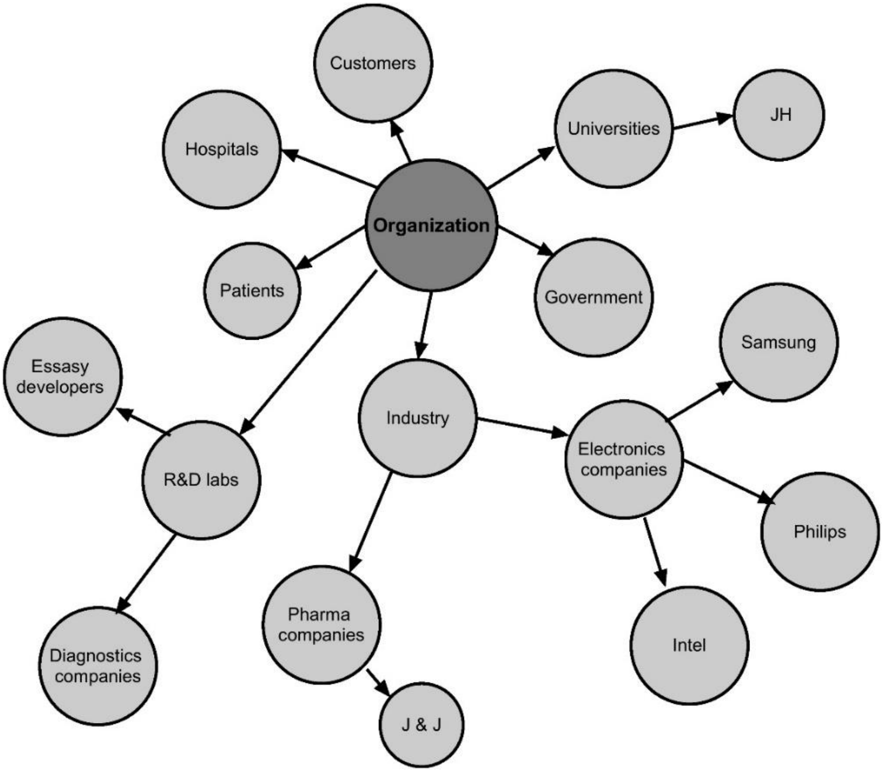

Analyzing Innovation Ecosystems

Evidence from the Belgian and Dutch nano-electronics industries

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My family and friends, I love you all! ☺

To:

My kind and beautiful mother Dr. Farideh Yaghmaei,
my caring and supportive father Mr. Bijan Yaghmaee
my loving and positive brother Dr. Pouria Yaghmaee
&
our cheerful best friend, Maxie

A small appreciation to your love

Executive Summary

This PhD thesis analyses constituents of the Belgian and Dutch nano-electronics innovation ecosystems. Over the past two decades, the advancement of technology has increased R&D costs, product delivery time and contributed to a lack of technical expertise. Organizations in a wide range of industries, particularly in high-tech industries, realized that they could not survive in isolation and needed to look outside their own businesses for innovation opportunities. Through various innovative collaborations, organizations have joined and grouped up with external partners to create innovation ecosystems; an open environment where participating partners collaborate, exchange knowledge, and expertise to maximize value and deliver objectives. In an innovation ecosystem, partners complement each other in resources and technical know-how, and their individual performances influence the overall performance of the ecosystem. This highlights the complexity of innovation ecosystems and the significance of recognizing the constituents of innovation ecosystems to successfully deliver the ecosystems' objectives.

Despite the significance of participating in an innovation ecosystem and its impact on developing the competitive advantage of organizations, scholars have mainly considered only one type of actor within the ecosystem, and have examined the ecosystem strategies from one specific perspective. Bearing in mind that actors co-create the value in an innovation ecosystem, this atomistic view does not offer a complete picture of the innovation ecosystem, nor does it offer a suitable evaluation of the innovative collaborations within an ecosystem. In this respect, through a holistic view, and considering the ecosystem's development, this PhD thesis explores the different constituents of innovation ecosystems in a typical high-tech industry.

Through a qualitative inductive methodology, 10 Belgian and Dutch nano-electronics innovation ecosystems that offer products in pharmaceutical and life science sector were interviewed. Interviewees were either strategic development managers, knowledgeable about the organizations' external innovative collaborations, or those in charge business development and open innovation. The informants responded to various types of questions, such as how the ecosystem creates and captures value? What are the possible challenges that the ecosystem may face during the collaboration? What is the role of partners? Who orchestrates the ecosystems and how this is strategically achieved? Using content analysis software (i.e. NVvio 11), data was analyzed and final themes/theories were created. This thesis is the first attempt to apply grounded theory development at an ecosystem level through a holistic lens, to explore different constituents (i.e.

value creation and capturing mechanisms and challenges, role of actors and orchestration strategies) of innovation ecosystems.

Integrating the results leads to the generation of a theoretical model. Considering the development of innovation ecosystems, the model creates a strategic blueprint of what organizations need to consider to successfully deliver their objectives. Results show that Belgian and Dutch managers and decision makers in the nano-electronics industry play crucial role, using distinct strategic plans to create, orchestrate, and shape innovation ecosystems to maximize their value and successfully deliver these objectives. Besides the theoretical model, this thesis offers large and multinational companies, small and medium enterprises (SME), intermediaries, academic institutes, and the government agencies involved in the nano-electronics or similar high-tech industries several managerial practices that may facilitate their decision-making. Managers in industrial firms and academic institutes need to internally establish an open and transparent environment so personnel can communicate efficiently. In addition, through various networking sessions, organizations can recognize the mindset and objectives of their partners, develop trustable relationships, and commit to long-term innovative collaboration. Government policy makers can support ecosystem partners, especially SMEs, and provide long-term financial support to facilitate the innovative collaboration and indirectly resolve potential ecosystem challenges.

Considering the promising future of innovation ecosystems and their major contribution in the economic development of countries, this thesis offers several recommendations for future actions. The first is to explore the ecosystems strategies that other participants of the ecosystem such as hospitals and patient organizations use in interaction with other partners. The second is to further examine SMEs and the reasons that force them to leave an innovation ecosystem. The third is to concentrate on innovation ecosystems that are less successful or fail to deliver the ecosystems' objectives and understand the root cause. The fourth is to examine the dynamics of innovation ecosystems over time. The fifth is to analyze "low-tech" industries, compare the low-tech with the high-tech industries and pinpoint the major differences in the ecosystem strategies. Finally, the sixth is to explore similar research questions in innovation ecosystems in other regions or countries and evaluate the role of the government in the overall innovative collaboration of that specific region.

Samenvatting

Dit proefschrift analyseert innovatie ecosystemen in de Belgische en Nederlandse nano-elektronica. In de afgelopen twee decennia heeft de technologische vooruitgang de O&O kosten van bedrijven drastisch verhoogd, de tijd om producten te ontwikkelen verlengd en het gebrek aan technische expertise verscherpt. Organisaties in vele industrieën, meer bepaald in high-tech industrieën, realiseerden zich dat ze niet in isolatie kunnen concurreren en dat ze moeten zoeken naar innovatieve oplossingen in samenwerking met partners. Door middel van diverse innovatieve samenwerkingsverbanden werken organisaties samen met externe partners en in die zin worden innovatie-ecosystemen gecreëerd; een open omgeving waarin partners samenwerken, kennis en expertise uitwisselen om de waarde te maximaliseren en gezamenlijke doelstellingen te realiseren. In een innovatie-ecosysteem vullen partners elkaar aan inzake middelen en technische kennis en hun individuele prestaties beïnvloeden de performantie van het gehele ecosysteem. Dit wijst op de complexiteit van innovatie-ecosystemen en het belang om de bestanddelen van innovatie-ecosystemen te onderkennen en hun onderlinge afstemming te verstaan om de doelstellingen van deze ecosystemen succesvol te realiseren.

Ondanks het feit dat het belang van verschillende types van participanten in een innovatie-ecosysteem en hun invloed op het ontwikkelen van concurrentievoordelen van de deelnemende organisaties bekend is, beschouwden wetenschappers voornamelijk één type speler binnen het ecosysteem en onderzochten de strategieën vanuit een specifieke invalshoek. Gezien het feit dat verschillende actoren de waarde creëren in het innovatie-ecosysteem, biedt een atomistische weergave geen compleet beeld van een innovatie-ecosysteem, en biedt het ook geen passende evaluatie van de innovatieve samenwerkingen binnen een ecosysteem. Door middel van een holistische standpunt analyseer ik in dit proefschrift de ontwikkeling van ecosystemen door de componenten van deze innovatie-ecosystemen in een hoogtechnologische industrie in detail te bestuderen.

Door middel van een kwalitatieve, inductieve methode heb ik de innovatie ecosystemen onderzocht van 10 Belgische en Nederlandse organisaties die producten in de farmaceutische en levenswetenschappelijke sector aanbieden. De managers die ik ondervroeg zijn verantwoordelijk voor business ontwikkeling, open innovatie en strategie ontwikkeling. Ze hadden heel wat kennis over de innovatieve samenwerkingsverbanden van hun organisaties met diverse partners. De ondervraagde managers hebben geantwoord op verschillende soorten vragen, bijvoorbeeld hoe het ecosysteem waarde creëert en hoe verschillende partners

een deel van deze waarde toe-eigenen? Wat zijn de mogelijke uitdagingen die ze kunnen ondervinden tijdens de samenwerking? Wat is de rol van de verschillende partners? Wie orkestreert ecosystemen en hoe kan orkestratie succesvol gerealiseerd worden? Met behulp van "content analysis software" (NVvio 11) werden de data geanalyseerd en werden thema's gecreëerd die de bouwstenen vormen voor de ontwikkeling van een theoretisch kader. Dit proefschrift is een eerste poging die "grounded theory" toepast op het ecosysteemniveau door verschillende bestanddelen van een innovatie ecosysteem te onderzoeken (d.w.z. waardecreatie en waarde toe-eigening mechanismen, uitdagingen, de rol van actoren en orkestratiestrategieën).

Door de resultaten te integreren kan een theoretisch model ontwikkeld worden. Wat betreft de ontwikkeling van innovatie-ecosystemen creëert het model een strategische blauwdruk wat organisaties moeten overwegen om de doelstellingen succesvol te realiseren. Uit de resultaten blijkt dat Belgische en Nederlandse managers in de nano-elektronica industrie een cruciale rol spelen en een duidelijk strategisch plan gebruiken om de innovatie-ecosystemen te creëren, te organiseren om hun waarde te maximaliseren en de doelstellingen succesvol te realiseren. Naast het ontwikkelen van een theoretisch model biedt dit proefschrift grote bedrijven, kleine en middelgrote ondernemingen (MKB), tussenpersonen, academische instituten en de overheidsinstanties die betrokken zijn bij de nano-elektronica-industrie een aantal "best-practices" die het nemen van beslissingen kunnen vergemakkelijken. Managers in industriële bedrijven en academische instituten zijn verplicht om een open en transparante interne omgeving op te zetten, zodat personeel efficiënt kan communiceren. Daarnaast kunnen organisaties via de verschillende netwerkbijeenkomsten de ideeën en doelstellingen van hun partners begrijpen, vertrouwelijke relaties ontwikkelen en zich inzetten voor een langdurige innovatieve samenwerking. Beleidsmakers zouden ecosysteem partners, en vooral MKB's, kunnen ondersteunen en financiële steun verlenen om de innovatieve samenwerking te vergemakkelijken en de potentiële uitdagingen die ontstaan bij samenwerkingsverbanden binnen een innovatie ecosysteem op te lossen.

Gegeven de veelbelovende toekomst van innovatie-ecosystemen en hun belangrijke bijdrage aan de economische ontwikkeling biedt dit proefschrift diverse aanbevelingen voor verder onderzoek. Ten eerste moeten strategieën worden onderzocht die andere deelnemers van het ecosysteem, zoals ziekenhuizen en patiëntenorganisaties, gebruiken. Ten tweede moet de rol van het MKB binnen innovatie-ecosystemen verder onderzocht worden vooral de redenen die hen ertoe aanzetten om een innovatie-ecosysteem te verlaten moet verder geanalyseerd worden. Ten derde moet men zich concentreren op innovatie-ecosystemen die minder succesvol zijn of niet in staat zijn om de doelstellingen van de ecosystemen te realiseren. Ten vierde moet meer aandacht gaan naar de dynamiek van innovatie-ecosystemen. Ten vijfde dient men ecosystemen in laag-technologische industrieën te onderzoeken en deze dienen vergeleken te worden met innovatie-ecosystemen in hoogtechnologische sectoren. De vergelijking moet toelaten om belangrijke verschilpunten te ontdekken. Tenslotte dient dit onderzoek uitgevoerd worden in andere regio’s en landen. Door innovatie-ecosystemen in verschillende lande te vergelijken is het ook mogelijk om de rol van de overheid beter te evalueren.

Table of Contents

Tables

Figures

Glossary

Term	Definition
Actor	An organization which is an industrial firm, university, research center or other entity that participates in the value creation and capturing process in the innovation ecosystem.
Innovation ecosystem	Group of organizations that aims to jointly create and capture value from innovation activities (technical or business related innovations) (Adner, 2006; Adner & Kapoor, 2010; Ritala, Agouridas, Assimakopoulos, & Gies, 2013).
Interaction ties	The way in which relationships are connected and shaped among actors in the innovation ecosystem.
Open innovation	A paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology (Chesbrough, 2003).
Orchestration	Strategies that the central firm or orchestrator must carry out to coordinate, influence, and/or direct other actors in the innovation ecosystem (Nambisan & Sawhney, 2011).
Orchestrator	A central actor who participates in, establishes, and manages the innovation ecosystem (Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011).
Partner	Actor who participates in the innovation ecosystem and has a non-orchestrating role.
Value capturing	The individual firm-level actualized profit-taking; that is, how firms eventually pursue the reaching of their own competitive advantages and the reaping of related profits (Ritala et al., 2013). It is predominantly considered as an individual firm-related activity (Ritala & Hurmelinna-Laukkanen, 2009).
Value creation	The collaborative processes and activities of creating value for customers and other stakeholders (Ritala et al., 2013).
Value driver	A performance variable that creates value in a significant way.

"Every member of a team has got to understand that they are part of a jigsaw puzzle. If you remove one piece, the picture doesn't look right. Each player has to understand the qualities and strengths of their team-mates to win."

(Ferguson & Moritz, 2015)

Chapter 1

1 Introduction

1.1. Overview

Over the last two decades, the advancement of technology has generated opportunities for organizations to grow outside of their comfort zones and establish innovation ecosystems. Innovation ecosystems are defined as group of organizations that aim to jointly create and capture value from innovation activities (technical or business related innovations) (Adner, 2006; Adner & Kapoor, 2010; Ritala et al., 2013). According to Basole (2009) innovation ecosystems are able to adopt and evolve. Furr, O'Keeffe, and Dyer (2016) proposed that, compared with R&D alliances that focus on developing innovations, exploring and building knowledge that has been defined over a period of years and partners that rely on contracts, innovation ecosystems mainly focus on commercializing the innovations. They are designed to discover, explore and validate big opportunities across firms in a very short time. In this regard, organizations have realized that stand-alone innovations may lead to technical difficulties, delays in delivering their products, but also unnecessary R&D costs. Particularly in high-tech industries, the increasing need for access to complementary assets and the rising costs of projects have encouraged organizations to participate in innovation ecosystems and enhance their competitive advantage through a maximization of their joint values. Over the years, organizations have learned that innovation ecosystems are complex environments that require a continuous exchange of knowledge in an open manner. Figure 1 shows the consistent significant degree of openness [1]

[1] This figure is generated based on the informants' responses to the question of how open their ecosystem is. The x-axis shows the name of the innovation ecosystems and the y-axis illustrates the openness of the ecosystems with respect to their external interactions. The more an innovation ecosystem engages in innovative collaborations the higher the degree of openness (Martini, Aloini, & Neirotti, 2012).

characterizing various innovation ecosystems within the Belgian and Dutch nano-electronics industry. The investigated innovation ecosystems seem to be quite open in their exchange of knowledge. In other words, they interact with external partners to innovate.

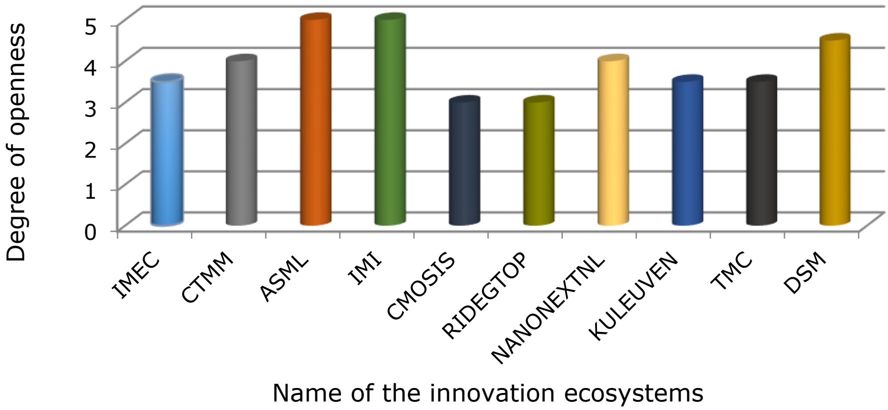

Figure 1 The degree of openness among the innovation ecosystems

As the actors' strategies are interdependent in innovation ecosystems, the performance of one actor may impact the performance of the others, and also the overall health of the innovation ecosystem (Adner & Kapoor, 2010). This implies that the success of the innovation ecosystem requires consistent evaluation, structure, and governance of the innovative collaborations among the actors for the creation and capture of joint value. Despite the significance of participation in an innovation ecosystem and its impact on developing the competitive advantage of organizations, scholars have only examined collaborations from an ecosystem perspective to a small extent. The researchers who explored innovation ecosystems mainly investigated one type of actor within the ecosystem, and overlooked the roles of the other participants (Adner, 2012; Adner & Kapoor, 2010; Dhanaraj & Parkhe, 2006; Hu, 2011; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011; Rampersad, Quester, & Troshani, 2010b; Rohrbeck, Hölzle, & Gemünden, 2009; Vanhaverbeke & Cloodt, 2006). As such, in these studies, the roles of the actors and orchestration strategies in the creation and capture of value were mainly considered from the perspective of one specific type of actor. Considering the fact that value is created jointly among actors in an innovation ecosystem, this atomistic view does not offer a complete picture of an innovation ecosystem, nor does it offer a suitable evaluation of the innovative collaborations within an ecosystem. This clarifies the research gap that exists in the innovation ecosystem literature and calls for further analysis.

1.2. Research questions

In this context, this PhD thesis aims to analyze innovation ecosystems in two European countries. By using a qualitative research methodology, the research intends to inductively investigate 10 Belgian and Dutch nano-electronics innovation ecosystems that offer innovative products in the pharmaceutical sector. By considering the dynamic process of ecosystem development, this research focuses on three main research questions. The first deals with how value is created and captured in the innovation ecosystem, and the potential challenges that actors face in their value creation and capturing activities. The second determines the different roles that actors play in their innovation ecosystem. The third looks at the strategies that orchestrators may adopt to govern their innovation ecosystem more effectively.

The theoretical model (See figure 2) illustrates three components that are investigated in this thesis. This is a combination of three individual models that are examined in response to each research question and offers a processual perspective of the ecosystem developments. Red boxes respond to the first research question. Green sections acknowledge the second research question and blue boxes answer the third research question of the thesis. In the following section each block of the model is explained thoroughly.

