MASTER'S THESIS

AN OPEN INNOVATION APPROACH TO THE RADICAL INNOVATION PROCESS

An Analysis of the Management of the Process of Radical Innovation in an Open Innovation Paradigm

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PREFACE

Being the last part in our master's studies, this master's thesis we have been working on for the past months have been truly an interesting, albeit arduous journey. The field of innovation management and business administration is truly an interesting one, which made it ever so hard to choose a subject. Finally the choice was made, Open Innovation, after which we embarked on a journey where we not only gained new knowledge but also learned to value perseverance and diligence as a way to conduct work. We sincerely hope that this thesis will be of enjoyment to any potential reader and serve as an introduction to the managerial possibilities of Open Innovation, especially those related to the radical innovation process.

Finally, we would wish to extend our deepest thanks to the following people;

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ABSTRACT

This thesis amends some existing theoretical gaps and an overall lack of empirical studies regarding the ways R&D managers can use Open Innovation during the management of the radical innovation processes' early development phase.

Using existing theories, an interview guide and an analytical model was created. These were later used during the gathering and analysis of empirical data. Our sampling involves three of Sweden's largest companies, representing three distinct industry fields. Interviews took place during April 2010, and all the interviewees were R&D managers with previous experience with Open Innovation and radical innovation.

The results reveal that the managers do use Open Innovation when managing radical innovation, and point to both benefits and issues brought about by using Open Innovation during this process. The use of Open Innovation during the management of radical innovation can be divided into two main aspects; the actual extent to which it is used, and the ways the managers use it. Our results reveal that the extent varies from an early peak, an in between Open Innovation chasm and a final increase. Furthermore, our studies also show that the main ways the managers use OI are; exploitation and creation of revenue streams, knowledge leveraging and integration, and finally to create superior products using broad knowledge networks.

Key words: Open Innovation, Radical Innovation, R&D management, Analytical Model.

ACRONYMS AND ABBREVIATIONS

List all the acronyms and abbreviations (followed by an explanation) that are found in the paper.

ATH – Already Tried Here

CAP – Customer Active Paradigm

CC – Core Competence

CI – Closed Innovation

II – Incremental Innovation

IMI – Innovative Medicines Initiative

IP – Intellectual Property

MAP – Manufacturer Active Paradigm

NIH – Not Invented Here

NSH – Not Sold Here

OI – Open Innovation

PLC – Product Life Cycle

RI – Radical Innovation

RQ – Research Question

R&D – Research & Development

SDK – Software Development Kit

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1. INTRODUCTION

This chapter includes a short historical overview, followed by a problem discussion, limitations and a formalized research question.

1.1 BACKGROUND

Innovation was predominantly viewed as a linear model in the days of Schumpeter, and has since then undergone four conceptual overhauls (Rothwell, 1994). Early on, the concept of innovation was viewed as being closed, with users held outside the development process (e.g. Vannevar Bush's view on innovation in 1945 and Igor Ansoff's view on users' inabilities in 1957). Managers, influenced by coeval views, neglected the importance of knowledge sources outside their company. Eric von Hippel argued against this logic, which he called Manufacturer Active Paradigm (MAP), and presented an alternative, which he called the Customer Active Paradigm (CAP), where the user was the locus of innovation (Hippel, 1978). In 1986 he elaborated on this theory and focused on lead users as a source of novel product concepts. Managers now needed to turn their attention outwards and create R&D environments that could realize lead user ideas. Innovation has since then become a more open, global process, driven by user customization and the importance of short time to market (Chesbrough, 2003c).

However, this recent open approach did not take into account some of the issues of modern innovation management, e.g. Xerox, one of the most innovative companies in modern time, consistently failed to capitalize on their innovations. After studying Xerox, Chesbrough (2003) pointed out the need for "Open Innovation" (OI), which is *the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively* (Chesbrough, 2006, p. 1). By using OI, managers get access to tools which reduce many of the uncertainties inherent to innovation process management, and especially those related to radically new innovations. Examples include an emphasis on incorporating tried technologies into new concepts, early focus on market aspects, exploiting innovation results not supported by existing business models, and use external knowledge sources etc. OI has since been subject to academic scrutiny; Ollila (2009) lists dominant themes and Chesbrough (2009, 2010) presents the field of OI and current trends. However, there is still much to learn about the possibilities, limitations, scope and implications of OI. Radical innovation (RI) has received a lot of scholastic interest over the decades, however, the effect OI has on R&D managerial practices during the RI process remains unstudied (Gassman, Enkel, & Chesbrough, 2010). Furthermore, to the best of our knowledge, there is only a single empirical study, i.e. O'Connor, 2006, on how OI and RI relate to one another. There is thus a need for further empirical studies within this field.

1.2 Problem Area

There is a need for improved managerial approaches to the RI process, a process where success is often hampered by ambiguous market signals, technological uncertainties and embryonic competitive structures (Tao, Probert, & Phaal, 2010). Upon reviewing OI it becomes evident that many benefits of OI would support R&D managers in their work with RI (Gassmann, 2006). Thus there is a need to develop a framework which incorporates OI into the process of RI (Tao, Probert, & Phaal, 2010). As aforementioned, this framework would enable R&D managers to make better use of their innovation results and improve these results by actively using outside knowledge sources. Furthermore, it would fill gaps in the theoretical field, such as; the scarce attention given to managerial implications of OI (Chiaroni, Chiesa, & Frattini, 2009a), the translation of OI aspects into managerial implications (Kobe, 2006) and how OI practices can be adopted into the process of R&D (Ili, Albers, & Miller, 2010) and especially RI (O'Connor, 2006).

1.3 Limitations

Narrowing down the research scope, and taking into account that businesses are located on continuums of openness, the focus is on R&D managers working with the RI process in companies who claim to use OI (for details as to exactly how this selection process was made the reader is referred to the methodology section).

A way to divide the RI process is into two main areas; namely *development* and *marketing*, both of which include: *technological* and *administrative* aspects. Simply put; development results in an actual invention, which by marketing becomes an innovation. Technological aspects deal with the actual technical development and the technical tools used. Administrative aspects include managerial tools and the actual management of the technical development. With that in mind, this thesis has an overall emphasis on the administrative aspects of the development phase. However, market aspects and marketing is not separate from development, and technical improvements are often made during marketing. This parallelism is complex and will, for the sake of the study, be simplified by viewing the innovation process as more stage-like than what it actually is.

1.4 Purpose and Research Question

The claimed benefits of OI are relevant to any study on RI management; our research is focused on examining the ways in which R&D managers can use OI whilst managing the development phase in RI. The research also adds to the existing knowledge by conducting further empirical studies, i.e. conducting interviews with R&D managers working with RI.

To clarify; the research question (RQ) is:

In what ways can R&D managers use Open Innovation during the management of the radical innovation process' development phase?

We hope that our contribution will expand the existing body of knowledge in mainly two ways: by mapping the use of OI during the management of RI, and further adding to knowledge by pointing out previously unnoticed effects of OI. To answer the research question an analytical model will be developed, building on existing theories. Also note that a general answer is expected RQ, due to differences in the use of OI, e.g. company A might use some elements that company B does not.

2. THEORETICAL REVIEW AND FRAME OF REFERENCE

Understanding the underlying logic of OI antecedes the understanding of latter reasoning. This section contains: a historical overview, an explanation of the need for a more open paradigm, and its connection to the RI process. The existing theories will act as the base in the newly developed analytical model, which is a major reason of the extensiveness in this chapter.

2.1 THE NATURE OF INNOVATION – RADICAL INNOVATION

Innovation has evolved throughout history and the concept can be ambiguous to some. To avoid ambiguity; innovation and especially RI will be explained in this section. As to the actual evolution of the innovation concept the reader is referred to 2.2 for a brief overview.

Innovation is here defined as: *market proven ideas/concepts with novel market and technology significance*, a definition that draws from Abernathy & Clark's work in 1985. Innovations are either; radical (RI) or incremental (II). II reinforces established organizational capabilities and RI forces it to cope with newness in terms of both market and technology (Tao, Probert, & Phaal, 2010). RI is crucial for firms to dominate world markets and achieve growth (Tellis, Prabhu, & Chandy, 2009).

Innovation can be further divided into categories and measured on continuums (e.g. high-tech/low-tech, radical/incremental, technical/administrative, process/product etc. see appendices A, B, C & D for further details.). All these continuums, along with the predominant managerial logic of the governing innovation paradigm, affect innovation management, i.e. the managerial modus operandi differs over generations. RI is an organizational & administrative perspective of innovation and is often inadvertent and develops in unintended loci of (or even outside) organizations, an indistinctness which makes RI hard to manage (Robinson & Stern, 1998). Abernathy & Clark (1985) categorizes innovation into 4 different categories based on their destructive/preservative power.

The organizations …		Technical Knowledge	
	is ..	*Preserved*	*Obsolete*
Market Knowledge	*Obsolete*	**Niche**	**Architectural**
	Preserved	**Regular**	**Revolutionary**

Table 1- Four categories of innovation according to Abernathy & Clark

The innovation category *architectural* renders existing market and technical knowledge obsolete (ibid), e.g. when mobile phones first appeared both the marketing and the technical knowledge of the stationary phones was made obsolete in many ways.

Henderson & Clark (1990) focus more on the technical aspects of innovation and omits the market aspect. They divide innovation into: incremental, modular, architectural and radical on the basis of whether the core concepts are reinforced or not and whether the linkages between core components are changed or left unchanged. Using a hard drive to exemplify; if the rotation speed is improved to augment performance but the parts and linkages between them remain unchanged then the innovation is considered to be incremental, however if the parts are altered so that the magnetic header is swapped to an optical one, and the magnetic disk plates are changed to optical ones then the innovation is considered to be radical.

