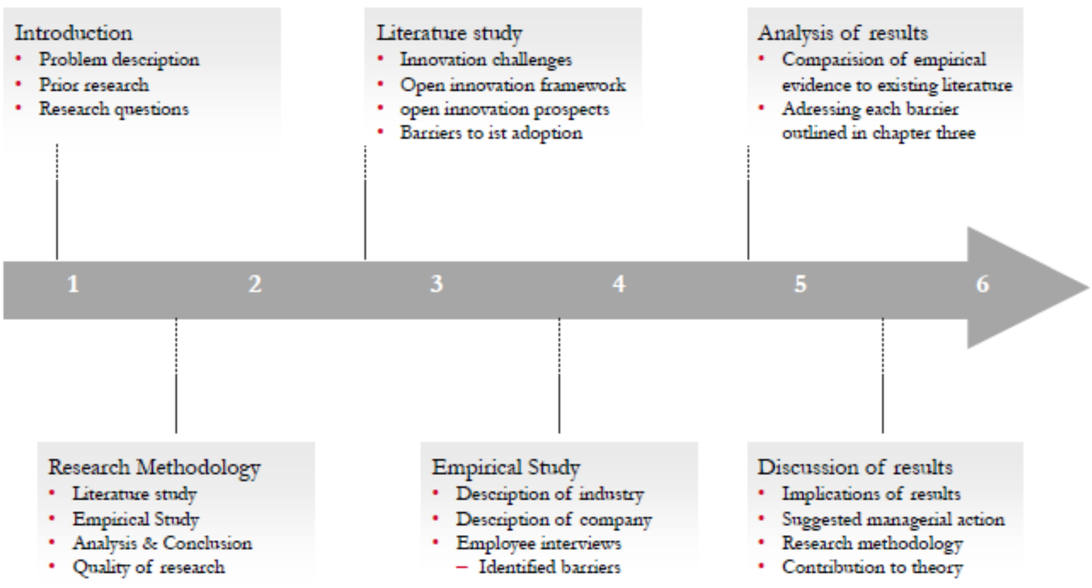

Figure 1.1- Thesis Outline

2 Research Method

This chapter describes the general process through which the research was conducted and how the research question was answered. It furthermore outlines how the literature study and empirical investigation were performed and how the data finally was analyzed. In the last section the researcher includes a discussion regarding the quality of the research.

2.1 Overall Methodology

Since the question motivating this research revolves around people and organizational behavior, the study was designed to follow a qualitative approach in the gathering and analysis of data, which means that the emphasis is put on words rather than numbers. Qualitative research is especially suitable for the investigation of human behavior, as it allows for comprehension of different opinions and crucial context characteristics (Bryman & Bell 2011). The first step in the research was a literature study, followed by an empirical investigation. The literature was mainly used to guide the research, often referred to as a *deductive* process, where the aim becomes to test and challenge existing theories, rather than generate new ones. The relationship between theory and empery will follow the natural science model of *positivism*. Characterizing for the research process was the continuous iteration, a weaving back and forth between theory and empery, adjusting the research question as more knowledge was gained. The final research question became; "*what are the barriers for a manufacturing company, i.e., a company in a more mature industry context, to "open up" its innovation process*[3]*? And will such a company benefit from doing so?*

The main question was in turn allowed to be broken down into three underlying questions which could be researched individually; (i) *what does open innovation really mean and why do companies open up their innovation practices?,* (ii) *what are the hurdles and risks opening up the innovation process?* And; (iii) *are there any managerial countermeasures to reduce or even overcome those hurdles and risks?*

The demonstrated questions served to guide the literature review, which main objective was to create a theoretical framework against which the empirical data then could be analyzed.

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[3] Innovation process specifically refers to the *outside-in* innovation process, i.e., the sourcing of external input to enhance internal innovation capabilities.

The empirical investigation and framework for data collection followed a case study design, focusing on certain parts of the investigated organization. The case study was chosen because of its flexibility to use multiple data gathering methods, but also for the sake of in detail being able to investigate a single situation or closed system. The case is a topic of interest in its own right (Bryman & Bell 2011) and it enables the researcher to identify important phenomena, e.g., identifying barriers to open innovation while also increasing the understanding of how things work (Huizing 2011). To obtain as many perspectives as possible, three data gathering methods were used; (i) unstructured interviews, (ii) documentary data collection and (iii) participatory observation. The use of multiple data sources allows for *triangulation,* a method that helps to reassure reliability and quality of research. In addition, argumentation has whenever possible been complemented with quantitative data to add credibility and reassure objectivity of research.

2.2 Literature Study

The literature study started from a clear problem trigger and could therefore immediately focus on identifying barriers and hurdles towards the implementation of open innovation. The aim was to construct a framework highly relevant for the investigated context, e.g., barriers to open innovation in a mature industry, but since this is an almost unsearched area, only little research had been done in the particular area, the suggested framework also includes findings from closely related fields. The review started by searching Chalmers e-library and browsing the web for relevant articles, books, reports, scientific journals, blogs and web pages. When interesting material was found, the literature and references corresponding to those sources were iterated and a new search began. This process was repeated continuously until the end of the research process. Reading material was also obtained using the local library.

2.3 Empirical Investigation

As the case study aimed to identify potential barriers towards deploying open innovation practices in the more mature industry, a deep analysis of the innovation situation within a MMC in the given context took place. The case study can be described as being of *revelatory* character, meaning that the researcher got a special opportunity to investigate the problem from an angle that normally isn't possible, in this case from a position within the organization while participating in daily work. The researcher thus got access to a wide range of documents and proprietary information that else wouldn't have been accessible and was furthermore able to learn more about, and observe, the problem from within the researched context. Data was as mentioned collected using three methods whereby the most important became semi-structured, open-ended question interviews.

2.3.1 Semi-structured interviews

The research was revolving around internal employees participating in core innovation activities and the level of analysis was determined to certain groupings of those people, representing different functions of the organization, i.e., the IP-, Research-, Development- and Corporate Innovation departments. The particular functions were selected in respect of high involvement in R&D and innovation related activities.

The semi-structured approach to the interviews and the open ended questions were chosen because they would allow the individuals to discuss and share their own opinions, while the researcher could adapt the questions to the interviewee's relative level of understanding of the investigated topic. Ten interviews were held with employees representing the selected functions, individually in person, and lasted between 45-60 minutes. The conversation always started with the researcher defining the open innovation concept and then asking the interviewee to exemplify a similar situation his or her own experience within the company.

Due to privacy reasons, most interviews were not recorded. The researcher took notes that were transcribed directly after the interviews in order to reduce the risk of losing information. Whenever there were additional questions or a need for clarification, the researcher got in contact with the interviewees directly in person. Since the level of analysis was on different groupings of people, caution to avoid cross-level misattribution was taken by always referring to the specific source whenever opinions or facts were stated.

2.3.2 Documentary data collection

The collected documents represent "official" documents as they are derived from organizational sources (see Bryman & Bell 2011). The type of document ranges from internal and external correspondence, internal memos, meeting minutes, external consultancy reports, contracts, oppositions, patent search reports, patent evaluation forms, decision making forms, process charts, strategy updates, negotiation protocols etc. The vast majority of the documents are still protected under so-called "non-disclosure agreements", why such documentation haven't been included in the appendices.

Using documents as source of data requires knowledge on which documents there are and how to determine their "quality" as to secure reliability of the research (Brymann &

Bell 2011). In analyzing those texts, the researcher has taken an active role to the interpretation of the information and recognized the fact that documents have a connection and therefore shouldn't be assessed independently from one another (Bryman and Bell 2011).

2.3.3 Participatory observation

The researcher has participated in daily work by working as an intern in the Corporate IP Department within the researched organization and thereby been able to observe situations meaningful for the research. The participation has led to informal talks about the topic as well as showed examples of real time challenges related to innovation activities. Whenever useful input has been obtained, it has been written down and sometimes also followed up by formal or informal interviews.

2.4 Analysis and Conclusion

The analysis was made by comparing the theoretical framework with the data obtained from the empirical investigation, revealing whether there were any correlations or contradictions between the two. Different barriers towards conforming to open innovation practices were identified and a comparison of the results between the researched functions allowed the researchers to draw conclusions, on which managerial recommendations could be given. All research questions are answered in course of this analysis.

2.5 Quality of Research

Lincoln and Guba (1985) cited in Bryman and Bell (2007 p.43) suggest using *trustworthiness* as criterion assessing the quality of qualitative studies, since traditional measures of reliability and validity rather is concerned with the adequacy of measures. The trustworthiness criteria consist of four different aspects and those will now be assessed in relation to this research:

Credibility: Corresponds to the traditional criterion of internal validity and answers the question of how believable the findings are. The findings in this research are believed to be very credible because of the parallel use of three different data gathering methods allowing for triangulation. Credibility has also been increased by sourcing input from different parts as well as functions of the investigated area, e.g., the researched departments where representatives from several different BU's have been interviewed, to reduce the risk of enlarging narrow minded perspectives.

Transferability: Corresponds to external validity and concerns the question whether the results of the study can be generalized beyond the specific research context. The findings in this report are very context specific and could as such not be generalized. However, many elements of the researched area are covered by the theoretical framework, which partly also is a representation of closely related contexts, why the researcher could claim her findings to at least be relevant and partly applicable to other companies with similar context characteristics. The steps of the research are clearly described and it should thus be fairly easy to perform a similar study again.

Dependability: Corresponds to the traditional reliability criteria which consider whether the results of the study can be repeated another time. For the time being, now and until a few (2-3) years ahead, the results are believed to be very reliable. One interesting aspect however, that possible could change the whole result of this research, is the rate of increased complexity and convergence of the relevant technology fields. The research clearly showed that parts of the organization more active in those technology fields also had different attitudes towards open innovation, which had become a prerequisite for taking parts in those markets rather than "a choice of freedom". Thus in the future when technology has advanced even more and when the markets for those technologies has matured as well, the condition of innovation is likely different and so would the findings of the research.

Confirmability: Corresponds or is similar to objectivity, which addresses if the researcher has let personal values intrude to a high degree, while recognizing that complete objectivity is impossible. To increase confirmability, the researcher has let the interviewed personal approve the transcribed material and obtained input from supervisors within as well as outside the researched area. I addition, quantitative data has been used whenever possible to support argumentation and to increase objectivity of the findings.

3 Open Innovation Frameworks

The following section aims to give the reader a deeper understanding of the investigated area, firstly by comprehending relevant challenges and trends facing modern business and thereby explaining why “opening up” the innovation practices may be important. Secondly the open innovation concept is presented, defining the framework used for this study and lastly the theoretical framework is summarized.

3.1 Innovation Challenges in the New Economy

On a macro scale, new generations of people learn from knowledge once generated by the old generation. The “roll over” of knowledge is probably the largest investment of mankind and it seems to be growing larger and larger (Granstrand 2009). When this knowledge is new and useful to some, it may give rise to new innovations. Firms know about the economic importance of bringing new innovations to market and therefore invest tremendous amounts in R&D, i.e., knowledge new to the world. A big concern however is the diminishing returns. A firm’s innovation Effectiveness curve can be derived buy plotting the return on investment of each R&D project against the cumulative R&D spending in a given period, see *Figure 3.1* and as we can see, the only way to rotate the Innovation Effectiveness curve upwards is by increasing the returns on R&D. A task that becomes even more demanding since the complexity in technology increases and R&D outputs becomes multi-technological (Teece, 1989; Granstrand 1999).

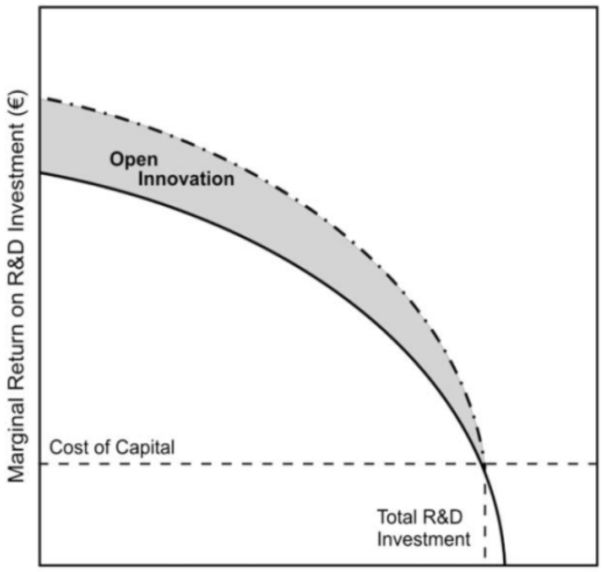

Figure 3.1 - Innovation Effectiveness curve. Source: Sarkar & Costa (2008).

The biggest challenge is thus to stay profitable when the environment changes, companies must therefore look to innovate the innovation model itself (Huston & Sakkab 2006) and their business models through which innovations finally will pass (Chesbrough 2006).

Three additional challenges are related to *the increasing globalization*[4]*, the increasing intellectualization of business* and the *rising issues regarding intellectual property*. As the global diffusion of information and knowledge accelerates, IP becomes more important (Teece 1998). During 2012 global patent filings grew 9.2 %, the fastest growth in eighteen years and faster than the recovery of the world economy (WIPO 2013). Disputes are increasingly arising in relation to the control of creative ideas, rather than in relation to the control of markets and material (Wurzer 2009), which may be demonstrated by the typical commodity which today already consists of 60 % know-how (PriceWaterHouseCooper 2013). Technology acquisitions will likely increase in all industries in the future, both due to IP assembly problems (Teece 1998; Granstrand 1999) but also to the gradual adoption of open innovation strategies (Huston and Sakkab 2006). The increased complexity derived from additional interfaces to external parties (Liechtenhaler 2009) and the risk of creating legal liability to someone else's IP (Gollin 2008) are both important issues to address. Managers in the new economy are therefore forced to adapt an Intellectual Property Right (IPR) focus in order to control the development of knowledge and innovations and to secure profits from their businesses (Heiden & Petrusson 2008).

3.2 The Concept of Open Innovation

In the "*open*" innovation model, companies make use of external ideas and competence, to strengthen its own innovation capabilities (Chesbrough 2003; Gassman 2006; Mortara et al., 2009). The funnel shaped diagram as revised in *Figure 3.2* is a common representation of this process, where the dashed lines symbolize that company boundaries become "*permeable*", as ideas flow from the outside environment to the inside and reversed. The concept is often contrasted to its predecessor, "*closed*" innovation, where companies relied almost entirely on internal channels for research, development and commercialization of inventions (Chesbrough 2003; Enkel & Gassman 2004).

[4] Globalization itself is rather a consequence of the emerging ICT technologies (communication and information technology) and the rise of mobile knowledge workers (Drucker 1973), than a cause of the new economy (Granstrand 1999).

Research projects were launched from the "*science and technology base*" of the company and ideas progressed linearly through the process, entered at the beginning and ended on the market or more likely, got stopped somewhere along the way (Chesbrough 2006).

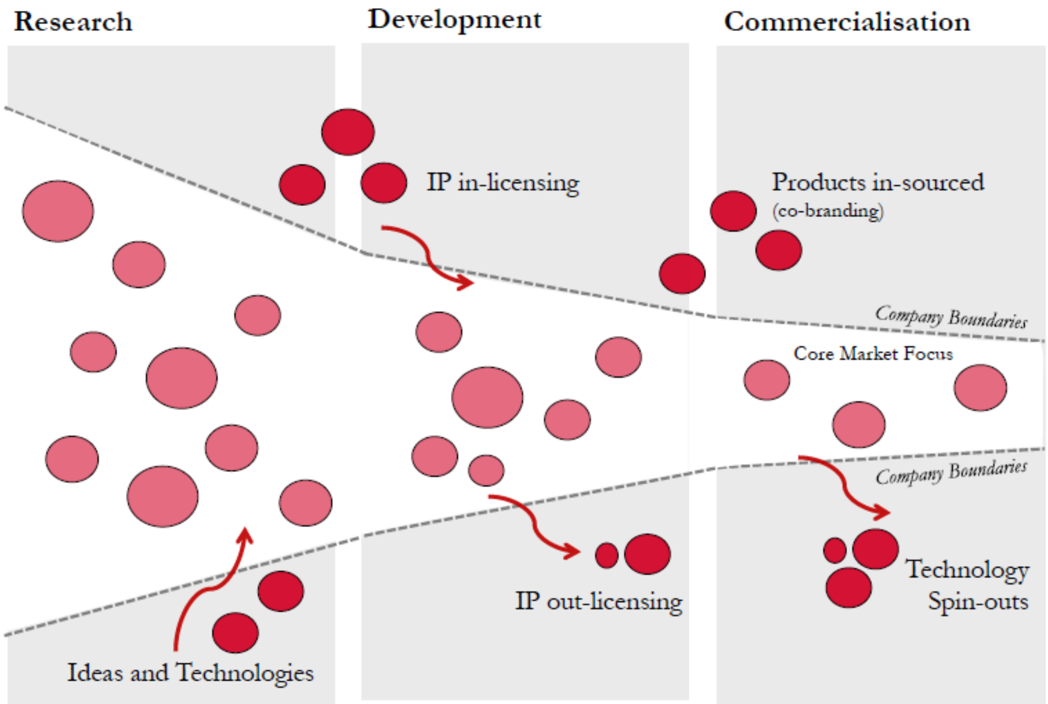

Figure 3.2 - Conceptualization of Open Innovation, adoption of Mortara et al., (2009).

Open innovation is on the contrary: *"the use of purposive inflows and outflows of knowledge and technology to accelerate internal innovation, and expand the markets for external use of innovation, respectively"* (Chesbrough 2003). The effective management of knowledge inflows will become increasingly important as today's competitive advantage often stems from leveraging discoveries of others (Chesbrough 2003; Chesbrough, Enkel & Gassman, 2010). The focus in this report will be on investigating barriers towards the integration of external knowledge inflows and a better definition of the open innovation concepts would thus be; "*innovation efforts that leverage external parties' knowledge and/or ideas, or individual problem solvers, to contribute to the internal innovation process"* (InnoCentive 2013). In other words, the inbound activities, are about enriching a company's internal knowledge base by integrating customers, suppliers and other external knowledge sources into the innovation process (Gassman & Enkel 2004) and thereby increase internal innovativeness (Piller & Walcher 2006).