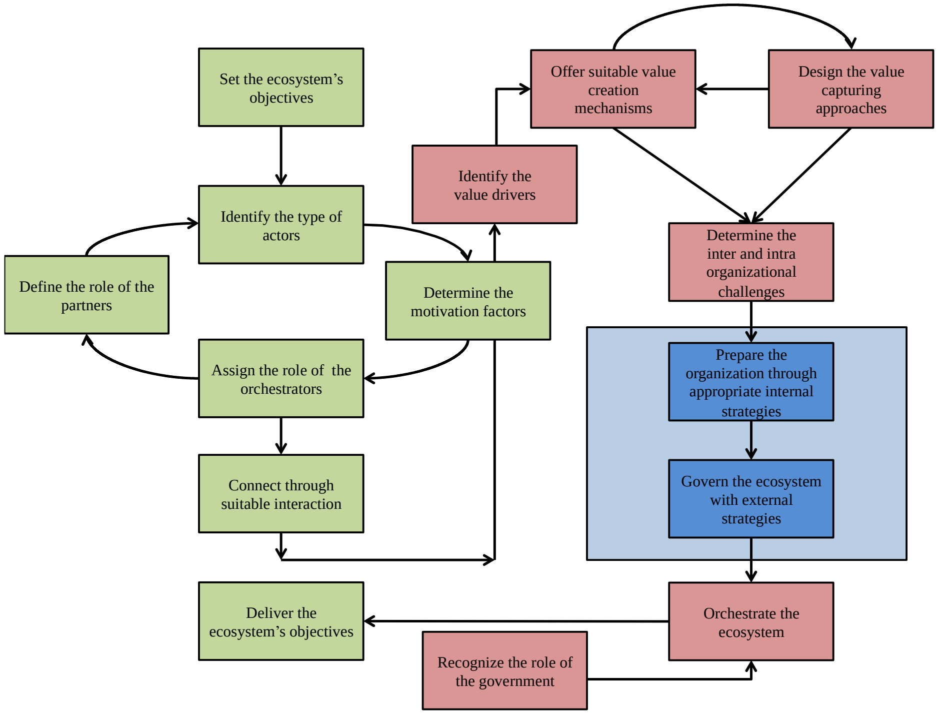

Figure 2 The theoretical model of the nano-electronics innovation ecosystem

1.3. The contribution of this research

The primary purpose of this dissertation is to contribute to the body of knowledge in the innovation ecosystem literature; more precisely, to advance the understanding of the challenges related to the creation and capturing of value in innovation ecosystems, as well as the roles and types of actors, the roles of the orchestrators, and the orchestration strategies in that context. In addition, the methodological approach of this thesis - a grounded theory developed from multiple case studies - is a method that is inductively based on real data. To the best of my knowledge, this thesis is the first attempt that considers the dynamic process of ecosystem development while inductively examines different constituents of (Belgian and Dutch) innovation ecosystems to generate new theories. The nano-electronics industry, a high-tech industry, has many interdisciplinary characteristics. The organizations in this industry rely heavily on open and collaborative innovation interactions. Furthermore, exploring the application of nano-electronics in the pharmaceutical sector provides a unique perspective in understanding innovation ecosystems in high-tech industries. It emphasizes the importance of collaborative innovation and its impact on the quality of healthcare systems and patients' lives.

In summary, this PhD thesis makes three main theoretical contributions. Firstly, it analyzes value creation and capture in an innovation ecosystem environment and the challenges that may occur during the process. Secondly, it connects the value creation and capturing mechanisms with the roles of the actors in the ecosystems. Thirdly, by acknowledging the important role of orchestrators, it investigates orchestration strategies that are essential for the ultimate value creation and capturing process. By integrating the analysis of the three explored research areas (i.e. value creation and capture procedures and challenges, the roles of the actors in innovation ecosystems, and the orchestration strategies), this thesis offers novel views on the nano-electronics innovation ecosystem (See figure 2) that are based on the dynamic approach of ecosystem development. Each step or block of the model (Figure 2) indicates essential strategies for establishing, performing, and orchestrating a successful innovation ecosystem. The arrows in the model indicate the relations between and the sequence of the steps. In the following section I explain the steps of the model.

1. Innovation ecosystems are required to define their objectives (i.e. the top green box).

2. According to the objectives, a leader or an orchestrator selects suitable type of partners that could offer the ecosystem best-required expertise and knowledge.

3. The orchestrator recognizes factors that motivate partners to join the ecosystem (Nambisan & Sawhney, 2011; Van de Vrande, De Jong, Vanhaverbeke, & De Rochemont, 2009).

4. Depending on the identified type of partners and their capabilities, the orchestrator assigns different roles to the partners.

5. Considering the role that partners play and the ecosystems' objectives, the orchestrator takes and plays various roles in the innovation ecosystem itself.

6. The orchestrator creates various interaction ties with partners. This allows partners to benefit form the innovative collaboration while they exchange knowledge and expertise.

7. Next is to acknowledge different attributes that drive partners to join the ecosystem to create and capture value (i.e. the red box connected to the green box of motivation factors).

8. This allows the ecosystems to offer suitable value creation mechanisms through knowledge platforms or innovative products.

9. In addition, they define best value capturing procedures so that partners could benefit from their collaboration. Since organizations do not properly create and capture value the first time they need to repeat this process. As such, the value creation and capturing process is iterated as long as partners collaborate with each other in the innovation ecosystem and create and capture value more efficiently.

10. Diversity of objectives among actors in search for value leads to various challenges. According to prior literature (Adner, 2012; Nambisan & Sawhney, 2011), it is important to identify the challenges and manage them. Hence, this step examines the potential inter and intra organizational challenges.

11. In order to manage the challenges, an orchestrator (Adner, 2006, 2012; Nambisan & Sawhney, 2011) and sometimes the government as two participating actors in the innovation ecosystem could resolve the conflicts. In this regard, the orchestrator applies orchestration strategies (i.e. the light blue box) that consist of suitable internal and external strategies (i.e. two dark blue boxes) to prepare the ecosystem to face the internal tensions and resolve the external issues. In addition, the government could participate and indirectly manage the conflicts.

12. These strategies facilitate the ecosystem orchestration process and lead the ecosystem to the last step of the model, which is to successfully deliver the objectives.

Besides the theoretical contributions, this thesis has several managerial implications. The theoretical model proposed in response to each research question offers a distinctive ecosystem analysis outlook to allow academic institutes and industrial firm researchers, as well as managers and decision makers in the nano-electronics industry to recognize the importance of collaborative innovation. By applying a well-defined strategic plan that has been adapted to organizations' business models, organizations can establish, orchestrate, and shape their ecosystems to be more successful. Finally, this dissertation offers (Belgian and Dutch) government policy makers a clear blueprint of innovation ecosystems strategies and their policy implications. By emphasizing the importance of the role of governments in innovation ecosystems, the findings of this study encourage governments to support and facilitate collaborative innovations in novel ways.

1.4. The structure of this dissertation

This dissertation comprises seven chapters. The framework of the dissertation is illustrated in figure 3. Chapter 1 consists of a general introduction to this study, outlining the nature and focus of this research. In addition, it presents the integrated theoretical model that is generated throughout the thesis. Chapter 2 presents prior studies on constituents of innovation ecosystems. In this chapter, former studies on "innovation networks," "innovation ecosystems," and "innovation ecosystem architecture" are systematically identified. After a thorough review of these studies, the different dimensions that scholars have already examined in the literature are critically reviewed. Through this process, several research directions for this dissertation are determined and presented. This chapter aims to disclose existing research gaps in different constituents of innovation ecosystem's literature and proposes different research questions.

Chapter 3 explains the research setting of this thesis. First, the nano-electronics industry is introduced as a typical high-tech interdisciplinary sector. Second, its various applications in the pharmaceutical sector are presented and its current and future innovation advancements in Europe are described. Moreover, the significance of exploring the nano-electronics industry from an ecosystem perspective is explained. Third, the methodology used in this study is presented. In this respect, a comprehensive overview of the selected grounded theory building procedure (Corbin & Strauss, 2014), data collection, and data analysis (i.e. NVivo content analysis software) (Eisenhardt, 1989a; Eisenhardt & Graebner, 2007; Yin, 2013) are provided. Furthermore, using the ecosystem at an analysis level, 10 individual Belgian and Dutch innovation ecosystems are introduced. Finally, a map of these ecosystems is shown.

Chapter 4 examines how value is created and captured in innovation ecosystems, and the challenges that organizations in the nano-electronics industry face in search of value are determined (See red boxes in figure 2). First, the building blocks of an innovation ecosystem are introduced; value drivers, value creation, and value capture, and the challenges that organizations face in creating and capturing value. Next, by using an inductive approach on six innovation ecosystems, the different factors that drive organizations to join innovation ecosystems, value creation, and value capturing mechanisms, as well as the main types of challenges are determined. The theoretical development generated from the case evidence shows the contributing factors of each building block, and the two types of challenges (i.e. intra-organizational and inter-organizational) that organizations face. It further briefly illustrates the number of strategies that orchestrators and governments can apply to resolve these challenges. Finally, this chapter proposes several guidelines for managers and policy makers in academic and industrial institutes, and government agencies.

Chapter 5 evaluates the roles of the different actors in nano-electronics innovation ecosystems (See green boxes in figure 2). By examining seven innovation ecosystems, this chapter explores the logic behind creating an innovation ecosystem, the types of partners, their roles in the ecosystems, and the types of interactions between them that are required to achieve their objectives. By following an inductive approach, a theoretical model was generated. The model illustrates seven different steps essential to realizing an ecosystem's objectives. The contributions of all the actors in the value creation process reveal that the actors are dependent on each other, and their roles and performance complement each other with respect to knowledge and resources. This chapter further offers several managerial implications for leaders and policy makers to establish innovation ecosystems, define roles and to manage their interactions in a way that successfully delivers their objectives.

Chapter 6 investigates orchestration strategies in innovation ecosystems, and examines how orchestrators internally prepare and externally govern their ecosystems' challenges to effectively collaborate with their external partners (See blue boxes in figure 2). Through a qualitative and inductive approach on eight innovation ecosystems, this research presents the two main categories of internal and external orchestration strategies. Internal strategies relate to strategies that organizations apply in order to prepare their personnel to collaborate with external partners. External strategies are techniques that organizations employ in managing potential conflicts with their ecosystem partners. Comparing the previous literature on strategic alliances, innovation networks, and innovation ecosystems, this research identifies novel strategies that exclusively focus on the orchestration of innovation ecosystems. The theoretical and cross-case analysis allows the generation of a theoretical model that illustrates the identified strategies in both internal and external dimensions. This model enables managers and policy makers in academic institutes, industrial firms, and government agencies to apply suitable strategies to internally prepare their organizations, and to externally orchestrate their collaboration within an innovation ecosystem.

Chapter 7 discusses the findings of this thesis, and illustrates a broader perspective of the nano-electronics innovation ecosystem. Furthermore, it presents the managerial implications of collaborating in innovation ecosystems, and proposes a number of new research horizons. Figure 3 illustrates the structure of this thesis, RQ represents the research questions, and TM indicates the theoretical model that is generated in each chapter.

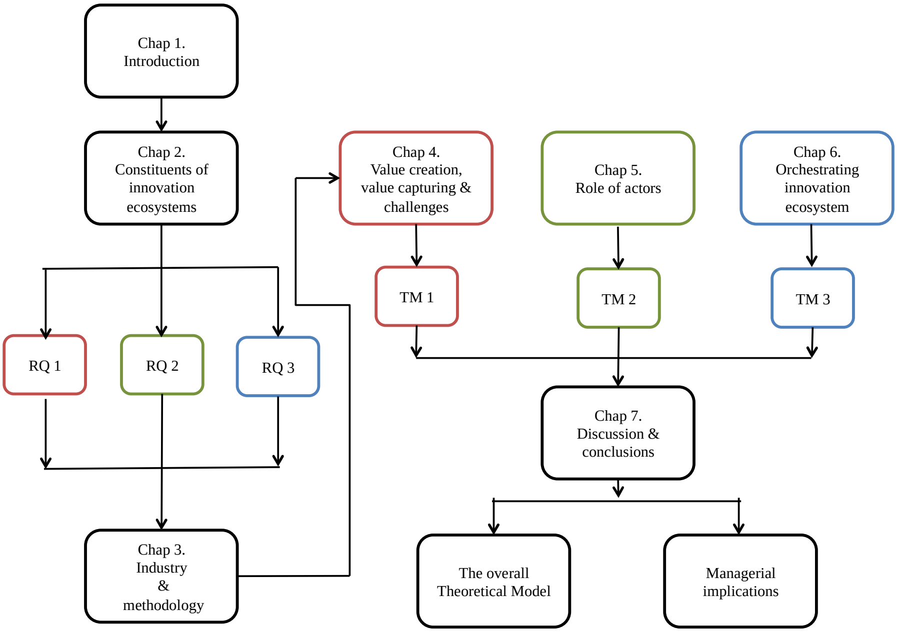

Figure 3 The structure of this thesis

Chapter 2

2 Constituents[2] of innovation ecosystems: a systematic review of the literature

2.1 Introduction

This chapter intends to identify the gaps in the innovation ecosystem literature and present the research questions. Through a systematic review of the literature first identifies the studies that have examined the constituents of innovation

[2] Constituent (2017) is a structural unit of a definable syntactic, semantic, or phonological category that consists of one or more elements (such as features) and that can occur as a component of a larger construction.

ecosystems, and second analyses the findings to determine the thesis research questions. It is important to note that innovation ecosystems are type of open innovations (Adner, 2006; Chesbrough, Vanhaverbeke, & West, 2006, 2014). According to Chesbrough (2003) open innovation is a paradigm that assumes firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Similarly, innovation ecosystems are defined as group of organizations that aim to jointly create and capture value from innovation activities (technical or business related innovations) (Adner, 2006; Adner & Kapoor, 2010; Ritala et al., 2013). Considering that innovation ecosystems are form of open innovations expands number of research areas (Chesbrough et al., 2014). According to the study of Vanhaverbeke, Chesbrough, and West (2014) there are several research areas in innovation ecosystem literature that require further exploration

The first is the level of analysis in open innovation. Studies have mainly concentrated on the firm level as unit of analysis. Only few studies have focused on the ecosystem level. The focus on firm-level open innovation leads to a number of shortcomings in research. One is the biased view of individual firms and collaborating partners (Vanhaverbeke et al., 2014). In other words, the firm provides its view on how it sees the collaboration overlooking other partners' views and objectives. Collaborations are successful when the objectives of all partners involved are taken into consideration. Additionally, an exclusive focus on firm-level factors may provide a narrow, managerial perspective that addresses the top managers' interests only. Furthermore, there is a lack of information and details on the open innovation mechanisms, which may result in potential challenges in implementing open innovation management. Moreover, analyzing open innovation at the firm level (i.e. the researcher's comfort zone) may prevent researchers from properly analyzing open innovation activities and engaging in a much broader perspective. This results in a lack of knowledge concerning external partners, which may in some cases lead to failure of open innovation activities. In contrast, an ecosystem view requires an in-depth understanding of the objectives and the incentives of all actors as such it gathers the perspective of all actors and provides an unbiased perception of the actors involved in the collaboration. Furthermore, a broader view on the open innovation dimensions can be offered, addressing different aspects of all partners and providing a better understanding of their incentives to collaborate. This will lead to better open innovation management and the ultimate success of the ecosystem (Vanhaverbeke et al., 2014). Therefore, in order to gain a more comprehensive understanding of the managerial implications of open innovation related to all actors in the ecosystem, it is essential to have an overall "innovation ecosystem" perspective. Hence, this study intends to concentrate on innovation ecosystem as the unit of analysis.

The second is examining different types of actors in the innovation ecosystem. Major studies that have examined innovation ecosystem have focused on profit organizations. Government agencies and other non-profit organizations, for example, universities, research centers, and regulatory agencies (Chesbrough, 2003), vary in their nature and objectives, and correspondingly, their performance in innovative collaboration is different. Studies have indicated that innovative collaboration can be beneficial for organizations such as charities and government agencies (Chesbrough & Di Minin, 2014). As a result, it is important to consider non-profit organizations and explore their potential collaboration in the innovation ecosystem. Similarly, studies have mainly investigated large firms in the innovation ecosystem and have only sporadically examined startups and Small and Medium Enterprises (SMEs). Managing value creation and capturing mechanisms in SMEs is different compared to large firms (Brunswicker & van de Vrande, 2014). Hence, winning strategies for large firms are not suitable to SMEs. This means that the value creation and capturing mechanisms need to be adapted to firms' strategies (Vanhaverbeke, Vermeersch, & De Zutter, 2012). Thus, it is important to investigate other sizes of industrial firms in order to understand their innovation strategies.

The third is orchestrating innovation through an ecosystem lens. Studies have further indicated the importance of innovation ecosystem orchestration and have concentrated on the overall behavior of actors in the ecosystem from a social network perspective (Basole, 2009; Nambisan & Sawhney, 2011). Limited studies have focused solely on value creation and capturing aspects and managerial perspective of ecosystems. Therefore, evaluating orchestration strategies from an ecosystem perspective is needed in order to develop an in-depth understanding of ecosystem orchestration. On the same note, scholars have acknowledged the existence of a hub-firm or an orchestrator in the ecosystem. Prior research has investigated different kinds of orchestrators in the ecosystem. Due to the complexity of the innovation ecosystems, orchestrators play important roles in resolving conflicts and managing the ecosystem. Earlier studies have identified and examined several orchestration strategies in specific industries. Acknowledging the fact that the role of orchestrators may vary according to the objectives of the ecosystem, in-depth research is required to identify other strategies and examine various approaches that orchestrators may utilize in orchestrating the innovation ecosystem. Indeed, a precise step-by-step guideline for orchestrators may facilitate their managing role in the ecosystem (Dhanaraj & Parkhe, 2006; Nambisan & Sawhney, 2011).

In summary, despite many studies on open innovation, the innovation ecosystem perspective has received limited attention from scholars. Though some scholars examined innovation ecosystems, to the best of my knowledge, a comprehensive and systematic review of existing literature on innovation ecosystems' constituents is lacking.

Considering the importance of the ecosystem perspective and lack of in-depth investigation of prior literature, this chapter, through a systematic approach, intends to summarize the findings and insights of prior studies on the "innovation ecosystem" and critically review and analyze them. In doing this, it tries to shed light on specific research gaps in the innovation ecosystem literature, pointing to relevant research questions that, once explored, will make a significant contribution to extant research.

In the following section, I present the existing literature on innovation ecosystems as form of an open innovation, value creation and capturing in the ecosystem, and the role of orchestrators in the innovation ecosystem. Next, the methodology used to conduct this systematic review is explained, followed by detailed descriptions of the findings. Later, three research directions are discussed and research questions are generated. Last, concluding remarks are presented.

2.2 Innovation ecosystems: a form of open innovation

In the earlier form of innovative collaboration, organizations interacted with each other at dyad and firm level. They would create a temporary collaboration link to exchange knowledge and technological resources to complete a project or task (Agarwal, Croson, & Mahoney, 2010; Kale & Singh, 2009; Parkhe, 1993; Zaheer, Gulati, & Nohria, 2000). Over the past decades, advancements in technology have increased the complexity of projects and have forced firms to expand their research and development through interaction and exchange with other partners. In this respect, organizations that lack competency in a certain technology are forced to seek other external partners. Firms in a value chain collaborate with third parties to receive complementary products and components (Teece, 1986). The combination of value chain and complementary products is called a value network (Amit & Zott, 2001) or an ecosystem (Iansiti & Levien, 2004a). As firms grow and expand their R&D, they attract new customers and partners, utilize the external knowledge, and create a long-term collaboration with other partners in an innovation ecosystem. Interaction between partners in an open environment becomes a major requirement for the sustainability of the organization (Alexy & Dahlander, 2013; Enkel & Gassmann, 2010; Laursen & Salter, 2006;

Lichtenthaler, 2011). While value is created and captured in these interactions, lack of complementary knowledge may limit new inventions. In this way, collaboration with various types of organizations in an ecosystem creates a unique but dynamic environment for future innovations.