Since there exists so many definitions on what RI is there is a need to define how RI is viewed in this thesis. RI is viewed as a competence destroying process where the required knowledge to exploit the invention is different from existing knowledge. Existing products are in many cases rendered non-competitive. The mobile phone example above is an excellent example, whereas the optical hard drive, although being radical in terms of the invention, fall short on making existing knowledge obsolete. Managers who managed the development of the optical drive may not have had to change much in there managerial aspects of the process, this is not the case when dealing with innovation that requires totally new market knowledge as well, and incorporates a multitude of knowledge sources to assemble new components into new core concepts that better fulfill market needs. In this thesis RI is thus viewed a process where:

Market Knowledge	Made obsolete
Managerial Process	Management of RI is reassessed
Component Knowledge	Need for new knowledge
Core Concept	Need for new knowledge

Table 2 - The nature of radical innovation

2.2 THE GENERATIONS OF INNOVATION

Elucidating the importance of OI, a pertinent historical overview, based on Rothwell's 1994 and Ortt's 2008 articles, is crucial prior to delving into how OI can facilitate the management of RI. The first generation (1950s – mid-1960s) was characterized by a strong belief in the omnipotence of technology, and consumer booms which resulted in the *Technology Push* concept; an in-house linear progression model from R&D originating scientific discoveries to the marketplace (Rothwell, 1994). The following second generation (mid-1960s – early 1970s) saw intensified competition and balanced supply and demand which led to the *Market Pull* approach; an emphasis on marketing with

R&D as a reactive role to realize ideas identified on the market (ibid). The subsequent third generation (early 1970s – mid-1980s) abandoned static scale economies for a greater focus on cost control/reduction. Contemporary research pointed out the need for a new model; the *Coupling Model*, which included both the preceding models and added feedback loops (ibid). Ensuing, the fourth generation (early-1980s – early 1990s) now viewed firms' Core Competence (CC) as the main source of competitive advantage and a way to enter new markets (Prahalad & Hamel, 1990). Focus also turned on globalization, strategic alliances, the ability to overcome problems associated with shorter PLCs, parallel development and wide scale integration (Rothwell, 1994). Later research showed that CC often becomes core rigidities or core incompetences if company growth is too centralized around those CC (O'Connor, 2006). With proposed fifth generation Rothwell (1990) elaborates on the fourth generation and points out the future importance of speedy innovation processes. Time to market is seen as the new CC. Furthermore, the role of IT, lead users, iterative development sequences and the importance to access external know-how is emphasized (ibid).

Generation:	First	Second	Third	Fourth	Emerging fifth
~Time:	1950-1965	1965-1970	1970-1985	1980-1990	1990-2000
Main focus:	Technology Push	Market Pull	Coupling Model	CC & Japanese production techniques	Speed to market and IT

Table 3 - Overview of the five generations according to Rothwell, 1994

2.3 End of the Linear Model & Accessing Outside Knowledge

The predominant logics of the first four generations has been debated in the past decade, where researchers point to the end of the linear model (e.g. Gassman, 2006; Chiaroni et al., 2009a, 2009b; Chesbrough, 2003a, 2003b, 2003c, 2010). The innovation process has evolved to incorporate external sources, multiple channels for technology exploitation and internationalization of R&D (Chiaroni, Chiesa, & Frattini, 2009a). The innovation process is now more iterative and interactive (Gassman, Enkel, & Chesbrough, 2010). As aforementioned, R&D managers can make use of the benefits of OI in their work with RI and alleviate some of the managerial issues they face today. However, successfully adaptation of OI requires new approaches to everyday RI work.

The concept of relying on external knowledge sources leads to the question *can the objective be achieved more economically by licensing another organization's technology than by initiating an internal R & D project?* (Twiss, 1992, p. 3). External knowledge/technology acquisition requires R&D managers to open up the innovation processes and is key to a competitive advantage based on others' discoveries (Chiaroni et al., 2009b; Gassman, 2006; Enkel et al., 2009; Chesbrough, 2006, 2009, 2010; Hippel, 2009). OI relies on exploitation of outside ideas, R&D managers need therefore encourage their researchers to scour for outside ideas and create internal exploitation paths.

In the past R&D managers had few options as to how to commercialize discoveries not supported by the firm's overall strategy. Contemporary research lists the different alternatives modern R&D managers have. Chiaroni et al. (2009a) elaborate on the ideas of West & Gallagher (2006) and present the 4 basic strategies of technology exploitation; pooled R&D, spinouts, selling complements and attracting donated complements. Chesbrough (2009) explains how successful exploitation of outside technology and strategic alliances are paramount to reduced time to market.

2.4 THE CONCEPT OF OPEN INNOVATION

Many companies fail to fully capitalize on internal R&D (Chesbrough, 2003a). The ruling logic of generating and marketing ideas has changed; upstarts have exerted great competition on leading enterprises and conduct very little or no basic research, and market ideas in a whole new fashion. Harnessing external ideas whilst leveraging in-house R&D outside the firm's current operations is the essence of OI (Chesbrough, 2003b). The CI linear model required total control for successful innovation; from idea generation to marketing (Rothwell, 1994; Chesbrough, 2003b). Industry practice was to invest profits from internal R&D breakthroughs into new R&D projects (Chesbrough, 2003a). The implications for R&D managers are obvious; internal R&D success needed the best researchers; intellectual property (IP) management is essential and with a strong pursuit for defensive IP comes a natural aversion for outside sources of knowledge.

Chesbrough (2003b) put together a list of contrasting principles between CI and OI.

	Closed Innovation Principles	Open Innovation Principles
Field of expertise	The smart people in our field work for us.	Not all the smart people work for us so we must find and tap into the knowledge and expertise of bright individuals outside our company.
Function of the own R&D	To profit from R&D, we must discover, develop and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
Attitude regarding research	If we discover it ourselves, we will get it to market first.	We don't have to originate the research in order to profit from it.
Market ambition	If we are the first to commercialize an innovation, we will win.	Building a better business model is better than getting to market first.
Sources for ideas	If we create the most and best ideas in the industry, we will win.	If we make the best use of internal *and* external ideas, we will win.
Intellectual property	We should control our intellectual property (IP) so that our competitors don't benefit from our ideas.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model.

Table 4 - Contrasting principles of CI and OI as depicted in Chesbrough, 2003b

Whilst no company is on either end of the scale since it is more of a continuum than a dichotomy it is still interesting to illustrate the differences between OI and CI in its extremes. CI companies will

manage their RI processes way differently than OI companies. Since RI inherently demands new market and technical knowledge, OI companies will have the upper hand in a number of areas, e.g. CI companies who focus on in-house development often reinvent the wheel and overlook already functional solutions. Fig. 1 below demonstrates CI and fig. 2 OI at their extremes, in reality no company is CI or OI on all accounts and exist more on a continuum between OI and CI in several aspects. In the CI method (shown below in Fig.1) companies focus on research projects that originate from within the company boundaries, research these and only continue to develop those that are supported by the current business model. The project is then taken through in-house development where the concept is that was selected during the research phase is developed into a complete market ready product/service which then is marketed to become an innovation.

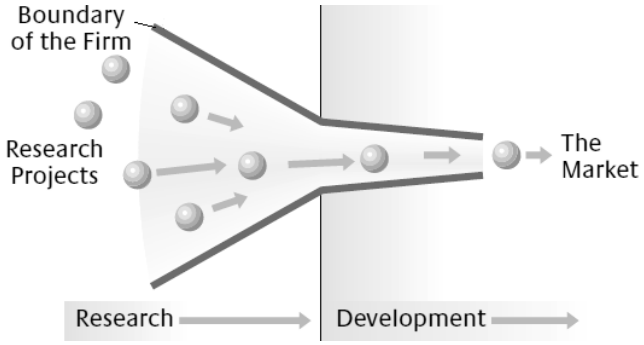

Figure 1 – An illustration of the Closed Innovation Model as depicted in Chesbrough, 2003b

With OI the process (shown below in Fig.2) of RI is somewhat different. Firstly, research projects do not necessarily originate from in-house conceptualization. Project can here originate from customers, other companies etc. These projects are then developed into market ready concepts, but with a difference: those that are not supported by the current business model have the option of exploitation through spin-offs, joint ventures, licensing etc.

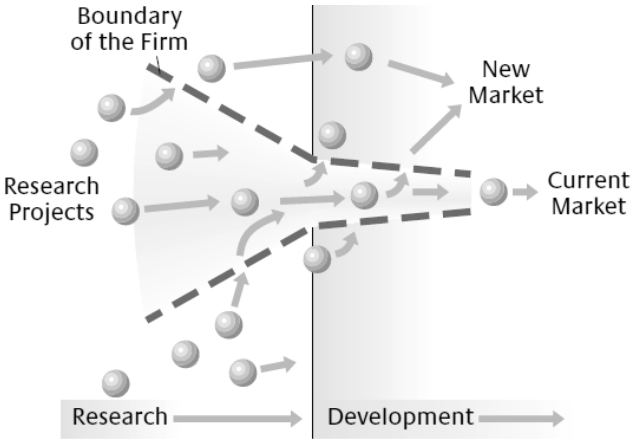

Figure 2 - The Open Innovation Model as depicted in Chesbrough 2003b

As aforementioned, the linear CI process is nearing its end. Chesbrough (2003a, 2003b, 2003c, 2006) points to why:

- Increased mobility of competent technical and managerial personnel across firms
- Rising quality and relevance of university research
- The explosion of college graduates and increasing quality and quantity of human capital
- Growing quality and quantity of international research
- Emergence of venture capital and private equity

Venture capital and corporate incubators support nascent companies' ability to threaten existing establishments (Gassmann, 2006). Prototyping is also cheaper, opening up the possibility for customers to try out new concepts at reduced costs (Kobe, 2006). This combined shifts the locus of innovation to startups, universities, research consortia and other outside organizations (Chesbrough, 2003b). Finally, shorter PLCs and the need for faster time to markets pushes R&D managers to eschew a closed innovation approach (Allio, 2005; Enkel, Gassmann, & Chesbrough, 2009).

