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Open Innovation Activities in Swedish Cleantech

Jacob Ferlin and David M. Szabo

Supervisor: Rick Middel
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Abstract

Open innovation has a history of being researched on a few large companies in a qualitative manner. An often neglected field of research, but increasingly receiving more attention, is on open innovation activities among SMEs. Especially SMEs in the cleantech industry are of interest since cleantech companies can solve or develop solutions to the global environmental problems and contribute at the same time to economic growth.

In this thesis, the continuum of open innovation activities among Swedish SMEs in the cleantech industry are explored using a quantitative approach. In the questionnaire, eight open innovation activities and different trends are measured representing two open innovation perspectives - exploration and exploitation. Thus, our research question is: "What open innovation activities are performed by Swedish SMEs in the cleantech industry?"

Our findings show that the Swedish SMEs in the cleantech industry engage in many open innovation activities and that they have increasingly done so for the last three years. Motivations for open innovation are mainly knowledge, innovation processes, and market-related motivations while challenges mainly are resources and organization/culture. We didn't find significant differences between the manufacturing and services industry. On the other hand, we found differences in customer involvement between small-sized enterprises and medium-sized enterprises. Small-sized firms are involving customers in their open innovation processes significantly more in the cleantech industry. Moreover, cluster analysis suggests Swedish SMEs in the cleantech industry are using a more complex combination of open innovation activities (i.e. SMEs in different clusters adopt open innovation activities in not a trend like manner) than the one-dimensional adoption found in earlier research (i.e. some SMEs in one cluster are simply more open than others in an another cluster).

Keywords: open innovation, small- and medium-sized companies, incidence, motives, challenges, cluster analysis

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Abbreviations

IP: Intellectual property

MNE: Multinational enterprise

OI: Open innovation

R&D: Research and development

SME: Small and medium sized enterprises

1. Introduction

This section starts with a background in innovation and its increasing importance to companies and society as a whole. An introduction to open innovation and the cleantech industry is made, which goes into what inspired this research – a publicly owned research institute with a goal of helping SMEs with open innovation. This leads on to the purpose and research question of this thesis. Last, some pre-made delimitations and the research outline are also presented.

1.1. Background

Succeeding in the management of innovation is crucial for firms in order to survive (Ortt & van der Duin, 2008). Still, innovation is challenging. If the firm is successful, it creates value and profit, sustainable competitiveness, as well as a striving workplace able to attract productive and creative staff. If it is not successful, then serious and perhaps terminal problems are waiting around the corner. If companies are not engaging in the management of innovation, their competitors still do, and they will soon be out of business (Dodgson, Gann, & Salter, 2008).

Not only for the firm is innovation important, but the interest of innovation from the perspective of society is great. One example of innovation's importance is Horizon 2020, "the biggest EU Research and Innovation program ever with nearly €80 billion of funding [from 2014 to 2020]" (European Commission, u.d.). This financial instrument is aimed at securing Europe's competitiveness in the global landscape by driving economic growth and create jobs.

But innovation is extremely complex, as there are many different types and dimensions of it. Innovation can be seen as an outcome, a new product, a process, or service. But it can also be seen as a successful change by definition in itself while any innovation process, in contrast, can fail in supporting a successful new idea (Dodgson, Gann, & Salter, 2008).

Since innovation is so crucial for success there has historically been lots of effort on normative nature innovation studies. Best practice of innovation has changed historically and every timeframe in history has had its own idea of what is recommended – usually called innovation generations (Ortt & van der Duin, 2008).

A relatively recent phenomena and one such answer of how to tackle this complexity of innovation is that firms "need to adopt more plastic and porous models of innovation by being open to external sources of ideas and routes to market and engage with a larger number and wider range of

collaborators" (Dodgson, Gann, & Salter, 2008, s. 67). Chesbrough (2003) coined the term *open innovation* to describe this shift from previously used 'closed' innovation in which new product development was considered within internal R&D only.

But because of this complexity, there is no wonder there is no way of doing innovation that works for everyone and everything. Innovation, thus, requires an adaption to the environment in which it operates (Dodgson, Gann, & Salter, 2008) (Ortt & van der Duin, 2008).

The cleantech industry is one such environment that has increased in attention for the last couple of years because many countries consider cleantech technology as a solution to sustainable growth. Cleantech technology offers an opportunity to develop, produce, sell and export technology to other countries while reducing the environmentally negative effects (Strandberg, Bergfors, Fortkamp, & Lindblom, 2013). Cleantech companies can solve or develop solutions to the global environmental problems and contribute at the same time to economic growth.

The subject of this thesis is thus how open innovation is used in the cleantech industry.

1.2. Open innovation

In 2003, Chesbrough coined the term open innovation to describe the phenomenon in which organizations rely increasingly on external paths of innovation. It is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, Vanhaverbeke, & West, 2006, s. 1). The paradigm stresses the importance of using ideas from outside the firm to innovate, as well as those internal ideas, can be taken to market outside of the current business of the firm. Closed innovation, on the other hand, is the opposite of this new paradigm and is thought of as "traditional vertical integration model where internal research and development (R&D) activities lead to internally developed products that are then distributed by the firm."

Open Innovation is based on the following principles (Chesbrough H. W., 2003):

- Not all needs can be addressed within the company and it is important to seek knowledge and people outside the company.
- Relying on external R&D centers and using the internal R&D to make the management and development work together is important, this way the internal R&D can get some portion of the total value created.

- It is not necessary to depend only on the research that was originated internally to profit from it.
- To build a good business model is often better than to be the first on the market.
- If the firm uses the best of the internal and external, it is very likely to succeed.

The differences between open innovation relative to earlier theories are (Chesbrough, Vanhaverbeke, & West, 2006, s. 11):

- Equal importance is given to external knowledge, in comparison to internal knowledge.
- The centrality of the business model in converting R&D into commercial value.
- Type I and Type II measurement errors (in relation to the business model) in evaluating R&D projects.
- The purposive outbound flows of knowledge and technology.
- The abundant underlying knowledge landscape.
- The proactive and nuanced role of IP management.
- The rise of innovation intermediaries.
- New metrics for assessing innovation capability and performance.

Ortt & van der Duin (2008) further placed open innovation within the wider concept of contextual innovation management. In a historical discussion about what the next development of innovation management might be, Ortt & van der Duin (2008) argues for a shift in thinking: today there is not one best practice of innovation management, an often argued case historically, but instead each innovation management practice is adapted for its business circumstances – contextual innovation management: "Open innovation is not the only available option for every company or industry" (Ortt & van der Duin, 2008, s. 527). This contextual dependency has been known as one of the least understood parts of open innovation and more research is needed to know how external environment characteristics affects firms (Huizingh, 2011).

1.3. Cleantech

Cleantech Industry

As an industry definition, we used Vinnova's definition that delimits EU's ETAP (Environmental Technology Action Plan) definition (Strandberg, Bergfors, Fortkamp, & Lindblom, 2013). The reason for using this definition was that Vinnova collected a list of Swedish cleantech companies

that we could do our analysis on. Also, Vinnova uses a clear definition and shows how it limits EU's ETAP definition.

Cleantech is prevalent, affecting many industries, firms, managerial functions and corporate strategies. Cleantech is attracting venture capital, and high-tech clusters, such as the Silicon Valley and Boston (The Economist, 2008). Moreover, cleantech is global, with significant business activity taking place in Germany, Scandinavia, the Middle East, India, and China, to name but a few regions (van der Slot, 2012).

The cleantech sector is characterized by the following sectors and branches:

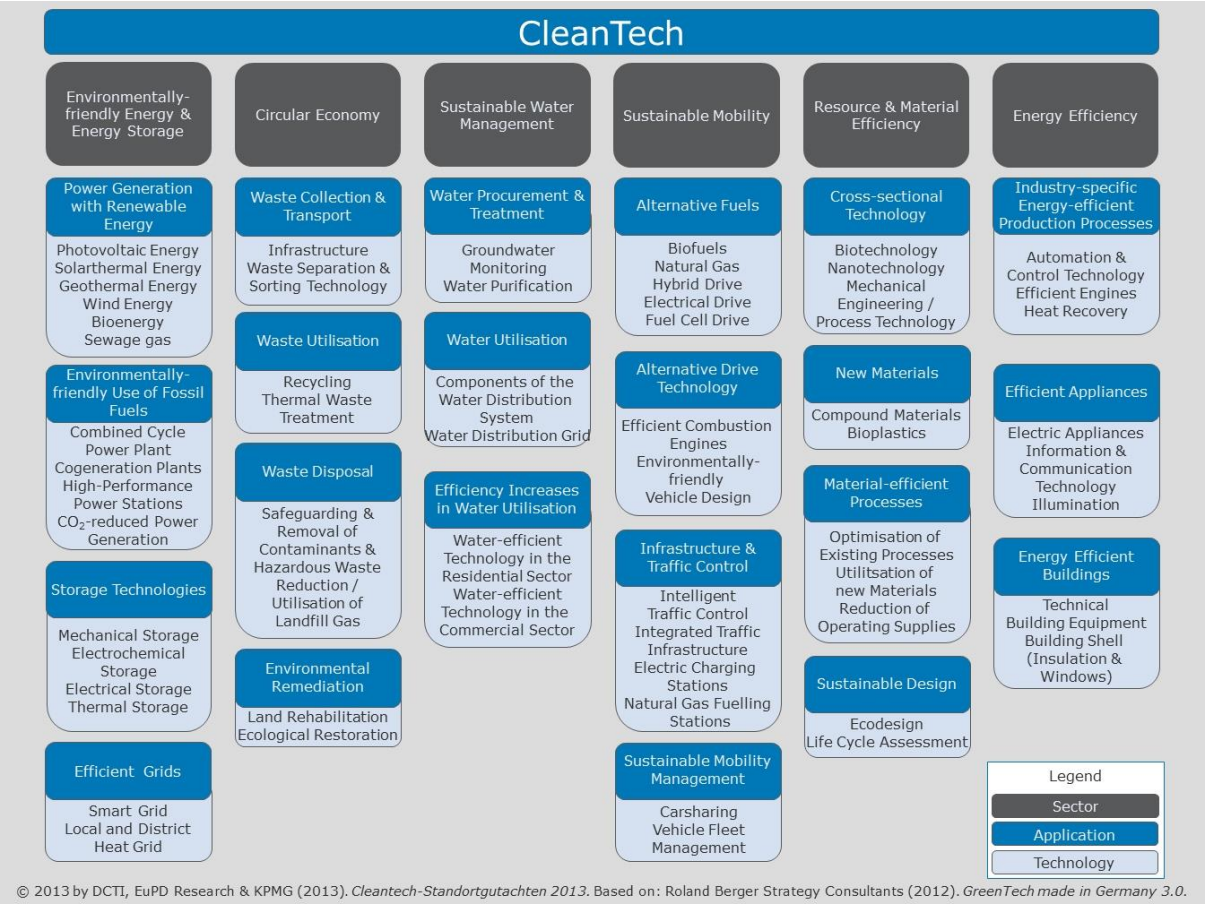

Figure 1. KPMG's cleantech classification (Rentmeister, 2013).

As we can see from the graph, the main parts of the industry are:

- environmental friendly energy,
- energy storage,

- circular economy,
- sustainable water management,
- sustainable mobility,
- resource and material efficiency and
- energy efficiency.

These diverse cleantech activities all attempt to yield superior performance at lower costs; to eliminate or reduce significantly negative ecological impacts, and to upgrade the productive and responsible use of natural resources (Cleantech Group , 2015).

According to the Cleantech Group's 2015 global list of the 100 most prominent cleantech companies, we can get a picture about the most important sectors in the cleantech industry.

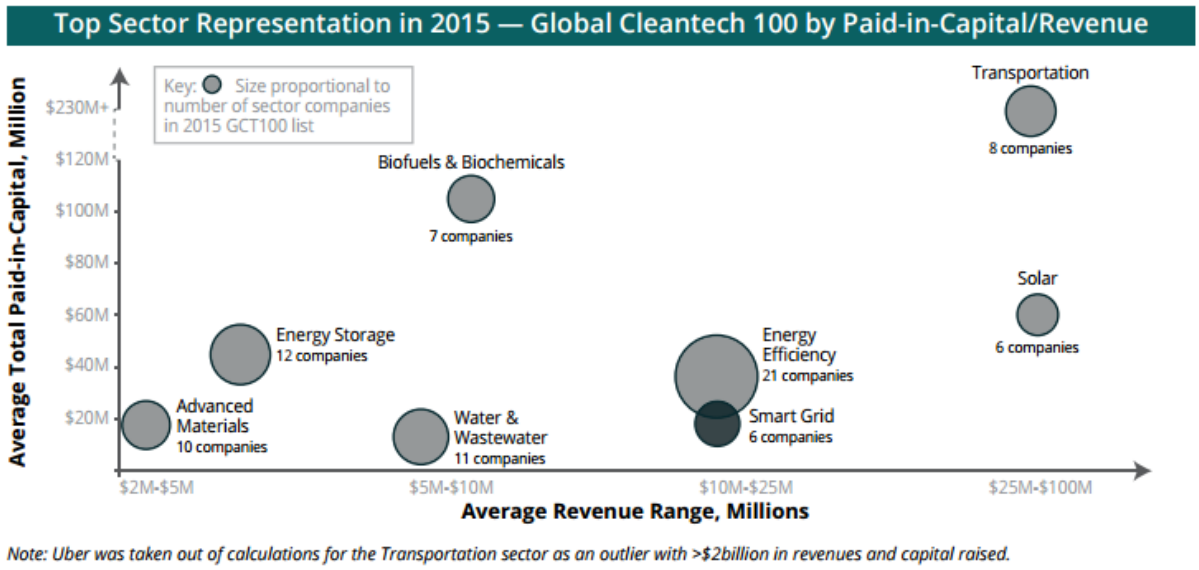

Figure 2. Cleantech Group's global top 100 cleantech companies (Cleantech Group , 2015).

