Managing disruptive innovations through co-innovation processes

A case study at Infineon Technologies AG

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All of these experiences culminated in the journey of this master thesis project where I realized that my hard work and perseverance were also the result of the support I had around me.

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This thesis project is a culmination mark in my exciting student journey, I am now looking forward to the next chapter of my life.

Enjoy the read!

Monika Vu kim
Munich, 2019

SUMMARY

Increasingly companies are facing tough challenges due to fast paced technological developments, shortening product life cycles and new forms of business models. Therefore innovating is crucial for companies to stay competitive and enter new markets. Large corporations have difficulty in breaking silos and developing breakthrough innovations due to pressures in the form of financial performance and resistance to change. It seems that due to volatility of markets and technological developments, companies need to "join the race" in order to survive. For the purpose of benefitting the innovation space network companies can interact with external parties. Research shows that collaboration with external actors lead to sources of higher innovation performance. Nevertheless, the innovation process is very intricate as it involves many complex interactions and challenges. Innovation depends on people´s expertise, capabilities and creative capacities. Companies need to recognize this and provide an environment that can foster innovation.

Infineon Technologies AG Corporate Supply Chain Innovation department recognizes the need to innovate in a peripheries of its core technological developments. The department is involved in several co-funded European projects which aim towards digitalization improvements. Previously, the company was focusing on a technological push, thereafter moved towards market pull and catering customers´ needs. However, it was usually a one-way interaction. Since the company realizes the need to innovate in order to gain competitive advantage and develop capabilities in a digitized revolution, it finds collaboration projects as an opportunity to innovate together – creating a two way co-creating interaction. The main company´s objective *is to explore ways to better coordinate relationships between partners, to find ways to innovate and to foster knowledge management practices*. Since the firm wants to improve its innovation performance, certain *processes* need to be develop to stimulate innovation. Infineon Technologies AG does not have processes for managing disruptive innovations therefore is in need to design a model that would enable the company to manage them, the main objective of this master thesis is to design:

A model which prescribes processes for management of disruptive innovations between firms, on a case study of Infineon Technologies AG Corporate Supply Chain Innovation department.

In order to reach objective of this master thesis, a following main research question is formulated:

How to facilitate inter-firm innovation management processes of disruptive innovations in the context of Infineon Technologies AG Corporate Supply Chain Innovation Department?

The thesis project takes a Design Science Project approach and is divided into five phases: 1) research motivation 2) requirements definition through exploration of theoretical foundation 3) design and development of the artefact 4) demonstration of the artefact through validation and 5) evaluation and conclusion.

The first phase provides research context and motivation for pursuing this thesis topic as well as detailed explanation of the methodology. This thesis project follows a Design Science approach which utilizes multi-qualitative methods including literature review and a case study. The literature review enables the author to investigate the topics´ opportunities and problems; when knowledge understanding is satisfactory it enables generation of requirements and finally artefact design. Whereas case study research verifies a designed model. The literature review is used as necessary science base which provides a better understanding of the theory and practices within the topic area and flexibility to the research as new data and insights might add or change the direction of the research. A case study method allows for investigation of phenomena in their natural settings and derivation of critical insight. It is especially useful in the new topic areas in which important factors and patterns can be identified. The single, embedded case study includes semi-structured interviews and secondary sources for data gathering. Lastly, the formulation of sub-research questions guides the development of this thesis project.

The second phase provides a theoretical foundation on the topic of disruptive innovation and inter-firm relationship management. The literature on disruptive innovation synthesizes the definition of disruptive innovation, reviews various innovation management practices and finally analyzes how the literature dealt with disruptive innovation processes. Taking micro – perspective, innovation is disruptive when a company enters new market and /or develops new technologies. The first innovation models dating back to the beginning of 20th century represented closed systems, internal to the company. New challenges triggered the development of new models - open systems allowing for integration of internal and external forces. Nevertheless, it has been found that the management of disruptive innovations must be treated differently. The result of the literature review on disruptive innovation is the description of the innovation process steps: strategic frame, opportunity identification, idea generation, concept definition and selection, prototyping and launching.

The literature on inter-firm relationship reviews various frameworks that try to describe relationship management. After a comprehensive overview of various elements, four main categories are identified and characterized: relational (trust, commitment and coordination), structural (information sharing, quality of conflict resolution, multiplexity and interaction frequency, resource (intellectual, technology, financial, concept and knowledge and strategic (shared values). The literature seems to lack models that connect innovation performance with a comprehensive list of relationship characteristics. Nevertheless, some researchers began developing models that configure certain dimensions to the innovation performance. The third aspect that appeared relevant in the topic are co-creation forms which are various points / ways companies can co-create. It was found that co-innovation is the newest form which captures excellently disruptive innovation requirements and inter-firm relationship requirements. On one hand, co-innovation model is able to face external challenges by linking various external and internal sources, on the other hand it can also better accommodate co-creation processes. It does not focus on one collaboration form but rather on the whole innovation process. Hence, it can be perceived as a new capability.

Co-innovation captures collective intelligence and network effect to create value among participants, where main focus is on the act of togetherness and collaboration. The main motive is to create values which are originated from new customer value, customer base, product/ services, efficiency of the value chain or business models (S. Lee, Olson, & Trimi, 2012). Co-innovation is composed of four elements: co-creation, collaboration, innovation platform and convergence. They are used as basis for the development of this thesis artefact – conceptual model.

The third phase consists of artefact design built on the literature findings and generated system requirements. The result is a comprehensive Co-Innovation Model which captures the most important and relevant elements of disruptive innovation process management and inter-firm relationship management. The model is designed as a tool for organizations to enable successful realization of disruptive innovations through management of partner organizations in the innovation process which would lead to increased quality and rate of disruptive innovations.

The fourth phase is an artefact validation through testing of the designed conceptual model on a case study. The case study research chosen is GeniusTex project which is a smart service platform project for smart textiles carried out by seven project partners. It is suitable since conceptual model elements such as innovation platform, co-creation, convergence and collaboration can be found and are applicable. The analysis of the case study should allow to generate useful outcomes and recommendations for the scientific body of knowledge and the company. The focus is mainly on meeting theoretically generated requirements. The analysis of semi-structured interviews and questionnaire led to verification and validation of the model on the case study.

The outcomes of the analysis imply that co-creation element acts as a foundation of the co-creation processes following iterative steps of strategic frame, opportunity identification, idea generation, concept definition, concept selection, prototyping and launching. At each of this step, there is partner organization involvement in order to emphasize joint activities. Collaboration element is crucial in incentivizing the right environment. It was found that the consideration of relational, structural, resource and strategic elements can largely set the tone for collaborative environment. Hence, high partnership orientation with moderate structural intensity, long distance of knowledge and concept spaces create the most disruptive innovation settings. Convergence means merging of various fields / knowledge / technologies which would otherwise be not considered. Convergence lays in the space of finding links between partners.

The fifth phase evaluates the artefact design on the fulfillment of the requirements which were found in the theoretical review. The conceptual model is deemed as suitable for the achievement of the goal once it has a potential to reach the desired outcomes.

The overall conclusion for this thesis is: in order to facilitate inter-firm innovation management processes of disruptive innovations Infineon Technologies Corporate Supply Chain Innovation department should implement co-innovation management practices. The co – innovation model has a network structure composed of co-creation, collaboration, innovation platform and convergence affordances. By expanding these elements to its practical implications, the company is able to implement a comprehensive and implementable solution. Scenario with actionable steps was developed as a recommendation for the company.

Lastly, this thesis ends with the description of the theoretical, general and managerial implications. By identifying limitations, recommendations for future research are given as starting point for model improvements in the topic of co-innovation.

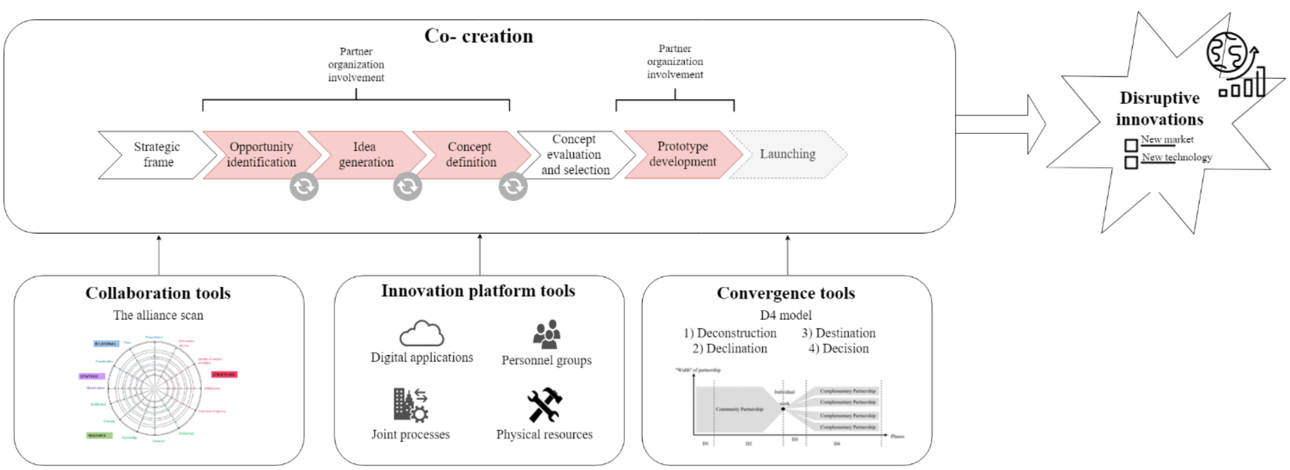

Fig. 1 Conceptual model

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ABBREVIATIONS

COSEM	Complex System Engineering and Management
DSP	Design Science Project
FIT	Fraunhofer Institute for Applied Information Technology
IFAG CSC E IN	Infineon Technologies AG Corporate Supply Chain Innovation Department
IFX	Infineon Technologies
IoT	Internet of Things
ITA	RWTH Aachen Institute of Textile and Technology
PLM	Product Line Manager
R&D	Research and Development
TIM	RWTH Aachen Research Area Technology, Innovation, Marketing and Entrepreneurship

CHAPTER 1 INTRODUCTION

Innovating is crucial for companies as this is the only way to stay competitive and enter new markets. The competitive pressures in the form of increasing pace of technological developments and of depreciating equipment costs and of shortening product life cycles determine whether a firm stays in the market (Sampson, 2007). Innovation is thus “life blood of corporate survival and growth” (Rowley & Sambrook, 2009). Globalization and digital transformation bring additional challenges, as innovations are diffusing much faster and the society uses new ways of communication and interaction. Therefore, traditional methods for handling innovations are not suitable anymore.

For the past decades, innovations were mainly originated from within companies, usually in R&D departments (Linnarsson & Werr, 2005). Companies developed different ways to generate ideas through integration of cross-functional teams, inter-departmental communication or knowledge management software systems (Min et al., 2005), (Schilling, William, & Hill, 1998). However, internal innovations are not competitive enough. Open innovation and knowledge sharing are crucial in developing new technologies (Monczka et al., 2010). Especially, in the industries such as electronics, semiconductors and biotechnology that have high technology intensities, complex supply chains, high equipment and resource costs (Gassmann, 2006). Moreover, there is a need to think and act globally hence there is a necessity to work in collaborative innovation projects (Min et al., 2005), (Rothaermel & Deeds, 2004).

1.1 Problem introduction

Despite the efforts to create innovation environments, the process to make things happen seems fuzzy. Big corporations have plethora of resources and capabilities to innovate, however they often respond slow to the market. Moreover, they prefer to stick to their status quo, as “it has always been done like that” (Jean, Sinkovics, & Hiebaum, 2014). In that sense people are confused about the ´innovation´ term itself. At the same time, companies realize that innovation is crucial for sustainable development (Bremmers & Sabidussi, 2008).

The problem lays in the complex interactions between actors in the innovation process. Due to the many interfaces, there seem to be a huge gap between idea generation and idea execution, as well as sustainability of innovations over time (Ahmed, 1998). For most part, it seems that there is a lack of resources or sufficient knowledge on what is “out there” (Bossink, 2002). For idea creators, right manufacturers are essential to produce their ideas, they on the other hand rely on their suppliers to provide right components. Furthermore, there are many challenges that might inhibit the development of innovations such as handling of communication or knowledge management. Another important issue is that innovation does not source from an individual but rather team efforts. Not only the lack of knowledge is inhibiting for innovation, but also the lack of innovation inducing environment (Sengupta, 2009). Taking all these complexities together there is a need to systematically organize knowledge in the innovation management and collaboration spheres for organizations to design models that enable them to make bold changes.

More often companies want to stay ahead of the competitors and develop disruptive innovations through creating unique ideas with long term value that would provide high performance benefits, the ability to create new opportunities or cost reductions (Frishammar, Dahlskog, Krumlinde, & Yazgan, 2016). However, disruptive innovations are particularly challenging to manage since they entail unknown grounds and methods, unexpected events, inevitable failures, unfamiliarity, uncertainty and lack of control (Phillips, Lamming, Bessant, & Noke, 2006). The literature on this topic suggests that the opportunity arises when interacting with external partners as they can lead to high innovation performance (leading to disruptive innovations) by successful innovators (Wagner, 2008), (Jiang & Li, 2009). As stated by Romero & Molina (2011) "a source of innovation will be companies from other industries, because we know the most innovation is based on a recombination of existing knowledge, concepts and technology".

Despite these observations and high ambitions of companies to innovate the literature is quite fragmented in the domain of innovation management and inter-firm relationship management. It is not clear how companies can manage disruptive innovations between firms.

1.2 Thesis project objectives

It becomes apparent that innovation is a complex process which not only involves many different actors but also their expertise, capabilities and creative capacities. The ability to innovate depends on many different factors such as the company environment and culture. Without explicit emphasis on the innovation, people might often fall behind other emerging economies and markets. In order to better understand the key factors and tools to foster integration, this thesis project focuses on:

A model which prescribes processes for management of disruptive innovations between firms, on a case study of Infineon Technologies AG Corporate Supply Chain Innovation department.

The model is designed based on the existing body of knowledge on the topic of innovation management and inter – firm relationship management. On one hand, the topic touches a practical problem on the other hand there are apparent knowledge gaps in the scientific body. Hence, this project takes a Design Science Project approach to reach this project´s objectives. This project looks at the main topics and fills the research gaps in these fields, as well as add insights by merging these topics. The purpose of this project is to achieve a new artefact that reaches defined objectives, and at the same time adds scientific knowledge in the disruptive innovation (entering new markets and/or new technologies) domain. This Design Science based model is used to prescribe processes to facilitate local communities (firms) to implement it in practice in the innovation projects. Based on the analysis, practical and specific recommendations can be given to corporate companies. Moreover, generalizable advices can also be generated since the model is developed using an overall research body on the topic (not limited to specific industry sector).

1.3 Thesis project main question

In order to reach objectives of this thesis project, the main project question is formulated as follows:

How to facilitate inter-firm innovation management processes of disruptive innovations in the context of Infineon Technologies AG Corporate Supply Chain Innovation department?

By answering this main project question, the final outcome of this project is a designed artefact in the form of a model which when validated takes the most important factors from the literature and from the practical used cases that can be used by the company to facilitate inter-firm relationship for disruptive innovations. Consequently, contributing to the overall innovation ecosystem.

1.4 Thesis project relevance

To reach this thesis´ objectives and answer the main research question, a Design Science Project approach is used (Johannesson & Perjons, 2014). The rationale for choosing this approach and its execution are elaborated in the next chapter (Ch. 2). In this sub-section, scientific and societal relevance are illustrated in Figure 1. Relating to the scientific contributions, a Design Science oriented project focuses on the global practices which means it produces generalizable results. Moreover it uses an overall research strategy and rigorous research methods for data collection. The results must relate to the existing body of knowledge which means existing models and theories are used as the scientific basis. Lastly, the project results must be disseminated to the researchers and local practice community. According to Johannesson & Perjons (2014), the author of this thesis decides to take strategy in which a solution to a local practice is developed in the specific context (Infineon Technologies) and then general solution is developed based on the implications on the local perspective. Specific knowledge gaps are analyzed in depth in the literature review sections.

The societal relevance lays in the complex interactions between actors in the network who participate in the innovation system which are perceived as users of the system. It touches the process of innovation (practical process) and therefore the management of this process is utterly important. It has a private and public domain since it involves actors from private domains (companies) as well as public (academic knowledge, public fund supports).

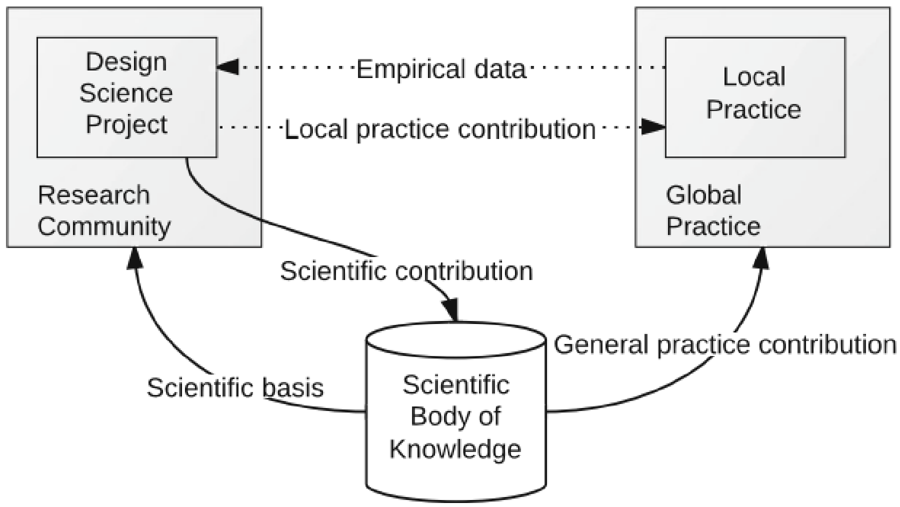

Figure 1 Local and global practices in design science project. Adapted from Johannesson & Perjons (2014).

1.5 Thesis project scope

This thesis project is executed on a case of Infineon Technologies AG Corporate Supply Chain Engineering Innovation (IFAG CSC E IN) department in Munich. Infineon Technologies wants to be at the forefront of the semiconductor industry by proactively trying to engage in innovative and digitalized projects with external companies. Thinking in an innovative way is paramount in a successful fulfillment of projects´ objectives. Nonetheless, these type of practices are new to the company, hence it has not yet developed capabilities to coordinate such complex innovation processes. It wants to implement new, effective and successful models / processes that can govern these complex interactions and to learn to innovate. The deliverable of this project should prescribe processes to follow in order to successfully manage innovation management processes. The scope of the model is focused on disruptive innovations (new market and /or new technologies in a micro – perspective level), relationship management between partner firms (customers, suppliers or competitors are not included) and new collaboration forms (excluding forms after launching phase).

Although this research project is conducted within the corporate environment, the scope can be expanded to other users of this project outcomes since the artefact of this project is based on the scientific body of knowledge rather than on the specific characteristics of the company. The local practice is used to extract empirical data for validation and evaluation. Nevertheless it is apparent that not only the case study company struggles with the complexity of innovation management practices but also other large companies that deal with variety of actors and stakeholders, intricate supply chains and communication issues.

1.6 Thesis project outline

This thesis project follows a Design Science Project framework (Johannesson & Perjons, 2014) and is divided into five phases (see Figure 2). The description of the methodology to conduct this thesis project is in the next chapter (Ch. 2). The first chapter presents the background, objectives and the relevance of this thesis project. Subsequently, phases of the framework dictate the flow between chapters. This thesis project is divided into five phases. The first phase, chapter 3 provides the context and research motivation. The second phase consist of the theoretical foundation that presents the body of knowledge on the topic of innovation management and inter-firm relationship management, as well as synergetic topics between them; chapter 4 gives an overview of the current state of art for the innovation management, as well as interesting research gaps; chapter 5 provides an overview of the topic on the inter-firm relationship management and chapter 6 dives deeper in the co-creation forms. Based on the theoretical foundation review, requirements are defined in the next chapter. The third phase is oriented towards the conceptualization of the artefact, a conceptual model of co – innovation in chapter 7. The fourth phase includes validation of the theoretical model; chapter 8 includes the analysis of the case study research by providing validation insights. The fifth phase consisting of model evaluation checks the requirement fulfillment found in the theory (Ch. 9). The last chapter, Chapter 10 concludes this thesis and provides recommendations for future research.

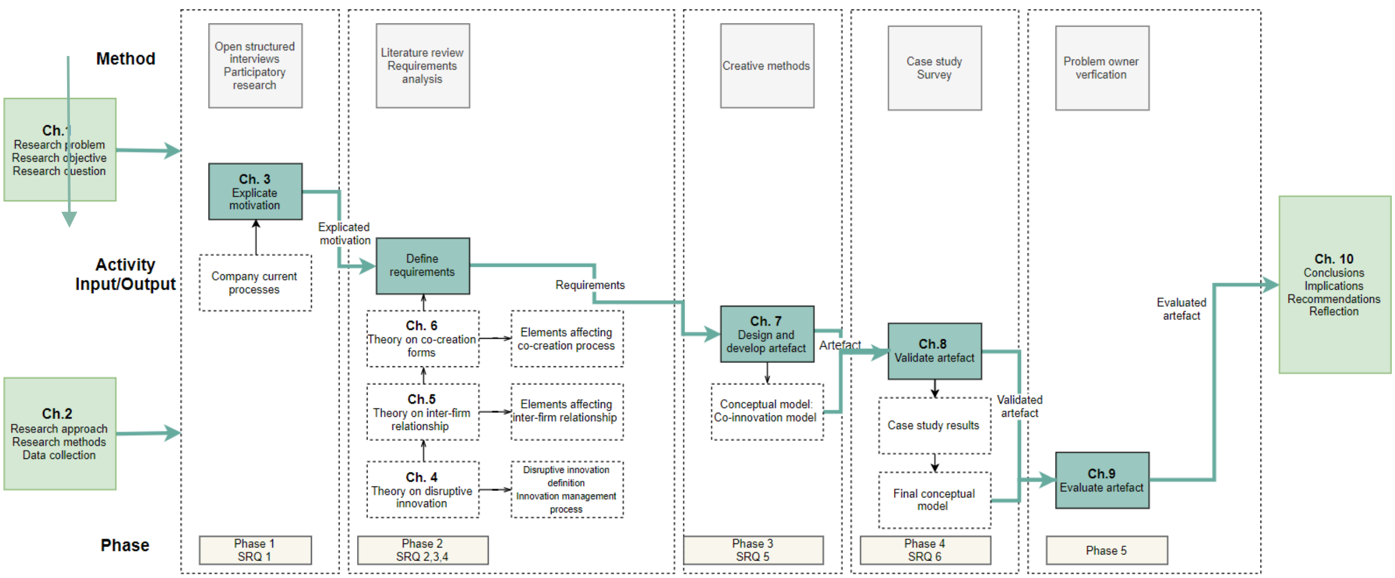

Figure 2 Thesis project outline. Source: own illustration.

CHAPTER 2 METHODOLOGY

First chapter gave a background on the topic, problem and objectives of this this thesis project. It served as an input for the research approach and methods. Based on the project goals, this chapter provides explanation for the methodology framework. Choosing appropriate methodology is crucial since it brings rigor to the project execution. In order to follow the framework sub-research questions are formulated with their respective methods to answer them.

2.1 Design Science Research Approach

A Design Science Project (DSP) framework by Johannesson & Perjons (2014) is used as the main research approach. This framework is used to structure phases of this thesis project. According to Johannesson & Perjons (2014), a Design Science is "the scientific study and creation of artefacts as they are developed and used by people with the goal of solving practical problems of general interest". Hence the outcome is an artifact and a scientific contribution. An artefact is a response to an existing practical problem which is determined by stakeholders' goals and requirements. It fulfills their needs, tackle problems and help grasp new opportunities (Johannesson & Perjons, 2014).

This approach is suitable for reasons that can be tackled with design science approach. Firstly, this thesis topic concerns a practical problem which means that the focus topic - innovation management practices involve actionable items in order to reach desirable solutions. There is gap between a current state and a desirable state. Current innovation management processes are outdated and are not suitable for emerging challenges. The desirable state is the process that enables users to create disruptive innovations. Secondly, the practical problem is to some extent wicked which means that it is difficult to solve due to complexities. Hence, the solution should enable the dynamic nature and allows for changing requirements. Moreover due to its wicked nature, it allows for flexibility when not all requirements are known upfront. In this project, the practical problem is regarded as a promising opportunity for improvement which is driven by the research scope. The wickedness in this project lays in the constant challenges, organizational structures and knowledge management practices that corporations have to face. Thirdly, the identified problem requires an artefact – a solution which could solve the specified problem based on the scientific body of knowledge. In this research project, the artifact is the prescriptive model which prescribes processes for managing disruptive innovations between firms. The scientific contribution fills the knowledge gaps found the in the analyzed knowledge domains. Fourthly, this approach allows for participatory research in the exploration phase. In this project context inputs are needed to better understand the practical problem.

Below in Figure 3, the Design Science Project framework by Johannesson & Perjons (2014) is adapted for this thesis project´s outline and methods. Each step is explained below, the next sub-chapter describes chosen research and data collection methods. From the original framework, the first step is "Explicate Problem" and the outcome is "Explicated Problem", in this project it is changed to respectively "Explicate Motivation" and "Explicated Motivation". This is due to the fact that the problem in this project is "driven by curiosity" (Johannesson & Perjons, 2014) rather than an explicit problem. Additionally, "Demonstrate Artefact" and its outcome "Demonstrated Artefact" is named as "Validate Artefact" and "Validated Artefact" since the application of the designed artefact is not possible to be implemented in the thesis time frame. However, it can be validated / tested on a case study project at the company.

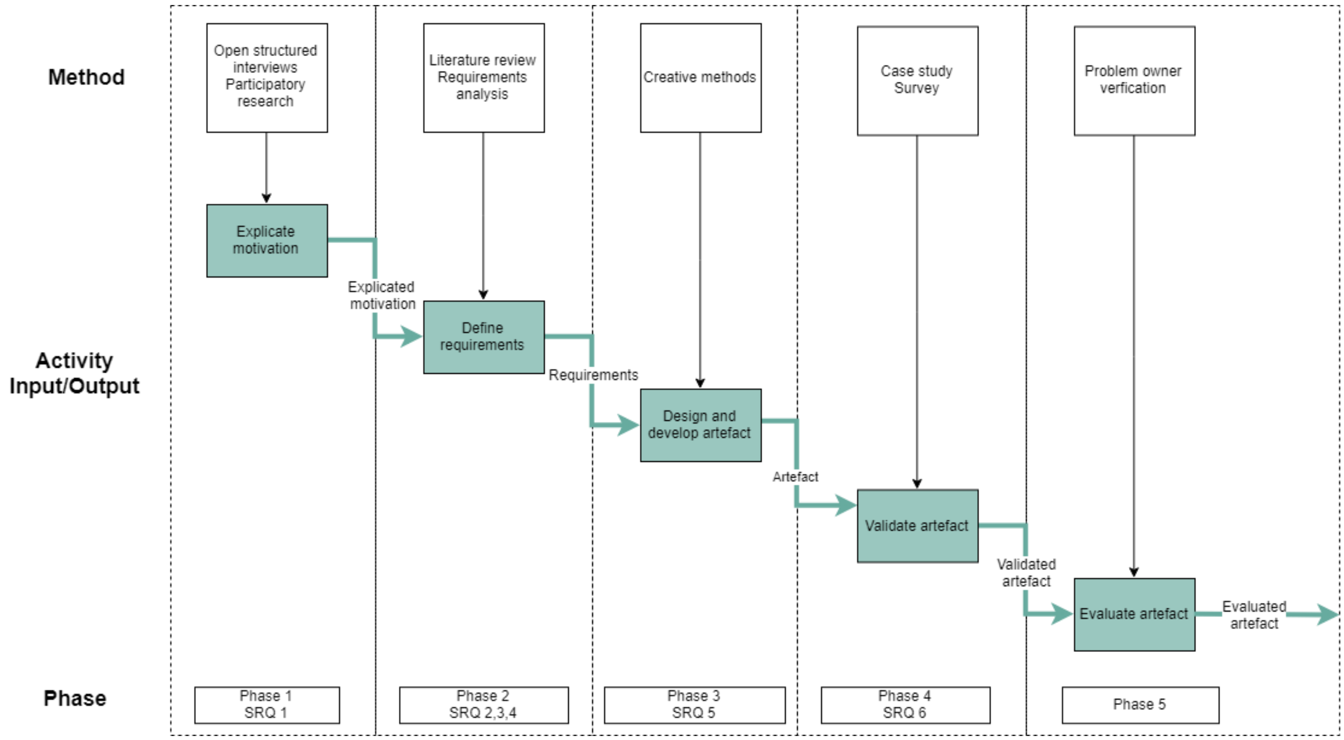

Figure 3 Design Science Project framework. Adapted from Johannesson & Perjons (2014).

The first phase, *explicate motivation* is about analyzing the problem which is significant not only in the local practice but also in the global practice. Since this research is driven by curiosity, this phase is less elaborated since the motivation for this research is embedded within a case study company. The second phase, *define requirements* acts as a frame in which an artefact can be designed. The third phase, *design and develop artefact* creates an artefact that addresses the motivation (problem). It includes certain structures and functionalities. The fourth phase, *validate artefact* is used to test the designed artefact on real life case. It shows whether the artefact is a good response for the problem. The fifth phase, *evaluate artefact* shows how the artefact fulfills the requirements. This thesis project is *Requirements – and Development – Focused Design Science Research* since the majority of the work is focused on the requirements definition and artefact development (Johannesson & Perjons, 2014). This also means that *explicate motivation* is briefly summarized and the *artefact evaluation* is concise.

2.2 Research and data collection methods

In order to logically execute steps in the framework various research and data collection methods are used to ensure reliable and valid knowledge. Formulating sub-research question sensure that the right answers are found. Refer to Figure 3 for phases´ visualization.

2.2.1 DSP: Phase 1

The first phase of the framework, *explicate motivation* is used to explore the current local practice system and the opportunities which can improve this system. The first sub-research question is:

1. *What are the opportunities in the current innovation management system?*

The first sub-research question specifies local motivation for investigating the topic of innovation management and inter-firm relationships. In order to follow the right problem, it is imperative to understand the current system and find gaps and opportunities to improve that system.

Data method: In order to answer this sub-research question, a participatory research method is used. Participatory observation allows for more in-depth understanding of the topic which cannot be provided by the literature review. The author of this thesis project interns at the case study company and therefore has direct opportunity to explore the topic through direct engagement of the project related to the topic of the thesis. This method considers local perspectives and local knowledge as research inputs. The author is exposed to daily routines and experiences of the employees. Moreover, engaging in discussions and working with employees of the Corporate Supply Chain Innovation department gave valuable insights into the formulation of this thesis topic.

Data collection: The list of interviewees was suggest by the Head of the CSC E IN Department (see the list Table 1). The names of the contacted interviewees are hidden to preserve their anonymity. These employees were previous members of the CSC E IN department who worked on the disruptive innovation topics or work on the topic related to disruptive innovations. The results of interviews were transcribed and key topic areas were identified (Yin, 2011).

Table 1 Exploratory interview

Interviewee	Position	Topic
[redacted]	IFAC ATV SMD EMEA FAE AC	Innovation Accelerator project
[redacted]	IFAG PMM DCDC	Innovation management
[redacted]	IFAG IPC BID	Innovation Accelerator project
[redacted]	IFAG PMM SMD STM EA	Innovation management
[redacted]	IFAG PMM ACDC RDA	Innovation management
[redacted]	IFAG PMM SMD STM PAM	Partnership

2.2.2 DSP: Phase 2

The second phase, *define requirements* requires exploration of the scientific body of knowledge in the core topic of this thesis project. In order to answer the next sub-research question a literature review method is used.

The literature review allows for exploratory research since it provides a better understanding of the theory and practices within the topic area. Moreover, it gives the flexibility to the research as new data and insights might add or change the direction of the research (Silverman, 2013). By exploring different aspects of innovation and relationship management, theoretical knowledge can be built. The literature review provides the state of art for the different aspects of innovations, e.g. Type of innovation (product, service, or technical), or Nature (incremental, radical) etc. Furthermore, the literature review gives an overview of proven concepts within specific context e.g. the globalization of technological innovation in manufacturing companies (Iammarino, 2002).

In order to find relevant sources, set of keywords for a selected topic were utilized in search database engines such as Google Scholar, Science Direct, Emerald Insights and TU Delft library catalogue. Most relevant articles were published in the following journals: *The Journal of Product Innovation Management*, *International Journal of Operations & Production Management*, *The Academy of Management and R&D Management.*

In order to limit the number of papers analyzed to a manageable number, keyword search terms were applied to appear only in titles. Moreover, published dates were also relevant since many theories were built on the previous concepts, therefore it was paramount to read papers in a consecutive order. A mixed of different research methods (ground theories and empirical) were useful in identifying generality of study implications. Further, abstracts of up to 50 scientific papers were checked and the most relevant publications were selected. Snowballing helped with finding papers on similar topics that were fundamental in the found research papers. Main key areas, data sets, methods and findings were transcribed in data sheets (Excel and OneNote). After thoroughly reviewing selected papers, the most relevant theories and models were synthesized, subsequently main articles became theoretical foundation for this thesis.

Considering an overall design driven approach, a literature review method brings rich and research based experiences of decades of researchers work on these topics. Since most often companies introduce new processes solely based on practice, they do not always understand why they fail (Basole & Russell, 2015). Synthesizing the theoretical and empirical literature brings sound evidence for choosing certain methods or tools in the design of an artefact (model).

The following sub-research questions are deploying literature review method:

2. *What is disruptive innovation? How is it managed?*

The second sub-research question relates to the field of disruptive innovation, which is the core topic of this project. The analysis of the concepts gives a better overview of the state of the art in science. Moreover, it is important to understand how research has dealt with managing this type of innovations in academia, and what managerial implications are. The results are presented in Chapter 4.

Data collection: In order to answer this sub research question, desk research is performed by using renowned search engines. The key words search terms are: *innovation, transformational innovation process, supplier innovation, technology push, new product development process, transformational innovation, disruptive innovation, managing disruptive innovation*. Different combinations of these words were input as well. The search engines generate textual resources such as peer reviewed journal articles which provide reliable sources of knowledge.

Data analysis: Papers were analyzed and ordered by the published dates. The key summary points and components were noted in the Excel Sheets in a table format. After reviewing several papers, the categories (table headers) were further defined. The results are presented in the table format. This is one of the most common approach to summarize the literature review.

3. *Why is inter-firm relationship important for management of disruptive innovations?*

The third sub-research question looks at the other core aspect of the research mainly the relationships between organizations. The relationship between buyer and supplier is assumed to be a major factor in the innovation process, therefore it is important to understand what key topics are relevant. The results are presented in Chapter 5.

Data collection: In order to answer this sub research question, desk research is performed similarly as for the previous sub-question. The key words search terms are: *buyer-supplier relationship, partnership innovation supply chain, partnership alliance, alliance supply chain innovation, technology push partnership, managing interfirm innovation, building co-innovation relationships*. The search engines generate textual resources such as peer reviewed journal articles which provide reliable sources of knowledge.

Data analysis: The papers were analyzed and ordered by the published date. The key summary points and components were noted in the Excel Sheets in a table format. After reviewing several papers, the categories (table headers) were further defined. The results are presented in the list format, since it gives more room for explaining the elements in this section.

4. *What elements affect the inter-firm relationship in management of disruptive innovations?*

Once the innovation topic and inter-organizational relationships have been investigated, new concepts emerged. Big concepts were broken down into its components to understand better various phenomena and to synthesize the body of knowledge. The fourth sub research question incorporates knowledge from the first two chapters. Without them, the logic is broken. The results are in Chapter 6.

Data collection: Desk research keyword search on: *co-innovation, co-creation, collaboration, convergence, co-development, communication, knowledge management (*and their combination).

Data analysis: The papers were analyzed and ordered by the published dates. The key summary points and components were noted in the Excel Sheets in a table format. After reviewing several papers, the categories (table headers) were further defined. The results are presented in the table format. This is one of the most common approach to summarize the literature review.

2.2.3 DSP: Phase 3

The third phase of the framework, *design and develop artefact* uses requirements formulated from the literature review and systematically organizes theories by using creative and scientific methods.

In this phase, the fifth sub-research question is:

5. *What elements to include in the design of a model?*

Based on the synthesis of the literature review, crucial factors and elements in the inter-firm relationship management of disruptive innovation are critically analyzed. The steps in building the artefact are explained in detail in Chapter 7.

2.2.4 DSP: Phase 4

The fourth phase is *validate artefact* which requires testing a designed artefact in a real life situation. A case study method seems to be the most suitable for this situation.

Case study method allows for investigation of phenomena in their natural settings and derivation of critical insights (Veryzer, 1998). It is especially useful in the new topic areas in which important factors and patterns can be identified (Bruce, Daly, & Towers, 2004). The topic of the project deals with relationships, communication, and knowledge management which by nature have qualitative traits. Case study method can capture these phenomena. Moreover, the topic of the project deals with complex social interactions and involves difficult patterns and mechanisms. The qualitative method is able to capture these naturally occurring social phenomena and generate comprehensive perspectives of research participants (Soosay, Hyland, & Ferrer, 2008). Furthermore, qualitative approach supports the development of theoretical and practical implications for theories and concepts (Soosay et al., 2008). The development of a case study follows principles given by Yin (2003).The components of research design are: a study´s question, its propositions, its unit of analysis, the logic linking the data to the propositions and the criteria for interpreting the findings (Yin, 2003). The method for presenting an evaluating case study research follows Anderson (2010), where checklist guideline is used (see Appendix A).

The *study question* concerns a "How" question since it has an explanatory and descriptive nature. According to Yin (2003), for this type of question, a case study method is most appropriate. The scope of the study is limited to key topic areas formulated in the research question, therefore other areas such as marketing, engineering or human resources are not included in this project. Hence the *propositions* are related to innovation processes and inter-organization relationships. This qualitative approach is used to test the theory in the practical context of the case study innovation processes

The selected case study is an innovation management in a semiconductor company – Infineon Technologies AG served as a main unit of analysis. It excellently suits this topic because it is one of the fastest growing high tech industry (Sivadas & Dwyer, 1998), (Gill & Ishaq Bhatti, 2010). Its core business technologies have many important applications such as in electronics, chips, security, power control systems, or automotive. The end product technologies consist of many different components and this involve a big network of knowledge carriers.

Semiconductor companies are suppliers of core components, however they have little influence on the innovation of end products. Therefore, the identified scientific gaps can be investigated in this environment.

The single case study unit is used as it can determine whether a proposed theory is correct or whether there are some alternative explanations. Since, the literature review is used for theoretical model representation, single case study can be used as validation. Additionally, the chosen case study is *embedded* because it will be focused on the department level at Infineon Technologies AG Corporate Supply Chain Engineering Innovation (IFAG CSC E IN) department in Munich).

Multiple sources of evidence are utilized for a case study analysis, these are direct observations, semi-structured interviews with key stakeholders used as primary data. The interviewees were presented with the objectives of the master thesis and the format of interviews. The method for analysis of interview transcript follows Burnard (1991) which is a stage by stage process for interpreting interview results. As secondary data, archival records (previous master thesis), company´s reports, handbooks and presentations are used. All these documents are available at the company´s intranet.

Taking an overall design approach of this thesis, case study is suitable since it can verify whether the design of the model fulfills the requirements that were found in the previous phase. Since it takes qualitative rather than quantitative requirements only case study seems to be most feasible.

In this phase, sixth sub-research question is formulated:

6. *What elements of co-innovation can be observed in practice?*

The conceptual model consisting of the elements found in the literature review is validated through a case study research method. Sixth sub research question collects practical evidence on how the embedded single case can utilizes the designed process. The analysis shows which elements identified in the theory appears to be relevant in practice and which not. The results are presented in Chapter 8.

Data collection: In order to answer this sub-research question, two data sources are used. The primary data are semi-structured interviews which were conducted with managers and team members of the case study unit (see list in Table 2). The participating companies in the case study unit have representatives hence the study sample was limited to them. A list of contacts was given by the project manager of the case study. Each interviewee was contacted and briefed on the topic of this master thesis. The interviews took up to 70 minutes, and were done either by telephone or in person. A semi-structured form allows for asking specific topics / concepts related to this master thesis and at the same time open up new topics which might be relevant to the research (Anderson, 2010). The interview questions are formulated on the basis of the requirements identified in the desk research (Anderson, 2010) (see interview guide in **Error! Reference source not found.**).

Additionally, a questionnaire which is aligned with the interview questions was constructed to obtain quantitative data on the perception of the elements of the theory (**Error! Reference source not found.**). The questionnaire asked participants on how important they perceived certain factors on a scale from 1 to 5 (least important to most important).

The secondary data are reports, previous master thesis dissertations conducted at the company and company´s presentations. They are valuable sources to gain knowledge on what has already been done in this topic, on background information how innovation topics are dealt, and on contact persons for various projects. The field notes are in the form of minutes of the meetings of the projects the author participates in.

Data analysis: Semi-structured interviews were audio recorded with voice recorder and transcribed in QDA Miner Lite. The interviews were coded according to the themes connected to the topic of this thesis. Moreover, not only the main topic themes were analyzed but also emergent themes (Anderson, 2010). After all the data was collected, the analysis followed a step by step approach by extrapolating key themes across all interviewee units. Additional emergent topics were analyzed to check whether there were any relevant themes or whether they can be considered under one of the anticipated themes (Anderson, 2010). The questionnaire results are analyzed in Excel.

Table 2 Case study interview list

Interviewee	Company	Position	Type	Duration
[redacted]	Infineon Technologies	Partner	Face to face	70 min
[redacted]	Infineon Technologies	Partner	Face to face	60 min
[redacted]	ITA	Partner	Telephone	60 min
[redacted]	Eccenca	Partner	Telephone	45 min
[redacted]	Asys	Partner	Telephone	90 min
[redacted]	TIM	Partner	Telephone	35 min
[redacted]	FIT	Partner	Telephone	35 min

2.2.5 DSP: Phase 5

The last phase is *evaluate an artefact* which summarizes the requirement fulfillment. This phase is checked with the problem owner.

2.3 Thesis project quality

2.3.1 Reliability

To ensure the reliability of literature review method, only peer review journal articles were used to synthesize the literature (Silverman, 2013). Moreover, the year of published papers helped with finding the original theory on which the research was built on. The author performed snowballing to find connections between papers and trace back sources. Moreover, the author closely looked at the methods for new theory building on the previous foundations. To ensure the reliability of case study research, all interviews were recorded using high quality recording systems (Silverman, 2013). Simultaneously, notes were made to ensure consistent understanding. Afterwards, the records were transcribed. Notes were made simultaneously and right after the interviews.

2.3.2 Validity

To ensure validity of the desk research, the author also looks at the literature overview of the papers and check whether other researchers found similar observations. Moreover, the author uses common literature review methods. To ensure validity of the semi-structured interviews, the author presented the transcript to the interviewers to check whether they would also come up with similar categories (Burnard, 1991).

2.4 Limitations

Design Science Project approach has several limitations which mainly balances issues between an artefact and scientific contributions. First of all, a project which overemphasizes the knowledge base could design an artefact which is impractical in real life examples. However, this thesis project being executed at the local practices (at the company) ensures that proposed designs are not separated from the existing processes. Moreover, practical used cases are also presented to prove concepts being implemented in practice.

In generalization of the case study findings, care must be taken to distinguish between statistical generalization and analytic generalization (Yin, 2011). Since this project involves a single case study, it would be incorrect to assume that what was found true in this particular case would work in the exact same way as for the larger population. Moreover, the strategy is taken to explore the phenomena in the local perspective and then to translate it to the general practices. The literature ensures that the findings are based on the general implication studies. Furthermore, the author of this project investigates how the study´s findings can inform about certain concepts and relationships and identifies other situations with similar concepts and constructs (Yin, 2011).

The number of interviews is limited in a timeframe of master thesis, perhaps larger sample could bring new insights, or bring strengths in certain claims. In order to minimize this limitation, contacted interviewers are prioritized in terms of their tenure and expertise.

2.5 Deliverable

This thesis project delivers two main deliverables:

1. Set of system requirements to be used to develop inter-firm disruptive innovation management practices.
2. An artefact in a form of *prescriptive model for* organizations to *manage disruptive innovation processes, the prescription of the elements of the model and set of recommendations.*

Despite the fact that the context is set for Infineon Technologies AG, the designed model is discussed in terms of generalizable implications for organizations with similar characteristics or goals.

2.6 Methodology chapter summary

This chapter explains how objectives and goals of this master thesis project are achieved through establishment of various research and data collection methods. First, rationale behind a chosen project approach, Design Science framework, is explained since it needs to match the goals of this project. Respective tools to carry out this project are presented as well. Next, sub research questions are useful in guiding the project flow in a logical and structured manner. The thesis project framework is presented below (Figure 4), next chapters will include this framework indicating stages being discussed (slightly modified for better visualization).