Managers can exploit OI in three main areas: funding, generating and commercializing. Since most companies lack clearly formulated RI project budgets, R&D managers need to connect RI project proposals with appropriate funding channels provided by the firm (Chesbrough, 2003b).

Generation of innovation can be explorative or exploitative in nature. Regardless of type managers need to support the use of external knowledge sources (ibid). Commercialization can be done either through a focus on profitably market ideas through in-depth customer knowledge, or building a portfolio of the best ideas regardless of source. Both these methods come with a different set of challenges and managerial implications (ibid).

The appropriateness of OI depends on the industry context. As Enkel et al. (2009) points out; the OI paradigm, pertaining aspects and strategic implications are not suitable for industry that are not; global, technology intensive, operate where different schools of science meet, in need of new business models and knowledge leveraging. In general one could say that *firms that can harness outside ideas to advance their own business while leveraging their internal ideas outside their current operations will likely thrive in this new era of open innovation*. (Chesbrough, 2003b, p. 41). Eric von Hippel claims that OI can prove to be beneficial across all industry sectors (Wilson, 2009), and research has shown an OI adoption throughout all industry sectors, whilst perceived benefits are somewhat different OI still seems to permeate industry strategies regardless of field, technology level or size (Chesbrough & Crowther, 2006). OI manifests itself in one of three key processes:

1. The Inside-out
2. The Outside-in, and
3. The Coupled process

The Inside-out process advocates profiting from bringing ideas to market, selling IP, and multiplying technology by transferring ideas to the outside environment. Fast time to market is the key focus and is, if need be, achieved by shifting the locus of exploitation outside the company's boundaries. Companies should not restrict itself to the market it serves directly but should expand using licensing, joint ventures, spin-offs etc. These different streams of income create more overall revenue from innovations (Enkel, Gassmann, & Chesbrough, 2009).

The Outside-in process is all about the integration of suppliers, customers and external knowledge sourcing that enriches the company's own knowledge base. Managers must realize that the locus of innovation and knowledge are not necessarily the same. Importance of innovation networks, new means of customer integration (e.g. crowdsourcing), mass customization, customer community integration and the use of innovation intermediaries such as innocentive, nine sigma etc. are all part of the Outside-in process (Enkel, Gassmann, & Chesbrough, 2009).

Whereas the two formers processes where one directional streams the Coupled process is about the co-creation with mainly complementary partners through alliances, co-operations and joint ventures during which both an inside-out (to market ideas) and an outside-in (to gain external knowledge) process is crucial for success (Enkel, Gassmann, & Chesbrough, 2009).

2.4.1 Criticism Raised Against Open Innovation, and the Response

Some (e.g. Nisoi, 1999; Ortt & Van der Duin, 2008; Herzog & Leckner, 2007) claim that OI is merely an elaboration of Rothwell's fourth generation with greater emphasis on openness, flexibility and the outside world (Chiaroni, Chiesa, & Frattini, 2009a). Chesbrough (2006) responds to this by stating that since OI accounts for previously unexplained anomalies in the process of innovation management and should therefore be recognized as a new paradigm in accordance to Kuhn's classification from 1962. Chiaroni (2009a) also points to researchers who claim that OI is yesterday's news; technology intensive industries have used open or network based innovation models for a long time. Gassman et al. (2006) lists previous collaborative research efforts not taking into account by Chesbrough. Aylen (2010) traces open network based innovation back to the 1920s.

Whether OI increases the risk of losing one's CC has been debated. However, O'Connor (2006) points to how many CC become core rigidities, Twiss (1992) states that internal R&D must be intact to support and realize external R&D findings. Internal R&D is maintained even though OI principles are adopted. Asakawa (2009) points out how CC is kept in-house and the importance thereof.

2.4.2 THE NEED FOR NEW METRICS AND NEW BUSINESS MODELS

Business model innovations influenced by OI are on the rise with increased awareness that superior business models prevail over better ideas and technologies (Chesbrough, 2007). R&D managers need to adapt to the changes and understand the underlying influence on the business model, which today are worth more than a leading edge technology (Chesbrough, 2003b). One of the changes is the view on IP as tradable assets (Gassman, Enkel, & Chesbrough, 2010). Business models have to adapt to this change in the role of IP and need to seek ways to capitalize on non IP related components of their business, such as propriety stuff and platform creation (Wilson, 2009). IP will be predominantly focused on protecting improvements and not the original idea (Wilson, 2009). Apart from IP, new metrics need to be devised that measure critical to success factors such as speed to market, incentives for exploitation of outside technology and external/internal tech ratio in upcoming products (Chesbrough, 2003b). The move from CI to OI is studied in detail by Chiaroni et al. (2009a, 2010) who outline detailed steps required for successful transition: unfreeze, move, institutionalize.

2.5 OPEN INNOVATION AND THE MANAGEMENT OF RADICAL INNOVATION

OI can be used successfully to facilitate the management of RI. Aforementioned challenges associated with RI, i.e. ambiguous market signals, technological uncertainties and embryonic competitive structures, are alleviated by accessing knowledge through external channels. OI thereby facilitates management of RI by increased market knowledge and investments in proven technology and alternative marketing channels (Gassman, Enkel, & Chesbrough, 2010).

There is no unambiguous answer to what the managerial benefits of OI are to R&D managers working with RI. Hippel (2009) points to the increased cost efficiency of OI since users bear more of the initial costs. He also claims that properly equipped users in an OI setting will always outperform MAP based innovation in terms of speed to market, something Chesbrough (2006) agrees with and adds that the development risks are minimized since investments are based on proven technology. Users also get more customer adapted products (Pontiskoski & Asakawa, 2009), due to earlier integration into the innovation process (Gassmann, 2006), and are, as Eric Raymond so eloquently put it, able to “scratch their own itch”. From a marketing perspective OI provides improved market overview through scouring and enables R&D teams to tap into external ideas and leveraging in-house R&D efforts outside current operations.

Whilst not the main focus of the thesis, it is important to highlight some of the limitations as well. Too much openness could mean loss of CC (Enkel, Gassmann, & Chesbrough, 2009), and disclosure of sensitive information (Hacievliyagil & Auger, 2010). Another issue is that the vast amount of customer gathered information overwhelms managers, who need new information handling systems

(Pontiskoski & Asakawa, 2009; Hacievliyagil & Auger, 2010). This lack of control also needs new management styles (Gassmann, 2006). OI implementation often demands costly reorganizations, as was the case with Nokia who relocated research centers due to them being too far away from universities (Dr. Bob Lannucci, seminar http://vimeo.com/1321131), and thus receives little support (Hacievliyagil & Auger, 2010). Limitations and challenges also include the attitude and mindset of the people involved (Ili, Albers, & Miller, 2010). The Not Invented Here (NIH) and Not Sold Here (NSH) mindsets hamper OI adaptation (Chesbrough & Crowther, 2006), but are possible to manage by highlighting the current system's limitations (Pontiskoski & Asakawa, 2009; Gassmann, 2006).

Challenges for OI teams further include: cognitive distance, low reciprocal commitment, unsafe learning climates, increased group uncertainty, power differences, low availability of resources etc (Chatenier, Verstegen, Biemans, Martin, & Omta, 2010). Virtual teams have issues resolving conflicts (Stark & Bierly III, 2009). Loss of knowledge, higher coordination costs, loss of control due to increased levels of complexity, troubles finding business partners, the imbalance between OI and CI are other reasons (Chesbrough, 2006).

However, these challenges are implicitly linked to managers work. The biggest managerial challenge is to assure employees that their skills are needed, albeit slightly modified. This especially holds true for R&D staff since they have to adapt to new job descriptions and roles (Wilson, 2009). They now need to be solutions brokers and work on social skills (Chatenier, Verstegen, Biemans, Martin, & Omta, 2010). Former investments remain the biggest barrier due to sunk-cost fallacy mindsets (ibid).

As to applying OI to RI O'Connor (2006) states that *the OI model offers firms an enormous help. If discoveries can be sourced from external parties as well as internal groups, and the innovation required to nurture those discoveries into business opportunities becomes more interactive with market and technology partners sooner, the life cycle of RI can be substantially shortened* (O'Connor, 2006, p. 63), mostly through interaction and networking (ibid). University collaboration can be a efficient and effective source of knowledge, furthermore, OIs market exploitation focus fares well with finding markets for RI projects (O'Connor, 2006). Larger companies often strive for operational excellence and thus have issues coping with the stochastic processes of RI. However, using OI to speed up the RI process managers can find it easier to gain support for RI projects, or as O'Connor puts it: *given the length of the RI life cycle, the OI concept offers great promise for helping enable RI in large established firms* (O'Connor, 2006, p. 65).

The value of innovation, particularly RI, lies in identifying the context and applying business resources to commercialize the results, regardless of where the initial idea originated. A fact

concurrent with OI (O'Connor, 2006). RI markets are characterized by a need of flexibility when it comes to market, business models and customer orders, traits common amongst startups and spinoffs (O'Connor, 2006). According to O'Connor (2006) RI is comprised of three distinct sets of competencies, which are linked to OI in certain ways (explained in detail in the following chapter):

2.6 THE ANALYTICAL MODEL

In this chapter the analytical model, and the underlying reasoning behind it, will be presented in detail. The development of the analytical model corresponds with the purpose stated earlier in the thesis. The analytical model will be a recurring connecting element between parts of the thesis. During the empirical chapter of the study, the interview guide will act as the basis for data collection and categorization. The interview guide builds partly on the analytical model, which then will be used to connect the data with the theories in the analysis chapter. Furthermore, the analytical model will highlight our main findings and conclusions in the conclusions chapter.