It can be seen that the Energy Efficiency is the biggest group now. Investor appetite has trended towards Transportation, particularly the software companies that are revolutionizing mobility supply chains, for example Uber and BlaBlaCar (Cleantech Group , 2015). Energy Efficiency remained popular for its 'capital light' nature (compared to other longer-horizon sectors, such as Biofuels & Biochemicals). Solar is on the downfall since 2009 and solar companies started to offer a solution in the emerging markets. Energy storing shows a growing trend since 2014. Most of the companies are in battery or ultracapacitor business. Agriculture and food are also showing an increasing trend with companies focusing on pest control and breeding technologies.

Motivation

China, Korea, Finland, Japan, Germany and other countries consider cleantech technology as a solution to sustainable growth. Cleantech technology offers an opportunity to develop, produce, sell and export technology to other countries while reducing the environmentally negative effects (Strandberg, Bergfors, Fortkamp, & Lindblom, 2013). Cleantech companies can solve or develop solutions to the global environmental problems and contribute at the same time to economic growth and create workplaces.

This connects to the topic of social entrepreneurship where social entrepreneurs solve environmental problems with environmental technologies (cleantech). Social entrepreneurship is thought of an important innovation source. Often social entrepreneurs use an inter-linked network, or ecosystem, which brings together diverse actors (Horwitch & Mulloth, 2010). The organization doesn't rely on its own internal R&D, instead it is using networks and leveraging ecosystems (Adner, 2006). Innovation becomes more open (Chesbrough H. W., 2003). These cleantech social entrepreneurs or ecopreneurs (Horwitch & Mulloth, 2010) have a wide network, use open innovation and solve environmental problems.

Hallencreutz et al. (2008) did a research on Swedish SMEs in the cleantech industry about their R&D collaboration. 72% of the small- and medium-sized companies collaborated with other research related institutes. This study confirms that Swedish SMEs are doing open innovation activities.

1.4. Motivation for the thesis

Theoretical view

Previous research about open innovation has been addressing mostly MNEs (Lee, Park, Park, & Yoon, 2010) and there have been calls for more specific studies on small and medium-sized enterprises (SMEs) (Remneland Wikhamn, Wikhamn, & Styhre, 2016), e.g. Gassmann, Enkel, & Chesbrough (2010) and Lichtenthaler (2008).

For this reason, we decided to explore the situation about SMEs and open innovation. This thesis assesses whether open innovation is relevant for SMEs and not only for MNEs in Sweden. A quantitative study of Remneland et al. (2016) was conducted among Swedish SMEs, but in the biotechnology sector and they didn't include any motivations, challenges, or clusters. To our

knowledge, this is the first research on open innovation activities in the cleantech sector that addressed SMEs in Sweden.

Practical view

For practitioners who wish to handle the complexity of innovation by using open innovation, it is crucial to know what future potential collaborators have and how these firms work with open innovation.

One such example is SP Technical Research Institute of Sweden. With its services within open innovation, SP is taking on the role of an open innovation intermediary to limit some challenges associated with open innovation, e.g. only 'friendly' partners are included and costs are limited before results are shown. At the moment, these friendly partners only consist of universities and SP's own research institutes. Even though this allows for a lot of possible partners, there exist opportunities to further develop the kind of potential collaborators that can be reached.

Such collaborators could be SMEs since smaller companies "provide an initial impetus for radical innovations, and sometimes become important partners in the creation and delivery of those radical innovations" (Chesbrough, Vanhaverbeke, & West, 2006, s. 32).

Also for practitioners in the cleantech industry, the thesis is of value since it allows for comparing oneself to others in the industry when it comes to how common open innovation is.

1.5. Purpose and research question

This study sets out to investigate what the current state of open innovation and SMEs are, i.e. how much of open innovation activities are they actually doing? Also, the motives and challenges are explored deeper than previous studies. The main research question this study sets out to answer is thus:

What open innovation activities are performed by Swedish SMEs in the cleantech industry?

1.6. Research outline

Theory

The theory section gives the reader a definition of open innovation and open innovation activities, followed by a literature review of how open innovation in SMEs have been studied before, together with previous findings on incidence levels, perceived trends, motives, and challenges for open innovation. Also, a review of previously explored clusters of how different SMEs use open innovation is covered.

Methodology

This section starts with the research approach, where the goal of the research and the research strategy are specified. Then comes the research design where it is explained why an explorative quantitative study was used. After, the survey methodology and the data collection is presented. Afterwards, the execution of the thesis is documented. Last, the research criteria are included where the validity and reliability of the study are explained.

Results

This section starts with motives and challenges of practicing open innovation activities. Then comes the incidence and perceived trends in the cleantech sector among SMEs. This section shows what trends exists among these SMEs and how they perceive the trends in open innovation activities. It is followed up by the incidence and perceived trends between size classes and between industries. Finally, the cluster analysis is conducted where similar companies are classified into clusters to see whether there are groups of companies who work with open innovation similarly.

Analysis

This section compares the findings from the theory to the actual results. Thus, the section compares the propositions from the end of each theory section to the results and draws conclusions about them. The incidence levels, the motives, challenges, the perceived trends, also the perceived trends between size-classes and between industries are analyzed.

Conclusions

This section draws conclusions from the theory and analysis and presents the most interesting findings. Also possibilities for future research and limitations to the study is covered.

2. Theory

The theory section gives the reader a definition of open innovation and open innovation activities, followed by a literature review of how open innovation in SMEs have been studied before, together with previous findings on incidence levels, perceived trends, motives, and challenges for open innovation. Also, a review of previously explored clusters of how different SMEs use open innovation is covered.

2.1. Open Innovation

Apart from the many positive sides of open innovation (OI) that Chesbrough, Vanhaverbeke, & West (2006) put forth, there has also been many critics of it. One critique is that the concept is not new and that a certain amount of openness in innovation has been present for a long time, see e.g. discussion by Chiaroni, Chiesa, & Frattini (2009).

Another critique is that the talk of a paradigm shift creates a division between closed innovation on one hand, and open innovation on the other, thus not allowing for an exploration of a continuum between closed and open innovation (Lazarotti & Manzini, 2009). Still, other argue that treating openness as a continuum is non-controversial among scholars studying OI (Dahlander & Gann, 2010).

There have been many studies exploring this degree of openness, e.g. Lazarotti & Manzini (2009). Reoccurring among these though are that they provide in-depth understanding for only a few aspects of OI, focuses on only one half of OI (either inbound or outbound), or that they only give a general bird's eye view of the topic (Lichtenthaler U. , 2008).

Inbound and Outbound Processes in Open Innovation

What does openness really mean and how has openness been studied? Dahlander & Gann (2010) went through all the papers on the subject in order to clarify what definitions of openness are used within the OI field. Two inbound processes are found: sourcing and acquiring, and two outbound processes: revealing and selling.

The revealing type of openness (outbound innovation and non-pecuniary) is defined as "how firms reveal internal resources without immediate financial rewards, seeking indirect benefits to the focal firm" (Dahlander & Gann, 2010, s. 703). This way of "freely" sharing innovations among e.g.

competitors has some advantages in certain situations. Pisano and Teece (2007) describe two environmental factors that shape how firms are able to capture value from innovation: the appropriability regime and industry architecture. Strong appropriability regimes are characterized by difficulty of imitation because of either (prominent) strong legal protection or hard to copy technology (e.g. software). Weak appropriability regimes offer other mechanisms to capture value: "such as developing complementary assets that would earn a return even if the innovation itself didn't" (Pisano & Teece, 2007, s. 282). There is a challenge in how firms choose what to reveal to the outside world, and especially for small firms that often lack resources to structure such a process (Dahlander & Gann, 2010).

Selling (outbound innovation and pecuniary) is defined as "how firms commercialize their inventions and technologies through selling or licensing out resources developed in other organizations" (Dahlander & Gann, 2010, s. 704). The idea is simply to leverage the R&D investments the firm has spent, making it possible for others to bring it to market. This approach has become more common, but there are difficulties that may prevent selling or out-licensing. Disadvantages are the disclosure paradox (an inventor revealing information for a potential licensee and the licensee may proceed to act opportunistically and steal the idea), significant transaction costs, and estimation difficulties of the value of the technology. Chesbrough & Rosenbloom (2002) elaborate that using different business models may yield very different value. A deliberate strategy may have to be used (Dahlander & Gann, 2010), or otherwise the firm may face the same situation as Xerox did when it was shown that the spin-offs and other external commercialization, in which Xerox missed to capture value, was worth more than Xerox itself (Chesbrough H. , 2002).

Sourcing (inbound innovation and non-pecuniary) is defined as "how firms can use external sources of innovation. Chesbrough, Vanhaverbeke, & West (2006) claim that firms scan the external environment prior to initiating internal R&D work. If existing ideas and technologies are available, the firms use them. Accounts of corporate R&D laboratories show that they are vehicles for absorbing external ideas and mechanisms to assess, internalize and make them fit with internal processes" (Dahlander & Gann, 2010, s. 704). Advantages are very much summarized by using discoveries of others for its own innovation process. As for disadvantages, there seems to be a curvilinear relationship between the search of sources for innovation and innovation performance

thus indicating an initial advantage but with dangers if becoming too dependent on external sources.

Acquiring (inbound innovation and pecuniary) is defined as "acquiring input to the innovation process through the marketplace. Following this reasoning, openness can be understood as how firms license-in and acquire expertise from outside" (Dahlander & Gann, 2010, s. 705). What is needed is expertise within the firm so that the acquired knowledge can be evaluated. It is also easier to assimilate the knowledge if the knowledge base is not too different, but too similar knowledge base and there will not be as many benefits for the firm.

From Inbound/Outbound to Open Innovation Activities

Huizingh (2011) covers many aspects of how to look at OI. One of them is the inbound/outbound distinction by Dahlander & Gann (2010) described above. Instead of inbound and outbound processes within OI, these processes have also been called acquisition/exploration and exploitation (van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009; Lichtenthaler, 2008). van de Vrande et al. (2009) further on operationalized OI into eight (binary) activities as they appear in Table 1, three activities for exploitation and five activities for exploration.

Table 1. Definitions of open innovation activities.

Activity	Definition
Technology Exploitation	
Venturing	Starting up new organizations drawing on internal knowledge, i.e. it implies spin-off and spin-out processes.
Outward IP licensing	Selling or offering licenses or royalty agreements to other organizations to better profit from your intellectual property, such as patents, copyrights or trade-marks.
Employee involvement	Leveraging the knowledge and initiatives of employees who are not involved in R&D, for example by taking up suggestions, exempting them to implement ideas, or creating autonomous teams to realize innovations.
Technology Exploration	
Customer involvement	Directly involving customers in your innovation processes, for example by active market research to check their needs, or by developing products based on customers' specifications.
External networking	It includes all activities to acquire and maintain connections with external sources of social capital, including individuals and organizations. It can be formal or informal networking activities.
External participation	Equity investments in new or established enterprises in order to gain access to their knowledge or to obtain others synergies.
R&D outsourcing	Buying R&D services from other organizations, such as universities, public research organizations, commercial engineers or suppliers.
Inward IP licensing	Buying or using intellectual property, such as patents, copyrights or trade-marks, of other organizations to benefit from external knowledge.

An alternative operationalization was done by Lichtenthaler (2008) in which only two variables was used, one for exploitation and one for exploration, but with seven-point Likert scales as the variables instead. Yet another measurement of open innovation was done by Enkel, Bell, & Hogenkamp (2011). Their perspective was to create a tool for management in order to monitor and control how a firm works with OI. Their goal was not so much about different activities but rather to figure out how mature the firm was when it comes to OI. Measurements were in the area of partnership capacity, the right climate, and the right systems and tools for OI.

Completely other perspectives are focusing on different stages of OI (from seeking opportunities to recruiting partners and capturing value) or how external contributions fit together with strategy, customer utility, and competition (Huizingh, 2011).

An alternative to look at what OI activities a firm perform, Lichtenthaler & Lichtenthaler (2009) offers the perspective of looking at capabilities for OI instead. A framework for OI was constructed but it could also be seen as a complement to the notion of absorptive capacity.

2.2. Motives for Open Innovation

van de Vrande et al. (2009) explored the motives for SMEs to engage in OI. For almost all of the OI activities (but especially for venturing, external participation, and customer involvement), market-related reasons were the most important. Market-related reasons include keeping up with market developments and to meet customer demands in order to increase growth, achieve better financial results and increase market share (van de Vrande et al., 2009). Also in line with Chesbrough & Crowther (2006) when they interviewed 12 large firms and found that the most common motive for external technology acquisition was growth. Going back to van de Vrande et al. (2009), they have an interesting conclusion that there seemed to be pretty much the same motive for all the OI activities, which further on made them conclude that venturing, external participation, and customer involvement are complementary OI activities.

Coras & Tantau (2013) concluded four main motives, based on theoretical grounds, which should make SMEs adopt OI: risk sharing benefit, alleviation of their cost structure, increasing their knowledge base and resource pooling. Also increasing the uncertainty of technological developments increases investment in external R&D in order to be able to follow new developments (Coras & Tantau, 2013).

What we anticipate then is that motives for SMEs to pursue OI activities are market-related reasons, risk sharing, alleviation of their cost structure, increasing their knowledge base, and access to resources.

2.3. Challenges for Open Innovation

OI has barriers and challenges and there were a few attempts to explore this subject. For example, establishing and maintaining partnerships, which relates to external networking and external participation, is both a crucial and time-consuming matter in OI (Huizingh, 2011). In addition, managing intellectual property is challenging when other actors are involved (Luoma, Paasi, & Valkokari, 2010). This second issue relates to inward and outward IP licensing in van de Vrande et al.'s (2009) OI activity framework. Moreover, OI managed by the internal processes of many companies is still more trial and error than a professionally managed process (Gassmann, Enkel, & Chesbrough, 2010). This points to not well developed innovation processes. Furthermore, it was found that SMEs have difficulties with labor shortages, lack of information, lack of infrastructure and lack of financial resources (Lee, Park, Park, & Yoon, 2010). Other potential barriers include lacking resources, free-riding behavior, and problems with contracts (Hoffman & Schlosser, 2001) (Mohr & Spekman, 1994). We used van de Vrande et al.'s (2009) framework of challenges and barriers as we thought it summarizes the most important hinders and barriers into categories well. Then main challenges for SMEs according to van de Vrande et al. (2009) among Dutch SMEs are organization/culture. We propose that organization/culture, not well developed innovation processes, lack of financing and infrastructure, and lack of other resources will be among the barriers of Swedish SMEs in the cleantech sector.