Before leaving this section it's important to note that open innovation reflects much less a dichotomy open versus closed than a spectrum with varying degrees of openness (Huizing 2011; Petrusson & Heiden 2009).

3.2.1 Motives to adopt open innovation practises

There isn't *one* single reason to why firms chose to open up their innovation practices. Motives are ranging from pure strategic to brute financial and the many advantages of cooperation have been confirmed by many scholars. Koschatzky & Sternberg (2000) even found that firms which do not exchange knowledge and collaborate, risk reducing their knowledge base on a long term basis. In line with that, recent research show that companies often experience a perceived inability to meet corporate growth objectives, absent acquisition of external technologies (Chesbrough & Crowther 2006; Huston & Sakkab 2006). The identified motives to open up the innovation practices are summarized in *Table 3.1* below.

Table 3.1- Motives to open up the innovation process

Strategic motives Reducing time to market Monitoring potentially "*disruptive technologies*" Access improved product features Improve the internal innovativeness by leverage external resources	Enkel, Gassman & Chesbrough 2009; Chesbrough & Crowther, 2006; Dröge et al., 1999
Financial motives Access to new geographical markets Improve product margins and reduce risk in technology development	Teece 1998; Chesbrough & Crowther 2006; Liechtenhaler & Ernst 2009; Reepmeyer et al., 2011
Technological motives Fill the development pipeline and accessing new ideas Allow a variety in product development Access new or supplementary product or process technologies	Nambisan & Sawheny 2007; Ceasaroni, 2004; Enkel & Gassman 2004
Operational motives Earlier identification of technical problems Fewer engineering change orders and the possibility to access prototypes	Enkel & Gassman 2004; Ragatz et al., 2002

3.2.2 Managerial challenges adopting open innovation practices

A central notion is the "*technology base*" of a company as well as of a product. The technology base means the aggregated asset of the technological competence or capability (knowledge and skills) that the company possesses or controls. Regarded as an asset the technology base can be acquired, developed and exploited in numerous ways. According to Granstrand (2009) there is one set of acquisition strategies to build up the technology base and one set of exploitation strategies to exploit it. Acquiring new knowledge and technologies[5] from external sources, can as seen in *Figure 3.3* be done in a number of ways; by performing internal R&D, by acquiring innovative firms, by creating joint ventures, by trading at technology markets or by using technology intelligence. The basis for the topology is the contractual form for supplying and seizing technology, including the absence of contracts[6]. The different contracts are ordered according to falling degrees of organizational integration, or conversely in line with increasing level of openness. Internal R&D is for example based on the employment contract, why it represents a high degree of organizational integration.

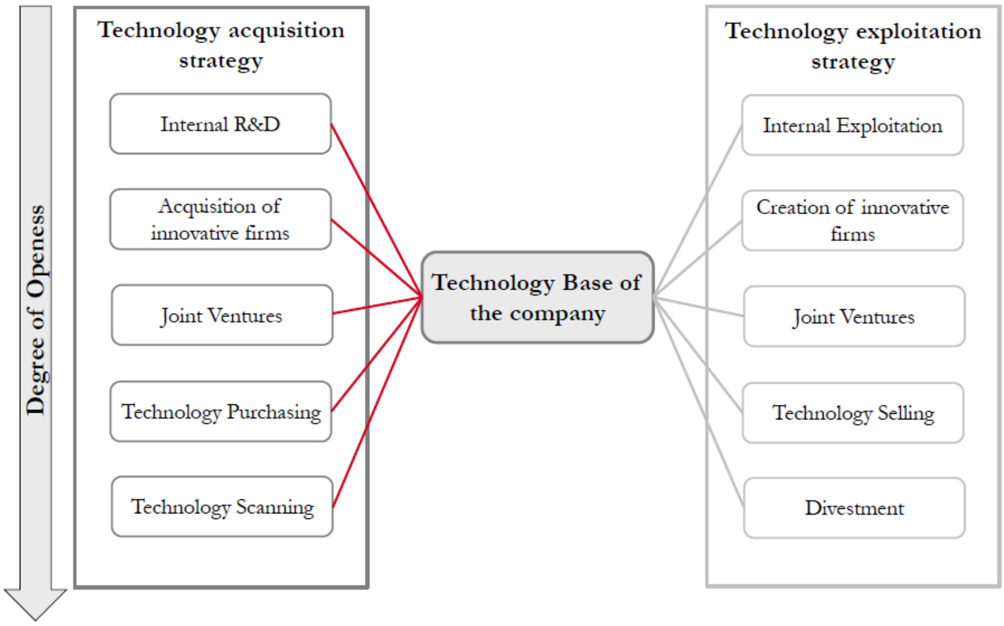

Figure 3.3 - Technology Sourcing and Acquisition Strategies, adoption of Granstrand (2009).

Scholars have distinguished management of technology and knowledge in three distinctive processes; *knowledge exploration, retention* and *exploitation* (Liechtenhaler & Ernst 2006). The three processes comprises; the knowledge generation inside the firm, the technology sourcing from external partners and the need of storing technological knowledge over time plus the maintenance of knowledge in inter-organizational relationships. When firms open up towards the outside environment, they must rely more strongly on the external coordination of the technology management tasks

[5] Knowledge can be tacit, i.e., informal, unstructured and unmodified but it can also be explicit, i.e., formal, structured and codified (Granstrand 2009). Technology is per definition a body of knowledge and technological information (Granstrand 2009) and as certain knowledge and technology becomes explicit, it can be protected (IPRs).

[6] In Granstrand's (2009) model technology scanning, storage, loss and leakage are refers to non-contractual modes, where technology scanning includes legal and illegal ways of acquiring technological know-how from the outside. Storage and leakage are no strategies per see, rather a residual of unappropriated technology, possibly leaking to competitors through their technology scanning efforts.

(Liechtenhaler & Ernst 2006), which often meets a lot of resistance (Gassman 2006). Opening up the innovation process will thus involve change, thereby the relevance of general change management concepts. Klein and Sorra (1996) suggest the following steps to achieve a good implementation climate:

Provide incentives for right use and disincentives for avoidance, i.e., monitor and measure progress, reward good use of new practices while not encouraging use of traditional activities;

(1) Remove obstacles by allowing "time to absorb and learn about the new practices";
(2) Develop skills for use, provide training and additional assistance, and;
(3) Listen to complaints and concerns.

3.3 Identified Barriers Towards Opening Up the Innovation Process

Mortara et al (2009) suggest there are particular four critical areas regarding the implementation of open innovation that have to be addressed: c*ulture, procedures, skills and motivation*. Barriers related so similar dimensions are confirmed by other researchers who also add the dimension of *trust* in people as well as in technology (Holmström & Westergren 2012), *performance measurements* as in corporate performance metric systems (Chesbrough & Crowther 2006; Chesbrough & Brunswicker 2013) and *strategies and goals* as to support open innovation activity (Chesbrough & Crowther, 2006). In addition, Liechtenhaler & Ernst (2006) suggests that potential *risks* associated with open innovation are a reason to believe that companies avoid opening up their innovation practices. The *context* in which the company operates is another factor impacting whether open innovation practices are being adopted (Golinghy et al., 2011). There is thus range of barriers that potentially limits firms from opening up their innovation practices. To explore some of those, the dimensions of; *context, culture, motivation, procedures, skill, trust, strategy* and *perceived risk* will be investigated in the section below.

3.3.1 Contextual barriers

Gassman (2006) does indeed conclude that a company's internal organization and strategy, rather than industry characteristics, is a major determinant for the implementation of open innovation. Never the less, Golightly et al., (2011) put emphasis on also investigating the relevant sector in which the company operates, since there is a sharp distinction between practices and approaches among investigated "open innovation companies". The authors found that different sectors have different needs of open innovation, some may even have limitations that restrict the impact of it, such as traditional cultures or requirements for secrecy or strong IP regimes, thus depending on sector characteristics, companies may be more or less likely to adopt open innovation practices. Five broader trends seemed to be especially influential; (i) *the relative influence of technology push on sector innovation*, (ii) *the length and complexity of the innovation cycle in the sector* plus if there were some *regulatory requirements*, (iii) *the approach to IP*, (iiii) *the preferred source of innovation* (from existing supply chain or from new sources) and (iiiii) finally *the overall disruption* (extent of change) *and turbulence* (pace of change) *in the environment.*

Enkel and Gassman (2008) report from a study among 144 European companies (all sectors), that clients represent a very important source for 78 % of the sampled companies, suppliers (61%); competitors (49%) and private and public research institutions (21%). Notably a large portion of "other" knowledge sources (65%) were very important, constituting of non-customers, non-suppliers, and non-competitors. The last observation goes well in line with the development of social networking, such as using intellectual crowds for corporate R&D (Howe 2006). The relative importance of internal and external knowledge sources varies across industries (Klevorick et al., 1995) and can be determined by a firm's technological position (Hermes, 1993). Previous research have indicated that internal R&D still is the predominant sourcing strategy for traditional engineering companies (Granstrand 2009; Chesbrough & Crowther, 2006; Liechtenhaler & Ernst, 2006) and the manufacturing industry as a recent adopter to the open innovation concept is no exception (Grandstrand, Bohlin, Oskarsson, & Sjoberg 1992; Hirsch-Kreinsen & Jacobson 2008).

Tables 3.2 and *3.3* demonstrate selected results from Hirsch-Kreinsen and Jacobson's (2008) study on innovation in the more "*low-tech*" industries[7]. From *Table 3.2* we can read that highly important sources of knowledge and information, as a percentage of the manufacturing enterprises in 20 EU member states are internal R&D, customers and suppliers, whereas competitors and enterprises in the same sector have significantly less importance.

[7] Source: CIS4. Cf. Table 12.1. Innovative companies in EU-27 member states without Austria, Ireland, Portugal, Latvia, Slovenia, Sweden and the United Kingdom, in Hirsch-Kreisen and Jacobsson (2008).

Table 3.2 - Sources of knowledge in manufacturing industry (MI)(%) of innovative enterprises

	Within the enterp rose group (%)	Suppl iers (%)	Clients or custom ers (%)	Compet itors or other enterpri ses of same sector (%)	Consultan ts, commerci al labs o private R&D institutes (%)	Univers ities or higher educati on instituti ons (%)	Govern ment or public research institute s	Confere nces, trade fairs, exhibitio ns (%)	Scientific journals; trade/tec hnical publicatio ns (%)	Professional and industry associations (%)
MI	**44.8**	**22.8**	**27.3**	**11.8**	**6.3**	**4.1**	**2.9.**	**12.7**	**8.1**	**5.1**

From *Table 3.3* we can observe the innovation and cooperation activities among the same manufacturers, and conclude that only one forth cooperates at all and of those who does, clients and suppliers are the preliminary partners. Competitors and private and public research institutions are the least involved partners. A critical challenge as partnerships become more common and as competition in emerging economies increases, is to balance the level of "*openness*" against that of "*security*" (Golightly et al., 2011).

Table 3.3 - Innovation activities & cooperation in the manufacturing industry (MI) 2002-2004[8]

	All types of cooperat ion; in % of all enterpris es	Other enterprises within the same enterprise group (%)	Suppliers of equipment, materials, components, or software (%)	Clients or custome rs	Competito rs or other enterprises of the same sector (%)	Consultants, commercial labs or private R&D institutes (%)	Universitie s or higher education institution s (%)	Govern ment or public research institutes (%)
MI	**25.2**	**8.5**	**16.1**	**13.7**	**7.3**	**8.9**	**9.6**	**5.8**

3.3.2 Cultural barriers

Overcoming issues of organizational culture is a major challenge opening up the innovation process (Golinghtly et al., 2012; Mortara et al., 2009). The culture concern is especially predominant among older firms with well-established norms and corporate values (Golinghtly et al., 2012). Opening up the innovation process will mean doing things differently or even contra dictionary to before, which may require a change in the deepest level of culture, i.e., the basic underlying assumptions, which is proved to be very challenging (Mortara et al., 2009). Within a big organization, it is however likely to find several *sub-cultures*, who react very different to the open innovation concept (Golightly et al., 2012; Mortara et al., 2009). Those exist because certain functions are intrinsically

[8] A percentage of European innovative enterprises

open by nature, while others are intrinsically closed (Mortara et al., 2009), for an overview see *Figure 3.4* below.

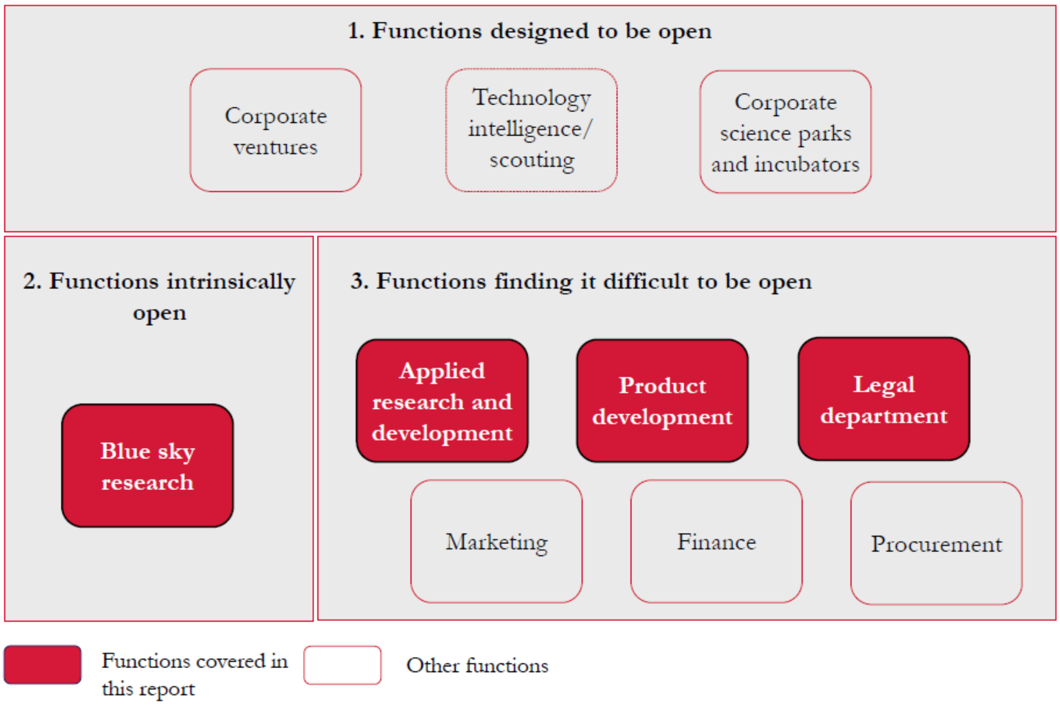

Figure 3.4 - Intrinsically closed versus open functions, adoption of Mortara et al., (2009).

The R&D function that long has been intrinsically closed is often experiencing the strongest cultural clashes to open innovation. Typical symptoms are a fear of redundancy and a lower perceived political influence in decision making as (Mortara et al., 2009). Supplementary to the phenomenon of sub-culture are *attitudes*, which in contrast may differ between groups of employees within the same sub-culture (Golightly et al., 2012; Mortara et al., 2009). For example "Blue sky researchers" are often more open towards external input than their colleagues in the applied R&D, who typically directs efforts to less speculative research and technologies (Mortara et al., 2009). Applied research teams are often led by managers motivated by goals and monetary returns from the product market (Hebda, Vojak & Price 2007), thus shows more the characteristics of an "*achievement*"[9] culture (Mortara et al., 2009).

Another barrier related to the organizational culture is the "*Not Invented Here*" syndrome (see Katz & Allen 1989), a phenomenon describing the situation when organizations or their parts only look at internally-derived ideas and technologies, unwarrantedly

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[9] Organizations differ in characteristics and organizational structure (for model see Pheasy 1993; Brown 1998), companies or divisions with a predominant "*achievement*" and "*support*" culture might be more suited for open innovation (see Mortara et al., 2009).

neglecting ideas and initiatives from the outside. Explanations for the negative attitude range from previous "bad" experiences, personal as well as second-hand, to employment insecurity when acquisition of external input is perceived to reduce the need of internal staff it could also be a reason of imbalanced incentive systems and risk adversity (Liechtenhaler 2009). The rivalry between particular BU's or business lines can also deter the leverage on internal resources (Golightly et al., 2012), similar to that of the NIH syndrome, but internally.

3.3.3 Trust related barriers

Managers who want to make use of a more open innovation process will have to make new decisions in development activities, answering the questions *when?, how?, with whom?, with what purpose* and *in what way?*, do we plan to use and acquire external knowledge and technology (Chesbrough & Crowther, 2006). Holmström & Westergren (2012) found that trust can be a barrier or conversely an enabler to implement those decisions. They found that the move towards a more open innovation environment is facilitated through the ways in which trust in people (e.g. the social networks) makes trust in technology possible. They point out that trust in information technology, for example, is especially important for the running of modern organizations and likewise an enabler of social action.

Another barrier closely related to this topic is the interaction between large organizations, its networks, smaller businesses, universities and even individual contributors, with whom a firm is looking to engage. Large organizations often see themselves as leaders or dominators of their eco-systems, while the different relative sizes, perspectives and previous experiences in collaboration, will impact the balance and value distribution (Golightly et al., 2012). A challenge for a large corporation is according to the same thus to see themselves as innovation "*orchestrators*", keeping a handle of many complex open relationships, while not strangling smaller entities by overly close control. This could namely hamper the quality of the innovative outcome (Golightly et a.l., 2012).