Many researchers have studied the RI process, and there is a lack of consistency in used terminology. However, the majority of the researchers build their models on the same underlying concepts so the differences are, albeit confusing, merely aesthetic. The main phases during the innovation process can be divided into: conceptualization, exploration, experimentation and exploitation. See table 5 on the next page for an overview. Do note that exploitation is not a part of the development phase.

Using figure 1 and 2, one can extract three distinct phases of the development process, which apply to both CI and OI; research, development and market. This thesis is partly an extension to the work of Tao et al. (2010), with the major difference being the focus on RI and the managerial emphasis. Thus, for the sake of comparability, the terminology used here will be the same as Tao et al. (2010) uses, namely: concept, component and completion. Using the table 5 as a base of reasoning, the research phase of OI corresponds to the *concept* and *components* phases of IRL, the development phase to *completion*, and market phase to *chasm competition* and *changeover*.

		Four Phases of the RI process		
	1. Conceptualization	**2. Exploration**	**3. Experimentation**	**4. Exploitation**
3 competences	Discovery		Incubation	Acceleration
Model **Technology Readiness Level (TLR)**	Basic Technology Research	Prove Feasibility	Technology development Technology Demonstration System/Subsystem Development	System test, Launch & Operations
Innovation Readiness Level (IRL)	Concept	Components	Completion	Chasm Competition Changeover

Table 5 – The four RI phases and how three existing RI models correspond to each phase

Conceptualization, exploitation and experimentation are all sub-phases to the development phase of RI. The concept sub-phase includes basic research and formulation of basic concepts that will later be explored. Common activities include: observe basic principles, radical new potential is identified, seizing opportunity discoveries, brainstorming, crowd-sourcing, conceptualization, confirming strategic fit and securing resources (Tao, Probert, & Phaal, 2010).

Components begin with a technical feasibility study where the individual components are tested, in parallel the business model takes shape. Common activities are; prototyping, basic construction, project management, IP management, and lead-user involvement etc. Completion includes activities that aim to mature the business model and finalize the product and system integration, this phase also includes activities that will form the business unit. The chasm, competition and changeover used by Tao et al. (2010) all refer to different stages of the product life cycle (PLC) (ibid).

With the RI part of the theoretical model explained, focus turns to OI. There are mainly two parts that are used; the three core processes of OI and the nine perspectives. Whereas, the three core processes; inside-out, outside-in and coupled, will make it easy to categorize the data later on in the analysis and for the analytical model, the nine perspectives will be used to code our interviews. For a comprehensive explanation of the nine perspectives please see methodology, section 3.6. Table 6 below illustrates our analytical model which connects OI to RI.

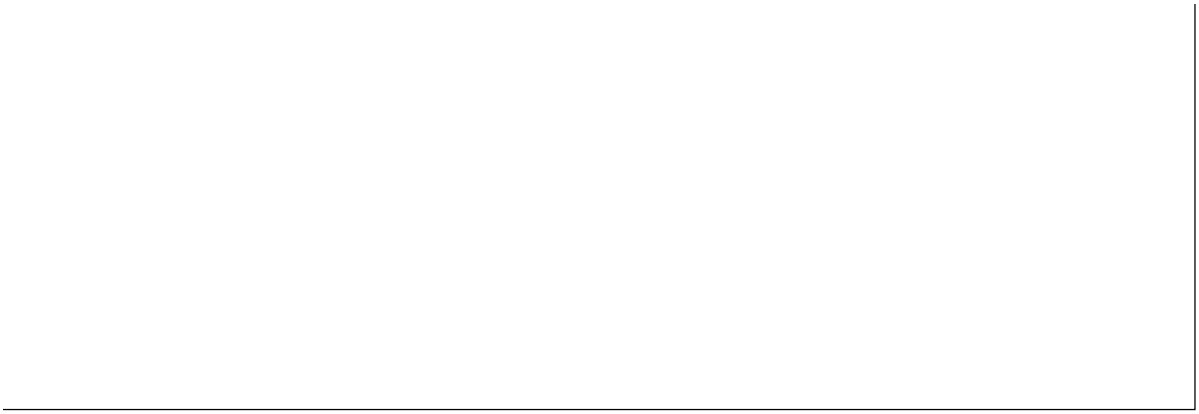

Table 6 – Analytical Model

As can be seen above, the three core processes of OI together with the concept, components and completion sub-phases of the RI development phase form the very essence of the analytical model. The model cross-links the three core processes of OI with the three sub-phases of the development

phase of RI. This makes it easy to follow the underlying reasoning to what ways managers can use OI whilst managing the RI process.

3. METHODOLOGY / RESEARCH APPROACH

In order to gather data for the framework, three semi structured interviews were conducted at: VolvoIT, SCA and AstraZeneca during April 2010. All three companies openly stated that they worked with OI and the interviewees were all R&D managers working with RI and OI. An emphasis on selecting interviews with some background in OI ensured that the concept was well known to them, e.g. one interviewee was in charge of implementing OI, and another had a documented academic background working with OI. Although this selection may affect the answers due to interviewees answering according to the theories and not actual events, we felt it was necessary since OI is a concept which is not widely spread.

3.1 LITERARY SOURCES

Databases used for literary sources are the following: Harvard Business Review, MITSLOAN Management Review, R&D Management, ABI inform, Directory of Open Access Journals, International Journal of Management Reviews and Academy of Management Reviews. Key words used to search the databases were: open innovation, external innovation, user innovation, community innovation, community engineering, sourcing innovation, open sources, lead user, and research and development community. Once an article was found, future key words would include the authors' names and the articles' own reference list. The most common names used were: Chesbrough, Eric von Hipple and Gassman. Articles that map the OI field proved particularly useful, especially Gassman et al. (2010) included many suggestions for in-depth study. Furthermore, there are two special OI issues available in the R&D Management database, presenting the most influential works within the field of OI to date.

3.2 RESEARCH STRATEGY

For this thesis, we have chosen a qualitative approach in order to answer our RQ. This decision was based on the fact that the field of OI is still in its formative stages and there are only a few industry adopters in Sweden. According to Bryman & Bell (2007) interpretation is in focus during qualitative research, and since the field is relatively new the locus of information may still largely be linked to managers active within the process of innovation. Furthermore, previous research, e.g. Tao et al. (2010), base their studies on fewer companies which they study more in-depth, of the very same reasons as we mentioned above.

3.3 EMPIRICAL MATERIAL

3.3.1 DATA SOURCES

To deepen our understanding and ensure a certain level of reliability, three different data sources were used. This prepared us for the interviews and, occasionally, supplemented the information gathered through the interviews. The used data sources are as follows:

Interviews: The primary data source was the three qualitative interviews. A semi-structured interview approach was chosen due to high levels of uncertainty regarding the knowledge levels of the interviewees. This uncertainty was perceived through a lack of actual tangible results stemming from OI efforts, us not knowing how knowledgeable the interviewees were, and finally to make sure that the discussion was kept flowing. The semi-structured interview was designed in accordance to the guidelines in Bryman & Bell (2007), where an overall open initial approach could later be steered in the direction of our choosing. Both of us took active part in the interview and, in accordance to Bryman & Bell (2007), observed the interviewee's reactions and behavior during the interview.

Documents: Usually the process of attaining documents and information regarding top level management practices and strategies can prove to be difficult (Bryman & Bell, 2007). However, since this particular study focuses on companies that have an open mindset and practice OI, there was little issue getting hold of the required information. Annual reports were studied together with the company specific web page. Companies who work with OI usually show their efforts to be perceived as truly open. This gave us insight into many of the projects that they had undertaken. The main underlying reason of studying these documents was to gain a holistic view of the companies in question prior to the interviews. Since our main question focuses on in what ways managers can use OI, discussing different projects where OI has been used was of great help.

3.4 DATA COLLECTION

3.4.1 THE INTERVIEW

The pilot interviews: A pilot study or interview is recommended prior to conducting the real one out of several reasons. Pilot interviews reveal whether or not the interviewees will be able to understand the questions asked, if the provided directions are clear, and gives a time estimate for the interviewers at the same time as bolstering their self confidence and ensuing that the acoustic quality of the recordings are up to par (Kvale, 1996). The results of the pilot studies were somewhat hampered by the fact that the students on which we conducted them on had no prior experience of R&D management, but also highlighted some of the deficits, which were later resolved.

During the interview: The interviewees chose the interview setting which ensured a relaxed environment in which they felt comfortable. Bryman & Bell (2007) advocate a secluded area in order

to minimize distractions, but also points out that the office might be a poor choice due to the interviewees feeling that they should present the company in good standards. In our case the interviewees themselves chose the cafeteria as the setting in all three cases. Whilst the underlying reason is unclear this ensured a relaxed environment, albeit not without its distractions.

The interviews lasted on average an hour. In the case of VolvoIT, the interview was conducted over two hours together with another research group who also studied managerial implications of OI. The interviews started with a brief introduction to the subject, terminology used, the intended setup of the interview, getting permission to use the company names in the thesis and a presentation of ourselves. All the interviews were recorded for future use and reference. Patel & Davidsson (2003) highlight that recorded interviews are an invaluable source when future issues with data handling occur.