2.4. Incidence Levels and Perceived Trends

Some first tentative evidence is found in Chesbrough (2003) as he cited statistics of how small enterprises contribute to total industrial R&D expenses in the US. They accounted for around 24% of all R&D spending in 2005, compared to only 4% in 1981 (National Science Foundation, 2006).

Besides, there have been multiple studies on the strengths and weaknesses of SMEs in their organization of innovation processes, e.g. Vossen (1998); Acs & Audretsch (1990). This work concludes that innovation in SMEs is hampered by a lack of financial resources, scant opportunities to recruit specialized workers, and small innovation portfolios so that risks associated

with innovation cannot be spread. SMEs need to heavily draw on their networks to find missing innovation resources, and due to their smallness, they will be confronted with the boundaries of their organizations rather sooner than later.

In today's increasingly complex and knowledge-intensive world with shortened product life cycles, such networking behavior has become probably even more important than before. Given these considerations, we anticipate that OI activities are not exclusively applied by MNEs, but will also be present in SMEs, and will be increasingly adopted. Both of the IP licensing activities though seems to be stagnant (only 4% and 5% perceived an increasing trend).

The specific incidence levels and perceived trend of OI activities that van de Vrande et al. (2009) found in SMEs are showed in Table 2.

Table 2. Incidence and Trends of OI activities among SMEs (van de Vrande et al., 2009)

		Perceived trend (%)		
	Incidence (%)	Increase	Stable	Decrease
Tech. exploitation				
Venturing	29	14	84	2
Outward IP licensing	10	4	95	1
Employee involvement	93	42	57	1
Tech. exploration				
Customer involvement	97	38	61	1
External networking	94	29	67	4
External participation	32	16	83	1
Outsourcing R&D	50	22	73	5
Inward IP licensing	20	5	93	2

Industries and size classes

The size of a firm can influence the way a firm adopts and practices OI. Size is an internal context characteristic (Huizingh, 2011). Smaller companies can benefit a lot from OI because their resources are sparse and their market reach is restricted. They have fewer assets to develop and maintain networks and enforce intellectual property rights (Huizingh, 2011). The size effect has been found in both technology exploitation and exploration (Lichtenthaler & Ernst, 2009) (Lee, Park, Park, & Yoon, 2010). As SMEs grow, they develop more formal processes, introduce managerial layers, rules and procedures (Greiner, 1972). It is easier for larger firms to obtain

financing for their R&D projects (Vossen, 1998). Also, larger firms have better-developed marketing channels, which makes it easier to realize the returns of their innovation (Vossen, 1998). In sum, we propose that OI is more regularly applied by medium-sized companies and that the perceived trends towards OI is stronger in this group of companies.

Prior research shows that there are differences in the adoption rate across industries regarding the incidence of and trend towards OI (Huizingh, 2011). In this thesis, we explore the differences between manufacturing and services industries. Services and physical goods differ in intangibility, inseparability, heterogeneity and perishability (Atuahene-Gima, 1996). Services and manufacturing companies have different offerings and there might be a difference in the adoption of OI. As physical products are more separable and homogeneous, it is much simpler to outsource parts of the R&D process (outbound process) or to in-source new ideas and technologies that fit with the current business (inbound process) (van de Vrande et al., 2009). In addition, OI is more frequently practiced in industries characterized by globalization, technology intensity, technology fusion, new business models and knowledge leveraging (Gassmann O. , 2006). We claim that the first three characteristics, as defined by Gassmann (2006), are more applicable to manufacturers than to services companies, in other words manufacturing companies usually tend to operate in larger geographical regions and their processes demand higher investments in capital and technologies (van de Vrande et al., 2009). It follows that for services the opposite applies because services are relatively intangible, simultaneous and heterogeneous in nature. Therefore, we propose that the incidence and adoption of OI will be stronger in manufacturing industries.

2.5. Open Innovation Clusters

Are all OI activities necessary for the firm? Huizingh (2011) suggested for future research whether or to what extent firms need the capacity to perform all OI activities or if some activities can compensate for others. Thus, giving rise to different OI strategies. Lichtenthaler & Lichtenthaler (2009) touched upon this subject in their framework of OI capabilities and hypothesized that certain capabilities can compensate for other. Thus, it is not only of interest to see incidence level of OI activities at an industry level since such averages might hide groups of firms performing completely different OI strategies.

van de Vrande et al. (2009) grouped homogenous firms when it comes to what OI activities are performed and found three clusters. The first cluster consisted of firms doing the most OI activities.

About 22% of the SMEs were grouped into this cluster. The second cluster was the largest one (about 68%) and the firms were involved almost always in employee involvement, customer involvement, and external networking. As for the third cluster (about 10%), those firms also rely a lot on customer involvement but are not involved in more complex activities such as venturing, buying or selling IP, and outsourcing R&D. This is consistent with Lichtenthaler (2008) when he looked into how common OI was among medium and large companies (van de Vrande et al., 2009).

Table 3. Incidence of OI activities among clustered Dutch SMEs (van de Vrande et al., 2009)

	Cluster 1 (n = 133) (%)	Cluster 2 (n = 411) (%)	Cluster 3 (n = 61) (%)
Tech. exploitation			
Venturing	40	27	15
Outward IP licensing	44	1	0
Employee involvement	98	99	38
Tech. exploration			
Customer involvement	98	99	77
External networking	99	100	44
External participation	44	31	11
Outsourcing R&D	70	48	21
Inward IP licensing	86	0	5

Apart from differences among OI incidence levels being a result of the innovation strategy for the focal firm, such differences might also be a result of a transition process of becoming more open, but still having some 'closed' activities (Huizingh, 2011). Gassmann, Enkel, & Chesbrough (2010) reports that OI often starts with simple outsourcing deals and then moves on to more OI activities. Poot, Faems, & Vanhaverbeke (2009) explored the transition process of OI among firms in the Netherlands and "convincingly show that there is a positive trend in the extent to which organizations (1) apply knowledge that originated outside their boundaries, and (2) engage in formal collaboration with external partners for innovation purposes" (s. 197).

But even if there are transitions going on, there seems to be evidence of different archetypes of how firms use OI based on firm-internal weaknesses, such as information and capabilities related impediments; as well as risk related impediments (Keupp & Gassmann, 2009). "Specifically, our findings suggest that firms whose internal innovatory activities are confronted with impediments

to innovation are more likely to use OI more intensively (both 'broader' and 'deeper')" (Keupp & Gassmann, 2009, s. 336).

Because of all this research on different OI strategies, OI transition processes, and OI archetypes, we expect to see different homogenous groups of firms that perform different levels of OI activities.

2.6. Open Innovation in the Cleantech Industry

As it was shown in the introduction, many countries consider cleantech technology as a solution to sustainable growth. Also, the majority of the Swedish cleantech companies are conducting OI activities (Hallencreutz, Lindquist, Lundequist, & Waxell, 2008). Hallencreutz et al.'s (2008) study focused on how these companies collaborate within their R&D activities with institutions and universities. The following questions were asked that are relevant for this thesis:

- What do the enterprises focus their R&D activities on?
- Do the R&D activities happen in collaboration?
- What challenges do the enterprises have in their R&D?
- Is there a connection between R&D activities and growth?

176 companies answered the survey with a 37% response rate.

The first question focuses on the motives of the R&D activities. Product development was more important than process development, whether we talk about creating new products / processes or developing new products/processes. 70% of the respondents concentrate on new product development. This is an interesting finding because according to van de Vrande et al. (2009), market-related motives were prevalent in venturing, external networking, and customer involvement.

The second question focuses on whether the companies collaborate in R&D. 72% of the Swedish SMEs in cleantech do collaborate with research institutes. In van de Vrande et al.'s (2009) study, 94% of the Dutch SMEs did external networking.

The third question focuses on the challenges in R&D activities. The question asked, "why would the company not invest more resources on R&D?" This question concentrates on a broader range of innovation rather than only OI activities, but OI activities are a part of all R&D activities. Most

of the enterprises thought that internal financing was the biggest hinder, followed by time and external financing. In van de Vrande et al.'s (2009) research, financing was not dominant at all, neither were resources. This might be an industry specific issue and it could be a future research topic.

The fourth question focuses on the correlation between R&D activities and growth. Hallencreutz et al. (2008) didn't find any significant levels between the R&D activities and increased growth in turnover.

Also, an important note that SMEs are often mentioned as the center for innovation and development in the business life (Hallencreutz, Lindquist, Lundequist, & Waxell, 2008).

This section showed some differences between van de Vrande et al.'s (2009) study and Hallencreutz et al. (2008). It would be interesting to explore the motives and challenges in different OI activities among Swedish SMEs in the cleantech sector. We could see that SMEs in the cleantech sector conduct collaboration activities (Horwitch & Mulloth, 2010), but do they conduct other OI activities? If yes, which ones and why?

2.7. Concluding Remarks of Theory

If we were to make conclusions on our research question based on theory, the following points are expected:

The most important motives for SMEs to engage in OI are market-related reasons, risk sharing, alleviation of their cost structure, increasing their knowledge base, and access to resources. Most important challenges are: organization/culture, not well developed innovation processes, lack of financing and infrastructure, and lack of other resources will be among the barriers of Swedish SMEs in the cleantech sector.

Within the field of OI for SMEs, two main processes are identified: exploitation and exploration. Within these two processes there have been earlier research on eight specific activities. In exploitation these activities are: venturing, outward IP licensing, and employee involvement. In exploration these activities are: customer involvement, external networking, external participation, R&D outsourcing, and inward IP licensing. Three activities (employee involvement, customer involvement, and external networking) are expected to be adopted by more than 90% of the SMEs

in the cleantech industry. Outsourcing R&D are expected to be adopted by around half of the SMEs the rest of the activities are adopted by a lower number of SMEs (venturing, outward IP licensing, external participation, and inward IP licensing).

The perceived trends are mostly stable, but leaning to increasing for all OI activities except outward IP licensing and inward IP licensing. A similar trend is expected in in our study.

From previous research, it was argued that manufacturing firms can outsource their R&D easier, are more global and technologically intense than service firms, therefore, we expect the incidence and adoption of OI to be stronger in manufacturing industries than in the services industry.

Furthermore, smaller companies have less resources for innovation processes and we expect that OI is more regularly applied by medium-sized companies and that perceived trends towards OI is stronger in this group of companies.

As for clusters among the cleantech SMEs, there are expected to be big differences between adoption levels of OI in similar patterns as van de Vrande et al. (2009) found:

- very large group of SMEs (cluster 1 and 2, combined these two clusters consists of about 90% of all companies in the sample) doing activities of employee involvement, customer involvement, external networking, and inward IP licensing while cluster 3 lacks behind.
- more spread of incidence levels among the clusters when it comes to venturing, external participation, and outsourcing R&D. This means that the incidence levels won't be similar among the clusters.

3. Methodology

This section starts with the research approach, where the goal of the research and the research strategy are specified. Then comes the research design where it is explained why an explorative quantitative study was used. After, the survey methodology and the data collection is presented. Afterwards, the execution of the thesis is documented. Last, the research criteria are included where the validity and reliability of the study are explained.

3.1. Research Approach

The Goal

The overall purpose of this research study was to examine how Swedish cleantech SMEs work with OI. Also, if there is a perceived trend in the chosen activities, what motives and challenges these companies had while conducting OI activities and what clusters exists among the enterprises.

Research Strategy

The primary research was quantitative in nature. It was explorative, it tested which OI activities the actors used, what challenges and motives they had and if there were perceived trends in the past 3 years in conducting OI activities. We developed and tested propositions on the differences between manufacturing and services companies and between medium-sized and small-sized firms. We operationalized the questionnaires to be able to quantify the results on 5 point Likert-type scales (1 = greatly increased, 5=greatly decreased). The questionnaire can be found in Appendix 1. Questionnaire

A quantitative study was used for multiple reasons. First, with a quantitative study, we could collect a large-amount of data across manifold cases. After data collection and analysis, the results can be generalized. Second, a quantitative study makes it possible to analyze the results more objectively than in a qualitative study (Bryman & Bell, 2011). Although the respondents had some questions to write own answers, these answers were coded later and quantified.

A quantitative study also has some drawbacks. It is inflexible in the data collection phase. It is impossible to modify the survey during the collection, if the questions are not presented as clearly as possible for the respondents, the respondents might misunderstand them, interpret them in a subjective manner and bias arise. For this reason, it is important to introduce multiple controls so the respondents have a common understanding of the research questions and research topics. That

is why we introduced definitions to each section and did two pilot testing, with one of our classmates and with our supervisor to know if the questions can be misunderstood.

Figure 3 gives a summary of the research approach and the subsequent deliverables.