3.3.4 Motivational barriers

Open innovation is a people driven process rather than organizational (Golightly et al., 2012), therefore appropriate motivation and incentive systems must be put in place, else it may present a big obstacle to the implementation (Chesbrough & Crowther 2006). In general, the research field change management would argue that people often are reluctant to change, as changing structures, power distribution and revenue streams may affect them negatively (Linner et al., 2012). Thus, lacking incentive systems and poor implementation plans will likely not motivate employees to support and encourage the new practice (Klein & Sorra 1996). Another closely related challenge is to sustain sufficient commitment over time, in order to realize the first benefits from implementing the open innovation concepts (Chesbrough & Crowther 2006). To sensitize and motivate a broader range of employees to the potential advantages of open innovation, organizations may include "open innovation experiences" into personal career development objectives (Golightly et al., 2012). A problem for motivated individuals is often the missing formalized career path for "open innovation pioneers" (Chesbrough Gassman & Enkel 2010). Employment models also vary greatly, which in terns impact the openness of the employees (Mortara et al., 2009). Such issues are according to the researchers often being underestimated and are often invisible to those outside the culture, but those can create severe miss-understandings and yield different expectations in collaboration activities.

Arora, Fosfori & Ronde (2014) investigated whether the location of the licensing decision mattered in terms of increased licensing activity by looking at the two factors; *difference in information* and *difference in incentives* and found that the BU's have superior information about licensing opportunities compared to centralized licensing departments, but lack incentives to act, because success is measured through performance in the product market. Thus, when BU's are in charge of licensing, they may forego valuable licensing opportunities, making decentralized licensing functions less efficient. Centralizing licensing would potentially reduce the danger that decisions are based on narrow interest of the BU.

3.3.5 Strategic barriers

Chesbrough & Crowther (2006) noticed that companies beyond the high-tech industries, who successfully managed to open up their "*inbound*" innovation process, started with a top-down strategy and clear alignment between the need to meet business growth objectives and the desire to look outside for technology. The companies however often struggled to decide whether the focus of openness should be on optimizing incremental development practices, or to create step-change growth options, or both. The research showed that adopters to the open innovation concept perceived it extremely important to provide focus and a clear top down direction, while greatly involving R&D in due diligence and integration activities.

Another aspect of success is the balance between "*independence and integration*" of open innovation activities (Mortara et al., 2009). Some companies create independent open innovation teams to work with the traditional configuration of the organization towards implementation, but it is observed that this "gluing on top" often not results in a successful implementation (Chesbrough & Crowther 2006). Huston and Sakkab (2006) points out that open innovation efforts at least have to be in line with, but preferably also a part of corporate strategy.

Many companies struggle in finding the right balance between the use of external and internal ideas. The IP strategy is thereby often found to be a disabler of open innovation efforts (Alexy, Criscuolo & Salter 2009). Negative effects occur when IP is transformed from a means of capturing value of innovation to an end in itself. Many companies patent everything that resides from their R&D activities, which not only results in huge costs, but in huge waste and in scaring away people with whom collaboration could be beneficial, called the "IP *Medusa Effect*" (Alexy, Criscuolo & Salter 2009). The common "*no patent, no talk*" policy often prevents collaboration if there isn't already a filed patent. The interest in IP has also spread to the universities, who likewise insist on their own IP terms before collaborating with industry, which may present a major barrier to collaboration. The "*one-size-fits-all*" approach to IP is very limiting to open innovation (Alexy, Criscuolo & Salter 2009). To increase the usefulness of corporate IP, P&G for example established a "use-it-or-lose-it" IP policy, where technologies developed in-house will be considered by the licensing department if they haven't been used within five years after its grant. If a patent cannot be licensed, it will not be renewed, thereby saving running costs and promotes collaborative innovation (Huston & Sakkab 2006).

3.3.6 Procedures

Open innovation practices require internal collaboration (Chesbrough 2003; Gassman & Enkel 2006). Managers are dependent upon internal expertise in judging new product and technology prospects (Granstrand 2009) and resources must be gathered in order to assimilate, adapt and improve upon the original technology and put suitable IP strategies in place to protect it (Mortara & Ford 2012). Opening up the innovation process thus often need appropriate changes in internal procedures and structures to support internal as well as external network development (Chesbrough & Crowther 2006; Mortara et al., 2009). If people are not allowed to move around within the organization, the intensity of essential internal networks and the so-called "cross-functional ties" will likely make employees less open (Chesbrough & Brunsvinkler 2013). When operatives have difficulties relating to the range of aspects concerning the overall business, rotation becomes especially important (Mortara et al., 2009).

The reluctance to change organizational procedures and structures is often called the Organizational Inertia (Ford & Probert 2011) which refers to the role structured routines play in constraining company's competitiveness. Over time companies often develop highly structured routines in order to reduce costs associated with information acquisition and coordination, which now may hamper the firm's ability to adapt the structures to better facilitate survival in the new environment.

Another barrier is the lack of appropriate open innovation infrastructures and tools, such as platforms for sharing internal as well as external information and tools for online idea management (InnoCentive 2014). The role and availability of technology in the move from closed to open innovation, both in making the transition and in sustaining inter-organizational "ties", maters (Innocentive 2012; Westergren & Holmström 2012).

Gassman et al., (2010) notes that internal processes, through which companies manage open innovation activities, rather are trial and error based, than properly managed. Companies in general (not only mature industries) thus lack a "*formula*" helping managers decide when and how to use the different open innovation practices, and at what stage in the innovation process collaboration is most effective, with whom collaboration shall be done and how external parties are found and selected (Gassman et al., 2010).

3.3.7 Performance measurements

Companies who want to engage in open innovation practices need to adjust measurement systems for their employees as well as organizations, in order to better point the direction towards increased "*openness*" (Golightly et al., 2012). Metrics and incentive systems must be aligned to encourage success, whether in open or closed environments, since both strategies are complementary to one another (Chesbrough & Crowther 2006). One challenge is that open innovation initiatives often are used as proxy to improve other measures (Chesbrough & Crowther 2006; Golightly et al., 2012) and are therefore not in focus. Beyond measuring the contribution of external technology to returns, on organizational level, there are several alternative ways to use open innovation performance metrics. Recent developments point in the direction of individual performance measures, built to drive performance of individuals. One such example is to measure "*client satisfaction*", which in theory will lead to a greater focus on serving clients and if open innovation is the best way to drive that measure, it will be used (Golightly et al., 2012).

3.3.8 Skill

A firm's ability to develop and utilize inter-firm relationships and to adapt and exploit external knowledge, is critical to their success in transferring this knowledge to the outside environment. A company thus needs certain capability and skill to effectively be able to open up their innovation processes. Mortara et al (2009) found that there is no perfect blend of open innovation capability and skill, but failing to acquire the necessary ones, is proved to be a clear obstacle to its implementation. Enkel & Gassman (2008) found it is especially essential for companies to develop *absorptive-*, *multiplicative* and *relational capability*. Closely related research streams have identified that also skills in the use of ICT (information and communication technology) and skills in the use and management of IP, are essential prerequisites for open innovation initiatives to emerge. The open innovation "s*kill set*" relevant for this research is visualized in *Figure 3.5*.

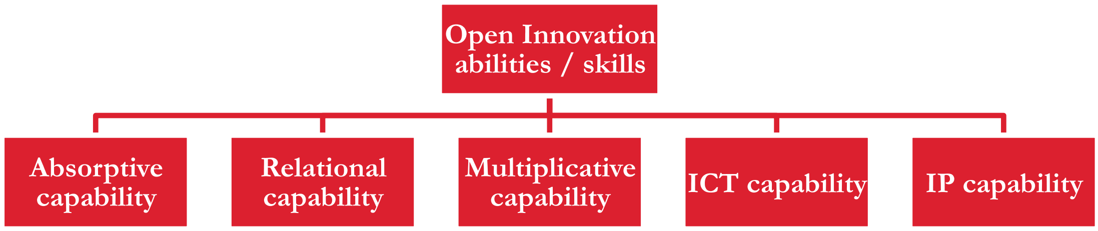


Figure 3.5 - Summary of the open innovation "skill set"

Absorptive capability is the ability to recognize valuable new knowledge, assimilate it and apply it to commercial ends (Enkel & Gassman 2008). In other words, a company must skillfully be able to manage the identification, creation and application of new knowledge. This is becoming challenging in the current environment since the abilities to develop multi-technological outputs often are "*functionally and spatially dislocated*" over organizational and geographical boundaries (Tietze 2012), and technology generation and application processes are becoming increasingly complex and expensive (Enkel & Gassman 2008). The efficiency of knowledge creation and application is conditional to the well-known concept of "*absorptive capacity*" (see Cohen & Levinthal 1990). A high absorptive capacity enables companies to internalize external knowledge effectively (Spithoven, Clarysee & Knockaert 2010) and is critical to a firms innovation success (Cohen & Levinthal 1990).

Multiplicative capability is the ability to select the right partners, willing and capable of multiplying the new technology and reversed; the ability to codify and share knowledge with the chosen partners (Enkel & Gassman 2008). The multiplicative capability is strongly connected to the exploitation of knowledge, but it also relates to a firm's ability to select appropriate partners and to transfer its knowledge on to those partners, yielding a more fruitful outcome. The ability of networking, i.e., to identify and build up strong networks in relevant areas and to bring in innovations only where internal R&D still can add value, is a difficult to acquire but essential open innovation skill (Chesbrough & Crowther 2006).

Relational capability is the ability to build and maintain external relationships (Enkel & Gassman 2008). In the era of open innovation firms will increasingly need to engage in high level collaboration with different parties, at different stages in the R&D process (Fowles & Clark 2005). A company can differentiate through its networks, i.e., through the collaborations, joint ventures or activities it undertakes. Relationships with complementary companies, universities, research organizations and even competitors may be a firm's major asset and thereby source of competitive advantage (Gassman & Enkel 2008). The management of networks and network "*ties*" and the aspect of trust in this process, can sometimes be a big issue that is closely connected to the process of changing the logic of innovation, from closed to a more open model (Holmström & Westergren 2012). In addition, a firm's ability to utilize information and communication technology (ICT) efficiently may help develop other capabilities necessary for open innovation and also provide a smoother flow of internal as well as external knowledge and ideas (Bharadwaj 2000).

ICT capability is the "*ability to mobilize and deploy IT-based resources in combination, or correspondence with other resources and capabilities*" (Bharadwaj 2000 p. 171). Effective ICT system and tools reduces the perceived distance between and among external parties and employees, whilst leading to a smother flow of ideas, knowledge and information. Successful innovation relies not just on the development of ideas, but also in the ability to protect and execute these ideas.

IP capability is the ability to protect and execute new ideas (Kalypso 2014). For many companies, developing an IP strategy and managing their portfolio of IP assets is a major challenge (Harrison & Sullivan 2011; Rivette & Klein 2000). In prior theories IP was treated as a by-product to innovation (Chesbrough 2006), but it has now become crucial for almost every industry to develop skills in IP management. Enterprises must know how to respect IP rights of others, while learning about the multiple ways there are to accessing external IP, without creating legal liability, such as looking for "*IP free zones*", finding alternative solutions, "*design around*" or even using IP as a "*bargaining chip*", e.g., legal defects in the IP owners right (the other party) (Gollin 2008). The process just described is referred to as a "*freedom to operate analysis*" which firms must be able to perform. Firms must also be able to perform technology licensing (Granstrand 2009). The license constitutes the legal basis of in- and outflows of knowledge (Arora, Fosfuri & Gambardella 2001; Chesbrough 2003; Granstrand 2009) and is thus a mean to govern collaborative activities and ultimately also to control the in- and out flow of knowledge and IP between organizations (Chesbrough 2006).

3.3.9 Potential risks

Despite the success of some pioneering firms, many other are often reluctant to excessively opening up their innovation processes, due to potential risks (Liechtenhaler & Ernst 2006; Rivette & Klein 2000). The most prominent risks associated with the "*opening up*" of the innovation process, according to Liechtenhaler & Ernst (2006) are;

- The risk of limiting internal development of critical technological knowledge;
- The risk of increasing dependency on external technology providers, and;
- The risk of increased complexity derived from additional interfaces with external parties.

In line with Liechtenhaler & Ernst (2006) identified risks, Chesbrough, Enkel & Gassman (2010) concluded in a survey of 107 companies that the strongest perceived risks are related to; the loss of proprietary knowledge (48 %), loss of control in IP (41%) and to higher complexity in coordination of innovation activities (41%). Gollin (2008) points out another relevant risk related to IP, that of creating legal liability in relation to a third party. The risk of "limiting internal development of critical technological knowledge" is identified by Cohen & Levinthal (1990) who noticed that companies relying heavily on external partners in fact often neglect internal development of technological competencies, which according Liechtenhaler & Ernst (2006) may result in three negative effects; (i) no or little building up and/or maintenance of technological core competencies, (ii) decreasing absorptive capacity, as a result of the loss of valuable internal technological knowledge and skill, required in order to identify and assimilate external inputs, and lastly (iii) lower motivation of internal R&D staff, who might perceive open innovation practices a threat to their own work. Replacing internal technology development completely thus increases the risk of losing essential technological knowledge, which is needed to maintain the capability to effectively identify and assimilate external knowledge. The risk of *"increasing dependency on external technology providers"* has a strong focus on maintaining knowledge outside firm boundaries, which may result in limitations to the firm's internal knowledge base (Liechtenhaler &

Ernst 2006). The risk of "*increased complexity derived from additional interfaces"* results from the multitude of relationships, which aren't necessary stable over time (Liechtenhaler & Ernst 2006) and the higher complexity in the coordination of innovation activities (Chesbrough, Enkel & Gassman, 2010).

The last risk is related to escalating transaction costs. A technology transfer has as any other transaction, costs associated with it (Mortara & Ford 2012). A technology consists of *"implicit knowledge"* in form of documents as well as *"tacit knowledge"* existing in the mind of those who developed it (Granstrand 2009). Gaining access to tacit knowledge without input from involved individuals, is often costly and very time consuming (Mortara & Ford 2012). External technologies also often need to be adapted to match a firm's internal needs and those adaptation requirements seem to be underestimated in many cases (Huston & Sakkab 2006; Liechtenhaler & Ernst, 2006; Mortara & Ford 2012).

3.4 Identified Managerial Countermeasures to Overcome Barriers

Open innovation often starts in a decentralized manner and some divisions are already practicing it to some degree. There are formal and informal practices for managing open innovation. In the early history companies rather applied a trial-and-error based manner to the management of it (Chesbrough & Brunswickler 2013). Today however, scholars argue that a more formalized approach for the management of knowledge inflows and outflows is needed (Liechtenhaler & Liechtenhaler 2009). A formal approach would mean that a company uses a documented strategy for open innovation, writes down and standardizes procedures for implementing it and also implements different types of performance metrics, to measure and evaluate the impact. Incentive system to motivate individual action is also designed and implemented. In contrast to formal procedures, there is a more informal dimension of managing open innovation; reading upon organizational culture, norms, values and relationships. Managing open innovation requires attention to the formal as well as the informal dimension (Chesbrough & Brunswickler 2013).

Several studies show that involvement of top management in the transition towards a more open environment, has helped to change organizational culture (Chesbrough & Crowther 2006; Golinghtly et al., 2012; Mortara et al., 2009). Companies who successfully overcame the NIH syndrome provided strong leadership, a focus and clear direction, accompanied by means of effective communication (Golightly et al, 2012). The challenging task to integrate external knowledge or technology into internal processes and commercial products can be addressed by developing certain skill. Scholars suggest using cross-functional teams, where people can build on each other's strengths (Mortara et al, 2009). A company can also assign internal "champions", who interacts with different functions across the enterprise, supporting the integration of the new technology in the current development phase-gate process (Chesbrough & Crowther, 2006). Managers need to make IP an enabler rather than a disabler of OI efforts. Companies shall conform to a "case-by-case approach" instead of the "one-size-fits-all" IP policy that often makes productive external opportunities going to waste (Alexy, Criscuolo & Salter 2009). They shall develop a business-lead IP strategy that translates into smart IP policies and processes, where employees know how IP fits into the overall value-capturing corporate strategy. For example, licensing IP in and out when possible (Rivette & Klein 2000), divest and prune IP when needed (Harrison & Sullivian 2011), applying for patents only to protect the most valuable inventions (Alexy, Criscuolo & Salter 2009) and acquiring external IP only where internal R&D still can add value (Chesbrough & Crowther 2006). To minimize the risks associated with open innovation, companies shall continue to develop their internal technology and knowledge base, in order to benefit from relationships and technologies of external partners also in the future (Liechtenhaler & Ernst 2006; Mortara & Ford 2012). They may also consider acquiring external knowledge from multiple partners to diversify risks (Liechtenhaler & Ernst 2006). There are also benefits from building long term relationships, which can facilitate the development of mutual trust (Holmström & Westergren 2012).

3.5 Summary Theoretical Framework

To summarize, adopting open innovation appears to require practices that are highly focused and aligned with overall business objectives. Effective adoption also typically requires overcoming additional challenges such as; cultural as in the not invented here syndrome (NIH) and the more structural as in strategy, procedures, measurement and incentive systems. The biggest challenges in itself is likely to manage the transition from a closed towards a more open innovation environment internally, maintaining the momentum and support from the employees long enough to reap the first benefits of the new practices. The theoretical framework in summarized in *Table 3.4*.