2.3 Value creation and value capturing in the innovation ecosystem

The increasing trend towards innovative collaboration with external partners has encouraged many scholars to explore the innovation ecosystem phenomenon. Collaboration in an innovation ecosystem enables organizations to increase knowledge transfer and develop their technology. Organizations create and capture value differently. They continuously adapt to the requirements of the new partners and the ecosystem as a whole. This indicates that collaboration influences each organization (Bruneel, D'este, & Salter, 2010; Perkmann & Walsh, 2009) and the performance of one may influence the performance of others and eventually the performance of the innovation ecosystem (Adner, 2006; Iansiti & Levien, 2004b). Considering the fact that actors in the innovation ecosystem interact with each other, it is important to understand how actors jointly create value when they are highly dependent on each other (Vanhaverbeke & Cloodt, 2006). Collaborative actors are generally used to making decisions within their organization's boundaries and consider their partners as potential competitors. In an innovation ecosystem, the total value created depends on how well the partners' objectives and goals are aligned, and how well partners commit to and invest in complementary assets (G. A. Moore, 1991; Teece, 1986). As partners complement each other's capabilities and resources, value is not produced in isolation but co-produced with all partners involved. In innovation ecosystems, value creation is at the center of the business strategy and therefore it is important to understand what firms can bring to the ecosystem. Gomes-Casseres (2003) indicated that, in innovation ecosystems, firms do not compete with each other, but groups of partners compete with other groups. This means that there is collective competition. In the innovation ecosystem, actors create value through rethinking their roles and interrelationships. Therefore, value creation is not just about adding a value step, but it is about reinventing the value creation system through a reconfiguration of the roles played by different actors and the relationships among them (Ramirez & Wallin, 2000).

Companies have to capture part of the value they jointly created. According to Brandenburger and Nalebuff (1996), the total value created in the value creating system equals the sum of the value appropriated by individual actors. Value appropriation depends on the bargaining power of individuals (Brandenburger & Stuart, 1996). Bargaining power is the position of firms in the ecosystem, which reflects the ecosystem's centrality and participation in multiple ecosystems (Lorenzoni & Baden-Fuller, 1995; Nohria & Garcia-Pont, 1991). It can also be referred to as the role of infrequent resources that companies bring to the innovation ecosystems (Brandenburger & Nalebuff, 1996; Ghemawat, Collis, Pisano, & Rivkin, 1999). Since the strength of the innovation ecosystem depends on the commitment to the joint value creation, it is critical to ensure that each participant in the innovation ecosystem captures some of the value in order to stay committed. Therefore, value distribution must be fair among participants (Vanhaverbeke & Cloodt, 2006). While participating in an innovation ecosystem might be beneficial for some actors, others may not gain as much as they intend to and instead reduce their participation in the ecosystem and withdraw. Thus, it is essential that all actors get compensated in a proper way in the innovation ecosystems.

2.4 The innovation ecosystem and the orchestrator

An innovation ecosystem thrives because different partners bring complementary competences to the ecosystem. The complementarity characteristic of the innovation ecosystem indicates that actors collaborate with different types of partners. The diversity in the types and objectives of the actors in the innovation ecosystem adds to the complexity of the ecosystem environment (Batterink, Wubben, Klerkx, & Omta, 2010). Therefore, the interaction of actors for joint value creation and capturing becomes a challenging task (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008; Håkansson & Ford, 2002; Pittaway, Robertson, Munir, Denyer, & Neely, 2004). In this respect it is important that an actor leads the ecosystem and resolves the challenges within the ecosystem (Iansiti & Levien, 2004a; Lichtenthaler, 2011; Smits & Kuhlmann, 2004; Winch & Courtney, 2007). This can be referred to as "ecosystem governance" (Pittaway et al., 2004; Provan & Kenis, 2008) or "ecosystem orchestration" (Dhanaraj & Parkhe, 2006; Nambisan & Sawhney, 2011). The orchestrator (Dhanaraj & Parkhe, 2006; Nambisan & Sawhney, 2011) or the hub firm (Nambisan & Sawhney, 2011) is the main actor responsible for the design and management of the innovation ecosystem (Batterink et al., 2010). R Normann (2001) and Gomes-Casseres (2003) assert that in the innovation ecosystem, the orchestrator brings actors with disparate assets and competences together, utilizes the capability of each actor, identifies their objectives, establishes proper strategies that achieve goals that go beyond arm's length relationships, and ultimately shapes the innovation ecosystem (Iansiti & Levien, 2004a; Richard

Normann & Ramirez, 1993). On the same note, Iansiti and Levien (2004a) argue that in order to manage the innovation ecosystem, the orchestrator is required to consider two different aspects. The first is to identify how to structure and manage the innovation ecosystem so that value creation is maximized, and the second is to arrange an agreement so that the jointly created value is shared among the participants and innovating organizations. Gomes-Casseres (2003) points out that the collective competiveness of the actors depends on the size, the technological capabilities, leadership, absence of competition, and other innovation ecosystem aspects. Since actors compete with each other to capture more value from the ecosystem, the orchestrator not only has to manage potential tensions, but must also discourage any competition in the innovation ecosystem. It is clear that organizations only join the innovation ecosystem if they receive high returns. This means that the orchestrator must ensure that all participants are better off in the innovation ecosystem than when they leave the ecosystem. In this regard, the orchestrator is required to manage and orchestrate the value creation and capturing process among partners.

Accordingly, considering the importance and complexity of innovation ecosystems, it is essential to further investigate prior studies and identify what has been analyzed and what requires further exploration.

2.5 Methodology

In order to identify previous studies on constituents of innovation ecosystems, the following procedures were followed, according to a step-by-step process. First, specific keywords such as "open innovation", "innovation", "network", "ecosystem" and "orchestrator" were identified. Second, the keywords were combined in different forms, [e.g. innovation network * OR ecosystem * AND orchestrator], to construct search strings. Third, the search string was used in the Google Scholar search engine to identify related publications. Fourth, based on the inclusion (i.e. relevant to innovation ecosystem) and exclusion criteria (i.e. discuss other ecosystems, business networks and so on), the identified articles were manually filtered. Fifth, 20 studies that majorly focus on "innovation ecosystems" were identified of which 17 were journal articles and the remaining 3 were graduate theses. Next, in order to investigate the content of the papers, abstracts of the studies were imported in to NVivo 11 and coded according to the content of the paper. In the final stage, the studies were thoroughly reviewed based on their subject theme and later various sections of the study were identified.

2.6 Findings

Results suggest that 20 publications (17 articles and 3 graduate theses) that focus on the constituents of innovation ecosystems came out between 2004 and 2014 (See appendix A), mainly published in Business, Management and Strategy-

Table 1 The industrial classifications of the reviewed studies

Industry	No. of studies	References
Primary Industries		
Energy industry	1	(Hogenelst, Treffers, Podoynitsyna, Stultiëns, & Smetsers, 2014)
Agriculture	1	(Batterink et al., 2010)
Manufacturing Industries		
Aerospace industry	1	(Nambisan & Sawhney, 2011)
Textile industry	1	(Hu, 2011)
Service Industries		
Healthcare	1	(Adner, 2012)
Internet services	1	(Iansiti & Levien, 2004b)
Information technology	5	(Adner, 2012; Mankevich, 2014; Nambisan & Sawhney, 2011; Rampersad et al., 2010b; West & Wood, 2008)
Mobile	2	(Basole, 2009; Ritala, Armila, & Blomqvist, 2009)
High-tech Industries		
Electronics & related		
Electronics	3	(Adner, 2006, 2012; West & Wood, 2008)
Nano-electronics	1	(Leten, Vanhaverbeke, Roijakkers, Clerix, & Van Helleputte, 2013)
Semiconductor	1	(Adner & Kapoor, 2010)
Software	1	(Bosch-Sijtsema, Petra, & Bosch, 2014)
Telecommunication	2	(Botero & Diana, 2012; Rohrbeck et al., 2009)
Agricultural biotechnology	1	(Vanhaverbeke & Cloodt, 2006)
Pharmaceutical Industries		
Biotechnology	2	(Iansiti & Levien, 2004b; Rampersad et al., 2010b)
Bio-pharmaceutical	1	(Smart, Bessant, & Gupta, 2007)
Pharmaceutical	1	(Dhanaraj & Parkhe, 2006)

- Classification is based on Pittaway et al. (2004) industry analysis

related journals, and a few were available in Information Technology, Industrial Marketing and Entrepreneurship, and Regional Development journals. Results indicate that the service and high-tech industries are more intensively researched among the selected studies. Table 1 shows the industrial classifications of the studies. This illustrates the importance of collaborative innovation in such industries.

In addition to the industry, the country in which the research was conducted was also reviewed. The majority of studies (ten studies) were performed in Europe and in the United States of America (five studies). This may indicate that innovation ecosystems are practiced more often in European companies, which has led academics to pay more attention to exploring innovation ecosystems than other countries. To further investigate the papers, the content of each paper was categorized into different topic areas (See table 2). Table 2 presents the unit of analysis for each reviewed study. All investigated studies took an ecosystem perspective, with two of them simultaneously focusing on the ecosystem and the firm levels.

Table 2 The open innovation level of analysis of the reviewed studies

Open innovation level of analysis	No. of studies	References
Ecosystem level	20	(Adner, 2006, 2012; Adner & Kapoor, 2010; Basole, 2009; Batterink et al., 2010; Bosch-Sijtsema et al., 2014; Botero & Diana, 2012; Dhanaraj & Parkhe, 2006; Hogenelst et al., 2014; Hu, 2011; Iansiti & Levien, 2004b; Leten et al., 2013; Mankevich, 2014; Nambisan & Sawhney, 2011; Rampersad et al., 2010b; Ritala et al., 2009; Rohrbeck et al., 2009; Smart et al., 2007; Vanhaverbeke & Cloodt, 2006; West & Wood, 2008)
Ecosystem and firm level	2	(Nambisan & Sawhney, 2011; Ritala et al., 2009)

Next, the contents of the studies were categorized based on different themes[3]. Table 3 shows that the main concentration of research on innovation ecosystems was on the management strategies and the orchestration strategies of such ecosystems. While management strategies focuses on managing innovation ecosystem from a general perspective, the orchestration strategies concentrates on processes that mainly applied by orchestrators or hub firms.

[3] After reading abstracts of all 20 papers the categories were identified and generated in NVivo 11. Later each paper was coded to the corresponding category.

Table 3 The content categories of the reviewed studies

Contents Categories	Description	No. of studies	References
Creation of innovation ecosystem	Studies that concentrate on creating and establishing an innovation ecosystem	3	(Rohrbeck et al., 2009; Smart et al., 2007; West & Wood, 2008)
Evolution of innovation ecosystem	Research which explores the evolution and growth of innovation ecosystems	1	(West & Wood, 2008)
Ecosystem strategy	Studies that emphasize different ecosystem strategies	3	(Basole, 2009; Bosch-Sijtsema et al., 2014; Hogenelst et al., 2014)
Innovation strategy	Research which focuses on innovation strategies from different perspectives	2	(Adner, 2006; Hu, 2011)
Management strategy	Studies that present diverse management strategies for successful innovation ecosystems	7	(Adner & Kapoor, 2010; Botero & Diana, 2012; Hu, 2011; Iansiti & Levien, 2004b; Mankevich, 2014; Rampersad et al., 2010b; Vanhaverbeke & Cloodt, 2006)
Orchestration strategy	Research that looks at a variety of orchestration strategies and processes applied by orchestrators	6	(Batterink et al., 2010; Botero & Diana, 2012; Dhanaraj & Parkhe, 2006; Leten et al., 2013; Nambisan & Sawhney, 2011; Ritala et al., 2009)

This highlights the importance of the governance of ecosystems among other categories. In addition, "establishing innovation ecosystem" and offering various "ecosystem strategies" were other areas that received considerable attention.

With respect to different frameworks that studies presented in their research, table 4 illustrates that the number of frameworks proposed in managing and orchestrating the ecosystems were higher than other proposed plans (See table 4).

Furthermore, the type of actors on which the selected studies were focusing was investigated (e.g. academic researchers at universities and research centers, executive managers at industrial firms or perhaps government agencies' point of view). As actors have different objectives in innovation ecosystems, their perceptions may differ. As such, it is important to recognize the perspective taken in the studied papers.

Table 4 The frameworks presented in the reviewed studies

Framework presented	No. of studies	References
Management strategy	11	(Adner, 2006, 2012; Adner & Kapoor, 2010; Hogenelst et al., 2014; Hu, 2011; Iansiti & Levien, 2004b; Rampersad et al., 2010b; Ritala et al., 2009; Smart et al., 2007; Vanhaverbeke & Cloodt, 2006; West & Wood, 2008)
Orchestration strategies	5	(Batterink et al., 2010; Dhanaraj & Parkhe, 2006; Mankevich, 2014; Nambisan & Sawhney, 2011; Rohrbeck et al., 2009)
Orchestration model	1	(Leten et al., 2013)
Management & orchestration strategies	1	(Botero & Diana, 2012)
No frameworks are discussed	2	(Basole, 2009; Bosch-Sijtsema et al., 2014)

In this respect, table 5 shows that studies were mainly undertaken from the industrial firms' point of view rather than from the point of view of other types of actors in the ecosystem. With respect to the size of the industrial firms, the papers I reviewed mainly investigated large corporations, paying less attention to SMEs (See table 6). This may reflect the fact that large firms are more actively interacting with other actors and are more likely to form innovation ecosystems.

15 studies in my sample focused on the role of orchestrators and highlighted the importance of their role in the innovation ecosystem (See table 7). This validates the importance of the orchestrator's role in the innovation ecosystem among the business and strategy researchers.

The reviewed studies were also analyzed to determine the specific aspects that were investigated in the innovation ecosystem. Scholars mainly focused on the success of the ecosystem (13 studies) as an important goal to achieve. The remaining studies concentrated on other aspects of the innovation ecosystem (See table 8).

The reviewed studies indicate that scholars in the innovation ecosystem literature have mainly focused on European industrial firms, especially large companies. In addition, they have mostly focused on management or orchestration strategies to successfully govern innovation ecosystems. Indeed, the importance of the orchestrator's role in this process was acknowledged by most of the researchers.

Table 5 The perspectives of the reviewed studies

Type of ecosystem actors	No. of studies	References
Universities	2	(Rampersad et al., 2010b; Smart et al., 2007)
Research centers	3	(Leten et al., 2013; Rampersad et al., 2010b; Smart et al., 2007)
Industrial firms	20	(Adner, 2006, 2012; Adner & Kapoor, 2010; Basole, 2009; Batterink et al., 2010; Bosch-Sijtsema et al., 2014; Botero & Diana, 2012; Dhanaraj & Parkhe, 2006; Hogenelst et al., 2014; Hu, 2011; Iansiti & Levien, 2004b; Leten et al., 2013; Mankevich, 2014; Nambisan & Sawhney, 2011; Rampersad et al., 2010b; Ritala et al., 2009; Rohrbeck et al., 2009; Smart et al., 2007; Vanhaverbeke & Cloodt, 2006; West & Wood, 2008)
Government agencies	1	(Rampersad et al., 2010b)
All actors	1	(Rampersad et al., 2010b)

Table 6 The size of industrial firms in the reviewed studies

Firm size	No. of studies	References
Large	13	(Adner, 2006, 2012; Adner & Kapoor, 2010; Basole, 2009; Bosch-Sijtsema et al., 2014; Botero & Diana, 2012; Iansiti & Levien, 2004b; Leten et al., 2013; Nambisan & Sawhney, 2011; Ritala et al., 2009; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006; West & Wood, 2008)
SMEs	3	(Batterink et al., 2010; Hogenelst et al., 2014; Hu, 2011)
Not specified	4	(Dhanaraj & Parkhe, 2006; Mankevich, 2014; Rampersad et al., 2010b; Smart et al., 2007)

Table 7 Studies that focused on the role of orchestrators

Role focused	No. of studies	References
Role of orchestrator discussed	15	(Adner, 2006, 2012; Adner & Kapoor, 2010; Batterink et al., 2010; Bosch-Sijtsema et al., 2014; Botero & Diana, 2012; Dhanaraj & Parkhe, 2006; Hu, 2011; Iansiti & Levien, 2004b; Leten et al., 2013; Mankevich, 2014; Nambisan & Sawhney, 2011; Ritala et al., 2009; Vanhaverbeke & Cloodt, 2006; West & Wood, 2008)
Role of orchestrator not discussed	5	(Basole, 2009; Hogenelst et al., 2014; Rampersad et al., 2010b; Rohrbeck et al., 2009; Smart et al., 2007)

Table 8 Studies that concentrated on the success of the innovation ecosystem

Topic	No. of studies	References
Success	13	(Adner, 2006, 2012; Adner & Kapoor, 2010; Batterink et al., 2010; Botero & Diana, 2012; Iansiti & Levien, 2004b; Leten et al., 2013; Mankevich, 2014; Nambisan & Sawhney, 2011; Rampersad et al., 2010b; Ritala et al., 2009; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006)
Failure	1	(Adner, 2012)
Managing innovation risk		(Hogenelst et al., 2014)
Value creation and capturing		(Adner & Kapoor, 2010; Vanhaverbeke & Cloodt, 2006)
Focal firm's power		(Hu, 2011)
Aligning R&D strategy		(Bosch-Sijtsema et al., 2014)
Inter-firm relationships		(Basole, 2009)
Challenges in managing networks		(West & Wood, 2008)
Network design principals		(Smart et al., 2007)
Orchestration strategies		(Dhanaraj & Parkhe, 2006)

2.7 Discussion

This chapter aimed to identify prior studies on different constituents of innovation ecosystems and systematically analyze them. While in this chapter I concentrated on the "innovation ecosystem" literature and focused on the strategic point of view of such ecosystems, there is a broad range of research on industrial networks, localized innovation networks and coordination within networks. Scholars in industrial network have focused on strategizing the industrial network with respect to strategic management thinking to enhance the firms' performance (Gadde, Huemer, & Håkansson, 2003), organizing and transferring knowledge creation through lead firms (Boari & Lipparini, 1999), resolving the conflicts (Finch, Zhang, & Geiger, 2013), internationalization of industrial networks and interdependencies of firms within the networks (Johanson & Mattsson, 2015), and customer involvement in product development (Laage-Hellman, Lind, & Perna, 2014). With regard to localized innovation networks, researchers have mainly concentrated on first, proximity of innovation networks and have examined how geographical proximity influences the technology transfer activities in the innovation networks (Boschma & Frenken, 2010; Echeverri-Carroll & Brennan, 1999; Rallet & Torre, 1998). Second, they have focused on the regional innovation systems and clusters and have compared the knowledge dynamic of various regions and have determined the locality of the clusters (Coenen, Moodysson, Ryan, Asheim, & Phillips, 2006). And third, they have evaluated the development policy within the localized networks. In this respect, scholars have examined the influence of cluster policies in the economic development of regions (Vale, 2011). Besides to industrial and localized innovation networks, the coordination of innovation networks have also being examined in prior literature. In the same vein, scholars have addressed the dynamics of coordination with respect to characteristics of coordination mechanisms and have evaluated the networks' evolution (Gardet & Mothe, 2011). Further, scholars have investigated the impact of network factors such as trust and commitment in coordination within networks (Rampersad, Quester, & Troshani, 2010a).