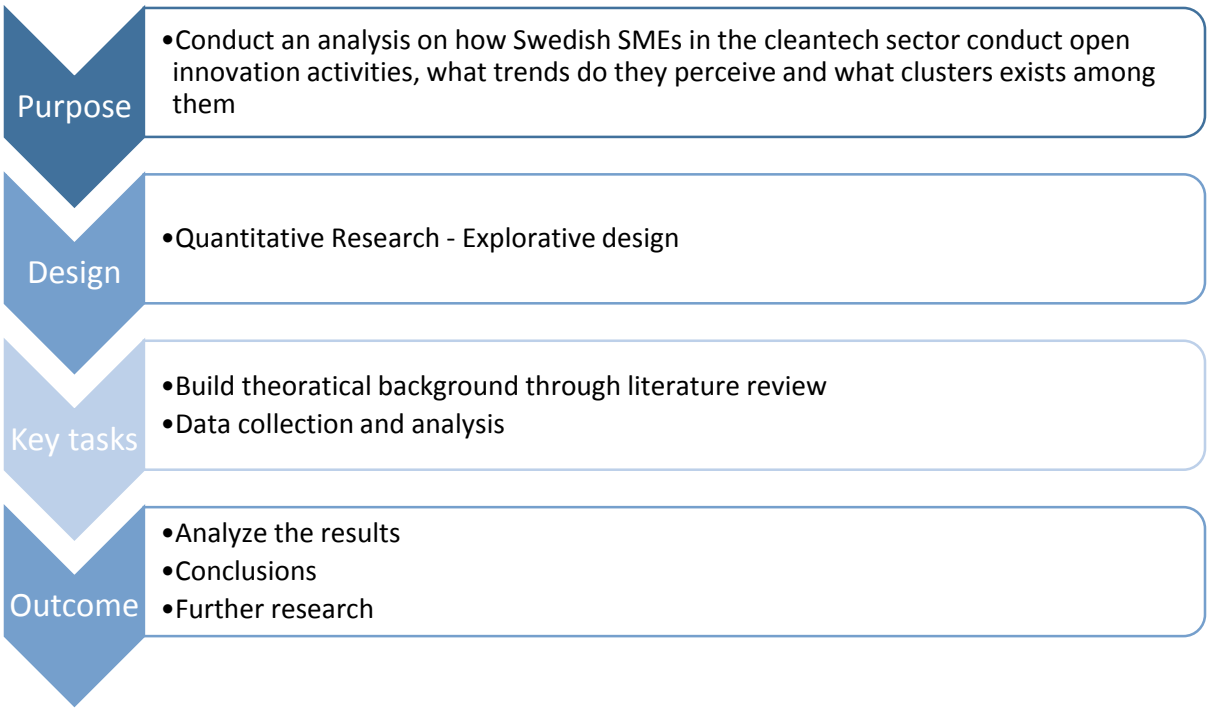

Figure 3. Research approach and the subsequent deliverables

3.2. Research Design

This thesis is first an explorative thesis measuring to which extent Swedish cleantech SMEs apply OI activities and whether there is a perceived trend towards increased adoption over the past three years. Moreover, the motives of SMEs to engage in OI activities and challenges encountered were explored.

The research relies on the framework of van de Vrande et al. (2009) as secondary research. van de Vrande et al.'s (2009) research was an explorative study, examining how SMEs in the Netherland work with OI, which challenges they have and what perceived trends exist in the adoption of OI activities.

Mostly closed-ended questions (multiple choice) were used from van de Vrande et al.'s (2009) framework. This could have resulted in researcher bias, therefore, we added a last "other" option at the end of the multiple choice questions, where the respondents could answer open-endedly so that we could catch outside answers (Newbold, 2010).

3.3. Survey Methodology

In order to collect the data for the research, interviews or questionnaires can be used. We wanted to collect as many observations as possible in the given time to explore the underlying thesis question and to test different factors in the framework. For this reason, questionnaire seemed to be the better choice as it allows to gather more data than doing interviews in a given time. We used an online questionnaire through the platform of Webropol and sent the questionnaires through email to the respondents.

There are a lot of advantages of using self-completing questionnaires compared to interviewing. One of them is that they are quicker to administer (Bryman & Bell, 2011). Thousands of questionnaires can be sent out online by one click. They are also more convenient for the respondents to fill out. One disadvantage might arise when the respondents misunderstand the questions as there is no interviewer who can answer additional questions on how to interpret the questions. To avoid this bias, we used the same question patterns in each section and added definitions to all of the terms that were difficult to understand. Another issue might arise with low response rates. Also, we emphasized that those people who fill out the survey can have a look at the current trends in innovation in their industry and that they can get a copy of our research to increase the response rate.

Questionnaire

We based our questionnaire mainly on van de Vrande et al.'s (2009) framework, but we changed the open-ended question format (for motives and challenges) to closed format to increase the response rate. We consulted this with our supervisors and both of them agreed on this point. For example, instead of asking what challenges the respondent's company has, we took the results of van de Vrande et al.'s (2009) study and transformed them into multiple-choice questions. At the end, we included an "other" option if the answer choices didn't cover the reality.

Also, we connected the questionnaire to our theory. In the end of each theory section, a proposition was formed that we wanted to test among the respondents. For example, at the end of the perceived trends for the size factor, our proposition sounded as: "*In sum, we propose that open innovation is more regularly applied by medium-sized companies and that trends towards open innovation are stronger in this group of companies*." We transformed this proposition to "*What is the incidence and perceived trends in open innovation activities between size classes among Swedish SMEs?"* We designed our questionnaire to test all of these propositions and we drew conclusions from them. The main sub-questions that we formed are the following:

- *What are the motives to perform open innovation activities?*
- *What are the challenges to perform open innovation activities?*
- *What is the incidence and perceived trends in open innovation activities?*
- *What is the incidence and perceived trends in open innovation activities between size classes?*
- *What is the incidence and perceived trends in open innovation activities between sub-industries?*
- *What are the incidence and perceived trends if the companies are put into homogenous groups according to how they practice open innovation?*

The questionnaire design can be found in Appendix 1.

3.4. Sampling and Execution

First, we designed the survey and we talked with our supervisor for feedback. After the feedback was implemented and the survey was developed, we searched for a database with cleantech companies. We used Vinnova's (Swedish governmental agency for innovation systems) already

finished list of Swedish cleantech companies since it offers a more unique and more distinct perspective on the industry (Strandberg, Bergfors, Fortkamp, & Lindblom, 2013). Apart from using simple SNI codes, an industry classification similar to NACE were used in which all Swedish companies are divided into different groups, according to the business description. The Vinnova study lets experts gather lists from many different sources to complement what can be achieved from SNI codes alone. 5500 companies were found using the first step. Then experts in the area of cleantech development made a manual review of all companies which made the list shrink to 1571 companies, mostly because of lack of R&D intensity.

At 2016.04.04-05, we filled in the Vinnova's database with the missing information. We were searching for the organization's number on Retriever database, http://www.foretagsfakta.se/, eniro.se, allabolag.se. Then we fed the organizations' number to Retriever database and got a list of the companies with all the information we needed. In total, we had 1571 companies. The number of companies shrank from 1571 to 1484 in this step due to companies going through a fusion with another company, going bankrupt or there wasn't enough information about the company from secondary sources.

Then we fed in the organization numbers to Retriever and fetched a list with the number of employees and other facts for each company. Since this thesis is interested in SMEs (10-499 employees), the list shrank further to 681 companies.

After this, we chose a random sample of 420 companies so that a 20% response rate would give us the about 84 responses required for a 95% confidence level and confidence interval of 10. The random numbers were generated from RANDOM.ORG, a true random number service that generates randomness via atmospheric noise, on 2016-04-05 09:23:01 UTC.

Before sending out the questionnaire to the respondents, the questionnaire was sent to our supervisors from Handelshögskolan in Göteborg, for the first pilot testing.

Next, we called around 20-30 companies to ask for a person who can answer our questionnaire. We found out that SMEs usually don't have anyone working with innovation and it is the CEO or someone working with marketing/sales who could answer our survey. Our telephone pitch can be found in the Appendix 2. Phone pitch.

After we realized that usually the CEO is the right person to answer our questions, we gathered the CEO's mail addresses to our selected random sample from secondary sources (homepages, allabolag.se, eniro.se). Then, we designed our mail invitation and both the mail and the reminder that can be found in Appendix 3. Survey Mail Invitation and Appendix 4. Survey Mail Reminder.

Afterward, we sent out the survey to the sample. After sending out the first mail, in the first 24 hours we sent a reminder, and gathered 50 responses. After the 1st reminder, we sent a second reminder and had then gathered a total of 58 responses. Then we closed the survey.

The average time to complete the questionnaire was estimated to be ten minutes. This consisted of both the screening questions and the core research questions.

Final Sample

Out of a possible 364 sent out questionnaires, 58 responses were gathered over a period of two weeks. This gives a response rate of 16%. The baseline target to ensure the reliability of the study was reset to a minimum of 40 responses (Hamid & Marcantoni, 2015). This target ensured a 95% confidence level and a 15% confidence interval.

3.5. Research Criteria

Validity

Internal validity

Credibility means whether there can be another variable that is causing causality. It answers the question that how confident can we be that the independent variable is at least in part responsible for the variation in the dependent variable. As we examined shortly the relationship between the turnover and OI activities and found no correlation, there can't be any third variable that affects the no correlation (see Appendix 5.). We put this analysis in the further research section.

External validity

External validity means whether the results of the study can be generalized exceeding the particular research context (Bryman & Bell, 2011). We expected a 20% response rate that would give us the about 84 responses required for a 95% confidence level and confidence interval of 10 for a population of 681 companies. We had 16% response rate and got 58 responses and thus, this weakens the external validity.

At some of the sections in our survey, the number of responses is low. We would have expected more answers to venturing and both inward and outward IP licensing. Relevant statistical tests were used for the small response rate, but a larger response rate would be desirable.

Reliability

Stability

Stability means whether the results are stable over time. If we chose to measure the group again, how big would be the variation over time in the results obtained? We applied probability sampling and used Vinnova's public list of cleantech companies (Strandberg, Bergfors, Fortkamp, & Lindblom, 2013). Anyone using the same method could have arrived at the conclusion that we did with little variation over time.

Also, the attributes of OI activities were taken from existing research during the literature review, it can be argued that the stability of the measures was accounted for.

Internal Reliability

Internal reliability was tested through the use of Cronbach's Alpha.

The Figure 3 below shows our alpha.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,719	,754	3

Figure 4. Cronbach's Alpha test

As it can be seen from the figure above, the number of observations for the Cronbach's alpha test was three. The reason for this is that the alpha test didn't work well when the sample size for certain questions was below 10. For the items / Likert-scales that exceeded 10, the alpha showed over 0.7 result, which is acceptable. A Cronbach's alpha value of >0.7 depicts strict internal consistency among the items (Nunnally, 1978).

Reliability in general

We would like to mention that one of our screening question and the perceived trends questions were not consistent. As a screening question, we asked how long the CEO have been working for the company, whereas at the trend questions we asked about the past 3 years. We assume that those CEOs that haven't worked at the company for 3 years, answered the trend question with not only his/her personal experience in mind, but with how the firm has done before he/she started working. This fact might affect the reliability.

In addition, our survey was in English and was sent out to mostly Swedish CEOs. Bias might arise because English for the Swedish speaking CEOs is a second language. We mitigated this bias by asking our supervisors, and one classmate to proofread the questionnaire so that it is as clear as possible for not Swedish speakers. Moreover, we added definitions to each section where some of the terms were not clear and we followed a pattern in each section so that the questionnaire would be easy to follow and to understand.

4. Results

This section starts with motives and challenges of practicing open innovation activities. Then comes the incidence and perceived trends in the cleantech sector among SMEs. This section shows what trends exists among these SMEs and how they perceive the trends in open innovation activities. It is followed up by the incidence and perceived trends between size classes and between industries. Finally, the cluster analysis is conducted where similar companies are classified into clusters to see whether there are groups of companies who work with open innovation similarly.

Motives for Open Innovation Activities

Table 4 shows that for most of the OI activities pursued by SMEs, the most important motives were knowledge, innovation processes, and market-related ones. For the greater part of the respondents, using new innovation methods is a way to keep up with market developments and to meet customer demand, which should result in increased growth, better financial results, or increased market share (van de Vrande et al., 2009). Knowledge related motives were the most important for companies to engage in customer involvement (59%), external networking (70%) and external participation (100%). Many SMEs believe that it is necessary to use a wide range of methods to outperform the competitors and to keep up with the ever-changing customer demand. Motives related to control, focus and costs were considered less important by SMEs.

Most of the respondents conduct employee involvement, customer involvement, and external networking, which motives help to improve products, to be informed about with market developments and to keep the employees involved and motivated in the product or service development process.

The motives for employee involvement are different than the other innovation objectives. This can be an outcome of an internal policy or to use the available talent optimally and to keep the employees motivated.

Important to know that not all options were available to choose for respondents, but an “other” option was always at one’s disposal to select/write an answer that wasn’t captured by the other motives.

Table 4. Motives for each OI activity among Swedish SMEs in cleantech industry (multiple answers allowed)

Motivation	Technology exploitation			Technology exploration		
	Venturing (n = 14) (%)	Employee involvement (n = 34) (%)	Customer involvement (n = 34) (%)	External networking (n = 37) (%)	External participation (n = 9) (%)	Outsourcing R&D (n = 17) (%)
Control	29	32	18	5	11	6
Focus	21			16	33	18
Innovation process	50		56	57	56	47
Knowledge	36		59	70	100	76
Costs	21		21	30		35
Capacity	21		3	51	11	88
Market	21	44	50	41	56	18
Utilization		65				
Policy		18				
Motivation		76				
Other	7		6	6		6

Table 5. Definitions of motivations in each category

Control	Increased control over activities, better organization of complex processes
Focus	Fit with core competencies, clear focus of firm activities
Innovation process	Improved product development, process-/ market innovation, integration of new technologies
Knowledge	Gain knowledge, bring expertise to the firm
Costs	Cost management, profitability, efficiency
Capacity	Cannot do it alone, counterbalance lack of capacity
Market	Keep up with current market developments, customers, increase growth and/or market share
Utilization	Optimal use of talents, knowledge, qualities, and initiatives of employees
Policy	Organization principles, management conviction that involvement of employees is desirable
Motivation	Involvement of employees in the innovation process increases their motivation and commitment

Challenges for Open Innovation Activities

Table 6 shows the extent to which the barriers matter for each of the different types of OI activities. The challenges in the categories of organization/culture and resources appear to be the two most important factors across all OI activities, not counting outsourcing R&D in which also financing was an equally important hurdle. Important to know that not all options were available to choose for respondents, still an “other”-option was always at one’s disposal to select / write answers that

weren't captured by the challenges options. Because of this, that organization/culture and resources appears to be the most important could potentially be a consequence of that they were simply the options most often available as an option. But not only were organization/culture and resources almost always an available option, they also scored top percentages almost all the times, which points to the result that they indeed are important.