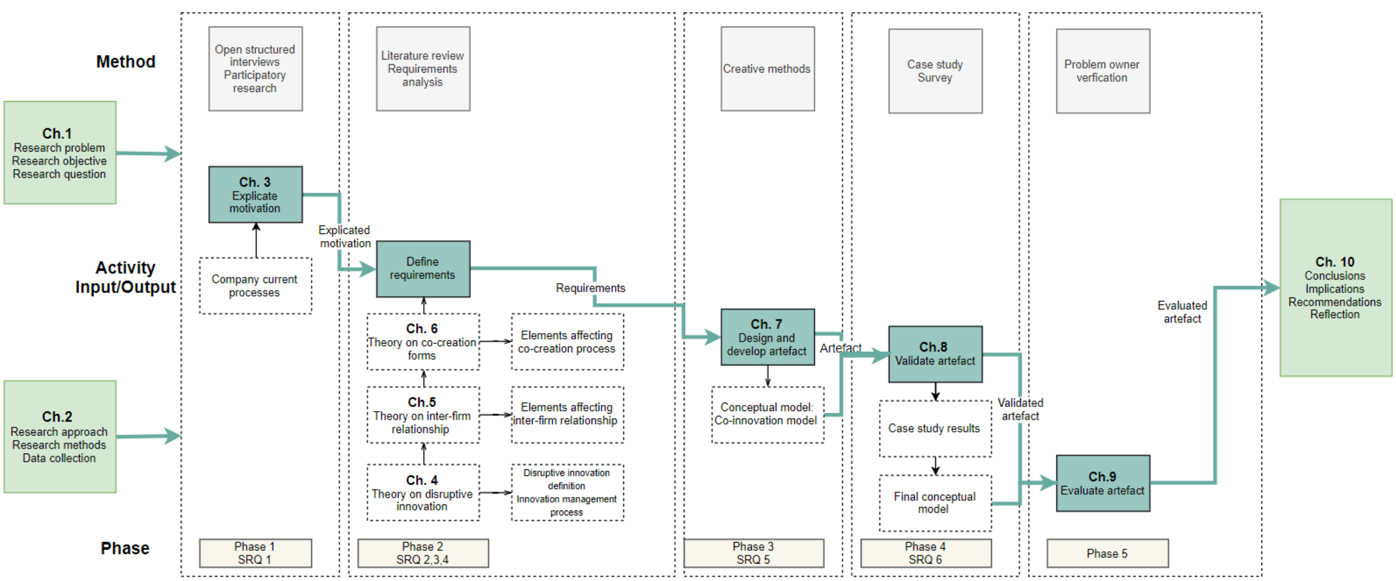

Figure 4 Thesis project outline

CHAPTER 3 EXPLICATE MOTIVATION

The first phase of the Design Science Project framework requires *explication of the motivation* (Figure 5). This chapter gives a brief overview of the current system and motivation behind researching this topic. As was explained in the methodology section, the problem focuses on the exploration of the opportunities. Therefore, the conventional problem analysis is not used. The first sub-research question is answered in this section:

1. *What are the opportunities in the current innovation management system?*

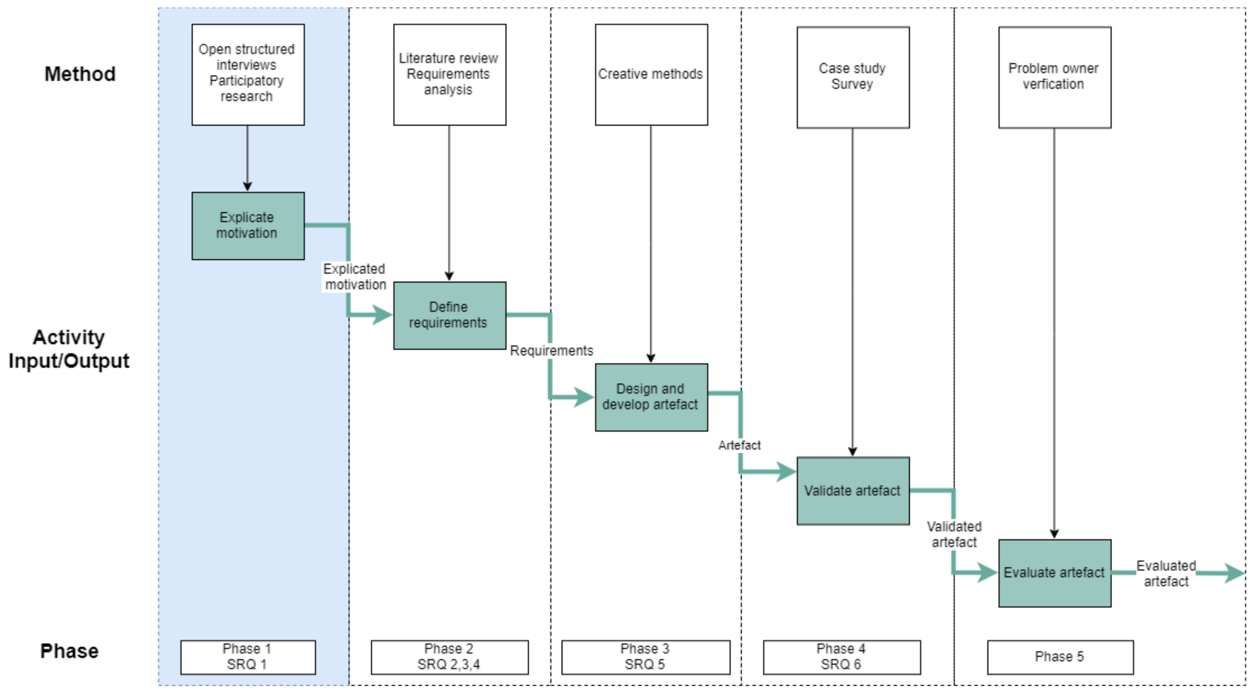

Figure 5 Design Science Project Phase 1

3.1 Current system as a thesis project context

The project context is given at Infineon Technologies AG. In order to better understand the organization´s structure, main points are presented on the procedures related to the innovation management and inter-firm relationships. The information is gathered through semi-formal meetings with employees of the company and internal documents. More detailed information on the semiconductor industry and the company´s processes are in **Error! Reference source not found.**, and the results of open interviews are in Appendix E.

The analysis on the semiconductor industry led by PWC, brings into light certain issues such as the fact that companies need to be able to distinguish themselves in new ways and bring distinct values for the market (Gloger, Rakesh, Ogrins, & Anand, 2018). This differentiation strategy ensures competitive advantage in midst of increased complexity of end technologies. Companies must be decisive about their value proposition and understand what their capabilities are. There is no one best strategy or solution for the emerging challenges, rather companies need to think in different ways to innovate their portfolio. There is no doubt that semiconductor industry will be continuously growing, however it needs to adapt quickly to emerging trends and challenges.

Infineon Technologies AG as a leading worldwide semiconductor solutions provider is also facing these challenges. The strong presence in the market achieved through a global R&D network in 36 facilities, 16 manufacturing sites and 47 sales networks across Europe, North America and Asia makes the business even more complex. The company has a divisional model serving 4 types of application groups (Figure 6):

- Automotive (ATV)
- Power management and multimarket (PMM)
- Industrial Power Control (IPC)
- Digital Security Solutions (DSS)

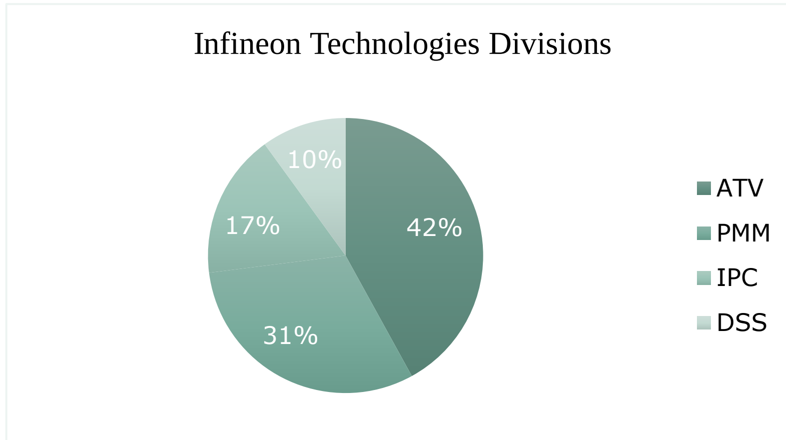

Figure 6 Infineon Technologies Divisions

Additionally, there are also functional departments at the company such as Corporate Supply Chain, Front End, Back End and many more. The author of this thesis is an intern at the Corporate Supply Chain Innovation department in Munich, which mainly deals with knowledge and education management, supply chain simulation and research, innovation services and order management (Infineon Technologies, 2018).

Investigating the topic of innovation management, the current innovation process follows a closed innovation system which integrates mainly market pull and to a lesser extent technology push (Rothwell R., 1995) and addresses incremental innovations (small continuous improvements to technologies). The basic innovation process at the company can be simplified to the following model (Figure 7):

Figure 7 Current innovation management at Infineon Technologies. Source: own illustration.

In general, employees are aware of the fact that disruptive (radical) innovations are extremely difficult. It is rather encouraged to stay within the boundaries of known market and known technologies (Ansoff matrix[1]). Therefore, employees are very focused on core business products, and do not have time for out-of-the-box projects. One of the employees emphasizes the point that innovation management for disruptive innovation is ultimately a strategic decision.

Despite some effort to encourage innovation culture, there are several points which are problematic in making company´s cultural shift. First of all, there does not seem to be a transparent overview of innovations being developed at the company, it often happens that the same ideas are executed in parallel. Moreover, technologies are developed behind closed doors of R&D where there is lack of communication between different units and functions. This is due to the fact that the company has very strong divisional model. Secondly, due to the fact there is constant

[1] https://www.mindtools.com/pages/article/newTMC_90.htm

focus on core projects, there is no space for experimenting, employees could use some extra time for "hobby projects". Thirdly, fast prototyping seems to be a big issue because there is no capacity to be able to obtain parts for prototyping. Trying fast and learning from it seems to be crucial in the semiconductor industry. Ideas are much easier sellable when can be presented with a minimum viable product. Employees asked drew attention to the current innovation management practices and confirmed that there are indeed no processes for innovation management of disruptive innovations. The biggest issue seems to be budget and resources, however when the topic was brought, they concluded that there is a lot of potential in developing environments that could stimulate such innovative environments.

Investigating the topic of inter-firm relations, the exploratory partnership is very limited. Usually partnerships are formed based on the needs of the Product Line Managers (PLM), where projects are already predefined. This also comes from the fact that the company has divisional model. The opportunity arises when considering potential partners who are not within the typical Infineon´s partner ecosystem, such as e-textile companies. On one hand, there are established partners who contribute to the incremental innovations (within core product portfolio of the company), and the relations seem to strengthen with more successful projects. On the other hand, it might inhibit the company from exploring new potential partners.

Investigating the topic of co-innovation, some efforts have been made in the past to address the challenges of disruptive innovations such as the Corporate Strategy 2007, Pelican group project 2012, or IFX Crowdfunding 2015 initiatives, however, they have not been implemented properly. The main problem was that research was still geared towards projects in the current portfolio, and the business strategies rarely address time horizons of more than 5 years (*Innovation Accelerator*, 2016). In 2016, Innovation Accelerator was proposed to nourish transformational innovation (disruptive ideas) and overcome the valley of death (see Figure 8). Despite well-functioning business processes for core low to medium risks business, disruptive innovations lack attention and structure. Despite these efforts, no sustainable structured emerged (Innovation Accelerator, 2016). Consequently, it resulted in many missed opportunities. Therefore, Infineon Technologies AG needs to develop sustained models to address these challenges.

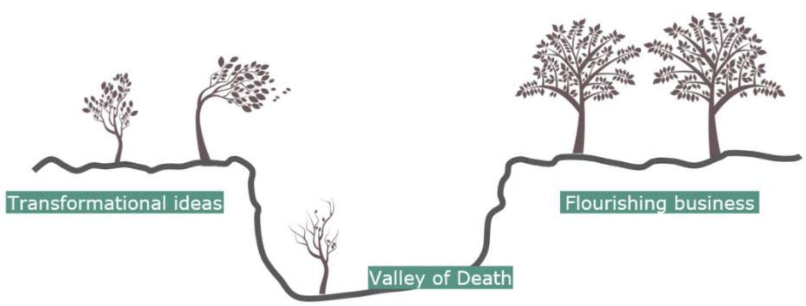

Figure 8 The Valley of Death. Source: Infineon Technologies presentation.

3.2 Thesis project motivation

Having understood the context of the current innovation and partnership systems, it is now possible to explicate the motivation. The first output of the framework is then explicated motivation.

Innovation is surely a practical topic which means that it involves actionable items in order to reach innovative solutions. Therefore, in order to investigate the implications of the innovation process, a case study on the company is used.

Infineon Technologies AG Corporate Supply Chain Engineering Innovation (IFAG CSC E IN) department undertakes several European co-funded projects such as Productive 4.0. The main objective is to "achieve improvement of digitalizing the European industry by electronics and ICT, open the doors to the potentials of digital industry and to maintain a leadership position in Europe". The project is divided into several work packages, key responsibilities of Infineon Technologies lay in the area of architecture and concepts, innovative Internet of Things (IoT) enabling components, framework – exploitation platform, automation and project management (Productive 4.0, 2017). There are also other projects connected to Productive 4.0, such as German co-funded project called GeniusTex. The objective of this latter project is to develop a complete value chain for smart textiles via an innovation platform and to strengthen the German economy in the long term and sustainably through new smart production processes, products and services in the areas of telecommunications, production and electronics.

In practice, the company has catered for customers´ needs to innovate its products through incremental improvements. However, it was usually a one-way interaction. Since, the company realizes the need to innovate in order to gain competitive advantage and develop capabilities in a digitized revolution, Infineon Technologies finds these type of collaboration projects as an opportunity to innovate together – creating a two way co-creating interaction.

Furthermore, Infineon Technologies wants to be at the forefront of the semiconductor industry by proactively trying to engage in innovative and digitalized projects. Thinking in an innovative way is paramount in a successful fulfillment of projects´ objectives. Nonetheless, these type of practices are new to the company, hence it has not yet developed capabilities to coordinate such complex innovation processes. It wants to implement new, effective and successful models / processes that can govern these complex interactions and to learn how to innovate.

The main objective for the case study company *is to explore ways to better coordinate relationships between partners, to find ways to innovate and to foster knowledge management practices*. Since Infineon wants to improve its innovation performance, certain *processes* need to be develop to stimulate innovation (Berkhout, Hartmann, & Trott, 2010). These type of projects go outside of the core business of Infineon (regarded as disruptive), there is no formal process for handling them. On one hand, there is a lot of space for generating ideas and developing innovative digitalized solutions, on the other hand it is difficult to maintain these ideas and create solid business cases. The problem lays in the discrepancy between disruptive ideas and incremental business ideas, as well as in the complexity of interactions between project and problem owners and solution seekers.

3.3 Initial business requirements

The purpose of developing certain capabilities such as innovation management systems needs to be aligned with the overall company´s objectives and business values. Since the company´s background was presented, the business requirements are specific for the company. These initial requirements differ from the requirements which will be formulated in the next phase of this project since they are based on the company´s motivation rather than on scientific basis.

For companies to stay competitive, they have to be profitable through bringing societal, economic and environmental benefits. Based on the business / problem owner´s objectives (Head of Corporate Supply Chain Innovation department), the initial requirements are as follows:

1) Customized innovation process which would be supported by people, information and innovation tools.
2) System which has the ability to effectively identify, define, evaluate and develop new innovations.
3) System which has the ability to facilitate creation of disruptive innovations.
4) More effective provision of products and services.
5) Deliver value to employees.
6) Deliver value to the communities / industries.
7) Bring economic, societal and environmental benefits.

These initial system requirements provide boundaries for this thesis project. Further research through literature review on the topics of innovation management and inter-firm relationship management would allow to enrich and redefine them.

3.4 Explicate motivation summary

The first phase of the Design Science framework requires an explication of the motivation which is explored through the analysis of the current system at the local practice (case study company). As was mentioned in the methodology section, the Design Science project is embedded in the local practice hence specific practical motivation for researching this topic is presented in this section. The first sub-research question is answered in this chapter.

CHAPTER 4 REQUIREMENTS: DISRUPTIVE INNOVATION

The output of the first phase which is *explicated motivation* can be used as an input for the second phase, *define requirements* (Figure 9). Knowing the motivation, the next logical step is to explore in depth the topics mentioned in the previous section. The requirements are generated based on the scientific body of knowledge which is a crucial component of the Design Science framework. This chapter covers the first building block of the second phase.

This chapter gives an overview of the literature on the topic of innovation. First, the theory on the disruptive innovations is explored through different concepts and definitions. In this section, the definition of "disruptive" is presented. Secondly, the evolution of innovation management is critically reviewed. Lastly, current trends on the innovation topics are presented. This chapter answers the second sub-research question:

2. *What is disruptive innovation? How is it managed?*

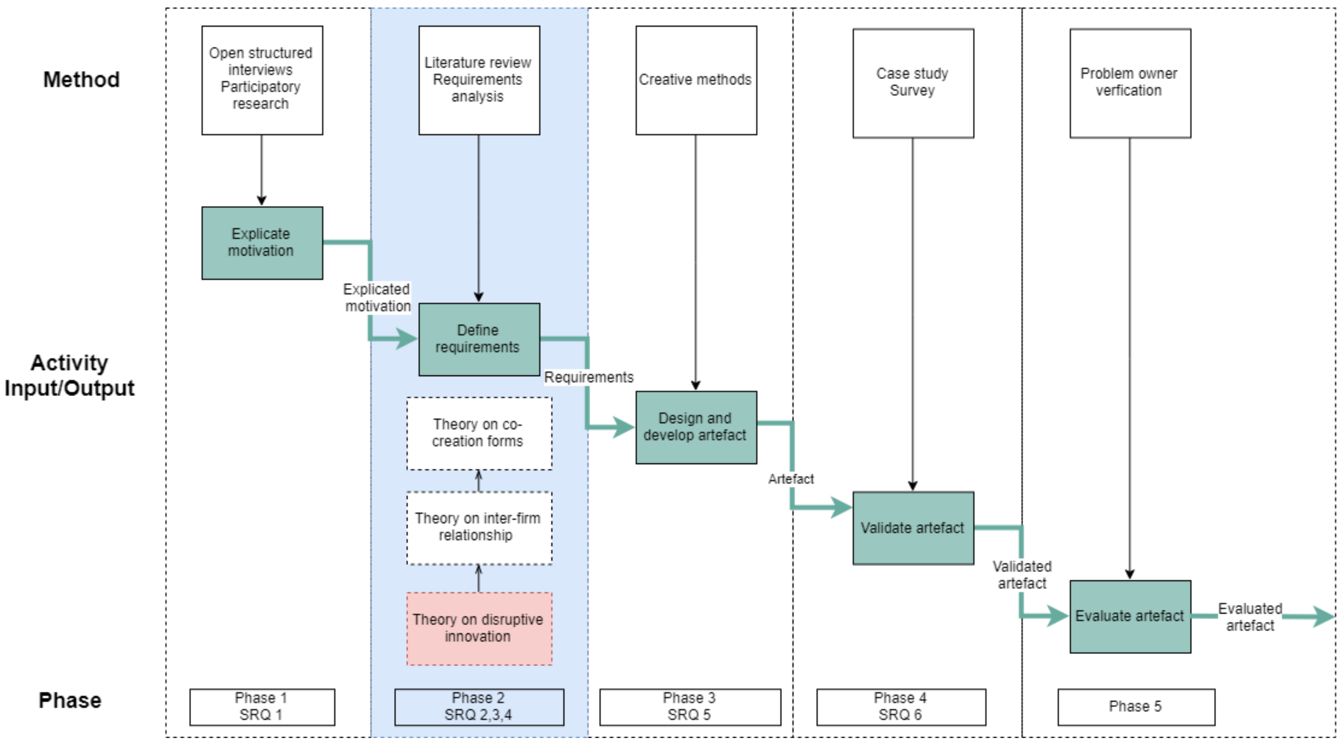

Figure 9 Design Science Project Phase 2 (disruptive innovation)

4.1 Disruptive innovation definition

Innovating is crucial for companies as this is the only way to stay competitive and enter new markets (Bremmers & Sabidussi, 2008). Companies need to face turbulent and highly complex environments (Xu et al., 2007). The competitive pressures in the form of increasing pace of technological developments, complexity of products and of depreciating equipment costs and of shortening product life cycles determine whether a firm stays in the market (Sampson, 2007), (Trott & Hartmann, 2009). Some other emerging challenges are shift in the socio – economic fields (e.g. more stringent environmental regulations) or in the lifestyle (e.g. increased mobility) (Tidd, Bessant, & Keith, 2005). According to the study of Tidd et. al., (2005), the average corporate survival rate for big companies is half as long as for a human. Innovation is crucial for businesses to grow and survive (S. Lee et al., 2012).

In the academic world, there does not seem to exist one authoritative and clear definition of innovation. The reason behind is that it has many different aspects, and research usually covers only one or a few aspects of innovation. Rowley and Sambrook (2009) conducted a content analysis on 60 definitions of innovation, categorizing them into six main groups according to

- Stages: steps in the innovation process (creation, generation, implementation etc.);
- Social: entity involved in the innovation process (organizations, firms, customers, and developers);
- Means: resources needed for innovation process (technology, ideas, market and inventions);
- Nature: form of innovativeness (new, improve, change);
- Type: output of innovation (product, service, process, technical); and
- Aim: outcome an entity wants to achieve through innovation (succeed, differentiate, compete);

Taking all these attributes of innovation, the definition of innovation is synthesized to: “innovation is the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace” (Rowley & Sambrook, 2009). These attributes are good basis for capturing the essence of innovation above the disciplinary context. Despite the fact that ´innovation´ is used commonly in plethora of research, very often the attributions of innovation are omitted. This might lead to confusion and applying unsuitable methods and recommendations. For example, one strategy for managing innovation might only improve a product, whilst the real aim was to create something new. Hence, the differences in approaching them is very crucial (Tidd et al., 2005). The ambiguity has also been observed by Veryzer (1998), who emphasized the fact that innovativeness depends on the perspective: whether a new technological capabilities needed to be developed or the way technology was applied. The criticality of this notion is also emphasized by Harvard Business Review article: “if we get sloppy with our labels or fail to integrate insights from subsequent research and experience into the original theory, then managers may end up using the wrong tools for their context, reducing their chances of success” (Christensen, Raynor, & McDonald, 2015).

Therefore, how innovation is managed is a key strategic issue for a company to undertake. Moreover, the rise of globalization and multi-discipline requires firms to go beyond their own discipline specific perspectives (Aelker, Bauernhansl, & Ehm, 2013). “Globalization and technological advances are driving organizations to extend the boundaries of R&D teams from traditional co-located settings to dispersed or virtual settings” (Berkhout et al., 2010).

Garcia and Roger (2001) also caution of the danger of ambiguous innovation term classification. They analyzed different dimensions of innovation by considering marketing and technological perspectives, as well as macro level and micro level of innovativeness. An innovation can become discontinuous (disruptive) from the perspective of market - innovation requires new marketplaces or new marketing skills; or from perspective of technology – innovation requires discoveries in science and technology (Garcia & Roger, 2001). A product might not be technologically breakthrough from R&D standpoint but can be for a market. Both perspective can be easily represented with S-curve phenomena (Figure 10).

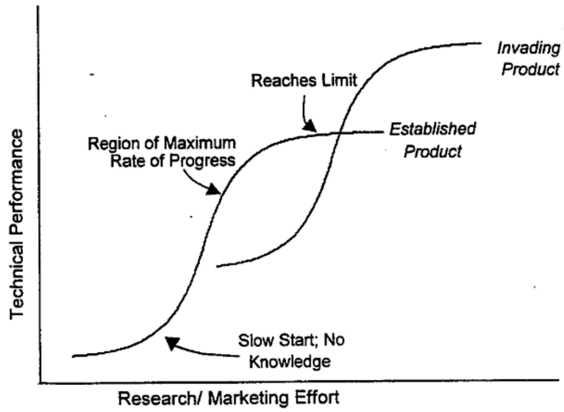

Figure 10 Technology - Marketing S-Curve Phenomena. Adapted from Garcia & Roger (2001)

The macro perspective compares the newness of innovation to the world, and is exogenous to the firm. It is somewhat ambiguous to know at present time if the innovation is actually ´innovative´ to the world since it can only be judged from the perspective of time, examples include World Wide Web, Watt steam engine or telegraph (Evanthia, 2016). The micro perspective perceives innovativeness in terms of firms´ own operations, capabilities and competencies. It shows differing perceptions of firms´ innovation. The same product might be disruptive for one firm but not for the other, e.g. For IBM, manufacturing electronic vehicles would be a discontinuous innovation, but for General Motors it would be just incremental innovation. An innovation that is disruptive for a firm might be both on the micro and macro level.

Additionally, the nature of innovation should not be categorically classified but rather seen from the continuum perspective, as observed by Robbins & Gorman (2014) this continuum "depends upon perceptions of those familiar with the degree of departure of the innovation from the state of knowledge prior to its introduction".

Creating innovations that are both technologically and market disruptive, from macro and micro level can hardly be planned. These innovations diffuse and spread along the S-curve making it very difficult to classify inventions. On the other hand, a micro-level perspective is much easier to influence, as there are certain measures the company can do to innovate. Garcia & Roger (2001) gathered several measures that can assess whether an innovation is new to the market and /or new technology (see Table 3). If the company wants to generate radical ideas, it can use these measures to assess that. Whether a company can become innovative depends on many different factors such as the culture of the company, the incentives or the talent network. Therefore, this project focuses on the micro-perspective. Disruptive / discontinuous / transformational innovations terms are used interchangeably and are regarded from firm´s perspective.

Table 3 Micro perspective on marketing and technology. Adapted from Garcia & Roger (2001).

Micro – level perspective on marketing	**Micro – level perspective on technology**
• Customers/ clients totally new to the firm • New market approach (customer contact, advertising promotion) • New competitors for the firm • Product use (needs served) new to the firm • Class of service/product totally new to the firm • Improvements / revisions to existing company products • Satisfies clearly identified customer / client need	• Newness of the technology: how large is required technology change in order to develop the product • Science and technology knowledge base newness to firm´s R&D • Production process new to the firm • Product technological newness to the firm • Modification of technology currently in use at the firm • Degree of difference for other products in technical characteristics or specifications

• Fit with managerial skills and preferences / expertise / resource capabilities • Firm´s prior experience for selling product in this line of business • Product / service was more complex than we have introduced into the same market • Responds to important changes in customer needs / wants • The product technology is new to the customer	• Complexity of manufacturing technology

Radical innovation is about creating unique ideas with long term value that would provide high performance benefits, the ability to create new opportunities or cost reductions (Frishammar et al., 2016). Moreover, it needs to bring economic values and be known to other actors. Inventions on the other hand are ideas that do not necessarily go beyond firms´ walls (Bogers & West, 2012). Therefore, innovation is seen as a transformation of inventions into business values (Sandberg, 2002).

Disruptive innovations entail unknown grounds and methods, unexpected events, inevitable failures, unfamiliarity, uncertainty and lack of control (Phillips et al., 2006). It is not only challenging to manage these externally, but also internally. Very often these innovations would compete with internal projects (Frishammar et al., 2016). As was observed from the literature, radical innovations are complex. Therefore high technical expertise, high creativity level, intensive research, high understanding of the market, and high engagement with network actors are needed.

4.2 Innovation management process evolution

The literature on innovation management process is extensive and goes back to the beginning of 20th century. The first innovation models present closed innovation in which companies developed ideas internally (Linnarsson & Werr, 2005). The most common steps undertaken are idea generation, idea development, production, marketing and distribution. Firms usually would use internal resources and capabilities (leadership styles, human capital, and in-house technologies) to go through these stages. It was a typical technology push process. Research and development (R&D) department would use basic science to develop technologies or products, and then marketing and sales departments have to adjust their approach to what was invented (Figure 11). With the rising complexity of customers´ needs and wants, it became more difficult to just push technologies. On the opposite side, a market pull emerged which would mainly take sources of information from the market (Figure 12). Companies developed different ways to generate ideas through integration of cross-functional teams, inter-departmental communication or knowledge management software systems (Min et al., 2005), (Schilling et al., 1998). It was observed that there was a big imbalance between market pull and technology push, therefore research scientists developed various models to couple these approaches (Figure 13). For example, by putting team members from various functional silos. However, internal innovations were not competitive enough hence firms started to look outside of the boundaries of their walls to ensure their competitiveness.

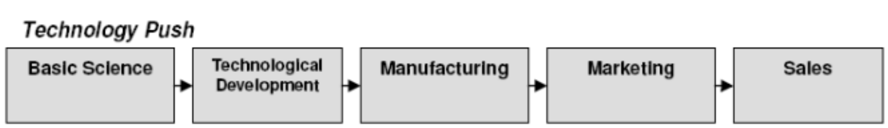

Figure 11 Technology Push Innovation Model. Adapted from Preez & Louw (2008)

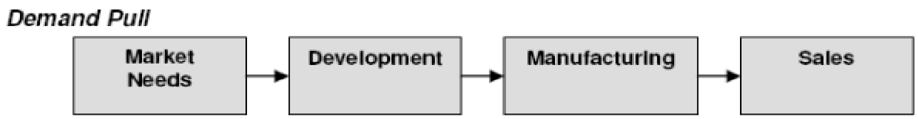

Figure 12 Market Pull Innovation Model. Adapted from Preez & Louw (2008)

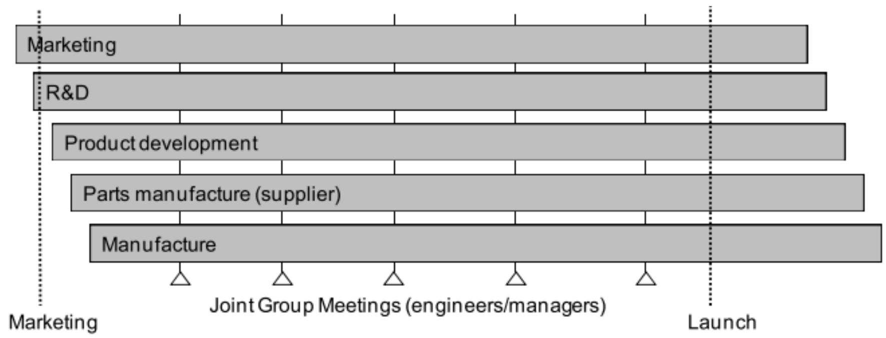

Figure 13 Interactive Innovation Model. Adapted from Rothwell R. (1995)

Consequently, the next wave of innovation models emerged, entailing collaborative innovation process. External resources were utilized to improve the value chain. This was reinforced by the development of ICT, which allowed firms to collaborate across the globe. Research suggested that interactions with external actors and sources led to generating high innovation performance by successful innovators (Wagner, 2008), (Jiang & Li, 2009). Networked structured combined core competencies and expertise of organizations to create a value more relevant to customers´ needs (Romero & Molina, 2011). That resulted in creation of partnerships, strategic alliances and joint ventures (Preez & Louw, 2008) (Figure 14).

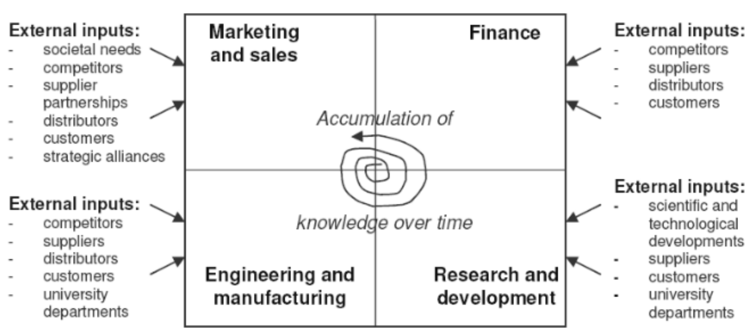

Figure 14 Networking Innovation Model. Adapted from Romero & Molina (2011)

In the beginning of 21st century, open innovation concept emerged. Collaborations were not confined between companies, but also were open to research institutes, communities, universities and individuals, which resulted in utilization of external and internal paths (Preez & Louw, 2008). The idea of keeping secrets behind confined walls of a producer as sole source of innovations is being challenged (Saragih & Tan, 2018). The globalization and rapid spread of information in a digitized society calls for new models.

Open innovation was seen as being more suitable for radical innovations, as input was taken from all over the globe (Bogers & West, 2012). The relations between firms have been exemplified with less rigid procedures and more explorative alliances. In the literature, it has been observed that inter – organizational networks are key since they are the source of knowledge and learning. These on the other hand will lead to creation of new knowledge base for product and process innovation (Avans, 2017) (Figure 15).

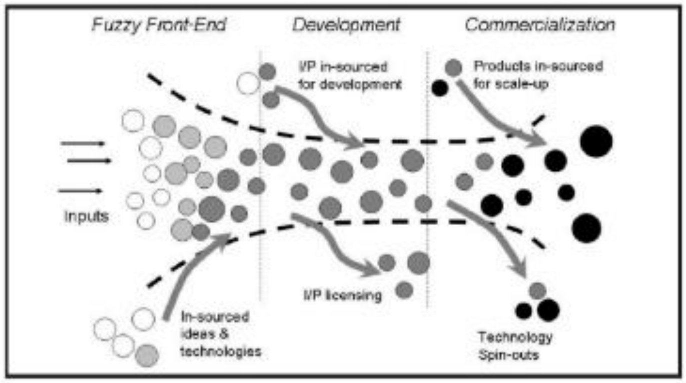

Figure 15 Open Innovation Model. Adapted from Chesbrough (2006)

There are many different innovation models, and researchers are constantly adapting their models to accommodate emerging challenges. Old models might not be very relevant with today´s interconnected world, new technologies and new organizational structures. Researchers put efforts in overcoming research limitations and use more real life examples. Table 4 summarizes innovation model generations identified in the literature.

Table 4 Innovation management evolution. Source: own illustration

Type	Generation	Model	Characteristics	Authors
Closed innovation: develop competencies internally	First	Technology push	Linear and sequential process, innovation originates from R&D solely	Myer and Marquis (1950)
	Second	Market pull	Linear and sequential model, innovation originates from market	Roberts Uttterback (1970)
	Third	Coupling model	Integrating R&D and marketing	Cooper RG. (1990)
	Fourth	Interactive model	Integrating technology push and market pull	Rothwell R. (1995)
Collaborative innovation: entering new forms of partnerships, strategic alliances, joint ventures, licensing, patent sharing	Fifth	Networking model	Integrating external linkages, system integration and knowledge accumulation	Swan et. al,. (1999)
Open innovation: collaborations not restricted to only firms but with external parties such as research institutes, universities, individuals	Sixth	Open innovation	Integrating internal and external ideas	Chesbrough H. (2006)
	Seventh	Co-innovation	Integrating various internal and external sources, collective intelligence	Von Happel et al., (2011) Chesbrough H. (2012)

4.3 Management of disruptive innovations

Having explained the different aspects of innovation and the evolution of innovation on a strategic level, the most important issue in this topic is *How to manage these innovations successfully*? As presented in the previous paragraphs, innovation is a process, and its outcome can be influenced by different success factors. Therefore it is a process that can be managed (Tidd et al., 2005). This project tries to capture the most important elements of innovation process which would not result in a rigid structure but allow for a dynamic capability.

Innovation management is “a practice undertaken to manage innovation or new product and new service development process” (Oke, 2007). It involves sequencing of activities with complex system coordination, integration of strategy, technology, operations, structure and human resources (Xu et al., 2007).

The opportunity arises when considering radical innovations since large and established corporations usually have very sophisticated and perfectly developed strategies for core innovations (optimizing existing products for existing customers) (Un, Cuervo-cazurra, & Asakawa, 2010). In contrast, transformational innovations are much more difficult to manage. Managing disruptive innovations is extremely challenging because technologies and markets are unknown for the focus company. There are high financial risks. The process is messy and needs to be iterated several times. Moreover, there is a high degree of uncertainty since traditional financial measures such as ROI or net present values are not suitable (Mcdermott & Handfield, 2000).

In managing disruptive innovations, a well-known stage gate process has been perceived as having many flaws (Figure 16). The main limitation is that it is a linear process prone to missed opportunities. It focuses on the components of the whole system, at specific gates and at specific economical values. Innovation process should be seen holistically, by taking the whole value chain (Berasategi, Arana, & Castellano, 2011). The innovation process “should not be forced into a simple one way pipelines, but rather be organized by interconnected cycles with feed forward and feedback connections, from linear to non-linear thinking” (Berkhout et al., 2010).

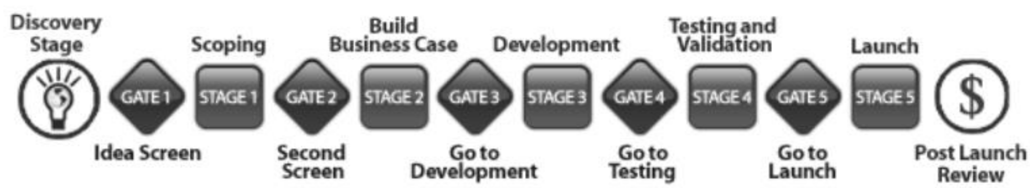

Figure 16 Stage Gate Innovation Model. Adapted from Cooper RG. (1990)

Some authors in the area of innovation management tried to tackle these flaws and developed models and processes for managing disruptive innovations. Despite these efforts, it is still very ambiguous whether these models can be implementable and whether they reach the goal – creating disruptive innovations. Nevertheless, a literature on this topic was thoroughly examined by looking at the key influencers of innovation model development (from 90s to present times). The results of the key issues from literature review are presented Appendix F.

It can be observed that models for disruptive innovations should have a right environment to encourage exploration through network effects. A synthesis on these innovation models suggests the following:

- Innovation model includes mostly these stages: strategic frame / insights, opportunity identification / idea generation, concept development, concept evaluation / feasibility, development and implementation.
- Innovation can be regarded as market or technology disruptive.
- Integration between stages is crucial, the discrepancy leads to loose connections. Emphasis on holistic view.
- Innovation process needs to have exploratory approach and include flexible processes. Rigidity kills innovation.

Keeping in mind that the model should have exploratory and flexible approach, for the sake of visualization and based on the above mentioned observations, the following model captures key points (Figure 17). The method used to capture key observation follows Preez and Louw (2008).

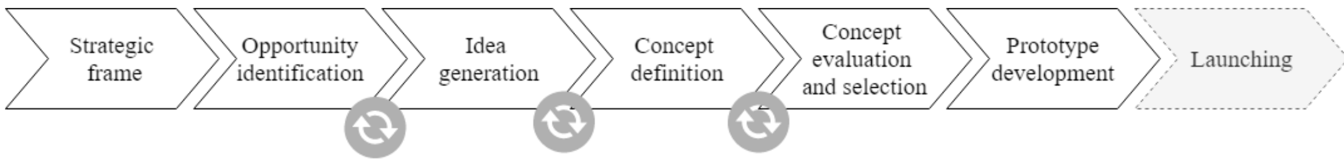

Figure 17 Innovation process. Source: own illustration

In comparison to sequential model which in many research studies have been shown inadequate to the innovation processes (Teece, 1989). Innovation process requires rapid feedback and quick learnings (Teece, 1989). Therefore the process is composed of consecutive steps, however they are interlinked with loops. Moreover, it has to be transparent, as mentioned in the research "independent research activities often proceed down identical or near identical technological paths, this is often wasteful and can be minimized if research plans are coordinated" (Teece, 1989)

The first focus point is to define the strategic frame and align that with the company (Aagaard, 2008). The strategy allows companies to identify opportunities and set the frame to gain competitive advantage. It is about setting an overall ecosystem in which business objectives, people and processes are in place (Romero & Molina, 2011). In this phase, not too many rigid objectives should be defined as this might affect the radicalness of innovation (Wagner, 2008). This phase should rather include decisions related to the platform for generating and identifying ideas. The vision of the company can be introduced to product strategy or product platform strategy (Aagaard, 2008). In either way, company needs to be aware of its capabilities and technologies at hand. Factors that supports this phase are: articulation of strategic actions, investing in organizational enables, keeping attention, developing organizational mechanism that supports innovation creation (Aagaard, 2008). It is important to emphasize the fact that the willingness for companies to innovate needs to be internal.

The second phase it the opportunity identification which involves creative phase where individuals recognize opportunities in the plethora of options that are out there (Aagaard, 2008). In this phase employees explore and experiment (Brown & Eisenhardt, 1997). They would combine different discipline and knowledge across without considering any constraints. At the same time, they need to evaluate the potential stimuli for an organization. It is about proactively generating seeds for opportunities to develop (Preez & Louw, 2008). In this phase more information is known from partners, competitors, customers, markets and technologies. Here, the company goes beyond its own capabilities. Factors that support this phase are: dispatching brokers and bridges innovators or using the web (Katzy, Turgut, Holzmann, & Sailer, 2013). In this phase, companies basically search for other companies who can bring opportunities and identify potential technologies or partners.

The third phase is idea generation which is an active process of generating various ideas. This step is highly intertwined with the previous steps, because once the opportunity has been identified, thoughts and ideas can be combined to create a major idea (Robbins & Gorman, 2014). Very often inventions would sources from problem solving issues. Factors that support this phase are various creative tools such as brainstorming, focus groups or workshops (Aagaard, 2008). It is important that these activities are semi-formalized, as ideas should not merely reside in ´people´s heads´ but be available for other people (Preez & Louw, 2008).

The fourth phase includes concept definition which is a transformation of technologies into products, and workable concepts (Veryzer, 1998). Different combinations are generated, these can be done in parallel through organization structure, or the number of concepts can be distributed between various knowledge actors (McDermott & Colarelli O'connor, 2002) Some other basic information needs to be included such as product requirements, components and specifications. In order to foster creativity, there does not need to be clear or well defined idea selection, it should be left to the responsible people to develop concepts that most resonate with their skills and capabilities (Robbins & Gorman, 2014). In traditional innovation management practices, in this phase many ideas are usually killed or abandoned. Therefore, openness and experimentation need to be encouraged. This phase should serve as a learning experiences, and follows fail fast but smart principle (Preez & Louw, 2008). Furthermore, customer voices are usually not included (Veryzer, 1998).

The fifth phase puts more formal structure to the process, which is concept evaluation and selection. Companies assess concepts on the evaluative criteria such (Aagaard, 2008):

- Marketing (market trends, market potential, competition)
- Technology (concept novelty, technical feasibility, skills availabilities)
- Business (time to market, strategic alignment)
- Human factor (usability assessments)

Research by Monczka et al., (2010) shows good practices of large corporations to evaluate ideas. It has been argued that for radical ideas, a separate dedicated business unit which could evaluate and select ideas is beneficial as it ensures dedication (Björk, Boccardelli, & Magnusson, 2010). Moreover, in order to ensure flow of radical ideas, some level of uncertainty and exploration needs to be accepted. Moreover, transparency and knowledge how to move forward should be assured by for example an "innovation team" (Björk et al., 2010).

The sixth phase, prototype development is also critical in the innovation process because the benefits of connecting external and internal links are highlighted. Companies can work together to build prototype where expertise and knowledge of people are shared (Midler, 2008). Innovation might involve ´architectural integration´ which means involving the upstream area of cooperation (Midler, 2008) This phase includes project planning, the management of the design and engineering phases. The core team is comprised of the project managers and engineering specialists. The planned product are communicated to the marketing team, however their role is still small. Prototypes need to be tested as well and modified if needed. Since the product might be radically new and not well known by mass customers, it is recommended to involve lead users (Lilien et al., 2001). Their information might be useful for technicalities, but as addressed before users should not determine the whole course of actions as this might inhibit the innovativeness.

The last phase is launching, which shifts the focus towards production and supply chain issues. Once prototypes passed all the necessary testing and usability activities, the final decision for launching needs to be made by a firm. It is important to emphasize the possibility for companies to stop before the product is marketed (Midler, 2008). Since companies have their own operations scaling up of products needs to be considered. This last phase concerns the development and rollout of the new innovation which concerns product development issues and goes beyond the scope of master thesis, this project excludes a launching phase.

4.4 Disruptive innovation sub-conclusion

This chapter brings the topic of disruptive innovation by first synthesizing the literature on the definition of disruptive innovation, reviewing various innovation management practices and finally analyzing how the literature dealt with disruptive innovation processes. Taking micro – perspective, innovation is disruptive when a company enters new market and /or develops new technologies. The first innovation models dating back to the beginning of 20th century represent closed systems, internal to the company. New challenges triggered the development of new models - open systems allowing for integration of internal and external forces. Nevertheless, it has been found that the management of disruptive innovations must be treated differently. Hence, this chapter concludes with the description of the main points that have to be considered when dealing with disruptive innovations. The illustration of the innovation management process and its description is presented. Second sub-research question: *What is disruptive innovation? How is it managed?* is answered.

CHAPTER 5 REQUIREMENTS: INTER-FIRM RELATIONSHIP MANAGEMENT

Previous chapter shed light on the topic of innovation management. The trends show that network effects and collaboration are increasingly important. Companies can no longer depend on their own resources, and therefore need to look outside of their walls. This chapter gives an overview on the topic of relationship management between firms. Chapter 5 serves as one of the building blocks for the requirements development (Figure 18). The third sub-research question is explored in this section.