Considering the literature on the constituents of innovation ecosystems, the overview of findings of this chapter highlights three important research areas that need further investigation. In the following section, I elaborate on these areas and I suggest important research questions that need to be investigated further in this thesis.

2.7.1 Actors and joint value creation in the innovation ecosystem

In the systematic review I conducted, scholars mainly examined industrial firms and more specifically large corporations (Adner, 2012; Adner & Kapoor, 2010; Basole, 2009; Batterink et al., 2010; Bosch-Sijtsema et al., 2014; Hu, 2011; Mankevich, 2014; Nambisan & Sawhney, 2011; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006). These studies focused on different topics: internal R&D and external drivers of innovation ecosystems (Bosch-Sijtsema et al., 2014), establishing partnerships in emerging ecosystems (Basole, 2009), value creation and capturing in the innovation ecosystem (Adner & Kapoor, 2010; Vanhaverbeke & Cloodt, 2006), orchestration and innovation ecosystem management strategies (Adner, 2006, 2012; Adner & Kapoor, 2010; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011; Ritala et al., 2009; Vanhaverbeke & Cloodt, 2006), and government involvement (Rohrbeck et al., 2009). With respect to SMEs, studies focused on the role of the hub-firm (Hu, 2011), orchestrating the innovation ecosystem (Batterink et al., 2010), and innovation processes (Hogenelst et al., 2014). Moreover, studies that focused on academic institutes mainly examined the IP orchestration model in the research centers (Leten et al., 2013) and innovation ecosystem design strategies at universities (Smart et al., 2007). Among the reviewed studies, only one study considered industrial firms, academic partners and government agencies, and simultaneously examined the key management processes that actors apply in the innovation ecosystem (Rampersad et al., 2010b).

Scholars mainly focused on large and multinational corporations and less focused on startups, SMEs, and other types of actors. Similarly, the frameworks that were presented are suitable for one specific type of actor (i.e. large firms) and cannot be automatically generalized for other types of ecosystem participants. In addition, scholars paid less attention to the complementarity and interdependency of the actors and their roles in the innovation ecosystem. Innovation ecosystems consist of various actors that collaborate to jointly create and capture value (Adner, 2006; Adner & Kapoor, 2010; Ritala et al., 2013). In a more general form, industrial firms, academic institutes, and government agencies participate in an innovation ecosystem (Etzkowitz, 2010; Leydesdorff, 2013) (See figure 4).

Industrial firms refer to startups, SMEs, and large multinational corporations that design or manufacture products or offer services to customers.

Universities, as part of the academic sector consist of researchers and professors that interact through various forms of formal and informal collaboration channels to create knowledge. The outcome of this group is mainly joint publications or tool development. In addition, graduate students such as PhD students collaborate with researchers or industrial partners to transfer knowledge.

Research institutes or research centers are also part of the innovation ecosystem. The advancement of technology has led to an increase in the number of research centers across the world. Researchers in various research institutes perform different experiments to discover new drugs to cure diseases or to generate new technologies to design industrial equipment.

Governments also play a role in the innovation ecosystem. Government agencies and research labs collaborate in the ecosystem to create an environment where knowledge and value can be created and shared among the actors.

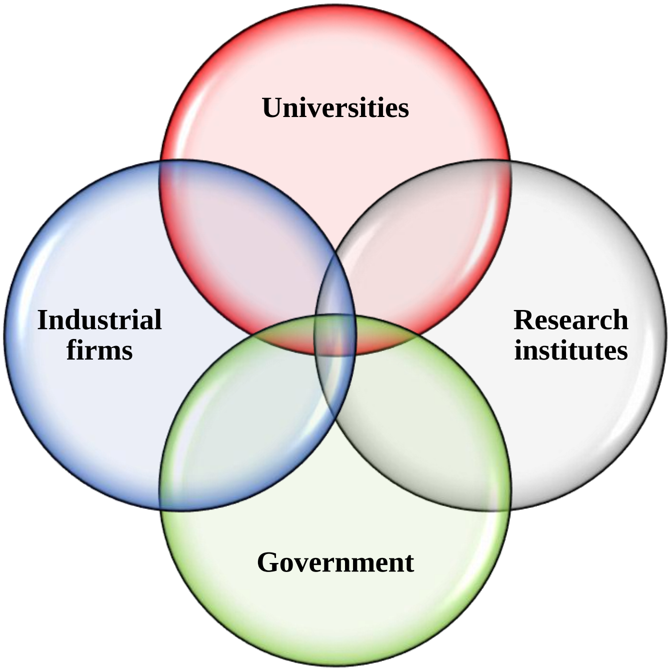

Figure 4 The schematic illustration of the main types of actors in an innovation ecosystem

In a more complex innovation ecosystem, other types of actors such as hospitals, patient organizations, technology transfer offices, and other parties participate. Indeed, value cannot be created within a single firm and it is essential that firms in the ecosystem collaborate with each other (Batterink et al., 2010). Considering the fact that value is jointly created in the innovation ecosystems and all actors participate in generating new knowledge it is important to focus also on other types of actors. The behavior of one actor may impact the creation and distribution of value and the health of the overall ecosystem (Iansiti & Levien, 2004a) and the difference in their objectives may lead to potential challenges in the innovation ecosystem (Adner & Kapoor, 2010). As such, I focus on all participating actors (i.e. universities, research centers, industrial firms, and government agencies) in the innovation ecosystem to recognize various perspectives, enhance our understanding of the innovation ecosystem and more precisely, the value creation and capturing processes in the innovation ecosystem and managing the challenges. In this respect, *this thesis intends to fill this gap by investigating how actors jointly create and capture value in the innovation ecosystems and identifying the challenges that they may face in such ecosystems.*

2.7.4 Orchestrating and non-orchestrating roles in the innovation ecosystem

According to the reviewed literature, many scholars have acknowledged the crucial role of orchestrators in the innovation ecosystem with respect to managing conflicts and facilitating interactions (See table 7). Studies have mainly focused on the role of the orchestrator in maximizing co-ownership and leading partners (Leten et al., 2013), in integrating and leading platforms to manage the challenges in the ecosystem (Adner, 2006, 2012; Adner & Kapoor, 2010; Dhanaraj & Parkhe, 2006; Nambisan & Sawhney, 2011; West & Wood, 2008), in adding value, leading, and linking complementary products (Batterink et al., 2010), their dynamic role in the ecosystem development (Mankevich, 2014), and their individual and organizational capabilities (Ritala et al., 2009). Reflecting on the role of the orchestrator, Adner and Kapoor (2010) mentioned that the absence of a leader in managing the challenges with external partners could destroy a firm's competitive advantage in technology leadership.

Despite the fact that scholars in the innovation ecosystem literature recognize the importance of orchestrators and examined several orchestration processes and strategies, the orchestrator's role was mainly defined in isolation neglecting the role of other actors in the ecosystem (Batterink et al., 2010; Dhanaraj & Parkhe, 2006; Hu, 2011; Nambisan & Sawhney, 2011). Diversity among actors in an innovation ecosystem leads to complicated interactions (Batterink et al., 2010). While staying innovative, actors continuously adapt to the new environment and maintain their stability. This creates several conflicts among actors in balancing their new relationships, determining the most appropriate collaboration practices, and corresponding to direct and indirect relationships (De Bruijn & Heuvelhof, 2008; Dhanaraj & Parkhe, 2006; Gilsing et al., 2008; Håkansson & Ford, 2002; Pittaway et al., 2004). Scholars have suggested that an orchestrator or a focal firm in an ecosystem can deal with challenges while managing the innovation ecosystem (Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004a; Lichtenthaler, 2011; Nambisan & Sawhney, 2011; Smits & Kuhlmann, 2004; Winch & Courtney, 2007). Reflecting on the diversity of actors in the innovation ecosystem, their complementarity in joint value creation and their interdependency, the role of an orchestrator can only be defined with respect to other actors and their roles and interactions within the ecosystem. In addition, each actor has the potential to act as an orchestrator during the ecosystem life cycle. As such, to better understand the innovation ecosystem, it is important to also define and articulate the role of non-orchestrators in the innovation ecosystem. *In this respect, this thesis,* *through an ecosystem lens, attempts to fill this gap by investigating different roles of actors (orchestrators and non-orchestrators) in the innovation ecosystem.*

2.7.3 Orchestrating processes in the innovation ecosystem

In prior literature, scholars have mainly emphasized the importance of the innovation ecosystem management or orchestration and several studies focused on the orchestration processes. In this respect, scholars have offered an innovation ecosystem management framework mainly based on: fundamental risks that actors face in the innovation ecosystem (Adner, 2006), orchestration processes and strategies based on the innovation design (Botero & Diana, 2012; Dhanaraj & Parkhe, 2006; Nambisan & Sawhney, 2011), managerial strategies with respect to trust and communication (Rampersad et al., 2010b), and a framework in line with the companies' objectives (Botero & Diana, 2012). In addition to managing innovation ecosystems, scholars have identified two major factors that have led to the success of such ecosystems. The first is the role of the orchestrator (Adner, 2012; Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011) and the second is the relationship between the actors (Botero & Diana, 2012). It is assumed that strategies designed and applied in the ecosystem should reflect the complexity of the interactions and the level of innovation. In other words, strategies should match the ecosystem environment (Iansiti & Levien, 2004a). According to Moller, Rajala, and Westerlund (2008), managing innovation at the ecosystem level is appropriate as it helps to understand the value proposition and suggests various management strategies. Acknowledging the fact that the orchestrator is responsible for managing the external ecosystem and operates as an organizer when companies develop new innovations or commercialize new products, highlights the crucial role of orchestrators in shaping the innovation ecosystem, stimulating collaboration among partners, setting the research agenda, and adding value through their capacities (Klerkx & Aarts, 2013).

In sum, it can be said that individual firms and actors in the ecosystem have unique management strategies that reflect their objectives and business model structure. Since actors are interconnected and value is jointly created and captured in the innovation ecosystem, the success of the innovation ecosystem is dependent on the health of each actor and the orchestration strategies of the innovation ecosystem. As such, it is vital to orchestrate the ecosystem and create a suitable platform for value creation and capturing procedures among actors. A well-planned, step-by-step orchestration procedure by an actor who leads and orchestrates the ecosystem could resolve the challenges (Nambisan & Sawhney, 2011). *In this respect, this study intends to fill this gap by considering different* *types of orchestrators in the innovation ecosystem and exploring various orchestration strategies used by them to manage and resolve the challenges.*

2.8 Conclusion

My review of the extant literature on different constituents of innovation ecosystems resulted in 20 relevant studies that were analyzed in various categories. According to Gomes-Casseres (2003), innovation ecosystems relate to the integration of value creation and distribution, external resources, inter-organizational ties, and ecosystem governance. Considering the fact that joint value creation and capturing is only possible at an ecosystem level (Adner & Kapoor, 2010; Pitelis, 2009; Ritala et al., 2013; Vanhaverbeke & Cloodt, 2006) and different actors participate in the ecosystem to maximize their value, highlights the complexity of the ecosystem environment. Moreover, the interdependency of actors and their influence on each other's performance indicate that an analysis of innovation ecosystems requires a holistic perspective (Adner & Kapoor, 2010; Chesbrough et al., 2014; Gardet & Mothe, 2011; Parida, Westerberg, & Frishammar, 2012; Rampersad et al., 2010b; Traitler, Watzke, & Saguy, 2011). To further expand our knowledge regarding innovation ecosystems, this PhD thesis is therefore designed to investigate three unexplored research questions in nano-electronics, a typical high-tech industry. *The **first** is to study how actors create value and capture value in the innovation ecosystem and determine the challenges that actors may face during this process. The **second** is to identify the different roles that actors (orchestrators and non-orchestrators) play in the innovation ecosystem and the **third** is to explore the innovation ecosystem orchestration strategies given that I aim at understanding value creation and capturing processes and I have a clear view on the role of all partners in an innovation ecosystem.* This thesis is the first attempt to explore innovation ecosystems within this research setting. It intends to fill the gap in the literature of value creation and capturing mechanisms in innovation ecosystems, the role of actors, and orchestration of innovation ecosystems. It attempts to present several novel theoretical models that are uniquely generated and later integrated to create an overall step-by–step guideline for academic researchers, industrial practitioners, and government authorities who participate in innovation ecosystems.

Chapter 3

3 Industry and methodology

3.1 Introduction

In this thesis, I concentrate on the innovation ecosystem as a unit of analysis. For this purpose, and in order to investigate the research questions posed in this thesis, I will apply a qualitative methodology to study Belgian and Dutch nano-electronics innovation ecosystems. In this chapter, first the nano-electronics industry and its applications are explained. Later, the grounded theory development, data collection, and data analysis procedures are comprehensively illustrated. Finally, each case study is described, and the underlying innovation ecosystem is mapped.

3.2 The nano-electronics industry

Nanotechnology is a technology that deals with dimensions and tolerances smaller than 100 nanometers[4]. In other words, it involves the manipulation of individual atoms and molecules. Nanotechnology is considered to be inherently interdisciplinary, as it extends across chemistry, engineering, physics, medicine, etc. (Kaplan, Milde, & Cowan, 2014; Wild, 2017; Wry, Greenwood, Jennings, & Lounsbury, 2010). It enables the creation of new devices and new ways of enhancing quality of life. The development of nanotechnologies typically entails the generation and transfer of knowledge within and between universities, private firms, and governmental research institutes (Nikulainen & Palmberg, 2010). The three main areas of nanotechnology applications, which partially overlap, are nano-electronics, nano-materials, and nano-biotechnology. The applications of this technology can be seen in materials, electronics, the environment, metrology, energy, security, robotics, healthcare, information technology, pharmaceuticals, agriculture, manufacturing, construction, transport, food processing, and storage (Miyazaki & Islam, 2007; Nikulainen & Palmberg, 2010; Ochekpe, Olorunfemi, & Ngwuluka, 2009; Shea, 2005; Stylios, Giannoudis, & Wan, 2005; Tegart, 2003). For instance, in electronics, nanotechnology enhances the development of new materials for electrical transformers, which are critical components in power systems to provide energy. In healthcare and medicine, the application of nanotechnology in molecular imaging and molecular diagnosis has advanced molecular and cellular imaging, targeted nanoparticle drugs for cancer therapy, and integrated nanodevices for early cancer detection and screening (Nie, Xing, Kim, & Simons, 2007). The advancement of nanotechnology and its rapid pace of development have changed and expanded manufacturing capabilities in many industries. It is assumed that this technology has a horizontal impact on industries, great implications for human health, environmental sustainability, and national security. In addition, nano-technology is one of the main drivers of technological and economic changes, and industrial competition (Galatsis et al., 2015; Ochekpe et al., 2009; Renn & Roco, 2006; Wild, 2017). For this reason, the governments of countries such as the United States, Canada, Japan, China, and in Europe, have emphasized their support for the growth of this technology through investing significant funds and considering its various aspects in their national science and technology development agendas.

On a similar note, the European Commission has assigned a specific innovation agenda and policy plan to increase industry funding, and to contribute to economic

[4] Nanometer is commonly used in nanotechnology, the building of extremely small machines.

development. Globalization has compelled countries to develop their economic and technological innovations. This has forced Europe to compete with its highly productive and high added-value competitors such as the United States and China. As one of the leading areas in manufacturing, electronics generate 1300 billion Euros in added value. In the electronics sector, the semiconductor industry has a major role compared to other sectors (e.g. materials and equipment) in terms of job growth and economic advancement in Europe. Over the past decade, this sector has shifted from micro-electronics to nano-electronics, requiring more precise technological strategies.

Today, the nano-electronics industry is growing faster on average than other industries globally (Kroes, 2015). Annually, a huge amount of money is spent on research and development in this area. Around 10% of the global GDP (70,000 billion USD) in the United States is based on nano-electronics products and services. In Europe, similarly, this industry has accounted for 700 billion Euros in economic value over the past decade (Buckler, 2013). Nano-electronics innovation ecosystems encompass the whole value chain from semiconductor equipment and materials suppliers, to the designers and manufacturers of semiconductor microchips, and system integrators who integrate microchips with end-user applications. It connects universities with leading research institutes, large corporations, and SMEs throughout the innovation chain. European semiconductor industries are estimated to have an economic value of 30 billion Euros. The development of nano-electronics components with respect to design and manufacture requires high R&D investment. On average, the European semiconductor industry invests 20% of its total revenues in research and innovation (Buckler, 2013; Kroes, 2015; Wild, 2017).

Considering the rapid development of nano-electronics and its impact on the quality of healthcare, it is important to further investigate this technology and its applications in the pharmaceutical sector.

3.2.1 Nano-electronics and pharmaceutical applications

It is crucial to note that nanotechnology is one of the enabling technologies that is distinctive in generating new innovative medical products and medicines (R. Moore, 2007). This has impacted several industries with more traditional business models. The nano-electronics industry, as a major and game changing high-tech industry globally, is rapidly growing, and its applications in the pharmaceutical sector have led to tremendous technological innovations (Ochekpe et al., 2009). Many companies have used this technology to develop diagnostics tests, faster clinical results, and better-quality diagnostic devices to improve the quality of patients' lives (Nikalje, 2015). The high intensity of the research and development in this field has directed organizations to interact more closely with different industries. Notably, in the pharmaceutical industry, clinical trials and drug development take a significant amount of time, which means that pharmaceutical companies require a long time to achieve their desired efficiency. In addition, development costs in these industries are high, and for a drug to reach the market, it may require eight to twelve years of research (Wauters, 2008). Furthermore, around 10% of the drugs that reach the market are in the high-risk and high-cost sector of the pharmaceutical business (Wauters, 2008). The high cost of R&D, the complexity of research projects, and the long delivery times of the projects are some of the main reasons that have motivated researchers in the pharmaceutical and life science industries to collaborate with other high-tech industries such as nano-electronics. For instance, Johnson and Johnson, Roche, and Bayer are three of the main pharmaceutical companies that apply this technology to advance their products. In this respect, Johnson and Johnson develop medicines, medical devices, and personal care products. In addition, they investigate the environmental impact and safety of their products. Similarly, Roche applies this technology to manufacture labels for in-vitro products, as well as material and surface coating for pharmaceutical products, sensors, and test strips. Indeed, it can be argued that the actors or organizations in the pharmaceutical sector are mainly required to collaborate to stay innovative, and no actors can change or impact the value chain "alone" (Ochekpe et al., 2009; Reichman & Simpson, 2016). It is further assumed that firms in the nano-electronics industry innovate in a dynamic environment, where innovative abilities are necessary for the survival and growth of these firms (Parida et al., 2012).

3.2.2 The future of the nano-electronics industry in Europe

In recent years, a European nano-electronics research group has identified several potential industrial research areas (Aeneas & Catrene, 2012). As a result, the European Commission has adopted a strategy to double European chip production by the year 2020. In addition, two other leading projects, the Graphene and the Human Brain Projects, were also defined under the "Horizon 2020" program. In this respect, the European government has directly funded and aligned its strategy to conduct, develop, and support micro and nano-electronics research projects. Among the research centers in Europe, three significant ones (i.e. IMEC, LETI, and Fraunhofer) have agreed to provide their expertise and business competencies to support the main industrial areas (Galatsis et al., 2015). Indeed, direct funding by the government and other agencies involved in nano-electronics research projects facilitates academic and industry partners to interact within and outside their innovation ecosystems.