The timeframe might be a bit too short for a study of this nature. This is the main reason why we also used documents as empirical data, to add to our findings and confirm them. The interviews started as being open and focused on the conceptual phase of the RI process since companies use OI mostly in that early phase. After half the time had passed we steered the interview towards a more structured one where we asked about the topics that had not been discussed prior to moving on to the other two phases. The process was then repeated during these two phases.

3.5 SAMPLE

Few companies state that they actively pursue OI, fewer still have reached tangible results, a fact which influences the way the sampling was done. To get hold of companies that could provide valuable input for our studies we finally searched for similar studies within the field of OI that were conducted within Swedish companies. By doing so we ensured that the companies in question conducted OI practices and that we got in touch with the right persons to speak to. Early efforts to find companies proved to be unsuccessful; these efforts included Google searches and telephone inquiries at Sweden's top 10 largest companies and researchers studying the field of OI. Early efforts also included getting in touch with smaller local companies, but these were not familiar with OI.

The field of OI is broad and as aforementioned not all companies conduct their OI practices in the same way. To be able to ensure some degree of generality we initially focused on two companies within two distinctly different fields; AstraZeneca (an international biopharmaceutical company) and VolvoIT (a branch of the Volvo group working with industrial IT solutions). We were referred to a person working with OI at SCA (a conglomerate which, among other things, produces tissues, personal care products, packaging etc.) during an interview. These three companies each represent a

field of interest; biopharmaceuticals, IT and chemistry/material science. All interviewees held R&D managerial positions within their respective companies, and are all active in the RI process.

3.6 INTERVIEW GUIDE

All the interviews started with factual warm-up questions, after which the interview guide was shown and discussed (when possible the interviewee received a copy prior to the interview).

The interview guide was designed as a tool for ourselves since we knew little of what kind of answers to expect. In an attempt to simplify future efforts the categories were ready-made prior to the interviews. When coding the categories we used the nine perspectives of OI provided by Gassman et al. (2010) in combination with the three phases of the RI process. This method may be too deductive to be successfully used in our studies; therefore a couple of empty boxes were included in case new information had to be added.

The interview guide then provided the general direction by us asking in which ways the managers used OI in the concept, component and complete phase of the RI process. The dialogue was kept open to the highest possible extent but when needed we would use the nine perspectives to steer the conversation in a more favorable direction, e.g. if stuck we could ask a question directly related to the perspective at hand; "let's discuss outsourcing of IP" etc.

		Concept	Component	Complete
Nine perspectives of OI	Spatial			
	Structural			
	User			
	Supplier			
	Leveraging			
	Process			
	Tools			
	Institutional			
	Cultural			
	Interesting quotes			
	Previously unmentioned perspective			

Table 7 - Interview guide with the nine perspectives of OI, room for quotes and additional room for unmentioned perspectives

In the interest of clarity, a brief explanation of the nine perspectives which we used to code the interviews can be studied below:

1. **Spatial**: relates to globalization of innovation and the use of knowledge sources on a global scale
2. **Structural**: the outsourcing of R&D efforts, alliances, use of universities etc.
3. **User**: lead user integration and mass user customization

4. **Supplier**: emphasizes the importance of early phase integration so that the suppliers can take an active part in the RI development
5. **Leveraging**: external expansion and exploitation of knowledge and IP, relates to the opportunities of capitalizing on discoveries outside the organization's boundaries
6. **Process**: the inside-out, outside-in and coupled (this will not be used to the same extent as the others due to the others being a part of the process in one way or the other)
7. **Tools**: which enable users to take an active role in the development of RI, opening up the innovation instruments (e.g. mod making tools in the PC game industry), online communities etc.
8. **Institutional**: free revealing of findings, licensing etc.
9. **Cultural**: the mindset of the organization, Not Invented Here (NIH), Not Sold Here (NSH), Already Tried Here (ATH), value outside competence

3.7 Analyzing the Data and Ensuring Validity

The recordings were listened to again to ensure that no valuable information was lost, however, due to the limited amount of resources at hand there are no transcripts saved. The actual recordings are logged and stored at a safe location.

The interviews were summarized in a table using the interview guide and then mailed to the interviewees for final confirmation. After these steps of reaching for validity the empirical findings were analyzed with the use of our framework. At this stage it became evident that the framework could not incorporate all the findings and was therefore altered to reflect the interviewees' opinions and our findings.

3.8 Methodology Discussion

Patel & Tebelius (1987) argue that there are four concepts that researchers should take into consideration during information gathering; *applicability, compliance, reliability* and *accurateness*.

Applicability embodies the choice of; collection techniques and the study group, in relation to the purpose of the study (Patel & Tebelius, 1987). Looking at the RQ: "*In what ways can R&D managers use Open Innovation during the radical innovation process' pre-market phase*", our choice to use companies multinational companies that openly state they work with OI, makes a degree of sense in terms that conglomerates often conduct R&D and apply managerial techniques that smaller companies do not. However, smaller companies are becoming increasingly innovative and the locus of RI is shifting towards them as aforementioned. Sadly the smaller companies we contacted were not familiar with OI and not overall positive when it came to interviews. Interviews as the main data source, makes sense in relation to our RQ and the resources at hand. The effect of the environment, in which the interviews were conducted, is another factor. The advantages of using

a cafeteria is the ensured relaxed setting and the overhearing that took place. Negative parts include the background noise, which makes listening through the tapes a tedious task at best.

Compliance deals with sensible ways of data collection, processing and analysis (Patel & Tebelius, 1987). Using a Dictaphone to record and store the interviews was a tremendous help when the work after the interview began, providing us with quotes and clarifying statements. The analysis also includes real life examples to make the results more comprehensible.

Reliability deals with factors including the interview guide and setting (ibid). The pilot interviews prior to the real ones helped us finalize the interview guide. The formal questions at the start of the interviews acted as a natural starting point of the interview. To the greatest possible extent we both took active roles in the interviews to ensure an open and flowing dialogue, both also took notes which were later cross-checked to ensure that we had reached the same conclusions. In our opinion the interviewees gave truthful answers, some more open than others, but that is to be expected.

Accuracy can be reached trough honesty and diligence when processing and analyzing the data (ibid). The use of a Dictaphone made it possible to go through the material several times to ensure accuracy. However, Dictaphones only record so much, and the silent communication is lost. All interviews took place in April, 2010, which minimizes differences related to environmental factors. All the interviews were on separate days so that we had time to work on the data while it was as fresh as possible.

As to using the nine perspectives to categorize our interviews, it worked well but some issues arose on the way when it became evident that some perspectives were missing. This will be further discussed during the analysis where the framework is finalized and developed to include these.

4. EMPIRICAL DATA

The data collected through the interviews revealed some interesting insights into the ways managers use OI during the management of the early phases of the RI processes. The data reveals some differences between the companies, which is to be expected and, since the framework we aim for is general in nature, of use to us. Below the empirical data will be presented, grouped in the three phases of the RI process for the sake of clarity. Please note that all quotes under empirical data are translated from Swedish to English by the authors, and is not direct quotes but author translations.

4.1 CONCEPT

The interviews show that the managers extensively use OI principles during the concept phase of RI.

Virtualization of R&D helps utilizing sources on a global scale. All of the companies are multi-national and through the use of virtual R&D they could utilize knowledge sources on a global scale. There was a slight difference between the companies, while two of the companies used spatial aspects of OI on a human resource plane connecting them, one used it on a larger system wide scale. In summary, the spatial perspective of OI included:

- Virtualized R&D
- Use of global knowledge sources

Virtual brain storming sessions is one way to make us of global knowledge sources (2nd interview)

Collaboration was duly used in all three companies, although the emphasis was a bit different between them. University collaboration was deemed useful during long term R&D, and was generally seen as an effort which demanded high levels of commitment. Other uses for collaborative efforts were not as homogenous. VolvoIT claimed that collaboration was especially high when projects where deemed very complex and/or required input from diverse knowledge sources. SCA focused on collaborative alliances where SCA focused on applied research rather than basic one. AstraZeneca used strategic alliances as a means to create collaborative systems where costs were shared, and as a means to create value adding streams. Two of the companies claimed to use collaboration especially when they lacked in-house competence. IP related issues were present in all companies, albeit manifested differently. In summary, the structural perspective of OI included:

- Outsourced R&D
- University collaboration
- Collaboration when complexity was high
- Use external knowledge sources when in-house is lacking
- Alliances to reduce cost intensive aspects of RI
- Alliances to create better value streams

It is amazing, there are several hundred persons out there working on my problem (2nd interview)

The purpose of Open Innovation is to fill in existing knowledge gaps (1st interview)

The role users played varied in the three companies. VolvoIT made use of lead user integration through communities etc., and stated that the appropriateness of mass user customization varied depending on the nature of the innovation. Users are seen as a source for novel ideas and suggestions for improvement. SCA found users to be a good source for conceptual ideas on new improved product features, whereas AstraZeneca applied a different approach. Although, AstraZeneca did not use users as a source for novel product ideas, the R&D manager made it very clear that user feedback on medicinal use was very important for future development. To summarize the user perspective:

- Lead user integration

- Mass customization
- Source for novel product feature concepts
- Feedback on medicinal use during the concept (preclinical research phase)

The appropriateness of mass customization varies, IT related is easy, production is not (1st interview)

The supplier perspective was the one that received the least mention. Only VolvoIT stated that they integrated suppliers early on in the conceptualization phase through JAMs, this helped with the screening of ideas and increased the supplier's end user awareness.