3. Why is inter-firm relationship important for management of disruptive innovations?

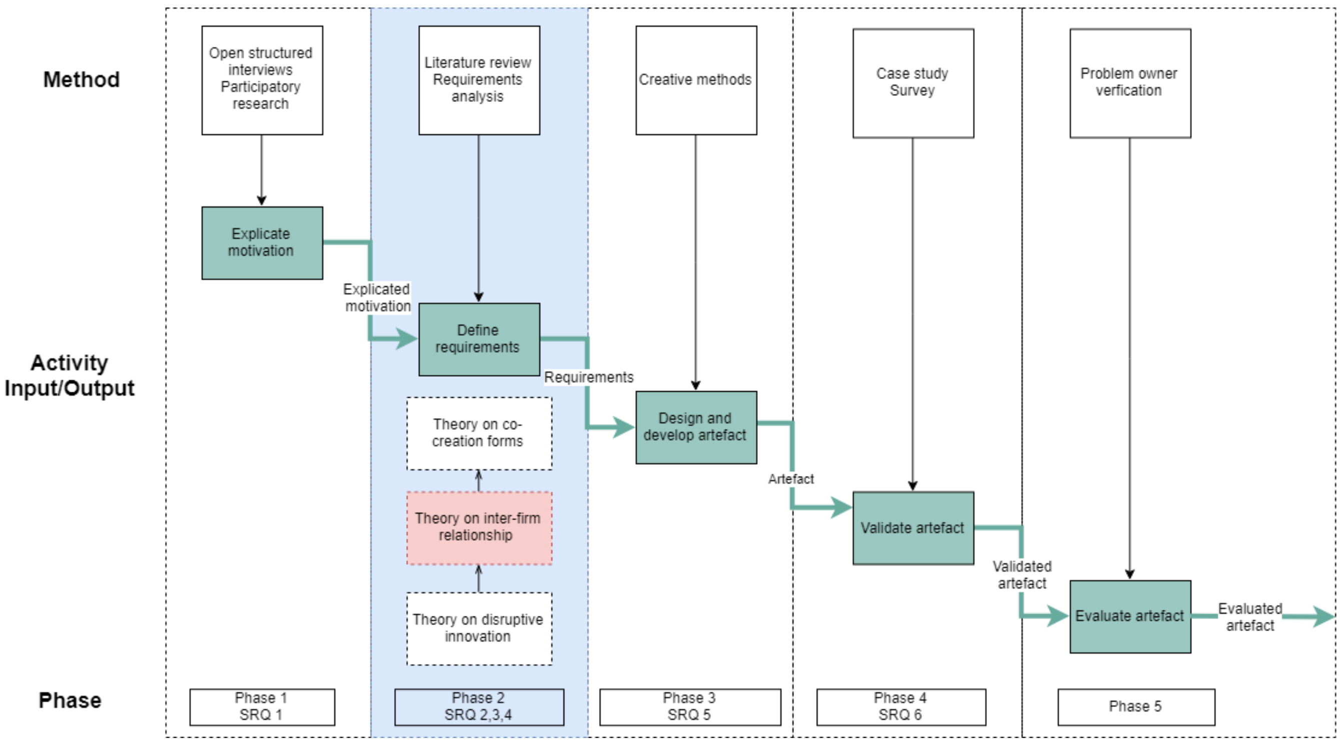

Figure 18 Design Science Project Phase 2 (inter-firm relationship).

5.1 The importance of inter – firm relationship management

Increasingly, the relationship management becomes a strategic decision which can bring competitive advantage through leveraging knowledge networks (Aarikka-stenroos, Jaakkola, & Helkkula, 2015). Some of the benefits for entering partnerships are decrease of development costs, shorter time to market, better customer requirements capturing, higher quality of products and services (Maloni & Benton, 1997). Relationships can be built with suppliers, customers, manufacturers, third part providers but also with competing companies. Coopetition is the concept in which competing companies cooperate because together they can leverage more, by for example exerting the same infrastructure (Frow, Nenonen, Payne, & Storbacka, 2015). For example, car manufacturers developed cars based on the Internal Combustion Engine (ICE). Despite the fact that each car manufacturer proposes very different product portfolio, they all include very similar components. As can be seen, relationship management is an important decision as it can help companies become market leaders.

Relationship building is advantageous not only in the cost-savings situations but also in the area of innovation. Research suggests that interaction with external actors and sources led to generating high innovation performance by successful innovators (Wagner, 2008), (Jiang & Li, 2009). Scholars agree that "a substantial part of the innovation occurs between buyers and sellers" (Roy, Sivakumar, & Wilkinson, 2004). In the research by Roy et al. (2004), the authors show that the interactions between partners lead to generation of incremental and radical innovations. An interesting observation was made by Romero & Molina (2011) stating that "a source of innovation will be companies from other industries, because we know the most innovation is based on a recombination of existing knowledge, concepts and technology". Moreover it is perceived as an interactive process in which exchange of knowledge leads to a learning process. That by itself is already creating an innovative environment, which is not constrained by a particular mindset of the company (Liao, Hu, & Ding, 2017).

Moreover, as has been examined in the literature, inter-firm relationship built on trust, collaboration and effective communication encourages partners to experiment and take risks, consequently nurturing innovative alliances (Jamali, Yianni, & Abdallah, 2011). Therefore close examination of the elements affecting inter-firm relationship is important, especially if the company wants to build an innovation ecosystem.

Despite many benefits, the relationship management process is a complex and difficult to manage. Companies need to understand the different factors that result in successful cooperation. That would include building, monitoring and assessing these interactions (Andersen & Kumar, 2006). In making strategic decisions for entering partnerships, risks should be included as well. These risks could include opportunistic behaviors, disagreements and conflicts (Sivadas & Dwyer, 1998). Moreover, there is no one governing body who could monitor communication between parties.

5.2 Types of inter-firm relationships

Relationship management in the innovation management is important however it should not be treated uniformly across all actors. Depending on the actors involved whether it is a customer, a supplier or an external party, the strategy to handle these relationships would be very different. Some of the considerations are the extent of involvement, the type, the intensity and many more. Once these factors are assessed then certain activities can be advised. Therefore, different types of relationships would lead to different ways of managing them (Berasategi et al., 2011). This might require the development of new complex combination of internal and external collaborations which can be achieved through new product/services or process innovation of new business models (S. Lee et al., 2012)

Snehota (1995) developed buyer-seller relations through four different dimensions: *actors*, *activities*, *resources* and *schema*. By analyzing various relations between these dimensions, they identified interactions which are formed over time, these are: *actor bonds* (actors´ each other perception), *activity links* (ways of doing business such as connecting technical, administrative, commercial activities*)*, *resource ties* (actors´ resource allocation and connection of resources elements such as technological, material, knowledge, finance etc.) and *schema coupling* (actors´ goals alignment) (Snehota, 1995). These layers are dependent on each other due to the network effect.

Scholars have developed various schemes to empirically explore above mentioned bonds. Due to the fact that these bonds and layers are not bounded by strict measures, scholars have generated many different categories and interpretations of these complex relations. The results of the literature review can be found Appendix G. The analysis of the literature brought evidence that the relations can be categorized into: relational, structural, resource and strategic dimensions. The remaining of the chapter explain them in more detail.

5.2.1 Relational dimension

In terms of the categories of the relationship management, early studies point out into the characteristics / attributes / competencies / aspects / dimensions / factors which are usually referring to similar elements (see table Appendix

G). These are internal structures within the relationship relating to the actor bonds. It refers to the perceptions of each other. As was mentioned before, the perception is most of the time presented from only one side (Inemek & Matthyssens, 2013). However, the results of these studies show that regardless of the perspective these "attributes / competencies" are significant. Therefore, it is clear that there is a category related to the actor bond (Snehota, 1995). The latest study puts it in a category either "relationship" or "relational". In dyadic relations considered in this paper, this relational category would refer to each party's consideration over its partners´ goals and needs. Moreover, these are exhibited through behavioral attitudes (Kim, Choi, & Skilton, 2015). Relational dimension determines the continuum of behavior that parties exhibit towards each other, it basically mobilizes or obscures resources in the relation (Kim et al., 2015). When parties intend to establish long term commitments and have high trust, then the relationship takes form of a partnership (collaborative). When commitment and trust are low and some conflicts might arise, then the relationship have rather transactional orientation (opportunistic) (Kim et al., 2015). From the literature (refer to Appendix G), the relational dimension can be measured through trust, commitment and coordination.

The relational dimension in the literature most often includes:

- Trust

It refers to "the extent to which one partner may depend on another to look after its business interests" (Roy et al., 2004), (Morgan & Hunt, 1994). Studies show that this dimension is one of the most crucial element of a relationship. Trust can refer to competence trust which is the firm´s trust in another firm´s abilities and capacities to fulfill their obligations (Sivadas & Dwyer, 1998), (Sharma, Young, & Wilkinson, 2015). It can also be a goodwill trust which is an implicit form of trusting a firm that it would look after its interests (Wong, Wilkinson, & Young, 2010). The interactions are more informal and higher knowledge sharing is enabled through higher trust (Roy et al., 2004).

- Commitment

It refers to "an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it; that is the committed party believes the relationship is worth working on to ensure that it endures indefinitely" (Mentzer, Soonhong, & Zacharia, 2000), (Mohr & Spekman, 1994). Parties expect that the relationship will be continuous, and that resources will be put to keep that relationship and future support (Roy et al., 2004) The higher the commitment the longer term relationship is expected. On the other hand, low commitment might mean focus on short term benefits only.

- Coordination

It refers to the "boundary definition and reflects the set of tasks each party expects the other to perform" (Mohr & Spekman, 1994). Actors act according to each other's needs and expectations. This element goes under the relational category as it is difficult to measure and is dependent on the parties´ willingness to coordinate and cooperate. High level of coordination leads to collaborative environment, whereas lower level of cooperation leads to competitive environment or arm length´s transactional nature (S. Lee et al., 2012).

5.2.2 Structural dimension

Another emergent category considers implementation issues or operational issues. It has more structured and controlled form which can be agreed upon between the two parties (Mentzer et al., 2000). Referring to Snehota (1995) on buyer – seller relations, this category refers to the activities links. It mostly involves joint issues such as joint programs, or conflict resolution techniques. Under this implementation category top management support, communication and conflict resolution can be included (Mohr & Spekman, 1994), (Sivadas & Dwyer, 1998), (Roy et al., 2004). In other words implementation issues could go under the *structural* category. As it refers to purely structural dimension in terms of activity links and the amount and frequency of interactions (Kim et al., 2015). It usually refers to the quantity, scope and mode of communication which does not necessarily refer to the attitudes of each parties (Roy et al., 2004). Hence, the structural dimension can be measured through communication, interaction frequency, multiplexity and conflict resolution.

The structural dimension in the literature most often include:

- Communication

It refers to the sharing of knowledge between parties through collection and management of information which would lead to effectiveness and efficiency (Morgan & Hunt, 1994). This is especially important for supply chain issues (Liao et al., 2017). For example, through collaborative forecasting, planning and replenishment (CPFR), suppliers know in advance what their customer´s demand will be (Mentzer et al., 2000). This goes along the value chain. Some benefits such as cost savings and reduction of inventories are observed (Min et al., 2005). The higher and more relevant information sharing, the closer the relationship can become (Mohr & Spekman, 1994). Information sharing is directly connected to communication, when information sharing is effective, meaningful and on time, the quality of communication is higher (Sivadas & Dwyer, 1998).

- Interaction frequency

Interaction frequency refers to the number of interactions both parties are committed to. It has been widely researched as this can be easily tracked by collecting the number of meetings, e-mail exchangers etc. (Roy et al., 2004)

- Multiplexity

Multiplexity refers to the number of links, layers and connections between parties (K. M. Lee, Kim, Cho, Goh, & Kim, 2012). This could also mean that various hierarchies have opportunity to communicate between different team functions, project leaders etc. (Roy et al., 2004).

- Conflict resolution

It needs to be in place in case there are any conflicts. It is an important issue since it really shows how committed companies are. As observed by Mohr & Spekman (1994) "the manner in which partners resolve conflict has implications for partnership success". There are many different techniques for conflict resolution, depending on the degree of quality. For example, in some cases parties would engage in a cooperative joint problem solving, in other cases a third party arbitration could be involved (Mohr & Spekman, 1994). This could also be tied up to the clarity of agreement since it provides mechanisms for mutual understanding on the terms and conditions (Sivadas & Dwyer, 1998).

Relational – structural matrix & innovation

Based on the above partnership attributes, Kim et al., (2015) developed a framework which captures collaboration through relational dimension (quality of relationship) and structural relationship (intensity of exchanges between parties). Depending on the level of relational and structural configurations, a partnership can be categorized into one of the four boxes (see Figure 19), (Johnsen & Ford, 2001). This framework is particularly important in the innovation management context since it tries to relate relational – structural dimensions to the patterns of inter-firm innovation

Moreover, it takes dyadic settings, which includes the perspectives of both parties rather than focusing on firm´s level. Hence certain dyadic configurations can help with defining the steps taken to achieve objectives e.g.

transformational innovation products. To illustrate how these configurations relate to the innovation topic, the following scenarios are analyzed:

Relation / Structure	Transaction orientation	Partnership orientation
High intensity		
Low intensity		

Figure 19 Configuration and pattern of inter-firm innovation. Adapted from Kim et al. (2015)

The partnership orientation - high intensity involves high commitments and rich information sharing. Usually, the type of innovation is incremental since parties have complementary skills and resources (e.g. seating system supplier and car maker). Moreover, the innovation is systemic, taking an overall product as a whole. Both parties focus on improving technical abilities and product / service features. Once parties are categorized in "grey box", formal agreements need to take place (Kim et al., 2015). Moreover, this type of relation is suitable for typical buyer – supplier relation. Partnership orientation with high intensity are especially suitable for complex products and uncertain markets (Kim et al., 2015). Routines and operational aspects need to be formalized. The risk with this type of innovation is that once certain first innovations have been established, in the long term too close collaboration may undermine innovativeness since partners get used to each other (Kim et al., 2015).

Partnership low intensity describes relations which are responsive but at the same time autonomous ("black box") Most of the time, the relation would depend on the project / product. It gives higher flexibility for both parties since for some projects one party might have higher stake, for some other party the other way around. This relation seems to be the most suitable setting for sustaining innovations long-term. This suits especially with businesses which are not in the same business area, because on one hand there is high trust and commitment but the operations do not need to be highly integrated. It provides higher opportunity to leap the benefits and find each other's innovation gaps.

Transaction – low intensity is typical outsourcing relationship through exchange of goods. For example, a buyer buys components fully developed by a supplier. There is low opportunity for disruptive innovation because the communication is unidirectional and piecemeal. This partnership is categorized as "white". Transaction oriented – high intensity has a form of exploitation partnership, in which one party wants to leverage capabilities and maintain its power. It combines white box with black box which can be called "zebra category".

5.2.3 Resource dimension

Referring to the literature review on inter-firm relationship (Appendix G). The third category that emerges in the newest studies refers to the resource structure (Park & Lee, 2018). These are external to relationships since they are built within each individual company. Referring to Snehota (1995) scheme, these relations refer to resource links. They can be regarded as external factors since they refer to the company´s expertise and resources which were built before any potential partnership commenced (Roy et al., 2004), (Athanasopolou, 2009). Depending on parties´ needs they can investigate each others resource complimentarity. The resource dimension refers to the effort each party wants to put in. It can include knowledge, monetary, intellectual and technology (Park & Lee, 2018), (Park & Lee, 2015). Monetary and intellectual are much easier to be formalized, whereas knowledge (expertise and experience) is fuzzier. The following component of resource dimension are explained:

- Knowledge (experience, skills)

High knowledge resource is highly important especially if one party does not possess knowledge in another party´s business area (Park & Lee, 2015). Especially in the electronics and semiconductor industries, sophisticated technologies need high expertise (Park & Lee, 2018).

- Financial (monetary, human resources)

Monetary resources such as direct financial investment or the number of human resources show how much effort contractually parties are willing to devote (Park & Lee, 2018).

- Intellectual (intellectual properties, patents)

Intellectual resource are highly relevant at early stages of partnership in order to ensure the protection of highly complex core technologies (Park & Lee, 2018). Agreements on the patent and ownership helps companies to effectively manage collaborative works.

- Technological

Technological resources are especially relevant in the product industries. They refer to the technologies that each party possess and can use to develop innovations. Tacitness of technology refers to the knowledge of the party, which cannot be always documented but can be exhibited through various relations (Roy et al., 2004). This is a characteristics that can evolve in business relations.

Resource dimension & innovation

In the literature, the resource dimension is presented as a fixed capability. The resources are basically boundaries of the companies. However, a different perspective was taken by Kazakçı et al. (2009) who looked at the resource dimension in the context of innovation management. In their research, the authors argued that exploratory partnerships which happen very early in the value chain can bring collaboration opportunities for innovative solutions. When parties do not have any set term objectives but rather want to explore each other's´ knowledge and space resources, the prospect of joint value creation is at horizon. This type of relationship could be perceived as a pre-arrangement of the relational – structural dimension described above.

The idea behind the knowledge – concept design space is based on the theory of design reasoning which formulates the interplay of K space (knowledge) and of C space (concept) (see Figure 20). The knowledge space includes everything that a designer knows (the product, services, competencies, norms, laws etc.). The concept space includes all the things that are new to a designer (Kazakçı et al., 2009). Taking two organizations into account and their level of particular knowledge and concept spaces, one can distinguish them through distances. Consequently, there can be four different instances.

The first instance, Partnership Type 1 happens when K space distance is low and C space distance is low, in this case both partners have similar competencies and knowledge. They are usually in the same business area and have similar resources, competitions etc. Hence, there is little room for innovative collaboration as they are often in the same market space. The opportunity arises when they can enter coopetition – a form of collaboration between competitors (Bengtsson, Gnyawali, Madhavan, & He, 2017). However, in this setting other goals are pursued such as cost effectiveness or sharing of resources. Partnership Type 2 is when K space is high and C space is low, in this case both partners have similar concepts but different knowledge. An example is two companies providing utilities but one provides gas and the other electricity. The innovation found in this space are usually incremental.

Partnership Type 3 happens when K space is low and C space is high, in this case they have similar competencies and knowledge but their concepts are different. For example, injection molding technology could be used for different markets. Through these concept differences, there is high opportunity for unconventional innovations. Partnership 4 happens when K space distance is high and C space distance is high, in this case both companies have different business and explore new concepts (Kazakçı et al., 2009). In this space, there is the highest opportunity for disruptive innovations.

New innovative ideas and concepts emerge when both parties try to combine each other's´ concepts and knowledge. One of the important steps in this process is to learn and understand partners´ knowledge. This design theory is especially useful since, it has not been yet combined with other dimensions such as relational and structural.

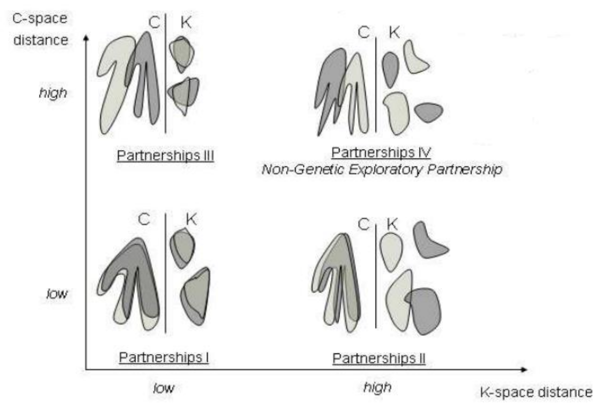

Figure 20 CK Design Theory. Adapted from Kazakçı et al. (2009)

5.2.5 Strategic dimension

The last, fourth category refers to the top management visions or values for entering partnerships. They refer to the schema coupling (Snehota, 1995). In other words, it concern parties´ goals and motives for entering partnership. It can vary from satisfaction, economic performance to innovation generation (Mentzer et al., 2000), (Roy et al., 2004). This can also be linked to the strategic visions, as it also includes power relations and dependency on each other (Wong et al., 2010), (Athanasopolou, 2009). Sharing similar goals might be useful in horizontal relations e.g. sharing risks, whereas for vertical relations these goals might differ e.g. customer satisfaction vs. high costs. In this project, it is assumed that the innovation generation is the main goal. The strategic dimension is explained through:

- Shared values

It means "congruence of general core or dominant values between organizations" (Maxham & Netemeyer, 2003). Both parties have certain principles that lead them achieving their goals. It is a very important aspect of relationship since it identifies perspective of each partners. Decisions are usually made in accordance to respective parties' values. The term which is related to the shared value in the relationship management would be a goal congruence which means that parties have similar goals and objectives. The higher shared values the easier trust is being built (Morgan & Hunt, 1994).

5.3 Inter-firm relationships sub-conclusion

When considering relationship management, there are many different models which emphasize various factors of antecedents, orientation or characteristics. Scholars have shown that they can have various outcomes, for example Mentzer et al. (2000) focused on the business performance outcomes through economic performance, customer loyalty and relationship effectiveness. On the other hand, Petersen, Handfield & Ragatz (2004) focused on the team effectiveness and finally on the firm financial performance and design performance. Despite various factors, most scholars agree that strategic partnerships lead to sustainable competitive advantage whereas transactional relationships usually leads to more competitive parity (Mentzer et al., 2000). However, these conclusions were often challenged by for example relational structural framework developed by Kim et al., (2015). There are many factors that need to be considered such as trust, information sharing or conflict resolution which lead to different relationship configurations. In turn, they can show the appropriateness of certain configurations to the objectives of the company.

In this project, the relationship management focuses on the innovation generation. The literature on inter-firm relationship management does not provide comprehensive overview between relationship building and innovation management. Nevertheless, the configuration patterns developed by Kim et al., (2015) and concept- knowledge design theory developed by Kazakçı et al. (2009) are first attempts to look at these two topics.

To conclude this chapter, evidence for why relationship management is important for companies is presented. The shear amount of literature on this topic shows that inter-firm relationship management is complex. There are many factors that should be considered. By conducting a literature review on this topic, the author brings the most important aspects and finds four main categories: relational, structural, resource and strategy; together with their respective measurement attributes. Figure 21 below illustrates main outcomes and visually represents them. The structure follows Avans (2017) alliance scan based on the author´s methods. The third sub-research question *Why is inter-firm relationship important for management of disruptive innovations?* is answered.

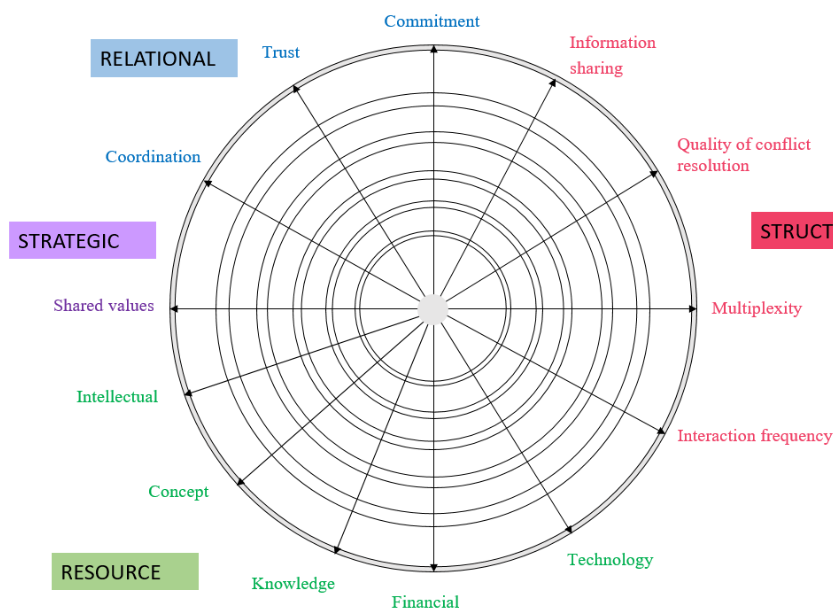

Figure 21 Literature synthesis on inter-firm relationship dimensions. Source: own illustration.

CHAPTER 6 REQUIREMENTS: EVOLUTION OF CO-CREATION FORMS

Previous chapter on relationship management presented various elements from the strategic point of view. This chapter looks at the relationship management embedded in the innovation management through various forms of collaboration. Hence, the evolution of collaboration at its various stages are presented. The concept of co-creation brings the logical flow for the rest of the chapter. The third building block of second phase is explored in this section (Figure 22). The fourth sub-research question is answered in this chapter:

4. What elements affect inter-firm relationship in management of disruptive innovations?

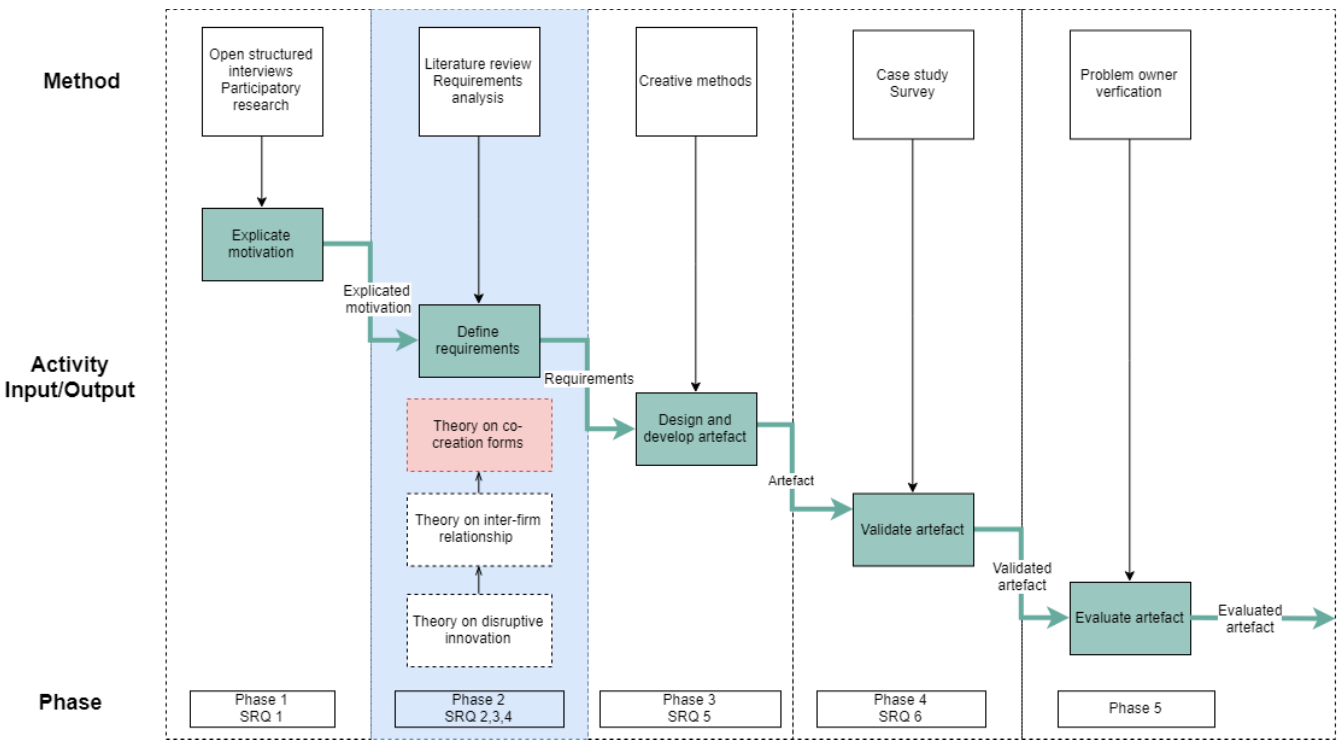

Figure 22 Design Science Project Phase 2 (Co-creation forms). Source: own illustration

6.1 Co- creation design framework

Research has shown that „innovation generation has increasingly been recognized as an outcome of interaction between a firm and various outside entities“ (Roy et al., 2004). However, innovation can be generated at various stages of the interaction. Research has rarely looked at this granular level of analysis. Research would focus on the overall antecedents of relationship management. On the practical side, firms very rarely have procedures and clear picture on the co-creation opportunities (Frow et al., 2015). The following chapter brings the "evolution of collaboration", which presents various forms of collaboration.

Collaboration can be exhibited in many different forms depending on the stage of the innovation process. Overall, it can be assumed that co-creation refers to all activities leading to "creating a compelling experiences in value creation" (Frow et al., 2015). The interactions can be developed at every stage of the process from co-designing to co-producing (Romero & Molina, 2011). The first stage of co-creation would be related to concepts and design issues such as concept definition, preliminary design thus involving co – design aspects (West & Bogers, 2013). In that phase companies can decide on defining key issues and outcomes, research aims and critical milestones. The next stage would include the actual co – development of the product. Frow et al. (2015) developed a co-creation design framework which refers to the design aspect of the co-creation and shows that co – creation activities lead to highly innovative interactions. The framework acts as a guideline for companies to make choices about several dimensions: motives, engagement platform, form, actors and level of engagement (Table 5).

Table 5 Co-creation design framework. Adapted from Frow et al. (2015)

	Dimensions				
Categories	**Motives**	**Engagement platform**	**Form**	**Actors**	**Level of engagement**
	Access to resources	Digital applications	Co-conceptualization	Focal firm	Cognitive
	Decrease costs	Tools	Co - design	Partner	Emotional
	Faster time to market	Physical resources	Co – production	Customer	Behavioral
	Create more competitive offerings	Joint processes	Co – promotion	Supplier	
	Build brand awareness	Personnel groups	Co – pricing	Competitor	
	Enhance customer experience		Co - distribution		

- The motives: whether companies collaborate to access resources, enhance customer experience or build brand awareness. These type of decisions should be made from a strategic point of view and take a holistic approach. Companies need to have right motivation for engaging in the collaboration (Frow et al., 2015).
- The engagement platform is a system which would allow actors to exchange their resources. This could be a digital applications e.g. websites, tools e.g. Software kits, physical resources e.g. Apple stores, joint processes e.g. connect + develop initiatives, personnel groups e.g. call center teams (Frow et al., 2015).
- The form: as mentioned before, collaboration can take place at many various points of interactions. For example, it can take a co-pricing form (pay-what-you-want restaurants), co-maintenance (Tesco encourages customers to recover trolleys), co- outsourcing (Apple outsource development of Apps) (Frow et al., 2015).
- The engaging actor, collaboration takes various forms depending on the actor. It can be with customers, suppliers, partners or competitors. This project however focuses on partner actors only (Frow et al., 2015).
- The level of engagement: refers to the relationship management which was extensively covered in the previous chapter. In the framework proposed by actor the level of engagement is categorized as cognitive engagement e.g. providing resources, emotional engagement e.g. commitment level, and behavioral engagement e.g. changing the behavior. The level of engagement would affect the duration of engagement as well which would be one-off, recurring or continuous (Frow et al., 2015).

All these dimensions are intertwined, depending on the motive, engaging actor and the level of engagement the collaboration can take many different forms and can use various engagement platforms. The next sub-chapter takes a closer look at those different dimensions through additional literature review insights.

6.1.1 Why co-creating? Co – creation motives

Entering any type of relationship needs to have a motive behind it. They are usually a source of strategic decisions. In the context of co-creation motives, the strategic alignment is an important issue since “strategically aligned partnerships are more readily capable of innovation” (Jamali et al., 2011). The research warns that actors are not always transparent about their motives, as some actors might want to take advantage of another parties (Rothaermel & Deeds, 2004). Nevertheless, building healthy relationship requires firm to be at least to some degree clear about their motives. The motives should be decided from a strategic point of view. One of the most common incentives for entering collaboration is to *access resources* such as outsourcing – part of the business activities are outsourced to a third party provider. Another is to *decrease costs* by sharing resources e.g. in a production. *Faster time to market* is enabled through faster development. *Create more competitive offerings*, involvement of customers bring higher benefits. *Build brand awareness* through hybrid marketing systems. Lastly, *enhance customer experience* through customization and differentiation (Frow et al., 2015), (Trott & Hartmann, 2009).

Alongside these motives, companies can also gain access to knowledge in inter- firm cooperation as well as in inter-firm competition, the research suggests that the acquired knowledge is essential for the innovation success (Zhang, Shu, Jiang, & Malter, 2010).

6.1.2 How to co-create? Engagement platform

The engagement platforms such as digital applications, tools, and physical resources became increasingly important in the development of collaborations. Especially, when considering digitalization of technologies. The communication and collaboration forms evolve along these technologies. For example, augmented reality headsets allow virtual collaboration on the same products. Teleconferences often remove the necessity for physical presence. Therefore, firms need to identify the co-creation opportunities and reconfiguration of appropriate platforms. Engagement platforms can have different forms depending on their purpose. One example is Apple´s online app store which contains over 800,000 applications which are not develop exclusively by Apple but by developers. In order to encourage application developers to create apps and decrease the barrier, Apple offers a software development kit (which in this framework would be considered as a tool platform) (Frow et al., 2015). Another example is Vaisala, a global company specializing in the industrial and environmental measurements. In one of the cases, the company jointly developed a mobile measurement equipment allowing for remote measurements and a digital platform to allow storage and transfer of data (Frow et al., 2015)

Abhari et al. (2017) developed a model which breaks down functionalities of the digital platform necessary to create innovative environment. There are three affordances: ideation (creativity), collaboration and communication. Creativity is measured through ideation process which gives the possibility to propose new product or service ideas. Collaboration encourages actors to interact together on a new proposed idea through collaborative tasks such as calculating budget, or choosing materials for a product. It is comparable to the social exchanges in the social network, where participants are able to obtain knowledge from other nodes. Communication is a general activity which allows everyone in the community to interact without commitments. It can take forms of information provision, discussions or knowledge sharing. Table 6 categorizes various actions that can be taken, as well as examples of tools that can facilitate these behaviors. Used cases are presented to show some good practices within this field.

Table 6 Innovation platform dimensions. Adapted from Abhari et al. (2017)

Dimensions	Actions	Tools
Ideation	Submit new idea / concept Describe / present new idea / concept Monitor idea evaluation process Revise and submit new idea / concept	Forms Design Revision Presentation Comparison Monitoring
Collaboration	Find new projects/concept /idea Review different ideas / concepts Vote for different ideas / concepts	Search Suggestion Review Design

	Contribute to project/idea development/ improvement / commercialization	Select Accessibility
Communication	Share knowledge Solicit votes / support Discuss new idea / concepts / projects with community Network with community	Networking Access Messaging Forum Discussion

One of the most successful innovation platforms is Quirky.com which offers online platform for everyone to submit a product idea and share part of the profit with the community members who contributed in some ways to the development of the product. It has attracted more than 1.2 million users, and more than 200 consumer products were invented. This platform includes ideation affordances through various functionalities such as submission of ideas, collaboration affordances through search, evaluate, review and vote for different ideas and communication affordances through use of social profiles for messaging, networking, or online brainstorming (Abhari et al., 2017).

This platform seems successful since community members can be creative in their submissions, and the more creative they are, the more members they can attract. Apart from a learning experience, and contributing to the development of interesting concepts, members are incentivize financially as well. Moreover, it has two way collaboration and communication directions. Other platforms such as 99design, Brainrack or Crowdspring usually involve rather outsourcing type of innovation, in which members can acquire someone´s else expertise (e.g. design logo or websites). These type of digital application platforms leverage the fact that anyone can have access to the pool of skills from all around the world. Nevertheless these platforms still lack "the content of the knowledge", which means that these platforms are beneficial for social networks where people can be easily found.

Looking at another type of engagement platform – physical resource. The research by Moultrie, Nilsson, Dissel, Haner and Janssen (2007) shows that psychical spaces can create creative innovative environments. More and more companies pay attention to the development of workspaces that enhance creativity. For example, IDEO, a design consultancy incorporates various resources such as visualization and modelling facilities. When introducing innovative spaces, strategic motivations should be considered. For example, the emphasis could be on the *innovation efficiency* (improving productivity through operational efficiencies), *innovation effectiveness* (improving the number and the quality of ideas), *teamwork (*improving communication and interaction) and *capabilities* (improving dynamic capabilities). Moultrie et al. (2007) developed a framework which connects the strategic intent with a realized intent by taking into account the process of creation and the process of use (Figure 23).

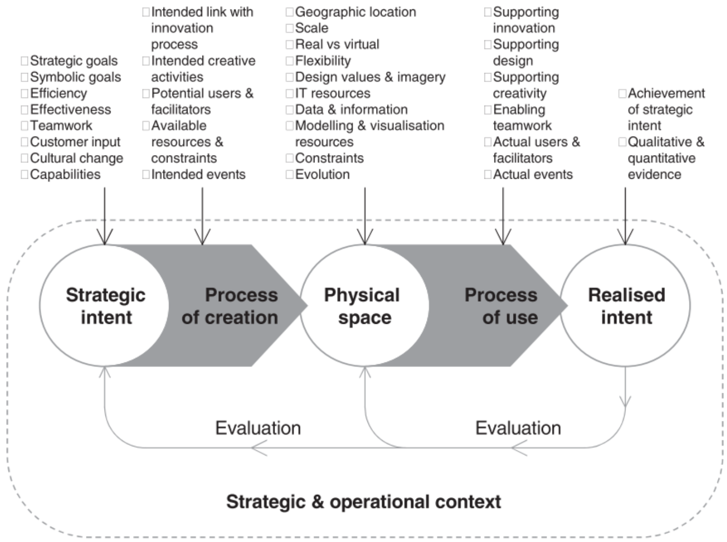

Figure 23 Framework for innovation space. Adapted from Moultrie et al. (2007)

Since the framework is analyzed from the perspective of the innovation (as a strategic and realized intent), the scope would cover the *intended link with innovation* (Moultrie et al., 2007). The space would include the whole process from research, design, implementation and exploitation. The space includes resources that can support these processes (technical resources, physical resources, financial resources). The environment should be coupled with the existing or new innovation processes. Additionally, the physical embodiment would be directly connected to the process of creation. For example, the facilities could include simple tools such as cardboard and flipchart or tools and machines to conduct rapid prototyping.

One example of a successful innovative space is makerspace which is a collaborative work space for exploring, learning, making and sharing purposes. An interesting aspect of makerspace is that it creates "more of a mindset of creating something out of nothing and exploring your own interests"[2]. Companies can thus learn from running these type of places as they foster curiosity, critical thinking and entrepreneurial skills. One of the big factors in considering makerspace is the administration support and staff members (Benjes-Small, McGlynn Bellamy, Resor-Whicker, & Vassady, 2017).

Another crucial elements of an engagement platform is personnel group. It can be either exemplified as a group of people that manages and supervises the innovation process, by for example helping inventors, providing support and be the contact person for all different types of issues. On the other hand, it could also be a dedicated group of people that work continuously on innovative projects. Usually, these teams are formed through professionals from different disciplines and backgrounds. Research has shown that high performing teams include ambitious, creative and committed members (Chanal, 2013). There is a wide range of competencies that could potentially lead to successful performance of the team. The main tasks that they need to manage are: managing inter-organizational collaboration, collaboration for creating new knowledge and managing the innovation process (Chatenier, Verstegen, Biemans, Mulder, & Omta, 2010).

6.1.3 What to co-create? Co – creation forms

Referring to the framework of co-creation solutions (Table 5), the co-creation forms go through the whole value chain from the conception of ideas, designing, production, promotion, pricing, distribution until maintenance. Since,

[2] https://www.makerspaces.com/what-is-a-makerspace/

the innovation process in this project is scoped until launching, only the first few concepts will be examined: co-conception, co-development and co-innovation.

6.1.3.1 Co creation form: co – conception

Conception of ideas happens at a very beginning phase of the innovation process. In the open innovation context, the practice of co- conception seems to be most beneficial in the exploratory partnerships. At this stage there are no functional or technical specifications.

In the context of co-conception of ideas, convergence is about merging different capabilities, competencies and knowledge to create new values in the system. It is based on the "convergence of seemingly unrelated things to meet the existing or new demand" (S. Lee et al., 2012). These inter-organizational capabilities can assure process innovation (S. Lee et al., 2012). This is one of the biggest factors in creating disruptive innovations since it puts expertise of different actors together such as manufacturers with banks (Perks, Gruber, & Edvardsson, 2012). One example is Bangkok International Hospital which not only provides medical services, but also airline reservations or airport pickups.

In order to leap the benefits of convergence capabilities, companies can enter exploratory partnerships in which technology exploration is central in the strategic pursuits. The common purpose for interested actors is to explore emerging technologies through exploration of technologies in different sectors and industrial partners. Referring to the Concept - Knowledge theory in the previous chapter (Kazakçı et al., 2009), Gillier and Piat (2008) developed D4 design process which uses similar concepts and shows the path from developing functional specifications from the community of partners to developing technical specifications with complementary partnerships (Figure 24).The process starts with *Deconstruction (D1)* which looks at the technological properties. The second step is *Declination (D2)* which groups previously identified properties to generic functions. The third step includes *Destination (D3)* which translates the generic functions to specific markets. In this phase the space is moved from knowledge area to solution area. Finally *Decision (D4)* evaluates technology and markets. Table 7 shows practical illustration of this process.

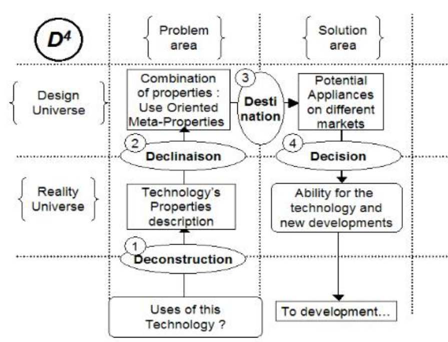

Figure 24 Diagram of D4 design process. Adapted from Gillier & Piat (2008)

Table 7 Example of D4 design process. Adapted from Gillier & Piat (2008)

Steps (duration)	Output	Example
D1 (30 min)	Technical properties	The technology functions within a large temperature range
D2 (20 min)	Generic functions	It is feasible to spread liquid over a surface from a large temperature range

D3 (60 min)	Ideas	Microfluidic material
D4 (15 min)	Assessment of ideas´ feasibility and potentiality	Feasible but over certain range only

This design process shows the possibility to explore each other's resources and capabilities (Kazakçı et al., 2009). On one spectrum partners can have similar knowledge and competencies (e.g. Renault and Nissan) which would mostly lead to incremental innovation. One the other spectrum, industrial partners can come from different businesses. The logic behind this model allows for generation of unconventional and disruptive ideas since partners are not constrained by the fact that others´ businesses might be completely different. Furthermore, the focus is more on the technology rather than a final product. Therefore, new and unexpected applications can emerge. The diagram of the method is depicted in Figure 25.

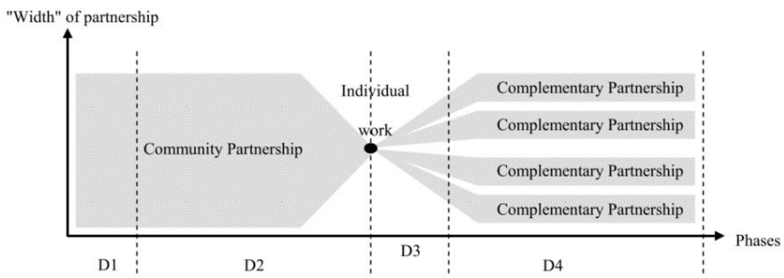

Figure 25 Shift from exploratory partnership to convergence. Adapted from Gillier & Piat (2008)

6.1.3.2 Co-creation form: Co – development

Co-development refers to the set of activities translating conceptual ideas into prototypes and finally viable products. The activities include joint project teams in which members from both parties collaborate and develop products together. They could either do it at one of the company´s premises, or some parts of the project are executed by one party, and another parts by another party. This would involve concurrent engineering and platform methods (Midler, 2008). Through collaborative design approaches, parties could achieve higher efficiencies. The co-development model includes a small group of selected partners, tenders which are based on the specific system requirements, clear distribution of roles and responsibilities, the ongoing interaction on the project interfaces and direct monetary benefits (Scheffran, Marmer, & Sow, 2011). This step would also include clear negotiation issues on the confidentiality agreements, IPs, expectations), as well as identification of information sharing methods and tools (Le Dain, Calvi, & Cheriti, 2009).

Despite the fact that these relations brought a lot of benefits and cost optimization solutions, it overshadowed the innovation process. Nowadays companies realize that innovation is crucial in the competitive sustainability. Nevertheless, they have to face the dilemma: on one hand companies need to focus on their productivity and increase the efficiency to meet customers´ demand (incremental innovations), on the other hand they should also develop and explore new innovative solutions that can bring high market values (Midler, 2008). Due to these emergent challenges, scholars have researched a new concept - co- innovation, which is explained in the next section.

6.2 Co – innovation as a solution

Looking at the literature on innovation management and inter-firm relationship management, it can be concluded that this new co-innovation concept emerges from the co-development concept (granular level, Ch.6) as well as from the challenges of an open innovation (high level, Ch.4).

From the co-development perspective, traditional companies are facing several challenges. New opportunities arise from non-traditional players such as telecommunications for automotive industry. The initiatives to make innovations are no longer "pushed" by suppliers but can also be "pulled" by a manufacturer (Midler, 2008). Moreover, objectives can be changed at any stage of the project. The cooperation must be focused on value creation rather than pure costs benefits. New business models are taking advantage of knowledge externalities (Midler, 2008). Consequently, there is a need to look beyond just co-development.

From the high level perspective (recall chapter 4), the co – innovation emerges from open innovation as it provides an environment which does not necessarily include formal arrangements. The key emphasis is on "compelling experiences with network effects for value creation" (S. Lee et al., 2012). Moreover, it embodies experiences, engagements and co-creation values which are not imitable by competition. This process involves "previously unconnected stakeholders" (Vereijssen et al., 2017). The literature on open innovation is comprehensive and dates back to beginning of 21st century, however the literature on co-innovation is relatively new and only few scholars have looked at the definition of co –innovation.