Outsourcing R&D differentiates itself in another manner, a large share of respondents who answered did not experience any challenge with it (35%). In fact, this 35% share is larger than any of the challenges of the same practice.

Of the three answers in the "other" category concerning customer involvement, no respondent further explained what challenge they had experienced.

For these comparisons, though, it has to be stated that van de Vrande et al. (2009) used a method of open-ended questions while this study used the closed kind.

In sum, the biggest challenges were organization and culture and resources. Most of the respondents didn't have a challenge with R&D outsourcing. We had in part conflicting results with van de Vrande et al.'s (2009) study. Venturing appeared to be related to one of the main barriers to innovation, but external participation and outsourcing R&D were the activities where most of the respondents didn't have any challenge.

Table 6. Challenges for each OI activity (multiple answers allowed)

Challenge	Technology exploitation			Technology exploration		
	Venturing (n=14) (%)	Employee involvement (n = 34) (%)	Customer involvement (n = 34) (%)	External networking (n = 37) (%)	External participation (n = 9) (%)	Outsourcing R&D (n = 17) (%)
None	0	12	18	5	22	35
Administration	14	-	-	22	11	6
Finance	21	-	-	30	-	29
Knowledge	21	-	-	-	22	-
Marketing	7	-	-	-	11	-
Organization/Culture	57	-	44	46	56	29
Resources	57	74	32	38	-	29
IPR	-	-	15	11	-	-
Quality of partners	-	-	-	16	-	12

Adoption	-	-	15	-	-	-
Demand	-	-	9	-	-	-
Competences	-	15	-	-	-	-
Commitment	-	26	-	-	-	-
Idea management	-	21	-	-	-	-
Other	0	0	3	0	0	0

"-" marks option that was not available for the respondent

Table 7. Definitions of challenges in each category

None	If no challenge was selected by respondent, it was interpreted as "none" by authors
Administration	Bureaucracy, administrative burdens, conflicting rules
Finance	Obtaining financial resources
Knowledge	Lack of technological knowledge, competent personnel, or legal/administrative knowledge
Marketing	Insufficient market intelligence, market affinity, marketing problems of products
Organization/Culture	Balancing innovation and daily tasks, communication problems, aligning partners, organization of innovation
Resources	Costs of innovation, time needed
IPR	Ownership of developed innovations, user rights when different parties cooperate
Quality of partners	Partner does not meet expectations, deadlines are not met
Adoption	Adoption problems, customer requirements misjudged
Demand	Customer demand too specific, innovation appears not to fit the market
Competences	Employees lack knowledge/competences, not enough labor flexibility
Commitment	Lack of employee commitment, resistance to change
Idea management	Employees have too many ideas, no management support

4.1. Incidence Levels and Perceived Trends

Table 8 shows the incidence of OI activities in our sample of SMEs. The five last columns give an overview of the evolution of the use of these activities in Swedish SMEs. The table shows the shares of respondents conducting various aspects of technology exploitation and technology exploration and the extent to which they perceived a great or slight increase, stabilization or a great or slight decrease in the application of these activities in the past 3 years. Table 8 shows that employee involvement (59%), customer involvement (59%) and external networking (64%) were the most common among the OI activities. Outward (12%) and inward (7%) IP licensing, external participation (16%) were only conducted by the minority of the respondents. R&D outsourcing and venturing were conducted by the third of the SMEs.

It can also be seen, the share of respondents perceiving an increase over the past 3 years is considerably larger than the share with a decrease. These results suggest that OI is not just

conducted by MNEs, but also applies to a great sample of SMEs, and moreover, OI is on average increasingly adopted, which is in line with van de Vrande et al.'s (2009) findings.

Table 8. Incidence and perceived trends in OI activities (n = 58)

		Perceived trend (%)				
	Incidence (%)	Increased greatly	Increased slightly	Stable	Decreased slightly	Decreased greatly
Tech. exploitation						
Venturing	24	21	36	29	14	-
Outward IP licensing	12	14	43	29	-	14
Employee involvement	59	9	47	32	12	-
Tech. exploration						
Customer involvement	59	18	47	29	6	-
External networking	64	11	57	22	8	3
External participation	16	22	67	1	-	-
Outsourcing R&D	29	6	59	29	6	-
Inward IP licensing	7	20	20	60	-	-

4.2. Incidence Levels and Perceived Trends between Industries

Similarly, to the size-classes analysis, Table 9 provides an alike output about the differences between the manufacturing and services industry. Significances were analyzed with the Mann-Whitney U-test.

Table 9. Incidence of and perceived trends in OI activities between industries

	Incidence			**Perceived trend**		
	Manufacturing (n=16)	Services (n = 42)	Mann–Whitney Z(U)	Manufacturing (n=16)	Services (n = 42)	Mann–Whitney Z(U)
Tech. exploitation						
Venturing	25%	24%	0,807	1	0,60	0,558
Outward IP licensing	19%	10%	0,47	0,33	0,67	0,711
Employee involvement	63%	55%	0,848	0,80	0,39	0,207
Tech. exploration						
Customer involvement	63%	57%	0,669	1,00	0,67	0,291

External networking	75%	60%	0,684	0,83	0,52	0,309
External participation	25%	12%	0,339	1,25	1,00	0,558
Outsourcing R&D	44%	24%	0,261	0,86	0,50	0,267
Inward IP licensing	6%	7%	0,784	0,00	0,33	0,564

The left-hand side of Table 9 shows a few differences between the manufacturing and services companies. Employee involvement, customer involvement, and external networking seem to be the main type of OI activities by both the manufacturing and services enterprises. Manufacturing enterprises do better on every OI activity, but the results are not significant. In addition, the response rate was low among firms with 100-499 employees in venturing, inward and outward IP licensing activities and we would have got a clearer picture and stronger significances with bigger sample size.

The right-hand side of Table 9 showed that means average trend scores are consistently positive, which means that the trend towards OI activities is perceived in both industries. Although, we didn't find any significant differences. In a survey of manufacturers, where Lichtenthaler (2008) analyzed industry differences in detail, he too didn't find significant differences. To sum up, we didn't find any vital differences between the manufacturing and services industries in the matter of the incidence and trend towards OI activities.

4.3. Incidence Levels and Perceived Trends between Size Classes

In the first two paragraph, the steps of the analysis will be showed. First, we checked if the distributions are normal for each OI activity. The incidences for each OI activity follow a not-normal distribution (binomial). For this reason, we used a non-parametric test, called Mann-Whitney U-test for two independent (discrete), non-paired datasets (samples) on significant median differences. Mann-Whitney U-test is the equivalent for the independent t-test for non-parametric distribution and for tests with small sample size.

We examined the median differences because the mean is not a robust measure of central tendency (robustness deals with outliers) (Newbold, Carlson and Thorne, 2010).

Table 10. Incidence and perceived trends in OI activities between size classes

	Incidence			**Perceived trend**[a]		
	10–99 employees (n=44)	100–499 employees (n =14)	Mann–Whitney Z(U)	10–99 employees (n=44)	100–499 employees (n =14)	Mann–Whitney Z(U)
Tech. exploitation						
Venturing	25%	21%	0,67	0,64	1	0,628
Outward IP licensing	14%	7%	0,795	-2	-2	0,116
Employee involvement	61%	43%	0,907	0,57	0,33	0,599
Tech. exploration						
Customer involvement	57%	57%	0,079	0,92	0,25	0,04*
External networking	66%	43%	0,56	0,68	0,33	0,308
External participation	16%	14%	0,7	1,14	1	0,726
Outsourcing R&D	32%	21%	0,986	0,79	0,00	0,032*
Inward IP licensing	9%	-	-	0,25	-	-

* $p<0.05$ level

[a] Average score with great increase coded 2, slight increase 1, stable coded 0 and slight decrease -1, great decrease coded -2.

Table 10 compares the incidence and trend towards OI for the differences between small- and medium-sized enterprises. For a clearer presentation, trend scores have been averaged. It can be seen that small-sized enterprises (10-99 employees) are more likely to engage in OI. On all technology exploitation and exploration activities they are doing slightly or substantially better, although the differences are not significant.

As for perceived trends, the right-hand side of

Table 10 shows a few substantial differences. Most of the values in the column of respondents with 10-99 employees are larger. Especially for the technology exploration activities small-sized enterprises are much more involved in these OI activities. The results were found significant for customer involvement and R&D outsourcing. Although, on the R&D outsourcing only 3 firms

with 100-499 employees answered the perceived trend question and all of them thought that this factor remained stable in the past 3 years, so there was no variation in the answer. In addition, the response rate was low among firms with 100-499 employees in the inward and outward IP licensing activities and we would have got a clearer picture and stronger significances with bigger sample size.

The results raise an important aspect of the findings by Lichtenthaler (2008), who inferred that firm size did not have a major impact on the degree of technology exploration, but it did affect technology exploitation. In our case, there wasn't a significance difference in the incidence levels, but in the perceived trends. In addition, van de Vrande et al. (2009) found that medium-sized enterprises are more involved in OI activities and the perceived trend is stronger for them too compared to small-sized companies. van de Vrande et al.'s (2009) finding contrasts our results. One explanation for this can be that our study was conducted in the cleantech sector in Sweden while van de Vrande et al.'s (2009) study was conducted in the Netherlands without restriction on the industry, but the contrasting results could be a topic of future research. In summary, we found that small-sized enterprises perceive a greater perceived trend in both customer involvement and R&D outsourcing than their medium counterparts.

4.4. Open Innovation Clusters

To understand whether or not it is possible to classify the companies into groups (clusters) according to how similarly they work with OI, a cluster analysis was performed. First, the dichotomous variables of whether a particular OI practice is performed or not is used as the clustering variables. A non-overlapping hierarchical (agglomerative) clustering procedure is chosen since it can handle the dichotomous variables we use (Wedel & Kamakura, 1998) (IBM SPSS, 2012a).

As for the measure of similarity, squared euclidean distance was chosen which in this case simply means the number of dissimilar cases (IBM SPSS, 2012b). Finally, the commonly used Ward's method is used (see e.g. Lichtenthaler (2008)) for the clustering algorithm flowing procedure as it appears in Janssens, De Pelsmacker, & Van Kenhove (2008, s. 323). This clustering process results in three clusters, as appears in the icicle diagram (Figure 5).

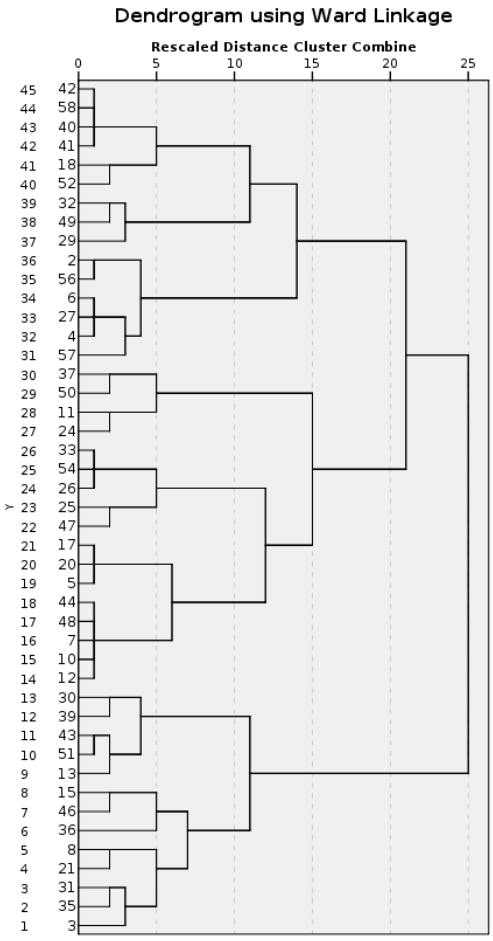

Figure 5. Clustering procedure

Table 11. Incidence of OI activities across three clusters

	Cluster 1 (n=15) (%)	**Cluster 2 (n=13) (%)**	**Cluster 3 (n=17) (%)**	**Kruskal-Wallis Chi-square (df=2)**
Tech. exploitation				
Venturing	73	0	18	19.346**
Outward IP licensing	0	54	0	19.951**
Employee involvement	87	46	88	8.377*
Tech. exploration				
Customer involvement	100	62	65	7.157*
External networking	100	92	59	10.282*
External participation	27	0	29	4.505
Outsourcing R&D	53	69	0	16.952**
Inward IP licensing	27	8	0	5.822

** p<0.01, * p<0.05

Cluster 1 consists of companies in which OI activities are very common, especially in venturing, employee involvement, customer involvement, and external involvement - two activities from each of the exploitation and exploration perspectives. To note also that this cluster is characterized by no outward IP licensing, while inward IP licensing is fairly uncommon (27%) but still almost all companies doing inward IP licensing can be found in this cluster (but the result is not significant).

In cluster 2, external networking is very common (92%) while outsourcing R&D and customer involvement are moderately common, 69% and 62% respectively. Further on, venturing, external participation, and inward IP licensing are none existent or very low. What really sets this cluster apart is that it captures all companies with outward IP licensing.

As for the third cluster, it has a high level of employee involvement but is very low (or nonexistent) for venturing, outward IP licensing, outsourcing R&D and inward IP licensing.

The differences on incidence levels between the clusters were tested with a Kruskal-Wallis Chi-square test, the significance levels are seen in Table 11.

As for perceived trends among these clusters, there is once again cluster 1 that sets itself apart from the other two. Employee involvement has a significantly larger average than the other clusters while external participation is larger than cluster 3. There appears also to be a significant (but on $p<0.1$ level) on the external networking practice.