Table 3.4 - Summary Theoretical Framework

	Definition in report	Identified barrier to open innovation	Suggested managerial countermeasure
Context	The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood and assessed.	• Regulatory requirements in industry • Conservative approach to IP (defensive) • Internal R&D is the principal source of new knowledge. • It's hard to find the right balance open vs closed	• Foster a culture where OI always is considered as option for new knowledge, build trust in relations • Increase the understanding of offensive as well as defensive IP strategies
Culture	The arts and other manifestations of human intellectual achievement regarded collectively, within the corporation.	• Traditional values • NIH syndrome • Strong sub-cultures • Rivalry between internal functions	• Strong leadership and top down direction, using means of effective communication • Involve R&D early in OI transition
Trust	The firm belief in the reliability, truth, ability or strength of someone or something.	• Low trust in external technologies (tech) • Low trust in external sources (people) • Low trust internally (people) • Unbalanced value distribution in collaboration networks	• Build long term relationships, those may facilitate the development of mutual trust • Involve R&D early in technology acquisition processes
Motivation	The reason or reasons the employees have for acting or behaving in a particular way.	• Imbalanced incentive systems • No formal career path for OI pioneers • Not enough commitment to sustain OI activities over time	• Design incentive systems to motivate individual action • Implement new performance metrics to evaluate OI impact
Strategy	The plan of action or policy designed to achieve an overall aim, where the goal is the object of someone's (corporation or individual) effort.	• There is no top-down strategy for OI • OI isn't in line with corporate strategy • There is no corporate technology strategy • There is a "no patent no talk" IP policy • There is an "*IP Medusa effect*"	• Focus effort, document OI strategy • Craft technology acquisition and • exploitation strategies • Design a business-lead IP strategy, connected to smart IP policies and processes
Procedures	The series of actions conducted in a certain order or manner, including the arrangement of and relationship between the parts of the corporation.	• OI initiatives don't fit into current processes or organizational structures • OI leads to actions contra dictionary to those that were done before • Lack of appropriate open innovation tools and infrastructures (IT solutions)	• Write down and standardize procedures for OI • Integrate OI in current processes • Provide appropriate OI tools (ICT's)

Performance Measures	The process of collecting, analysing and reporting information regarding the performance of an individual, organization, system or component.	• OI initiatives are used as to improve other measures, thus not being measured at all • Measurements on organizational level fail to capture and encourage proxy individual action	• Align performance measures to encourage success, weather in closed or open environments • Implement individual performance measures tied to OI experiences • Measure items such as "customer satisfaction"
Skill	The ability to do something well; an expertise, capability or special competence.	• Not possessing the right blend of open innovation skills • Difficult to coordinate the broad variation of skills, which mostly are "*functionally and spatially dislocated*" • External coordination of technology management tasks	• Build cross-functional teams to build on internal strengths • Assign internal OI champions to support integration of new technologies • Provide training for OI activities
Potential Risks	The possible but not yet actual situations involving exposure to danger	• Loss of proprietary knowledge • Limiting development of internal skill and core technological competence, thus impeding future absorptive capability • Increasing dependency on external technology providers • Increasing complexity derived from additional interfaces with external parties • Escalating transaction cos	• Continue to develop internal technology and knowledge base • Acquire technology from multiple sources and practise IP management • Acquire technology only where internal R&D still can add value • Evaluate acquisition prospects thoroughly, i.e., performing legal, business and technical due-diligence

4 Empirical Investigation – a Case Study in Manufacturing

This chapter outlines the results from the empirical study that revolved around the innovation tasks within the investigated organization. The main emphasis has been on semi-structured interviews; see overview in *Table 4.1*. Many useful insights are none the less derived from collecting official documents and participating in every-day work. The section firstly presents objective information gathered about the research context, which is followed by the more subjective information gathered from the employee interviews.

Table 4.1 - The interviewed employees, their functions and positions

Function	Position	Interviewee
Corporate IP	Head of IP	A
Corporate Innovation	Innovation manager	B
Corporate Research	Research engineer	C
	Research engineer	D
Development (BU)	Head of development	E
	Head of projects	F
	Development engineer	G
	Development engineer	H
	Development engineer	I
	Development engineer	J

4.1 Construction in General, the MMC in Particular

MMC is a manufacturer of tools and consumables to the global but professional construction, building and maintenance industry. As we've learned, open innovation prerequisites may not only depend on individual employees' strategic choices and the internal structures, but also on characteristics of the industry where the company operates (Golightly et al., 2011). The aim of this section is therefore to describe the context in which MMC operates.

The construction industry is very traditional and hasn't been transformed by many radical innovations, compared to higher speed, -technology intensive industries, like for example computing or automotive, where entire systems can change only within a few years (Linner et al., 2012). In contrast, the construction industry is characterized by longer innovation cycles, lower technology intensity and in general, lower R&D costs. However, this picture is changing. Construction industry now faces challenges, such as increasing material- as well as labor costs. The increasing requirements on buildings both in terms of safety, quality, cost and sustainability, call for new innovations in the sector and so Linner et al (2012) have performed research on the particularities of innovation in this sector and found that innovation in construction may be broken down into the following seven categories:

- **Level 1: Construction Materials:** may for example refer to innovations related to the development of ultra-strength concrete.
- **Level 2: Construction machinery/production technology**: referring to incremental or disruptive innovations used on- or off-site, for example improved robotic cranes or automated construction sites.
- **Level 3: Construction components:** this level reflects the modular structure of a building. There are many ways to modularize construction products.
- **Level 4: Construction time:** referring to the time necessary for planning, set up, construction and finishing. To improve the time dimension, radical solutions in other levels will be required.
- **Level 5: Construction ecology:** this level refers to ecological factors related to the construction process or to the construction product. Innovations could be related to the recycling of building materials and machinery.
- **Level 6: Construction product performance:** level six refers to improved performance among the production products or to the related services. The use of sensors and actuators, enhancing performance and serviceability, are increasingly being embedded in our environments, which become even smarter.
- **Level 7: Construction management:** the last level refers to innovations related to the managerial level.

4.1.1 Inside the investigated company

The firm evolved from being a small family business, founded 1941 in Liechtenstein, to a big multinational corporation, still family owned, supplying professional clients with system solutions for efficient and safe construction. Beyond offering commodities for sale, the service offer includes fleet management, i.e. leasing of tools, software solutions as well as engineering, training and consulting services (MMC 2014). MMC is well known for its direct sales model, where no less than 2/3 of the company's 22.000 employees are working every day (Annual Report 2013). The organization's purpose is to *"passionately create enthusiastic customers and build a better future*" by following the corporate strategy of *"sustainable value creation through leadership and differentiation"* (internal memoranda 2014). About 30 new products reach the market each year and to stay in front, MMC spends 4-5 % of annual sales on R&D. A number that 2013 corresponds to a 50 % spending of annual profits (derived from MMC Annual Report 2013). The corporate values as documented reflect upon *integrity, courage, teamwork* and *commitment* (MMC 2014) and the philosophy is to win as a "*high-performing team*".

The value proposition to their customers is to increase productivity on the construction sites, with a strong emphasis on *productivity*, *quality* and *safety.* The typical product portfolio is very diverse, containing a broad span of technologies; from chemicals in fire stops and chemical anchoring elements, to optics, software and wireless communication technologies in range meters and intelligent measuring systems (MMC 2014). The company brand is well established in the industry and the company frequently receives design and innovation awards for its products, they recently got awarded "Best in class by tools" in the Trade Magazine (2014) and won several design prizes as part of the "iF product design award" (MMC 2014). The company is market leader in their niche and has as one of the first power tool providers also embraced the ICT trend, directing a lot of resources to software development and their software applications are considered very "*modern*" in the construction industry (MMC 2014).

4.1.2 Internal Procedures for portfolio planning and innovation

The Product Portfolio Management process (PPM) is supporting and coordinating innovation activities at the MMC. The general objective of the process is having established a common set of terms so that everyone is talking about the same. The purpose is also to define a frame for action, so that everybody knows what has to be done. As we can see in *Figure 4.1* on the next page, the process follows the generic phases of research, development, and commercialization, where the latter is divided into product maintenance and phase out. We can also see that the research phase consists of "*research"*- and "*technology"* projects (red) whereas the development phase consists of new "*product development"* projects (red) and "*change to current product"* type of projects (gray). The *"patent"* process as visualized in gray formally runs throughout the whole development cycle except during phase out and so does the so-called "*risk analysis"*.

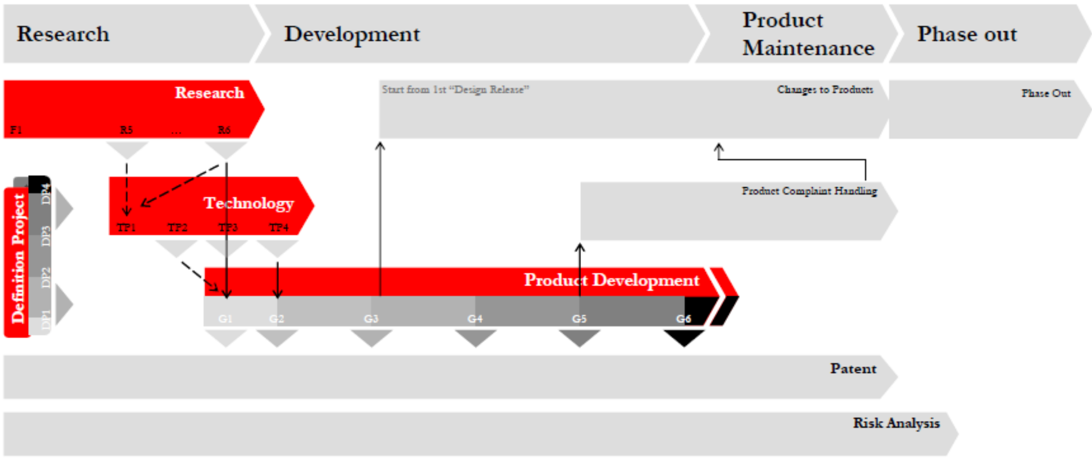


Figure 4.1 - Product Portfolio Management process (PPM), (Internal memoranda).

The clearly defined process is a result from the past, where there often were confusion in the R&D community what was to be considered research and what was to be considered development (internal memoranda 2014). The global process team within the company therefore decided to revise the current process, to a simple, easy to understand and result oriented (stage-gate) process. The result yielded PPM (*Figure 4.1*), which is clearly defined, thoroughly documented and visible to everyone and the global process team "*owning*" it, provides for training, material and implementation plans. The three processes Research, Technology- and Product Development, are especially important for this research. The processes, their objective and tasks are visualized in *Figure 4.2* below.

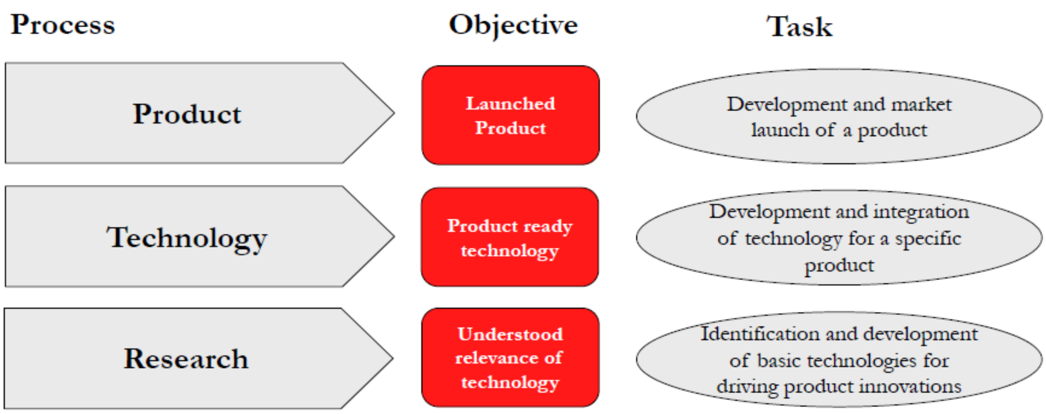


Figure 4.2 - Illustration of the three core technology processes, their tasks and objectives

The aim of the Research Process is to understand *"company relevance"* of a potential technology whereas the aim of the Technology Process is to reduce risk in product development, by selecting and developing the *"right"* technology concept. The aim of Product Development is to develop and launch finished products.

4.2 Result from Employee Interviews

The following section presents the results from the semi-structured interviews held with employees in Corporate Research, Corporate Intellectual Property, Corporate Innovation Management and Development. The presentation of the results follows the investigated dimensions of *context, culture, trust, motivation, strategy, procedures, measurements, skill* and *perceived risks*.

4.2.1 Working with R&D within the company

The company brand is a premium brand and interviewed employees sometimes refer to it as being the "*Ferra*ri" in their markets. Internal staff also describes the company as being the one *"innovator"*, who sets the new trends, impacts regulations and brings the latest innovations, whereas the competition either imitates or tries to copy their solutions. The high quality and safety in MMC products is an important business advantage as the company wins approvals in certain product areas and thus gets a chance to gain exclusivity to certain markets and furthermore, to influence new industry regulations (interviewee F). New innovations are often based on so-called *"system solutions"* which is a concept where the interplay between several Hilti products is key to increased utility and customer satisfaction (interviewee H).

The freedom the company has in bringing new innovations to the market may sometimes be limited by the customer. Construction tools and consumables in general, apparently don't change very fast so customers don't expect any radical changes. In fact, - *"customers sometimes don't want to change their way of getting the job done"* (interviewee G). The interviewees also stressed the fact that if a new product innovation would lead to the slightest price increase, it could be perceived as very negative by the customers, as certain products are bought in very high quantities. Identified innovation objectives among the development engineers were thus often instead to lower cost in production, rather than aiming for break-through product innovations. A development engineer responsible for a line of supplies explained that "*it's both time consuming and very costly to develop improvements because certain product lines are already very mature"* (interviewee H). The relatively high maturity of many technologies seems to make it less beneficial to look outside for external knowledge. A development engineer thereby explained that *"our products have been on the market for several decades and so the internal knowledge about the technologies is very high and it's therefore less likely to find useful knowledge anywhere else"* (interviewee H). Another development engineer currently working on a "*face-lift*" of an old flagship technology explained *"since we were first to launch this tool in 1962, it isn't likely that anyone else has more knowledge about the technology than us"*.

Worth adding to the else so mature industry context is that the company also develops technologies in more complex, converging technology fields such as electronics, mechatronics, optics and software. The interviews thereby revealed that especially one BU, responsible for the majority of the emerging technologies, acted fundamentally different compared to the rest. The head of the BU said in an informal talk that they were the *"small entrepreneurial start-up within the company, defining the way forward*". One development engineer working in the same unit confirmed that their product life cycles had gone shorter, technologies changed faster and therefore the traditional stage- gate model for product development had become more iterative as innovation in the field required more collaboration externally and closer interaction with for example customers for system testing and verification (interviewee J).

4.2.2 Investigating the cultural aspects of the NIH-syndrome

The interviewed engineers frequently mentioned the MMC as "*market leader*" or as "*outperformer*" and that it thereby would be shameful having to "*copy"* or "*buying in*" solutions from someone else. The brand promise to their customers is to "*Outperform"* and to *"Outlast*". Translated into action in R&D it would mean to develop products that are able to outperform that of the competition while outlasting it, i.e., perform longer than any other solutions (interviewee H). The strong belief in and reliance on the internal technology base and internal capabilities to achieve that target is especially evident in the product development community. A development engineer working on one of the more mature product lines said; *"if we ever seek to obtain input from the outside, it will be when there is no other way to go. It actually happened once, after that we had been trying to solve a technical problem for months"* (interviewee F) and the decision to finally collaborate with a competitor came from top management. Another said *"our internal knowledge foundation has been developed for years and since many technologies in the industry are quite mature, it isn't likely that improvements will be found outside of MMC"* (interviewee J). A third engineer explained that many firms in the automotive industry collaborate on resources, whereas Ferrari doesn't. Likewise, MMC as a premium brand must care for both exclusivity and quality, therefore most of the development activities are purposively performed in house (interviewee F). The dominant objective for acquiring external technologies among the development engineers would be to cut costs but sometimes also to shorten time in development (interviewee F,G,H & I) but as one interviewee points out, *"acquiring external technologies* *may speed up the initial process, but it also risks taking longer due to reluctance among internal development engineers, who can't identify with it and aren't convinced about its applicability*". He continues explaining that one time the reluctance towards an external technology was so strong that it resulted in contra productive behavior, proving the external technology's "*wrong being*", instead of integrating it in the current R&D pipeline. The low acceptance to external knowledge and technology may thus be a problem that when materializing, would slow down the whole development process. Two of the interviewed engineers also believed that university research wasn't that much of a help in product development, but that it probably was good for exploring new phenomenon or coming up with new ideas (Interviewee H & I).

As a slight contrast, the corporate research community showed other attitudes towards external input. Universities and other research organizations were regarded as highly valuable external sources where researchers could gain access to expert competence as well as to research tools and facilities. The engineers in the research community often seek to gain access to those experts by integrating and interacting a lot with external parties. The researchers' job in the so-called *"fuzzy front end"* is to investigate new technologies and manufacturing processes for the future (interviewee C). "*In this job, the researchers are responsible for maintaining their external networks of research specialists, professors, PhD students, universities and other companies* "(interviewee B). The interviewee keeps explaining that the researcher's personal network is one of the greatest assets and therefore it's part of the job description to maintain them. Another researcher explained that "*external links are important for gaining new technological insights and we often outsource for example testing and material analysis to experts and partners in other industries*" (interviewee D).

A final observation in regard of culture is the perceived difference between the seven BU's, where openness is found to be more or less supported. Beyond the obvious differences distinguishing the BU's from one another such as; size, type of technology base, relative technology maturity level, annual profit contribution to the MMC group and relative market share, there are differences in attitudes and to what degree external partners are involved in development activities. There are for example BU's that engage in joint venturing activities to perform collaborative development whereas there are BU's that don't. In this regard the IP manager describes the company as a constellation of seven smaller companies and that there is a continuous competition to get as much of the corporate resources as possible.

4.2.3 Trust in people and trust in technologies

The company manufactures almost all core products such as tools and special consumables in house. The production takes place in so-called "Technologieführerschaftswerke", meaning technology leadership production plants, which are globally distributed, equipped with local R&D teams who works on improving production technologies (interviewee F). The aim with the plants is to provide the highest technological competence in production possible and to improve core technologies through technology push. The interviewed engineers, especially in the product development function, articulated a noticeable dis-trust in external partners and their technologies. They expressed a worry that others *"can't achieve"* what we can and that there only are a "*few attractive collaboration partners*" who actually can meet MMC's quality standards. The interviewees particularly stressed the fact that MMC provides solutions for safety applications and compared it to the situation of buying a car. All products and partners must therefore meet tough safety requirements and comply with industry regulations. Any from the outside incorporated technologies, products etc., must therefore, regardless development stage, pass through the internal core processes for product development (described in section 4.1.2) and if it isn't a substantially better technology, it isn't worth the while incorporating it (interviewee F).