Leveraging was something that was very hard to distinguish and categorize in RI phases. External expansion and exploitation of knowledge and IP was appropriately used, its uses included formulation of new forms of marketing, e.g. in the case of VolvoIT the openness demanded that leveraging of knowledge was integrated in the marketing strategy. SCA did not have a fully operational leveraging strategy when the interviews were conducted, but exploiting and creating revenue streams from externalized research results was a discussed topic. AstraZeneca made use of private public IP solutions, where shared efforts are exploited by all parties involved. In short:

- Leveraging influences other strategic areas and demands innovative strategic solutions
- Creates alternate revenue streams

Volvo leverages on outside knowledge and creates products that are better as a whole (1st interview)

As to the OI processes used, all companies had elements of all three. VolvoIT focused a lot on coupled processes and inside-out where they could utilize the strategic strength of Volvo. SCA used outside-in processes to gain access to creative problems solvers, inside-out as a means to license patents and coupled with its suppliers. AstraZeneca in turn used outside-in and inside-out processes to license ideas and substances. Coupled process was used during cost intensive research. In short:

- All companies used all three OI core processes, albeit somewhat differently

Cooperation with competitors when locating biomarkers is crucial to cut costs (3rd interview)

Tools used included online communities, creating Wikipedia of production thus opening up the innovation instruments, and finally enable users to develop and conceptualize.

We need to create tools that allow users to scratch their own itch (1st interview)

The institutional perspective held different importance aspects for all companies. Whereas SCA claimed that they used only licensing, a statement largely shared by AstraZeneca by creating private public license agreements, VolvoIT used free revealing to enhance their strategic strengths.

- Free revealing

- Licensing

Free revealing needs confidence in own abilities. Even if I tell you, you cannot steal it (1st interview)

The cultural perspective was something all companies stressed as essential to success. Both VolvoIT, SCA and AstraZeneca felt the influence of NIH, and two of the companies claimed they had issues with NSH and ATH as well. SCA and AstraZeneca pointed out that both their respective industries are historically very IP protective, however, they both claimed that the culture is slowly changing for the better. Encouragement to value outside competence and a long term focus is seen as key factors to change the cultural aspects to the better. In short, the cultural perspective included:

Mindset is essential to successfully using OI in the RI process

Diversity is reached through open approaches

Need to work long-term and encourage R&D staff to value outside knowledge

Pharmaceuticals was a closed IP focused industry, but it is changing for the better (3rd interview)

Long term commitment is needed to overcome issues with present cultural mindsets (2nd interview)

4.2 COMPONENT

Continuing the spatial discussion but with a component phase in mind the following was discussed during the interviews. Yet again differences between the three companies are expected and were noted. All three companies used globalization of innovation; SCA made use of glocal adaptation, which is the use of global knowledge sources to meet local demands, VolvoIT created and facilitated global innovation environments where concepts could mature with the help of global knowledge sources, and AstraZeneca made use of virtual R&D and sources on a global scale by creating platforms and system solutions incorporating other high-tech devices. In short:

- Using sources on a global scale
- Glocal adaptation
- Create global innovation environments

Structurally, collaboration continued during the components phase, prototyping of high complexity was an area where the structural perspective came into good use. Alliances were especially important when the costs are high, as in the case with AstraZeneca where phase 1-3 studies are immensely costly, and where data analysis can be outsourced. University collaboration was present in the cases of VolvoIT (students working with realizing the concepts into prototypes), and SCA where institutes played a role in testing and evaluating. In short:

- Collaboration when complexity is high
- Collaboration with universities and institutes

- Outsource parts of the R&D
- Alliances where win-win situations are achieved

Users' role in the component phase was slightly altered. VolvoIT recognized the possibility for earlier "kill-go" decisions and more efficient development. SCA adopts lead user practices and continuously verifies development against lead users, lead users are useful to map out the customer benefits of new technology. In AstraZeneca's case the users where integrated in a different matter; mass customization and personalized medicine with focused patient groups. In short:

- Lead user integration and mass customization
- Process management and kill-go decisions are easier
- Results might not be as good as in-house, but are way more resource friendly

Results are not as good as in-house developed ones, but way more efficient. With the resources that are now made available we can focus on improving customer ideas (1st interview)

Suppliers' roles are mainly to screen ideas and co-develop the prototypes. Furthermore, AstraZeneca was the only one who mentioned leveraging through knowledge management (IMI call topics 7-9). During the components phase the nature of the processes remained somewhat unchanged, coupled processes used by AstraZeneca were aimed at reducing costs, and those adopted by VolvoIT at creating overall more advanced solutions. AstraZeneca also mentioned using outsourced R&D for sensory data analysis and development and VolvoIT used outside-in processes for market scanning. SCA claimed that they adopted an in-house policy during the applied research phase. The rest of the perspectives remain underutilized in comparison, only VolvoIT uses tools (by letting users take part in the construction) and free revealing on every step on the way. Both VolvoIT and AstraZeneca have issues with the NIH mindset. However, VolvoIT also pointed out that the loss of modesty which comes with successful company growth can be detrimental.

4.3 COMPLETE

From a spatial perspective two of the companies recognized possibilities, both VolvoIT and AstraZeneca by creating product concepts that are too advanced for one sole company to develop, furthermore, VolvoIT saw the possibilities to use communities to develop their products through software development kits (SDK) and open development kits. In short:

- Create concepts that require global knowledge sources
- Tap into development resources outside the company borders

From a structural perspective VolvoIT pointed out that OI can be used to fill in existing knowledge gaps on how complete system solutions are best used. VolvoIT also pointed out that the success rate was significantly higher, 11% of RI made it past the complete phase into marketing. SCA focused on

actively seeking out that which is ready made and tried, with the aim of incorporating it if supported by business strategy. AstraZeneca pointed out that costly phase 3 completions, can be made more resource friendly through alliances, especially with firms with a particular know-how. In short:

- Alliances
- Seek out tried solutions
- Fill in knowledge gaps
- Higher success rate

11% of radical innovation made it past the complete phase (1st interview)

VolvoIT used users through lead user communities and mass customization through SDK with the possibility to share customer created applications. At SCA glocal adaptation was pointed out and at AstraZeneca the emphasis was yet again on personalized medicine. On the topic of leveraging, only AstraZeneca commented that the use of the IMI project gave them special leverage opportunities. From a process perspective AstraZeneca and VolvoIT used coupled processes to increase innovativeness and combine strategic strengths. AstraZeneca and SCA use outside-in processes to attain new market knowledge. SCA also licenses solutions that do not fit the business model.

As for the tools perspective; VolvoIT commented on the need and difficulty related to opening up the innovation instruments, and the importance of opening up source codes to enable users to develop themselves. In the case of AstraZeneca however, the perception of tools is somewhat different. AstraZeneca's ideas involve creating tools that the users can use to contribute with useful data. This will be achieved through collaborative attempts with the telecom industry in other do create systems where standardized journals, user gathered data, and telecom cooperate to create solutions better suitable for the patient's needs. In short:

- Open up the development instruments to enable users to develop
- Individualize and include users even post-market
- Create system solutions that provide unique value chains

As to the cultural mindset; NIH was still present but all interviewees pointed out that long-term plans are in effect against it. Another interesting note is that political resistance towards projects can be diminished through OI and active involvement, since the benefits are more widely known and realized. Furthermore, AstraZeneca pointed to the use of system wide innovations.

Competitiveness doesn't stem from WHAT you use: it stems from HOW you use it (3rd interview)

4.4 Overall Comments

During coding it became evident that not all items could be placed in one category alone, some, such as “Virtual R&D” was used in more than one phase. It also became clear that the model was not able to incorporate all the interesting items that surfaced during the interviews. Some, e.g. the comment on *how hard it is to deal with the mass of user generated information* is in the grey zone, but others such as *need for new business models* were a harder fit. The analytical model thus needed to be expanded to incorporate these, by commenting: *quotes* and *other perspectives* after it.

4.4.1 Quotes and Other Perspectives

As aforementioned, managers raised some interesting points during the interviews which do not fit into the theoretical framework. All three interviewees pointed out the high degrees of trust OI required, everyone involved is required to be fully committed to the task at hand, and it is not the company’s own gains that are in focus but the function of the whole chain. Furthermore, by using OI problems with a negative inclination to them can be transformed into something more positive which engages people, e.g. climate issues can be turned into a collaborative effort where you monitor your CO_2 emissions and turn it into a game. OI thus demands a more holistic system view where companies see themselves as parts of a greater value chain, this chain enables the creation of value previously unattainable. A holistic view influences the entire mission and business strategy of companies involved. Furthermore, the market issues related to RI are alleviated by an increased market focus and customer integration, which translates into increased RI success rates. Using OI, companies can focus more on applied research and optimization.

4.5 Interview Summary

A summary, highlighting main findings of collected interview data, is presented in the table below:

Perspectives	Concept	Component	Complete
Spatial	Virtual R&D Use of global sources	Global innovation environments	Use global & external knowledge & resources Virtual R&D
Structural	*Collaboration with/when:* complexity is high in-house knowledge lacking	*Collaboration with/when:* complexity is high to fill knowledge gaps	Fill in knowledge gaps Use ready-made solutions
User	Lead User Integration Mass Customization	Lead User Integration Manage "kill-go" Efficient development	Lead User Integration Mass Customization Glocal
Supplier	Early supplier integration	Early supplier integration	
Leveraging	External exploitation of knowledge and IP Buy/sell ready-made solutions Revenue streams from innovations not supported by internal strategy		

Tools	Online Communities Enable users to develop	Enable users to develop	Enable users to develop System solutions
Institutional	Free revealing of findings Licensing IP	Free revealing of findings	Revealing of findings Licensing IP
Cultural	Mindset is essential NIH, NSH & ATH present	Mindset Outside competence NIH, NSH & ATH	Outside competence NIH, NSH & ATH

Table 8 - Interview summary table. Main findings are listed.

As aforementioned, not all perspectives were covered. Perspectives not found in the table are: the increased importance of trust and commitment, positive connotation to problems, altered business strategies and company missions as a result of a more holistic view and finally performance augmentation.