When considering the nano-electronics industry in Europe, it becomes evident that the organizations in this sector are high-tech and R&D driven, given that innovation is vital to retain a competitive advantage in this industry. Moreover, it is crucial that all the parties in the value chain ensure sustainable innovation along with long-term commitment. The long research time, high costs, and risks in the nano-electronics industry in general, as well as in pharmaceutical research projects in particular, have forced organizations to expand their innovative collaboration. In this respect, as there are enough examples of new collaborative models in nano-electronics innovation ecosystems, it is worth exploring this industry and concentrating on ecosystems that offer products in the pharmaceutical sector. As such, this thesis further investigates the formulated research questions in the context of nano-electronics innovation ecosystems with pharmaceutical applications. In the next section, the methodology applied, data collection, and data analysis are explained in detail.

3.3 Grounded Theory methodology

According to Miles and Huberman (1994), when there is a clear requirement of an in-depth understanding, casual inference, and exposed opinions of people under study, a qualitative research design should be used. One well-established qualitative research method is to build Grounded Theory (GT). According to Corbin and Strauss (2014), "grounded theory is a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon." In other words, it considers that people take an active role in responding to the events they have encountered. Responses are in the form of actions and interactions are based on people's socially derived definition of a situation. As such, this theory is grounded in the data found in studies undertaken by researchers.

Besides emphasizing theory building, this approach has unique characteristics compared to other qualitative methodologies. First, the theory is derived from collected data rather than from prior studies. Second, researchers do not have any pre-conceived theoretical framework, as this is contrary to the development of a theory from a specific set of data. Third, the data collection and data analysis are inter-related. This means that after the initial data collection, the researcher conducts the data analysis procedure, which is the basis for the subsequent data collection (theoretical sampling). Fourth, Grounded Theory does not deal with individual cases; it is the topic that drives the analysis. As such, each case study contributes to the development of the topic and the final theory. Finally, Grounded Theory does not have a pre-conceived design; therefore the research design develops during the actual research.

One of the most common and "most interesting" theory-building exercises is one that builds on cases (Bartunek, Rynes, & Ireland, 2006). "Building theory from case studies is a research strategy that involves one or more cases to create theoretical constructs, propositions and/or midrange theory from case-based, empirical evidence" (Eisenhardt, 1989a). According to Yin (2013), case studies are rich empirical descriptions of particular instances of a phenomenon that are based on different types of data resources. Central to building theory from a case study is replication logic (Eisenhardt, 1989a). Replication logic means that each case serves as a distinct analytical unit. Therefore, multiple cases are discrete experiments that serve as replications, contrasts, and extensions to the emerging theory (Yin, 2013). It is claimed that theory building from cases is "objective," due to the fact that its close adherence to the data keeps researchers "honest." It is assumed that, as the theory-building approach is grounded in rich empirical data, building theory from cases can create accurate, interesting, and testable theories.

According to Eisenhardt and Graebner (2007), theoretical reasoning relates to the exposure of an unusual phenomenon, the replication of findings from other cases, contrary replication, the elimination of alternative explanations, or the elaboration of an emergent theory. Although a number of studies have concentrated on innovation ecosystems, to the best of my knowledge, no studies have used Grounded Theory building on multiple case studies to explore research questions, and more specifically to examine nano-electronics innovation ecosystems (Adner & Kapoor, 2010; Iansiti & Levien, 2004a; Lubik, Garnsey, Minshall, & Platts, 2013; Nambisan & Sawhney, 2011). The phenomenon-driven research question on "analyzing the nano-electronics innovation ecosystems" is crucial, but it lacks a viable theory and empirical evidence. In this respect, to explore the research questions in this study, it is essential to use an inductive-based theory-building approach using multiple cases. Furthermore, theory-building studies based on case studies generally answer research questions that address "how" and "why" a phenomenon occurs.

According to Corbin and Strauss (2014), and Birks and Mills (2015), in Grounded Theory, the research process development consists of several steps, as illustrated in figure 5. These steps are comprehensively explained in the data collection and data analysis section.

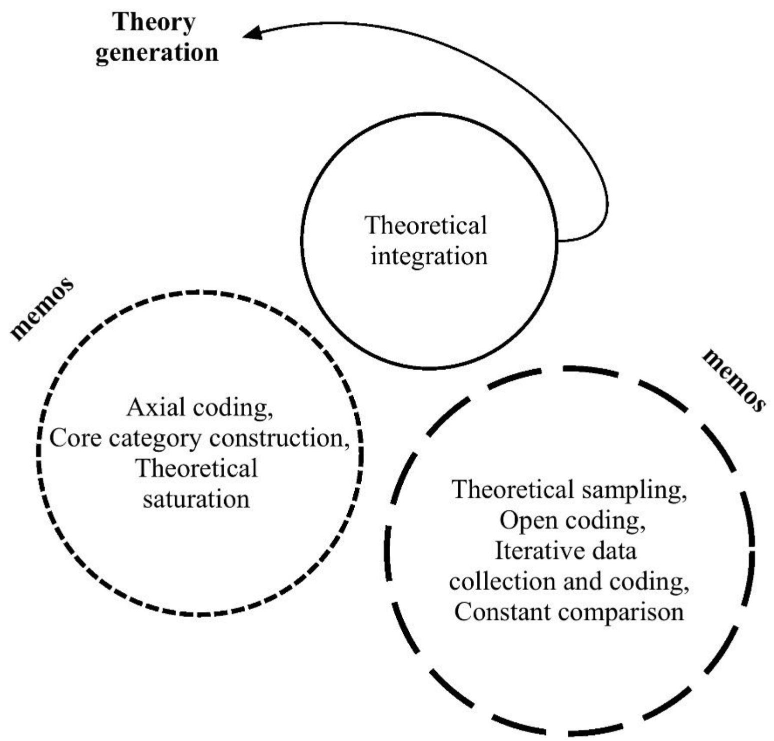

Figure 5 The theory generation procedure[5]

3.3.1 Data collection

It is presumed that qualitative data can present a chronological flow of events, and that one can observe which events lead to which consequences to determine useful explanations. In addition, novel findings in this type of study can lead to new integrations, which enable the researcher to look beyond the initial conceptions and revise the final framework (Miles & Huberman, 1994). In this thesis, multiple case studies are analyzed. It is anticipated that the use of a multiple-case research design is more compelling, and results in a more robust study (Eisenhardt & Graebner, 2007; Herriott & Firestone, 1983).

3.3.1.1 Data sampling

Theoretical sampling means "collecting data from people, places and events that will maximize opportunities to develop concepts in terms of their properties and

[5] Modified from Birks and Mills (2015, p. 13)

dimensions, uncover variations, and identify relationships between concepts" (Corbin & Strauss, 2014). With regard to the sampling method, during the initial phase, I applied purposive sampling, which is industry specific (i.e. nano-electronics). It is assumed that concentrating on a single industry avoids unnecessary "noise" with respect to industry factors (Westerberg, Singh, & Häckner, 1997). During this stage, according to inclusion and exclusion criteria, the cases were selected from two specific nano-electronics databases. The following attributes were the inclusion criteria: The nature of the innovation ecosystem (i.e. whether the represented organizations are universities, research centers, or industrial firms), the practice of open innovation (i.e. whether they are active in innovative collaboration with external partners), the country of origin of the organization, which is either Belgium or the Netherlands, and whether they offer products in the pharmaceutical or life science sector. Cases that did not comply with these specifications were excluded from this study[6].

In the second phase, a theoretical sampling was conducted (i.e. inter-relating the data collection and analysis) (Corbin & Strauss, 2014; Miles & Huberman, 1994). A total of 10 cases were selected from Belgium and the Netherlands (Eisenhardt, 1989a). Thus, this study was performed through theory development based on studies (Eisenhardt, 1989a; Yin, 2013), and employed comparative (Eckstein, 1975; Lijphart, 1975) and cross-case analysis techniques (Eisenhardt, 1989a).

3.3.1.2 Data sources

Two datasets are being used in this thesis. The first set of data was obtained through interviews. Interviews are a highly efficient way of gathering rich, empirical data, especially when the phenomenon is infrequent (Eisenhardt & Graebner, 2007). In this research, the interviews were semi-structured and open-ended, and were conducted through face-to-face meetings, Skype, or telephone calls. The second source of data consists of the participants' and their partners' websites, press releases, brochures, booklets, magazines, memos, partner feedback, and self-observation, which complemented the data analysis procedure. This type of data provided information on the organizations' missions, business partners, collaborative innovation, and the type of projects that they are involved in.

The interview data collection was conducted over four months, while the other data were collected throughout the overall research period (i.e. 24 months). In total, 10 innovation ecosystems (equally distributed in Belgium and the

[6] The exclusion criteria comprise the nature of the ecosystem representative is not a university, research center or industrial firm, the organization does not practice open innovation, it does not originate from Belgium or the Netherlands, or it does not offer products in the pharmaceutical or life science sector.

Netherlands) were analyzed in this thesis. With respect to the size of the participants, four are small, one is medium, and the remaining participants are large and multinational companies[7]. The informants were researchers, senior or top managers in technology and innovation, business development, and R&D departments that are knowledgeable about innovation ecosystem strategies and innovative collaboration (See table 9).

3.3.1.3 Data collection- interviews

For data collection purposes, interview scheduling was used. Interview scheduling is a series of questions (open questions), which address the research questions and related topics. During the preliminary stage, a list of potential cases was selected from the "AENEAS" (Association for European Nano-electronics Activities) and "CATRENE" (Cluster for Application and Technology Research in Europe on Nano-Electronic) databases. A total of 19 organizations representative of their innovation ecosystems were selected according to the inclusion and exclusion criteria of this study. During the second stage, all the potential cases (i.e. organizations that represented their innovation ecosystems) were contacted by email or telephone, and were introduced to the objectives of the research and the interview. They were then also invited to take part in this study. In all, 10 organizations responded to the invitation and were interested in participating in the interviews. As a next step, meeting arrangements such as the venue, date, and time were made. At the time of the interview, in order to have a clear and coherent interview experience, the questions were sorted in a logical order and categorized according to similar research objectives.

At the interview sessions, prior to the start of the actual interview, the intention of the research and the purpose of the interview were explained to the interviewees to ensure a clear understanding of this study. The interviews lasted between 40 minutes and two hours (resulting in a total of 250 pages of transcribed text). It is important to indicate that, when using a case study approach, the interview questions are developed according to the interviews that have been conducted, and the questions are modified in order to address the objectives of the study more precisely.

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[7] Here the total number of employees defines the size of the organization. Small <50, 50 ≤Medium <250, and 250≤ large and multinational companies. "What is an SME? - Small and medium sized enterprises (SME) - Enterprise and Industry." *ec.europa.eu*. Retrieved 2015-06-12.

Table 9 The demographic summary of the interviewees

Innovation ecosystem	Type	Interviewee's position	Date of interview	Location
ASML	Manufacturing company	Director of Strategic Technology Program	20th Dec 2013	Veldhoven, Netherlands
CTMM	Public-private partnership	Communication Manager	19th Dec 2013	Eindhoven, Netherlands
CMOSIS	Manufacturing company	Director of Sales and Marketing	11th, Dec, 2013	Antwerp, Belgium
DSM	Science-based company	VP Open innovation	20th Jan 2014	Heerlen, Netherlands
IMEC	Research center	Senior Scientist – life science technologies	13th Dec 2013	Leuven, Belgium
IMEC	Research center	SVP Strategic Development	23rd Dec 2013	Leuven, Belgium
IMEC	Research center	Business Development Manager - life science technologies	17th Jan 2014	Leuven, Belgium
IMI	Public-private partnership	Legal Manager	16th Jan 2014	Brussels, Belgium
KULEUVEN	University	General Manager – LRD Central Management	17th Jan 2014	Leuven, Belgium
NANONEXTNI	Dutch research consortium	Program Director, Program Officer	15th Jan 2014	Utrecht, Netherlands
RIDGETOP	Technology provider	CEO of Ridgetop group, Europe	18th, Dec, 2013	Brugge, Belgium
The Dutch Government	Government agency	Business and Market Developer - Energy board of North Holland	11th Dec 2015	Amsterdam, Netherlands

Thus, the interview questions[8] were modified slightly after the second interview to cover the other potential dimensions of this research. The interview sessions were recorded, and any observations or informal discussions were noted[9]. Later, each interview was transcribed within 48 hours of the interview session. Due to the theoretical sampling, the analysis of the data and data collection were conducted at the same time in order to create a much clearer way of selecting the next participant out of the remaining cases and the final theory development. The interview questions were divided into four sections. Each section was related to each research question, and consisted of a series of questions (See appendix E).

[8] See appendix B
[9] The participants gave their consent to archive the data at the time of the interviews, during the research, and publication. Due to the anonymization of our data, we disguised our informants' real names. However, with the consent of our informants, the companies' and partners' names were revealed.

3.3.1.4 Data collection- archival data

During each interview, I was presented with the available brochures, booklets, magazines, or newsletters of the organizations. In addition, field-notes and other personal observations during the interviews, partner feedback, as well as the organizations’ websites, news presses, and other related materials (around 350 pages of text) complemented my data collection. A total of approximately 600 pages of text were used as a data source for this study, which expanded the range of available information for this research.

3.3.2 Data analysis

The analytic process followed inductive development logic (i.e. bottom-up), which was based on sorting data, coding, and comparisons that characterize the Grounded Theory approach. This process is comprehensively explained in the following section.

The first stage of the analysis was open coding the transcripts. Open coding is described as a process that “fractures the data and allows one to identify some categories, their properties, and dimensional locations” (Corbin & Strauss, 2014). The texts in the transcripts were open coded using *in vivo codes*. At the initial stage, statements or words that illustrated an important concept were coded. Next, the codes and categories were systematically compared and contrasted multiple times to generate new and more complex categories. In addition to the transcripts, self-reflective memos (speculations and questions) were also generated during the analytical process and kept for cross-referencing the codes and categories at a later stage. This improved the rearranging and replacing of the codes and categories during the analytical process.

Later, through axial coding, the codes and categories were combined. Axial coding enabled me to find the link and relationship between the sub-categories, and to create higher or core categories. The core categories were assigned *in vivo* category labels. The categories were combined to create themes or concepts, which are more abstract and general. At the final stage, selective coding was performed. According to Corbin and Strauss (2014), selective coding is systematically selecting the core categories and relating them to other categories to check the validity of the relationships, and filling the categories that need further refinement and development. Figure 6 illustrates the steps from the codes to generating theory in qualitative research.

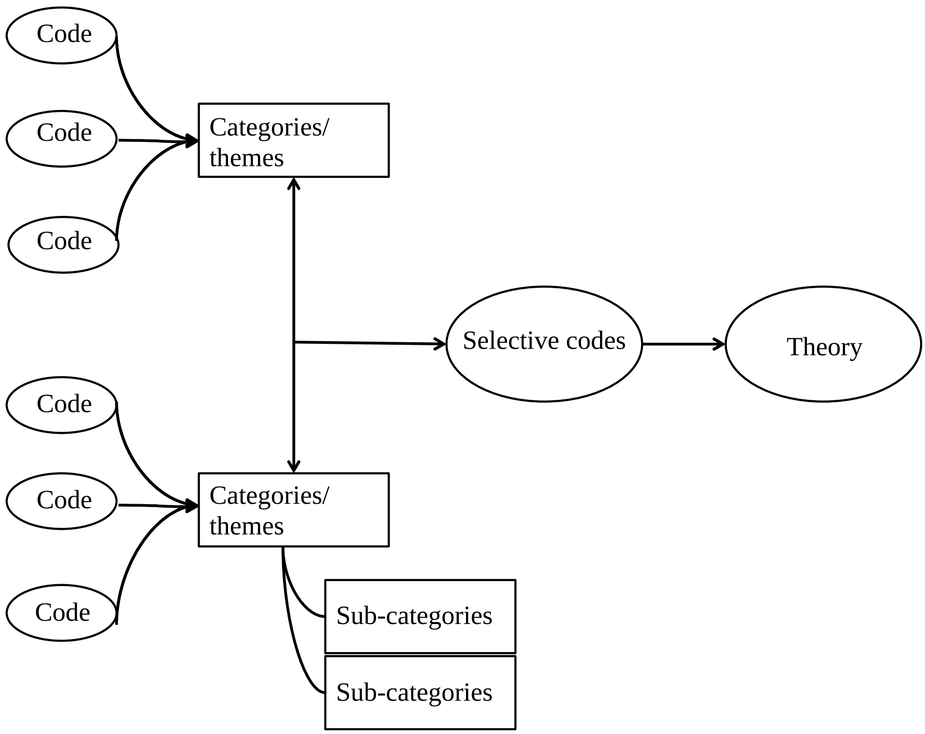


Figure 6 The code to theory generation process

In addition, the codes and categories were compared and contrasted further until saturation was reached. Saturation is the stage in the analysis when further analysis does not produce any new codes or categories, and all the data have been counted to develop the theory. For the purposes of this research, qualitative analysis software was used to support the analysis procedures. Computer-assisted qualitative data analysis software (CAQDAS) enables the researcher to illustrate a clear picture of the data, while it also provides an audit of the data analysis process (Welsh, 2002). As such, in order to analyze the data, NVivo 11 was used (Binsfeld, Whalley, & Pugalis, 2017; Jones, Macpherson, Thorpe, & Ghecham, 2007; Pittaway et al., 2004; Rohrbeck & Arnold, 2006). This software enabled me to generate the open and axial codes, the sub-categories, and the categories, as well as the final core categories and themes for the theory-building development. Through this analysis procedure, I explored all 10-innovation ecosystems. In order to respond to each research question in chapters 4 to 6, I selected diverse number of case studies (i.e. ecosystems) in each chapter that provided the most comprehensive range of responds to the specific research question and analyzed them to generate the theory and the model.

3.3.3 Theoretical sensitivity

One aspect of Grounded Theory research that is frequently mentioned is theoretical sensitivity, which refers to a personal quality of the researcher. This quality can be created through the literature, professional and personal experience, and maintaining a balance between creativity and science (B. G. Glaser, 1978). I achieved theoretical sensitivity by reviewing the literature of the phenomenon of the study, and investigating different aspects and dimensions of the concept. The professional experience of working with industries, the interview process, interacting with the participants, contacting the organizations' partners, and the analytical procedure all enhanced my understanding of the research and the stories around it, which, according to B. G. Glaser (1978), was able to increase the sensitivity. In addition, I occasionally took a step back and asked various questions to make sure the story was sound, and I kept asking myself what was really happening. Furthermore, I maintained an attitude of skepticism. In other words, I checked all the theoretical explanations in the study with the actual data to see if they would fit together. Finally, I followed the research steps from the data collection to the analytical stage. This enabled me to channel the data and design a rigorous study that is free of any biased or misleading assumptions (Corbin & Strauss, 2014; B. G. Glaser, 1978; Lincoln & Guba, 1985).

3.3.4 Reliability, validity, and trustworthiness

Although reliability and validity are crucial criteria for quality in quantitative studies, they are referred to as credibility, neutrality, or conformability, consistency or dependability, applicability, or transferability in qualitative studies (Lincoln & Guba, 1985). In this respect, NK Denzin and Lincoln (1994) have suggested that trustworthiness in the findings of qualitative research is related to the four factors of credibility, transferability, dependability, and conformability. Credibility is confidence in the truthfulness of the findings. Validity in qualitative research, according to Winter (2000), does not have a single term, but is a contingent construct that is grounded in the process and intentions of particular research methodologies and projects. Credibility in qualitative research (i.e. validity) can be measured by a triangulation procedure (B. Glaser & Strauss, 1967). This means using multiple sources of data to explain a phenomenon when conducting a research study. Norman Denzin (1978) indicated that triangulation could eliminate biased opinions and enhance the truthfulness of the researcher of the phenomenon. As such, to increase the credibility of the study, a triangulation procedure was used. Various sources of data such as interview transcripts, self-reflective memos, companies' websites, newsletters and brochures, partner feedback, self-observations, and other related documents enabled me to reduce biased interpretations, and increase the credibility and truthfulness of the findings. This implies that "the validity of potential" sources of data were gathered from a similar phenomenon (Padgett, Mathew, & Conte, 2004).