Since co-innovation topic seems to be synergetic of disruptive innovation management and inter-firm relationship; and constitutes a logical next step (on a granular and high level), the authors decides to explore deeper this topic.

The literature review summary on co-innovation can be found in Appendix H. Starting with the definition, co – innovation captures collective intelligence and network effect to create value among participants (S. Lee et al., 2012). The main focus is thus on the act of togetherness and collaboration (Saragih & Tan, 2018). The main motive is to create values which are originated from new customer value, new customer base, new product/ services, and new efficiency of the value chain or new business models (S. Lee et al., 2012), (Vereijssen et al., 2017). For example, increased supply chain value can be executed through processes such as Just-in-Time, Lean Manufacturing or Six Sigma. However, the main emphasis lays in the "value creating avenues". Co- innovation is thus "the cooperation and collaboration to innovate and is a crucial value creation element for any organization"[3]. The constructs / elements of the models mainly touch understanding of different views, inclusivity of diversity of stakeholders, various engagement methods and wide range of disciplines (Vereijssen et al., 2017). The main focus is on the exploration and learning experiences enabled by innovative technological solutions (Bremmers & Sabidussi, 2008), (Midler, 2008).

The co-innovation model developed by Lee et al. (2012) is used as the basis for the development of this thesis research model because it is a first attempt to define a co-innovation concept through several key elements. Moreover, newer research based theirs model on the one Lee et al. (2012) developed. The principle of co-innovation is that it is built on *the co-innovation platform, co-creation of experiences, collaborative arrangement and convergence of ideas* (Figure 26). *The co – innovation platform* is the space where a firm can create value through new business models, new products /services or new efficiency of value chain (S. Lee et al., 2012) (Saragih & Tan, 2018). *Co – creation* refers to actionable activities in which stakeholders actually participate in the creation of new values. This means that it refers to the overall process. *Collaboration* is exhibited through inter-organizational relationships, where participating actors have similar purpose. An important element here is the context / strategic intent, the companies should be or be willing to be innovative and agile (Avans, 2017). *Convergence* refers to the merging of ostensibly unrelated things. These usually are achieved through coupling of inter-organizational functions or different industrial services. These inter-organizational capabilities can assure process innovation (S. Lee et al., 2012), (Saragih & Tan, 2018). It has a big potential in creating disruptive innovations since it puts expertise of different actors together such as manufacturers with textile companies.

[3] https://www.hackerearth.com/blog/innovation-management/co-innovation-concept-benefits-examples/

Figure 26 Co-innovation model (S. Lee et al., 2012)

6.3 Co-creation forms sub-conclusion

This chapter points to the fact that there are many different forms of co-creation. Some scholars have pointed out the issue of the clash between the "logic of alliance" and "logic of innovation" (Sivadas & Dwyer, 1998). On one hand, it is often argued that in order to achieve successful alliances, goals and responsibilities must be clear. On the other hand, innovation requires flexibility and freedom to experiment. However, this chapter brings newer perspective to the research by looking specifically at the co-innovation as a capability to jointly develop innovations without the clash.

The literature on co – innovation is relatively new. It responds to the challenges such as high cost pressures, digitization and automation, new competition and cultural changes. It has the advantage of creating innovation and new opportunities, and at the same time increases productivity and enables change. Some examples of big corporations implementing co – innovation concepts include Tata Motors, SAP, Apple and BMW. [4] As long as the company strives to be competitive and develop innovative capabilities, it needs to develop new business models for managing disruptive innovations.

Despite the fact that this new concept can provide competitive advantage, creating this eco-system is not easy. It could require companies to change or adapt their culture, to create strategic vision, governance and sense of urgency. As observed by Lee et al. (2012) "the road to co- innovation is not smooth and easy, organizations do not have much choice but to join the race". The conceptual model tries to address these challenges. The fourth sub-research question: *What elements affect inter-firm relationship in management of disruptive innovations?* is answered.

This is also the last chapter in the second phase of the Design Science framework. The requirements are summarized in the next section, as it directly influences the design of the artefact.

[4] https://www.hackerearth.com/blog/innovation-management/co-innovation-concept-benefits-examples/

CHAPTER 7 ARTEFACT DESIGN

Previous phase of this Design Science Project framework laid a theoretical foundation on the innovation management and inter-firm relationship management. The literature review enabled an author to find different innovation process models and their evolutions. Key aspects affecting inter-firm relationships were identified with regard to the innovation process. Further literature investigation led the author to focus on the co-innovation concept as the suitable foundation for the conceptual model. Finding a co-innovation concept is deemed as sufficient for fulfilling the knowledge gaps which is a necessary step for designing a model.

In this chapter, a third phase of the Design Science framework begins (Figure 27). The author of the thesis tries to fill the research gap by summarizing the main concepts and outlines the relationships between them. Consequently, the artefact in the form of a conceptual model is built based on the synthesis of the theoretical foundation and generated requirements. The innovation process management is built and altered to incorporate collaboration decisions. Moreover, this new model includes co-innovation concepts. The steps for designing a co – innovation model are explained below. The fifth sub-research question is tackled in this section:

5. *What elements to include in the design of a model?*

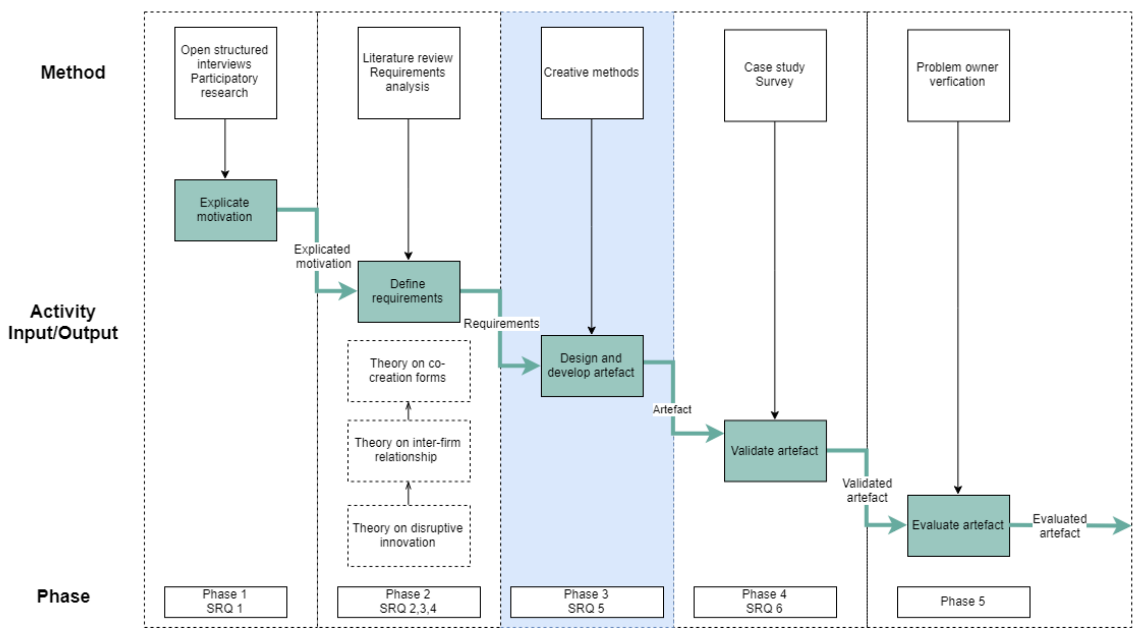

Figure 27 Design Science Project Phase 3

7.1 Requirements elicitation

Requirements are necessary inputs for the design and development of the artefact. In chapter 3, initial company´s requirements were formulated in the consultation with the problem owner. After the analysis of the topic through the literature review on the innovation management and inter-firm relationship management (Ch.4,5 and 6), initial system requirements for the conceptual model are enriched and can be summarized in Table 8 (Jamali et al., 2011), (Björk et al., 2010), (Berkhout et al., 2010). These were also consulted and accepted by the problem owner.

Each requirement is derived from the subsequent topics mentioned in the literature review. In Table 8 topic chapters and references are presented. Refer to Figure 28 to see the logical flow between requirements. The first 3 requirements are ´must haves´ considered as fundamental building blocks and observed in the literature. Once these combined 3 requirements are met, it would lead to requirement 4 which is to ´incentivize to innovate´ – the sub-objective of the model. However, it is possible that in the current system there are already some other motivating mechanisms. Hence, the next three requirements are needed (5 to 7) as found in the literature to facilitate the development of disruptive innovations. Due to the fact that the topic scope is within disruptive innovation, the conceptual model´s main objective is to create disruptive innovation climate (8 - must have). Going beyond the company´s objectives and following the literature, the model is a lot more valuable when it also brings learning experiences and effective provision of products and services (9 and 10). They are considered as ´nice to haves´ because this model is not the only way to provide such abilities. Combining these two would lead to value creation. The last requirements are on a higher level (11-12), where the model should bring value to the actors who will be dealing with the implemented conceptual model. These values can be varied depending on the interests, benefits and so on. Therefore, it is not in the scope to provide a list of all possible values but rather direct the model towards value creation.

Table 8 System requirements list. Source: own illustration

Req. ID	**Requirement**	**Topic**	**Reference**	**Must have / Nice to have**
1	The model enables interactive process between various actors	Innovation management process, open innovation (Ch.4.2) The importance of inter – firm relationship management (Ch.5.1) Co – creation (Ch.6.1) Co- innovation (Ch.6.1.3)	(Wagner, 2008), (Jiang & Li, 2009), (Bogers & West, 2012), (Xu et al., 2007), (Roy et al., 2004), (Midler, 2008), Bremmers and Sabidussi (2008), Vereijssen et al., (2017)	Must have
2	The model enables exchange of various forms of knowledge	Management of disruptive innovation (Ch.4.3), Co- innovation (Ch.6.1.3)	A.Aagaard (2008), G. Berkhout, D. Hartmann, P.Trott (2010), P. Robbins C. Gorman (2014), Vereijssen et al., (2017)	Must have
3	The model develops exploratory partnership capabilities	Types of relationships (Ch.5.2), Co- innovation (Ch.6.1.3)	(Mohr & Spekman, 1994), Kazakçı et al. (2009), Kim et al., (2015), Avans (2017)	Must have
4	The model incentivizes to innovate	Management of disruptive innovation (Ch.4.2, 3.3) Engagement platform (Ch.6.1.2), Co- innovation (Ch.6.1.3)	(Tidd et al., 2005), R. Veryzer (1998), N. Preez, L. Louw (2008), Abhari et al. (2017)	Must have
5	The model develops abilities to effectively identify, evaluate and develops disruptive innovations	Management of disruptive innovation (Ch. 4.3), Co – conception of ideas (Ch.6.1.3) Co – development (Ch.6.1.3)	(Oke, 2007), (S. Lee et al., 2012), (Kazakçı et al., 2009), (Midler, 2008)	Must have
6	The model integrates digitized technologies	Co – creation, engagement platform (Ch.6.1.2), Co- innovation (Ch.6.1.3)	Abhari et al. (2017), (S. Lee et al., 2012),	Must have
7	The model develops abilities to effectively configure partnership opportunities	Type of relationships (Ch.5.2)	Snehota (1995), (Kim et al., 2015), (Roy et al., 2004), (Morgan & Hunt, 1994), (Morgan & Hunt, 1994)	Must have
8	The model creates a disruptive innovation climate	Disruptive innovation (Ch.4.1), The importance of inter – firm relationship management (Ch.5.1), Engagement platform (Ch.6.1.2), Co- innovation (Ch.6.1.3)	Garcia & Roger (2001), (Liao et al., 2017), (Moultrie et al., 2007), Abhari, Davidson, Xiao (2017), Saragih, Utama, Tan (2018)	Must have

9	The model provides learning experience	Innovation management process, open innovation (Ch.4.2), The importance of inter – firm relationship management (Ch.5.1), Type of relationships (Ch.5.2), Co- innovation (Ch.6.1.3)	(Min et al., 2005), (Schilling et al., 1998)	Nice to have
10	The model creates effective provision of products and services	Disruptive innovation (Ch.4.1), Co- innovation (Ch.6.1.3)	(S. Lee et al., 2012), Saragih, Utama, Tan (2018)	Nice to have
11.1 11.2 11.3	The model creates values to the employees, stakeholders and communities / industries	Co – creation (Ch.6.1), Co- innovation (Ch.6.1.3)	(Frow et al., 2015), (Trott & Hartmann, 2009)	Nice to have
12	The model creates societal, economic and environmental benefits	Co- innovation (Ch.6.1.3)	Initial high level requirement	Nice to have

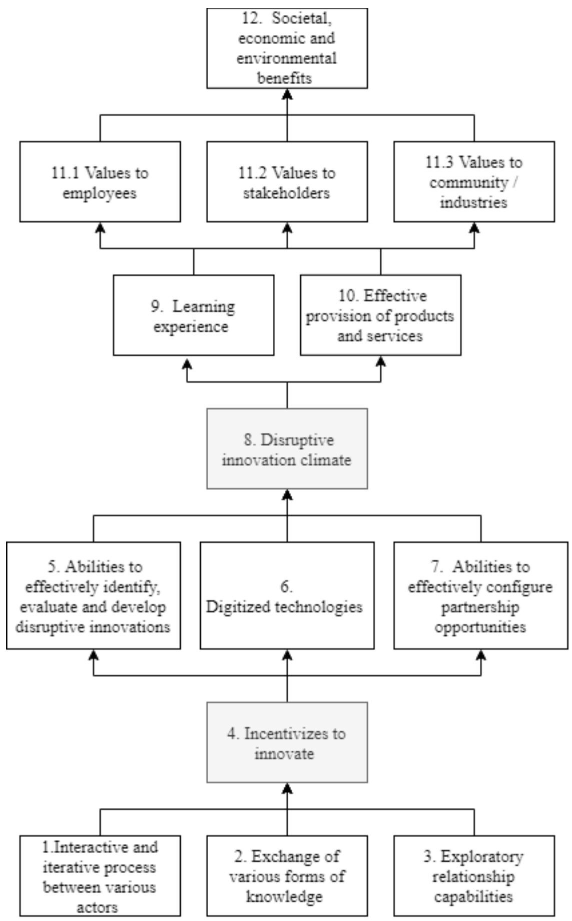

Figure 28 System requirements visualization. Source: own illustration

7.2 Design Co-Innovation Model

Once requirements are formulated, they can be used as an input for the design and development of an artifact. In this design project, the artefact takes a form of a conceptual model which prescribes processes for managing disruptive innovations between firms. The conceptual model is called "Co-Innovation Model".

The conceptual model is built through a step-by-step approach (step 1 to step 4) according to the sequence of the literature review, starting from disruptive innovation process management, inter-firm relationship and collaboration forms (see Figure 29). The final synthesis of the steps should lead to the initial design of the conceptual model. Moreover, at each step how requirements are incorporated and why they are important are explained.

The model should prescribes processes to follow by firms in order to successfully manage innovation management processes. The scope of the model is focused on disruptive innovations (new market and /or new technologies in a micro – perspective level), relationship management between partner firms (customers, suppliers or competitors are not included) and new collaboration forms (excluding forms after launching phase). The model should be applicable to the case study company and provides useful insights for the firm. The remaining of the chapter explains the buildings steps.

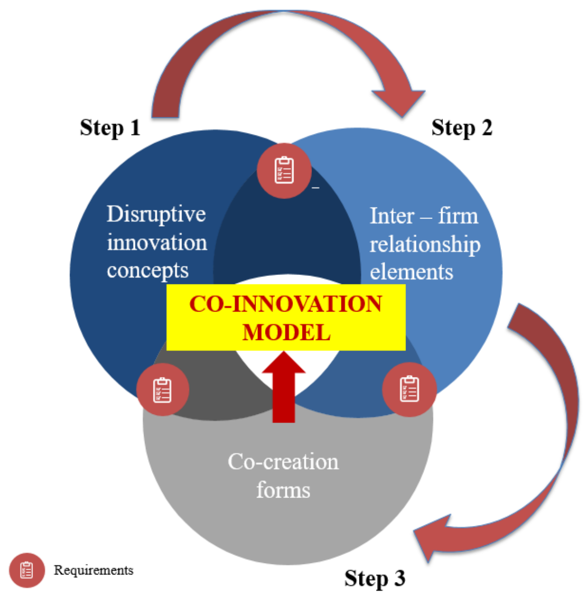

Figure 29 Steps in building a conceptual model. Source: own illustration

Co-Innovation Model: Step 1

The first element of the model is innovation process management steps which are illustrated in Figure 30. Firstly, the innovation process is presented in Chapter 4 (Figure 17) which captures the main components of the innovation process and at the same time incorporates new features such as the iterative nature of the process and the importance of opportunity identification (Req.1) (Preez & Louw, 2008). The detailed description of the phases can be found in Chapter 4.3. For the purpose of simplicity, the process is presented in a sequential form, however it is important to emphasize that the elements of this process have iterative loops between stages. Ideas can be revisited and continuous feedback is encouraged (Req.2). This part of the conceptual model has dynamic behavior which allows procedures and ideas to be explored and matured (Req. 2) (Brentani & Reid, 2012).

The structure of the process is based on the research of Preez & Louw (2008) that gives guideline into synthesizing the literature findings on the various phases in the innovation management process. Hence, the structure could look differently in terms of nomenclature e.g. instead of ´opportunity identification´, some scholars name it ´environmental scanning´ or ´knowledge search´. Some authors make more distinct separation between phases e.g. concept feasibility and concept refinement. However, the author believes that this represent the most important steps well (choices were explained in detail in Ch. 4.3). Below, the requirements fulfillment checklist can be found in Table 9.

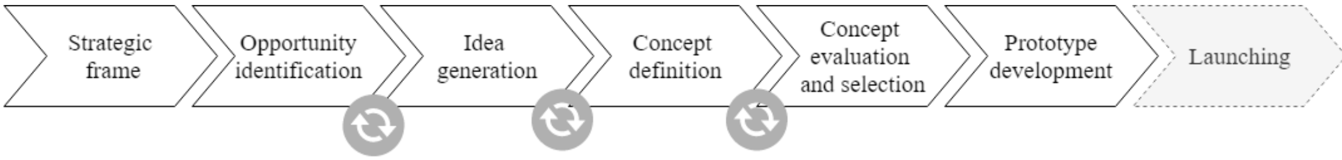

Figure 30 Innovation process model (step 1). Source: own illustration

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Table 9 Step 1 requirement checklist

Requirements	1	2	3	4	5	6	7	8	9	10	11	12
Step 1	x	x	x									

Co-Innovation Model: Step 2

The next step of the model should capture inter-firm relations. Following the literature on partnership decision, the steps to be taken are: 1) Establish strategic need for partnership 2) Develop and evaluate 3) Establish partnership 4) Maintain and refine (Req.3) (Maloni & Benton, 1997) . The partnership decision comes down to the evaluation. In chapter 4, a literature review on inter-firm relationship produced key collaboration attributes. The collaboration decision could be examined thoroughly by developing tools or methods to facilitate the decisions such as through an *alliance scan* (Figure 31). The alliance scan which includes common attributes of inter-firm relationship found in the literature: relational, structural, resource and strategic could measure them in a certain scale (Req.3). A similar relationship continuum was developed by Jamali et al., (2011) and Avans (2017) using Insights Learning and Development methods and the process of including attributes of collaboration follows a study by Johnsen and Ford (2001).

Each partner can use this tool to make initial assessment – scanning of partners. Each dimension is measured on a scale from 1 (lowest) to 5 (highest). The higher the score for relational and structural dimensions, the higher the intensity and partnership relation (Req.3) (refer to Figure 31). Regarding the resource capabilities of the partner, the higher the score the larger the distance between the knowledge and the concept dimension. These four dimensions cover a whole range of issues since the relational dimension captures a personal fit and connectivity between partners, structural dimension captures operational fit and action specific issues, and resource dimension captures exploratory knowledge space, and strategic dimension covers strategic – network fit (Req.7) (Avans, 2017).

Such comprehensive alliance scan fills the research gap by combining various aspects together thus creating 4-dimensional inter-firm configurations. These dimensions can be directly related to the innovation environment. For example, it was found in the literature that partnership (high relational score) – low intensity (low structural score), and high distance between knowledge and concepts have potential to lead to disruptive innovations (Req.4 and 8). The case study research in the following chapter will examine this phenomena.

This element of the conceptual model could also be presented in various forms, however this representation is believed to be easily understood and not too complex. Moreover, the structure is based on the Avans (2017) which was well acknowledged. Below, the requirement fulfillment checklist is presented in Table 10.

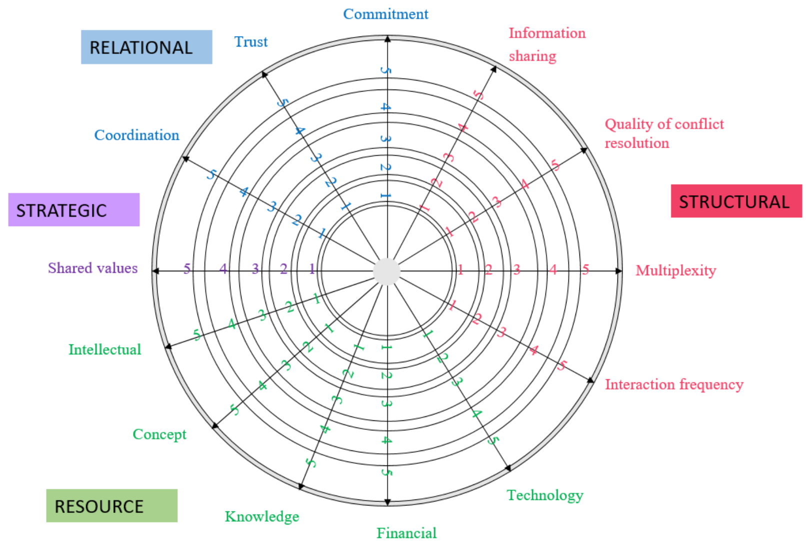

Figure 31 Alliance scan (step 2) Source: own illustration

Table 10 Step 2 requirement checklist

Requirements	1	2	3	4	5	6	7	8	9	10	11	12
Step 2			x	x			x	x				

Co-Innovation Model: Step 3

The third step includes the main outcomes of the co-creation form literature. The co-innovation model developed by Lee et al. (2012) is used as the basis for further refinement of this thesis co-innovation model. This model is found to be the first one to bring key elements and characteristics of co – innovation. However, the model was not developed in detail. It lacks insights into these key elements – *What do they mean? How can they be used?* And *How are they linked?* are not clear. Hence, the objective of this step is to expand these elements into well understood measurement / process forms which are also aligned with the definitions found in the literature.

Saragih et al. (2018) redefined this framework by adding two additional pillars to the model “complementarity and coordination”, these according to the author can be included in the previously developed “collaboration scan”. Complementarity is linked to the resource dimension, whereas coordination to the relational dimension. Nevertheless, the method used by Saragih et al. (2018) to develop a co-innovation framework is partially used as a guideline.

As was presented in Chapter 6, co-innovation model consists of *the innovation platform, convergence and co-creation affordances* and *collaboration* (Req. 5, 6, 7, 8 and 9). These concepts have been explained in detail in Chapter 6 and took rather static form.

The innovation platform can take several forms e.g. digital applications, tools or personnel groups (Ch. 6.1.2) (Req. 6). Convergence has been found as the activity of merging various concepts and ideas (Req. 5). Therefore, a D4 design process suits well within a framework (Gillier & Pillar, 2008). Co – creation was found as the series of activities where companies work together (Req. 1, 7, 9). The author synthesizes the concept of co-creation to the innovation processes mentioned in step 1 (Figure 30). Lastly, collaboration refers to the relationship management – multi-actor participatory actions (Figure 31*)* (Saragih & Tan, 2018). The final result of this step can be seen in Figure 32. Below the figure, the requirement fulfillment of this step is presented (Table 11).

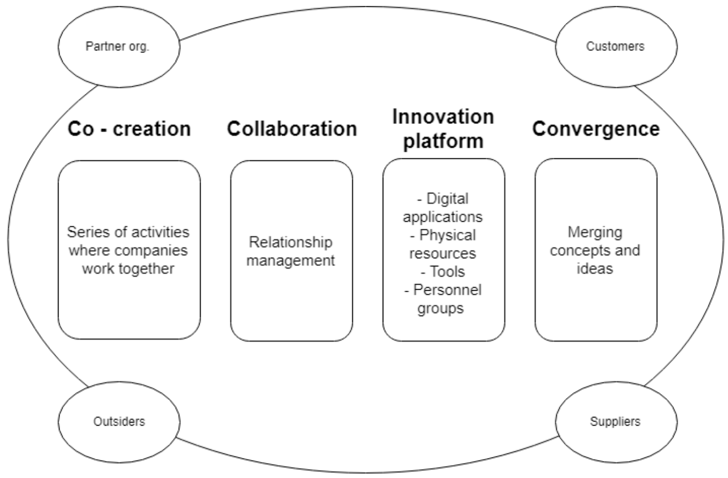

Figure 32 Innovation Process Model (Step 3). Source: own illustration

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Table 11 Step 3 requirement checklist

Requirements	1	2	3	4	5	6	7	8	9	10	11	12
Step 3					x	x	x	x	x			

Co-Innovation: Step 4

The last step is to integrate previously mentioned steps and find opportunities in which co – innovation affordances bring partners together. In order to construct a model which works bidirectionally, the partnership opportunities should be explicitly stated in the model (Req.7). Additionally, the model fills the research gap in a collaboration forms identified by Frow et al. (2015) as co-innovation was not considered as one of the co-creation forms. However, the authors mentioned that new forms of co-creation are possible in the future research.

The final representation of the conceptual model can be found in Figure 33 below (step 4). As mentioned before, co-creation involves the basic steps of the innovation management process, from strategic frame to prototyping (launching). It includes the iterative processes within steps to allow for exchange of knowledge and interactions. Moreover, *partner organizational involvement* is emphasized at every step of the process to include co-innovation opportunities (indicated in red color), these opportunities should not be regarded externally, but internally, within the process. The elements belonging to the innovation platform (digital application, joint processes, physical resources and personnel groups), to the convergence (D4 method) and to the collaboration (alliance scan) can be regarded as enabling *tools* necessary to introduce co-innovation concept in the co-creation process. Therefore, the arrows from these three boxes are directed towards the co-creation box.

It is assumed that these tools have dynamics effect on the co-creation process and they can have varied intensity of relations. For example, the innovation engagement platform might be most useful in the idea generation phase, as its digital form could help with both effective knowledge protection and knowledge sharing (Jean et al., 2014). On the other hand, an engagement platform in a physical form can be more useful in a prototype phase by for example introducing makerspaces. The concept definition phase might find convergence tools most relevant since partners can use D4 model to find unconventional concepts for their technologies. The collaboration tool can be used at the opportunity identification to explore unconventional partner's business areas. These type of relations are going to be verified on a case study research.

All in all, the model allows for inclusion of a large diversity of background and expertise where partners can explore, interact, discuss and exchange ideas and information which would bring value to the participants of the system (Req. 10, 11). Consequently affecting the performance of the organization (Req.12).

Exploring above mentioned steps in the innovation process and examining the partnerships patterns, it allows for discovery of interaction patterns in the co-innovation pattern strategies (Bossink, 2002). This is particularly crucial in the disruptive innovation environment (Berkhout et al., 2010). It is expected from this model that it enables complementary partnerships and synergetic alliances which would result in empowerment of the innovation process and consequently the generation of disruptive innovations.

Overall, this model is developed to enable innovation strategy choices, ideas / creativity management, adequate selection and decisions, implementation and development of innovative human resources to create an environment stimulating disruptive innovation cycle. Putting all elements together, the final Co-Innovation Model design fulfills the requirements (Table 12). The next step is to test this model on a real life example.

Table 12 Step 4 initial conceptual model requirement checklist

Requirements	1	2	3	4	5	6	7	8	9	10	11	12
Step 4	x	x	x	x	x	x	x	x	x	x	x	x

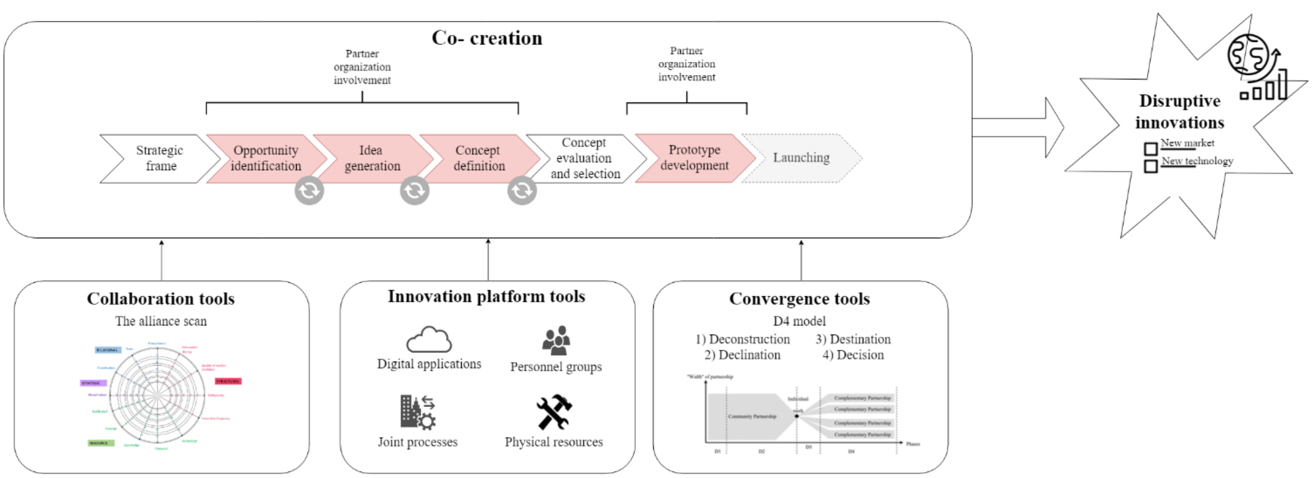

Figure 33 Co-Innovation Model (Step 4)

7.3 Co-Innovation Model considerations

Having explained different elements of co-innovation model and its benefits, it is useful to raise some important questions related to inter-organizational cooperation. The interaction is complex since it is difficult to predict future pattern interactions. Some issues might be raised such as: *Who owns Intellectual Property? Who will spend money and time? What is the balance of benefits between parties?* These questions are relevant since cooperation with external partners brings not only benefits but also risks. Moreover, the degree of dependence and power imbalances are important considerations. The power- interest issues can be observable most notably through the size of the company, big corporations have considerably higher power in for example winning intellectual property disputes. On the other hand, co-innovation concepts relies on the unknown knowledge territories, therefore this model should deter companies from opportunistic behaviors. Nevertheless, the power relations seem to be rather difficult to implement in the model hence it is out of this thesis project scope. In designing / refining versions of this conceptual model, it is important to include limiting factor considerations (Stjernstro & Bengtsson, 2004). New systems and models could be designed to govern these type of issues, for example there can be new IP management systems (Romero & Molina, 2011).

Another important issue is the balance between paradoxes: formal and informal structuring (process in place but allow for exploration) and level of involvement (focusing on core project vs. devoting time on disruptive projects). This imbalance is also known as the conflict between the “logic of innovation” and “logic of alliances” (Linnarsson & Werr, 2005). On one hand, innovation requires flexibility and openness to create, on the other hand traditional alliances require the need to form agreed contracts before going into alliances. Therefore, in the development of the model “relatively unstructured partnerships” are encouraged in such a way that no firm commitment are made from the very beginning (Linnarsson & Werr, 2005). However, fear appears in having too open communication as this might result in the diffusion of intellectual properties (McDermott & Colarelli O’connor, 2002). Hence, the relationship management topic is crucial since relationship built on trust, collaboration and effective communication encourages partners to experiment and take risks. Consequently nurturing innovative alliance (Jamali et al., 2011).

As suggested by Zhang et al., (2010), alliance learning can bring valuable knowledge to the company therefore developing cooperative relationships (even if partners could be potential competitors) is encouraged. Similar conclusions were drawn from the research stating that even if partnership fails, there is a learning experience (through either interactions or accessing technological capabilities) (Stuart, 2000).

Therefore, the proposal for co-innovation needs to take into account these complexities and tries to reduce them. The above constructed co-innovation model has the potential to fulfill the system requirements. This co – innovation model includes multidisciplinary and multi-stakeholder approach and takes social and technical inputs.

7.4 Artefact design sub-conclusion

This chapter explained in detail steps and rationale behind building a conceptual model. The Co-Innovation Model incorporates affordances which were found in the literature review and creates links between them. The theoretical conceptual model is used to determine and to evaluate ways to manage partner organizations in the innovation processes in order to increase the quality and rate of creating disruptive innovations. This co-innovation model is built to serve as a tool for organizations (in this project case for Infineon Technologies AG) to enable successful realization of disruptive innovations. The remaining chapters illustrates a case study research to validate the model. Based on the analysis, the refinements of the model are possible. Validation of the model is important since it can show whether theoretical findings are feasible in various real life business situations. Since, the Co-Innovation Model purpose is to be used as a tool, a case study method has the opportunity to prove that. Moreover, the concepts found in the literature review can be studied in practical settings, in detail. Sub research question 5, *What elements to include in the design of a model?* is answered in this section.

CHAPTER 8 ARTEFACT VALIDATION: CASE STUDY RESEARCH

Previous chapter presented the design of the artefact, the next phase of the Design Science framework is *artefact validation* (Figure 34). The goal of this section is to validate the theoretical conceptual model in real business life within the context of the company. Consequently, it would be possible to investigate different elements of the model, how they affect the innovation process and inter-firm relationship management and to propose a final model with possible modifications. Finally, recommendations can be given to the company on the managerial implications, as well as future research recommendations to the scientific body of knowledge. The input of this case study research is the artefact design (Co-Innovation Model, see Figure 33). The sixth sub-research question is answered in this chapter:

6. *What elements can be observed in practice?*

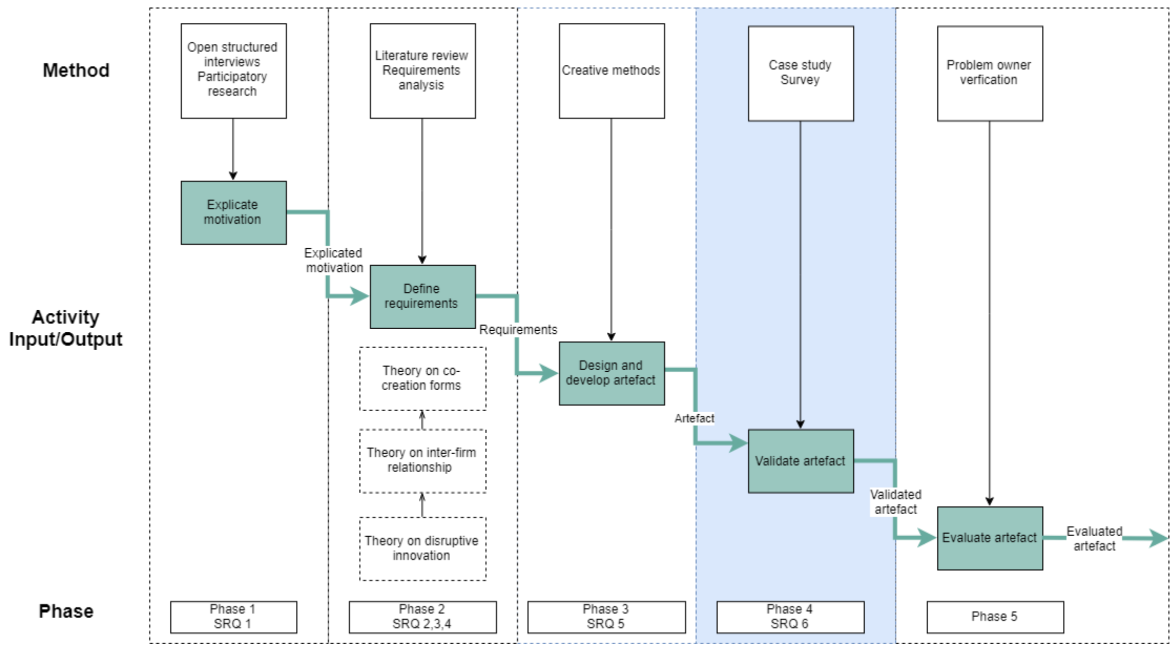

Figure 34 Design Science Project Phase 4

This chapter is divided into the following sections:

1) The choice and scope of the case study
2) The description of the case study: GeniusTex
3) The stakeholder analysis
4) The case study results analysis:
a. Co-creation
b. Collaboration
c. Innovation platform
d. Convergence
e. Disruptive innovations
5) Final Co-Innovation Model

8.1 The choice of the case study unit analysis

Infineon Technologies AG Corporate Supply Chain Department deals with various innovation topics and wants to bring further the topic of disruptive innovations by finding new opportunities and collaboration projects. By doing that it strives to enter new markets and develop new technologies – outside of the core products of Infineon Technologies. One of the projects that the department is involved is the co-funded European project called GeniusTex, a smart textile service platform. This project is used as a unit of analysis of master´s thesis research since its nature allows for the assessment of the conceptual model.

First of all, from the perspective of Infineon Technologies, it deals with disruptive innovations because textile industry is regarded as a new market. The company does not have expertise in this field and sees opportunities in the field of smart textiles where it can apply its technologies (e.g. sensors, semantic web). In this case, it does not belong to either market pull or technology push but rather in the co-creation space. Secondly, it involves several partner organizations that come from different business areas (research institutes, orthopedic industry); their knowledge and concept spaces are distant from Infineon, therefore there are many opportunities to learn and exchange expertise. Thirdly, the project deals with new innovative solutions, the market for smart textiles is at the infancy therefore there is a big opportunity to become leader in this field, and thus gain competitive advantage. Fourthly, the project objectives are aligned with the company´s motivations to develop abilities to innovate, which is largely driven by cooperation with partner companies. This project addresses the need to create digital ecosystems for streamlining the collaboration of business partners of various disciplines, supporting early customer engagement, and helping developing new and viable business models collaboratively.

Since the scope for case studies is limited to the projects undertaken by CSC IN department, only GeniusTex project seems to be the most suitable. Other projects for example related to ´Semantic Web´ ontologies[5] deals with only a software architecture for developing uniform vocabulary in the domain of semiconductors, or ´Lead time based pricing´ focuses only on the business model in a field of revenue management. These are innovative solutions, however they are not considered disruptive, do not include different domain partner organizations, and are focus mainly on core Infineon Technologies business.

In conclusion, this project case study is suitable since conceptual model elements such as innovation platform, co-creation, convergence and collaboration can be found and are applicable. The analysis of the case study should allow to generate useful outcomes and recommendations for the company. The focus is mainly on meeting the case study company-generated requirements. Nevertheless, since the analysis takes into account perspectives of the project partners, there is higher reliability for generalization of the findings. Moreover, all of the partners perceive GeniusTex project as the opportunity for developing disruptive products. Hence, additional recommendations on the conceptual model can be generated for other companies that strive to implement co-innovation concepts.

8.2 The description of the case study: GeniusTex

GeniusTex is a smart service platform project for Smart Textiles[6]. It is a 24 months funded project by a Federal Ministry of Economic Affairs and Energy composed of a consortium of industrial partners and research institutes. The kick off meeting was in April 2018, at the time of the thesis the project is almost halfway. The project is led by RWTH Institute of Textile Technology (ITA). The partners are: ITA, Fraunhofer Institute for Applied Information

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[5] Ontology – a model of entities and interactions in the domain of knowledge or practice; a set of concepts composed of things, events and relations which are specified to generate an uniform vocabulary for exchanging information and for computers to be readable. https://whatis.techtarget.com/definition/ontology

[6] Smart textiles are fabrics that are designed to include technologies that can provide increased functionality. These textile fabrics can sense and react to the environmental stimuli and respond in the controlled way. https://www.omicsonline.org/open-access/smart-textiles-and-nanotechnology-a-general-overview-2165-8064.1000181.php?aid=40254

Technology (FIT), RWTH Aachen Research Area Technology, Innovation, Marketing and Entrepreneurship (TIM), Infineon Technologies AG (IFX), Asys Group, Ottobock and Eccenca. See Figure 35 for the project stakeholder representation. The project´s main objective is to develop a complete value chain for smart textiles via an innovation platform and to strengthen the German economy in the long term and sustainably through new smart production processes, products and services, in the areas of telecommunications, production and electronics. More detailed information on the project (work packages and their distribution can be found in Appendix I).

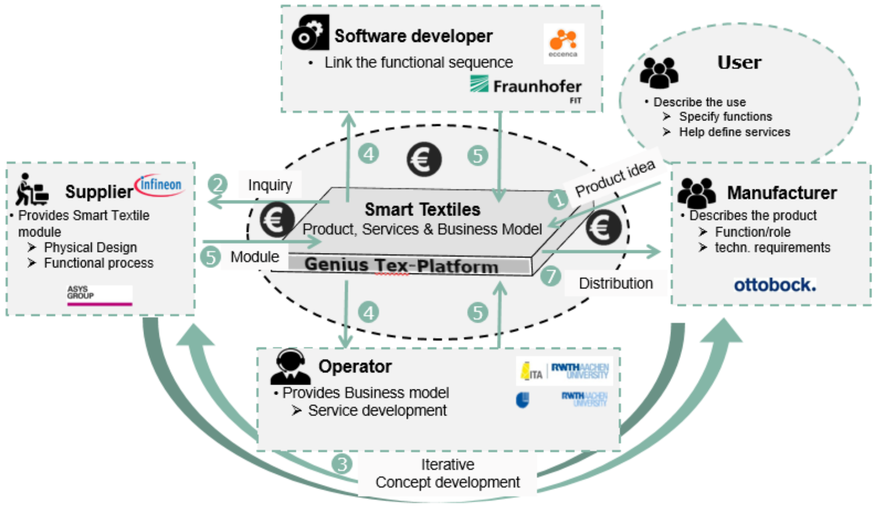


Figure 35 GeniusTex project visualization. Source: Genius Tex documents.

GeniusTex project is divided into four solution sections:

1. Design of interfaces in the innovation process.
2. Implementation of an open information technology innovation platform.
3. Product modularization & product-oriented design of cyber-physical manufacturing processes for smart textiles.
4. Broad-based pilot testing of the innovation platform on industrial applications with the involvement of users.

Smart Textiles are currently experiencing great interest in the areas of medicine, sports, fashion, building technology and automotive industry. ID TechEx predicts a market of approximately € 2.8 billion for 2026 with an average annual growth of 34% (GeniusTex documentation). Intelligent products are the foundation for creating new markets and customer groups through digital business models such as platforms, as-a-service models, or data-driven models. The transformation to the digitized production of intelligent products is the next logical step in sustainably strengthening the competitiveness of product developers, suppliers and service providers. However, market players in the electronics and textile industries are shying away from the complexity and dynamics of the combined value chains. If German industry does not manage to enter the market in a timely manner, service-oriented competitors from abroad will assume the pioneering role. For the first time, GeniusTex as B2B platform could allow German companies to manage complexities and dynamics of the value chain for Smart Textiles (GeniusTex documentation).

The need comes from the fact that one of the most important asset of companies is their ability to innovate, which is largely driven by co-operations with partner companies, the scientific contribution and market knowledge. To leverage and expand the market potential of smart textiles, networked digital ecosystems are needed to streamline the collaboration of business partners of various disciplines, support early customer engagement, and help develop new and viable business models collaboratively (Stoppa & Chiolerio, 2014). GeniusTex project strives towards leveraging these potentials (GeniusTex documentation).

8.3 Stakeholder analysis

In this section, the description of partners in the GeniusTex project are presented Table 13. The analysis is important in order to better understand the context of the interviewees´ answers. More detailed information on the scientific and technological contributions can be found in Appendix I.

Table 13 GeniusTex project stakeholders. Source: own illustration

Company	Company description	Role	Goals & interests	Logo
Infineon Technologies AG (IFX) (Munich)	German semiconductor manufacturer	Provide hardware (sensors)	Be a supplier of hardware, set up prototypes	
ITA (Aachen)	RWTH Aachen Institute of Textile and Technology	Research (Smart Textile)	Set up collaboration platform to bring smart textile into the market	
Eccenca (Leipzing)	Subsidiary of IT Solutions GmbH Data management solutions	Ontology	Develop ontologies , to create a tool for connecting ideas	
Asys Group (Dornstadt)	Global technology company and supplier of equipment for the electronic, solar and life science industry	Production	Build production lines for prototyping and printing	
TIM (Aachen)	RWTH Aachen Research Area Technology, Innovation, Marketing and Entrepreneurship	Research (Business models)	To develop business models for value creation to bring partners together	
FIT (Aachen)	Fraunhofer Institute for Applied Information Technology	Software	To develop a web based platform	
Ottobock (Duderstadt)	German prosthetics company	Provide hardware (prosthetics)	Not available during Master thesis timeframe (will not be analyzed)	

8.3.1 Infineon Technologies AG

Infineon Technologies is a leading global provider of semiconductor solutions. Infineon Technologies supports the objective of the project by contributing an expanded production information catalogue with appropriate semiconductors and expertise in selecting further processing services, develop a supply chain concepts for the delivery of functional samples, assessing the feasibility and profitability of supply chain. These contributions support the modularization of the smart textile components, the selection of suitable sensors, functional and technological clustering of sub-functions and product configurations for mass production (GeniusTex documentation).

By contributing to GeniusTex project, the company finds market entry opportunities for the development of long term competitive advantage of suppliers, service providers and manufacturers of intelligent textile. It strengthens the position of high tech industry in Germany.