5. ANALYSIS

The focus of this chapter is to connect the empirical data with the analytical model. This is achieved by analyzing how the three sub-phases, i.e. concept, components and complete, of the RI process' development phase, relate to the three core processes of OI, i.e. inside-out, outside-in and coupled.

It is important to stress that all companies do not use OI in the same manner, the applicability and appropriateness of OI depends on several factors, e.g. corporate culture, field of operations etc. Referring to the RQ, the analysis ignores the source of the statement and hence focuses on the "can".

The ways R&D managers use OI during the management of the concept sub-phase: The managerial use of OI during the concept sub-phase was predominantly outside-in related. Managers pointed out that basic research, and the formulation of basic concepts, is facilitated by the possibility to tap into external knowledge sources, both those that are user originated (mostly through JAMs where managers would gather a diverse group of people to conceptualize) and those that are global. Examples mentioned included the use of Innocentive and other innovation intermediaries.

Emphasis was put on the importance of bringing in external knowledge when in-house was lacking, and the importance of integrating users in the conceptualization. This increased the customer satisfaction with the final product's performance. Ways mentioned to do this included licensing ideas and gathering user feedback during the concept sub-phase.

Virtual R&D, virtual brainstorming and virtual whiteboards (e.g. CollaBoard) were all used as tools during the concept sub-phase of RI. This enabled tapping into knowledge, and collaboration over vast geographic distances. Crowd-sourcing was mentioned as a major source of novel product concepts, and lead user integration as a crucial part of management. The omnipresent NIH mentality was seen as the top managerial issue.

Even though the outside-in process was predominant, managers also applied the inside-out and coupled process. Licensing IP was the most noticeable use of the inside-out process, as a source of additional revenue streams when concepts were unsupported by the overall business strategy. Licensing was however hampered to an extent by the NSH mentality, i.e. *if we can't sell it, then no one can*. Free revealing of findings was another OI perspective adopted into the RI management, although not as clearly as other perspectives. The manager who made the most use of free revealing felt that as long as the internal concepts are part of a core strategic strength, then externalization and free revealing was positive and encouraged as it could lead to system-wide coupled collaborations. An example of free revealing is the conceptualization of the *WirelessCar* concept, where telemetric solutions benefitted from a multitude of competence sources, or as Enkel et al. (2009) points out; the use of OI is suitable where schools of science meet and complexity levels are high.

These connections between OI and RI raise two interesting questions regarding its implications, which will be discussed in the next chapter.

The ways R&D managers use OI during the management of the components sub-phase: Yet again the use of OI during the components sub-phase was predominately outside-in oriented. The most prevalent observation was how the use of OI diminished in the components sub-phase compared to the concept sub-phase, the reason why will be discussed in the next chapter.

Other than that, managers pointed to the use and the value of outside competence during the components sub-phase. Outside knowledge sources were effectively used, albeit differently amongst the three companies, to fill in existing knowledge gaps. An example of what managers used knowledge for was to increase the efficiency during the components sub-phase, e.g. by focusing on improving user developed ideas instead of constructing from scratch, resources could be used to further improve upon user developed ideas in early phases of materialization. The initial ideas generated were not of the same quality standard as those developed solely in-house, but the end result was better in terms of meeting user needs and the resources used during development. The major problem, mentioned by all three managers, was related to the omnipotence of NIH.

Our interpretation as to why the components sub-phase seems to use OI to a lesser extent will, as aforementioned, be discussed in detail in the next chapter. However, there is a need to briefly mention that the components sub-phase seems to be somewhat of an OI chasm, mainly due to the internal focus of this sub-phase. The concept sub-phase includes formulation of the business plan and preliminary networking to ensure viability of said business plan, and the complete phase includes the system integration of the individual components. The only coupled process that was mentioned was

the value of outside knowledge and continued work on the final business plan, and the clarification of final roles of involved parties. Inside-out processes belonged to the free revealing perspective, e.g. the opening up of innovation instruments that enhanced user development abilities.

One issue mentioned was the NSH mentality, which adversely influenced the possibility to incorporate outside competence and integrate that into the development.

The ways R&D managers use OI during the management of the complete sub-phase: During the complete phase the three processes were used equally. The use was somewhat similar to that in the concept sub-phase, which will be discussed in the next chapter. Inside-out related processes included; spin-offs, licensing of IP not supported by overall business strategy, and the opening of innovation instruments which enable users to develop. Spin-offs where only briefly mentioned, however licensing of IP seemed to play a greater part of the managerial strategy. Managers claimed to actively try to find alternate ways of exploiting findings if these were unsupported by the overall business strategy (simultaneously they also sought to find outside solutions to existing problems). Managers did however mention that lack of internal strategic support for external exploitation of radically new ideas could hamper the success of the process. This is somewhat interesting since RI by definition implies that existing market and technical knowledge will be made obsolete, which in turn would imply that RIs seldom find internal strategic support. Developing innovation instruments for users to develop was another main activity, and included active participation, e.g. SDKs and similar tools, but also more passive participation as automated processes for providing biometric data on a regular basis for analysis.

From an outside-in process point of view, managers sought to incorporate outside solutions in an attempt not to reinvent the wheel and minimize the risks by using tried solutions. Furthermore, they actively tried to involve lead users and mass customization into the complete sub-phase. The methods to achieve this varied greatly, and could span from providing SDKs to create value chains and systems where the user actively provided valuable feedback during their everyday lives. To exemplify; when a certain radical new system was developed the use of SDKs could enable users to customize the solutions according to their own needs. Another example to highlight the above is how sensory data would be gathered and sent back for analysis without the user's active participation.

Moving on the coupled process, things start to get really interesting. Whilst the essence of the findings are truly hard to describe, coupled processes during the complete sub-phase include; the creation of concepts that require multifaceted involvement of a multitude of knowledge sources, which leads to a propagation of concepts matured in larger value chains into a congregated system

solution of superior value. Since the actual meaning might be somewhat difficult to fully grasp, an explanation highlighting the above will follow in the next paragraph. One manager envisioned a collaborative value system which would highlight the meaning of the above essence.

The value system included: data gathering and analysis, standardization of data input, active participation of users and mass customization, and finally an innovative value systems where the whole is greater than the sum of its parts. The creation of concepts that require multifaceted involvement can be exemplified by: the end solution would include a concept where the end user would attain superior value; however this value needed a system that no one company could provide on its own. Therefore, the different companies agreed to contribute with their own special skills and knowledge sets and the concept was propagated, divided and matured within the value chain. It finally congregated into a solution incorporating each company's unique skill set to create a system solution that requires minimum user involvement, while maximizing the user benefits of the product.

The table below summarizes the analysis, developed through the use of the analytical model.

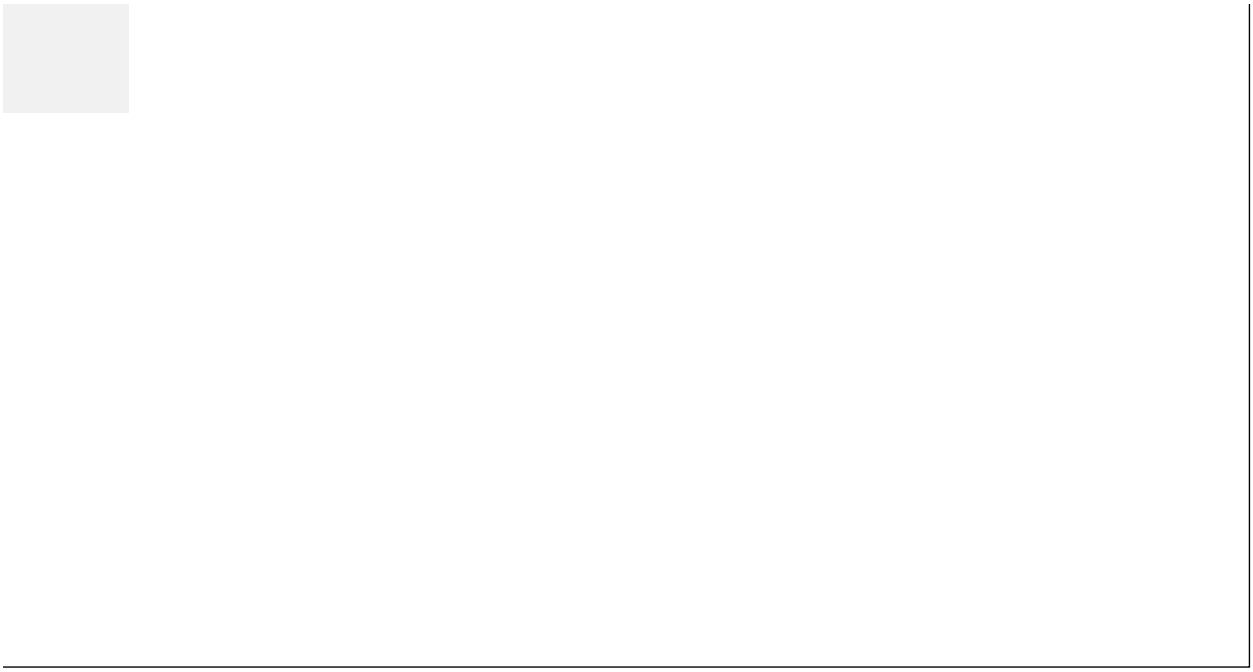

Table 9 - Concluding framework of implementing OI in RI

As previously mentioned some perspectives did not fit into the existing interview guide. During analysis it became evident that the only one that could fit the model was the one regarding business strategy changes. However, we chose to omit business strategy since it has neither a natural part in the three perspectives nor the three sub-phases.