Closely related to having trust in technologies is having trust in people. The head of projects in development explained that the "*MMC model*", which covers almost the entire value chain; from R&D, to production, packaging, marketing, direct sales, complaints and after sales services, is like a "*sealed information system*" where the perception is that proprietary knowledge is very well protected and sharing this information with parties outside the system, will first require the building of mutual trust (interviewee F). Another engineer in development explained that certain information wasn't accessible from abroad production facilities (interviewee G). A last example of the importance of trust is how the company interacts with its customers. For example, of their three categories of customers; (i) non-loyal, (ii) loyal and (iii) and specialists, mostly specialists are considered for closer collaboration and those candidates also have to be big enough, involved with MMC products and trustworthy (interviewee F). *"It must be possible to build mutual trust and the prospect mustn't cause any competitive threats"* (interviewee F).

4.2.4 Employee motivation and incentive systems

A little bit like google, 10 % of a research engineer's time is contractually planned for creative activities, which often mean to visit fairs, universities, other companies etc., but beyond that, there is no formal incentive system on corporate level encouraging open innovation practices (interviewee B). There is also no employee specific performance measure tied to open innovation experiences. The company does however incentivize personal development through a personal development process, where personal as well as business goals are set on an annual basis and discussed together with the closest manager (interview B).

For development engineers another motivation seems to be obtaining a patent, as it's a recognized achievement in the engineering community and connected with a monetary reward. A development engineer pointed out that *"it is a pride and accomplishment receiving a patent"* (interviewee H). In German law as well as in most European countries there is the Inventors Compensation Law applicable to most engineering companies which means that the inventor has the right for compensation as he assigns his intellectual creations to the employer. The MMC furthermore has an internal intellectual property department, responsible for the effective patent prosecution and as a result, MMC also owns a lot of patents (interviewee A. The ambition to always obtain patents, also for the second best solutions, can sometimes be contra productive. For example when patents have been applied for but sought for haven't been included in any commercial products (interviewee A). Corporate IP is lately trying to address this topic by basing the size of reward on whether the invention got embedded in marketed products (interviewee A).

Relevant in this matter is also to consider the degree of "self-motivation" among the employees, beyond that of the corporate incentive- or patent system. A development engineer explains that previous "*idea jams*" or "*internal idea boost camps*" organized by an external consultant, are no longer taking place since the new BU head took over. Targets are being pushed and the team has to launch new products although there aren't any new technologies to base them on at the moment (interviewee G). He expressed that the "*jams*" were helpful for the team in order to better capture and implement their own ideas and that they now didn't have time for it. The employees also miss an online platform for idea management where development engineers can post and share technical problems across the BU's (interviewee I).

4.2.5 Internal strategies and goals

Open innovation initiatives within the MMC do not follow any top-down driven strategy, it's rather an evolutionary developed process, taking place ad-hoc and opportunistically whenever a situation benefits from it. There is also no formal corporate level strategy, to better leverage internal resources but some BU's have initiated local initiatives. There is however something called the "*experience-exchange*" which is a workshop taking place a few times a year where managers for the many product development projects exchange key learnings (interviewee I). From the interviews the researcher could identify one function that has an articulated strategy in line with that of acquiring knowledge externally, which is the Corporate Research function. The goal and default strategy in that function is not to *"make"* but to *"buy"* technology, whenever the situation allows it. Creating a *"make or buy"* concept is another key delivery at one of the gates in the PPM process (described in section 4.1.2) where a decision is requested before projects may move on to the following gates. The main reason to buy instead of make comes from top-managements higher requirements on flexibility, as the global economy becomes more volatile and the desire to focus more on core competences, as specialization becomes more important (interviewee B).

The corporate strategy is articulated as; *"sustainable value creation through leadership and differentiation*" (internal memoranda). Each product is therefore developed in line with the Product Leadership Strategy (PLS), aiming to create highly differentiated products and services. The head of development in one BU said; "*to justify higher prices, which also are necessary in order to finance the direct sales model, products and services have to be strongly differentiated from that of competitors, that is why we develop many differentiating features in-house"* (interviewee E). The desire for exclusivity can also be linked to the internal IP activities and corresponding IP strategy. The MMC has an internal IP department consisting of seven patent attorneys and four para legal, whose aim is to create the best possible protection for the company's intellectual property. The IP prosecution is running very effectively and the department belongs to the benchmark in the industry (interviewee A). As a result of the desired exclusivity, the development departments are advised to secure protection on all pieces of emerging IP, also on the second best solutions, in order to block competitors. This strategy is clearly articulated in the Product Portfolio Management process (PPM), for description see section 4.1.2, where *"patent checks"* are key deliverables in some of the gates. The in theory often called *"freedom to operate analysis"* together with the patent prosecution steps must thus be made in corporation with the IP department before the project may move on to the next phase. The head of IP however expressed the concern that internal technology as well as product development mostly have gone quite far before the first IP checks are done, which causes inefficiency in operations and unnecessary costs (interviewee A). Sometimes after a first IP check, similar protected solutions are found and development team thus have to "*invent around*" or at that point obtain a license. In both cases additional time as well as funds has to be allocated the project and according to the interviewee.

4.2.6 Internal procedures

In the overall PPM process, the process supporting internal innovation activities (described in section 4.1.2 and visualized in *Figure 4.1)*, several projects are running at a time. As soon as an idea or technology passes the last gate in a particular process, the next project can be initiated. If objectives aren't met on time the project has to retry on the previous gate or it is being immediately stopped (interviewee H). Performance in the different phases is thus determined as whether content is being delivered on time. The procedures in PPM are in general strictly followed, but since projects are different in terms of resources, time and priorities, the process is allowed to be more or less dynamic (interviewee H).

The technology process which takes place in between the research- and product development process includes development as well as research engineers and is divided into three phases (interviewee C); *technology definition-*, *technology concept-* and *technology development*. The purpose of the definition phase is to analyze and evaluate technology requirements from a newly discovered customer need (market pull) or from a newly discovered technology (technology push). The different alternatives are thereafter evaluated and assessed in the technology concept phase. The selected technology is thereafter developed to prove a certain level of maturity (the typical outcome is a functioning prototype) and first when the technology is "*ready*", it gets passed on and implemented in the product development process, which is the responsibility of the BU's. (interviewee B)

Interviewed engineers who have worked both with technology – and product development projects confirmed that the projects closer to research were much more open for external input. One of the interviewed engineers who started his career doing "*technology definition projects"* described the process compared to that in product development, as *"less static and more open for new and even external ideas*" (interviewee I) but he also expressed the concern that despite the external involvement, very few ideas made it pass the gates.

Another interviewee explains that by the time a technology enters the Product Development process the need for external input is already fairly low and it becomes even lower as R&D receives more money (interviewee H). The additional funds are mostly spent in the technology process, which projects as a result are running longer and technologies thus become more "*ready*" before entering the product development process. This mean that changes to the original concept not only become less likely, the time disposable for product development also gets shorter, which a developer addressed by saying "*product development is running faster and faster so we don't have any time to search for solutions externally*" (interviwee F).

The different requirements on software development, compared to that one of classic mechanics and electronics have led to another innovation climate within one of the observed BU's, which distinguishes itself by having shorter information loops and more iterative workflows. The basic technology system is much more intense as software to a greater extent has to be integrated into final products and clients are therefore also integrated more closely in technology- and product development (interviewee E). The BU also sources knowledge from a wider range of external sources and the researcher can sense a closer cross-functional alignment between the development- and marketing function, since "*entire systems as well as single components continuously have to be tested, verified and adjusted with and to customer requirements*" (interviewee J). The need has thus created an internal process that rather is viewing back and forth between technology, product development and market, than following the static stage-gate model in every respect.

4.2.7 Measurements on performance

There are no measurements in place for technology acquisitions and technology transfers. As we have seen there are also no current reward systems or incentives for such activities, only for creating new inventions internally. Beyond standard financial performance measures on corporate level, such as return on sales, return on capital employed and profit etc., the investigated company focuses on a set of client measures, such as a Customer Satisfaction Index (CSI), a Customer Bonding Index (CBI) and a Net Promoter Score (NPS). The usability of those measures to innovation activities and its visibility to R&D employees is fairly low. Only the results of the indexes are communicated and they are furthermore based on the company as a group (interviewee F). It is left to every BU to define own performance metrics, beyond the ones required on corporate level (interviewee F).

4.2.8 Examples of internal capability and skill

The company makes as mentioned no less than 200.000 customer contacts (visits and personal telephone calls) every day, in which they foster and grow long term relationships. They also have a few closer collaboration activities with selected universities, suppliers and even competitors. During recent years, there have been opportunities to engage in a few joint ventures, where collaboration around innovation activities has taken place. Knowledge have then been transferred and integrated respectively, but due to the difficulty in assessing open innovation skills through the interaction in interviews, the researcher has in addition made a documentary data collection where collaboration activities from the past and their progression have been studied. Below follows three short examples;

4.2.8.1 A technology acquisition in the early 1990's

There is one interesting scenario from the company's history, where *"a person from the crowd"* approaches with a technology that in the end will contribute to substantial value and success, both technological and commercial. The company thus successfully integrates and translates the technology into commercial products. The technology was discovered, e.g., discovered the MMC, in the condition of a functioning prototype which furthermore was protected with several patents. The situation is rare; a patented prototype yet with possibility for MMC to gain exclusive user rights, is knocking at their door. The owner of the invention was a professor from a Nordic country and if it wasn't for his entrepreneurial action, MMC wouldn't have gained access to that particular technology at that point in time. In worst case, it could have been discovered by a competitor. After thorough technological as well as legal due diligence, involving both top-management, development-, IP-, and legal departments, MMC obtains an exclusive license to use, produce, market and sell the technology worldwide, until the last patent expires, for several of their applications. The inventor supported in the development process and additional patents were filed with his support. This is an example of a successful technology acquisition and external relationship.

The situation clearly indicates that there are undiscovered grounds outside, where valuable knowledge and opportunities can be sourced but yet, Hilti hasn't pursued any active strategy to facilitate similar situation in the future. According to head of projects, it is extremely difficult to find external competence (Interviewee E).

4.2.8.2 Standard setting with a competitor

At another point in time, MMC and a competitor accidently developed very similar, e.g., possibly dependent, technological solutions and both managed to obtain patent protection. When the competitor first realized that MMC was offering *"their"* technology in two strategic markets, they send a kind *"offer letter"* asking MMC to withdraw their products from the affected markets with immediate response. MMC answered with counter arguments and the situation escalated in long discussions. External patent attorneys got involved to make their judgments on the possible dependency of the patented technologies but since the outcome of a potential court decision still was very uncertain, both parties agreed to another solution, namely to put the patents in a patent pool and create an industry standard. They found out that the value to their clients as well as to the technology, in fact would be much greater if they would settle. The standard was to both parties' benefit successfully accepted by the European Commission and so they cross-licensed the patents to one another and enabled all third parties interested in the solution to obtain a license to fair, reasonable and non- discriminatory terms (FRAND). The standard is still in use.

To handle such a situation a company needs both skill and luck. If it wasn't pure luck, well then the situation challenged relational skills such as in dispute resolution and negotiation, IP skills as in technology licensing and technology evaluation.

4.2.8.3 Joint venturing with an external partner

The company's smallest BU is the one responsible for measurement equipment and application software, thereby also for many of MMC's most complex technologies. A few years ago a competitor and MMC got together and created a new legal entity, a joint venture, to develop new products with the latest technologies. MMC as well as the competitor possessed a lot of relevant know-how that they brought into the venture. The collaboration evolved without any major flaws, but as the first product and application software was put on the market, issues started to materialize. The company would therefore need access to the competitor's proprietary know-how. The issue has infected the whole collaboration and the company is therefore carefully considering alternative moves. Meanwhile, thorough testing is being done with the hope to detect the error that likely is occurring in the interface between the parties' technologies.

This in contrast to the previous examples, is a case were the integration of knowledge and technology into internal processes, products and applications haven't been as successful. A development engineer working on the case said that it is very problematic to access the other party's know-how.

4.2.8.4 An example of using ITC technologies to foster internal communication

Another skill to exemplify is the ability to utilize information and communication technology (ICT). Researchers have suggested that this ability may help in developing other necessary open innovation capabilities and also in providing a smooth flow of internal as well as external knowledge and ideas (Bharadwaj 2000). The company currently uses a chat platform called Lync, where short messages easily can be communicated, but there is no history function so information may not be saved. The other platform is called SharePoint, where each function has their own page where it also is possible to access pages of others. People can be followed, documents can be stored, shared and changed and there is a possibility to create and join a discussion. The platform is regarded as useful; however unclear overview and information overload are sometimes problematic (interviewee G). Regarding ideation and cross-business-unit collaboration in technological matters, there is currently no platform to share and discuss technical problems, questions or ideas (interviewee G).

4.2.8.5 Summary of Short Examples

To summarize, none of the examples above followed a formal sourcing process, they were rather results from opportunistic behavior. As of today, there aren't any sourcing activities taking place in order to identify or acquire knowledge and technology from external sources, apart from the sourcing activities in the research function.

4.2.9 Perceived Risks

The discussions with the interviewees revealed there are especially four risks that are closely associated with the opening up of the innovation process. Firstly the interviewed employees highlighted the risk of losing proprietary knowledge - *"before entering discussions with any potential partner, university or customer, a non-disclosure or secrecy agreement (NDAs) is always signed"* (interviewee F). Even within the company's internal value chain, precautious actions are taken to protect proprietary knowledge. Not sharing sensitive information with internal but oversee plants is such an example.

The second risk is related to the loss of exclusivity and control to differentiating product features. "*Flagship and core technologies are per default manufactured in-house, whereas other parts such as accessories or components are outsourced or bought in directly*" (interviewee H). To follow the Product Leadership Strategy (PLS) when developing new products is especially important given the direct sales model, - *"when a sales man meets customers on the production site, he must be able to demonstrate the differences between a MMC tool and that from the competitor"* (interviewee E). Buying in external technology would accordingto the interviewed engineers increase the risk of not remaining exclusive, since competitors may be able to access the same technologies.

The third mentioned risk is the increasing dependency on technology providers, - *"having to pay licensing fees causes less flexibility and if there are many licensed technologies in one product, our margins will shrink"* (interviewee I). Having to rely on external partners for technological expertise is also perceived as a risk, especially since the company provides safety applications but also because of the need to comply with regulations.

The fourth risk is related to involving IP in collaborations. An interviewee exemplifies by describing a situation where a joint venture partner kept important know-how for himself, instead of sharing it with MMC, who presumed it was a part of the deal. The interviewee continues saying "*it is challenging to separate who owns what and to anticipate legal- and business consequences of collaborations*" (interviewee J). The IP department also stresses the risk of creating legal liability by acquiring knowledge externally, for example when an inventor work for a third party who through the Inventors Compensation Law can claim the rights to the acquired invention.

The last observation is related to risk management in general. The graphic in *Figure 4.3* demonstrates an interviewed engineer's perception of how to reason around innovation. The conclusion is that when acquiring technology is right and when the company does it (corner down left), the situation is very good. However, whenever acquiring technology is wrong, and the company does it (corner down right), the situation is very, very bad (interviewee F). The rational in the engineering community seems to be not to acquire rather than to acquire, since it's a lot safer not winning as much, but being sure the potential loss is minimal.

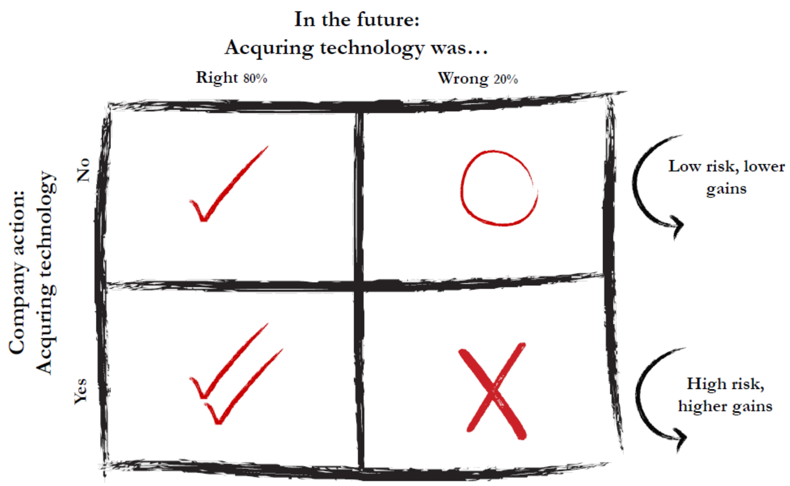


Figure 4.3 - Reasoning around risk, a perception of an interviewed project manager

4.3 Summary

This section has described the results from the empirical investigation, where barriers to open innovation have been studied relating to the dimensions of; *context*, *culture*, *trust*, *motivation*, *strategy*, *procedures*, *performance measurements*, *skills* and finally by highlighting *perceived risks*. The data used has largely been collected semi-structured interviews with employees in four functions: Corporate Research, Corporate IP, Corporate Innovation and Development.

5 Analysis

The analysis has its origin in the comparison of the previously presented theoretical framework and the empirical findings. Identified barriers towards opening up the innovation process are presented, discussed and summarized. The result of the analysis is carried forward to chapter 6, where a suggestion on managerial countermeasures will be elaborated upon. The conclusion of the thesis is presented in chapter 7.

5.1 Context and Industry Characteristics

Innovation in the construction industry hasn't been thoroughly studied before Linner et al (2012) performed their research and defined the seven innovation models that characterize construction. MMC can according to those most likely contribute with innovations related to innovation in terms of *production technology*, *time*, *product performance* but also in *construction management.* The empirical study has showed that customers and clients at the construction sites sometimes don't want to change their ways of *"getting the job done"* and engineers expressed that many ideas therefore can't be implemented. Previous research indicates that current customers in fact may limit a company's innovativeness (Ford & Probert 2011), thus "*conservatism*" in the construction industry may be a barrier preventing innovative efforts.