Transferability in Grounded Theory means that other researchers can apply their findings to their own research projects. To achieve transferability, different stages of the research were described in detail, and visual aids such as tables and figures were used to clarify the coding and theory development procedure. Dependability is another aspect that is used instead of reliability in qualitative research (Lincoln & Guba, 1985). Similarly, NK Denzin and Lincoln (1994) explained that dependability refers to the stability of the findings over time, and conformability to the internal coherence of the data in relation to the findings, interpretations, and recommendations. It is used to achieve dependability and conformability at the same time. Furthermore, Lincoln and Guba (1985) specified that an audit trail is a technique used to establish or increase trustworthiness, or to facilitate the evaluation of the degree of trustworthiness in a naturalistic inquiry. The audit trail or decision trail, as Koch (2006) suggested, involves the systematic recording and presentation of the information about the material and the data that are gathered, and the process of the qualitative research. It further illustrates the theoretical, methodological, and analytical process of the research (Bowen, 2009). To accomplish dependability and conformability, and to further enhance the trustworthiness of my research, an audit trail was retained to create an outline of the research process and the evolution of the codes, categories, and theory development. This consists of all the transcript texts, audio, *in vivo codes*, memos and self-reflective observations, other documents, and access to companies' and organizations' websites and brochures (Miles & Huberman, 1994). Moreover, to enhance the trustworthiness of this research, NVivo qualitative software was used to code the transcripts and other documents, and to generate the codes, the categories, and the themes. This software can increase confidence, as the codes can be traced from the open codes to their categories and themes (Robson, 1994).

In addition to the above, other researchers have helped with reviewing the coding procedures and data analysis. According to Eisenhardt (1989a), the use of multiple researchers improves the reliability of a study. Consequently, drawing from what has already been explained, it can be suggested that qualitative research is reliable and valid when it presents its trustworthiness through the credibility, transferability, dependability, and conformability of the research study, which can lead to defensible results (Johnson, 1997). Figure 7 summarizes the different procedures that were used in this research to further achieve reliability and validity. The arrows indicate the relation of the procedures.

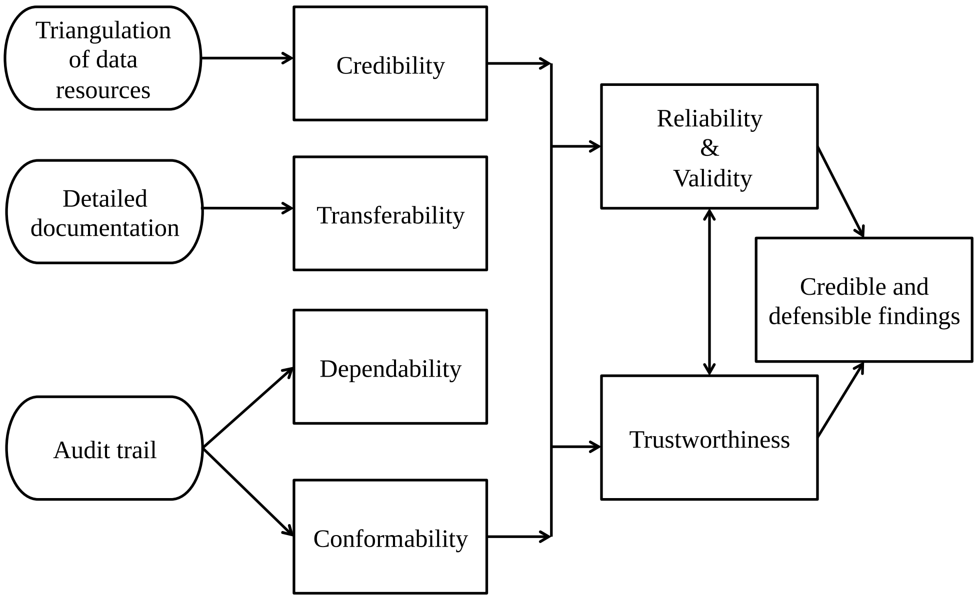


Figure 7 The reliability and validity approaches conducted in this research

In the following section, each case study is comprehensively explained, and the individual ecosystems are illustrated.

3.4 Case descriptions

In this section, each case box briefly presents the demographic specifications of the innovation ecosystem and comprehensively describes the function of each innovation ecosystem. Moreover, it illustrates the ecosystem map that was designed according to the informant's description.

Case box 1 - ASML

Founded in: 1984
Number of **employees:** More than 14,000 employees, 5,000 in R&D

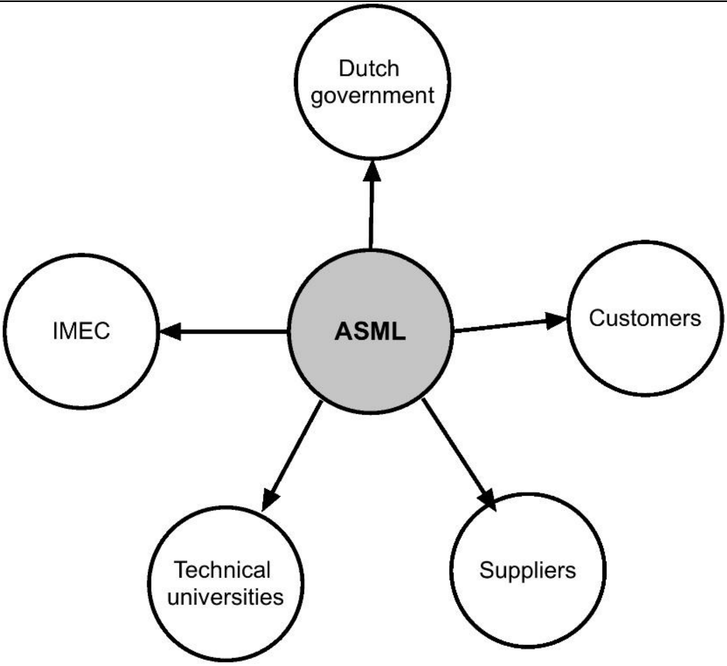
Headquarters: Veldhoven, Netherlands
Industry: Microelectronics, semiconductor and lithography industry

Approximate number of partners: Around 700 chip-manufacturing companies

ASML is a multinational company that manufactures microelectronics to improve the quality of life. It aims to invent and develop lithography machines, metrology systems and software products to enable customers (chip manufactures) to produce smaller, cheaper, more powerful, energy-efficient chips. This results in faster processing speeds that can influence various industries such as technology, healthcare, communications, energy and mobility.

For over three decades, ASML has followed Moore's law by constantly improving the capability of its lithography machines. The ASML ecosystem is built on an open innovation model that consists of partners from technical universities and research centers, industrial suppliers, governments and customers (mainly top chip manufacturers around the world) who collaborate together. In this ecosystem, ASML, as a system architecture and an integrator works with partners from different disciplines to offer research and development services. This model enables ASML to interact with some of the world's best companies and create a long-term relationship with them. Indeed, this encourages ASML partners to join the innovation ecosystem and expand their network in the industry. Moreover, the opportunity to access complementary assets and competencies and the technical and open innovation mentality at ASML motivates partners to join the innovation ecosystem. Similarly, ASML interacts with other partners to outsource some of the manufacturing and designing activities. In this respect, IMEC, one of the important partners of ASML, provides its high-tech and advanced machineries to ASML projects. This interaction can reduce the R&D cost and ensure the success of the project.

In addition, ASML financially supports its partners at a project level. In general, the Dutch government and ASML jointly fund projects at ASML and in return the government reduces the corporate tax of R&D personnel at ASML. With respect to technology challenges, ASML ensures the balance between solving technology encounters and delivering what customers require. This leads to trust between ASML and its customers.



Case box 2- CTMM (center for translational molecule medicine)

Founded in: 2006
Number of **employees:** 11

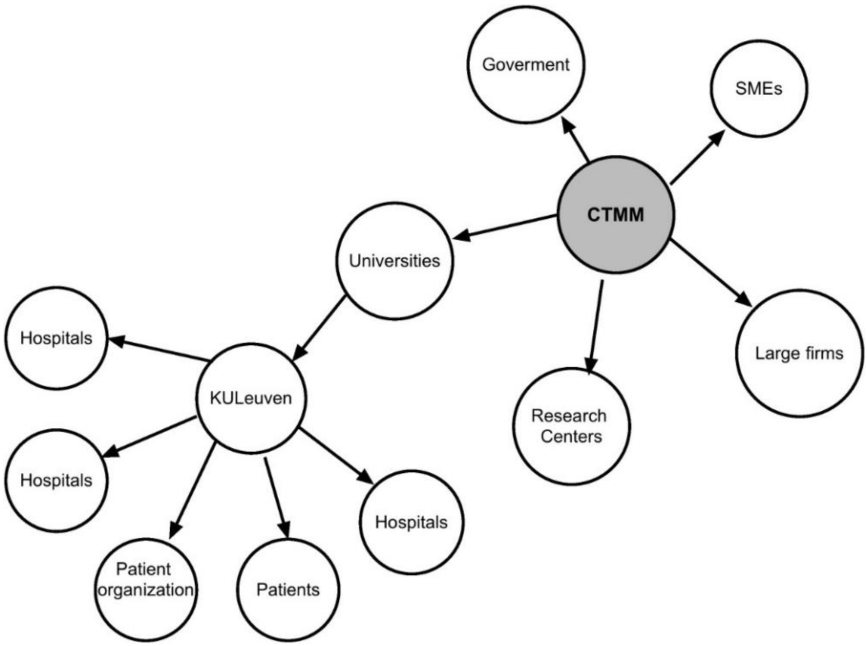
Industry: Nano-electronics & Life science and Health care
Headquarters: Eindhoven, Netherlands

Approximate number of partners: More than 100

CTMM is a public-private partnership that focuses on translational research for quick delivery of new technological inventions to patients. The Dutch government initiated CTMM to explore specific health related topics and connect the government to other partners in the innovation ecosystem. In order to achieve this, CTMM was founded in 2006 in Eindhoven, the Netherlands to concentrate on translational research in cancer, cardiovascular diseases, neurodegenerative diseases, and infection and immunity. In total, 11 program and project managers in CTMM interact to bring partners from industry, academic and research centers together to collaborate on defined research projects. CTMM aims to reduce the impact of diseases and improve the quality of life of patients.

The CTMM ecosystem consists of various industrial firms (more than 90 SMEs and large firms), academic institutes and government agencies. In addition, patient organizations and hospitals participate in CTMM projects. Patient organizations offer disease information and determine the critical requirements of patients. All partners collaborate so that scientific results can reach the patients in a faster way. This enables patients to have earlier and more accurate diagnostics tests in order to receive highly personalized therapies. In a typical project at CTMM, the Dutch government funds 50% of the project, industrial partners fund 25% and academic institutes fund the remaining 25%. Furthermore, CTMM and other supporting foundations such the Dutch Diabetes Foundations or the Dutch Kidney Foundations contribute additional funds.

Partners are encouraged to interact with CTMM to gain access to the external knowledge and to develop their network, and to receive financial support and access to the monitoring system that is provided through government and regulatory agencies. In return, CTMM jointly creates value by offering R&D services in different healthcare areas through its unique research and collaboration platform. When partners join the CTMM innovation ecosystem, they sign different project and partner agreements to protect their IP and clarify the working instructions.



Case box 3- CMOSIS

CMOSIS member of the ams group

Founded in: 2007
Number of employees: 80

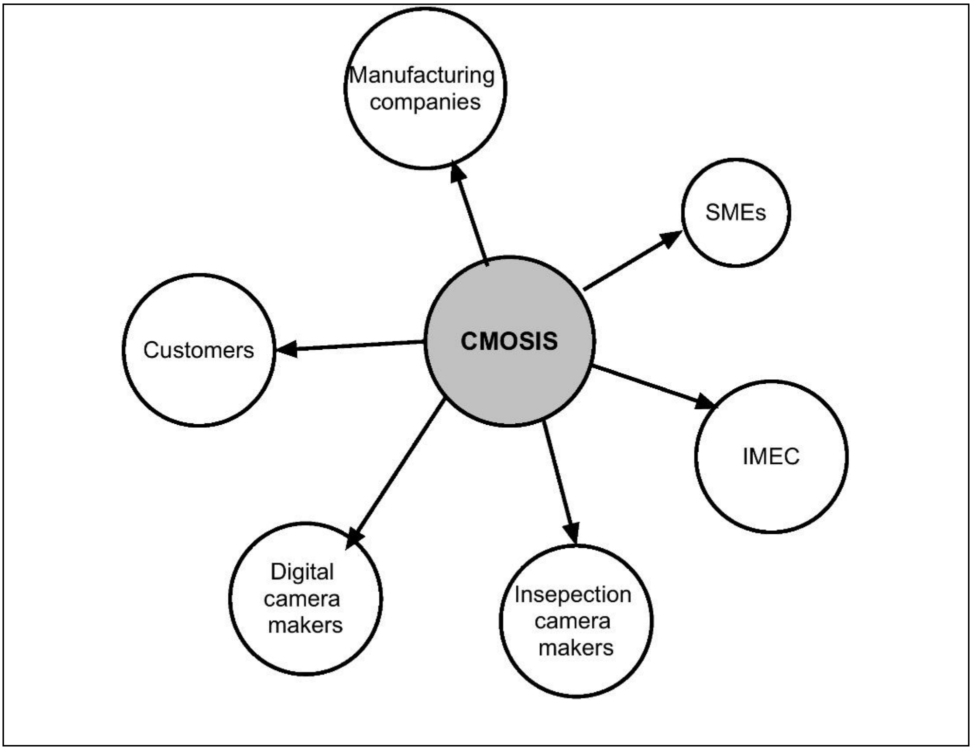
Headquarters: Antwerp, Belgium
Industry: Imaging sensor and medical

Approximate number of partners: More than 300

CMOSIS is an image sensor company that offers innovative image sensor solutions for various applications in machine vision, medical, broadcast, traffic and scientific photography imaging. It enables customers to create highly distinguished products, that are smarter, safer and easier to use and eco-friendly.

The CMOSIS ecosystem consists of large manufacturing companies, SMEs, inspection and digital camera makers, and research centers such as IMEC. The high-tech and innovative infrastructure and products at CMOSIS encourage partners to join the ecosystem. As partners interact with CMOSIS, they gain access to complementary products and competences. Through offering high-tech imaging sensor products and strategic ideas on new products, CMOSIS jointly creates value in the ecosystem. In the medical sector, CMOSIS has produced a number of custom designed image sensors that enable very precise medical imaging analysis.

Customers and partners of CMOSIS benefit from the advanced product and turnkey solutions that are offered to them. The top-down strategy that CMOSIS applies to interact with some of its partners allows CMOSIS to directly contact the right corresponding person and negotiate with them. In addition, CMOSIS has a flexible strategy with several existing partners, depending on the services they provide to CMOSIS.



Case Box 4- DSM

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

Founded in: 1902
Number of employees: 25, 000 employees

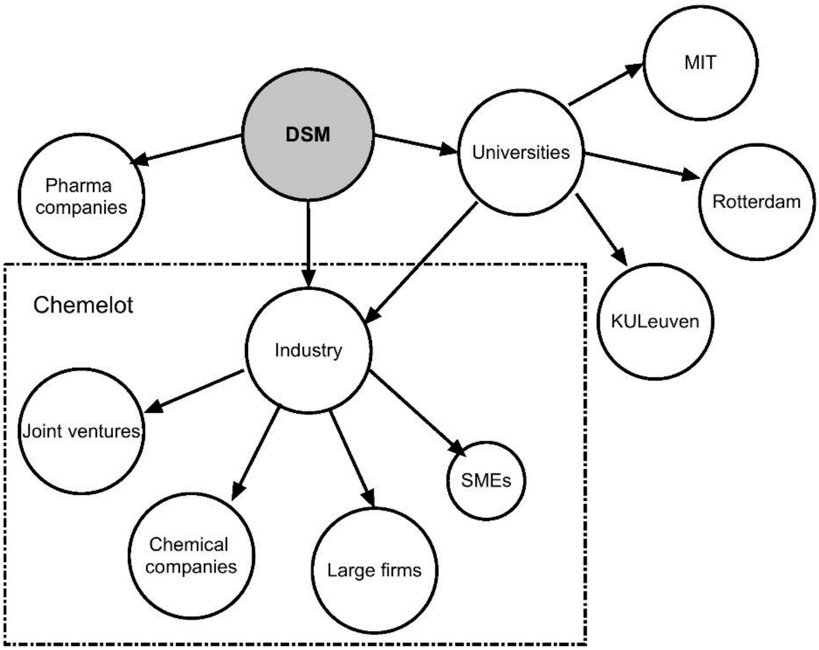
Headquarters: Heerlen, Netherlands
Industry: Life science and material science industry

Approximate number of partners: More than 100 partners

Royal DSM is a global science-based company that is active in the health, nutrition and materials sector. It offers innovative products and solutions to improve the performance of market-oriented companies across 17 global markets such as food and dietary, personal care, medical devices, automotive, electronics and so on. The Chemelot innovation center at DSM offers a variety of R&D and innovation management services and financial support to its partners. Through this center, partners receive assistance in licensing and venturing activities.

The Chemelot innovation center acts as the DSM ecosystem. Industrial partners such as large chemical and raw material companies, SMEs and joint ventures connect with universities and research centers in Europe and around the world to create value and to provide innovative products and solutions. Partners not only have the opportunity to access the external knowledge and networking, but they can also access the cutting-edge technology and state of the art laboratories. Moreover, the open innovation mentality at DSM and the joint IP agreement encourage partners to join the innovation ecosystem and benefit from the potential IP ownership.

DSM offers financial contributions to its partners and in total, has participated in 15 public- private partnerships. In collaboration with DSM, partners benefit from the legal and IP agreements and gain from the equal and fair contribution rights. DSM is a company limited by shares that are listed on the Euronext Amsterdam Stock Exchange. As such, it has a Managing Board and an independent Supervisory Board.