8.3.2 Institute of Textile Technology (ITA)

ITA is a research institute of RWTH Aachen, a leading textile institute in Germany and worldwide. It mainly focuses on mechanical engineering, textile process engineering, smart textiles, polymer technology, simulation and measurement technology. Moreover, it develops semi-finished products for various application fields such as life science, healthcare, housing, mobility and energy sector. It functions as a project leader of GeniusTex project. Its main contribution is to develop guideline for product modularization and product oriented design of production chains for connecting the platform with hardware.

As a research institute, the main interests are in the knowledge expansion and the development of "intelligent machines and materials". The purpose is to develop self-optimization machines, textile prototyping or integration of electronics components and materials. Moreover, the project helps with strengthening the position of institute as a leading partner in the Cluster of Excellence and Digital Capability Centers in IT and textile technologies.

8.3.3 Technology, Innovation, Marketing and Entrepreneurship Area of RWTH Aachen (TIM)

TIM provides a theoretical understanding of the new business model innovations. The goal is to analyze platforms by using multi-sided platforms based on the industrial concepts and simulations. It wants to add new research knowledge by exploring the mechanisms of platforms with new business models, collaborative development and incentives for companies to bring ideas and products to platforms. One of the main focus points are to design frameworks and explore digital platforms.

8.3.4 Fraunhofer Institute for Applied Information Technology (FIT)

FIT is research and development institute for user friendly smart solutions for business processes. It provides solutions for management of cooperation and innovation, life science informatics, internet of things, usability and user experience design. In the project, FIT is responsible for the development of the platform for suppliers, manufacturers and users to develop smart textiles by connecting digital ecosystems. This digital platform enables efficient collaboration between users, enables early customer involvement, makes cross functional information available and usable, supports collection and distribution of sensor data.

8.3.5 Asys Group

Asys Group is a leading global technology company and a leading supplier of equipment for the electronic industry. It produces a range of manufacturing and engineering equipment from simple handling systems, screen printing and production lines.

For GeniusTex project, Asys Group is responsible for the production of demonstrator line which can produce smart textile prototypes. Moreover, it strives to build a product which allows for flexible production processes regardless of the type of materials, sensors and other electronic components. The company takes the input from system requirements which are needed for the prototyping and incorporates them in the demonstrator line.

8.3.6 Eccenca

Eccenca is a data management solution company which drives automation, rationalization, analytics and data driven processes. It automates processes such as the integration of Two-Speed-IT landscapes, risk, supply chain management and Business Intelligence. It enables access to and integration of disparate data sources. For GeniusTex project, it contributes to the development of ontologies for smart textiles.

8.3.7 Ottobock

Ottobock is a German prosthetics company with its product portfolio ranging from computerized knee to fully articulated robotic hand prosthetics.

For GeniusTex project it brings a view of an industrial manufacturer of medical products and production of the intelligent orthosis. Moreover, it tests the practicality of the textile components on the measuring and feedback functions for patients and users.

Ottobock is described in this section since it is mentioned during semi-structured interviews, however at the time of the thesis Ottobock experiences company restructuring and therefore it is not reachable. Hence, the analysis cannot include this company.

8.4 Case study result analysis

Given a background on various stakeholders in the case study, the remaining of the chapter analyses the results of the case study research. QDA Miner Lite was used to code specific parts of the semi-structured interviews (Figure 36). As explained in the methodology section, codes are generated based on the elements of the conceptual model. The results of the interviews are given in quotes, and the respondents are labeled according to their organization name (names are removed to preserve anonymity). The results of the questionnaire on the level of importance of the conceptual model elements are also presented in graphs and discussed (average responses were calculated).

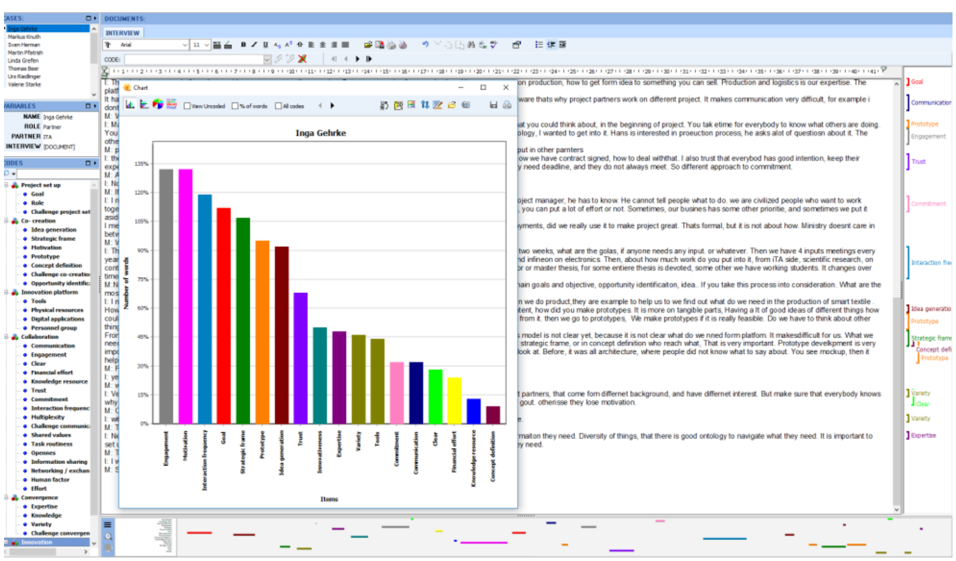


Figure 36 QDA Miner Lite. Source: screenshot of the program (illustration purpose only)

The goal is to validate a designed Co-Innovation Model (see model again Figure 37). Since the model is composed of many elements, the analysis follows a step-by-step approach similarly to the logic of building the initial conceptual model following a literature review sequence (Figure 38). However, step elements are investigated more detailed.

Firstly, the analysis starts with the co-creation element (innovation management process), then moves to the collaboration (inter-firm relationship), the innovation platform (collaboration forms) and to the convergence (collaboration forms). Secondly, the outcomes are analyzed against the degree of ´disruptiveness´. Thirdly, a whole conceptual model is analyzed by taking the most relevant insights of previous steps. Consequently, a final conceptual model is described and presented.

Additionally, after each section, the suggestion list is made which can be used to formulate general advice for the case study company. These recommendations are used to build scenarios on how Infineon Technologies AG can use this model. Generalizable insights are also drawn so that this co-innovation model can be applied for other companies. Finally, the requirement list is also checked on the basis of the results.

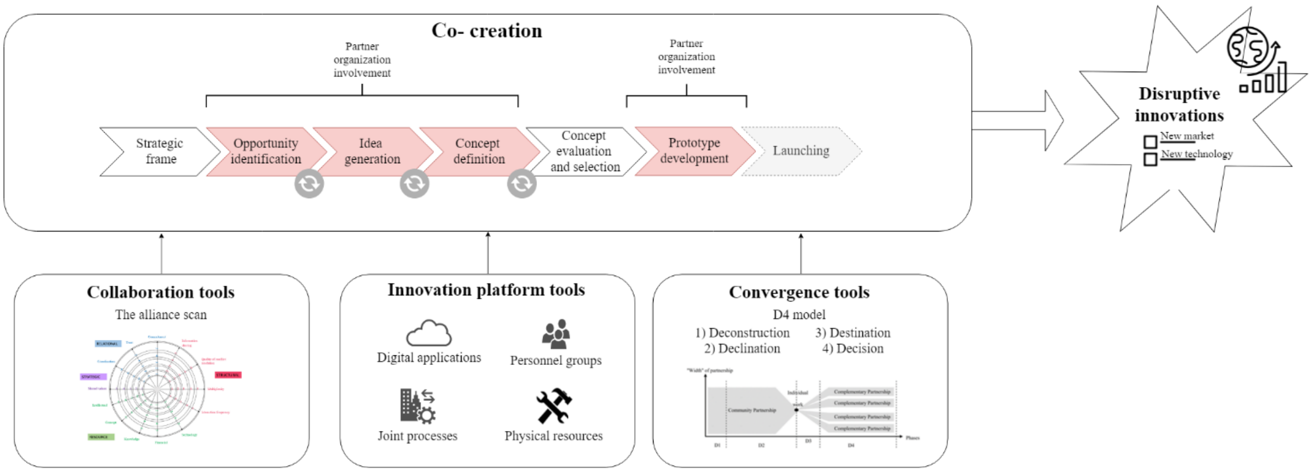


Figure 37 Conceptual model. Source: own illustration

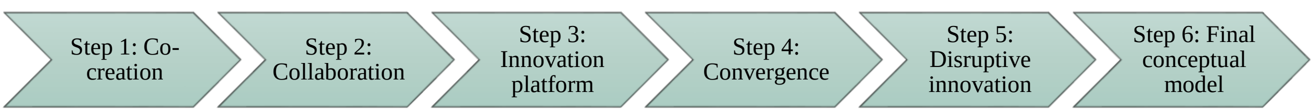


Figure 38 Analysis steps: Source: own illustration

Step 1

8.5 Co-Innovation Model: Co- creation

The first part of the Co-Innovation Model, co –creation element and its 8 step process are analyzed (Figure 39).

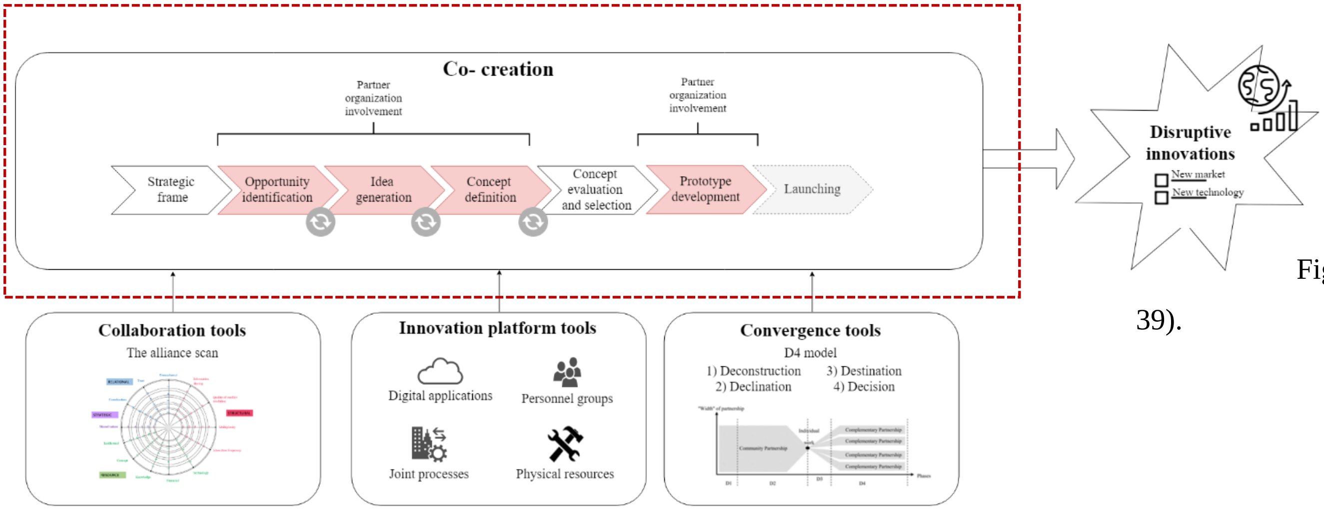


Figure 39 Co-creation analysis. Source: own illustration

8.5.1 Strategic frame

First step in the innovation process includes strategic frame. All of the respondents indicated that strategic frame is one of the most important steps in the project.

"Strategic plan is the most important thing, have a good list to start with, set up a project with milestones" (IFX) *"Before you can start, you need to know what you want to do"* and *"If you don't define how something should look like, the result is hard to achieve" (ITA)*

It is clear that strategic objectives are paramount in the project set up. Moreover, it was also observed that these objectives are used to set up an overall ecosystem rather than rigidly set boundaries. This has also been found in the literature to articulate strategic actions and develop supporting mechanisms (Aagaard, 2008). Therefore, starting with a clear goal such as for example implementing new innovation management system to explore new markets and develop disruptive innovations needs to be communicated to the whole organization. Leaders need to inform, motivate, challenge and guide their employees to create innovation- oriented organization and empowering them (Zerfass & Huck, 2007). The company needs to set clear objectives and to answer questions such as: Do we want to look into new markets or/and to develop new technologies?

8.5.2 Opportunity identification

The opportunity identification concerns active search for recognizing opportunities. As one of the interviewee observed:

"Recognizing opportunities in the new project is essential for sense making process. You have to be open for different opportunities which gives possibility to assess different areas of fields you are not familiar today" (ASYS)

It was observed that the opportunity identification comes largely from having genuine and intrinsic motivation to explore. Each partner has certain interests, but most of all they want to see how their solution can work, and be applicable in the final project solution. Moreover, exploring opportunities allows for knowledge exchange which accelerates the development of partner´s own products / services. Initial search for opportunities does not necessarily have to have financial incentives, for some partners having the possibility to look at the future markets helps with going ahead of other competitors.

Some ideas were suggested by interviewees to expand the horizon for searching opportunities, for example attending conferences:

"Be knowledgeable with scientific things, see what others are doing, learning what fields are new and so on" (IFX)

A very crucial point of this part is to tap into intrinsic motivation because then people have "their eyes and ears" open and stay curious. In GeniusTex project ITA is perceived as the dispatching broker and bridge innovator (Gassmann, 2006), it brings various terms and translates them to common understanding, as well as tries to find gaps and synergies between partners. The stage for opportunity identification and researching various fields is crucial in the early process – regarded as exploratory search (Bossink, 2002)

Analyzing strategic frame and opportunity identification, it makes sense that these are closely related, as strategic frame creates an overall direction, whereas opportunity identification involves certain exploratory actions to achieve defined goals.

8.5.3 Idea generation

The idea generation involves translating the opportunities into tangible concepts, by acknowledging opportunities, ideas are much more unconventional and radical.

In GeniusTex project, the idea for a "voting wristband" came up while exploring different configurations between sensors (Infineon Technologies AG product), textile materials (ITA) and production aspects (ASYS Group). The idea incorporates a barometric pressure sensor which can react to the differences in height and indicates a ´Yes´ act (raising hand) and ´No´ act (lowering hand). The idea to use a pressure sensor for this purpose is not typical for its functionalities. However, its purpose is to show that there are many different unconventional possibilities. The voting wristband is used as a prototype for understanding the most crucial development processes in smart textiles and how they need to be developed.

Furthermore, Asys sees other opportunities associated with a smart wristband such as smart watches which are able to support personnel in controlling machines and working more efficiently in the production processes. It would not only help with production effectiveness but also in making these processes more *"humane and attractive"* (Asys). Some other ideas were generated such as integrating electronics in mattresses or shoes which create opportunities for exploring patterns of sleeping or walking. As mentioned by ASYS:

"We wouldn't look into it in our normal daily business, but it is very interesting".

As the project moved along, Asys which initially was responsible for developing a demonstrator to simply produce smart textiles, is now also responsible for developing a new idea, a Pick & Place demonstrator which is capable of automatic exchange of tools. It was found that in order to produce smart textiles different things might be needed such as choice between conductive fiber and glues. These type of ideas came from multiple discussions with other partners who had their own requirements. Hence in order to integrate these various production requirements, a new idea had to be developed.

Another example of unconventional development of idea regards FIT. Initially, the partner was responsible for platform development where users can input and exchange ideas. However during discussions a new function came up – a configurator, which helps innovators structuring their ideas. The web based platform shows a user different configurations of components *"when someone is not sure how to describe ideas in details"* (FIT). As mentioned by a project partner:

"We wouldn't think about it actually" (FIT)

Similarly to the previous example the idea came from merging needs of various partners and understanding each other´s nature of business. Taking an individual perspective on the idea generation, it is important that employees have freedom – *"a space to be creative"* (IFX). Moreover, casual interactions with various employees (e.g. during lunch time) can bring innovative ideas as well. Therefore, it is important to create stimulating spaces where partners can interact not only in project settings but also in informal ones (Moultrie et al., 2007). This will be elaborated in the next section.

Consequently, radical ideas are generated through synergies and co- creation activities and it acts iteratively with the opportunity identification.

8.5.4 Concept definition

According to the interviewees concept definition is about combining ideas with design. Taking an example of Asys (Pick & Place demonstrator), they needed to think further into what materials are needed and what processes can be derived as well as what future developments might be needed. In the concept definition phase expertise is needed. It was mentioned multiple times that a lot of ideas can be generated provided that there is a basic knowledge in the innovation space. As much as it is advisable that the idea creators are not bound by ´old techniques´, they need to be able to comfortably operate in the domain area. Then the move from conceptual ideas are tested in the concept definition, where different combinations of ideas are generated and experimented. With regard to the voting wristband, the idea is to configure hardware in a way that can be applicable to other functionalities e.g. inserting microphone instead of a pressure sensor. In defining concepts it is important that there is a freedom to choose and explore different configurations (IFX). Moreover, it was found to be useful having an easy access to the wide pool of experts which can verify whether certain types of configurations are possible (IFX).

Furthermore, it was found that this phase needs to have iterative nature which consists of making early prototypes and refining them through feedbacks (FIT). It is a lot more useful to build small concepts and present them to other partners than presenting a big concept which might be then completely changed (FIT). These small developments are immediately shared with project partners. Knowledge sharing and iterative processes are needed in the innovation management processes (Preez & Louw, 2008). Hence, this phase really focuses on the overall architecture rather than strict end products (Brem & Voigt, 2009).

8.5.5 Concept evaluation and selection

There was no formal process for evaluating and selecting ideas. Through the discussion, partners had the freedom to assess whether the proposed ideas are possible. Due to the experiential nature of the concept development, perhaps selection was not needed.

8.5.6 Prototyping

All of the interviewers agreed that prototyping is a crucial point in the idea development. Prototyping shows what kind of things need to be considered. Whether certain configurations are feasible, or more technologically complex. Only through actual building up it is possible to see whether there are no *"cross between wires, or power supply shortages"* (IFX).

Moreover, prototypes helps with selling, convincing and motivating others to the idea:

*„We now have mockups such as a voting wristband, and suddenly everybody gets more involved because you have something to look at. Before it was just an architecture talk, where people did not know what to say, but then you see a mockup, it helps with innovation, to make things more concrete"(*ITA)

"Innovation cannot be done with pen and paper. You need to build and test things. Fail and learn from it. You always learn from failing not succeeding" (ASYS)

"Initially, he believed there is 30% chance it would happen and move forward but after seeing prototype, he has changed his mind. He believes in it much more" (IFX).

As one of the interviewees commented, it taps into psychological factors *because "you believe in an idea when you can actually have it in your hands"* (IFX). The act of building things make people more innovative in a sense that they can try out things which were not done before.

In this phase, it is important that innovators have tools and resources to quickly develop prototypes and showcase them to skeptics. It is also easier to communicate ideas for actors who have different expertise, who might not initially understand what type of struggles are there. Moreover, it is important that experimenting and failing are highly encouraged (Zerfass & Huck, 2007). That is usually very challenging in companies which are very focus on high profit margin and have time pressures. Nevertheless, companies should allow more freedom and time for their employees to speed up innovation. One of the ways to encourage experimentation is through hiring of students who are not entangled in very long-term projects (IFX).

Even though, this phase seems to be straightforward, it has not been extensively research in the innovation management topic. The key point is to build an environment that encourages prototyping and freedom to experiment. In the usual business, employees are overloaded with day to day business, but as can be deduced from the analysis, prototyping is key in selling radical ideas. It moves believers of incremental innovations to believing in disruptive innovations. At the same time, it also builds skills that the innovator should have: curiosity and learning from failures.

8.5.7 Launching

This part of the conceptual model is outside of the thesis scope and will not be discussed.

8.5.8 Partner organization involvement

As can be seen from the analysis of the steps in co-creation process, the partner organization involvement was present at the: opportunity identification, idea generation, concept definition and prototyping. It was especially intensified in the idea generation and concept definition. The initial challenge of not fully understanding all the technical terms or vocabularies was mitigated by the development of common understanding and by learning to explain things clearer. Once, this has been resolved, the partners could be fully involved at each stage, propose unconventional methods and ideas (e.g. Pick & Place demonstrator, web based configurator). Partners were encourage to visit each other´s site and develop ideas, for example it was possible to take some courses from ITA and use their facilities for smart textile prototyping.

8.5.9 Co-creation conclusion and suggestions

All the elements of the co-creation process as well as the links and patterns between them have been observed in practice. Consequently, it can be concluded that this part of the model is validated. Based on the results of the analysis, several suggestions are formulated:

- Communicate clear strategic frame through newsletters, web pages or posters (strategic frame)
- Provide up-to-date list of conferences and events and encourage attending them (opportunity identification)
- Provide opportunities for inter-organizational interactions, break silos (idea generation)
- Create stimulating workplaces (idea generation)
- Emphasize iterative nature of developing concepts (concept definition)
- Make physical tools and resources easily accessible, on time basis (prototyping)
- Provide facilities and instructions on how to use available resources (prototyping)
- Provide freedom to experiment (prototyping)

Step 2

8.6 Co-Innovation Model: Collaboration

The next part of the Co-Innovation Model – collaboration tool (alliance scan) is discussed in this section (Figure 40). As was found in the literature it consists of 4 dimensions: relational, structural, resource and strategic. In order to verify these findings, each respective element is discussed. Moreover, literature theory concepts are also analyzed. First, a result of the questionnaire on these elements are presented, then the comparisons to semi-structured interview results are made.

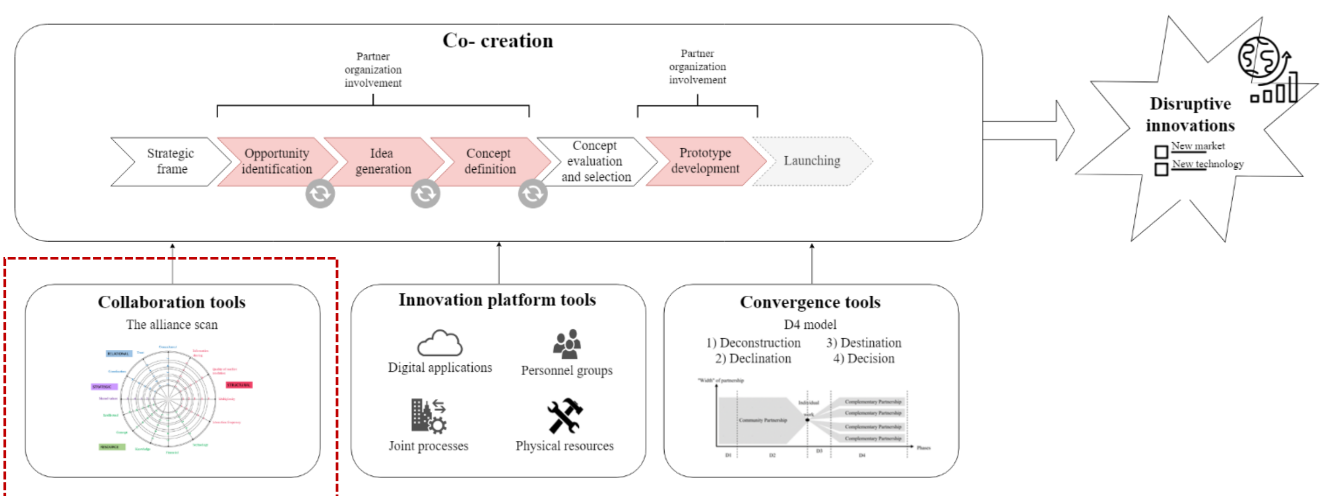


Figure 40 Collaboration analysis. Source: own illustration

8.6.1 Questionnaire results

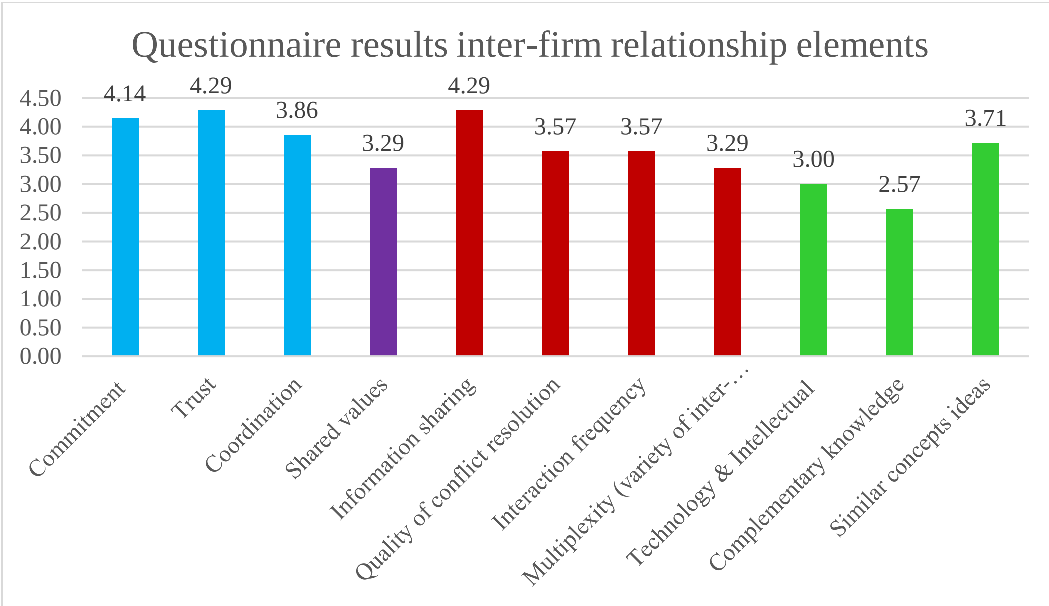


Figure 41 Questionnaire results inter-firm relationship. Source: Excel

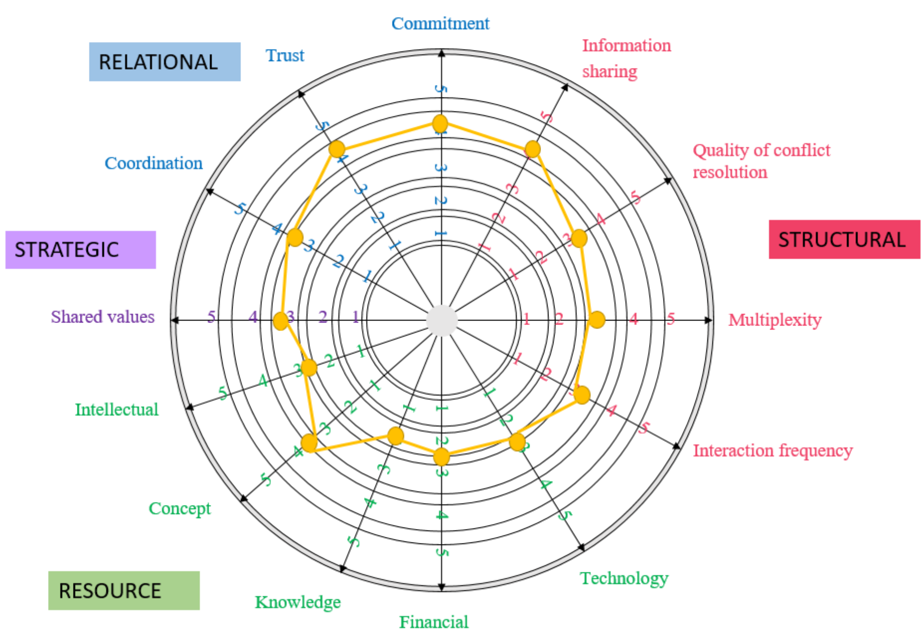


Figure 42 Visual representation of the alliance scan. Source: own illustration.

The elements of the inter-firm relationships were asked in the questionnaire on the level of importance (from 1 to 5), the results are also be compared to the interview analysis in the remaining of this sub-chapter. The exact results are presented in Figure 41. In the designed alliance scan the respondents would indicate their responses on the form as shown in Figure 42. This visualization helps to see whether there are any interesting patterns (or desirable patterns). From Figure 41, it can be noticed that the highest averages belong to the relational dimension (commitment, trust and coordination). The lowest averages belong to the resource dimension (technology, intellectual). In the perception of the interviewees the most important aspects of relationship are trust (4.29) information sharing (4.29) and commitment (4.14). These findings match with the literature, as these three aspects are mentioned as the most important factors in the relationship building (Papadopolou, Andreou, Panagiotis, & Martakos, 2001) . In the context of the project, trust is very high as the partners have very distant capabilities, and they need to put trust in partners´ abilities and competencies (Sharma et al., 2015). Moreover, all parties show commitment through their work delivery and involvement in the discussion meetings. Higher trust and commitment also reinforce information sharing. Partners perceive this as important to be able to move forward with the project. By having right motivation partners believe that this type of projects can be long term.

Analyzing the lowest score, complementary knowledge (2.57) and technology & intellectual (3.00) it can be inferred that in the context of innovation, they are not as important. It means that the partners do not have to share similar knowledge and technologies and it makes sense because then partners can go beyond their own expertise. Similar knowledge would create a certain ´bubble´ and might hinder innovativeness. The same goes for technological resources, each of the partner has very different technical expertise which helps with out-of-the-box thinking.

Relational dimension

8.6.2 Trust

Concerning trust issues, all of the interviewees believe that there is high trust and it is important in such projects. Moreover, the reason behind high trust is that each partner believes that the other partners are professional and have high expertise.

As mentioned by one of the interviewees:

"They give a lot of trust, I don't need to explain much, I made documentations on how to choose the elements, and they fully trust me. I trust others too, they have knowledge I don´t have". (IFX)

As can be seen by trusting each other, there is an "obligation" to perform well and to deliver high quality works. There is no pressure in providing very detailed explanation, it is suffice to explain the rationale behind making certain choices. For example FIT used to explain a lot of technical details which were not understood well by partners. However, they adapted and decided to explain only the most important steps.

Concerning trust, one of the interviewees emphasized the necessity to have face to face meetings. This project has rather remote nature which means that partners are spread geographically. Despite of this, there is still high trust and commitment.

Consequently, high trust environment needs to be developed in order to give space and confidence in developing ideas. Comparing to the questionnaire results, indeed trust is regarded as very important by all of the partners.

8.6.3 Commitment

All of the partners believe that everyone is committed, work hard and can rely on each other. There is high confidence that the work would be done satisfactorily. However, as was pointed out by one of the interviewees, the commitment also largely depends on the support from within the organization:

"I think the project within the company that doesn't have much support can be difficult for those who work on the these projects, to be as committed as they want" (TIM)

This argument could be connected to the public – private nature of an organization. In the research institutes, a lot of work can be devoted, whereas in the private organizations, the commitment can be largely limited by the number of projects one is involved in. On the other hand, rather contradictory comment was given on the administration and bureaucratic issues related to the research institutes affecting the commitment (Asys).

8.6.4 Coordination

The Coordination is mainly executed by ITA, as its formal role it to be a project leader. The majority of the interviewees mentioned ITA several times concerning problem solving issues, getting needed information and so on. ITA acting as the main initiator of the project engages in a frequent meetings with all the partners separately. It helps partners with solving problems and giving tasks. In the project, ITA mainly deals with understanding the business areas of partners and tries to develop common, understandable vocabulary. Several partners deemed it as important since it helps with the communication and boundary definition of tasks.

ITA also emphasized that it is important to make sure that everybody knows:

"Why they are in the project because you can get something out, but also that you can contribute".

That really helps parties to set expectations towards each other. By ensuring right coordination environment, parties work in a collaborative environment whereas setting low level of coordination could lead to lost motivation. On the other hand too much control is also not recommended since it can create hostile environment:

"*It is clear what every partner does, how we handle confidentiality, everyone is professional. I also trust that everybody has good intentions, keep their expertise. I can trust that they deliver what they say, on time and quality"* (ITA)

"We are civilized people who want to work together, we want to make great project, great results" (ITA)

Structural dimensions

8.6.5 Information sharing

Formal information sharing happens during bi-weekly teleconference meetings where each partner is obliged to report on their progress. Important topics are discussed, sub-deliverables are explained and the main issues are brought up.

Another type of information is the input of partners on their own processes and requirements. For example FIT needs inputs from all of the partners to develop web based content. In order to create structure in the data, Eccenca develops ontologies; they also need inputs from all of the partners to understand the connections between various product components and processes. On the other hand, Asys needs detailed information from IFX and Ottobock on the hardware specifications in order to develop production line configurations. However, it does not need much information from FIT or Eccenca.

Another area of information sharing regards the way it is communicated and understood. Due to the intertwined connections between various partners, it is highly important that partners understand each other´s nature of work and be on the same page through developing common basic vocabulary.

"Sometimes I get the impression that it is difficult to explain what we mean to partners, so that they would understand what we mean, and that they can be satisfied" (FIT).

"Sometimes it is difficult to have hardcore software developers, hardcore business developers and hard core product developers getting to the same point" (Asys).

It was mentioned that sometimes there is a friction between "software and hardware world" (Asys). It is much easier to communicate between product designers than between product designer and software designer. Hence "just" sharing of information is not enough, it is important that things are communicated clearly and understandably. This skill needs to be developed by partner companies, otherwise it hinders the development of the project (Perks, Cooper, & Jones, 2005). It was observed that in the beginning it took some time but after a while everyone was able to develop common terms.

Moreover, sharing information was found important because people can help with developing ideas or jointly solving problems. Being curious about other partners´ knowledge areas was also very useful. For example, when the topic of ontologies came up, ITA wanted to personally get involved in. Therefore, it is learning and contributing substantially in this space. IFX became interested in the production processes, and asks Asys a lot of questions to better understand their business processes.

Despite the fact that all the partners are open and willing to share information, there does not seem to be very high intensity of continuous information sharing. Furthermore, it was mentioned several times that not all information is shared because there is high trust. It can be concluded that there is rather high sharing of knowledge rather than intense sharing of "official information". The analysis also aligns with the results of the questionnaire, in which information sharing was regarded as highly important.

8.6.6 Interaction frequency

In terms of the interaction frequency, the project partners meet each other biweekly through a teleconference. The interaction frequency varies between partners, sometimes it is once a week, or more often. The most often used mean of communication is phone call, these can happen every week depending on the flow of the work. Most frequent communication happens between ITA and all other project partners. Moreover, there are 4 meetings per year where partners meet each other in person and discuss major milestones. All of the partners found regular teleconference useful, additionally they also appreciate that other partners are available outside of these meetings.

8.6.7 Multiplexity

In terms of multiplexity, there is a higher interaction between Eccenca and FIT since they are responsible for the website platform development. On the other hand, Asys interacts with ITA and Infineon since it concerns hardware issues.

One of the challenges with regard to the geographically distributed project partners is that partners cannot meet as frequently. At Asys, *"the work in one place is cultivated"*. According to the project partner people are able to work much more efficiently in one place. Hence, the solution could be to organize a place where partners can come and work together or else develop virtual meetings which could resemble the actual meeting rooms (Asys). It was mentioned that screen sharing is vital in the communication since it is much easier to show something, especially when other people are not familiar with terms (FIT). As was mentioned before face to face meetings are also important to develop trust and commitment (TIM).

8.6.8 Relational – structural matrix

Referring to the innovation configuration pattern of Kim et al. (2015), the analysis of the interviews indicates that the collaboration pattern has partnership orientation with medium intensity structure. First of all, there is high trust, commitment and coordination. Whereas information sharing is high in terms of required inputs and share of knowledge, however lower in terms of technical explanations. The interaction frequency is not very high, and is usually on the need to base frequency. The multiplexity is rather low since mostly phone calls and teleconferences are made. Furthermore, interactions happen only between the representatives of each partner. In this case study settings, inter-firm configuration pattern was found (Kim et al., 2015). It can be concluded that through partnership – medium intensity orientation, there is a higher chance for creating disruptive innovations.

Strategic dimension

8.6.9 Shared values

All of the interviewees shared a similar view that:

"Everybody tries to help through openness and collaboration"

All parties have similar principles in achieving their goals – openness, high commitment and motivation. They all strive towards successful development of the project and are highly involved. It can be said that they share similar values in achieving project´s goals. However, there are certain discrepancies in the perspective of the individual goals. The biggest difference is in the business value, for companies in general it would be much more important to have financial incentives. Whereas for research institutes, the value would be in expanding the knowledge base, contributing to the research or promoting its name.

TIM, as a research institute is rather scientifically driven. Whereas, it can be assumed that for Infineon Technologies AG or Ottobock (as suppliers) they might look at the project from revenue perspective. They would like to integrate their products in new fields of application (e.g. textile) or expand the use of certain hardware (IFX sensors) or ontology structure (Eccenca). Another partner sees this as a very efficient way of exchanging ideas and knowledge, where funding is not as relevant as for research institutes (Asys).

Hence, the partners share values in achieving goals, however the goal congruence is not very high among the partners. Nevertheless, on a higher level it can be deduced that ultimately their goal is to be more innovative and explore unknown areas through either research or product development.

Resource dimension

8.6.10 Knowledge resource

In terms of the knowledge resources, everybody agrees that each partner is expert in its own field. Consequently the perception of quality is rather high. However, in terms of knowledge effort, research institutes are perceived to be putting more effort because the research institutes can put as much resources as they can. On the other hand, companies need to focus on the business side. It could be somehow hindering the process since companies might not be so motivated if there is no clear business case. However, with regard to this project this does not seem to be the case.

In a case of IFX, there were not enough knowledge resources. It was mentioned that it could be more useful to have other people who can help with certain problems (IFX). This view could be somehow biased because at Infineon Technologies only one person was responsible for developing a hardware. Moreover, consultation with experts was rather limited. In other companies, it seems that internally there were enough resources.

8.6.11 Financial resource

Due to the nature of the project, human and financial resources are set (see table in Appendix I). The most resources are allocated by ITA and FIT, and the least by Infineon. Despite formal human resource allocation, some partners allocate more when needed. For example, Asys said that there are always at least 3 people working on the project every day, whereas the official allocation is 24 persons for 2 years. Despite the fact that Infineon has the least allocated resources, it has been very active in improving ideas by being highly involved. Hence, it is clear that structural dimension can differ substantially from relational dimension. In terms of financial resources, the research institutes get 100% funding from the government, whereas companies receive around 50%.

One of the interviewees said that the financial constrains can be hindering on many occasions. For example, if one party is committed to spend X amount of money, the development of certain ideas might be abandoned (Asys).

Hence, this is a challenge that two companies may face. Nevertheless, putting together various actors in the innovation ecosystem could potentially mitigate this challenge.

Another observation was made with regard to the type of the human resource:

"If you don´t have engaged PhD students who do not use time to do research outside of the project frame, then the company has no chance to see other sides" (TIM).

Hence, it is important to also include people who conduct research but not necessarily in the same way as researchers in R&D. It is important that silos are broken, and people research various fields. Moreover, one of the interviewees suggested that:

"Students who are highly motivated and do research, they can learn new things, for example programming. Students have much more freedom. Companies could hire more students to come up with solutions, build things and make it easier to see and be more innovative" (IFX)

It can be presumed that young workforce is not limited by the constraints of technologies, and can therefore develop unconventional ideas. Moreover, they are usually not overloaded with many long-term projects. As was mentioned several times during interviews, having time and space to experiment is crucial. Having not only research oriented but also young professionals can be advantageous in the creation of innovative ecosystem.

8.6.12 Technological and intellectual resource

Technological and intellectual resources were not discussed extensively. However analyzing the interviews, it can be inferred that the tacitness of technologies is quite high. Each party is expert in its own field but they are also very open to modify their own technologies. For example, it could be possible that some electronic components can be printed on a flexible material (IFX), or integrating ontologies in the FIT software. Therefore, it is observable that through the business relations, a lot of technological capabilities are exchanged.

8.6.13 Knowledge – concept space

Referring to the design space of Kazakçı et al. (2009) and by analyzing various dimensions of resources and technologies, the spaces between knowledge and concept resources are very high. All of the partners have very different knowledge (hardware, smart textile, software etc.), as well as their concepts (semiconductor, production line, software programs). Moreover, it was found that having such distant knowledge, exploratory partnerships are possible. All of the partners try to understand each other requirements and adapt to their needs. Hence in the design space, the resource dimension goes under partnership type 4, where there is a high opportunity for disruptive innovations.

The results from the questionnaire further support the above conclusion, interviewees indicated that *complimentary knowledge* is least important. On the other hand, higher score for *similar concepts* come from the fact that the design space is limited to a textile industry. Despite the fact that there are many opportunities to develop unconventional ideas, the scope is limited to smart textiles. Nevertheless, it could be hypothesized that through continuous interactions between partners, other ideas outside of the project scope could be generated. Consequently, longer term relationships might be established.

8.6.14 Collaboration conclusion and suggestions

From the analysis of the interviews on inter-firm relationship, it can be concluded that the collaboration part of the conceptual model is validated. First of all, as found in the literature, there are four distinct and differentiated dimensions of relationship: relational, structural, resource and strategic. In terms of relational element, all parties are committed and highly engaged. This creates trust and collaborative environment. High level of trust comes from the fact that there is a right coordination mechanism and high expertise among the participants. Structural dimension can be defined by information sharing, interaction frequency and multiplexity. Despite official biweekly meetings, parties are willing to interact more often with each other. Hence, structural elements are not directly related to relational dimensions. In terms of resource dimension, all of the resources (knowledge, intellectual, technological and finance) were relevant in the case. Lastly, strategic element, shared values is also distinct from the other dimensions since they defined on the higher level. It is about various perspectives on achieving goals.

Additional observation is made regarding communication issues (information sharing). It can be observed that information sharing and knowledge exchange are somewhat distinct and should be therefore separated. It is clear that knowledge exchange is very high. This perception of knowledge comes from the fact that parties operate in very different knowledge areas and the tacitness of knowledge is also significant. Moreover, it can be argued that high knowledge exchange would belong to the relational category since it affects the perception of each other (Kim et al., 2015). Knowledge sharing is not the same as knowledge resource because one party might have various expertise and capabilities but might not be willing to share this knowledge. For example, a supplier specialized in its own field simply provide requested materials and can even share information on the delivery but does not necessarily have to share its knowledge space. On the other hand, explicit information sharing is very different from knowledge sharing as it is more structured. In the project, it might be explicitly required to report on progress or develop documentations. It would then belong to a structural dimension.

To distinguish these three dimensions, the following illustration is made: a supplier specialized in its own field (high knowledge resource) provides requested materials and shares information on the delivery (high structural dimension) but does not necessarily have to share its knowledge expertise (relational dimension). The analysis of the interviews clearly bring these considerations. Project partners are openly sharing their knowledge and try to understand concepts and help in many occasions.

Distinguishing information sharing from knowledge sharing is therefore important in the development of inter-firm relations. The inter-firm dimensions are adapted as follows (change made in the yellow box) (Figure 43).

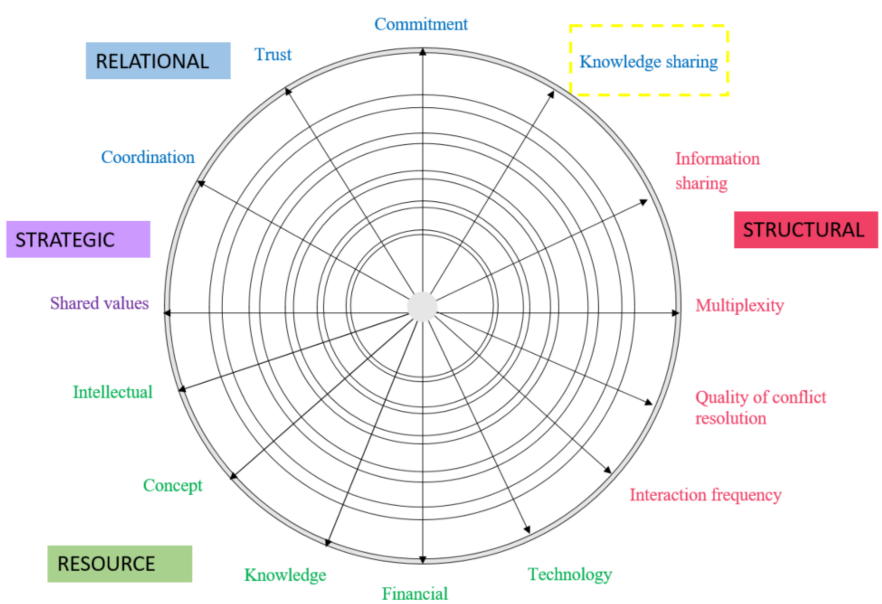


Figure 43 Adapted collaboration. Source: own illustration.

Overall, it can be concluded that these dimensions cover a comprehensive spectrum of inter-firm relations. In the case study project, the partnership has already been established therefore it was not possible to investigate the exploratory partnership opportunities. Hence, instead of naming collaboration elements as tools it is rather a collaboration assessment. In that case, the partner can not only use this frame for initial scanning (as was initially proposed), but also throughout the established partnerships. Assessment can be made several times during the project, and it can help to adjust certain areas to improve innovation management capabilities.

Moreover, the assessment can also be used for stakeholder analysis. Apart from a typical partner´s analysis on the goals, interests, SWOT etc., it can be visually represented in such a circular form. Since the elements can be easily quantified e.g. assessing the level of commitment on a scale from 1 – 5, various decisions (e.g. choosing partner, changing strategy) could be made quicker through assessment and scans.

Regarding the connection of the collaboration element to the first step of the conceptual model (co-creation), the collaboration is highly relevant in the idea generation phase, opportunity identification and concept definition.