6. CONCLUSIONS AND DISCUSSION

The purpose of this thesis was to create an analytical model to analyze the ways R&D managers could use OI during the management of the development phase of the RI process. Our results show that OI can indeed facilitate the management of RI. Our conclusions, and main contribution, of the analysis are mainly twofold:

1. **Mapping to what extent OI can be used during different phases of the RI process, and**
2. **Showing the main ways OI can be used during the management of RI**

Another contribution is our analytical model, which we hope will facilitate further research within the field of OI and the management of RI.

By using the analytical model we can depict our two main contributions and conclusions. First, the extent to which OI can be used during the development phase of the RI process is depicted in table 9. Thereafter, a presentation of the main ways OI can be used during the management of RI, is shown in table 10.

Tabell 10 – The extent OI is used during the management of the RI process' development phase

Our findings clearly distinguish the use of OI between the three phases. In the concept phase the possibilities of using OI are great, all three companies used it to a high extent in this phase. But when

it comes to the component phase the usage of OI declined drastically. However, in the completion phase the managerial usage of OI increases and solidifies.

The underlying logic might be elusive, and somewhat counter-intuitive, however, it does make a lot of sense. In the beginning of a product development project, a manager needs novel product ideas, concepts and solutions to problems; OI is here a very useful tool of the trade since the main focus is collaboration amongst interested and involved parties. The result is that a lot of ideas are generated and gathered through different types of collaboration sessions, e.g. JAMs, and the managers find partners that can contribute to the gaps of knowledge in order to materialize the project. In the next step, the components sub-phase, the manager needs to manage the materialization of the concept ideas and system solutions that were gathered in the concept phase. Interested parties have not created a system concept, in which their roles are clearly defined. The need for collaboration is thus lower since all involved develop their specific parts by themselves; of course there exists communication between the parties; however, not to an extent unique to OI. After the component phase, where every partner has contributed with their special knowledge and skills, the need for OI increases since all the parts now have to be combined to a functioning system. OI is very useful in managing this as this part of the project demands new ways of thinking and a lot of collaboration.

Table 10 presents the information from the three phases of the RI process perspective. The other natural way of dividing information is from the three core aspects of OI, since the study discusses the connection of OI in RI, so in table 11 the information is seen from an OI perspective.

Tabell 11 –Main ways managers can use of OI during the during the management of the RI process' development phase

During the inside-out process managers predominantly mentioned that the benefits of OI to the management of the RI process, is different ways of exploitation. Mostly, this took the form of the

externalization of findings and of information in order to gain access to additional revenue streams or reach collaboration with privies within the projects. One way of doing this is licensing IP since all companies are not be able to put all their radically new inventions to market, either due to company strategy permitting it or similar reasons, this does not however mean that they cannot earn revenue. By licensing, creating company spin-offs or even shifting company strategy, one can make good use of ideas that are not currently compatible with the company strategy. However this might evoke internal resistance if the company culture has too much traces of, NIH, NSH or ATH.

During the outside-in process the most common use of OI during the management of RI was knowledge leveraging. By opening up the company and revealing the underlying information about the problem, managers got access to a lot of different solutions and ideas to solve the problems. One form of this is to give the users special tools for problem solving, e.g. SDKs for software. However, by doing so the managers do take a small risk (related to being too open as mentioned under the limitations chapter), hence their competitors can see the company's weaknesses and also get hold of their SDKs. However, the benefits of having hundreds of people working on your problem, often without any other compensation than their own immediate satisfaction (which in itself is a powerful motivator according to Hippel), is often worth the risk.

Another way of solving problems was to buy ready-made solutions, or simply outsource R&D to others that specialized in the specific area where the manager needed help. However, this demands a new way of managing, now the managers need to look outside the company and have to find the best solution for problems on a global scale. There are several approaches to finding solutions to problems, one can look for companies that specialize in that area, or one can use innovation intermediaries and open up the problem for anyone to solve, etc. However, there are some minor problems with this, even if it is getting better according to the managers, the company culture and the NIH, NSH and/or ATH mentality. This is something that has to change for companies that are going to use OI in RI since the whole idea of OI is to open up the innovation process.

The most common way of using OI in the coupled process was through, the somewhat difficult to explain, method of first propagating concepts throughout the value chain, mature it and then congregate it into an overall superior offer. As the word *coupled* indicates the need for collaboration is highly important and during this system-wide process. Actually it is on such a wide scale that the managers need to emphasize creating good settings for collaboration to take place, as well as the creation of tools and platforms that could connect it all together. For such a setting it is highly important to have a large variety of people in order to get new ideas that are truly radical. However,

that is just one part of it, an more often than not necessitates the creation of totally new business models for all companies involved.

As previously pointed out there were some limitations to the nine perspectives in terms of capturing all the aspects of OI use for managers. One reason as to why was the share holistic magnitude, or that ever so hard to explain process of propagated concepts and congregated system solutions, which by any measure is a perspective of business strategy. Another was the emphasis placed on the trust and commitment aspects, or how OI transforms negative connotations to problems into positive ones.

Anteceding this study was the fact that no studies on the ways R&D managers could use OI during their RI practices where to be found. Our result hints to some interesting patterns that emerge, but we merely scratch the surface with this study and encourage further study within this field. One suggestion is to analyze specific industry differences of these emerging patterns, the way managerial roles need to evolve and whether or not differences exist between smaller and larger companies, and if so map them. Furthermore quantitative studies could reinforce our findings.

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7. APPENDIX

List of appendices:

7.1 Appendix A - Comparing incremental and radical innovation.

7.2 Appendix B - Serendipity of the innovation.

7.3 Appendix C - Component and concept newness of the innovation.

7.4 Appendix D - The market and technical knowledge aspects of innovation

7.1 APPENDIX A

Comparing incremental and radical innovation.

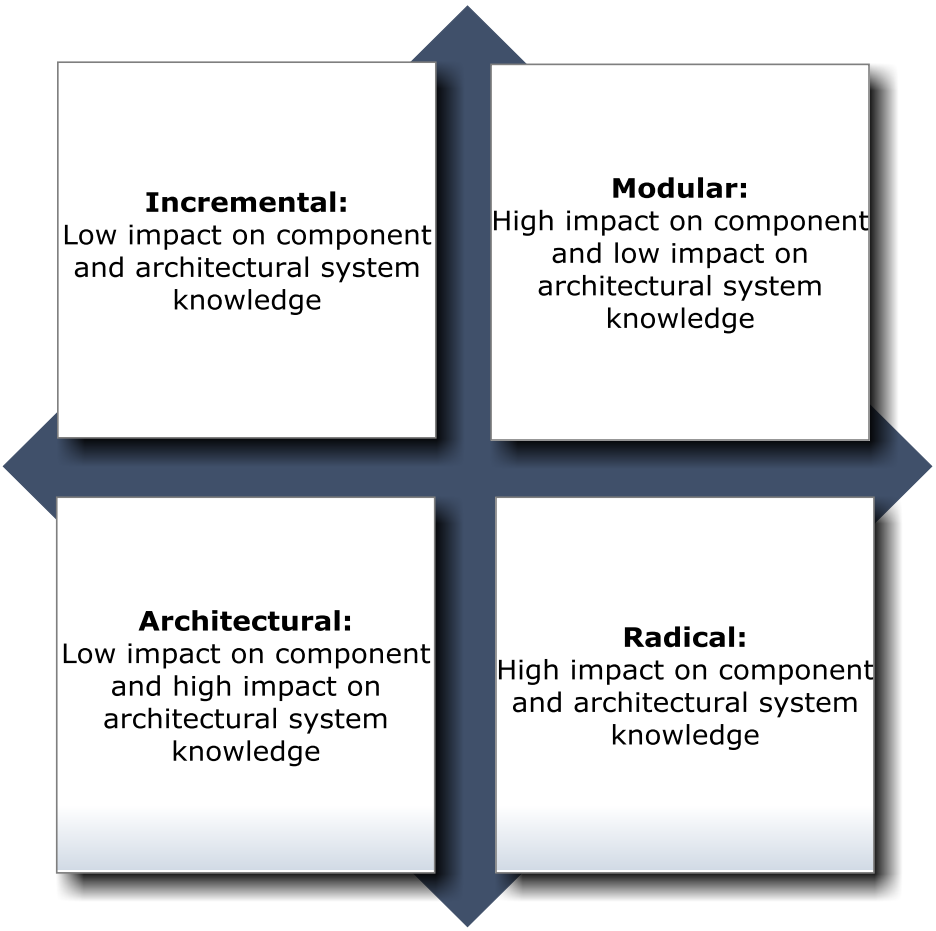
	Incremental	Radical
Emphasis	Improvements in existing	Transformational and novel
Knowledge	Knowledge augmentation/preservation.	Knowledge made obsolete
PLC	Towards end, perfecting existing concepts	Early phase, focus on new concepts and educating market / learning from market
Trajectory	Linear and continuous	Sporadic and discontinuous
Project management	Detailed plans prior to embarking on augmentation. Formalized stage-gate process	Impossible, business model and plan evolves through learning-by-doing. Informal model due to uncertainty
Key Players	Formal cross-functional teams	Informal networks, individuals
Resources and competencies	Standard resource allocation, all needed competencies are present	Competencies and resources are acquired from internal and external sources

7.2 APPENDIX B

Serendipity of the innovation.

7.3 APPENDIX C

Component and concept newness of the innovation.



7.4 APPENDIX D

The market and technical knowledge aspects of innovation

The organizations …		Technical Knowledge	
	is ..	*Preserved*	*Obsolete*
Market Knowledge	*Obsolete*	**Niche**	**Architectural**
	Preserved	**Regular**	**Revolutionary**