Case box 5- IMEC

Founded in: 1984
Number of employees: 2200 and 700 industrial residence

Headquarters: Leuven, Belgium
Industry: Nano-electronics and semiconductor industry

Approximate number of partners: more than 100

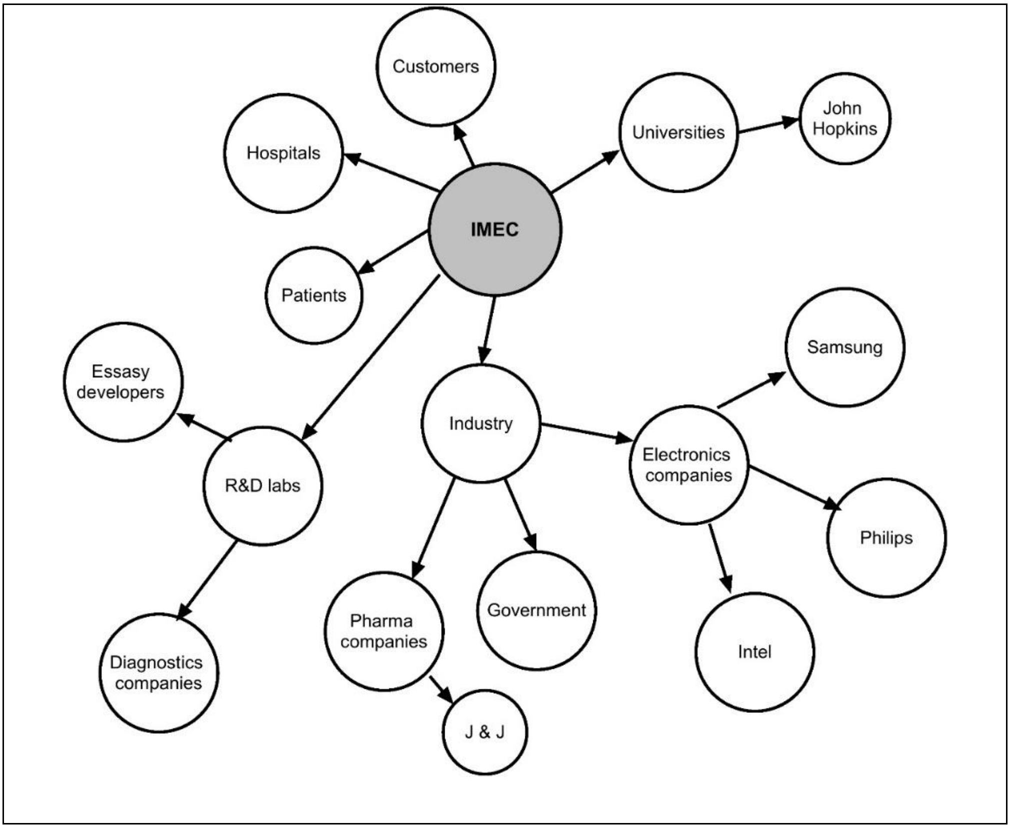
IMEC is a public world-leading research center in the nano-electronics industry. It utilizes its knowledge and expertise in ICT, healthcare and the energy sector to provide nano-enabled solutions that allow people to have a better life and so shape the future. In general, IMEC offers a variety of R&D services in health and life science, wireless, solar energy and image processing. In addition, it provides services to design, layout, prototype, fabricate, and test the products and bring them to the market.

The innovation ecosystem of IMEC consists of over 100 partners that are spread around the world. IMEC defines and initiates the innovation ecosystem by bringing partners from Industrial Affiliation Programs (IAPs) to collaborate on advanced nano-electronics technologies. Johan Van Helleputte, the former Vice President in charge of business development at IMEC, developed the IAPs concept in the early 1990s. This partnership formula brings industrial partners and IMEC research teams together to focus on a specific research program. It enables partners that usually take different positions in the semiconductor value chain to collaborate on a common platform program. The high cost and complexity of projects in the life science and semiconductor industry encourages partners to join the IAP program to reduce their costs and risks in R&D projects. They have the opportunity to participate and experiment with alternative technologies. In this context, whenever partners join an IAP program, they sign a bilateral contract that clearly defines the IP rules and technological scopes of the partners. IMEC as an orchestrator ensures that the partners capture some of the value by participating in the innovation ecosystem as they can co-own the technology they have been developing in programs (i.e. IAP) and they can license the technology developed by others in the program royalty free. Since the beginning in the 1990s, 587 partners have joined at least one program in IAP. In total, IMEC has coordinated 25 IAP programs since 2000.

Partners pay an entry fee to join the IAP program. To enhance the collaboration management of partners in IAP programs, IMEC has offered an IP-based orchestration model to its partners. Each partner works on a part of the program together with IMEC and they have a one-on–one relationship. First is the R0 that corresponds to some of the background knowledge that IMEC already has from the research of university students and researchers at IMEC. To get access to the relevant background IP, the participating members have already paid an amount. Second, the foreground knowledge that they generate can be divided into two parts. The first part is R1. In this part, partners co-develop the knowledge with IMEC, which is then co-owned with the company and IMEC. All other participants in the program can license it for free. The second part is R* that corresponds to all other partners that they can work with IMEC on a particular program. Here, they can also co-own IP and share it with everybody. However, the licensing cannot be sub-licensed to others beyond the participants in the program and thus has to stay within the program. Third is the R2 that partners have the possibility to pay the full cost of the generated IP and exclusively own the IP. By combining R0, R1 and R2, companies get a fully customized way of developing and appropriating the IP that they need.

IMEC's IAP program offers a platform for researchers to collaborate with other partners. This is the traditional model of IMEC. However, in order to enter the healthcare and medical industry, instead of working in an IAP model, IMEC needs to adapt the traditional model to the "The Dual Core" model. This is because it needs a key partner who can take the same position as IMEC in nano-electronics, but in the medical sector. The partner has to bring its own ecosystem to the model, as well as forming part of the IMEC ecosystem. By bringing two ecosystems together, the Dual Core is shaped, reflecting the core of the nano-electronics and the core of the medical field.

The Dual Core model can create a great deal of value as it functions across industries. While it captures the benefits of both the nano-electronics and medical industry, it can complicate the IP arrangements between the partners. In this model, not only IMEC is in the core, but John Hopkins University also performs a critical role in the ecosystem. As a result, the rules for value capturing become more complicated.



Case box 6- IMI (innovative medicine initiative)

innovative medicines initiative

Launched in: 2008
Number of employees & Researchers: Over 6000

Headquarters: Brussels, Belgium
Industry: Nano-electronics and pharmaceutical industry

Approximate number of partners: More than 100 partners, 30 in pharmaceutical industry

IMI is Europe's largest public-private partnership that is a joint collaboration between the European Union and the Pharmaceutical Industry Association EFPIA. IMI aims to develop healthcare by accelerating the development of patients' access to innovative and safer medicines. IMI facilitates research collaboration projects and brings together industrial partners and academic institutes to boost pharmaceutical innovation in Europe. In order to enhance innovation in the pharmaceutical industry, IMI performs in two different phases.

In the first phase (IMI 1: 2008-2014), IMI started the first Call for proposals and brought partners from industry, universities, public laboratories, innovative SMEs, patient organizations and regulators together to collaborate and resolve health-related challenges in Europe and so secure international competitiveness of Europe's pharmaceutical industry. IMI further tries to provide cost-efficient and effective treatments and medicines to patients. Indeed, cost efficiency can facilitate the coordination across the industry sectors and can lead to more reliable and accelerated clinical trials and better regulations. IMI 1 received a EUR 2 billion budget from the EU's Seventh Framework Program (FP7) and in-kind contribution from EFPIA and its member companies for 11 Calls of proposals. With respect to funding, it can be said that EFPIA companies are not financially supported by IMI, however, the EU funding supports the "public" organizations such as universities, small biotech companies, patient organizations and regulators that participate in the IMI projects. The success of IMI 1 encouraged the EU and EFPIA to promote the IMI and build on this success under the Horizon 2020 program.

In the second phase (IMI 2: 2014-2024), IMI has a total budget of EUR 3.276 billion that is mainly allocated to the EU Horizon 2020 program, EFPIA member companies and other associated partners at the project level. In this phase, IMI 2 concentrates on the needs of patients and society to accelerate the development of urgently needed treatments. In IMI 2, partners benefit in different aspects. The first is that projects that are defined under the Horizon 2020 program are more simplified. The second is derogation for IMI, which is limited to industry and IP rules. The third are the lighter financial rules and the fourth is the opportunity for other industrial partners that can contribute in kind. This partnership opens new commercial possibilities based on new services and products.

IMI has a multi-annual Scientific Research Agenda (SRA) that sets the priority for research collaboration areas. In IMI 2, the SRA is explicitly aligned with the World Health Organization (WHO) report of Priority Medicines for Europe and the World. In this respect, every year IMI publishes its Annual Work Plan that is approved by the Governing board and is aligned with the SRA instructions. In IMI, projects are launched in four steps. First, research areas are selected based on the priority of the research areas and the need to collaborate with external partners. Second, partners join together and receive consultations from IMI committees on their topic text. Third, the Call texts that are created by the research groups are sent to the IMI governing board for approval. During the final stage, after the approval, IMI launches the Call for proposals on their website and the European Commission participant portal where partners can access and participate in the project.

Currently, IMI has 50 projects specifically in health issues such as neurological conditions, diabetes, lung disease, oncology, inflammation and infection and other health-related areas. The funding model of IMI is clarified in the legislations creating the IMI 1 and IMI 2 and explains who contributes to which specific areas. Figure 8 illustrates the funding model and the contribution of partners for both phases of IMI.

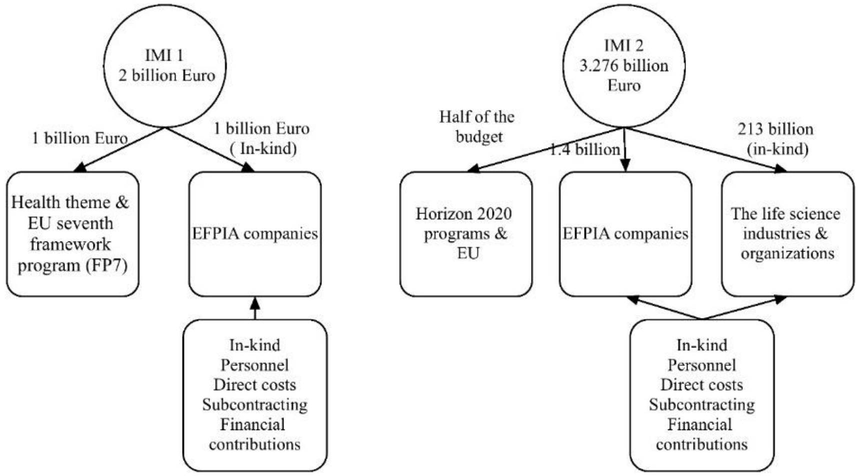
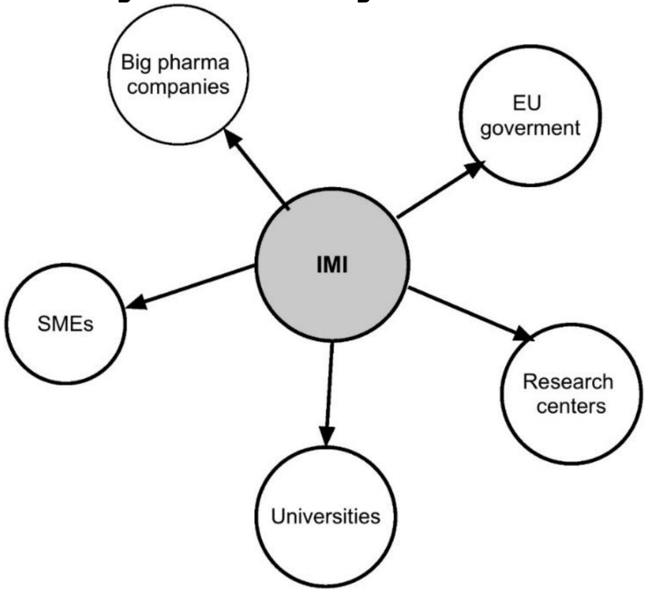


Figure 8 The funding model of IMI



Case box 7- KULeuven

KU LEUVEN	**Founded in:** 1972 **Headquarters:** Leuven, Belgium	**Number of employees at LRD**[10]**:** 90 **Industry:** Education, Nano-electronics, Nano-medicine, bio-Nano industry

Approximate number of partners: more than 100 partners

The Leuven Research and Development center facilitates the collaboration between industrial partners, securing and licensing IP rights, creating spin-off companies and stimulating knowledge-driven regional development.

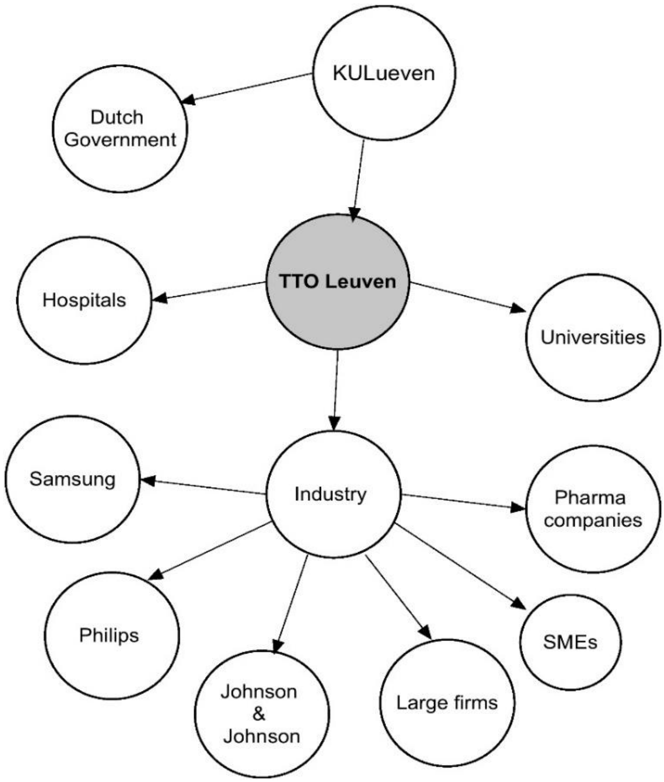
The innovation ecosystem of LRD at KULeuven consists of the Leuven University and other universities and academic institutes, hospitals, industrial companies (SMEs and large companies), leading pharmaceutical companies, and the Dutch government. Organizations join the innovation ecosystem not only to access the external knowledge and the networking opportunity, but also to access the complementary assets and technical expertise. KULeuven offers research and collaboration platforms that enable partners to share their knowledge. Through these platforms, KULeuven creates value for the partners. The credibility of KULeuven also encourages partners to join the innovation ecosystem. The close collaboration of partners further develops the transparency and trust in communication. In this respect, partners are encouraged to collaborate with the university. Moreover, the opportunity to access the government funds through the LRD center motivates partners to interact with KULeuven and receive financial support.

In order to create value, KULeuven offers innovation management services and education and training programs. In this context, the business development and innovative project services in an open collaboration environment enable the KULeuven and other partners to jointly create value. Furthermore, the consulting sessions and regional development programs enable KULeuven to jointly create value with the partners.

In return, KULeuven arranges different research contracts; IP, consortiums and consultancy agreements to ensure that partners can capture some of the value created in the innovation ecosystem and the IP of core partners involved in projects are protected. The entrance fee of partners entering the research projects further enables KULeuven to distribute the value in the innovation

[10] Leuven Research and Development (LRD) is the Technology Transfer Office (TTO) of the KU Leuven associations.

ecosystem. Every year, around 90 people in KULeuven collaborate with partners in around 2,000 new agreements.



Case box 8- NanoNextNL

Initiated in: 2009
Headquarters: Utrecht, Netherlands

Number of employees: 10 directors & 750 researchers
Industry: Nano-electronics, Nano-medicine, bio-Nano industry

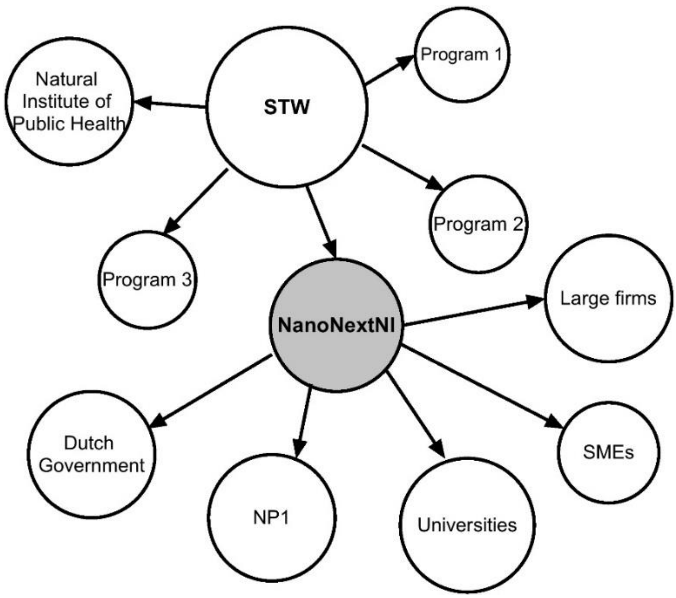
Approximate number of partners: 130 partners

NanoNextNL is a Dutch national research and technology consortium for micro and nano- technology. The program was an approved proposal "Towards a Sustainable and Open Innovation Ecosystem" from FES High-Tech Systems and Materials (FES HTS & M). The program consists of 10 themes and the Valorization program. NanoNextNL projects are combined in 28 programs in risk analysis, energy, nano-medicine, bio-nano and clean water areas.

NanoNextNL aims to assist in solving societal problems and creating economic value.

The ecosystem of NanoNextNL consists of medical universities, research and knowledge centers, industrial companies (SMEs and large companies), the Dutch government and the regulatory agencies. Partners join the innovation ecosystem of NanoNextNL through submitting their proposal for the research Call. Networking opportunities and collaboration with other stakeholders and partners in the industry encourage them to connect with NanoNextNL. The knowledge platform at NanoNextNL creates a stage for partners to jointly create value. Moreover, the project management services, open innovation mentality and technical expertise of NanoNextNL's researchers attract partners to join the innovation ecosystem and collaborate in research projects. NanoNextNL uses innovative products and an application of results in practice to create value. In addition, the IP framework at NanoNextNL enables partners, especially universities, to use their created IP and licenses to create a joint IP.

Although these aspects are important, the financial support that the Dutch government offers through NanoNextNL is attractive. Generally, the Dutch government funds half of the programs and partners fund the other half. For instance the total budget of NanoNextNL is EUR 250 million; half of it contributed by the 130 partners and the other half by the Dutch government. Since the government invests in the program, it regularly monitors the research activities and evaluates the performance of NanoNextNL and its partners.



Case box 9- Ridgetop Group

Ridgetop Group Inc
ENGINEERING INNOVATION

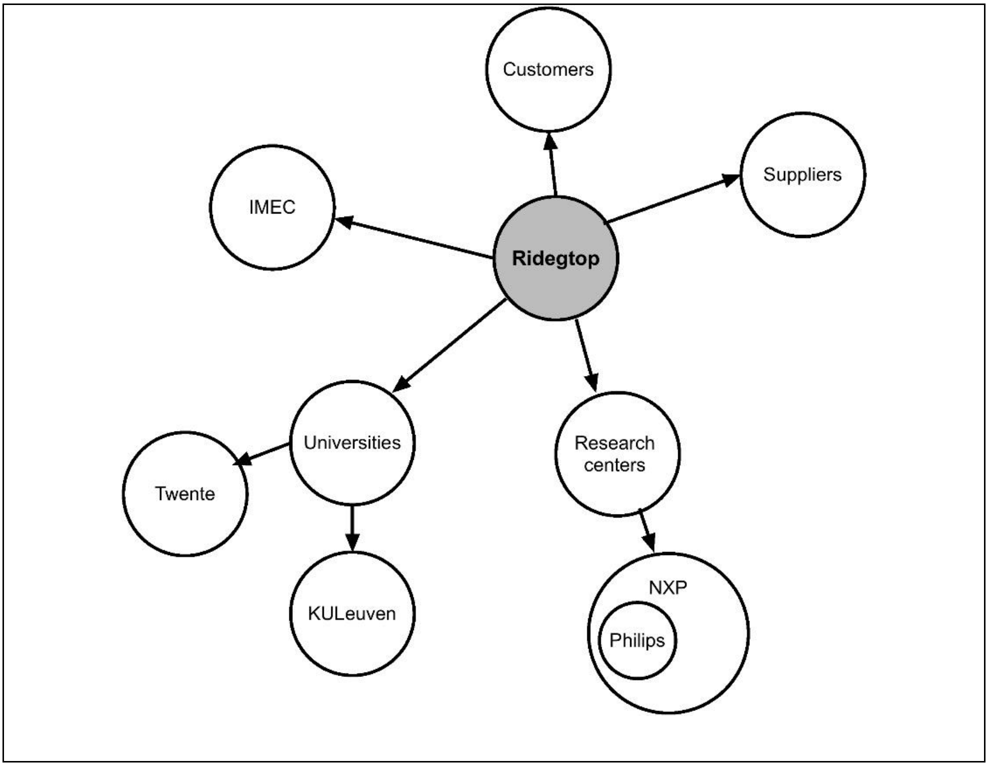
Founded in: 2011
Headquarters: Brugge, Belgium

Number of employees: 4
Industry: Semiconductor and electronics

Approximate number of partners: More than 100

The Ridgetop group in Europe offers applied research and technology solution products in different industries such as the semiconductor, electronics, energy and environmental industries. The products offered by Ridegtop group are various forms of advanced diagnostics, semiconductors, and design services. The Ridgetop ecosystem consists of many customers and suppliers in research centers (e.g. Philips), universities (e.g. University of Twente and KU Leuven University) and industrial firms. The flexible strategy, access to complementary infrastructure and products, and the technical leadership of Ridgetop have encouraged organizations to join the ecosystem. In this respect, Ridgetop jointly creates value by providing R&D services and application-oriented products with its partners. In addition, they support customers by providing the most effective solution to their technical problems.