Based on the analysis on the collaboration, the following suggestions are formulated:

- Establish high trust through face to face meetings, emphasis on the mutual interests and contributions (trust, coordination, multiplexity)
- Knowledge sharing through regular and multiplex interactions such as face-to face meetings, phone calls, workshops, co-working spaces, conferences etc. (interaction frequency, multiplexity)
- Ensure employees have good communication skills through trainings (information sharing)
- Partner with organizations who have high quality experts (knowledge resource)
- Incorporate research oriented workforce and/or young professionals, break silos (financial resource)

Step 3

8.7 Co-Innovation Model: Innovation platform

The third part of the conceptual model consists of the innovation platform tools (Figure 44). Each element is discussed with case study results. The qualitative analysis is triangulated with a questionnaire results.

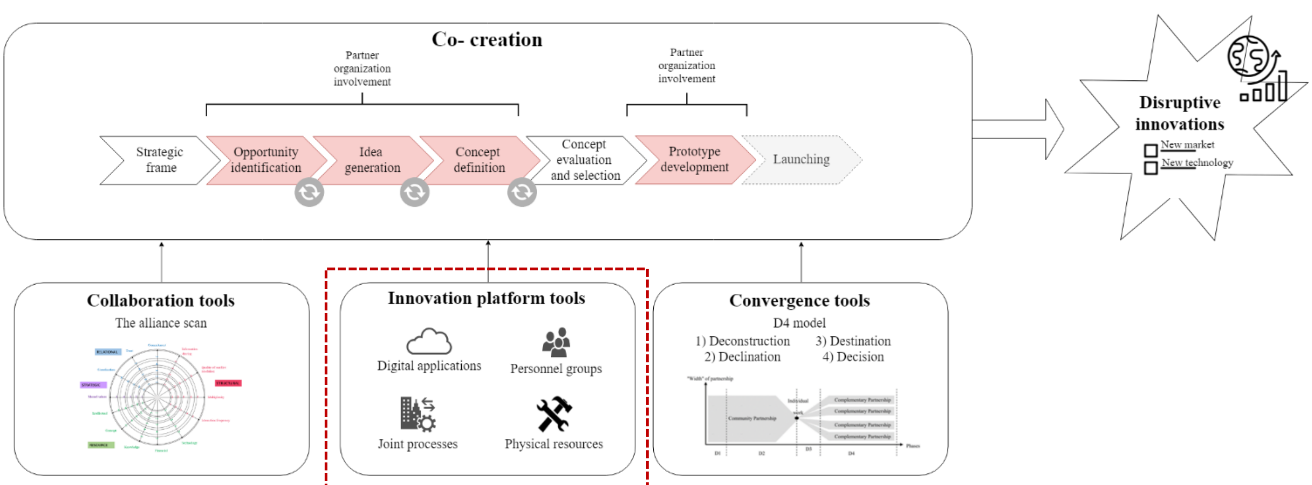


Figure 44 Innovation platform tools analysis. Source: own illustration

8.7.1 Questionnaire results

The innovation platform elements were gathered in the literature review (Abhari et al., 2017). The questionnaire was constructed similarly to the previous questionnaire: the interviewees were asked to choose the level of importance (1 least to 5 most important). The results can be seen in Figure 45.

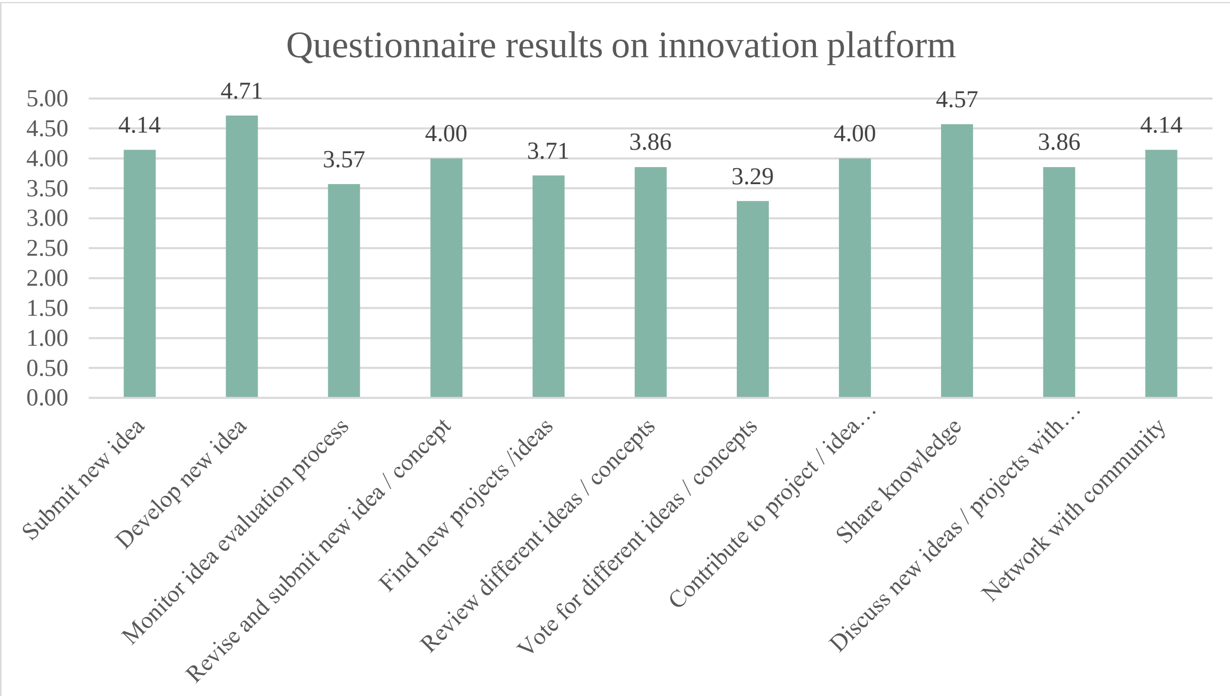


Figure 45 Questionnaire result on innovation platform

The results indicated that all of the elements are scored above 3 which means that they have significant impact on the innovation platform. The highest scores belong to *develop new ideas* (4.71) and *share knowledge* (4.57) hence the innovation platform should enable various partners to freely develop ideas using various tools. This is also connected to sharing of knowledge, because combining various areas is helpful in developing ideas. The importance of sharing of knowledge was also found relevant in the previous section. The lowest score is given to *vote for different ideas or concept.* This could be explain by the fact that voting has rather formal nature, whereas in the case study analysis the collaborative environment encourages discussion on the new ideas rather than casting votes.

In terms of the platform, all partners agreed that having a platform where ideas can be exchanged is crucial. In terms of the digital applications, a web based platform similar to what GeniusTex is developing is key in co- creation activities. It brings various partners together to innovate and to collaborate.

8.7.2 Digital applications

Regarding digital application different types of communication means are useful such as skype, e-mails or phone calls. The project partners use a FIT web based platform where documents are stored and exchanged. Especially, a daily report on changes was useful because people can easily keep track without the hustle of asking for information (IFX). Therefore, having an overview on the project / ideas, project changes is advised.

Another idea was proposed by Asys who introduces newsletter to inform everyone on *"what´s going on*". Hence, digital applications are relevant and important in the innovation platform development. Through various forms of digital applications, developing new ideas and sharing of knowledge can be facilitated.

8.7.3 Personnel group

Regarding personnel group two separate issues emerged: administrative and resource support.

First of all, it was mentioned that there needs to be *"some sort of control on who is registering"* and what is shared should be monitored (FIT). Hence in the development of the innovation platform a dedicated team could be installed. That team would be responsible for developing, managing and upgrading a platform. It would also verify whether proposed ideas on the platform are real. Moreover, it can also support finding resources and help with setting up projects. It could serve as a bridging point between various partners and facilitate innovation processes (e.g. in idea generation) (Brentani & Reid, 2012).

Secondly, accessibility to experts helps with generating new ideas:

"He [company employee] gave a lot of ideas, after meeting with him, when he mentioned some terms, I knew what to Google, what to search for. I didn´t even know what GitHub was if it wasn´t for him. After, we knew how to retract data, connect sensors etc." (IFX)

Moreover, the platform needs to have:

"Variety of stakeholder and variety of different expertise" (FIT)

Hence an innovation platform can include experts who can be easily reachable. Otherwise, it is difficult to know who to reach out. Everyone who has some expertise in certain fields can provide consultation. Some incentives need to be assured in order to attract knowledge experts.

8.7.4 Physical resources

Physical resources in various forms were mentioned during interviews. For example, physical places where partners can meet up in person and interact are crucial. In those spaces, not only meetings but also various creativity technique sessions or prototype building can be held. Moreover, such places could not only include various tools such as white boards, office supplies (Asys), but also building tools such as (electronics, 3D printers, textile materials) (IFX).

There needs to be space where partners can freely come in and enter joint activities. As much as physical spaces are useful, sometimes travelling time can hinder frequent interactions. It was proposed that it is easier if joint activity places are located centrally in big cities. One of the interviewee proposed that use of advanced technologies which could allow *"to have the feeling of being in the same room"* (ASYS) and would potentially increase collaboration and efficiency.

8.7.5 Joint processes

Digital applications, personnel group and physical resources are needed to develop joint processes. These joint processes range from idea generation, knowledge exchange, networking to prototype development. Personnel group is key in developing and monitoring the platform, digital applications are important in virtually connecting various expertise. Finally, physical resources are supportive in co-creation activities.

Even though there was a discussion on possible innovation platform ideas, the project group was not using non-traditional platform tools.

8.7.6 Innovation platform conclusion and suggestions

The innovation platform element of the conceptual model was found in practice and relevant. The four elements of the innovation platform covers comprehensive spectrum of factors that need to be considered in the development of co-innovation concepts. Moreover, it was found to be considered as an "architecture tool" that facilitates the development of the platform.

The innovation platform in its various forms is present at all steps of the co-creation (from strategic frame until prototype development). On one hand, a digital application tool can be used to generate ideas or find experts, on the other hand a co-working space can be used for idea brainstorming or building prototypes.

Based on the analysis of the interview, recommendations are made:

- Platform that includes functions such as: submitting new ideas, developing new ideas, monitoring evaluation process, finding new ideas, reviewing ideas, voting, contributing, sharing knowledge, discussing new ideas, networking with community (innovation platform)
- Platform which allows chatting, video calling and calling (digital application)
- Set up fixed administrative team (personnel group)
- Include easily accessible experts (personnel group)
- Develop a transparent means for sharing information (personnel group)
- Create a physical co-working space (physical resource)
- Develop advanced technologies (physical resources)

Step 4

8.8 Co-Innovation Model: Convergence tool

The last component of the conceptual model is the convergence tool Figure 46. In this section, convergence is explained against the results of the case study. It is important to keep in mind that D4 tool model was not explicitly applied in the project.

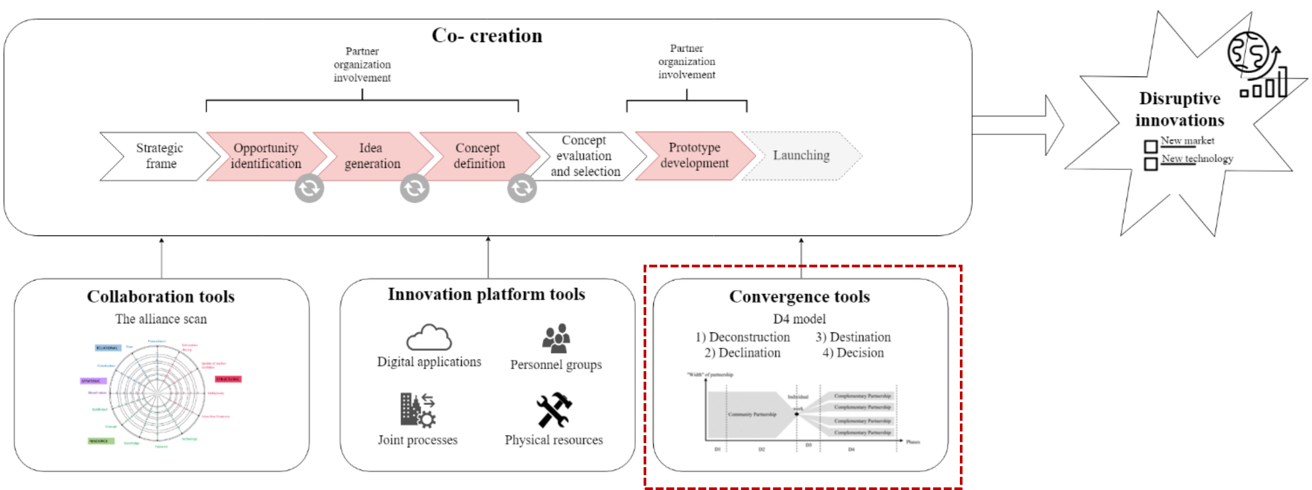


Figure 46 Convergence tools analysis. Source: own illustration.

Analyzing the interviews it can be deduced that some degree of exploratory partnership was present. Partners were exploring certain emerging technologies, but were largely limited to the scope of smart textiles. Moreover, project partners are not fully aware of the other parties´ business units. However, due to the limited field scope, convergence could be observed. Figure 47 below illustrates the process.

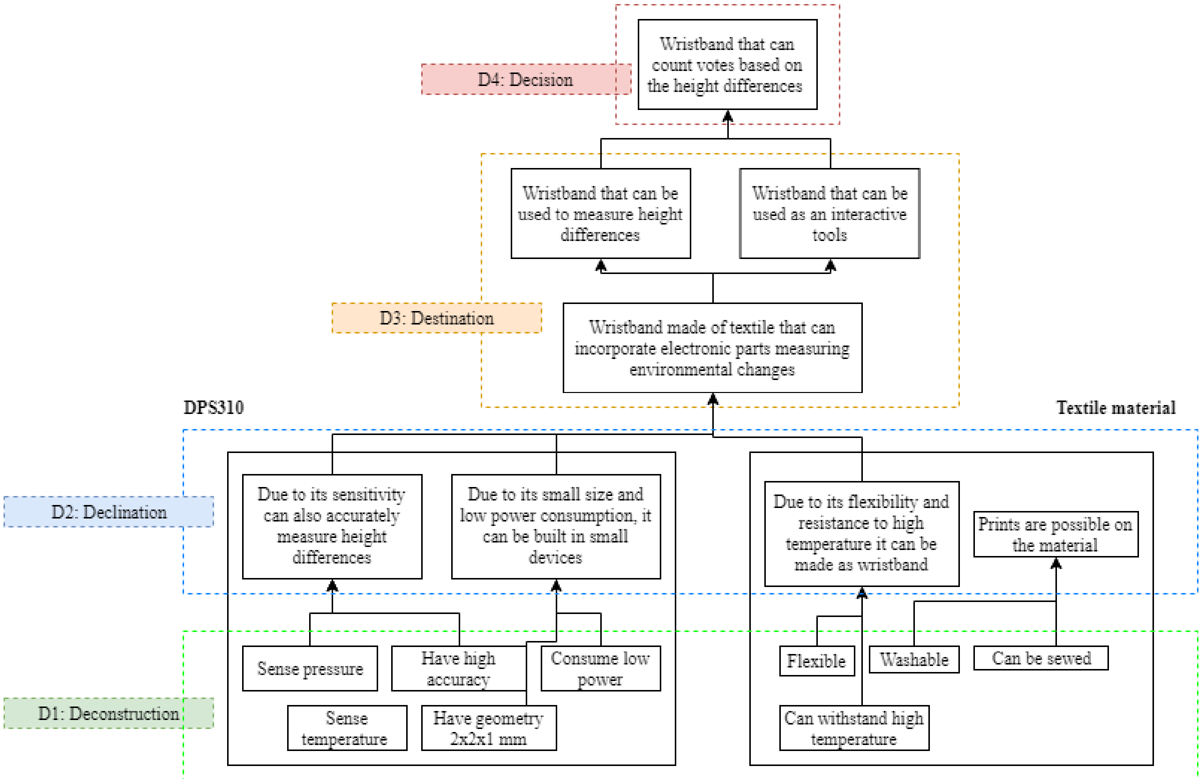


Figure 47 D4 model on GeniusTex. Source: own illustration

The first step (deconstruction) starts with available technologies and their properties. On one hand there is Infineon Technologies with DPS310 pressure sensor. All different properties were shared. The same goes for ITA with its textile material properties. The next step (declination) is about merging properties together and generating general functions. Destination takes these functionalities and translates them into many different ideas. For simplicity only few are presented. The final step (decision) is about choosing an idea and developing it. Hence it takes a structured approach to convergence of ideas.

It was mentioned by several interviewees that it is paramount that despite having different very distant knowledge space, there needs to be a common understanding of the field. In this case, partners put effort in learning about the field of smart textiles. For all of the partners (except of ITA), this field is completely unknown.

However, it is clear that the community partnership is very wide since all partners have very different knowledge:

"For example IFX knows a lot about technical stuff on microprocessors, Ottobock also has technical expertise but on totally different area" (TIM).

It was also observed that convergence is important in the innovation process since:

"Ideas do not come from one person. You need combination of different mindset and experts" (IFX).

Hence on one hand, the knowledge distance is very helpful in merging different domains and create disruptive innovations. On the other hand, it makes more sense to know what each party is talking about. There was not any formal process for organizing convergence of ideas, nevertheless it can be deduced that convergence activities took place. Perhaps the idea for voting wristband could have been very different if all possible ideas were brainstormed.

Moreover, it was observed that convergence in this case study was focused on the merging of concepts or ideas rather than the convergence of goals or working methods. Hence, the convergence element is most noticeable in the concept definition stage.

8.8.1 Convergence conclusion and suggestions

In conclusion, when partners from different fields come together with their own technological expertise, eventually ideas need to be converged. However, it cannot be concluded that certain tools could help with coming up with radical ideas. It is possible that ideas converge but through informal interactions or exchange of knowledge. Hence, this part of the model is adjusted from *convergence tool* to *convergence capabilities*. The analysis shows that people need to develop certain capabilities for merging seemingly unrelated concepts /technologies /ideas (Hidalgo & Albors, 2008)

Nevertheless, D4 model can be very useful in explaining technical terms in an accessible way. As was mentioned during interviews developing a common ground vocabulary is essential in the communication. One of the benefits of this model is that in the first step (D1), all the technology properties are presented. This makes it easier for all the partners to understand specific technologies. Therefore, it is much easier to come up with ideas for example for a pressure sensor once people know what properties it actually has. In step D2, combination of properties are generated (e.g. height with temperature). In the third step D3, having different knowledge and views are *actually "very helpful in radicalness of the ideas"* (FIT). Trying to converge general functionalities of separate technologies can lead to unconventional innovations.

Based on the analysis the following suggestions are made:

- Encouraging diversity of partners
- Predefined scope can be useful

Step 5

8.9 Co-Innovation Model: Disruptive innovations

The hypothesis of this thesis project is that this co-innovation model covers relevant aspects which would facilitate the creation of disruptive innovations. Hence, the case study looks also at the perception of the innovativeness and measures whether it fulfills the definition of disruptive innovation. Once the checklist is ticked, it can be deduced that the elements of the conceptual model indeed fulfilled all the requirements (Figure 48)

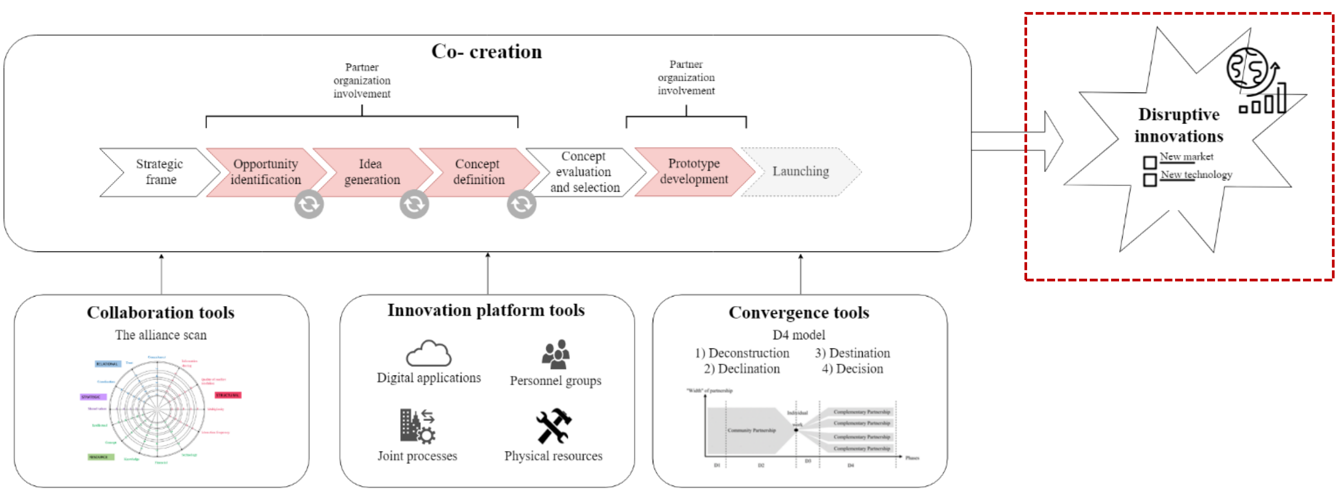


Figure 48 Disruptive innovation analysis. Source: own illustration

8.9.1 ITA

According to ITA (textile experts), the innovativeness lays in the approach smart textiles are produced and developed:

"The way we think about how we approach textile, for example by using ontologies, how to make production process sustainable, that you can easily make prototypes, you have various expertise put together"

In ITA´s perspective, the innovation is not bounded by certain products but rather by the approach and the process.

8.9.2 Eccenca

According to Eccenca, the project is very innovative and has not been done before. It is about:

"Integrating data with technologies and looking at how we can leverage it"

It is about looking at the product from various perspective. It helps the company to look at how people can use ontologies. For Eccenca, textile domain is very new and many features need to be developed.

8.9.3 FIT and TIM (Research Institutes)

According to FIT (software experts), the perception of innovativeness lays in the possibility for sharing knowledge and working together. As such, developing a web based platform as a technology is not new, however the idea behind is very innovative. Similar observation is made by TIM (innovation management experts), where innovativeness lays in the inclusion of many different domains and expertise. Usually, companies collaborate in a dyadic settings (between two companies or one company and a user). The field of networked co-creation is also something new for TIM.

8.9.4 IFX

According to IFX (hardware electronic experts), the innovativeness of the voting wristband lays in the use of its base product (pressure sensor) for voting. The act of voting is not innovative nor is pressure sensor but combining these two is perceived as innovative. The next phase is to combine different application areas such as electronics and textile with healthcare. Combining two markets (semiconductor and textile) can bring opportunities to find new markets (healthcare).

8.9.5 Asys

According to Asys (supplier of equipment), the developments of a demonstrator line and Pick & Place are very innovative since the *"whole picture of things need to be considered"*. In their standard product offerings, the automation is in their traditional business area, they are highly specialized in these technologies. However, through the inclusion of Ottobock and thus the development of prosthetics, human side needs to be included as well:

"It is more human centered, so it is much more innovative for us".

Moreover, Asys has not worked much with textile so for them it is *"new field of knowledge, huge market".* They also see opportunities into entering other markets such as sport or healthcare.

8.9.6 Disruptive innovation conclusion

In conclusion, all the partners in the project case develop disruptive innovations since they either enter new market and / or develop new technologies. As such it can be concluded that the conceptual model overall facilitates the creation of disruptive innovations.

Step 6

8.10 Final Co-Innovation Model

All in all, by analyzing this case study it can be concluded that the co-innovation concept is observed in practice. First of all, it captures the collective intelligence of the network (S. Lee et al., 2012) through high trust, commitment and sharing of knowledge. The environment facilitates the creation of new ideas and concepts (voting wristband, Pick & Place). Secondly, it creates value for all of the stakeholders. These values are exemplified through access to experts and new fields. It is clear that project partners are not solely focusing on financial incentives. Most partners did not mention financial incentives as their main reason for joining the project since they were focusing on the knowledge sharing and exploration. They perceive such collaboration as an opportunity to network and learn. This is crucial in the co-innovation environment. Thirdly, understanding different views, inclusivity of various stakeholders, and wide range of disciplines are also present in this case study. Partners put effort into developing mutual understanding and clearly explain their own technologies. Moreover, all stakeholders of smart textile life cycle are present – from suppliers of materials (ITA), suppliers of technical components (IFX, Ottobock), manufacturers (Asys), software developers (FIT, Eccenca) and business model developers (TIM).

Finally, a lot of attention is given to the exploration and learning experiences. Co-innovation does not necessarily results in disruptive products or services, but can also be exhibited through actor interactions. The traditional view on innovation, in which a company either requires a supplier to improve its products, or requires a client to use its products more innovatively is challenged by the concept of co-innovation. The way the innovation process is organized is much more valuable as it helps with developing abilities to converge to unconventional ideas and brings valuable experiences. Therefore, the definition of disruptive innovation is adjusted to also include *New Skills* (in addition to new markets and new technologies). Hence, initial hypothesis that the company wants to innovate through collaboration is supported.

In conclusion the model has been validated since all the elements of the Co-Innovation Model are tested on a real life example, co-creation process is supported through collaboration assessment, innovation platform tools and convergence abilities. Based on the analysis, the Co-Innovation Model has been enriched. The *Collaboration Tool* is changed to the *Collaboration Assessment* since it provides partners with a broader perspective. Moreover, it adds a dynamic element to the conceptual model where collaboration can be configured. Regarding convergence, the emphasis is on the *Capabilities* to merge different ideas and concepts. In the disruptive innovation definition, new market and new technologies are not the only indicators of disruptive innovation. The emphasis on the value creation through learning is also advantageous. Hence, *New Skill* is added to the definition. The final conceptual model can be seen in Figure 49 (changes are indicated in yellow dot boxes).

Based on the analysis, the following general suggestions are formulated:

- Clearly define steps in the co-creation process starting with sharing vision with the employees (strategic frame) as well as providing opportunities to execute each step. At the same time, each component of the process has iterative and transparent nature. Employees should not be stopped at stages and be encouraged to experiment. Stage gate process hinders innovation.
- Develop collaboration assessment tools to be able to develop desired innovation aiding configurations or recognize partnership opportunities through provision of trainings which are not only addressed to sales & marketing teams but also to developers/engineers etc. Emphasize various form of collaboration such as face-to-face meetings, company visits, joint workshops and attending conferences.
- Develop innovation platform tools supporting the co-creation process such as digital applications (web pages, forums, newsletters and virtual conferences), physical resources (labs, maker space, innovation hubs) and dedicated personnel group who develops and administers these tools.

- Develop convergence capabilities through trainings on various methodologies (e.g. D4 model), encourage joint work processes between potential partners not only established ones. Provide means for exploratory partnership.
- Recognize various forms of value creation such as learning experience, gaining new skills, acquiring knowledge about other fields of business.

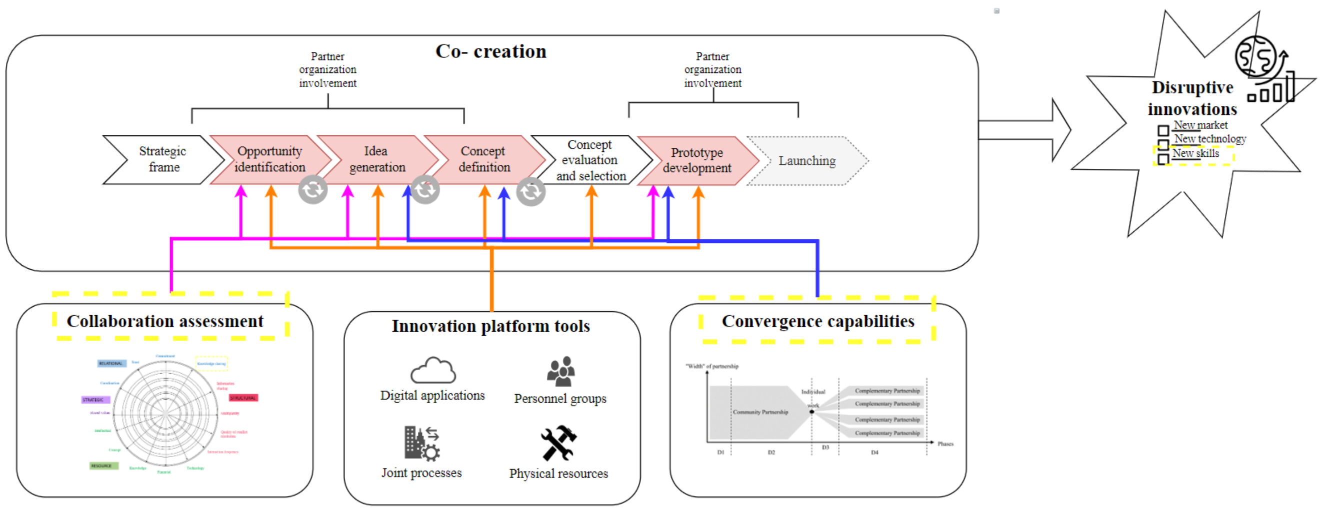


Figure 49 Final Co-Innovation Model

8.11 Implications of the Co-Innovation Model

The literature on co-innovation is limited, the earliest works date back to the beginning of this century. In comparison to the traditional innovation models, co-innovation concept has not been extensively empirically researched. Lee (2012) constructed the co-innovation model and argued that it consists of innovation platform, co-creation, convergence and collaboration. However, the authors do not specify what these elements actually mean and how they are related. Moreover, it has not been verified empirically. Hence, this master thesis develops this model further to define actionable steps that need to be executed through these elements as well as validate them empirically on a case study. This allows for generation of additional insights.

The co-creation element thus acts as a foundation of the co-creation processes following iterative steps of strategic frame, opportunity identification, idea generation, concept definition, concept selection, prototyping and launching. At each of this step, there is partner organization involvement in order to emphasize joint activities. In comparison to traditional innovation process model, the partner involvement is either at the last stage of the process or through formal “reporting” meetings. However, rarely partners have the ability to work together – at the same place and time.

The collaboration element is crucial in incentivizing the right environment. It was found that the consideration of relational, structural, resource and strategic elements can largely set the tone for collaborative environment. Hence, high partnership orientation with moderate structural intensity, long distance of knowledge and concept spaces create the most disruptive innovation settings.

Lastly, convergence in the conceptual model means merging of various fields / knowledge / technologies which would otherwise be not considered. Convergence lays in the space of finding links between partners. Convergence in this context does not necessarily lead to convergence of the same goals / interests or projects. Partners can simply explore rich community of partners and then converge to complimentary partners.

Moreover, these elements ensure that certain practices are more or less pronounced at various stages (e.g. digital tools are very useful in idea generation phase). As mentioned in Vereijssen et al. (2017) “How and when co-innovation is implemented must be tailored to the particular situation and may change over time”; the model shows not only how the frame of co-innovation can be constructed but it also emphasizes the possibility to be flexible and adaptable.

The implications for the model are drawn from the case study allowing to analyze and evaluate the elements found in the literature and to refine a model through artefact validation. The choice, whether to further redefine the model or to implement it, is depended upon the motivation (problem) owner. Taking the scope of this master thesis, the design phase of the artefact in the Design Science framework is stopped at this iteration.

8.12 Artefact validation sub-conclusion

This chapter presented the results of the case study which were used to validate the conceptual model. Overall, the case study method enabled to observe the elements of the model and draw interesting insights and individual element´s suggestions. The purpose of this model was to not only describe the elements but to also prescribe various processes. The case study research allowed to reach this aim. The results of this chapter is the refinement of the evaluated conceptual model and refinement to a final conceptual model in the scope of this project.

CHAPTER 9 REQUIREMENTS FULFILLMENT

Previous chapter attempted to validate the model on a case study research, thus the output – *validated artefact* can be used for the next phase of the Design Science project, which is to *evaluate the artefact* (Figure 50). This phase determines the extent to which the artefact can reach the explicated motivation and fulfills the requirements. There are many different ways to evaluate an artefact, the main focus of this phase is to evaluate the requirements on the artefact. The requirement fulfillment is directly observed from the artefact validation in the previous chapter, this chapter summarizes main points. As was mentioned in the methodology section, the evaluation phase is taken rather lightweight. Other possible evaluation methods will be elaborated in the next chapter, recommendation section.

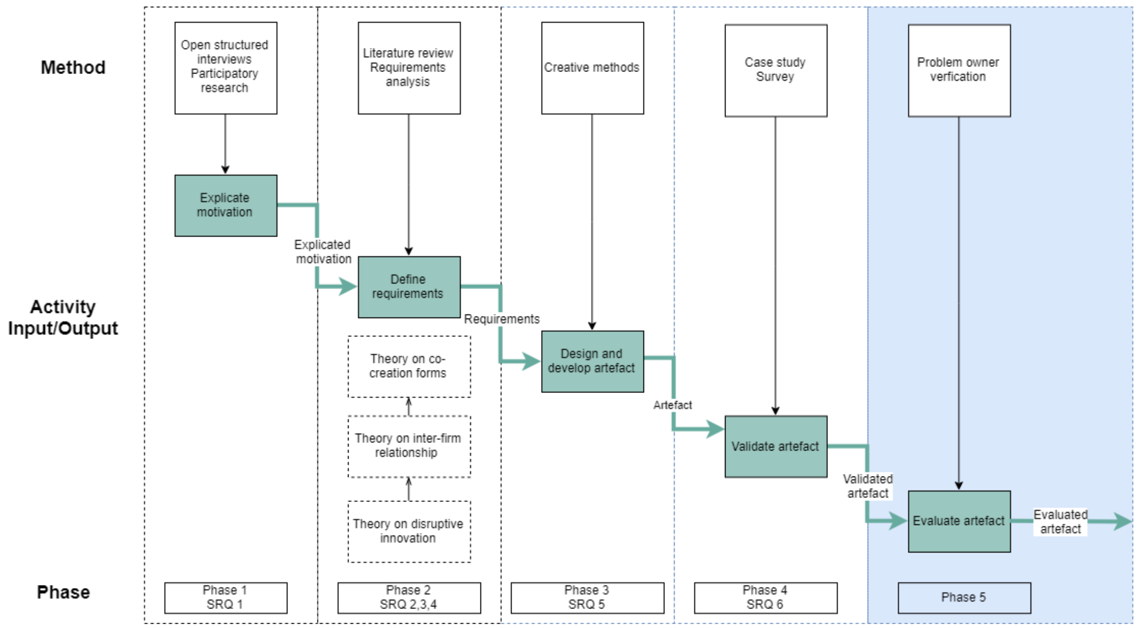


Figure 50 Design Science Project Phase 5

The proposed artefact is fulfilled once the requirements are achieved. In this section, each element of the Co-Innovation model is discussed with regard to identified requirements. An "X" indicates that certain requirement is fulfilled. See Table 14 below. The outcomes of this phase were consulted with the opportunity owner and accepted.

Table 14 Requirements fulfillment

	Requirement	**Co-creation**	**Collaboration**	**Innovation platform**	**Convergence**
1	Interactive and iterative	X	X	X	
2	Exchange of knowledge	X	X	X	X
3	Exploratory partnership capabilities	X	X	X	
4	Incentivizes to innovate	X	X	X	X
5	Abilities to identify, evaluate and develop disruptive innovations		X	X	
6	Digitized technologies			X	X

7	Configure partnership opportunities		X		
8	Disruptive innovation climate		X	X	X
9	Learning experience	X	X	X	X
10	Effective provision of products and services	X	X	X	X
11.1 **11.2** **11.3**	Values to the employees, stakeholders and communities / industries	X	X	X	X
12	Societal, economic and environmental benefits	X	X	X	X

Regarding the co- creation processes of the conceptual model, it meets almost all the requirements initially set. Through the various steps in the process, it allows for interactive and iterative processes, where at every point of the process various actors can exchange their knowledge. It is important that the partnership involvement is integrated in the process rather than treated as external force. Through the interactions with unconventional partners, people are challenged to think outside their boundaries and thus are incentivize to innovate. Since requirements 1 – 4 are considered foundational (must haves) and are necessary to meet the rest of the objective (recall the relations in Figure 28). Therefore, the co-creation is key in the conceptual model and is validated through the case study research.

Analyzing collaboration part of the conceptual model. The structuring of the collaboration elements is relevant and useful. The first four requirements 1 – 4 are also met. This is due to the fact that the presence of high relational dimensions lead to interactive processes and exchange of knowledge. High trust and knowledge sharing supports exploratory partnership capabilities and incentivize to innovate. High resource dimensions helps with developing abilities to identify and develop disruptive innovations. At the same time, medium intensity of structural dimension provides space for partners to be creative, to learn from each other and thus create disruptive innovation climate. Moreover, it also allows for configuring various forms of partnerships. Through the analysis of the study, it was possible to measure the intensity of relational, structural, resource and strategic elements. However, the results of the analysis highly affected the requirements fulfillment. It can be inferred that, for example low relational score could discourage partners from exchange of knowledge or incentivize to innovate. Hence, it is important that the configuration of various forms partnerships is ensured in the model.

Regarding the innovation platform it was found that its various elements are essential in the actual implementation of the innovation processes. Therefore, this part of the conceptual model can be regarded as the "toolbox". In addition to the first five requirements, it also includes requirement 6 since one of the elements is digital application. It is especially important since it allows for inclusion and interaction of various actors distributed geographically. When there is a lack of transparent overview on current innovation project – tools like web pages or forums can raise the visibility. Moreover, physical tools such as maker space can solve the problem of slow accessibility for prototyping.

The last part of the conceptual model is convergence element. Convergence was found as imperative in combining different fields. To do that, exchange of knowledge and the activity of merging seemingly unrelated subjects incentivize to innovate. Due to the fact that participants need to think outside of their expertise, it fosters disruptive innovation creation. Convergence also uses various digitized technologies for example design tools or programs to create conceptual designs.

Since the model creates a co-innovation environment for disruptive innovations, actors develop capabilities to also effectively provide products and services (Req. 9-10). The provision of products might not be a direct effect of the conceptual model but indirect since the co-innovation model emphasizes the ability to create value through interactions and innovative ways to approach innovation processes.

Within the company employees benefit from the model through the development of critical skills such as communication and creativity (Req. 11). They are also encouraged to make bold moves and to devout time for the development of disruptive innovations. The central value creation is in the learning experiences where employees can interact with various experts and develop new ideas (Midler, 2008).

Through co-innovation processes, value is also created for various stakeholders (e.g. partners). Partners develop similar capabilities and learn from each other through a network effect (Req.11). Finally by inviting communities to take part in the co-innovation processes e.g. through innovation platforms, everyone can benefit from the accessibility to the broad pool of skills and resources (Req.11). All in all, four elements of the conceptual model fulfills the foundational requirements which leads to fulfillment of the high level requirements (9-12).

All the requirements which were identified in the *artefact requirement* section are observed in practice. The evaluation was consulted with the opportunity (problem) owner who perceives requirements to be reachable with the designed artefact. This is the last phase of the Design Science project which resulted in the *evaluated artefact.* This thesis project ends at this last phase and evaluates the outcome in the next chapter. Nevertheless, the author of this project believes that further refinement to the design model are advisable. However, further iterations are not included in this design project. Recommendations for future research are included in the next section.

CHAPTER 10 CONCLUSIONS, CONTRIBUTIONS AND RECOMMENDATIONS

This chapter concludes the outcomes of the thesis: a design artifact in a form of a Co-Innovation Model which prescribes processes for organizations to manage disruptive innovations. Since, this master thesis follows a Design Science framework guided by sub-research questions, their answers are presented in short in this chapter. Finally theoretical, general and managerial contributions, reflection and recommendations for future research are discussed.

10.1 Sub-research questions answers

1. *What are the opportunities in the current innovation management system?*

The current innovation management system is not capable of dealing with disruptive innovations. Despite well-functioning business processes for core low to medium risks business, disruptive innovations lack attention and structure. The company realizes the need to innovate in order to gain competitive advantage and develop capabilities in a digitized revolution, Infineon Technologies finds these type of collaboration projects as an opportunity to innovate together – creating a two way co-creating interaction. The opportunity arises when analyzing innovation management system at the company. The company finds motivation in *exploration of ways to better coordinate relationships between partners, in finding ways to innovate and in fostering knowledge management practices*. Since Infineon wants to improve its innovation performance, certain *processes* need to be developed to stimulate innovation environment.

2. *What is disruptive innovation? How is it managed?*

Disruptive innovation from a micro-perspective is an innovation in which a company enters new market and/or develops new technologies. The literature traditionally has dealt with incremental improvements and concluded that disruptive innovation management differs considerably from traditional innovation management processes. The process for managing disruptive innovation should have a right environment to encourage exploration, have flexible and exploratory approach. The innovation management process is composed of strategic frame, opportunity identification, idea generation, concept development and evaluation, prototyping and launching. The process needs to incorporate holistic approach and integration between stages.

3. *Why is inter-firm relationship important for management of disruptive innovations?*

The inter-firm relationship management is important since it brings competitive advantages through interactions and knowledge networks. These interactions have proven to lead to higher innovation performances and learning experiences. By analyzing the comprehensive spectrum of inter – firm relationship types, they can be described in four main dimensions: relational, structural, resource and strategic. Through integration of these elements (holistic view rather than deterministic), it was found that certain configurations of the relationships lead to pattern of innovation. Therefore, striving towards high relational, and distanced knowledge-concept space can lead to the creation of the most stimulating environment between partners.

4. *What elements affect the inter-firm relationship in management of disruptive innovations?*

Various collaboration forms affect inter-firm relationship management of disruptive innovations. Setting a right configuration pattern as described in the previous sub-research question is useful for defining motives and level of engagement. However, the interactions vary at every stage of the co-creation process (co-design vs. co-pricing). In the existing framework of Frow et al. (2015), there is no suitable form for the management of innovations. Further analysis on the evolution of collaboration forms led to the emergence of a co-innovation concept. Co – innovation captures collective intelligence and network effect to create value among participants. The elements that create co –innovation are through co-creation, collaboration, convergence and innovation platform. These inter-organizational capabilities create an eco-system assuring process innovation.

5. *What elements to include in the design of a model?*

The artefact design is the conceptual model which integrates the main insights from the previous sub-research questions and takes step by step approach to build a comprehensive conceptual model. The model is based on the co – innovation model of Lee et al. (2012). The designed conceptual models expands its structure through describing the elements of the model and the relations between them. The basic model does not explain what these elements imply and how they can be developed. The proposed conceptual model looks thoroughly into the concept of co-creation by arguing that it is a process composed of innovation processes steps (strategic frame until launching), collaboration described by various dimensions of inter-firm relationship (relational, structural, resource, strategic), innovation platform taking diverse forms of engagement platforms (digital applications, physical tools) and convergence by applying tools facilitating merging of ideas. Consequently, the Co-Innovation Model is illustrated with each element being described.

6. *What elements of co-innovation can be observed in practice?*

Each component of the Co-Innovation Model was analyzed against the results of the case study through semi – structured interviews and questionnaires. The model has been validated and changes were proposed.

The first co-creation element is observed in practice, all steps are relevant and important in the co-creation process. The second element, collaboration is also observed in practice. It was found that high relational, medium structural intensity, high knowledge-concept space distance, and low strategic shared values are most suitable for the disruptive innovation environment. Adjustment was made to this element since *knowledge sharing* has been considered as relational element and important in the development of collaborative environment. Initially, the author proposed the *alliance scan* including the collaboration elements, however after analysis it is more appropriate to name it *collaboration assessment* which then takes broader and dynamic perspective.

The third element, innovation platform is observed in practice. It is considered as a tool which facilitates the co-creation processes. It is important that various forms are utilized, especially digital applications were found crucial. The fourth element, convergence is observed in practice. The initial hypothesis that convergence is about merging different ideas was more important in the co-innovation process than converging of shared goals or interests. The proposed D4 model was implicitly being applied. However, it was not used explicitly as a tool. Hence, convergence is considered as a *capability* rather than a tool.

MRQ: How to facilitate inter-firm innovation management processes of disruptive innovations in the context of Infineon Technologies AG Corporate Supply Chain Innovation Department?

In order to facilitate inter-firm innovation management process of disruptive innovations Infineon Technologies Corporate Supply Chain Innovation Department should implement co-innovation management practices. The Co – Innovation Model has a network structure compose of co-creation, collaboration, innovation platform and convergence affordances. By expanding these elements to its practical implications, the company department is able to implement a comprehensive and implementable solution.

The outcome of this Design Science thesis project is the designed Co-Innovation Model artefact which was tested in practice through a case study. However it is important to emphasize that this designed model was not implemented in a real life case since the model requires further iterations for improvements. Moreover, implementation would exceed the time frame of master thesis project.

10.2 Thesis project contributions

Referring to the Design Science Project framework there are two main outcomes of the project: an artefact (Co-Innovation Model) and scientific and general practice contributions (Figure 51). In this section these contributions are discussed. Additionally, a local practice contribution (for Infineon Technologies) is extensively elaborated.