Table 12. Perceived trend in OI activities across three clusters

	Cluster 1 (n=15)	**Cluster 2 (n=13)**	**Cluster 3 (n=17)**	**Kruskal-Wallis Chi-square (df=1 or 2)**
Tech. exploitation				
Venturing	0.8	-	0.0	1.477
Outward IP licensing	-	0.4	-	-
Employee involvement	1.0	0.3	0.2	7.164*
Tech. exploration				
Customer involvement	1.0	0.5	0.6	2.480
External networking	0.9	0.8	0.1	5.285^
External participation	1.5	-	0.8	3.086^
Outsourcing R&D	0.6	0.7	-	0.000
Inward IP licensing	0.8	0.0	0.6	0.625

* $p<0.05$, ^$p<0.10$
Average score with great increase coded 2, slight increase 1, stable coded 0 and slight decrease -1, great decrease coded -2.

5. Analysis

This section compares the findings from the theory to the actual results. Thus, the section compares the propositions from the end of each theory section to the results and draws conclusions about them. The incidence levels, the motives, challenges, the perceived trends, also the perceived trends between size-classes and between industries are analyzed.

5.1. Motives for Open Innovation Activities

As for motives for performing OI activities, two motives are almost consistently the top ones (Figure 6): innovation process (improved product development, process-/ market innovation, integration of new technologies) and knowledge (gain knowledge, bring expertise to the firm). Market-related reasons were common but compared to van de Vrande et al. (2009) they were never the top ones (except for external participation). Coras & Tantau (2013) expected lower cost and knowledge to be motives for SMEs to engage in OI. Knowledge certainly was important for Swedish SMEs in the cleantech industry, but cost does not appear to be as important as anticipated. Further on, when looking on motives on Figure 6 only venturing, customer involvement, and external networking can be seen as substitutes to each other since these activities share the same motives that are innovation processes and knowledge.

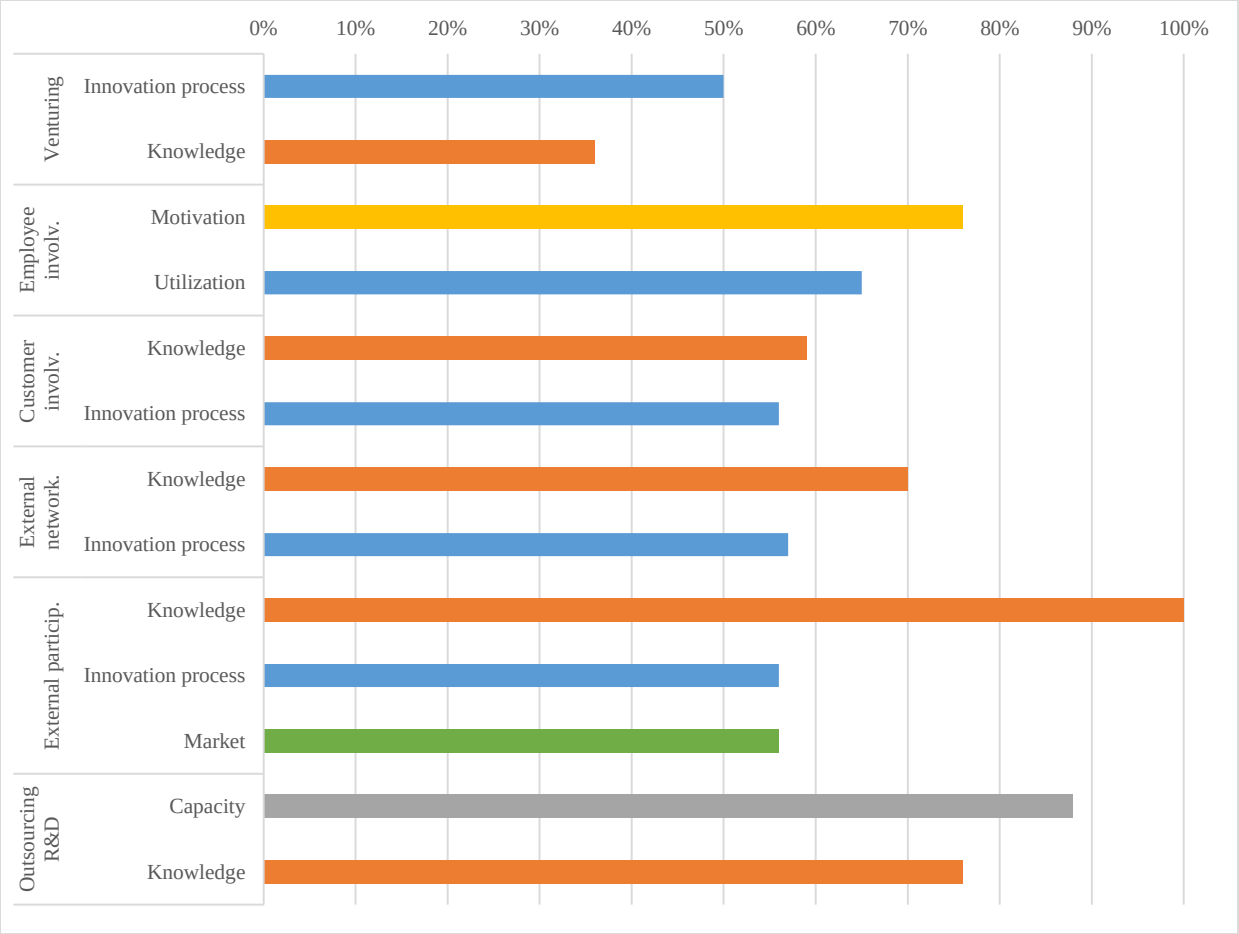

Figure 6. Top motives for each OI activity in Swedish SMEs in cleantech industry

5.2. Challenges for Open Innovation Activities

When it comes to challenges, organization/culture and resources appears to be common among the top challenges for Swedish SMEs in the cleantech industry. SMEs often don't have structured OI activities. We experienced this problem when we called companies in our database to ask after contact people and usually the firms didn't have anyone working with innovation, even in medium-sized enterprises. Also, SMEs usually don't have the resources to commercialize their innovation. This last point is in line with Gans and Stern's study (2003) and also with Hallencreutz, Lindquist, Lundequist, & Waxell (2008). In addition, SMEs also have fewer resources to build and maintain collaborative networks and to create and enforce intellectual property rights (Huizingh, 2011).

Compared to earlier research on OI activities among SMEs, there are both confirming and conflicting results. Van de Vrande et al. (2009) reported that the main barriers to innovation are related to venturing, external participation and outsourcing R&D (measured as having the fewest

non-responders). While this appears to be true for venturing in our study as well (all respondents selected a challenge), both external participation and outsourcing R&D actually got the most non-responders, indicating that relatively many did not perceive any challenge. We interpreted non-respondents as they didn't have any challenge in the given activity. Further on, van de Vrande et al. (2009) also reported organization/culture as being the most important challenge to OI activities overall.

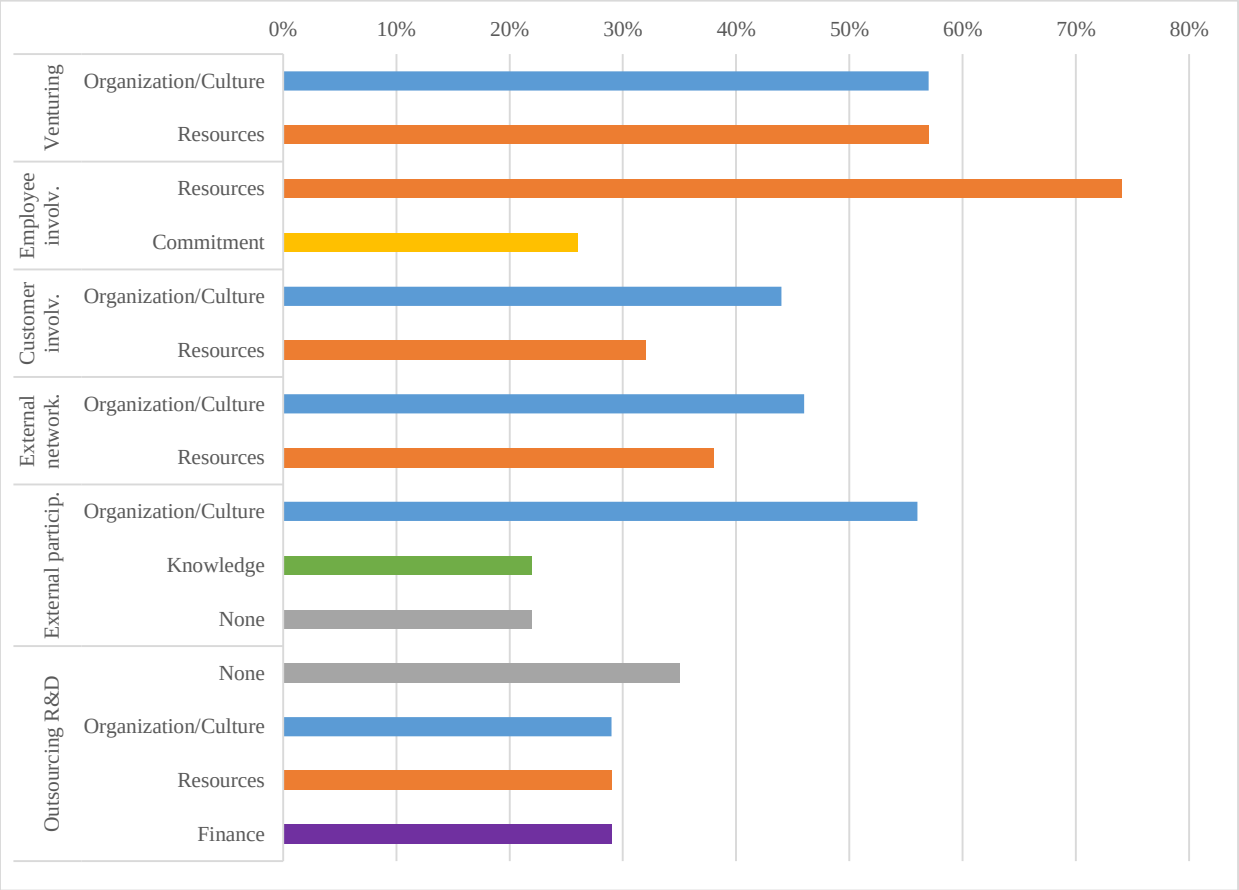

Figure 7. Top challenges for each OI activity in Swedish SMEs in cleantech industry.

5.3. Incidence Levels and Perceived Trends

External networking (64%), employee involvement (59%), and customer involvement (59%) are the most common OI activities and are performed by the majority of Swedish SMEs in the cleantech sector. Outsourcing R&D (29%), and venturing (24%) are fairly common while only a few companies perform external participation (16%), outward IP licensing (12%), and inward IP

licensing (7%). This result is in line with Lichtenthaler's (2008) study who showed that medium-sized and large manufacturers adopt OI activities.

The more popular activities, such as customer involvement and external networking are informal, unstructured practices which do not necessarily require substantial investments (van de Vrande et al., 2009). IP licensing (both inward or outward), venturing and external participation, on the other hand, entail financial investments, formalized contracts, and a structured innovation portfolio approach managing the risks. This discovery is in agreement with earlier research about innovation in SMEs (Vossen, 1998).

Comparing with earlier studies on OI activities in SMEs, van de Vrande et al. (2009) found higher incidence levels on six out of eight activities while only two exploitation activities (venturing and outward IP licensing) appears to be on par with the Swedish cleantech industry, see Figure 8. What is similar though is that top OI activities are the same (employee involvement, customer involvement, and external

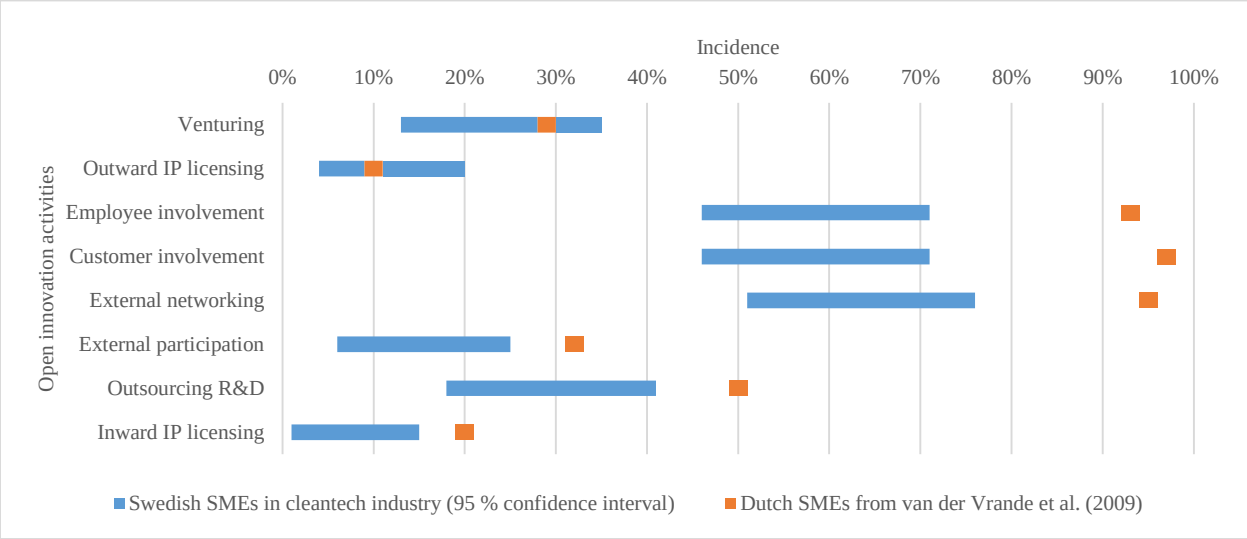

Figure 8. Incidence of OI activities in Swedish SMEs in cleantech industry

Thus, it seems Swedish cleantech companies indeed are worse at implementing OI than Dutch SMEs, especially if considering the seven years span between the two studies.