Another aspect that seems to affect open innovation adoption at MMC is the degree of technology maturity in the fields where the company operates. Many core technologies are quite mature and finding external competence greater or equal to the one kept in-house is among the interviewed engineers perceived as very unlikely. The relatively high maturity of the products as well as technologies also seem to result in new innovations that mostly are of incremental character or related to innovations in production and manufacturing technologies. Making improvements on products that already have reached a high level of maturity is according to the engineers expensive as well as time consuming, why the rational becomes to source knowledge for incremental innovations internally and trying to improve the cost position in production (see Granstrand 2010), possibly by integrating suppliers in the innovation process. Several interviewees from various BU's confirmed that innovation objectives often were to lower costs in production and that suppliers often were a part of this process.

The company does however also develop technologies in emerging, more complex technology fields and the research can show that open innovation efforts in those fields are more likely. Especially one BU was found to act fundamentally different compared to the rest. The situation demonstrates as Linner et al (2012) suggest that also construction industries with relatively mature technologies, gradually become more *"smart"* and the researcher can therefore conclude that open innovation, if not applicable to the whole investigated organization, at least seams very suitable for some part of it.

5.1.1 The investigated company's relative "Knowledge Source Position"

Enkel and Gassman (2008) concluded that among the four sources for external acquisition of knowledge in European companies; c*ustomers and suppliers, private and public research institutions*, c*ompetitors* and *other* sources, the most important (65%) was notably *other*. Zooming in on the manufacturing industry in Europe in particular, Hirsch-Kreinsen and Jacobsson (2008) reported that the most important external source was customers (27 %) and suppliers (23 %), whereas *the* most prominent source of knowledge was within the internal enterprise (45 %). Based on those insights, the researcher has made an attempt to assess MMC's relative *"Knowledge Source Position"* where the results of the external sources are displayed in *Figure 5.1*.

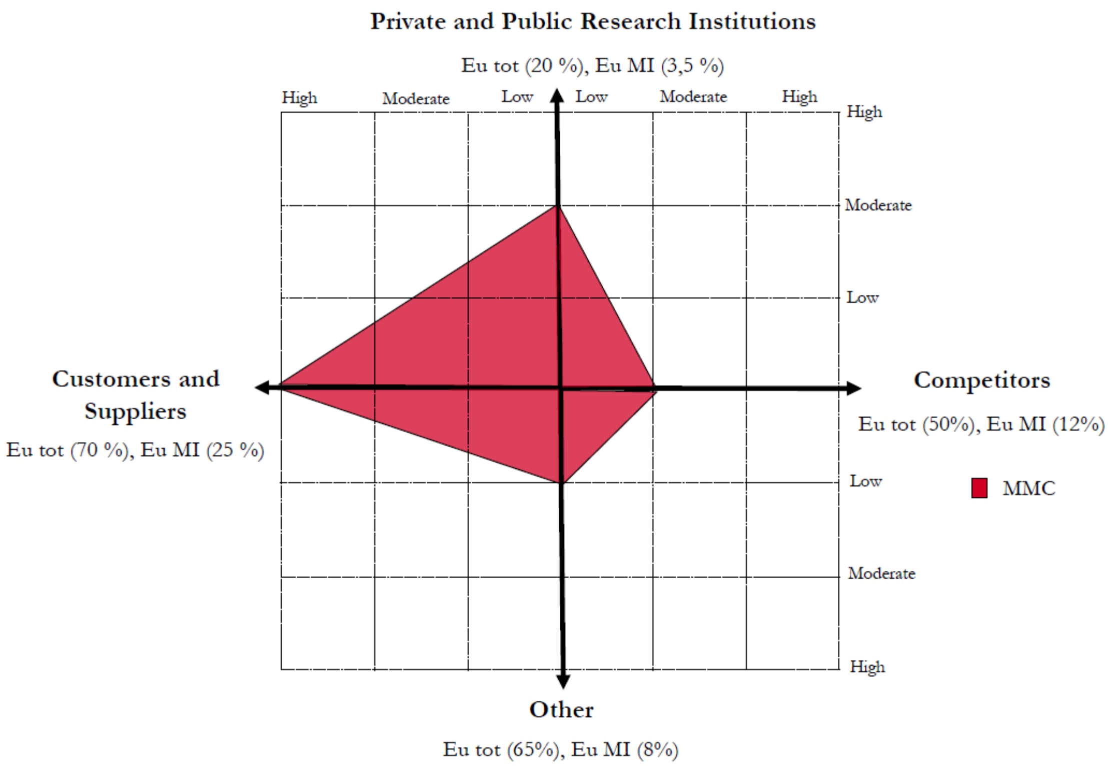


Figure 5.1 - Assessment of MMC's relative "knowledge Source Position"

The results were obtained by qualitatively assessing the four external sources: *customers and suppliers*, *public and private research institutions including universities*, *competitors* and *others* relative importance to Hilti's innovation practices. The result shows that customer and suppliers are the most valuable external source, followed by that of private and public research institutions including universities. Competitors and other sources are perceived as being of less importance. The results are thoroughly explained in the sections below.

Customers and Suppliers: Scholars have frequently mentioned MMC as a good example of where so-called *"lead users"* are involved in the innovation process (Gassman 2006; Schilling 2010), which is a direct benefit from the unique sales model. The company manages more than 200,000 customer contacts each day and those interactions seems to be highly important for the developers in order to understand the "*true"* customer needs, which ultimately support development of the *"right"* technical solutions (interviewee E,G,H,). This understanding is an important factor for MMC's innovation success, thus using customer as knowledge source is perceived as highly important. Suppliers are also frequently used, often with the aim to reduce cost in production (interviewee G,H & I). It is especially evident in situations where technologies and products are in the more mature stages of their life cycles, where it doesn't seem to be much room for any improvements on the products themselves. The impression is therefore that c*ustomers* as well as *suppliers* are highly important sources of external knowledge and that open innovation involving those sources, is explored to a great extent.

Private and public research institutions, including universities: are mainly used in the early phases of innovation, i.e., in the "*fuzzy front end"* (interviewee B) where also the majority of the so called *"blue sky researchers"* (se Mortara et al., 2009) operate. The development engineers however understood university research as a mean to *"increase the understanding of a phenomenon"* (interviewee F), rather than designing and/or testing new technical solutions. The practical usefulness of the source is by the interviewed engineers in development thus perceived as fairly low. The research function in contrast regarded such sources as highly valuable, since it "*provide access to experts, competence, facilities and tools*" (interviewee C & D). Another reason to engage with universities seemed to be to "*connect with future employees"*, which indeed is important in order to connect with hiring potential for tomorrow. The perceived value of public and private research institutions including universities as an external source of knowledge, thus differs between research and development employees. Since development acts closer to market and further away from "*fuzzy research*" it may be fair to assume that they don't perceive the value of those sources in the same way as researchers do. Considering the different value perceptions, the source's relative importance to innovation is determined as moderate.

Competitors: The company regularly uses competitors as source for external knowledge. Products are acquired to practice reversed engineering and screening of competitor patents is another well-established process. The target with the patent screening though, seems to be on reassuring freedom to operate rather than discovering new technologies, potential partners or trends. As one interviewee said *"running after the competition will never make you a winner"* and as most knowledge is sourced internally, competitors as a knowledge source are perceived to have a limited meaning.

Other sources: refer to any but the one mentioned above. Example of such a source could be intellectual crowds (crowd sourcing), industry networks, trade fairs, trade or science magazines etc. Especially researchers in the early innovation process are very likely to use some *"other"* sources as input for their everyday work. Trade fairs, magazines, experts and partners in other industries are consulted on regular basis and it seems natural for the engineers in the research practice to do so. Intellectual crowds are the new way of performing corporate R&D (Howe 2006) but the company hasn't yet seriously considered this source, although they've seen successful examples of it (se example in section 4.3.8.). Thus, the potential to better utilize this source is big and with that background, the relative importance of it to the company's current innovation activity is perceived as low.

5.1.2 Conclusion context assessment

Beside of sourcing new knowledge internally, customers and suppliers are perceived as highly important sources. Focusing too much on current customers may however risk hampering the company's innovativeness, especially since the customer base showed light "*conservatism*", don't wanting to change old ways. Competitors and others don't seem to be of as high importance as private and public research institutions and universities, with whom especially corporate research frequently collaborates. Thus, the company may be considered as very "*open*" in the sense that it engages in collaboration activities that sometimes require deep integration such as joint venturing activities, it may however at the same time be regarded as fairly *"closed"* since the main source for new knowledge still is internal R&D. The conclusion is that the company already is benefitting from using open innovation concepts and there is likely additional potential to open up the innovation process even further.

5.2 Cultural Dimensions of the NIH Syndrome

As we have learned, cultural concerns are often especially evident among older firms with well-established corporate values (Golinghtly et al, 2012) and changing the deepest level of culture, such as norms and beliefs, is furthermore very challenging (Mortara et al, 2009). MMC has a strong corporate culture, based on the values of *courage, integrity*, *team work* and *commitment*. Yet today the company is family owned and a special trust arrangement will make it stay that way also in the future. The corporate values in themselves aren't perceived as any barrier towards open innovation efforts, in fact three of them support it very well. *Courage* shall namely mean to embrace change, *team work* shall mean team work, regardless internal or external teams and *commitment* shall mean to take personal responsibility and we know that open innovation is a people driven process (Gassman 2006), to which individual employees have to commit. Hence forth, the corporate values as such don't seem to constitute any barrier towards open innovation, it's however still reasonable to suspect that certain sub-cultures, attitudes and norms actually do.

For example, the *"high performing"* culture seems to have been growing very strong internally and a negative consequence of this *"Ferrari"* culture seems to be the NIH syndrome (see Katz and Allen, 1989). Especially in the development function there is a very strong reluctance and/or dis-trust in external technologies as well as sources (see Mortara et al, 2009). The NIH syndrome as well as the phenomenon of sub-cultures within the R&D community can thus be verified. The research engineers who work for Corporate Research and the development engineers who work for the different BU's, had quit different attitudes towards external collaboration. The engineer community within the BU's was often opposing to share proprietary knowledge with third parties, sometimes also to share it internally within the organization. In general they were also not as positive about acquiring technologies externally. The lower acceptance among the development engineers is found to be a barrier that in some cases may risk slowing down instead of speeding up the internal development process.

The main motive among the development engineers to acquire knowledge externally is to reduce costs in production (interviewee F,G,H,I), whereas it for research engineers mainly is to gain access to competence, tools and research facilities. The engineering sub-culture in development showed a very strong belief in the internal technology base, which seem to result in a default strategy of sourcing knowledge internally, whereas it in research exists a default rule that de facto is to source externally, not to develop in-house, whenever possible. The natural source of new knowledge for the researcher is their personal but professional networks, containing other experts, universities, PhD students and partners in other industries.

Cultural differences (sub-cultures and attitudes) are thus observed between the research and development communities, but also among the development communities in the seven BU's, where openness is found to be more or less supported. The BU specific technology base and the technologies' relative maturity, seems to alter the condition for innovation in the BU. Whereby especially one distinguishes itself from the other by having a much more complex technology system, shorter information loops, a more iterative workflow and repeated testing against customer requirements, why the researcher senses a closer cross-functional alignment and collaboration between the development- and marketing function. Besides integrating clients more closely in technology- and product development, the BU also sources knowledge from a wider range of external sources. The higher technological complexity and the higher speed in the market seem to have contributed to an internal process that rather is viewing back and forth between technology and marketing, than following a static stage-gate model where also external collaboration is more accepted.

5.3 Dimensions of Trust

The interviewees, especially in applied research, expressed a *"dis-trust"* in external technologies and we have learned that trust in people enables trust in technology (Holmström & Wennergren 2012). Trust in internal colleagues, as well as in external counterparties, may therefore be an important prerequisite for the trust in new technology, thereby also a prerequisite for the opening up of the innovation process. Especially interviewees in development functions expressed a worry that external parties *"can't achieve"* what MMC can, referring to their technological knowledge. In addition, external technologies have to comply with high standards, which often cause an element of dis-belief among R&D employees. The tendency to *"avoid"* or *"dis-miss"* external sources in favor of internal has previously been referred to as the NIH syndrome. It is however possible that trust, or dis-trust, in people as well as technologies, could be one dimension that underpins the NIH syndrome. Low trust in people may also be an internal problem, when for example the exchange of knowledge between different functions such as the BU's gets hampered. For example, there is no corporate platform in place for promoting openness among development engineers between the different BUs, which may be an issue of trust or even of internal rivalry. The empirical investigation provided examples of internal competition and that there is an ongoing competition about the corporate resources. It's reasonable to believe that there are issues of trust involved in the creation of *"external ties"*, where dis-belief in people as well as in technologies may lead to less collaboration and less use of external knowledge sources.

5.4 Internal Motivation and Incentive Systems

We have learned there is a difference between organizational and employee motivation, also that open innovation is a people driven process rather than organizational (Gassman 2006). Therefore incentive systems must be put in place to encourage individual action (Mortara et al., 2009; Chesbrough & Crowther 2006). As of today there is no formal incentive system on corporate level encouraging openness among employees. One reason may be that it isn't yet a topic for the corporate agenda. A problem with the current motivation system on the other hand, is that it in some cases results in counter-productive open innovation behavior. For a development engineer for example, it's sometimes rational to avoid external technologies, at least to focus more on internal development of new ones, since there is a chance to receive a monetary compensation for assigned inventions. It is also a pride- and status contributing to a patent as a few development engineers said. The internal motivation among the engineers to obtain a patent may as it seems therefore favor development of internal technologies and thus reduce chances of open innovation opportunities to be discovered.

The motivation to act open furthermore differs between the interviewed groups. The research team who to some extent has *"openness"* in their job descriptions; through the task of maintaining their networks, but also through the 10 % working time booked for "*creativeness*", appear to motivate the researchers to act more open. The traditional career path for an employee may according to theory also be a barrier for the individual to act more open (Mortara et al, 2009), since it often doesn't allow for changing positions cross-functionally. The career path for a typical engineer at the company is to start somewhere within R&D, either in research or more towards development and as the career progresses, it's normal to move on to positions closer to market. The internal rotation is very high and employees are encourages to change positions every second or third year, which actually would enable rather than hamper open innovation diffusion within the company, since it helps in creating internal networks or equally "*internal ties*".

The conclusion of the motivation analysis is that there isn't yet any intrinsic motivation among the employees to act more open, which may depend on the lacking incentive system for open innovation behavior. The research function is one exception. They have goals containing open innovation elements (the 10 % rule) and a networking task, which indeed seam to motivate individual action. The somewhat imbalanced incentive to receive a monetary compensation for internally developed inventions may on the contrary work in dis-favor of open innovative efforts and even intensify the NIH syndrome, which shows that creating the right incentives is important.

5.5 Internal Strategies

It has been observed that functions with strategies and goals that somewhat require a more open innovation behavior, also pursue more *"openness"* than the other functions. The absence of open innovation goals or elements in a strategy (see Chesbrough & Crowther 2006) may in fact limit or even steer individuals away from pursuing open innovation actions. One example from the research that indicates that open innovation elements in a strategy may favor its adoption is the case of the technology strategy or "*acquisition goal*" in the Corporate Research function, where a "*buy*" instead of "*make*" technology-rule apply. The initiative is top-down driven and the motivation seems to be very strategic where the objectives are to achieve higher flexibility and a stronger focus on internal core competencies. There is thus no corporate strategy articulated to care for external acquisition of technology in order to enhance internal core competences and innovative capabilities. Research has previously indicated that the lack of a corporate technology strategy, i.e., a strategy setting forth for activities, makes it harder to implement open innovation (Granstrand 2009). In this regard Corporate Research has an open innovation "*friendly*" strategy to lean on, whereas the development function in the BUs, through the Product Leadership Strategy (PLS), has not. It rather seems that the PLS strategy impacts external technology sourcing in the BU'S negatively, by creating an overemphasis on feature exclusivity and control. It is perceived by the researcher that the strong desire to remain exclusive in the market leads to a culture where external technologies rarely are considered. Furthermore it leads to stark IP defensive behavior; where the aspiration to protect proprietary knowledge becomes higher than the desire to search for the better solution, no matter its source.

The conclusion is that open innovation initiatives at the company are evolving evolutionary when situations allows for it, rather than following a top-down driven strategy. The rational for open innovation in those scenarios also seem to be more cost- than opportunity driven. Research have previously showed that top-down driven open innovation strategies (Mortara et al., 2009), together with executive commitment, strong leadership and clear objectives (Chesbrough & Crowther 2006) are important prerequisites for succeeding with open innovation. Translated to the investigated context it would mean that the missing corporate technology strategy providing for direction, the low executive commitment for open innovation activities and the missing corporate open innovation strategy could constitute hurdles that in fact prevent the transition towards a more open environment. The research also shows that it seems to be a strategic clash between the Product Leadership Strategy (PLS) and that of open innovation, thus making the engineers perceive open innovation activities as contradictive to current practices and corporate objectives.

5.6 Internal Procedures

As we have learned, open innovation requires internal collaboration (Chesbrough 2003; Gassman & Enkel 2006). Opening up off the innovation process thus often needs appropriate changes in internal procedures and structures to support internal as well as external network development (Chesbrough & Crowther 2006; Mortara et al., 2009). The company is strongly process driven and the innovation activities are supported by a clearly defined process (PPM) that is described in writing, applicable to all projects and follows a stage-gate- logic.

The need for external input in the product development process is by the engineers perceived as fairly low since the technology process foregoing that of product development, aims to develop a technology concept as far as possible in order to reduce risk in product development. When a technology isn't mature enough or there is a problem, the project has to retry on the last milestone or it gets stopped. Thus, when a technology enters the product development phase, the need for external technologies, or knowledge, is already fairly low. The more money the technology projects receive, the more mature the technologies get before passed on to development, which ultimately seem to make the product development cycles run faster and faster. The time pressure during development is described as a barrier to look for external technologies, there is simply no time budget to search for alternative solutions and if an opportunity gets discovered, it is most likely a management decision required before its realization.

Another perceived barrier is the lack of appropriate open innovation infrastructures and tools, such as platforms for sharing internal as well as external information and tools for online idea management (see InnoCentive 2012; Westergren & Holmström 2012). According to the development engineers, there is little cross-BU knowledge exchange, only the managers get to go to experience exchanges. There is also no ideal ideation platform that could smooth internal knowledge flows and trigger knowledge sharing between and among the development functions. Employees are however encouraged to change positions on regular basis and so the fluctuation rate in general is quite high, supporting development of *"cross-functional ties",* which according to theory is a prerequisite for successful open innovation (Chesbrough & Brunsvinkler 2013).