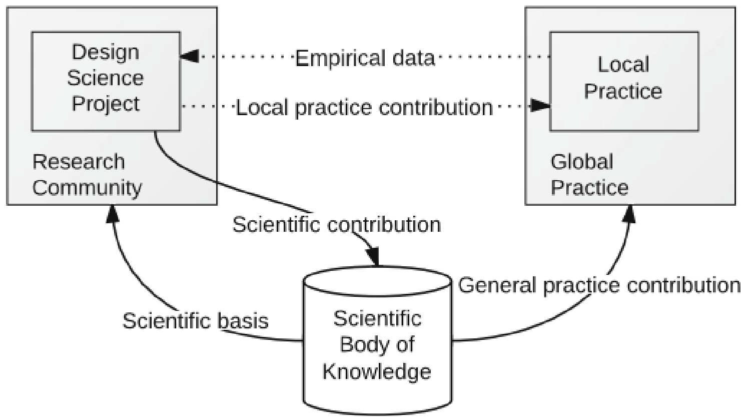


Figure 51 Scientific and general practice contributions

10.2.1 Scientific contributions

Scientific contributions are explained on how this thesis project contributes to the existing body of knowledge and what the impacts of found results are. Through reviewing literature on the topic of innovation management and inter-firm relationship, some domain specific gaps were found. However, in order to be more specific, this thesis aim is to fill the gap in the synergies between these two topics and thus in the co-innovation area. Moreover along with the Design Science framework, this project should produce scientific contributions which can be used as a general practice contribution in academia.

The main theoretical contribution lays in the exploration of a new concept co – innovation by examining its elements through innovation management and inter-firm relationship theories. It became vastly important to learn the basics of these theories to be able to draw new insights in the field of co – innovation.

Lee et al. (2012) laid first concepts of co-innovation, as observed by the authors, scholars still need to establish more firmly theoretical concepts of co-innovation and conduct empirical research to verify them. This master thesis adds to the theoretical foundation by revising the basic concept of the Lee et al. (2012) model and synthesizes them into a coherent system. It immediately finds it practical insights from a case study analysis on real life examples from a business and public domain. Moreover, it provides more validity in fulfilling the research gaps due to the combination of theoretical and empirical research and triangulation methods of combining qualitative and quantitative results.

The proposed model contributes to the domain of co-creation by proposing an integrative and holistic approach by finding links and relations between different elements of co-innovation, as mentioned in Aarikka-stenroos, Jaakkola, & Helkkula (2015), research tend to focus on just one dimension. Moreover, it includes various stakeholder perspectives on a similar issue. In the empirical research, data was gathered along a value chain from supplier to manufacturer. Whereas, most studies focus either on manufacturer – supplier relationship in B2B settings, or seller – buyer in B2C settings. The designed co-innovation model tries to make the process expendable or scalable to include the network effects. Apart from various horizontal and vertical actors, the case study topic – smart textile is also not widely covered. Hence this thesis research broadens the scope.

Moreover, as mentioned by several scholars when developing certain types of projects, it is important to focus on the “creation of an enabling environment” (Vereijssen et al., 2017). The co-innovation model was found to be focusing not only on the business process models but also on the enabling factors such as digital applications. Linking to the previous theoretical implication, this is due to the fact that the model has a comprehensive overview. The model addresses the need for developing new forms of relationship in the upstream level by integrating strategic levels with operational levels (Kazakçı et al., 2009). This is ensured by fulfilling the requirement of integrating exploratory partnership opportunities in the system.

All in all, the most prominent scientific contribution is to apply a holistic approach to the model by looking at the links between various dimensions of the co-innovation model of Lee et al. (2012). At the same time, it also disseminate these elements into measurable and concrete processes and capabilities.

10.2.2 General practice implications

General implications are derived from scientific implications but translated into practical measures which can be used by organizations who are interested in developing co-innovation capabilities for disruptive innovations. Moreover, since the topic focuses on inter- firm relations, it contains a lot of useful insights which can be used by companies.

First of all, the final Co-Innovation Model can be used by organizations that want to develop disruptive innovations and leverage their partnership opportunities through applying the principles of co-innovation. It was found that in the co-creation process there are many points where partner organization involvement can be integrated such as in the opportunity identification, idea generation or prototyping. Moreover, it is important that new processes are clearly communicated throughout the organization. In the newest studies on the product development, practitioners observe that cooperation needs to take place before development phases, they pointed to several interaction phases between partners. However, many researchers focus on either one specific phase or only give generalizable overview on the partnership opportunities (Midler, 2008). The proposed model can help managers to identify specific points in the innovation process and to develop subsequent suitable tools, capabilities or assessments. Hence, on one hand it gives a general overview on the process, but it also draws attention to the early processes such as idea generation.

Secondly, certain collaboration configurations leads to a higher probability of creating innovative settings. Striving towards high relational, medium structure, high resource distance and medium shared values is found to be the most optimal inter-firm formation. Depending on the goals, these can be adjusted. Since elements found in the literature can be measurable, they can also be traced and improved.

Thirdly, digital applications are key tools in deploying new strategies. This comes from the fact companies need to handle relations across borders with ease and accessibility. Certain tools can act as a central starting point for finding opportunities and involving stakeholders.

Fourthly, the model points to the fact that the diversity of expertise and functional areas are useful in the innovation processes. Therefore, knowledge and concept spaces distances could occur not only between firms but also within the firm. These observations are often emphasized in the literature (Bremmers & Sabidussi, 2008), however empirical studies still point out the issues of one dimensional teams. This could come from the fact that the communication is very difficult between technical, financial and marketing areas. As was also mentioned several times in the case study interviews, communication between “hardware and software people” is frictional. Nevertheless, by putting effort in the mutual understanding, greater benefits are observed.

10.2.3 Managerial implications for Infineon Technologies AG

The last type of the implication focuses on the case study company and the main problem owner (opportunity owner) of this thesis topic. The fact that this thesis research project is conducted at the company´s site provides an author good understanding of the context and wide access to the resources within the company. Hence, the implications will be closely relevant to the company and aligned with the current practices. The empirical part of the research uses a case study to validate the model and is used to make assessments. It was found that the conceptual model is applicable for the case study research company. Several suggestions were generated based on analysis of the case study

In general terms, Infineon Technologies AG can use the designed conceptual model to achieve its objective: *explore ways to better coordinate relationships between partners, to find ways to innovate and to foster knowledge management practices* through the concept of co-innovation researched in this master thesis. Hence the following recommendations are to be implemented:

First of all, the management needs to clearly define steps in the co-creation process starting with sharing vision with the employees (strategic frame) as well as providing opportunities to execute each step. At the same time, each component of the process has iterative and transparent nature. Employees should not be stopped at stages and be encouraged to experiment and work across various functions / disciplines. The problem mentioned in the current innovation management practices emphasizes the need to have management support. It that situation, the topic needs to be communicated cross- divisionally.

Secondly, the project team / initiating team responsible for deploying co-innovation concepts needs to develop collaboration assessment tools to be able to develop desired innovation configurations or recognize partnership opportunities through provision of trainings which are not only addresses to sales & marketing teams but also for other teams. Emphasize various form of collaboration such as face-to-face meetings, company visits, joint workshops and attending conferences. Moreover, introducing the topic of exploratory partnership can greatly benefit the projects since it challenges the status quo of current partnership exploration. As mentioned in the current practices, the need usually comes from project line managers. In order to foster exploratory partnership capabilities, new approach is promising.

Thirdly, develop tools supporting the co-creation process such as digital applications (web pages, forums, newsletters and virtual conferences), physical resources (labs, maker space, innovation hubs) and dedicated personnel group who develops and administers these tools. These tools are crucial in solving the problem of not having a transparent overview on the innovation management project. Moreover, it also helps to facilitate the prototyping processes which was also found as problematic.

Fourthly, develop convergence capabilities through trainings on various methodologies (e.g. D4 model), encourage joint work processes between potential partners not only established one. It also emphasizes the fact that innovation can be created cross-divisionally and not only behind “close door of divisional R&D”.

Lastly, the company needs to recognize various forms of value creation such as learning experience, gaining new skills, acquiring knowledge about other fields of business etc. Hence, the initial benefits might not be financially converted but since it touches strategic topics, it brings long-term benefits. Therefore encouraging employees to spend portion of their time on outside of the core tasks project is advisable.

Scenarios

In order to provide Infineon Technologies AG advice on how the company can use presented model, a scenario with concrete action points is developed. The main purpose of the co-innovation model is to be able to build an innovative ecosystem including interaction with partners and thus be generalizable not only in smart textile context.

For the simplicity scenario is divided into two phases. Only first phase is elaborated and can be considered as a pilot project. Specific actions are described (do what), prescribed (how), and reasoned (why). These actions are formulated based on the recommendation list which was compiled after each step of the case study analysis. The implementation of the first phase generates learning experiences and any other emerging issues. The second scenario is the expansion of the pilot project or a scale up of the model.

Phase 1: The implementation of the co-innovation model at Infineon Technologies AG with the main focus on the Corporate Supply Chain Innovation department. This department is considered as the focus actor, whereas other departments (ATV, IPC, PMM and DDS) are considered as partners. For the first phase, an infographic was sketched to visually present the following actions (see Appendix J).

Phase 2: The implementation of the co-innovation model at Infineon Technologies AG where the main focus is at the company level and is considered as the focus actor. All external actors such as companies, private entities are considered as partners.

Phase 1

Action 1

What: The department management clearly defines a strategic frame for implementing a "co-innovation initiative".
Why: The department wants to explore new markets and new technologies by pushing the boundaries of traditional approaches and methods. Moreover, communication to the department employees provides a management support.
How: Use various communication channels to reach all IFX employees (promotional campaign, newsletter, e-mail, posters, official events, innovation talks).

Action 2

What: Set up co-innovation initiative team
Why: Dedicated team who would make sure that the initiative is running. The team has responsibilities for developing a plan for an initiative.
How: The team is composed of full time employees with a mix of technical, business and research backgrounds. Among the responsibilities would be: administration tasks, organizing events, gathering information and resources, promotion of the initiative, networking, finding experts etc.

Action 3

What: Develop a context specific co-creation process model.
Why: Employees learn co-creation business models through discovering and learning of a new model with a non-traditional approach.
How: The team uses the conceptual model of this thesis and refine steps if needed. The model is easily accessible to all employees on various platforms (e.g. on company´s I-share). Typically, at the company there are several e-learnings modules which are required by Infineon Technologies. Hence, such as module can be developed on co-innovation initiative. The module needs to be practical with clearly defines steps and tools / methodologies.

Action 4

What: Propose structural / organizational changes.
Why: These changes support the commitment of the management on vision of the department. Moreover, these changes create more stimulating workplace. The management support is important in convincing employees for a change (Bremmers & Sabidussi, 2008).
How: The initiative team files a proposal to make workplace design changes (inspirational posters, whiteboards, open spaces, use cases projects at various places), to implement 10-20% work time to become an expert on a web platform, to work on non-traditional projects and to emphasize human resource diversity (hiring students, research oriented workforce at various functions)

Action 5

What: Develop a web based innovation platform

Why: The platform acts as a central point for co-innovation initiative. On this platform, employees can exchange ideas and projects, exchange knowledge, find resources and learn how to create things. Building a network ecosystem of disruptive innovators.

How: The webpage has many functions such as: submitting ideas, browsing ideas, being able to connect to the initiators and experts, having access to the resources and experts of the technologies (employees from various departments), sharing information, sharing resources (books, tutorials, useful websites), chatting, direct video calling options, finding categories of ideas (textile, health), finding event calendar on conferences, innovation events (sponsored trips), contributing (like Wikipedia) and many more.

Action 6

What: Implement an on-sight maker space.

Why: Maker space allows for hands on experiences and ability to experiment.

How: The initiative team files a proposal for building a maker space, which has equipment (physical tools, resources), library of Infineon products, an exhibition of used cases (prototypes, innovative projects e.g. robots). It also serves a place to organize workshops, trainings etc.

Action 7

What: Develop satellite co-working spaces

Why: Satellite spaces allows the company to be closer to the potential partners.

How: The initiative team files a proposal for creating co-innovation working spaces in major innovation hubs (big cities). These spaces are used for meetings, co-creation activities (brainstorm, concept development). It has interactive tools, advanced technologies (simulation of meeting rooms).It can also be used for networking event.

Action 8

What: Set up a continuous support system

Why: The support system executed by initiative team facilitates bringing partners together and helps with continuously providing new experiences.

How: The team searches and provides resources (e.g. company link webpage specializing in 3D printing on an initiative webpage). The team organizes co-working sessions, events, workshops and promotional activities.

Phase 2

As was mentioned, phase 2 will not be elaborated as it would consist of similar steps as in phase 1. However, certain major issues should be kept in mind while developing second phase. Regarding a web-based platform (action 5) in the first phase, the experts of the technologies were limited to IFX employees. At the second phase, this should be open up to various external experts (companies, private entities etc.). Sharing of information has to be taken with care to not leak company sensitive information. Contributing would need much higher control effort (members of the webpage should be allowed to contribute however quality needs be assured). Moreover, business values for joining a platform needs to be carefully considered. For example, members might be able to purchase resources directly from the web-page and partner can then sell their products.

An important argument should also be given to the creation of co-working spaces and organization of networking events (action 7). In the community of innovators, Infineon Technologies develops brand awareness which would be associated with being an active innovator. Hence, it gives many benefits because the company attracts attention.

10.3 Limitations

This thesis project has theoretical, practical and methodological limitations which might have influenced the direction of this project. It is useful to point these insights in order to direct future researchers on the improvements of the artefact design.

In terms of theoretical limitations, the list of scholars used in the theoretical foundation is not exhaustive. Broader overview on the literature might provide more detailed understanding on the topics. However, chosen literature is believed to be representatives of the research body of knowledge. This was ensured through careful analysis on the number of citations, date, bibliographies and so on. Moreover, a literature review type of papers were very useful in identifying main trends and topics. Hence, the author believes that the main points were captured in the analysis. Nevertheless, it is possible to explore more detailed aspects of literature elements such as collaboration or convergence.

In terms of practical limitations, the investigation of the conceptual model was conducted within one case study with a focus in one organization. It would be useful to involve projects of a similar requirement nature or at another company. This project designs a model which uses main inputs from a scientific body of knowledge which takes global perspectives in the development of the model. The conceptual model was designed in such a way that the company´s characteristics are not skewing the model but rather help to assess it. Hence, these elements were tested in the local perspective to verify these constructs. Therefore, the limitation is in the variation of the projects and variation of participating companies.

In terms of the company industry choices, it seem that the model was more suitable for disruptive technological settings. The designed artefact emphasizes accessibility to physical tools such as prototyping tools, makerspaces and other interactive tools as crucial in the innovation development. However, this might not be the case for disruptive service innovations which are rather abstract. In this case, the Co-Innovation Model could emphasize more individual´s ability to better conceptualize and organize ideas. In terms of the size of the firms, power - interest relations need to be taken into account too. In the model development this was briefly discussed as power relations are found to be difficult to implement in the model hence the discussion is outside of the scope of this project. However, it seems that the model was able to be tested on the case study which included partners from various sizes and the size of the companies did not appear during any of the discussions.

Another limitation regards the accessibility to the projects within the company. Since the author interns at one department (Corporate Supply Chain Innovation), the project choice was limited to the ones handled by the department. Nevertheless, for the topic exploration, all employees at Infineon Technologies AG were reachable. The author proactively searched for participants for open interviews data gathering who can bring their own knowledge on the topic of this thesis. It helped with understanding which were the most challenging aspects at the firm level rather than solely department level.

In terms of the time issues, the master thesis did not cover the whole time frame of the case study project (GeniusTex), it could be that at other points of the project (in the beginning or towards the end), some dynamics are changed and could influence the assessment of the model. Perhaps, other elements not included in the model might emerged or certain elements in the model might be more emphasized than they currently are. However, the conceptual model has a dynamic nature hence it should be possible to gather data at any point of the project.

Moreover the fact that this Design Science project was conducted around halfway the project could mean that the maturity level of partner involvement is quite high. Hence, most of the elements in the model could be observable. As discussed in the previous section, the fact that *collaboration affordances* were observed is due to the fact that there is high trust and commitment in the project. However, it seems that the project partners were already committed to a certain funded project so they had to deliver results. Since this design project emphasizes exploratory partnership as the main driving factor for co-innovation processes it could not have been observed in such a case study setting. In this case study, exploratory concept was mentioned by several partners as the motivation to join GeniusTex project.

In terms of the methodological limitations the initial conceptual model was designed based on the requirements found in the literature. However, they were verified by the focus case study company (IFX) and discussed jointly with problem owner. Since they were rather generic, they overlap well with the company´s requirements. However, it could be that at another firm, different additional requirements would be generated. Hence, the limitation lays in the inclusion / emphasis of certain elements in the model. For example, digitized application was one requirement and was included in the model. If another firm would not consider this as requirement it might have not been included.

Another limitation pertains to the fact that the study was conducted by one researcher where every part of the thesis was conducted by the author. It could introduce bias in interpreting literature, interviews and drawing insights from the analysis. Nevertheless, the author was methodological and followed qualitative research guidelines. For example to ensure validity of interviews, code structures were checked with the interviewees. Moreover, the supervision of the University Professors supported the author with following scientific rigor and ensuring quality.

10.4 Recommendations for future research

Based on the limitations found in the previous section, the recommendations are given for future researchers who are interested in further investigation of this thesis topics.

Firstly, the validation of the model should be conducted with other types of projects, in different settings and across different companies of various industries and geographic locations. Industries could include automotive, aerospace, food, pharmaceutical, electronics, home appliances and so on. The project should involve mixture of "unrelated business areas" e.g. art with electronics. The geographic location could involve interactions between companies of one continent (the Netherlands, France, Spain etc.) or across continents (between Asian and European countries). This would further verify the model in terms of its generalizability. Another differentiation could be in the type of organization – public or private. Since motivation and perception of innovativeness can vary considerably. Furthermore the designed artefact should also be empirically tested in service oriented industries and see which elements are more or less important. It seems that the degree of innovativeness is much easier to assess in the technology innovations rather than in process / service innovations since the former has tangible nature. It could be that the artefact needs to be refined specifically for service oriented innovations for example by adjusting one of the four co-innovation elements (e.g. instead of convergence of technologies it could be change to convergence of services).

Secondly, the focus of the study could be extended to all of the participating partners (not only Infineon Technologies but also ITA, TIM etc.). It would give broader scope on various perspective as well as practical implications. In this case tools such as power – interest matrix could be somehow incorporated in the model. Perhaps, the model could become more flexible, scoping to specific company´s requirements and configurations could lose the generalizability of the model. On the other hand, requirements of all participating actors might be contradictory hence verifying the model might be complex.

Thirdly, future research could investigate a case study unit at various time points, for example in the beginning, in the middle and at the end. Another option could be to take several different cases at only one points. Further on, these type of studies could be compared. Some other interesting insights in terms of the maturity of exploratory partnership can be observed. It is recommended to specifically focus on the very beginning stages of exploratory partnerships, perhaps make observations and gather data at the company fairs or innovation conferences. The fact that firms would have limited information on another company can greatly influence the appropriateness of the designed artefact.

Fourthly, the conceptual model scope was limited to partner organizations. However, it would be possible to expand this model to include other actors in the value chain such as suppliers and customers (Chesbrough, 2006). By connecting various actors in the system, a more comprehensive network is created. Similarly to terms and concepts mentioned in this thesis, collaborative network has potential for co- creation values through new sources of knowledge and resources, complementing capacities and skills (Romero & Molina, 2011). Networks can also reinforce innovation, however each interface (company – customer, company – supplier) would have different patterns. It would be complex to create models that can capture all these components. Nevertheless, future research could look at the innovation in broader network of co-creation.

Fifthly, in order check the robustness of the model it would be advisable to develop performance measures. It is recommended to measure ´before model implementation´ performance and compare it to ´after implementation´ performance. Depending on the objectives of the company they might differ hence it is essential to design measures that are relevant for the focus company. For example, one such measure could be *the number of disruptive ideas, the number of disruptive ideas completed, the usability of digital tools, the satisfaction of the employees, the satisfaction of partners etc.* These measures would further provide benefits and/or drawbacks for implementing the designed conceptual model. Moreover, quantitative measures can also bring evidence for quantifiable changes that the conceptual model achieved. It would also be useful to convince stakeholders who are more "number" oriented of the advantages of the model. At the same, it also brings out many qualitative issues.

To summarize main points for future research, the author proposes following iterations to the model (see Figure 52). First of all, in the *requirement* research process, possibly other requirements are identified either based on the literature or on a different company´s requirements. The *conceptual model* can be expanded to include other actors (customers, suppliers etc.). Then the model can be *validated* in different companies across industries and geographic locations. Further validation might bring some useful insights in terms of the identified elements in the literature and practice. This would be the first iteration process to validate the model.

The next round of iteration would include the implementation of the model in a real life settings, where expanding *literature review* on the performance measurements with regard to the co-innovation model is required. Thereafter implementing the model would allow to evaluate its robustness in the *conclusion / recommendation* section.

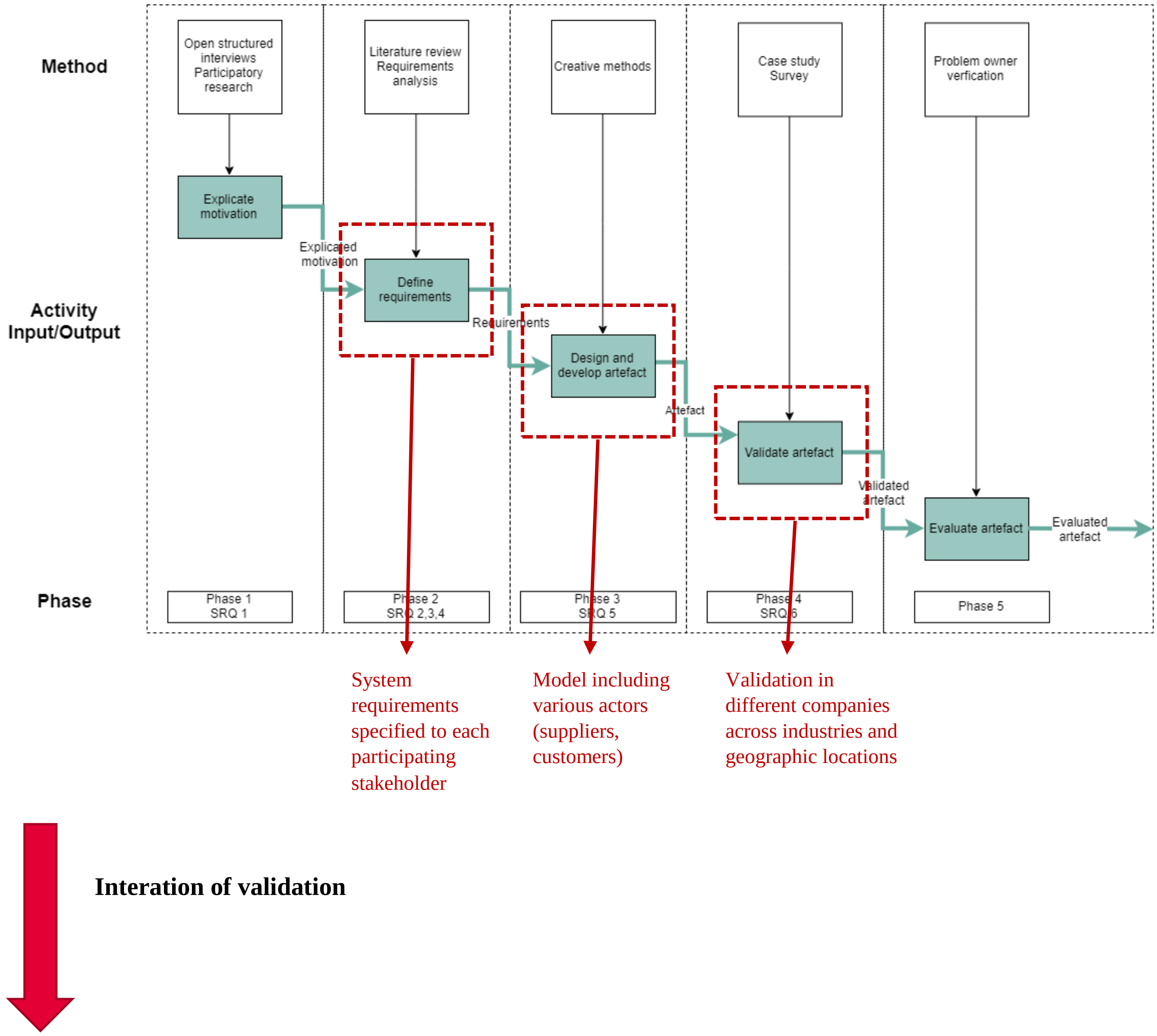
10.5 Reflections

In term of scientific relevance, this thesis topic fills the literature gap on the topic of inter – firm innovation management of disruptive innovations. This topic is believed to be very important since rapid technological development, globalization and many other challenges appear so quickly that the research community does not respond quickly enough. Therefore, there does not seem to be an extensive body of knowledge on relevant frameworks for the topic of inter – firm innovation management. The designed conceptual model addresses the need to develop a comprehensive and holistic model. It synergizes the topic into its component level by analyzing in detail three domains – *disruptive innovation management, inter-firm relationship and collaboration forms*. The outcome is an expanded co-innovation model which captures the above mentioned phenomena. The conceptual model does not only represent the elements but it also represents the dynamic nature of the innovation process through links and logical directions. Additionally, the models leaves with a lot of opportunities for future researchers to either further verify, expand or measure the model.

Moreover, the topic of co-innovation is novel in the literature hence there were not many available resources on this topic. On one hand it was very challenging because it was difficult to consult the theory with researchers, on the other hand it was very interesting because the topic resides in the new knowledge area. An author really understood well the value of detailed and thorough research on fundamental topics. Once the author had clearer understanding on the topics, it was rewarding to be able to distinguish subtle differences such as between concept of co-development and co-innovation.

Furthermore, since the topic is also new in practical settings, the author had to make sure that findings and concept of co-innovation are clearly explained. Sometimes, in the literature scholars tend to explain theories in a very scientific manner whilst topics are rather practical, addressed to organizations (companies, government etc.). Hence, it was important that insights made in this thesis project are scientifically driven but also easily understood by various stakeholders. One factor which had major influence on such an approach is that, the author conducts her thesis at the company´s premises whilst doing an internship. Moreover, the author was able to observe issues which were not investigated before. While trying to understand the intricate processes within the company, many interesting insights were made. The author believes that applying scientifically driven findings and models such as the designed co-innovation conceptual model can benefit the company greatly. Nevertheless since the designed artefact was not implemented but only evaluated on the requirements fulfillment it is difficult to predict whether it could practically reach the desired objectives.

Lastly, in terms of personal reflections, the author believes that this thesis project was both challenging and rewarding. The author was able to investigate and deepen the knowledge in interesting and new areas of theory. Moreover, the author was also able to gain better understanding of the processes at the company. Finally, this thesis project required to combine the knowledge, methods, tools that were taught in Complex System Engineering Master Program at TU Delft. The author believes that being able to experience company´s dynamics, to apply scientific rigor, to gather data, to analyze cases and to manage communication between various supervisors was extremely beneficial for personal and professional growth of the researcher.


Method
Activity
Input/Output
Phase
Open structured interviews Participatory research
Literature review Requirements analysis
Creative methods
Case study Survey
Problem owner verfication
Explicate motivation
Explicated motivation
Define requirements
Requirements
Design and develop artefact
Artefact
Validate artefact
Validated artefact
Evaluate artefact
Evaluated artefact
Phase 1 SRQ 1
Phase 2 SRQ 2,3,4
Phase 3 SRQ 5
Phase 4 SRQ 6
Phase 5
System requirements specified to each participating stakeholder
Model including various actors (suppliers, customers)
Validation in different companies across industries and geographic locations
Interation of validation

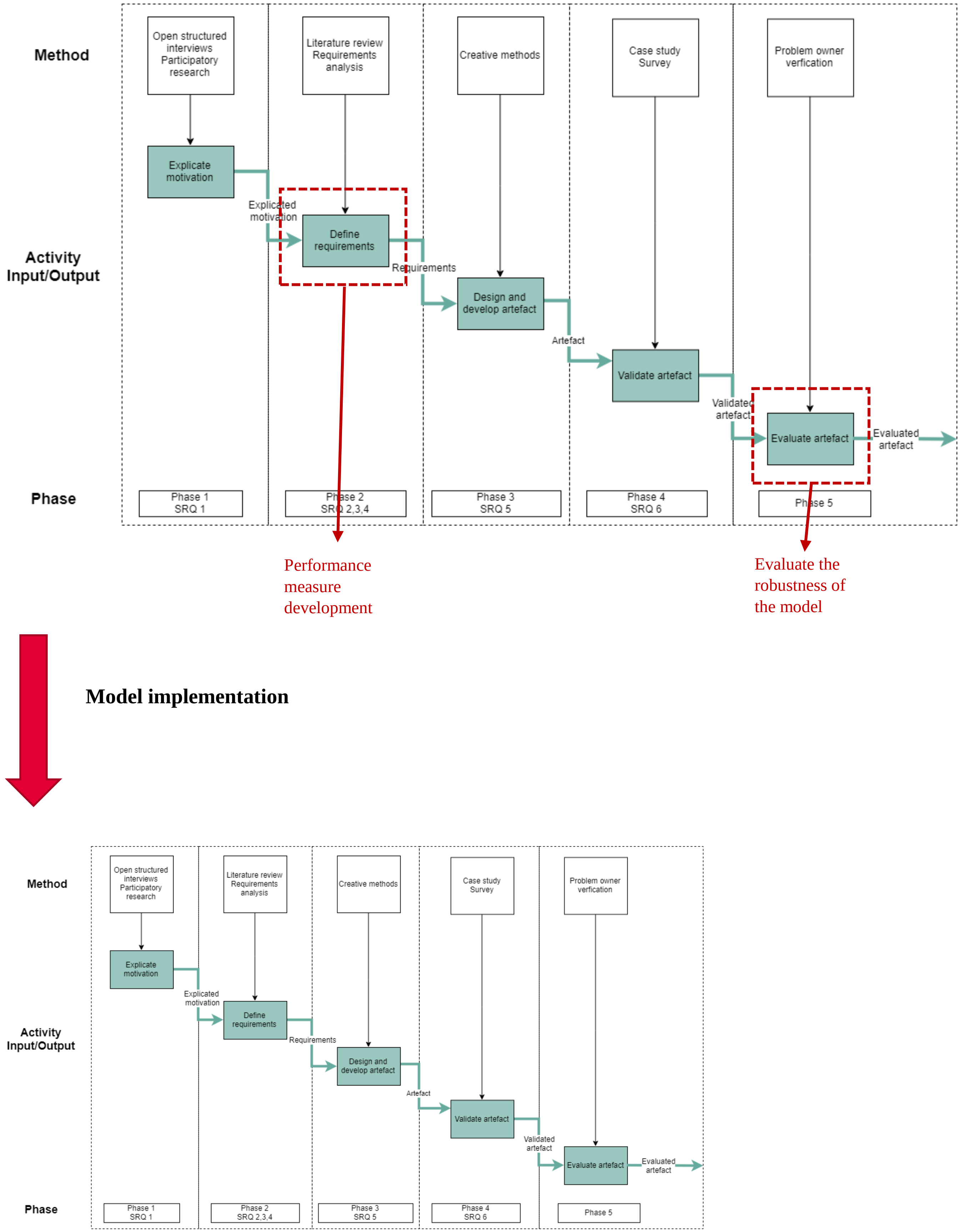


Figure 52 Future research iterations

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APPENDIX A QUALITATIVE RESEARCH

Checklist to review qualitative research (Anderson, 2010)

Appendix 1. Checklist for authors and reviewers of qualitative research.

Introduction

☐ Research question is clearly stated.
☐ Research question is justified and related to the existing knowledge base (empirical research, theory, policy).
☐ Any specific research or educational terminology used later in manuscript is defined.
☐ The process by which ethical and or research/institutional governance approval was obtained is described and cited.

Method

☐ Reason for choosing particular research method is stated.
☐ Criteria for selecting study participants are explained and justified.
☐ Recruitment methods are explicitly stated.
☐ Details of who chose not to participate and why are given.
☐ Study sample and research setting used are described.
☐ Method for gaining informed consent from the participants is described.
☐ Maintenance/Preservation of subject anonymity and confidentiality is described.
☐ Method of recording data (eg, audio or video recording) and procedures for transcribing data are described.
☐ Methods are outlined and examples given (eg, interview guide).
☐ Decision to stop data collection is described and justified.
☐ Data analysis and verification are described, including by whom they were performed.
☐ Methods for identifying/extrapolating themes and concepts from the data are discussed.

Results

☐ Sufficient data are presented to allow a reader to assess whether or not the interpretation is supported by the data.
☐ Outlying or negative/deviant cases that do not fit with the central interpretation are presented.
☐ Transferability of research findings to other settings is discussed.
☐ Findings are presented in the context of any similar previous research and social theories.

Discussion

☐ Discussion often is incorporated into the results in qualitative papers.
☐ A discussion of the existing literature and how this present research contributes to the area is included.
☐ Any particular strengths and limitations of the research are discussed.
☐ Reflection of the influence of the researcher(s) on the data, including a consideration of how the researcher(s) may have introduced bias to the results is included.

Conclusions

☐ The conclusion states the main finings of the study and emphasizes what the study adds to knowledge in the subject area.

APPENDIX B INTERVIEW GUIDE

Interview guide for semi- structured interviews

General questions

1. What is your role and responsibilities in the project?
2. What is the goal of the project?

Innovation related questions

3. What is your perception of the innovativeness of the product?

Innovation platform

4. Could you describe me an ideation process?
4.1 How ideas were created / developed?
4.2 How could others contribute?
4.3 Was there possibility to network externally / internally?
5. What platform do you use to communicate / share ideas? Please explain.
5.1 In your opinion, what could be more efficient ways of communication?

Convergence

6. How would you assess the degree of complimentary knowledge and concepts?
7. In your opinion, does convergence of ideas affect the radicalness of innovation ideas?

Collaboration

8. How would you assess the collaboration overall?
8.1 What was the frequency and means of collaboration?
9. Are processes / tasks to be done by each party clear?
10. What was the scope of effort regarding:
10.1 Financial resources?
10.2 Knowledge resources?
10.3 Intellectual resources?
11. What benefits this project bring to your party?
12. How would you assess the collaboration in terms of:
Commitment, trust, information sharing, shared values, quality of conflict resolution
Task routines, transaction specific investments, multiplexity, and interaction frequency

Co - creation

13. In your opinion which stage of the innovation is most critical? (Strategic frame, opportunity identification, idea generation, concept definition, concept evaluation and selection, partnership decision, prototype development)
14. In your opinion, what is the most critical factor in:
14.1 Strategic frame
14.2 Opportunity identification
14.3 Idea generation
14.3.1 Did you use any techniques for idea generation? Were they useful?
14.4 Concept definition
14.5 Concept evaluation and selection
14.7 Prototype development (were there prototypes developed?)

Other

15. What are critical factors in the successful development of the project?
16. Are there any tools in your organization that enabled innovativeness of the product? (Practices or processes)
17. What would you suggest X Company can do to enable innovation?

APPENDIX C QUESTIONNAIRE TEMPLATE

The following questionnaire is used to gather data for my master thesis in the topic of: *Building a co-innovation model for disruptive innovation management.* Taking your experiences and your perspective, please indicate your grades for the following questions. You can color a field or put an “x” in respective fields.

Eg.

1	2	3	4	5

Thank you for your valuable input!

1. In idea generation phase, how important are the following elements? (1 least important to 5 most important)

Ideation

a. Submit new idea

1	2	3	4	5

b. Develop new idea

1	2	3	4	5

c. Monitor idea evaluation process

1	2	3	4	5

d. Revise and submit new idea / concept

1	2	3	4	5

Collaboration

a. Find new projects /ideas

1	2	3	4	5

b. Review different ideas / concepts

1	2	3	4	5

c. Vote for different ideas / concepts

1	2	3	4	5

d. Contribute to project / idea development

1	2	3	4	5

Communication

a. Share knowledge

1	2	3	4	5

b. Discuss new ideas / projects with community

1	2	3	4	5

c. Network with community

1	2	3	4	5

2. Taking into consideration the relationship with partner, what was the degree of..? (1 the lowest to 5 the highest)

<u>Relational</u>

a. Commitment

1	2	3	4	5

b. Trust

1	2	3	4	5

c. Coordination

1	2	3	4	5

<u>Strategic</u>

a. Shared values

1	2	3	4	5

<u>Structural</u>

a. Information sharing

1	2	3	4	5

b. Quality of conflict resolution

1	2	3	4	5

c. Interaction frequency (several times a week or few times a month?)

1	2	3	4	5

d. Multiplexity (variety of inter-firm interfaces e.g e-mail, face-to-face)

1	2	3	4	5

Resource

a. Complementary knowledge. Is it important that the partner has similar knowledge (e.g. two airlines have similar knowledge on the same industry)?

1	2	3	4	5

b. Similar concepts ideas. Is it important that the partner has similar concepts (e.g. utilities for gas provider and electricity provider, different knowledge but same concepts of providing utilities)?

1	2	3	4	5

c. Technology and intellectual

1	2	3	4	5

APPENDIX D INFINEON TECHNOLOGIES CURRENT SYSTEMS

A1. Semiconductor industry

Semiconductor is a silicon based substance that conducts electricity under certain conditions, the conductivity can be altered based on the direction of the current or by introduction of physical properties such as heat or light (Investopedia, 2018). Semiconductors, commonly known as chips are integrated circuits components of electronic devices. In a semiconductor industry, chips are seen as a commodity goods, however it has vast amount of end market applications such as in computers, consumer goods, communication infrastructure, automotive and power industries.

The semiconductor industry has been rapidly transforming in recent years due to the rise of ICT and digitalized technologies. The need for sensing, computing power, communication and interactivity are needed for connectivity and cloud integration applications (Gloger et al., 2018). Nowadays, "smaller, faster and cheaper" attitude might not match the demand. Other factors such as configurability, system integration, software and power consumption seem to be more important.

The analysis on semiconductor industry led by PWC, bring certain issues such as the fact that companies need to be able to distinguish themselves in new ways and bring distinct values for the market (Gloger et al., 2018). This differentiation strategy ensures competitive advantage in midst of increased complexity of end technologies. What companies must do is to be decisive about their value proposition and understand what their capabilities are. There is no one best strategy or solution to the emerging challenges, rather companies need to think in different ways to innovate their portfolio. There is no doubt that semiconductor industry will be continuously growing, however it needs to adapt quickly to emerging trends and challenges.

A2. Infineon Technologies AG

Infineon Technologies AG (IFX) is a world leader in semiconductor solutions, with a reported sale of 7.1 billion Euro in 2017, and 37,500 employees worldwide. The average cycle revenue growth is at 9%, the segment result margin is at 17%+, and the investment to sales at 15%+ (Infineon Technologies, 2017).

The strong presence in the market is achieved through a global R&D network in 36 facilities, 16 manufacturing sites and 47 sales networks across Europe, North America and Asia. According to Semiconductor Annual Market analysis, Infineon is a leader in power discretes and modules (18.6% market share, compared to second position of ON Semi with 8.9%), and in microcontroller based Smart Card ISC (24.8% compared to NXP with 24.2%). In automotive industries, it holds second position behind NXP with 10.8% compared to 12.5% (Infineon Technologies, 2017).

Infineon Technologies operations are divided into four divisions.

- Automotive (ATV) – 42%
- Power management and multimarket (PMM) – 31%
- Industrial Power Control (IPC) – 17%
- Digital Security Solutions (DSS) – 10%

In the area of automotive industry, Infineon Technologies offers vehicle solutions for trucks, powertrain, safety applications, hybrid electric solutions, body and convenience. The product portfolio consists of microcontrollers, intelligent sensors, radar and radio frequency applications. Company´s goal is to enable clean (clean combustion engines and efficient drivetrain), safe (collision avoidance and advanced driver assistance), and smart (data integrity and individual convenience) vehicles. The main customers in this division are BOSCH, Autoliv, HITACHI, Hyundai, Continental and ZF. Most other customers are located in Europe (Infineon Technologies, 2017).

In the area of industrial power control, Infineon offers motor control and drives, wind energy systems, power supplies, construction, commercial vehicles and industrial power drives. These products need efficient transmission of electricity. The company´s portfolio covers drives (servo drives and elevators), home appliances (air conditioners and refrigerators), renewables (high voltage direct current transmission), and traction (high speed trains, locomotives and subways). The biggest customers are ABB, ALSTOM, Danfoss, Toshiba and Siemens. Products in this category are distributed either directly or via distribution partners such as Arrow, Avnet or Intron (Infineon Technologies, 2017).

In the area of power management and multimarket, Infineon Technologies offers solutions in the area of power management (computing, lighting and charger), radio frequency and sensing (mobile devices and cellular infrastructure) and high reliability (aviation and heavy industry). The biggest customers are Nokia, Dell, Osram, Samsung, Alibaba and Amazon (Infineon Technologies, 2017).

In the area of digital security solutions, Infineon Technologies delivers solutions for the connected world in a form of smart cards (smart card payment, electronic passports and transport ticketing) and embedded security (mobile devices, industrial and automotive security). Robust protection and protection against personal data infringement are paramount in this field. The biggest customers are Gemalto, GPO, HP, Lenovo and Microsoft (Infineon Technologies, 2017).

Besides these four main divisions, Infineon operations divisions strive to create competitive advantage through new approaches for increased productivity, optimization along the value chain and reduction and management of complexity. Within operations, there are several departments: frontend, backend, purchasing, finance and corporate supply chain.

Corporate supply chain (CSC) department strives to deliver customers product at the right time and at the right place. It deals with the management of the chain from the suppliers to customers and partners. Regarding the innovation of supply chains, the main focus areas are within knowledge and education management, supply chain simulation and research, disruptive innovation and order management (Infineon Technologies, 2018). The department is located in Munich and mainly deals with R&D.

Hence, the department is divided into four main columns:

- Knowledge management, education and SC Audits. The most recent topic touches the topic of semantic web.
- SC roadmap, simulation and complexity management.
- Digitalized supply chain, dealing with topics such as machine learning and artificial intelligence.
- Innovation services, dealing with topics such as disruptive innovations, lead-time based pricing and European co-funded projects.

A3. Innovation management system in Infineon Technologies

In the literature review, it was identified that innovation can have several meanings depending on perspective of an entity. For Infineon Technologies, an innovation is defined as a new idea that is brought to financial success. Since it is defined from the perspective of the company, it takes a micro perspective. The strategic goals of the company focus on four areas: financials, customers, processes and people, their respective goals can be seen in Figure 53.

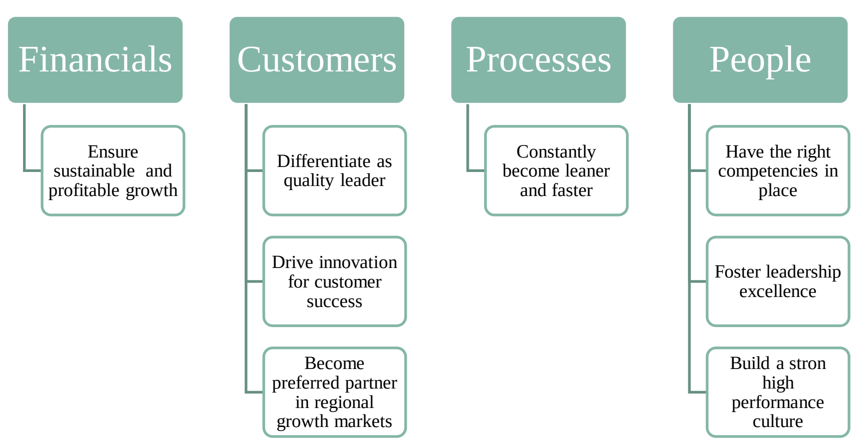

Figure 53 Strategic goals

The strategy is based on market segmentation and deployed at the divisional level (ATV, CCS, IPC and PMM). Innovation goals for Infineon Technologies is to be number 1 solution partner, to have right fit and market changing products and to have strong portfolio of intellectual property. The customer success is reached through several categories:

- Leadership (innovation net, living network, common language and recognition)
- People (technical ladder competencies and innovation star)
- Strategy (corporate strategy, product to system and core competencies)
- Partnerships and resources (collaboration with external and internal partners, university evening)
- Process, product and services (i-communities, innovation process and roadmapping)

Currently, innovation culture is executed through Innovation Net which includes frameworks for all the divisions (Business Innovation framework, Innovation Funnel), toolbox for i-communities, innovation days and common communication infrastructure.

Infineon Technologies uses an innovation funnel approach which is a ´guided innovation´ market pull (by looking at market trends and customer needs), as well as technology push (by looking at technology trends and experts ideas). The roadmap elements are divided into exploration and execution stages (Figure 54).

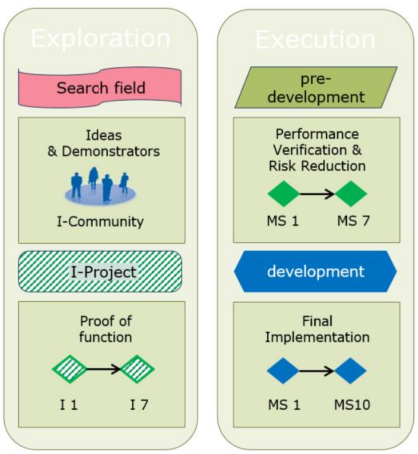

Figure 54 Innovation funnel

The first step is the search field which includes identification of new ideas for which solutions do not exist yet. Methods include i-community cooperation with universities, funding programs and PhD’s. The output of this stage is to produce a short description of the evaluated idea (problem statement, possible solution and proposal for I-projects.

At Infineon I-communities which are “protected space” for selected top experts who work together on a defined topic in a self-organized manner, sharing the goals to develop breakthrough innovations for the future of Infineon. The I-community consists of mentor, facilitator and members. The goal of this platform is to secure long term competitiveness by gathering best technical experts in the field (more details on I-community can be found in Appendix C). Currently, there are 600 i-communities (not all of them are related to innovation topics).