Even if Swedish SMEs in the cleantech sector are worse in implementing OI activities than Dutch SMEs, there is a positive finding. Swedish cleantech companies appear to be on a much steeper slope when it comes to increasingly adopting OI activities. In fact, the perceived trends are

increasing a lot more in all activities compared to van de Vrande et al. (2009). This can be seen from Figure 9. Perceived trends in OI activities among Swedish SMEs in cleantech industry where the light blue and orange parts (increase) outweigh the rest of the bar chart. Small firms usually lack resources to develop and commercialize new products in-house and, as a result, are more often inclined or forced to collaborate with other organizations (van de Vrande et al., 2009). This reason comes back to the challenges, as most SMEs perceived that they don't have enough resources to implement innovation (time or money).

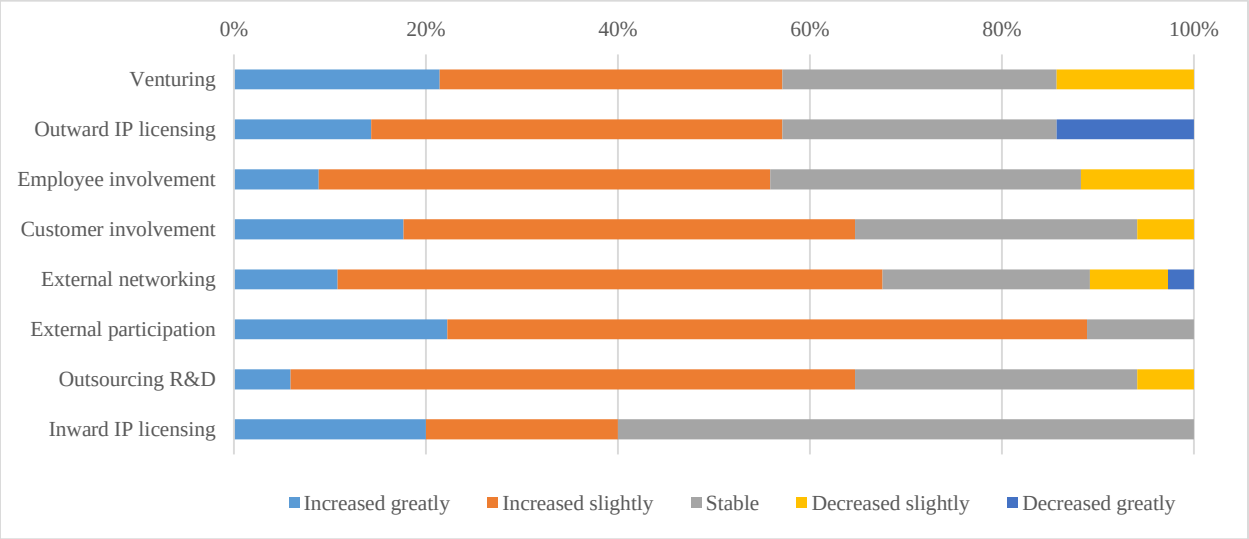

Figure 9. Perceived trends in OI activities among Swedish SMEs in cleantech industry

5.4. Incidence Levels and Perceived Trends between Industries

Drawing on previous studies, we expected that the incidence and perceived trends towards OI would be stronger for manufacturing companies (on the contrary to services companies). Although, from Table 9 we can see that both manufacturing and services enterprises conduct OI activities, but the results were not significantly different. This finding is in line with Lichtenthaler's study (2008). He investigated differences between industries in more detail and found no significant differences between manufacturing and services companies either.

5.5. Incidence Levels and Perceived Trends between Size Classes

There were significant differences between small and medium sized companies in customer involvement and R&D outsourcing perceived trends. The findings suggest that small enterprises are more inclined to involve customers or to outsource their R&D. The reason for higher perceived trend in customer involvement in the smaller companies can be that in the cleantech industry these

companies work in the development phase, closely with their customers, whereas medium-sized companies are regional, focusing more on sales and organization. To understand why smaller companies perceive a bigger trend in outsourcing their R&D is unclear and can be addressed in further research. Although, on the R&D outsourcing only 3 firms with 100-499 employees answered the perceived trend question and all of them thought that this factor remained stable in the past 3 years, so there was no variation in the answer. The findings of R&D outsourcing could be strengthened with a bigger sample size in this category and more answers from medium-sized companies.

5.6. Open Innovation Clusters

The cluster analysis revealed three groups of companies who intra-group work similarly with OI. Much like Lichtenthaler (2008) and van de Vrande et al. (2009), there are lots of differences on incidence levels of firms between the groups. van de Vrande et al. (2009) found three clusters that although they had different incidence levels on the OI activities, there were a repeating pattern: a) cluster 1 and 2 were often at the same incidence level with cluster 3 lacking behind (employee involvement, customer involvement, and external networking) see Figure 10, and b) the incidence level were decreasing similarly compared between the clusters (venturing, external participation, and outsourcing R&D), see Figure 11. Restating these patterns, one could also say that cluster 1 has a higher incidence than cluster 2 which has a higher level than cluster 3, if not cluster 1 has reached maximum possible incidence which often means that cluster 2 has the same incidence level.

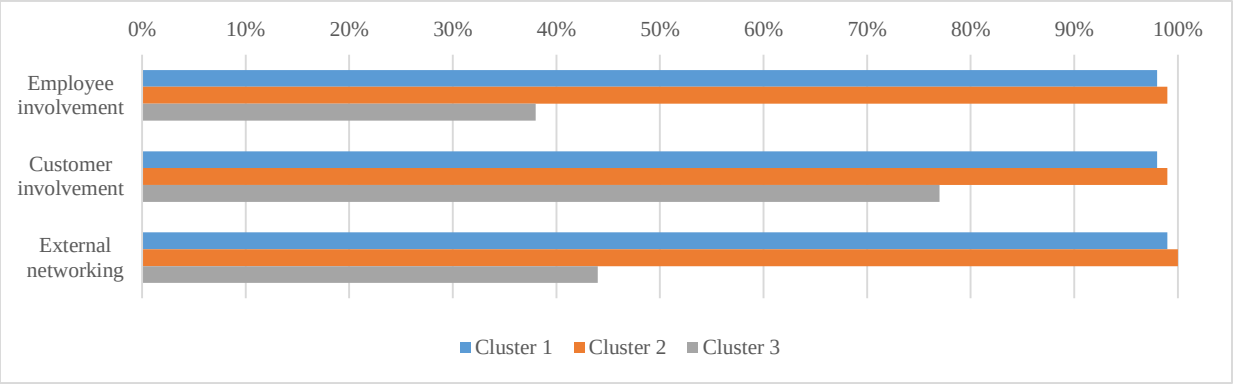

Figure 10. Dutch SMEs clustered from van de Vrande et al. (2009).

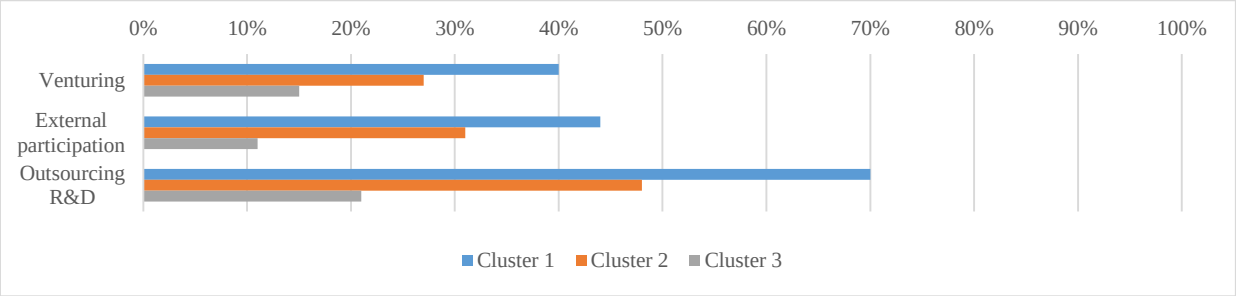

Figure 11. Dutch SMEs clustered from van de Vrande et al. (2009)

This pattern was not found in our result. What we found was instead a) cluster 1 has relatively high incidence of all OI activities, but is completely lacking outward IP licensing, b) cluster 2 has relatively moderate incidence level and contains all companies doing outward IP licensing, c) most companies doing venturing are found in cluster 1, and d) there seems to be an 'inverse' incidence level of employee involvement and external networking between cluster 2 and 3 (high in one cluster and lower in the other, and vice versa), see Figure 12.

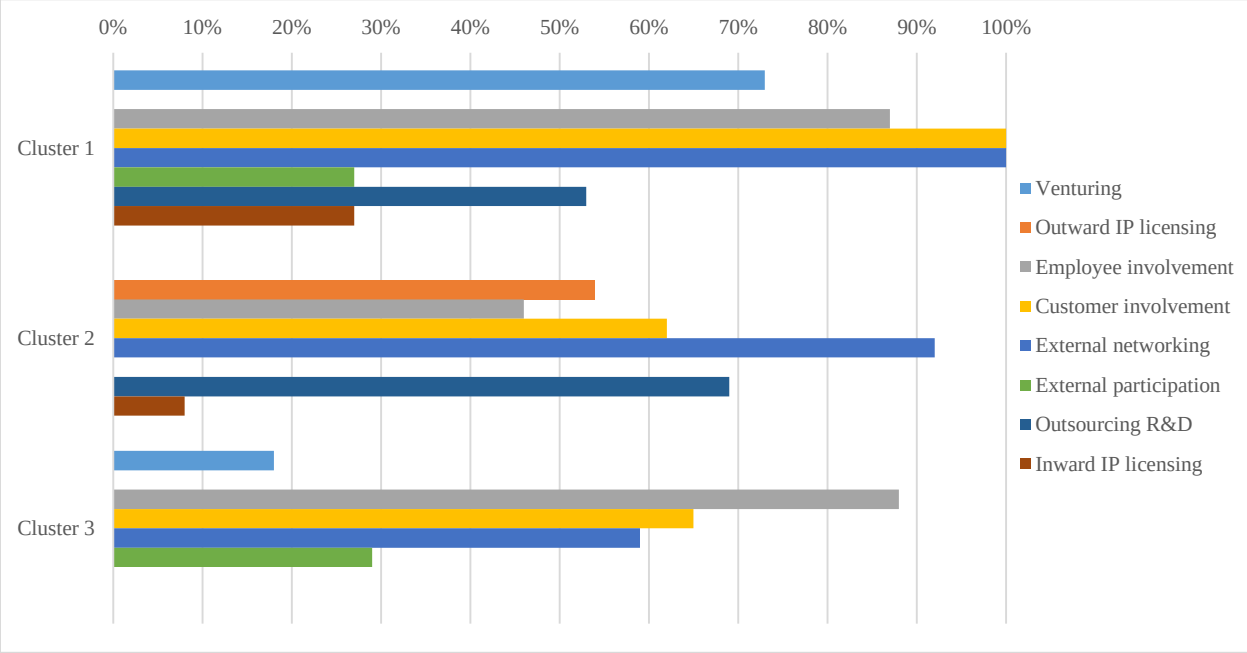

Figure 12. Incidence of OI activities among clustered Swedish SMEs in cleantech

The reasons for these different findings are not obvious, van de Vrande et al.'s (2009) clusters follow a linear trajectory which makes it easy to make the conclusion that OI in a sense is one-dimensional activity, i.e. some companies are simply more open over all.

Swedish SMEs in the cleantech industry instead seems to be using a more complex combination of OI activities. As cluster analysis is an exploratory methodology the results cannot be ruled out to be a consequence of chance. But it could also be a result of different strategies or transition processes (Huizingh, 2011) (Gassmann, Enkel, & Chesbrough, 2010) (Poot, Faems, & Vanhaverbeke, 2009).

6. Conclusion

This section draws conclusions from the theory and analysis and presents the most interesting findings. Also possibilities for future research and limitations to the study is covered.

The overall purpose of this research study was to investigate how Swedish SMEs conduct OI activities in the cleantech sector. The following research question guided the study:

What open innovation activities are performed by Swedish SMEs in the cleantech industry?

In total, eight OI activities were examined through a thorough review of the literature. These eight OI activities could be grouped into two categories: technology exploration and exploitation. Technology exploitation includes venturing, outward IP licensing and employee involvement. Technology exploration includes customer involvement, external participation, inward IP licensing and R&D outsourcing. Previous research showed that cleantech SMEs are conducting OI activities (Hallencreutz, Lindquist, Lundequist, & Waxell, 2008). This thesis focused on what OI activities SMEs are performing, what are the motives behind them, what challenges did they have, what are the incidence levels and perceived trends behind them. Also, if there are differences between the manufacturing and services industry, size-classes and if there are clusters among them with different characteristics.

The thesis was quantitative in nature and a self-completing questionnaire was used for the interviews. 58 answers were collected with a 16% response rate. At some sections (venturing, inward and outward IP licensing), more answers would have been desirable.

Our findings suggest that SMEs are performing OI activities and in the last 3 years they have increased their OI activities. This is in line with van de Vrande et al. (2009) and Lichtenthaler (2008). The main motivations that we found were to gain knowledge, have better innovation processes, and market-related motivations. In contrast to van de Vrande et al.'s (2009) study, market-related motives were never the top ones. Coras & Tantau (2013) found knowledge and cost as the main motives. However, the cost was neither among the top motives.

When it comes to challenges, we found that resources and resources and organization/culture were the main ones. Van de Vrande et al. (2009) reported that the main barriers to innovation are related to venturing, external participation and R&D outsourcing. In our findings, venturing seemed to be an important barrier, but our respondents didn't have a problem with external participation and R&D outsourcing.

External networking (64%), employee involvement (59%), and customer involvement (59%) are the most common OI activities and are performed by the majority of Swedish SMEs in the cleantech sector. van de Vrande et al. (2009) found higher incidence levels on six out of eight activities while only two exploitation activities (venturing and outward IP licensing) appears to be on par with the Swedish cleantech industry. Thus, it seems that Dutch SMEs are better in implementing OI activities than Swedish SMEs in the cleantech sector.

We didn't find significant differences between the manufacturing and services industry. This finding is in line with Lichtenthaler's study (2008).

On the other hand, we found differences in customer involvement between small-sized enterprises and medium-sized enterprises. Small-sized firms are involving customers in their OI processes significantly more in the cleantech industry.