To conclude, the stringent procedures and clearly defined processes and responsibilities, the tight deadlines together with the lack of appropriate open innovation tools, such as ideation platforms, are with this background likely to create barriers that at least make the development function less likely to open up towards the external environment.

5.7 Performance Measurements

Research have showed that metrics and incentive systems must be aimed at encouraging success, whether in open or closed environments, since both strategies are complementary to one another (Chesbrough & Crowther 2006). Research also shows that measures tied to client satisfaction would motivate open innovation action if that is the best way to improve that measure. It doesn't however seem to be that straight forward. The MMC does use clients' satisfaction indexes (three), but those aren't perceived to have any impact on the engineering community in R&D. Perhaps is it because the measures are on corporate level, thus not tied to any personal action, which was suggested by Golightly et al (2012). The data building up the indexes does furthermore not seem to be visible, which might be another reason they don't initiate individual action. The current metric systems are not believed to hamper open innovation activities in any way, but it would be interesting to see if and how individual performance measures, tied to client indexes, could impact open innovation practices.

5.8 Skills and Capabilities

A company will need certain capability and skill to effectively be able to "open up" its innovation processes. Among the most important we'll find; *absorptive capability*, *multiplicative capability*, *relational capability*, *networking capability* and *ICT capability*. Mortara et al (2009) found that there is no perfect blend of open innovation capability and skill, but failing to develop the necessary ones may be an obstacle towards open innovation implementation. The studied examples in section 4.4.8 exemplified how MMC managed the different set of skills in open innovation activities.

The absorptive capability referred to the level of effectiveness in which external knowledge can be internalized and integrated into existing products and processes. To develop absorptive capability a company must have a certain degree of technological competence in-house and MMC continuous investment in internal R&D, has allowed them to build up strong technical competence. A few successful examples show that the ability to assimilate and apply new knowledge to commercial ends is relatively good. The company sets 30 new innovations on the market annually (MMC 2014) and the ability to recognize valuable knowledge is perceived as very good, but it is likely true, that even a greater portion of valuable external knowledge can be identified if the company also would consider new sources, for example that of the intellectual crowds. In total, the *absorptive capability* will not be regarded as an underdeveloped skill that would act a barrier to the integration of external knowledge.

The *multiplicative capability* referred to the ability of sourcing, i.e., the skill to identify and build up strong networks in relevant areas, bringing in innovations only where internal R&D still adds value. MMC has during the recent years engaged in a few joint ventures, where corporation around innovation activities have taken place. Knowledge have then been transferred and integrated respectively. Some of the outcomes have resulted commercial success. The sourcing process was however not formally structured, it rather happened opportunistically. Disregarded the networking activities in the research function, no active sourcing strategy for acquiring external knowledge exist within the company. The conclusion is that the company likely have the ability to multiply knowledge and technologies with other parties, given a few successful examples. Based on the assumption that useful knowledge is widely dispersed (Chesbrough 2003) and that intellectual crowds can add substantial value to corporate R&D (Howe 2006), it is however likely to believe that MMC hasn't yet developed the ability to identify this useful knowledge fully, since there aren't yet many cases where this have actually happened.

The relational capability referred to the ability of building and maintaining external relationships. MMC has a long tradition of building and fostering deep relationships with their customers. They also have a few closer collaboration activities with selected universities, clients suppliers and even competitors. The few examples demonstrate that Hilti's relational capability likely is quite well developed and therefore shouldn't be a barrier towards the *"opening up"* of the innovation process.

The last skill to analyze is the ability to utilize ICT efficiently. Researchers have suggested that this ability also may help in developing other open innovation capabilities and in providing a smooth flow of internal as well as external knowledge (Bharadwaj 2000). The example of the instant messenger chat Lync and the windows application SharePoint show that internal ICT systems are in place however, there isn't any platform where the BU's easily can share and specify technological problems and source for technical solutions internally. The limited possibilities to do internal sourcing, may translate to barriers in performing external sourcing, simply because of old habits not to source knowledge external of the BU at all.

We've learned that the ability to protect and execute new ideas is an essential open innovation skill that for many companies is a major challenge (Harrison & Sullivan 2011; Rivette & Klein 2000). The company has an internal IP department that is responsible for the effective patent prosecution, based on the technology push from the BU's. There are essentially two identified IP processes where the first one is (i) IP prosecution, aiming to protect new technologies emerging from internal R&D and the second is (ii) the "*freedom to operate*" analysis. Both process runs very effectively and the company seems to be very good at obtaining patent protection on new inventions. There aren't however any active IP management activities, such as the active sourcing of external knowledge, technologies and IP or any active trading with external as well as internal IP. The licensing collaborations that were exemplified in section 4.3.8 were all initiated due to external circumstances. Arora, Fosfori & Ronde (2014) found in their research that BU's often have superior information about licensing opportunities, but lack the incentives to act, because of success being measured through performance in the product market, not in the technology market. The finding mainly applies to out-licensing of internal technology (IP) but it also show that the IP department may not have sufficient information to identify good licensing opportunities. It is therefore in this case likely that the BUs and the research function lack the right incentives to act and react on licensing opportunities/or that they haven't yet developed the ability to recognize opportunities and threats in the more complex IP landscape.

Employees in all investigated functions still have much to learn about the several ways there are to utilize and access external IP, without creating legal liability and without risking to lose proprietary knowledge. They also have to develop skills in contracting with emphasis on licensing, so that situations like the one described in section 4.3.8, where a collaboration partner claimed certain know-how not to be part of the collaboration, can be avoided. It is perhaps not about learning by doing, rather about learning by dealing, so the current IP skills at the company, mustn't be considered a barrier for open innovation to burst, but they must be improved in order to make open innovation successful.

5.9 Perceived Risks

Firms may be reluctant to open up innovation processes due to potential risks (Liechtenhaler & Ernst 2006; Rivette & Klein 2000). Replacing internal technology development with external sourcing for example, increases the risk of losing essential technological knowledge needed to maintain absorptive capability (Cohen & Levinthal 1990). The interviewed employees within the investigated firm confirmed that at least five major risks were perceived as major, in relation to the opening up of the innovation process;

- The risk of losing proprietary knowledge
- The risk of not being exclusive regarding differentiating product features
- The risk to jeopardize quality and safety in products and services
- The risk of business and legal complications by involving IP in collaborations
- The risk of dependency on external partners

Mentioned risks correspond very well to those already mentioned in section 3.3.9. In MMC's case, the risk of losing proprietary knowledge and the risk of not obtaining exclusive access and control of important IP, is perceived as a major hurdle to openness. The company is for example even careful sharing certain knowledge internally. Likely that because of mentioned risks, knowledge exploration processes mainly takes place internally. The increased complexity derived from additional interfaces with collaboration partners is a risk in theory (Lichtenhaler & Ernst 2006; Chesbrough, Enkel & Gassman 2010), which wasn't explicitly mentioned by any of the interviewed employees. However, the risk may be reflected in the resulting complications that IP can cause in collaborations. The interviewee at IP demonstrated this fact by exploring the scenario when knowledge is sourced from a third party, a person in the crowd for example, and when that party also have an employment agreement where the employer might show interest in the innovation. Gollin (2008) pointed it out the risk of creating legal liability in relation to a third party's IP, which thus might be a consequence of the increasing complexity in a firm's interfaces to external partners. The interviewees perceived the risk of increased dependency on external technology providers as having to pay licensing fees that; 1) may lead to shrinking margins and less flexibility and 2) to increased cost and time in development since the technology has to be adapted to MMC's specific needs. The risk can also be referred to that of escalating high transaction costs (see Mortara & Ford 2012). To conclude, potential risks may be a barrier that prevents the company from open up its innovation process to the external environment.

5.10 Summary Analysis

To conclude it is very important for the company to integrate customers and suppliers in the innovation process and they are very good at it. Customer integration helps the company understand "*true*" customer needs and thereby developing the "*right*" solutions. Supplier integration is important for improving cost position in production as well as for solving technical problems. The current level of integration of private and public research institutions and universities is very high, but only in the early phases of the innovation process. The main benefits lie in accessing key competence, research facilities and tools to a relatively low price. The sourcing of external knowledge in the research phase also allows for flexibility and focus on core competencies. Competitors are used as a knowledge source mainly for defensive reasons, i.e., for performing IP infringement and freedom to operate analysis, by using competitor patents, products (also called technology scanning) and marketing material. There is however a few cases where competitors have or are being used as strategic collaboration partners. In those situations, it is especially important to set forth for the controlled sharing and co-creation of IP, using license agreements with clearly defined object, scope, and rights to improvements. Using "other" external sources such as intellectual crowds is practically non-existing. It should thus be possible to "open up" the innovation practice more extensively but barriers such as the NIH- syndrome that is deeply rooted in the organizational culture prevent it from being widely adopted. In addition, the corporate strategy calling for differentiation and IP exclusivity seem to prevent open innovation opportunities from being discovered. May this behavior be a result of existing procedures and structures, low employee motivation, missing open innovation tools or infrastructures or because of the wrong blend of skills, is very hard to judge. Clear is however that open innovation has low attention from top-management, thereby also the lack of open innovation elements in most corporate strategies, which indeed is perceived as one of the greatest barriers to a wider adoption. The gradual movement towards a "*smarter*" environment is also spreading to the construction sites. The example of especially one BU, which is acting a lot closer to those emerging and converging technology fields, clearly demonstrates that open innovation could be beneficial for the company, sometimes also a prerequisite for providing technical solutions in those fields at all. Open innovation is therefore predicted to have a greater presence in the construction industry in the future and in order to manage the identified barriers preventing its adoption, formal and informal measures must be considered.

6 Discussion and Suggested Managerial Countermeasures

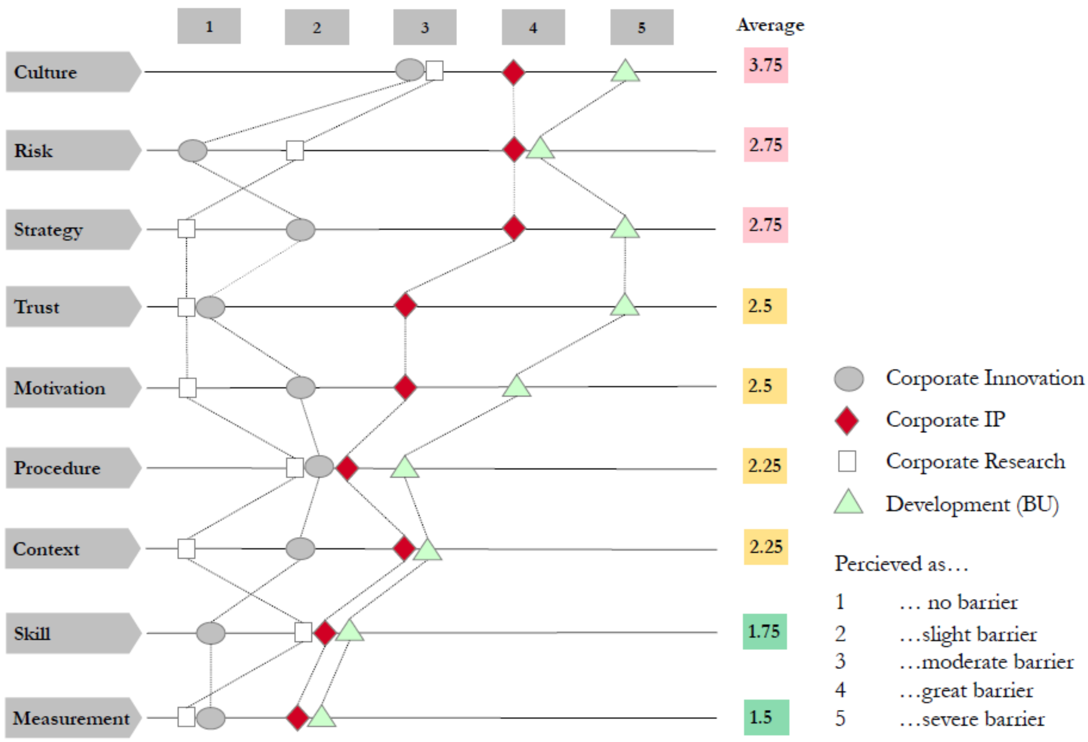
The chapter begins with a discussion of the results, including a discussion on whether those are in line with those of other research. After that suggested managerial countermeasures on how to prevent or even limit open innovation barriers will be presented and lastly, there is a section giving a few comments on the methodology used in crafting this report.

6.1 Results

The empirical investigation revealed that the company already is benefiting from several open innovation concepts, yet the major source for new useful knowledge is internal R&D. The reason is likely certain barriers, which seem to prevent a broader adoption. As an intelligent reader you may already have understood that the analyzed parameters, take c*ultural* issues for example, aren't mutually exclusive to those of *trust*, *motivation*, *risk, context* or even *strategy*. The analyzed dimensions are selected with support from theory and are there to guide the research and to help in framing and understanding the research outcomes. As we already have noticed the dimensions are closely interrelated and it is therefore very difficult to separate them from one another. Consequently, it would be wrong stating that one or the other dimension constitutes a greater barrier, but in order to provide managerial recommendations, the researcher has tried to make an assessment. Three groups of employees have taken part in the research and it's important that the analyzed dimensions also reflect the group's opinion and behavior individually. The assessment is purely qualitative, based on the researcher's subjective judgment from analyzing the situation as objective as possible. The results are demonstrated in *Table 6.1* on the next page. As we can read out, cultural-, strategic- and issues related to potential risks, seems to be the major barriers in the transition towards a more open innovation environment. The results also shows that the issues differ in magnitude depending on which internal function that has been observed, i.e., Corporate Innovation, Corporate IP, Corporate Research or Development within any of the seven BU's. The strongest cultural issue is the NIH-syndrome, which likely is underpinned by the following five factors;

- Strong internal technical competence
- Awareness of being the market leader
- Acting in a mature industry context, which lower the perception among the engineers of finding useful knowledge externally , and;
- Associated potential risks

Table 6.1 - Summarized results from empirical investigation: Barriers towards opening up the innovation process



The strong belief in the internal technology base is for example observed to cause distrust or miss-belief in external technologies and their sources. The high requirements on quality and safety in application plus the need to meet regulations yield the same reaction in the engineering community – lower trust in external technologies. It is furthermore perceived a great business risk failing to meet those requirements, why external technologies have to prove even greater technical elegance than internally developed, while overcoming barriers related to trust and internal acceptance.

The perceived risks associated with open innovation activities seem to make the NIH tendency intensify. Among the most frequently mentioned risks are;

- The risk of losing proprietary knowledge
- The risk of not being exclusive regarding differentiating product features
- The risk of jeopardizing quality and safety by not knowing external technologies
- The risk of creating business and legal liability by involving IP in collaborations
- The risk of dependency on external partners

The risks are most evident in the product development community, but could also be identified in the research- and legal departments. The mentioned risks interestingly allow themselves to be classified in one of the other researched dimensions. The risk of losing proprietary knowledge and the risk of creating business and legal liability involving IP in collaboration, are both highly related to IP and IP skill and could therefore be reduced by skillful and effective contract drafting and IP management. The risk of not being exclusive regarding differentiating product features is deeply rooted in the organizational culture but could also be an effect of the corporate differentiation and leadership strategy, which articulate high desires for exclusivity. The risk of jeopardizing quality and safety by not knowing external technologies is highly related to the company's absorptive capability, i.e., its ability to effectively identify, internalize and integrate external technology in internal processes and products, which is an important skill. The last risk - becoming dependent on external partners, can be limited by choosing several partners instead of few, but also by building long term relationships that can facilitate mutual trust. The conclusion moving on to the next section is that the mentioned risks underpinning the NIH syndrome, in fact can be reduced or even removed by addressing several of the other dimensions, such as skill, culture, strategy and trust.

The current objective to pursue open innovation as innovation strategy in development (BU) seems to be to lower cost in production and product development, whereas the motivation in research rather is to gain access to external competence and research facilities. Theory has previously showed that reducing costs often is of minor importance for candidates considering open innovation, whereas the access to new product features, new technologies and competence have been of far greater significance.

On the brighter side, the internal skillset doesn't seem to be a major barrier towards open innovation. The company has through its joint venturing activities, customer and supplier collaborations, university research and similar activities showed that they have the capacity to integrate, assimilate and to duplicate external technology and knowledge and to transfer knowledge to collaborating parties, as well as they have the ability to foster long term relationships and building new networks.

6.2 Suggested Managerial Countermeasures

As the researcher can conclude, embracing open innovation within the investigated organization likely represents an opportunity, both to enhance internal innovation capabilities but also to address current and future business challenges. However, to reap the outmost benefits of open innovation practices and to control related risks, the phenomenon will need attention from management. Open innovation can as we have learned be managed using formal as well as informal means and managers are advised to consider both (Chesbrough & Brunswickler 2013). The biggest barriers that have to be addressed as concluded from the analysis are of cultural, strategic and risk related character.

Cultural issues are especially strong within some parts of the organization, such as applied research and product development. Other companies who effectively overcame such barriers, provided a clear focus for open innovation efforts and targeted specific objectives, i.e., communicated whether the effort was used to close the growth gap in current- or in new business or in both. They furthermore documented an open innovation strategy, created a corporate technology strategy, provided for strong leadership and top-down direction, while involving R&D early on in technical due diligence as well as in decision making activities.

The corporate strategy is to achieve sustainable *value creation* through market leadership and product differentiation. Focusing on increased value creation while not considering new strategies for claiming a bigger portion of the value created, i.e., *value capturing,* could be one aspect of the strategy that can be improved in order to better support open innovation initiatives. A good strategy would encourage success whether in closed or open environments. Another aspect that can be improved is the strong emphasis on differentiating features and exclusivity which seems to result in an environment where good knowledge is seen as proprietary and thus most likely will be sourced in-house. An alternative strategy would be to search differentiating features around the globe and acquire the rights to integrate them in products, processes and services. As Gassman (2006) said -*"Open innovation starts with a mindset"*.