The second step is I-project which is used to explore feasibility and proof of function. It deals with medium risk and medium level of uncertainty. At this stage, the possibility for Intellectual Properties are delineated. Time, scope and budget are defined, and the project is set up according to the internal project regulations. Implementation follows system development handbook and technology development handbook. Only the first few phases are included in this step.

The third step, is pre-development which includes preliminary proof of performance and quality of components. Clearly defined project plan with end date is drafted resulting in the completely characterized component, qualified demonstrator and documentation. Implementation follows system development handbook and technology development handbook. More milestones and checklist rigor are followed here. This stage will be outside of the scope of this thesis since the average time for technological developments is longer than the duration of master thesis.

The final step is the development which is the realization of the qualified product which leads to revenue and profits. This stage will be outside of the scope of this thesis since the average time for technological developments is longer than the duration of master thesis.

A4. Analysis of the current innovation process

Analyzing the current innovation process, it can be inferred that Infineon Technologies follows a closed innovation system of an interactive model which integrates mainly market pull and to lesser extent technology push (Rothwell R., 1995). The basic innovation process at the company can be simplified to the following model (Figure 55).

Figure 55 Current innovation management at Infineon Technologies. Source: own illustration.

As mentioned before, the business model of the company focuses on the divisional model which means that each division has its own stream of revenue and focuses mainly on incremental innovations and continuous improvement of their own products. Moreover, experimenting and high risk decisions are not desirable since a lot of R&D budget is needed (on a scale of millions of euros). Moreover, the company is starting to shift more towards customer driven decisions and market driven insights by offering them system solutions. In general, employees are aware of the fact that radical innovations are extremely difficult. It is rather encouraged to stay within the boundaries of known market and known technologies (Ansoff matrix[7]). One of the interviewee emphasize the point that innovation management for disruptive innovation is ultimately a strategic decision. It is important that the management board is aware of this and initiate for example restructuring of the departments. Another way to start building innovation eco-system is to think of co-innovation spaces by building methods and communities (similarly observed in other companies e.g. Apple or Microsoft).

Further investigating the topic of innovation management, it became apparent that the innovation ecosystem is changing. The company has become more alert to the technological transformations related to digitalization such as artificial intelligence, blockchain and virtual reality. Therefore, there are more and more initiatives to showcase innovations through "Innovation Week poster sessions, startup exhibitions, Digitalks; these are small steps for transformational innovation". There is indeed "a potential in these innovations". However, most of poster presentations only show the idea or innovation but there is no official information on the follow up. Moreover, there are 200+ poster ideas presented during an Innovation Week, but there does not seem to be a transparent overview of innovations being developed at the company. As one interviewee observed "it often happens that the same ideas are being developed in parallel". This happens partly due to the decentralized nature of the company. Each division works almost like a separate entity as mentioned before, "Infineon Technologies does not wish to follow too centralized initiatives, divisions focus on their own business objectives". Despite, the fact that the development of projects should be executed on the divisional level, the idea generation and concept development can leap greater benefit by providing "transparency and good overview of what is going on". As was also identified in the literature review, collaboration reinforces creativity and innovative ideas.

Another issues which is related to transparency is the fact that very often R&D development happened behind the closed doors, well developed communication between different units and functions are missing. Therefore, some innovative ideas are well understood by sales force. This became problematic especially for "relatively new innovations or ideas" such as for Coil on Module, FORTE Class D amplifier or CoolSiC MOSFET projects. Hence, the close innovation model does not only exhibit at the company level but even at the division level.

Another important issue touches the topic of fast prototyping. In order to accelerate idea development, "we need to try fast and fail fast", which means that before formal project development starts there needs to be a room for prototyping ideas, "people need to see things, touch it and play with it". Ideas need to be presented in at least "the minimum viable product" form. It was observed that there might be a lot of ideas floating, but there is a chaos in organizing processes to bring them to at least a

[7] https://www.mindtools.com/pages/article/newTMC_90.htm

prototype. It is a vital step in selling a project since “once ideas are at certain stage, it has higher change for a spin out”. One of the interviewees mentioned the fact that developing prototypes from the simplest component is already enough to pitch an idea.

However, there is no such place where tools can be quickly obtained for experiments. The company does not have capabilities or expertise to do so. Either employees obtain resources ad hoc, by finding out themselves if there are any spare parts available or who is able to provide the knowledge and expertise. Another way is to “go through formal procedures of ordering certain parts, which are then inserted in the production line plan. It can take up to 3 months”. The team composed of marketing employees also realized that the company does not allow for “special / fast track lanes for innovative solutions”. According to one of the interviewees, this is a very difficult point since there are no available processes in place for early prototyping. However, if executed, two most important things are needed: the resources of team members and budget. Moreover, business owners are needed to support projects.

Lastly, interviewees also pointed out to the fact that employees are very focused on core technology projects and there is no time to devout for out-of-the box projects. This type of innovative projects require space to be able to experiment. The employees suggested that one way to free the time is to introduce either `required` 10 – 30% of employees´ time is spend on hobby projects, or to have dedicated teams who can not only monitor and review ideas but also provide enough expertise to accelerate innovation execution.

In conclusion, interviewees draw attention to the current innovation management practices and confirmed that there are indeed no processes for innovation management of disruptive innovations. However when the topic was brought, the employees concluded that there is a lot of potential in developing environments that could stimulate such innovative environment.

A5. Inter-firm relationship management at Infineon Technologies

Taking the nature of Infineon Technologies product portfolio, the company focuses on the development of hardware – its most basic components. Hardly, components are being developed from the application point of view. However, a new concept which was introduced recently P2S (components to systems) advocate for complete system solution offerings. The most successful projects incorporate this concept, instead of offering single solutions for its clients, IFX begins to offer a broader range of end solutions. Nevertheless due to its offering nature, IFX has developed a very wide range of partner network who can further improve IFX´s innovative solutions. Currently, there are 159 available online partners spanning over Asia – Pacific, Europe, Middle East & Africa, North America, South America and Japan. They specialize in over 15 applications fields such as automation, consumer, industrial, robotics, smart home and many more. Furthermore, they are categorize according to services, end system, development tools and infrastructure for systems (type of service). They are also categorize according to the product family such as power, microcontrollers, sensors, interfaces and evaluation boards.

Infineon divides partners into associated, preferred or premium ones, and they are further divided according to each division. In addition, to the online database, each division has its own ecosystem, totaling to around 400 partners. The categories are assigned to partners depending on the criteria types: contact details, company profile, existing alliances, offering, commitment, additional information and internal evaluation. For associated partner (lowest level), a business opportunity is considered as promising, but for premium partner it has potential for large business. Moreover, partners receive different benefits depending on the partnership category.

A6. Analysis of inter-firm relationship management

When project managers need to choose partners for their projects, there is a list of preferred suppliers. The comprehensive list of partner finder gives a very good overview on their individual expertise as well as used cases. Most relationships have transactional nature of contracts, it has not been in the common practice for IFX to focus on partnership, high intensity relationships. Usually, certain parts of supply chain or technologies are outsourced completely. Nevertheless, the shift goes towards more customer centric relationship management. Looking at the partner list, it also becomes apparent that most partners are within the core innovation / technologies.

It was also observed that partnership management is developed on the divisional level, in which specific teams handle partnership relations through contacts, setting up meetings, drafting contracts. Most of the time, the partner is found according to the business needs of product line (PL) which can be sometimes very specific. Rarely companies are contacted by IFX, however this has been done in the past. The divisional team finds out about companies through news, conferences and events and contacts them.

In some cases, IFX also organizes competition for universities to develop technologies using the company´s products such as Roboy[8] - a research competition to build robots. It helps the company to find new opportunities for collaboration with students. Except of the part when Infineon is the sponsor for competitions, usually a standard contract is required between two parties. It means that before any collaboration has started there are already certain objectives set.

The opportunity arises when considering potential partners who are not within the typical Infineon´s partner ecosystem, such as e-textile companies. On one hand, there are established partners who contribute to the incremental innovations (within core product portfolio of the company), and the relations seem to strengthen with more successful projects. On the other hand, it might inhibit the company from exploring new potential partners.

A7. Co-innovation at Infineon Technologies AG

The topic of co-innovation is not only new in the research community but also in the industry. Such concept is not known among the employees. Reviewing public articles, some awareness has been raised by the management board of the company. They realize that "Shaping the digital transformation on our own would be a big challenge since markets and business models are changing rapidly. Co-innovation can give us early exposure to new and potentially disruptive end applications". Moreover, it was observed that "The Internet of Things and big data bring new players into the electronics market and require strong collaboration across different know-how domains. Co-innovation is key to business success in this dynamic environment". Nevertheless, it was found that this topic is not being extensively discussed on the strategic nor operational level.

Some efforts have been made in the past to address the challenges of disruptive innovations such as the Corporate Strategy 2007, Pelican group project 2012, or IFX Crowdfunding 2015 initiatives. However, they have not been implemented properly. The main problem was that research was still geared towards projects in the current portfolio, and the business strategies rarely address time horizons of more than 5 years (*Innovation Accelerator*, 2016). In 2016, Innovation Accelerator was proposed to nourish transformational innovation and overcome the valley of death (see Figure 8) Despite well-functioning business processes for core low to medium risks business, disruptive innovations lack attention and structure. Despite these efforts, no sustainable structured emerged (*Innovation Accelerator*, 2016). Consequently, it resulted in many missed opportunities. Therefore, Infineon Technologies

[8] https://roboy.org/

APPENDIX E CURRENT SYSTEM INTERVIEW RESULTS

This appendix contains summaries of interviews that were conducted with former members of disruptive innovation team. The interview was open structured in which interviewer asked about the setup of team, projects, innovation processes and current situation on the innovation management.

Interviewee 1: [redacted] (IFAC ATV SMD EMEA FAE AC)

Disruptive innovation are outside of core competencies of Infineon Technologies. Interviewee 1 worked on two projects in the disruptive innovation team: mice projects (lifecycle) and neural networks.
The idea behind innovation project was to build patents basis. Input key competencies of IFX e.g. pressure sensors to new applications, outside of core competencies.
We were researching for patents, and other members were filing patents. For the future, it could be useful. Once IFX decided to go for these new applications, IFX would have had patents for certain technologies.
With mice project, it went quite far, we had initial collaboration with Research Institutions.
There were smaller teams working on project within a whole disruptive innovation team. One person would know more because this person has worked on it longer, and thus become a team manager. It was a team within a team.
There is a high fluctuation of team members. They tried to make sure that there is a transition point, so old students could transfer some knowledge to new students.
Once a week there was a meeting with supervisor, he would have given feedback.
The goal was to do it in-house. With mice project, we had to do it in house, we met with people from Villach about competencies of sensors, and with Fraunhofer a bit on prototyping. Especially with projects like mice. Be careful about reputation. The technical aspect was in house. With this project, we set up a prototype of a project rather than the product itself.
The team: electrical engineer, electrical engineer and the other in innovation project. The third person was responsible for business case, presentation etc. The setup was a bit like startup in the company, with people of all different backgrounds.
There were a lot of challenges, there was quite a lot of theory because the main goal was to bring it to the patent, knowing different milestones (coming from the fact that the team was composed of students who never worked on projects), articulating well enough (coming from different disciplines, talking about technical things).
It is difficult to work with other partners. It depends on the decision making. If it is in our competencies, and there is an opportunity. If business case shows management there is a high volume, yes partnering would not be a problem. High benefit, quick to market it would be highly possible. If it is something really, really innovative, and risky it would be difficult. For example, if it is only composed of students representative.
Supervisor would be a business owner, it is not a problem. Find people with technical area who would spend some time on it, do this as a hobby. It is difficult to get experts, otherwise you need budget. You need man-hours in the business case. It all depends on the setup.

Interviewee 2: [redacted] (IFAG PMM DCDC)

We need to first understand what innovation in our company is. The industry we are working on involves a lot of money. Even incremental innovations such as improving chips cost 5 – 20 million Euro. There is a big misconception on the innovation concepts.
For disruptive innovation, entering for us is very difficult, it might involve building new factors, setting up supply chains, finding new customers etc. We lack people who know how to build things, assemble our products to systems, and know external products. We would have need different types of people, different types of supply chains.
We realize that our components can have wide spread of applications, but we do not understand certain applications.
In the simplest from, the innovation starts with an idea, crafting of business plan, get funds, ramp up, until minimum viable product. Then it goes into divisions, and then business owners start funding and spin in and out.
Getting parts ad-hoc is difficult, if you want to experiment, the labs are usually full capacity. Freeing machine to build is difficult.
We want to be more on a safe side, and partner with big companies who are able to develop. It also takes long time, 3 to 4 years for customer to develop certain products.
You cannot keep on pushing your products, it does not always work, especially if you work in a conservative environment. Profit comes after many, many years sometimes in 5 to 7 years. With venture capitals, it is different.

For innovation ecosystem, you need people from outside, people who are willing to go beyond and above. It could be possible to build a space inside IFX who could build community, build things and test. Once ideas are at certain stage, you can spin out and do start up.
There is a MakerSpace, where there are equipment and machines to do mockups. From there, you could pair with tech funders, accelerate startup environment. Good way would be to look at partners outside.
In terms of initiatives, we have Business Excellence division who seek partnership with universities and startups. Ideas seem to be difficult to realize within the company.
Activities that we do: DES (central R&D) take charge for hackathon, DDG (digital demand generation) who supports mass market, they bring information on integration of products, do mockups, designs.
Another approach is to make investments (e.g. BMW garage). Then a separate entity is responsible for creating their own supplies, build platforms and groups.
There is a lot of chaos to establish innovations, there is always an open gap despite the fact that there are many consumer products.
One of the challenges is a patenting system. We know the whole package, but we do not know specific. In a disruptive innovation team, we filed 12 invention disclosures. However, they were not specific enough. We use it as an attacking strategy, for example licensing as a pricing strategy.
The problem with innovation is not necessarily generating, most of the time ideas are good but bringing it is very difficult. Take design thinking approach, do networking, find whether it would work etc. You need labs, make products, proper documentation. Build labs with at least lowest safety standards. Important thing is to optimize ideas by exchanging ideas, making interviews make early prototypes. Pitching ideas could also be good.

Interviewee 3: [redacted] (IFAG IPC BID)

In our disruptive innovation team, we worked in parallel on specific ideas. It usually involved a lot of research, checking whether they are patentable.
I worked on a smart mirror concept. The concept usually involved google patent search, weekly meetings, writing invention disclosure. We would have given it to legal patent department.
Usually, each patent has one or several business owners, and percentage goes to each inventor. The process in in the invention disclosure involved the goal, Infineon products, applications, business model canvas.
I made the concept on the system level: which sensors, parameters, components, state of art and budget. But not detailed to technical aspects. We also made marketing promotion for this invention.
There is no exhaustive list of products, it is difficult to know what components to include in the system.
There does not exist really an overall innovation program, usually innovations come from groups (locally). For example, in supply chain in a specific production site, they improve things on their own. We have UBOT projects (in Supply Chain area).
From R&D, e.g. microphone was pushed by R&D and it turned out to be a good business, which was outside of core business.
Another tool is Your Idea Pay (YIP), in which you can submit ideas to the process improvement at IFX. Experts review them and it could become a project, and employees got rewarded. Only ideas related to financial process improvement are reviewed.
There are some collaborations, for example with TUM we had design boot camp on the design thinking process, business model canvas. Makers Lab to build hardware and create prototypes. Collaboration on hackathon. Groups of Phds working on the technical level.

Interviewee 4:[redacted] (IFAG CSC E IN)

Innovation is starting through poster sessions with start-ups, Tech Radar, Digitalks. People network and exchange e-mails that is how contacts are established. We should emphasize more prototyping, we have to do this step by step with a sequence of prototyping. For example, we started with a ping pong game, now we are developing a voting wristband. How can we bring it further to textile application? We need to learn how to make innovations, trying fast and failing fast.
I prefer ideas being developed separately, so people converge to the same conclusion by their own. The business case is then stronger.

Interviewee 5: [redacted] (IFAG PMM ACDC RDA)

The organizational structure is product segment centric. Each division has its own stream of revenues, and profits to be made. Each product segment has its own limited budget, whatever is done from the central department is considered as overhead. Because there is such focus on profits, there is no space for outside the box ideas. We are focus a lot on continuous development of technologies as healthy growth. In general, innovation is very difficult. Here, we focus on day to day business, get simple things, it is a very classic evolution of big corporations. In terms of innovation, we are starting customers in the center, and work with them. We are now offering system approach not just purely product approach, which is already a big step.

Innovations happen usually at the boundaries, not where big masses are. Innovation is especially difficult in this industry, since business case involves a lot of money, for example 10 million R&D budget just for prototyping.

Why companies cooperate? Sometimes to reach a mass scale, which is called coopetition. If companies want to standardize something, they need to cooperate to create similar standards, so everybody starts doing the same things. This is called open standards, when community works together to achieve something. One company sometimes cannot realize by itself. Given example: mobile phones (data transferability). Of course, you have to be careful not to create cartels.

In such big company with such complex life cycles, innovation can only be considered from strategic point of view (long term). For example, startups do not have this patient but look at short term quick innovations.

You also have to consider how big is the project? What size of the investment is needed? What decisions are being influenced? In high tech industries, the development can take 10 to 15 years.

Startups are much faster, they operate in the faster space where they make fast prototyping. Therefore, this is something attractive, we need to think whether I can get products to market quicker. Developing quickness to market could a key strategic advantage. At Infineon Technologies we also look at innovations such as image sensors, IoT. We also need this ability to find synergies. For example Amazon started as a simple webshop bookstore, but then it added more operations related to logistics and shipping goods. Other things are much easier to create, for example websites with Wordpress, whereas in the past you would have develop them from scratch.

Another thing to consider is legal issue. Think of contracts, intellectual properties and licensing. Who is the final product owner? What are the risks? Consider big companies with small companies, the imbalance is huge. Big companies are slow because they usually require NDAs, drafting them, meetings etc. take a lot of time, by the time things are agreed, missed opportunities.

Discussion on Ansoff innovation matrix (new technology and new markets). Ideas might be there, but the issues is always with getting there, implementation of ideas. Innovative ideas also come with higher risk, however company can never grow fast if always stay inside (known market, known technology). There are many research companies publishing reports on next big innovations, but if these are already there it means they are already known. Aren´t disruptive innovations now known? However, with unknown markets we cannot know what the probabilities for success are. Depending on the degree of risks, portions of R&D are allocated. Example, only 10% of budget would go to high risk projects, whereas the rest would go to low risk projects.

Things to consider if you would like to develop some sort of framework. First a self- awareness survey: where are you now? And where do you want to innovate? Where are our innovation partners? How much budget could be allocated for innovation? What decisions are impacted? You could consider micro investing, putting IP, patents in a free floating innovation space?

Then you can think of creating co- innovation spaces by building methods and communities to think about and create this ecosystem (like Apple or Microsoft). Use network approach: social activities, workshops, learning patterns. Take inspiration from innovation summit, other companies. Conduct innovation workshops with universities, do we have business models? How can we quickly prototype? Am I gaining speed?

You could also consider outsourcing to gain speed. Can I outsource innovation? If you consider innovation as production, could it be outsourced just like any other processes? By putting companies together, one making technologies and the other thinking about how to innovate, new environments could be created.

Innovation requires fuzzy thinking, things do not go linearly. Innovation should be at the heart of strategy. For Infineon it would definitely require a huge step change. We basically sale hardware, we do not have environment for disruptive innovations.

Interviewee 6: [redacted] (IFAG PMM SMD STM PAM)

The partnership varies from division to division, I can only talk on the situation in PMM. For example, DSS is very secretive that is due to the security reasons. Partnerships are done at all levels, from conceptualization to commercialization. We also involve universities and create some projects together. Our main products are sensors, radars and MEMEs, so we try to find projects that would use our products.

Usually product line contacts us with a need and we can give them recommendation who to contact. For example, if they need a design agency, we have a list of companies. Mostly, partnership needs are driven by product line, when they need something specific. We meet with project manager or technicians and they tell us what they need. We have conversation about what partners to bring. We need to have good understanding what they need, so we talk with several people in the team, but mostly with project leader. We are usually managing relationships through partnership contracts. We meet with partners, we tell them what we need, and they also tell what they want. As long as there is interest, there is opportunity.

Once, initial understanding is there, we have a standard agreement with benefits and commitment section. Other parts can be changed depending on each other's interests and needs.

We also have partner finder on the website. There is a list of companies we are partnering. There are different categories, so the basic one would include logo to indicate they are business partners, use our products, give access to trainings etc. With higher level of engagement, we share market trends etc. Usually, the longer the relationship, the higher the category, so partners overs time become premium partners. However, if it comes to big companies e.g. Google could become premium partner straightaway.

Companies contact us, but sometimes we find companies when we found them interesting. We invite them and talk, see if there is anything in common. Most of the time, we rather find companies based on the specific needs of PL.

When we invite companies, usually PL meets with them or some technical experts. I can also attend meetings and then pass information. Usually there is not much brainstorming in the partnership relations. Companies I found through conferences, news.

Sometimes, we partner with companies to learn. For example, for ultrasonic project, PL was exploring how our microphone could fit, what would be specifications. Another time, we also collaborate on projects with students. Or we organize competition, where students look at our products and see how it can be used. For example Roboy, we are sponsors there, and students develop a robot using our sensors. We also use these inventions on events such as Electronica. We provide funds for some projects, we are in jury panel for innovation award in Germany.

In terms of the project management, it all depends on the agreements between project manager and the company. There are not formal procedures. It is really case by case situation. Some parts are done by other teams, for example IP related topics are handled by legal department. Technical project management is not done in this team.

Innovation is such is not there at Infineon. The company is trying to pursue and starts doing that by building good relationships. But more openness is still needed. It´s really about the mindset, but then again it is hard in large companies. In PMM, the management board realizes the need to change and tries to become more agile. There are some departmental restructuring being done. Restructuring and trainings are needed to be done more often. We also start to initiate system to market thinking, when we look more at the market. There is Next Level of Sales and Marketing initiative, they try to look at new strategies to approach customers. In our department, we are trying to initiate emerging applications project for new ideas. But we are still a small team.

It is quite hard to raise awareness, it needs to be addressed why changes are important. I think it is a matter of time.

Project: Next Level of Marketing and Sales

Subproject: G2M

Project in which the project team conducted interviews with marketers and sales forces on the past projects. The purpose of this project is to take good practices that led to the succession of the project. Each project was also evaluated on the innovativeness of the product for Infineon. Projects which were categorized as 3 (most novel) were also analyzed. Since the author took part in the interview interpretation, good insights regarding the innovation process were included in the master thesis. Screenshot of data collection can be found below.

Categ	Product	Deliverable	Product	Place - Customer	Keyword	Customer novelty	Place - Application		Price
Unknown	Forte Class D Audio Amp	Strategic Fit Analysis							
Unknown	Forte Class D Audio Amplifier	Market & Competitor Insights		Understand the ecosystem and its standard bodies or industry standards. Move from a component only approach to a system approach. Build a network of partners that ODMs use to develop their overall system solution. E.g. enter the Apple "made for iPod" (MFI) ecosystem, generate an MFI toolkit compatible to it for 3rd parties that the ecosystem users can easily source.	Ecosystem	1	Make a thoughrough market survey with available customers, to assess if initial chosen market segment is the right one to address with new tech. Do not assume it will be the right one. Other segments in the same market might be more suitable. E.g. instead of wireless speaker segment look into in-built TV speakers segment (i.e. market is "audio", sub segment is "TV" - "Wireless speakers").		
Unknown	Forte Class D Audio Amplifier	Requirements Capturing	Strong alignment with lead customer can avoid "surprises" on features.	Take early customer feedback seriously. They might know better than you.	Openness	1			
Unknown	Forte Class D Audio Amplifier	Value Proposition							
Unknown	Forte Class D Audio Amplifier	Pricing						Deta esta incu nece addi case	l competitor tear down analysis can help h a base line for competitor costs. If "must beat ent" is necessary, competitor based pricing is ry, unless a specific customer value driver is ed markedly better than competition, in which ue based pricing is the preferred approach.
Unknown	Forte Class D Audio Amplifier	Market Introduction Plan		When dealing with new technology, first focus on "n" customers first (n<5), and then move to a mass market approach to avoid exposure and learn from the experiences with them. You need to first have some evidence and positive feedback from the market before going "wide". E.g. selected small to mid size volume select lead customers, instead of many big players.	G2M Category Change	1			

APPENDIX F LITERATURE REVIEW DISRUPTIVE INNOVATION

Title	Author	Definition of innovation	Phases	Differences / factors influencing	Findings / implications
Discontinuous innovation and the New product Development Process (1)	R. Veryzer (1998)	Discontinuous: significant new technologies and are recognized as offering significantly enhanced benefits. Considering customer´s perspective	1) Dynamic Drifting phase 2) Convergence phase 3) Formulation phase 4) Evaluation preparation phase 5) Formative Prototype phase 6) Testing and design modification phase 7) Prototype and commercialization phase	• High degree of technological uncertainty • Greater distance from the market (time and familiarity) • Degree of informality • Importance of product champion • Formulation of product application • Concept testing and business assessment discourage disruptive innovation	• Exploratory • Less customer driven • Inherently messy • Driving forces • Product champions
Idea management in facilitation of pharmaceutical front end innovation (2)	A.Aagaard (2008)	Disruptive/ radical: highly revolutionary or discontinuous, and represents a new paradigm that can generate new wealth whilst transforming or displacing some parts or all of an established market Incremental: the planned, organized and systematic process of ongoing, incremental and companywide change of existing practices aimed at improving company performance	1) Strategic frame and business focus 2) Opportunity identification 3) Environmental scanning and knowledge search 4) Idea generation and idea gathering 5) Idea evaluation and idea selection 6) Idea maturation 7) Product concepts	• Radical discovery projects are handled differ in comparison to more incremental discovery projects • Structuring innovation too much may hamper exploration and radical innovation	
A framework for managing the innovation process	N. Preez, L. Louw (2008)	Fugle model´s innovation funnel	1) Idea generation / identification stage 2) Concept definition stage		• Break the process into smaller stages • Quality of process

			3) Concept feasibility and refinement stage 4) Portfolio stage 5) Deployment stage 6) Refinement and formalization stage 7) Exploitation stage		• Activities that make sense before next gate • Some direction and focus needed • Holistic approach driven by cross-functional teams • Network approach required • Information efficiency
Connecting technological capabilities with market needs using a cyclic innovation model	G. Berkhout, D. Hartmann, P.Trott (2010)	Cyclic innovation model	• Technological research (create technical capabilities and technical functions) • Market transition (create social insights and customer value) • Scientific exploration • Product creation	• Environment must be created where a large diversity of people with a broad range of backgrounds can freely interact and exchange information	• Socio-technical framework • Sufficient interaction • Cross disciplinary network
Innovating the innovation process: an organizational experiment in global pharma pursuing radical innovation	P. Robbins C. Gorman (2014)	<u>Radical:</u> new technology or new scientific know-how; and new consumer groups, new segments <u>Incremental</u>: used an existing technology, mode of action, science; or extended to either new technology or new market but not both	1) Discovering and generating new idea 2) Choosing among competing ides 3) Embedding the new idea in the organization	• Radical new product ideas benefit by being separated from normal firm routines • Prioritization of external networking led to radical innovation ideas • Engagement in open creativity • Type of leadership	
The front end of radical innovation: a case study of idea and concept development at Prime Group	J. Frishammar E. Dahlskog C. Krumlinde (2016)	Radical: creating new and unique ideas and concepts with long-term value that offer significant performance benefits, cost reductions or the ability to create new businesses	1) Insight analysis 2) Problem clarification 3) Problem formulation 4) Idea development 5) Concept development	• Radical ideas and concepts can be created through a formal process with rather distinct phases • Emphasis on problem formulation	

APPENDIX G LITERATURE REVIEW INTER-FIRM RELATIONSHIP

Authors, year, title	Categories	Elements	Methods / approach	Case	Implications	References
Mohr and Spekman (1994) Characteristics of partnership success: partnership attributes, communication behavior and conflict resolution	(1) Attributes of the partnership (2) Communication behavior (3) Conflict resolution techniques (4) Successful partnership	(1). • Commitment, coordination, trust (2). • Quality, information sharing, participation (3). • Joint problem solving, smoothing, domination, harsh words, arbitration (4). • Satisfaction, dyadic sales	Empirical test of the model ; Surveys (statistically measured)	Vertical relationships between manufacturers and dealers in the context of computer industry; Perspective of dealer (buyer)	• Insights into better management of relationships to ensure success; • Success of partnership (satisfaction and dyadic sales); • Manner in which partners attempt to manage the future scope and tone of their relationship.	Anderson and Narus, 1990; Day and Klein, 1987; Dwyer, Schurr, and Oh, 1987; Frazier, Spekman, and O'Neal, 1988; Salmond and Spekman, 1986
Sivadas and Dwyer (1998) A comparison of organizational factors influencing new product success in internal and alliance based products	(1) Cooperative competency (2) Top management support	(1). • Trust, communication, coordination (2). • Inter – unit communication, auditability, goal cohesion, attitudinal solidarity, • Clarity of agreement, lack of resistance	Model from Zirger and Maidique (1990) based on literature review, case study research and exploratory interview in the electronic industry; Survey with multiple regression analysis	The semiconductor industry (600 sampling companies) The healthcare sector	Integration of new product development and alliance literature. Cooperative competency and top management support contribute to new product success	
Mentzer, Min and Zacharia (2000) The nature of interfirm partnering in supply chain management	(1) Partnering antecedents (2) Partnering implementation (3) Business performance outcome	(1). • Interdependence, conflict, trust, commitment, organizational compatibility, top management vision (2). • Information sharing, technology utilization, strategic interface teams, organizational issues, joint programs, asset specificity,	Theory expansion through hypothesis building		• Continuum exist from to strategic to operational partnering • Implementation of strategic partnering leads to sustainable competitive advantage • Operational partnering leads to competitive parity	Achrol et al., (1990), Smith and Barclay (1997), Bucklin and Sengupta (1993)

		establish joint performance measures (3). • Economic performance, customer satisfaction and loyalty, relationship effectiveness			• Operational partnering far easier to achieve	
Roy, Sivakumar and Wilkinson (2004) Innovation generation in supply chain relationships: a conceptual model and research proposition	(1) Factors internal to relationship (2) Factors external to relationship (3) Interaction (4) Innovation generation	(1). • Information technology adoption • Commitment (input commitment asymmetry, attitudinal commitment asymmetry) • Trust (competence trust, goodwill trust) (2). • Tacitness of technology • Stability of demand • Network connections (within industry, across industries) (3). • Quantity, scope and mode of communication (4). • Incremental innovation, radical innovation	Framework based on theory building	Buyer – seller relationship in upstream supply chains	Guidepost to facilitate better management of innovation generation in supply chain relationship	Hakansson (1987); Leonard-Barton (1993); Kalakota and Whiston (1999); Anderson and Weitz (1992), Gundlach, Achrol and Mentzer (1995); Joshi and Stump (199); Barclay and Smith (1997), Nonaka and Takeuchi (1995); Bowersox, Closs and Stank (2000)
Athanasopoulou (2009) Relationship quality: a critical literature review and research agenda	(1) Dimensions of relationship quality (2) Consequences of relationship quality (3) Antecedents (4) Relationship quality (framework)	(1). • Trust, commitment, satisfaction, communication, conflict (2). • Business / service / channel performance • Relational benefits including anticipation of future interaction • Satisfaction (3).	Cross referencing of papers published in major journals in the marketing areas (literature review on 64 studies)	Relationship of companies with customers	The development of the framework on relationship quality	

		• Characteristics of two parties (similarity, expertise) • Relationship attributes (length and duration) • Offer characteristics • The role of environment (4). • Trust, commitment, customer satisfaction, conflict, cooperation, opportunism, power, adaptation, atmosphere, bonds				
Wong, Wilkinson and Young (2010) Towards an empirically based taxonomy of buyer – seller relations in business markets	Relationship atmosphere	• Power and dependence • Cooperativeness and competitiveness • Trust and opportunism • Understanding and non -understanding • Closeness and distance • Commitment and non-commitment	Empirical study on a large scale database of buyer seller relations		Taxonomy of business relations including buyer and seller perspectives: disgruntled follower, manipulative leader, benevolent independent, arm´s length and close	Gaski 1984; Hallén and Sandström 1991; Rotter 1967; Williamson 1975; Kim and Frazier 1997a, b; Sharma et al. 2006
Sharma and Young (2013) The nature and role of different types of commitment in inter-firm relationship cooperation	Aspects of cooperative business relationships	• Commitment (value based, affective, behavioral, locked in, obligation based) • Trust • Cooperation • Relationship value • Conflict	Model association through regression and causal path analysis testing	Industrial Marketing and Purchasing Group´s multi-country study of business relationships between Indian firm and trading partners	Various kinds of commitment to build effective relationships	(Anderson and Narus, 1990; Doney and Cannon, 1997; Walter and Ritter, 2003; (Morgan and Hunt, 1994
Kim, Choi and Skilton (2015) Buyer- supplier embeddedness and patterns of innovation	(1) Relational dimension (partnership – transaction) (2) Structural dimension	(1). • Collaboration, commitment, trust, information sharing, information sharing, norms of reciprocity, forbearance, shared values, quality of conflict resolution (2). • Interaction frequency, multiplexity, transaction specific	Literature on social embeddedness (conceptual paper)	Dyadic construct	Configurational approach to innovation patterns in inter-firm settings (dyad)	Dwyer et al., 1987; Dyer et al., 1998; Heide and John, 1990; Morgan and Hunt, 1994; Spekman, 1988; Uzzi, 1997; (Beckman and Haunschild, 2002; Marsden

		investment, task routines, mutual dependence				and Hurlbert, 1988
Park and Lee (2018) Early stage value co-creation network – business relationships connecting high tech B2B actors and resources: Taiwan semiconductor business network case	(1) Resources (2) Relationships	(1). • Monetary or human resources • Knowledge resources (knowledge, experience, information and skills) • Technology resources • Intellectual resources (IP, patent assets) • Efficiency resources (time and effort) (2). • Trustworthiness, commitment, number of decision making capabilities	Building theory from a case study Grounded theory coding	Semiconductor foundry business model (Taiwan´s foundry business model network) Manufacturer perspective	The value-co creation is extended from later stage to early stage in the value chain	Daniel et al. (2002), Corsaro et al. (2012) Jaakkola and Hakanen (2013), Hakanen (2014), Lacoste (2016), Eslami and Lakemond (2016) Vargo and Lusch (2008, 2011), Jaakkola and Hakanen (2013) Vargo (2015), Akaka and Vargo (2014) Rusanen et al. (2014)

APPENDIX H LITERATURE REVIEW CO-INNOVATION

Title	Authors, year	Definition	Motives	Constructs / elements	Outcomes	Case studies
The development of co-innovation strategies: stages and interaction patterns in interfirm innovation	Bossink (2002)	Organizations create new products, processes by sharing complementary resources, knowledge and competencies and go through several stages of strategy making in which they interactively explore, develop and realize their co-innovative ambitions	Create values: • Create new products • Create new processes • Create new organizations	• 5 stages: recognition, research, relationship set up, ramp up and ongoing management • Interaction patters		Aerospace, agriculture, automotive, chemical, education, textile
Co- innovation: what are the success factors?	Bremmers and Sabidussi (2008)	Learning networks in cooperation with the government	• Barriers and success factors for co-innovation projects	• Perceived costs and benefits: attitude, perception of competitive advantage, cost and risk awareness • Stakeholder norms and support: strategic fit • Capabilities (Controllability): behave as intended; the availability of the assets, competences, capabilities	• Success factors: goal congruence, investment and value dependency contributing to the willingness to cooperate • Unanimity on the project goals and strategy early in the stages of the project • Technical knowledge to understand context • Knowledge of groups	20 supply chain projects and 8 biological product development projects
Shifting from co-development to co-innovation	Midler (2008)	• Any relationship between supplier and manufacturer that is forged in relation to an innovative feature • For each partner, this cooperation is a phase in the	• New stakes demands • Redistribution of roles • Implies viewing profitability and fairness as a multigame learning process	• 4 phases: exploration, contextualization, development and deployment • Dimensions of innovation process: learning strategy, decision making and risk management process, institutional adoption of		Car manufacturing

		innovation route, which means that by definition the other partner is able to reuse the knowledge generated ruing the cooperation		the innovation trajectory, work method, type of intercompany relationship • The innovation route: exploration outside of the product development cycles and the activities that are related to the matching process of these features with the flow of new products of the firm		
Investigating co-innovation in exploratory partnerships : an analytical framework based on design theory	Kazakçı, Giller and Piat (2009)	Partners explore and progressively construct a common project and an agreement on the sharing of tasks and outputs	Value creation opportunities and access external resources	• Finding or building collective partitions and complementary knowledge through process or matching and or building • Co-exploration of C spaces: restructuring C spaces to reach collective partitions • Co- exploration of K spaces: new knowledge as a medium for exploring partner´s old knowledge	• In order to reach a common projects in C space, partners explore each other's concepts to detect collective partitions that allow building common concept spaces • New knowledge can be used to explore partners capabilities and competencies to establish common innovation topics	
Co-innovation : convergenomics , collaboration , and co-creation for organizational values	Lee, Olso and Trimi (2012)	Platform where new ideas or approaches from various internal and external resources are applied differently to create new value or experience for all stakeholders	The new world, environment, and ecosystem Creating values: • New customer value • New customer base • New efficiency of value chain New product, services	• Evolution of innovation: conceptual overview of co-innovation through basic elements: close, collaborative, open, innovation, co-innovation • Co- innovation platform: where an organization can create value • Convergence: convergence of seemingly unrelated things to meet the existing or new demand		Case studies Workshops

				• Collaboration: inter-organizational relationships (open source collaborative community) • Co-creation: enterprise works in collaboration with all the stakeholders		
The co-innovation alliance scan , tool for effective collaboration with external partners	Avans (2017)	Collaborating within international alliances and networks, a source of knowledge and learning, a larger knowledge base or improved process and product innovation	Select and access co-innovation patterns	• Analysis (strategic fit): the strategy of the partner, business models, systems and procedures • Action (operational fit): balance of power, improving continuously • Innovation (network fit): agile and flexible, knowledge sharing, the network of partners • Connectivity (personal fit): organizational culture, trust and commitment, personal click		Workshops
Addressing complex challenges using a co-innovation approach : Lessons from five case studies in the New Zealand primary sector	Vereijssen et al., (2017)	Interactive process that brings together knowledge from many stakeholders, to support changes in the technology, markets, regulations and other practices that support the commercialization and implementation of the knowledge to improve production, exports, profits	• Enhance rate of adaptation and adoption of technologies from research, science and technology investments • Bring actors in a coordinated, interactive co-innovation • Virtual environment in which external actors can or believe they can contribute to new ideas or solutions • Higher levels of value co-creation in their communities	• Understand problems from many different views • Inclusive in terms of diversity of stakeholders • Engagement methods: one on one meetings, phone calls, formal meetings, • Stakeholder engagement: passive participation, interactive, functional, self-mobilization • Range of disciplines involved (single, multidisciplinary) • Scope of potential impact (efficiency gains, value chain)	• Depending on complexity of problems, different approaches may be chosen • Flexibility and adaptability important in achieving positive results	5 research projects in New Zealand (agriculture)

Co-innovation platform affordances Developing a conceptual model and measurement instrument	Abhari, Davidson, Xiao (2017)	A new business model enabled by social media technology		• Ideation affordances • Collaboration affordances • Communication affordances	• The development of an instrument designed to measure the various aspects of the affordances of co-innovation platform affecting co-innovation process	First phase: 22 co-innovation platforms, Second phase: Quirky.com
Co-innovation : a review and conceptual framework	Saragih, Utama, Tan (2018)	Act of collaborative actions carried out by various internal and external stakeholders towards creating distinctive and exceptional value in the market	• Value innovation: a new strategic logic that challenges firms to make either exceedingly unique differentiation or extra ordinary low price value propositions in the market • Customers have significant impacts in creating values with firms • New customer value • New customer base • New efficiency of value chain • New product, services	• Collaboration: multi-actors active participatory action with distinct characteristics and resources. They must acknowledge the roles of external stakeholders. • Coordination: ensure harmonious orchestration of various contributing actors with their unique resources towards synergetic goals desired by the company • Convergence: entices various contributing actors towards a shared and focused purpose • Complementarity: between technological, institutional, organizational resources and capabilities shall be incorporated properly • Co-creation: create enticing experiences with customers	• Initiated discussions on how co-innovation can be implemented in various organizational settings • (Future research: detailed understanding how each of this element can be practiced in different organizational settings and industries)	IBM, Lake Nona, Mekanims, Webaasto, Nike and Apple, Propellerheard

APPENDIX I GENIUSTEX STAKEHOLDER ANALYSIS AND RESOURCES

I1. GeniusTex work packages and work distribution

Work package	Work packages	Infineon	Eccenca	Ottobock	ASYS	ITA	TIM	FIT
TP1	Basics and overall concept definition	1	1	2.5	1	3	6	5
WP 1.1	System Analysis	0.5	0.5	0.5			1	1
WP 1.2	Product specifications			0.5				
WP 1.3	User interfaces			0.5			1	1
WP 1.4	Order interfaces			0.5		1	2	1
WP 1.5	Production interfaces	0.5			1	1	1	1
WP 1.6	Service implementation interfaces			0.5				1
WP 1.7	Economics of the whole system		0.5			1	1	
TP 2	Product modularization	2	3	1	9	9	2	
WP 2.1	Modularization of Smart Textiles	1	2		4	4	2	
WP 2.2	Selection of sensors and microcontrollers	1	1	1	2	2		
WP 2.3	Smart Textile design – sensor interface				3	3		
TP 3	Manufacturing processes selection	7.5	0	0	9	14	0	0
WP 3.1	Developing production scenarios	2			2	5		
WP 3.2	Economic evaluation of production chains	2			1	4		
WP 3.3	Logistics concepts modules	2.5			2	2		
WP 3.4	Implementation of database software	1			4	3		
TP 4	Software implementation	0	8	1	0	2	2	31
WP 4.1	Prototype development – platform interface		3					18
WP 4.2	Prototype development of Software 1Development Kit (SDK)							10
WP 4.3	Evaluation of SDK and platform		1	1		2	2	3
WP 4.4	Semantic Data Integration		4					
TP 5	Development of Business Models	0	3	1	1	1	23	1
WP 5.1	Platform requirements		1	1	1	1	1	1
WP 5.2	Development of Business Models		2				8	
WP 5.3	User and usage data valuation						8	
WP 5.4	Barrier identification						6	
TP 6	Smart Orthosis module	2	0	3.5	4	9	0	1
WP 6.1	Pre-development of orthosis			1				
WP 6.2	Smart Textile ordering	1		0.5		1		
WP 6.3	Configuration of Smart Textiles			0.5		1		
WP 6.4	Production of Smart Textile	1			4	4		
WP 6.5	Service implementation			0.5		1		1
WP 6.6	Orthosis production			1		2		
TP 7	Project management and implementation	0	9	0	0	4	4	4

WP 7.1	Project management		6					
WP 7.2	Re-evaluation / business models		2			2	4	4
WP 7.3	Communication		1					
WP 7.4	Coordination with Korean partners					2		
	Total number of persons	**12.5**	**24**	**9**	**24**	**42**	**37**	**42**

I2. Stakeholder analysis

Company	**Scientific and technological objectives**
Infineon Technologies	• Selection and structuring of semiconductor products (sensors and actuators) for use in textiles • Summary of administrative and technological information about the products • Analysis of existing technologies for possible configuration options in order to adapt them to use in textiles • Analysis of required quality functions in order to provide "bare-dies" • Offer specific "bare-dies" as prototypes • Identification and selection of appropriate service providers to enable the use of the "bare dies" in the consortium • Transfer of the current, successful supply chain concept and knowledge into a concept for intelligent textiles • Support and advice in the definition of requirements for the platform and interfaces from the perspective of the supplier
ITA	• Collaboration on joint business activities of manufacturers, suppliers and service developers and the development of new business models efficiently supported early customer involvement in production engineering • Makes cross-functional information available and usable • Supports collection, aggregation, distribution, and evaluation of sensor data for Smart Textiles • Development of coherent networked Smart Services for Smart Textiles
TIM	• The comprehensive collection and analysis of the requirements and needs of the individual participants in the platform to be developed. • Derivation of design parameters for the business model aspect of the platform. • Developing concepts to enable collaborative innovation on the platform, especially through customer engagement. • Identification of barriers in the implementation and operation of the platform as well as the derivation of concepts for overcoming them. • Systematic development of business model alternatives for the involved stakeholder groups and exemplary validation of a business model alternative with application partners
FIT	• Development of coherent networked Smart Services for Smart Textiles • Development of tools for the semantic integration of data from external information systems • Development of lightweight tools for structuring and categorizing Smart Textiles information • Development of efficient search procedures • Development of tools to support collaboration and key collaborative product engineering activities • Development of tools to support innovation management during the design and production of smart textiles by capturing and exploiting customer requirements • Develop solutions to protect corporate intellectual property and user privacy • Development of a tool for the joint orchestration of Smart Textiles Services

APPENDIX J CO-INNOVATION INITIATIVE INFOGRAPHIC

Infographics on Co-Innovation initiative at Infineon Technologies (scenario 1).