Moreover, cluster analysis shows that there are big differences on how Swedish SMEs in the cleantech industry are using OI activities. Especially the different patterns compared to earlier research are very interesting. Earlier research found clusters following a linear trajectory which makes it easy to make the conclusion that OI in a sense is a one-dimensional activity, i.e. some companies are simply more open over all. Our clusters are instead a bit more complex: What we found was that a) the first cluster has relatively high incidence of all OI activities, but is completely lacking outward IP licensing, b) cluster 2 has relatively moderate incidence level and contains all companies doing outward IP licensing, and c) most companies doing venturing are found in cluster 1, and d) there seems to be an 'inverse' incidence level of employee involvement and external networking between cluster 2 and 3 (high in one cluster and lower in the other, and vice versa). As cluster analysis is an exploratory methodology the results cannot be ruled out to be a consequence of chance. But it could also be a result of different strategies or transition processes.

For future research: Our findings show that Swedish and Dutch SMEs differ in their motives and challenges in conducting OI activities. Whether or not this is a consequence of different countries or different industries would be interesting to look into in future research. Furthermore, our results showed Swedish small-sized enterprises perceived a bigger trend in outsourcing their R&D activities than medium-sized firms. Moreover, the list of OI activities is not a complete list and it doesn't cover all OI activities. We understand that this can be a limitation, but we think that there could be more research done about the different OI activities and which of them are common across industries. A last possibility of future research would be to look more in-depth into the reasons for why the particular clusters were so different compared to other studies and not following the one-dimensional tendency seen in Dutch SMEs.

6.1. Limitations of the Study

In all research studies, there are some limitations present. First, we would like to mention that our thesis was executed in Sweden. The results may not apply to other countries.

Second, the survey was in English and we sent it to mostly Swedish CEOs, this might result in subjective bias in their interpretation.

Third, some OI activities were very broadly defined. With more narrow definitions, we could get a more precise view on OI in SMEs.

Fourth, our study was conducted in the cleantech industry. Other industries have different dynamics and our results might not apply to other industries.

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8. Appendix

8.1. Appendix 1. Questionnaire

0 What is the name of the company?

0.1 How many years have you had your current position (including time with similar responsibility at the same company)?

0.2 Has the company developed at least one innovation in the past 3 years? Select all that apply.

1 Have the company started up new organizations drawing on internal knowledge?

1.1 How did venturing activities change in the past 3 years?

1.2 What were the reasons for the company to engage in venturing activities?

1.3 Were there any challenges / barriers to venturing activities?

2 Have the organization sold or offered licenses to other organizations to better profit from your intellectual property?

2.1 What kind of intellectual property have you sold or offered?

2.2 How did licensing activities change in the past 3 years?

2.3 What were the reasons for the company to engage in outward IP licensing activities?

2.4 Were there any challenges / barriers to licensing activities?

3 Have you leveraged the knowledge and initiatives of employees who are not involved in R&D to realize innovations?

3.1 How did you leverage the knowledge and initiatives of employees who are not involved in R&D to realize innovations?

3.2 How did employee involvement activities change in the past 3 years?

3.3 What were the reasons for the company to engage in employee involvement activities?

3.4 Were there any challenges / barriers to employee involvement activities?

4 Have you directly involved customers in your innovation processes?

4.1 How did you involve customers in your innovation processes?

4.2 How did customer involvement activities change in the past 3 years?

4.3 What were the reasons for the company to engage in customer involvement activities?

4.4 Were there any challenges / barriers to customer involvement activities?

5 Has the company collaborated with partners to support innovation processes?

5.1 How did collaboration activities change in the past 3 years?

5.2 What were the reasons for the company to collaborate with partners in innovation processes?

5.3 Were there any challenges / barriers to collaboration activities?

6 Has the company invested equity in other organizations to gain their knowledge?

6.1 How did external participation activities change in the past 3 years?

6.2 What were the reasons for the company to invest equity in other organizations?

6.3 Were there any challenges / barriers to equity investments?

7 Has the company outsourced R&D activities?

7.1 To which organizations did the company outsource R&D activities?

7.2 How did R&D outsourcing activities change in the past 3 years?

7.3 What were the reasons for the company to outsource its R&D?

7.4 Were there any challenges / barriers to R&D outsourcing?

8 Has the company bought intellectual property?

8.1 What kind of intellectual property has the company bought?

8.2 How did inward IP licensing activities change in the past 3 years?

8.3 What were the reasons for the company to engage in inward IP licensing activities?

8.4 Were there any challenges / barriers to collaboration activities with partners?

8.2. Appendix 2. Phone pitch

Hej,

Mitt namn är [] och jag är student på Handelshögskolan i Göteborg. Jag gör en forskningsstudie tillsammans med SP Sveriges forskningsinstitut om öppen innovation.

Jag undrar om jag skulle kunna få mail-adress till en person / få tag på en person hos er som jobbar med innovation?

Det är bara en kort enkät på ca 10 minuter som behöver besvaras, och det ni får ut av studien är att veta hur ert innovationsarbete jämförs med liknande företag.

(Om de ej har en sådan person, fråga efter produktutveckling) (Om de ej har en sådan person, fråga efter R&D/Forskning och Utveckling) (Om de ej har en sådan person, fråga efter VD)

8.3. Appendix 3. Survey Mail Invitation

Hi!

I am a final year master student at the University of Gothenburg and am currently working on a benchmarking study, together with SP Sveriges Tekniska Forskningsinstitut, in my Master's Thesis project. The research aims to understand how small and medium enterprises in the cleantech industry are using open innovation (i.e. using ideas from outside the firm to innovate, and that internal ideas can be taken to market outside of the current business of the firm).

Problem: Open innovation has been said to promise faster, cheaper, and less risky development of products and services. But how many companies are actually adopting this paradigm, and what problems arise? That's where this research comes in.

The following questionnaire contains some structured questions that, through your contribution, will help this study attain fruition.

Questionnaire link: [link]

Average time to take the survey is 10 minutes. The results of this survey will be completely anonymous, and no identities will be revealed in the final report.

I am available to respond to any questions you may have regarding the study, and will be glad to share my research findings with you once the research is completed. I believe, given your line of work, this study will help you gain some valuable insights as well.

Have a nice day!

8.4. Appendix 4. Survey Mail Reminder

Hi,

Just a friendly reminder for the survey I sent about a week ago. After more people have answered, I have seen that most people answer in just about 5 minutes.

Let me know if you forward the mail to another person (so I can send another to him/her), the link to the survey may not work otherwise.

Let us find out how to work with open innovation!

I am a final year master student at the University of Gothenburg and am currently working on a benchmarking study, together with SP Sveriges Tekniska Forskningsinstitut, in my Master's Thesis project. The research aims to understand how small and medium enterprises in the cleantech industry are using open innovation (i.e. using ideas from outside the firm to innovate, and that internal ideas can be taken to market outside of the current business of the firm).

Problem: Open innovation has been said to promise faster, cheaper, and less risky development of products and services. But how many companies are actually adopting this paradigm, and what problems arise? That's where this research comes in.

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I am available to respond to any questions you may have regarding the study, and will be glad to share my research findings with you once the research is completed. I believe, given your line of work, this study will help you gain some valuable insights as well.

Have a nice day!

8.5. Appendix 5. Regression Analysis

With the regression analysis we were interested if there is a linear regression between open innovation activities or trends and the turnover change in the past 3 years. Before conducting the regression analysis, we checked if there is a relationship between open innovation activities and turnover change in the past 3 years.

First, a normality test was conducted on the turnover data from 2010 till 2014. The following table shows the results.

Table X Normality test on the turnover change between 2010 till 2014.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
VAR00001	,400	58	,000	,336	58	,000

a. Lilliefors Significance Correction

Turnover change data (var00001) doesn't follow normal distribution, the Shapiro-Wilk test is below 0.05. Next, we checked the correlation between the open innovation activities and the turnover change. When we have a categorical (ordinal or dichotomous) and an interval / ratio variable we can use Spearman's rho to see the correlation between the variables (Bryman, 2011). Also, Spearman's rho can be used with non-parametric data, because the turnover data doesn't follow normal distribution. Correlation coefficient ranges between -1 and +1. If the significance value is smaller than 0.05 then the result is significant. The following table shows the multivariate analysis on the correlations.

Table X. Correlation among the open innovation activity variables and the turnover change between 2010-2014.

Correlations

			turnover_change	venturing	outward_IP_licensing	employee_involvement	customer_involvement	external_networking	external_participation	outsourcing_research	inward_IP_licensing
Spearman's rho	turnover_change	Correlation Coefficient	1,000	-,115	,189	-,147	-,104	,085	-,038	-,169	,098
		Sig. (2-tailed)	.	,454	,214	,334	,499	,579	,802	,266	,522
		N	45	45	45	45	45	45	45	45	45
	venturing	Correlation Coefficient	-,115	1,000	-,288	,159	,159	,061	,144	-,029	-,085
		Sig. (2-tailed)	,454	.	,055	,297	,297	,689	,345	,852	,579
		N	45	45	45	45	45	45	45	45	45
	outward_IP_licensing	Correlation Coefficient	,189	-,288	1,000	-,184	-,041	,200	-,215	,171	,043
		Sig. (2-tailed)	,214	,055	.	,227	,788	,189	,157	,260	,777
		N	45	45	45	45	45	45	45	45	45
	employee_involvement	Correlation Coefficient	-,147	,159	-,184	1,000	,037	,141	,155	-,090	,201
		Sig. (2-tailed)	,334	,297	,227	.	,807	,355	,309	,556	,185
		N	45	45	45	45	45	45	45	45	45
	customer_involvement	Correlation Coefficient	-,104	,159	-,041	,037	1,000	-,129	-,103	,017	,037
		Sig. (2-tailed)	,499	,297	,788	,807	.	,397	,499	,914	,812
		N	45	45	45	45	45	45	45	45	45
	external_networking	Correlation Coefficient	,085	,061	,200	,141	-,129	1,000	-,203	,242	,164
		Sig. (2-tailed)	,579	,689	,189	,355	,397	.	,180	,109	,281
		N	45	45	45	45	45	45	45	45	45
	external_participation	Correlation Coefficient	-,038	,144	-,215	,155	-,103	-,203	1,000	-,046	,177
		Sig. (2-tailed)	,802	,345	,157	,309	,499	,180	.	,765	,245
		N	45	45	45	45	45	45	45	45	45
	outsourcing_research	Correlation Coefficient	-,169	-,029	,171	-,090	,017	,242	-,046	1,000	,162
		Sig. (2-tailed)	,266	,852	,260	,556	,914	,109	,765	.	,288
		N	45	45	45	45	45	45	45	45	45
	inward_IP_licensing	Correlation Coefficient	,098	-,085	,043	,201	,037	,164	,177	,162	1,000
		Sig. (2-tailed)	,522	,579	,777	,185	,812	,281	,245	,288	.
		N	45	45	45	45	45	45	45	45	45

What we have observed is that the sample is not true for the population, because the results are not significant for any of the open innovation activities. In other words, there was no significant correlation among the variables.

Next, we examined if there is a relationship between the perceived open innovation trends and the turnover change in the past 3 years. The following tables show the Spearman's rho correlation among the variables.

Table X. Correlation between the venturing trend and the turnover change between 2010-2014.

			turnover_change	venturing_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	,005
		Sig. (2-tailed)	.	,988
		N	14	14
	venturing_trend	Correlation Coefficient	,005	1,000
		Sig. (2-tailed)	,988	.
		N	14	14

Table X. Correlation between the outward IP licensing trend and the turnover change between 2010-2014.

			turnover_change	outward_IP_licensing_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	,094
		Sig. (2-tailed)	.	,842
		N	7	7
	outward_IP_licensing_trend	Correlation Coefficient	,094	1,000
		Sig. (2-tailed)	,842	.
		N	7	7

Table X. Correlation between the employee involvement trend and the turnover change between 2010-2014.

			turnover_change	employee_involvement_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	,251
		Sig. (2-tailed)	.	,159
		N	33	33
	employee_involvement_trend	Correlation Coefficient	,251	1,000
		Sig. (2-tailed)	,159	.
		N	33	33

Table X. Correlation between the customer involvement trend and the turnover change between 2010-2014.

			turnover_change	customer_involvement_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	-,272
		Sig. (2-tailed)	.	,120
		N	34	34
	customer_involvement_trend	Correlation Coefficient	-,272	1,000
		Sig. (2-tailed)	,120	.
		N	34	34

Table X. Correlation between the external networking trend and the turnover change between 2010-2014.

			turnover_change	external_networking_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	,068
		Sig. (2-tailed)	.	,691
		N	37	37
	external_networking_trend	Correlation Coefficient	,068	1,000
		Sig. (2-tailed)	,691	.
		N	37	37

Table X. Correlation between the external participation trend and the turnover change between 2010-2014.

			turnover_change	external_participation_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	-,179
		Sig. (2-tailed)	.	,644
		N	9	9
	external_participation_trend	Correlation Coefficient	-,179	1,000
		Sig. (2-tailed)	,644	.
		N	9	9

Table X. Correlation between the R&D outsourcing trend and the turnover change between 2010-2014.

			turnover_change	outsourcing_research_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	-,294
		Sig. (2-tailed)	.	,252
		N	17	17
	outsourcing_research_trend	Correlation Coefficient	-,294	1,000
		Sig. (2-tailed)	,252	.
		N	17	17

Table X. Correlation between the outward IP licensing trend and the turnover change between 2010-2014.

			turnover_change	outward_IP_licensing_trend
Spearman's rho	turnover_change	Correlation Coefficient	1,000	-,258
		Sig. (2-tailed)	.	,742
		N	4	4
	outward_IP_licensing_trend	Correlation Coefficient	-,258	1,000
		Sig. (2-tailed)	,742	.
		N	4	4

None of the correlations between the trends in open innovation activities and turnover change between 2010 -2014 were significant (p = 0.05). The Sig. (2-tailed) value is never smaller than 0.05. That means that the correlation we observed in the sample can't be generalized to the whole population. Thus, there is no relation among the variables and there is no regression either.