To reduce risks associated with open innovation and collaboration, as well as improving internal innovation effectiveness, other companies have worked with managerial countermeasures to reduce the impact of said risks in case they materialize. In this situation it will mean to develop and improve upon the dimensions underlying the identified risks, such as skill, culture, strategy and trust. To reduce risks related to IP, the company could strive to develop better skills in IP management and try to create a business-lead IP strategy. Employees should also be welcome to learn more about IP and how it can be used to capture value, if integrated properly in the value creating processes of the enterprise. To reduce the risks associated with "not knowing the external technology", technical-, legal- as well as business related due diligence should be thoroughly performed before acquiring the technology. It's furthermore a good idea to keep investing in internal R&D, to maintain and improve upon absorptive capabilities and technical competence. To manage the risk of not being regarded as exclusive in relation to differentiating product features, it will firstly be important to realize that exclusivity can be achieved by other means than through internally sourced knowledge and secondly, that there must be strategies in place for how to access it.

Finally, open innovation is a people driven process so managers also has to work with the right incentives in order to motivate individual action. Let the best practices from the more open BU's spread across the organization and increase internal interaction and speed of internal knowledge flows by providing the necessary open innovation tools, such as IT platforms for idea collection and management. Perhaps tie incentives and/or performance measures to open innovation experiences and celebrate the early wins. The greatest managerial challenge is likely to create an open innovation culture, where external and internal sources of knowledge are considered not as substitutes but as complementarities to each other. The suggestion is therefore to provide corporate direction through documented technology strategies, where the aim would be to provide guidance in technology acquisition as well as exploitation decisions, as well as to encourage the active consideration of external technology and knowledge. For an overview of the identified barriers and the suggested approach to management, see *Figure 6.1* below.

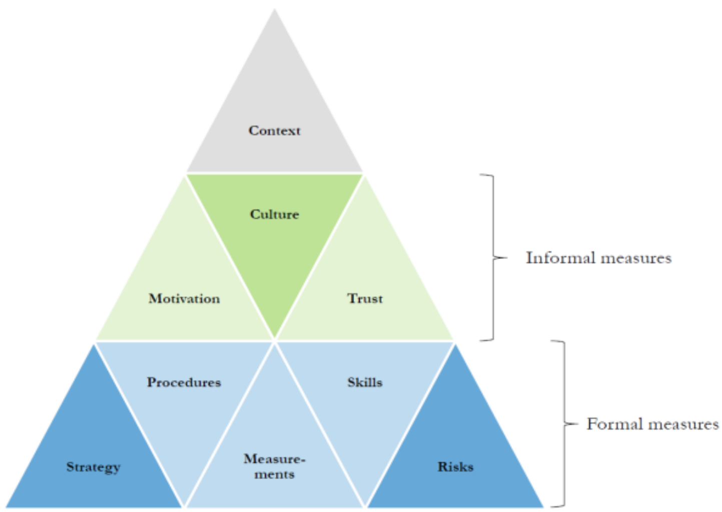


Figure 6.1- Suggested areas of formal and informal managerial countermeasures

6.3 Research Methodology

The research is based on a single case study within a particular organization in a very specific context and so the results are not claimed to be broadly generalizable. Using case studies is very good when trying to understand phenomena or why thing works as they do and that those results not always are transferable, is rather an empirical problem (Bryman and Bell 2011). The research started off with an extensive literature study defining the state of the art and that, together with the collected input from within, as well as from outside of the investigated context has helped to avoid that the report is influenced too much by knowledge that is not generally applicable. The ambition was to analyze all identified dimensions that could contain barriers towards the implementation of open innovation in order to be as exhaustive as possible. However, not all dimensions were as important or "*big of a problem*" to the investigated case. In addition, it's possible that other dimensions not found in this research affect and represent barriers conforming to open innovation practices.

6.4 Contribution to Management Theory

Barriers to open innovation adoption have previously not been investigated with the particular focus on construction/manufacturing/more mature industry/ contexts. Mortara et al (2009) investigated barriers across many industries and found that those in general could be related to organizational *culture, structures, motivation* and *skill.* This research can confirm that especially *cultural* dimensions such as sub-cultural norms and attitudes are very relevant for the investigated context. Holmström & Wennergren (2012) investigated barriers focusing on the manufacturing industry in particular and found that also *trust,* in people as well in technologies was an important prerequisite for open innovation to happen. This research can show that low trust in people, internal as well as external, plus low trust in external technologies lead to a higher risk adversity, which in itself seems to impact open innovation efforts negatively. This result can confirm that of Liechtenhaler & Ernst (2006) who suggest that companies limit external exposure in light of potential risks. The last dimension that seemed to have an especially large impact on open innovation adoption in the investigated context was internal strategies such as; IP-, technology, product and corporate strategy (see Chesbrough & Crowther 2006), which didn't align well with open innovation initiatives.

The main barriers to open innovation adoption in the investigated context are thus related to culture, norms and attitudes, internal strategies and perceived risks.

7 Conclusions

The purpose of this research was to empirically investigate barriers to open innovation practices in the more traditional industry, by performing a case study and analyzing the innovation activities at MMC, a manufacturing company providing the professional construction industry with tools and supplies. The objective of this research was, (i) to highlight potential barriers towards "*opening*" up innovation practices that previously were more "*closed*" and (ii) to provide suggestions on managerial countermeasures to reduce or even overcome those barriers and thereby contribute with new knowledge relevant to open innovation practitioners, decision makers, researches or other that could be interested in open innovation and its adoption in the more mature industry contexts.

7.1 Answer to sub-questions

The study has provided answers to the following questions:

What does open innovation really mean and why do companies open up their innovation practices?
Open innovation means to accelerate internal innovation processes by purposively harnessing flows of both internal and external knowledge by establishing new links (Chesbrough 2003; Sarkar & Costa 2008). It may also mean to establish new paths for product and service commercialization, but that circumstance has been disregarded in this research, which only focus was on "*innovation efforts that leverage external parties' knowledge and/or ideas, or individual problem solvers, to contribute to the internal innovation process*" (InnoCentive 2013). We've also learned that there isn't one single reason to why companies chose to open up their innovation processes, as motives are ranging from strategic, technical, operational and pure financial. The strongest motives for the investigated organization were to lower cost in production (development engineers) and to gain access to expertise, competence and research facilities (research community).

What are the potential hurdles and risks opening up the innovation process? The process of "*opening up*" involves change and there is plenty of research on general change management arguing that people as well as organizations often are reluctant to new concepts, because of current norms, organizational structures, revenue streams or power positions that may have to be altered (Hayes 2010). As firms open up their innovation practices, there is thus a range of barriers that can limit the benefits from adopting the concept. Identified barriers are related to the *industrial context, organizational culture, employee motivation, procedures and organizational structure, internal skills, trust, corporate strategies* and finally to the *perceived risks*, which to a great extent are showed to be related to the loss and control of proprietary knowledge and technology.

Are there any managerial countermeasures to reduce or even overcome those hurdles and risks?
There are both formal and informal means to manage open innovation. In the early history of the concept more trial-and-error based approaches were common but today scholars argue that a formalized approach to the management of knowledge inflows and outflows is needed (Liechtenhaler & Liechtenhaler 2009). The formal approach means to use a documented open innovation strategy, to write down and standardize procedures for its implementation but also to implement different kinds of performance metrics, to measure and evaluate impact. The more informal dimension of management shall strive to foster an open organizational culture, with norms, values and relationships that supports open innovation efforts.

7.2 Answer to research question

The main question that has been answered is:

Which are the barriers for a manufacturing company, i.e., a company in a more mature industry context, to "open up" its innovation process[10]? And will such a company benefit from doing so?

Open innovation in the context of the investigated firm, acting as premium supplier and partner to the professional construction industry, is already being successfully applied, yet to a varying degree throughout the organization to enhance internal innovation capabilities. There are enough internal examples proving that a variety of open innovation concepts, such as customer and supplier integration, university and partner research already are in use and that they work very well. None the less, the greatest identified barriers to implement open innovation extensively throughout the organization are closely related to corporate culture, corporate strategy and perceived risks. The biggest cultural barrier is the NIH-syndrome which likely is underpinned by several factors including perceived risks;

- Strong internal technical competence
- Awareness of being the market leader
- Acting in a mature industry context, which lower the perception among the engineers of finding useful knowledge externally , and;

[10] The Innovation process specifically refers to the sourcing of external input to enhance internal innovation capabilities.

- Associated potential risks

The risks associated with integrating external knowledge are especially strong within the applied research and development functions within the different BU's and seem to make the NIH syndrome intensify. The most prominent risks as a result of the interviews were;

- The risk of losing proprietary knowledge
- The risk of not being exclusive regarding differentiating product features
- The risk of jeopardizing quality and safety by not knowing external technologies
- The risk of creating business and legal liability by involving IP in collaborations
- The risk of dependency on external partners

As we can conclude, the identified risks are closely related to the dimensions of strategy, skill, corporate culture but also to trust. Thus, managerial countermeasures for reducing those risks are found by investigating the corresponding dimension underpinning it. The recommended action is to create an open innovation culture by providing strong open innovation leadership and to make open innovation a part of corporate strategy by also focusing on the capturing of value and not only the creation of it. Reduce associated risks by building trust in people as well as in technology by keep investing in internal R&D and in the improvement of open innovation skill, especially related to IP.

7.3 Proposal for Further Research

This study has provided initial insights to open innovation adoption in the construction industry. The investigated company is already performing open innovation in many regards but internal attitudes, strategies and a high risk adversity seem to prevent the company to fully reap the benefits of open innovation practices.

Since the study is one of few in this particular context, a replication of a similar study would provide data for comparison and thus be useful in testing the external validity. Another limitation to the result of this study is the thin base of empirical evidence, why another suggestion would be to perform a similar study and include respondents also from other departments such as; marketing, controlling, design etc., to provide a wider scope of perspective and a more holistic picture. The investigated industry interestingly shows evidence of gradually becoming more "*smart*", e.g., getting more exposed to new, emerging and complex technologies, where open innovation practices seem to gain importance. It would therefore be interesting to perform a quantitative study determining whether other companies in the same context also perceive this change and whether they as a result are changing their mode of innovation and to what extent they do.

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Appendices

A. Questionnaire Semi-Structured Interviews

Time & Place:

Interviewee:

Preparation: Please read the lead questions below and think about some examples in relation to your personal experiences

To what level of satisfaction are your technology needs met by internal R&D?

- How is the typical innovation process outlined? What stages/gates are there?
- Who is involved?

Does your BU sometimes look to bring in external input*, i.e., external technology, knowledge or intellectual property from others?

- What could be the motivation behind, what is a likely outcome given your process?
- Are OI efforts being opportunistically done or do they follow a formal systematic?
- Who may decide whether, when, what and from whom external inputs* are to be acquired?
- What are in your opinion the major difficulties acquiring external inputs to enhance the innovation process*?

If not, why is it so?

- Would the open innovation concept be contradictive to other internal processes and incentive systems? In that case, which?
- What in your opinion are the major drawbacks/risks using open innovation as innovation strategy?
- What do you experience (believe) is most difficult in acquiring external technologies?
- Do you think some people in the company are more open to open innovation initiatives? (tip* personal motivation, career development, business objectives, long vs long term strategy)

Definitions

- **Input***
  Technology, Knowledge and IP (intellectual property, i.e., patents, trade secrets, designs etc.**)**

- **Open Innovation***
  Innovation efforts that leverage external parties' knowledge, technologies and/or ideas, or individual problem solvers to contribute to the internal innovation process*. Open innovation activities may include working with external constituencies (e.g partners or suppliers), crowdsourcing ideas from outside the organization, participate in expert problem solving networks, hosting innovation events with external stakeholders, acquiring or licensing IP (technology and technological know-how)from external parties

Barrier	Corporate Function				
	Corporate innovation	Corporate IP	Corporate research	Development (BU)	*Tot/4*
Culture	3	4	3	5	3.75
Perceived risks	1	4	2	4	2.75
Strategy	1	4	1	5	2.75
Motivation	2	3	1	4	2.5
Trust	1	3	1	5	2.5
Procedures	2	2	2	3	2.25
Context	2	3	1	3	2.25
Skill	1	2	2	2	1.75
Measurements	1	2	1	2	1.5

Perceived as…	
1	...no barrier
2	...slight barrier
3	...moderate barrier
4	...great barrier
5	...severe barrier

C. Original Tables from Hirsch-Kreisen & Jacobsson (2008) – Innovation in Low-Tech Firms and Industries

Table 12.2 Highly important sources of information for innovation, as a percentage of innovative enterprises, 20 EU member states

	Within the enter-prise group (%)	Suppliers (%)	Clients or custom-ers (%)	Com-petitors or other enter-prises of the same sector (%)	Consult-ants, com-mercial labs or private R&D institutes (%)	Univer-sities or other higher education institu-tions (%)	Govern-ment or public research institutes (%)	Confer-, ences trade fairs, exhibi-tions (%)	Scientific journals; trade/ technical public-ations (%)	Professi-onal and industry associa-tions (%)
High-technology industries (HT)	59.0	18.9	41.4	15.0	4.3	6.3	3.1	14.9	10.8	3.8
Medium-high-technology industries (MHT)	53.1	18.0	32.5	11.8	6.1	6.1	3.3	10.8	7.5	4.5
HMHT-industries	54.3	18.2	34.2	12.4	5.7	6.2	3.2	11.6	8.1	4.4
Medium-low-technology industries (MLT)	41.5	23.3	26.1	10.5	5.9	3.6	3.0	12.0	6.3	4.4
Low-technology industries (LT)	39.9	26.2	22.6	12.1	6.6	2.9	2.6	14.6	9.4	6.3
LMT-industries	40.6	24.9	24.1	11.4	6.3	3.2	2.7	13.5	8.1	5.5
Manufacturing	44.8	22.8	27.3	11.8	6.3	4.1	2.9	12.7	8.1	5.1
Services (excluding public administration)	44.1	25.2	19.3	10.5	6.4	2.9	2.5	9.2	8.0	6.6
Total	45.6	23.1	26.5	12.2	5.8	3.7	2.7	11.5	8.3	5.5

Sources: CIS4. Cf. Table 12.1. EU-27 member states without Austria, Ireland, Portugal, Latvia, Slovenia, Sweden and the United Kingdom. Suppliers: Suppliers of equipment, materials, components or software.

D. Original Tables from Hirsch-Kreisen & Jacobsson (2008) – Innovation in Low-Tech Firms and Industries

Table 12.3 Innovation activity and cooperation during 2002–4 (in percentage of all innovation enterprises)

	Enterprises with innovation activity. % of all enterprises (%)	All types of cooperation; in % of all innovative enterprises (%)	Other enterprises within the same enterprise group (%)	Suppliers of equipment, materials, components or software (%)	Clients or customers (%)	Competitors or other enterprises of the same sector (%)	Consultants, commercial labs, or private R&D institutes (%)	Universities or other higher education institutions (%)	Government or public research institutes (%)
			(Cooperation partners; in % of all innovative enterprises)						
Food products and beverages	38.0	21.6	6.4	14.1	9.8	6.4	7.9	6.7	4.3
Tobacco products	31.2	28.6	20.4	20.4	4.1	2.0	8.2	6.1	2.0
Textiles	38.7	21.7	5.7	13.9	10.9	6.4	7.6	7.0	4.7
Wearing apparel; dressing	18.0	14.9	2.9	9.8	10.0	4.4	4.3	1.9	2.2
Tanning, dressing of leather; luggage	25.8	15.2	2.0	7.4	8.3	3.4	4.1	2.4	4.0
Wood and products of wood and cork, except furniture	32.1	19.2	3.7	14.8	8.9	5.7	4.5	5.4	2.8
Pulp, paper and paper products	45.1	23.0	11.2	19.3	11.6	8.0	8.0	6.3	3.1
Publishing, printing, reproduction of recorded media	50.2	14.4	4.9	9.7	7.1	3.6	4.3	2.2	1.3
Coke, refined petroleum products and nuclear fuel	22.5	44.0	23.1	29.9	17.2	15.7	17.9	21.6	18.7
Rubber and plastic products	51.6	24.3	8.1	15.7	13.6	6.2	8.2	9.7	5.1
Other non-metallic mineral products	42.6	18.3	6.3	11.9	8.1	5.7	7.1	7.0	4.8
Basic metals	48.1	34.1	11.8	19.6	19.7	7.8	9.2	18.1	10.1
Fabricated metal products, except machinery	42.9	20.7	4.8	11.3	11.3	6.0	6.2	7.2	4.2
Furniture; manufacturing n.e.c.	41.4	20.5	4.2	15.1	9.9	5.4	6.0	5.7	2.8
Recycling	37.4	19.1	2.4	14.1	6.8	4.9	8.3	8.9	3.2
High-technology industries (HT)	63.0	37.4	13.3	22.6	22.8	11.2	13.3	18.9	9.3
Medium-high-technology industries (MHT)	54.1	31.3	12.6	19.1	18.0	9.4	11.3	15.0	8.8
HMHT-industries	55.7	32.6	12.7	19.8	19.0	9.7	11.7	15.8	8.9
Medium-low-technology industries (MLT)	41.6	23.3	6.8	14.5	12.9	6.6	8.1	8.5	5.0
Low-technology industries (LT)	34.0	20.3	5.8	14.2	10.1	5.9	6.9	5.2	3.4
LMT-industries	37.0	21.6	6.3	14.3	11.3	6.2	7.4	6.6	4.1
Manufacturing	41.7	25.2	8.5	16.1	13.7	7.3	8.9	9.6	5.8
Services (excluding public administration)	26.8	27.4	10.7	18.9	12.2	9.3	9.0	6.6	5.3
Total	39.5	25.5	9.5	16.5	13.9	8.3	8.9	8.8	5.7

Question: 'During the three years 2002 to 2004, did your enterprise cooperate on any of your innovation activities with other enterprises or institutions? Innovation cooperation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active cooperation.' Sources and notes: see Table 12.1.

Source: CIS4. See Table 12.1. EU-27 Member States without Ireland.