When customers join the ecosystem, Ridegtop has a flexible approach. Based on the product and the solutions that are provided to them, they sign a customized contract. Moreover, Ridegtop interacts with customers at different levels of the organization, from technical people to mid-management and higher management. Other partners of Ridegtop agree to a non-confidential agreement. This enables partners to recognize their benefit in interacting with Ridegtop ecosystem.



Case box 10- TMC

Founded in: 2000

Headquarters: Eindhoven, Netherlands

Number of employees in technical department: 550 employees

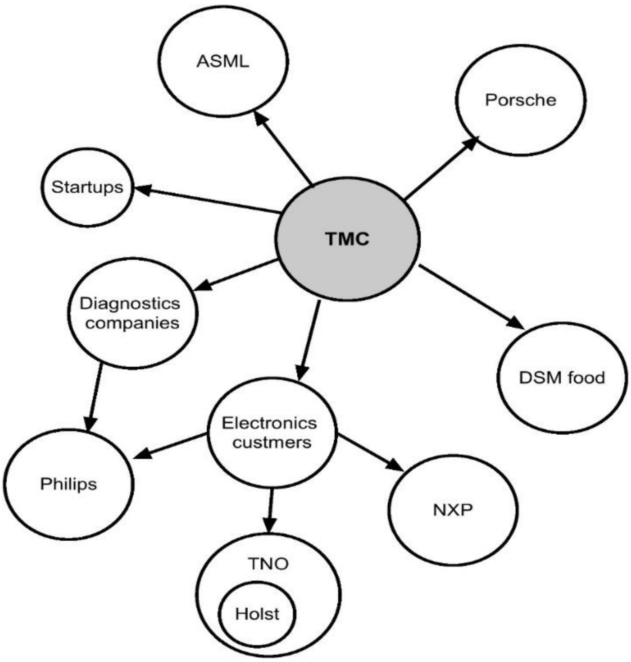
Industry: Nanotechnology, electronics and chemical industry

Approximate number of partners: More than 300 partners

TMC is a Dutch insourcing agency that connects people with enthusiasm and knowledge for large and small technological breakthroughs. It provides customers and entrepreneurs a platform for personal and professional development in projects.

The TMC ecosystem consists of more than 300 partners. Large electronics customers such as Philips, NXP and TNO as well as diagnostic companies, SMEs and startups interact with TMC to access the knowledge of skilled technical people, reduce their research costs, save their IP and interact in multiple projects. In this respect, TMC creates value through R&D services on application-oriented projects. In other words, it encourages on important projects that are rarely conducted at universities. The entrepreneur lab at TMC is an incubator for great ideas, which acts as platform for people to join and present their business ideas to the board of directors. Once the board approves the business idea, they can allocate funds to develop the project. This encourages people at TMC to stay innovative. In addition, TMC allocates a training budget to account managers to coach and train people. Courses are offered in a variety of entrepreneurship programs in different research areas such as chemistry, nanotechnology, and electronics. Stimulating employees and their ideas enables TMC to provide higher skilled entrepreneurs.

When partners join TMC, they agree on a "non-disclosure agreement or NDA", based on their projects research topics. Through this agreement, partners are able to collaborate full time on multiple projects. This not only enables partners to interact in projects, but also allows them to keep their IP protection. NDAs offer customers similar innovation processes on different products and production procedures.



Chapter 4

4 The value creation and value capturing mechanisms and the challenges in Belgian and Dutch nano-electronics innovation ecosystems

4.1 Introduction

Open innovation has become mainstream in the innovation management literature (Chesbrough et al., 2014). Among studies that have concentrated on open innovation, most have focused on the firm level approach and only few have examined the open innovation phenomena at the dyadic level, the project level

(Du, Leten, & Vanhaverbeke, 2014), or the individual level (Elmquist, Fredberg, & Ollila, 2009). The "innovation ecosystem" perspective (Adner, 2012; Adner & Kapoor, 2010; Basole, 2009; Dhanaraj & Parkhe, 2006; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006) offers another underexplored level of analysis with great potential to be studied from an open innovation perspective. It is important to see innovation at the ecosystem level, including different stakeholders that are active players jointly creating value and experimenting with new ways of performing tasks and creating new products and services (European, 2015).

The open innovation framework (Chesbrough, 2003, 2006; Chesbrough et al., 2006, 2014) explains the operational and economic potential of innovation ecosystems. One of the important aspects in an innovation ecosystem approach is how ecosystem partners jointly create and capture value in an ecosystem (Adner & Kapoor, 2010; Iansiti & Levien, 2004b; Lubik et al., 2013; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006). Prior research has investigated the relationship between value creation and firm performance, the role of different organizations in ecosystems, and how an innovation ecosystem can be set up and be organized. Co-creating and co-capturing value in an innovation ecosystem is not easy; it follows a specific logic, since actors do not function in isolation—rather, what they do and how they perform affects the performance of others and the ecosystem as a whole. In an innovation ecosystem, it is the interconnection and integration of resources and competencies among the actors in the ecosystem that determines the innovation potential (and thus the value creation potential) of the ecosystem. Value is co-created and co-captured and therefore we need to move away from firm-level business models to ecosystem-focused business models in order to study the interdependence of the activities of the actors in an appropriate way.

How can co-creation and co-capturing value in innovation ecosystems be examined in a useful way? Partners in an ecosystem can create value far beyond what they can achieve individually or pairwise as partners in a strategic partnership. To investigate the co-creation and co-capturing process it is essential to analyze three distinctive (building blocks) but relating concepts; such as value drivers, value creation and value capturing.

First are value drivers. The quest to create value starts with an understanding of performance variables that create value in a significant way; in other words, the key value drivers. Value drivers can be diverse and multiple. In nano-electronics, the costs and risks associated with the introduction of a new generation of chips have increased in the last decades. Firms can no longer bear R&D costs alone and the risk of betting on the wrong technology has a detrimental effect on their performance for years. Prohibitively high R&D costs and mounting risks are value drivers pushing nano-electronics companies towards collaborations where they can share costs/risks to the benefit of all participants.

Second is the joint value creation where firms join in collaborative process to create value for customers and other stakeholders. Value drivers and joint value creation cannot be considered separately from how different partners in an innovation ecosystem capture value.

Third is value capturing which is crucial for partners in an ecosystem as each of them must gain from being a member of an ecosystem, for if there is no gain, partners will leave and the ecosystem will collapse. The need to capture value automatically creates tensions. On the one hand, partners have to collaborate in an effective and trustworthy way to create value. On the other hand, partners have to generate profit and will try to capture part of the value they create together. Numerous tensions on sharing the value may deteriorate the collaboration between partners, leading to a weakening of the ecosystem. This inherent tension between joint value creation and capturing creates a series of challenges that must be managed at the ecosystem level. I will pay attention to these challenges and how ecosystem management can solve or alleviate tensions stemming from these challenges.

To shed light on how value is created and captured in innovation ecosystems and to identify the challenges during these processes, I focus on the Belgian and Dutch nano-electronics industry. I will explore the building blocks of the ecosystems—value drivers, value creation and value capturing mechanisms—and identify the challenges that may occur among actors in the ecosystems. In this chapter I concentrate on the red sections of figure 2. In contrast with prior studies, not one specific type of actor in the ecosystem is focused on, but instead the point of view of different types of actors that are involved in ecosystems within this industry are considered. This inclusive approach is necessary to understand how each partner's contribution helps to create joint value and how their individual objectives and profit targets may lead to tensions in the ecosystem.

Actors in six innovation ecosystems[11] were interviewed to investigate how value is created and captured and what challenges they may face in these ecosystems. The coding procedures from the interview transcriptions resulted in the identification of six value creation mechanisms, three value capturing approaches, and two categories of challenges, of which several are novel and have not been identified in previous literature (See appendix C tables i to iv).

In the next section, I explore the literature on value drivers, value creation and capturing, and the challenges in ecosystems. In the third section, the nano-

[11] IMEC, IMI, DSM, ASML, NanoNextNl, and University of Leuven Association /KU Leuven

electronics industry in Belgium and the Netherlands is described, the methodology used, as well as the steps taken towards generating the concepts of value drivers, value creation and capturing, and the challenges. In the fourth section, the results are presented by introducing the theoretical model and how it is applied in nano-electronics. Finally, the findings are discussed.

4.2 Background literature

In this section, first the building blocks of innovation ecosystems are explained: value drivers and value creation and capturing mechanisms. Second, the management challenges within ecosystems are explored.

4.2.1 The building blocks

According to Richard Normann and Ramirez (1993), ecosystems are related to value systems that are set up to deliver value for a targeted customer group. Ecosystems offer a unique and coherent framework for understanding the formation of inter-organizational networks (Vanhaverbeke & Cloodt, 2006). In general, different value drivers encourage organizations to jointly create value in ecosystems. First, organizations join an innovation ecosystem to access novel technologies and research methods. Porter (1985) suggested that new value is created when firms develop new procedures using new methods, new technologies and/or new raw materials. In this regard, Amit and Zott (2001) and Ranjay Gulati (1999) indicated that novelty keeps customers and strategic partners from migrating to other networks and competitors.

Second, organizations may join to access the ecosystem's complementary products/services. This means that the value in the ecosystem can be created with respect to different forms of technology innovation, customer satisfaction, and after-sale services. Vanhaverbeke and Cloodt (2006) conducted a study investigating open innovation in value networks in the agricultural biotechnology industry. They suggested that complementary factors are one of the reasons why organizations join an innovation ecosystem to enrich the value creation in agri-biotechnology industry. In the same context, in their study on publicly traded American and European e-businesses, Amit and Zott (2001) proposed complementarities as one of the objectives among the businesses, which can be enhanced through increase of revenue.

Finally, organizations join ecosystems to maintain efficiencies in cost and time. In a study on business models for open innovation, Saebi and Foss (2015) indicated that in market-based innovation strategy, reducing transaction and coordination costs enables organizations to create value. Similarly, Vanhaverbeke and Cloodt

(2006) and Amit and Zott (2001) showed how efficiency is one of the main value drivers in ecosystems. For instance, partners join the IMEC ecosystem to gain access to innovative research equipment. While IMEC partners reduce their R&D costs and risks, they receive faster results. Due to value drivers (e.g. access to novel technology and infrastructure and efficiencies in cost and time), organizations cannot perform in isolation and are required to collaborate with partners. Complexity of projects is another factor that pushes them to interact with ecosystem partners. Generally, performing in an ecosystem means creating value.

The ecosystem value creation is not an individual task, but actors co-produce value together through rethinking their roles and interrelationships (Gomes-Casseres, 2003; Vanhaverbeke & Cloodt, 2006). This highlights the importance of considering all actors involved in the ecosystem. Vanhaverbeke and Cloodt (2006) investigated how organizations can jointly create value in an ecosystem through new product development and technology innovation. Lubik et al. (2013) explored value creation of university spin-offs from a radical, generic technologies perspective. This study indicated that firms actively seek to cultivate their relationships to create value. In another study, Nambisan and Sawhney (2011) considered value creation with respect to ecosystem orchestrator. Focusing on one type of actor may not give the complete overview of the ecosystem, but rather it may only present the perspective of the actor under consideration.

When organizations join an ecosystem, they enter into a relationship that creates value as such, they expect to receive a benefit in return. This means the value created jointly has to be shared among parties, otherwise they may withdraw from the joint effort (Gomes-Casseres, 2015).Value sharing or capturing is referred to as value earning in a more neutral fashion. It is important to note that bargaining power shapes how value can be captured in the ecosystem. It indicates to what extent the partners in an ecosystem can capture value for their contributions. Prior literature indicates different approaches to capture value in an innovation ecosystem. Designing guidelines that enable an equitable distribution of IP rights among partners and allocating product/service incentives to partners are some of the value capturing mechanisms identified (Nambisan & Sawhney, 2011).

Brandenburger and Stuart (1996) suggested that value creation in the value chain should be defined in combination with value appropriation. The quality of collaboration between partners and the value sharing among them both define how much value the ecosystem can create (Vanhaverbeke & Cloodt, 2006).

Besides the innovation ecosystem literature, marketing scholars have also focused on co-creation of value with customers with respect to creating a service-dominate logic framework (Vargo & Lusch, 2008, 2016), the ecosystem perspective (Vargo

& Lusch, 2011), and exploration and explication of value co-creation (Payne, Storbacka, & Frow, 2008). If value is created by a group of actors at the ecosystem level, it requires a detailed understanding of the mechanisms from the perspective of different actors. As this may lead to better performance and success of the ecosystem, further explanation on how to create and capture value at the ecosystem level is essential.

4.2.2 The ecosystem challenges

When actors join an ecosystem, they become dependent on each other to create or capture value. In other words, poor performance of one actor can affect others. In this context, Adner (2006) suggested that it is easy to underestimate the challenges since they seem like someone else's problem. Thus, differences in interaction set the stage for obstacles in the ecosystem (Gilsing et al., 2008; Håkansson & Ford, 2002; Pittaway et al., 2004). In order to manage the ecosystem better, it is important to understand the potential challenges that could occur. Below, some of these challenges are outlined.

The first challenge is to balance existing and new relationships. An ecosystem as a network of resources creates inertia, therefore it is crucial to construct a stable environment for actors to interact and operate in (Dhanaraj & Parkhe, 2006; Håkansson & Ford, 2002). Second, it is challenging to manage the individual objectives of different organizations within the ecosystem. Lack of appropriate management practices may result in project failure (De Bruijn & Heuvelhof, 2008; Dhanaraj & Parkhe, 2006; Håkansson & Ford, 2002). The third challenge relates to the need to balance informal and formal relationships in the ecosystem. Actors in the ecosystem interact through formal interactions (e.g. contractual agreements), informal relations (e.g. informal meetings, trust) or combined relations. It is important to manage and balance these interactions in such a way that actors find a suitable position to benefit from the interaction (Leydesdorff, 2013; Pittaway et al., 2004; Ring & Van de Ven, 1994).

In summary, innovation ecosystems represent an important topic of discussion for scholars. However, what has been discovered in the previous literature is limited. Scholars have identified three types of value drivers: access to novel technology and research methods, access to complementarity products, and efficiencies in cost and time (Amit & Zott, 2001; Porter, 1985; Saebi & Foss, 2015; Vanhaverbeke & Cloodt, 2006). In value creation, product and technology development and developing/maintaining relationships were determined as co-creation mechanisms (Lubik et al., 2013; Maine & Garnsey, 2006; Vanhaverbeke & Cloodt, 2006). In addition, setting up guidelines for equitable distribution of IP rights as well as allocating incentives were determined as value capturing mechanisms (Nambisan & Sawhney, 2011). The stability of the environment, differences in organizational objectives, and imbalance between informal and formal relationships are some of the challenges that ecosystem partners face (Dhanaraj & Parkhe, 2006; Håkansson & Ford, 2002; Leydesdorff, 2013; Pittaway et al., 2004; Ring & Van de Ven, 1994).

Although scholars have concentrated on determining several value creating and capturing procedures, they have not comprehensively identified the portfolio of mechanisms that organizations use to co-create and co-capture value. Notably, those scholars that focused on exploring the mechanisms only concentrated on one type of actor (i.e. SMEs, large corporates, orchestrators or academic institutes) and did not evaluate different approaches that other actors utilize in ecosystems. Equally, the challenges discovered in the prior literature are few and do not cover all potential tensions. In order to understand how partners create and capture value, one has to take a holistic approach, as they are dependent on each other within an ecosystem. Considering a single actor's perspective does not represent value creation and capturing at the ecosystem level. Understanding why actors collaborate (i.e. value drivers) clarifies how actors are required to collaborate (i.e. value creation). This is only possible through the ecosystem perspective, as actors jointly create value and try to benefit from collaboration. Consequently, this study intends to fill the gap in the literature by concentrating on all types of actors in ecosystems and investigating other value creation and value capturing mechanisms, as well as the potential challenges actors may face during these processes.

4.3 Method

This section explains the research setting and the methodology applied to investigate the research question.

4.3.1 Research setting and sample

The research setting is based on nano-electronics innovation ecosystems. Section 4.3.2 briefly illustrates the methodology of the research (See chapter 3 for a comprehensive overview of the research setting and methodology).

4.3.2 Methodology

Prior studies on value creation and capturing primarily concentrated on a single case study or applied quantitative or mixed methods in analyzing their results (Adner & Kapoor, 2010; Vanhaverbeke & Cloodt, 2006). Among the few studies that applied qualitative methodology specifically grounded theory-building, only value creation mechanisms were observed and value capturing or challenges in the innovation ecosystems were unexplored (Amit & Zott, 2001). As such, to investigate how ecosystem partners create and capture value and identify related challenges, a grounded theory qualitative approach on multiple case studies was used (Corbin & Strauss, 2014; Eisenhardt, 1989a). Six out of 10 innovation ecosystems (i.e. ASML, DSM, IMEC, IMI, KULeuven, and NanoNextNl) that covered wider range of mechanisms in respond to the research question were selected for further analysis of this study (Miles & Huberman, 1994) (See section 3.4 for extensive case descriptions).

4.4 Findings

In line with Eisenhardt (1989a), I created a cross-case analysis table (See table 10). The table illustrates the contributing elements of each building block (i.e. value drivers, value creation, and value capturing mechanisms) and the challenges across cases. Each block is the final theme that is generated from the coding analysis in appendix C.

According to table 10, academic institutes, and industrial firms have different value drivers this means that they have different incentives to engage in an innovation ecosystem. This leads organizations to create and capture value in distinct way hence experience different type of challenges. In this regard, universities, research centers and science-based companies have mainly similar value drivers. This leads these institutes to create value in a same way. For IMEC and KULeuven for instance access to external knowledge drives them to the joint value creation. As such, they both create knowledge platforms and offer education/training programs to share ideas and create value. In order to capture value, academic institutes mainly use agreements and contribution rights to benefit from the joint value creation. Simultaneously, the challenges that they face are mainly similar. With respect to industrial firms, access to research infrastructure is one of the main value drivers that force organizations to jointly create value through innovative products. The table also shows that organizations mainly use agreements to capture value. Perhaps this is one of the secured and transparent approaches that can be used to capture benefits. With respect to challenges, nearly all organizations have to deal with differences in mindsets of ecosystem members. Moreover, it is clear that the organizations facing funding issues also have to deal with partner withdrawal.

Table 10 The cross-case analysis of innovation ecosystems

Case	Type	Value drivers									Value creation					
		Access to external knowledge	Access to other assets	Access to open innovation mentality	Flexible strategy	Risk reduction	Financial support	IP	Transparency and trust	Reputation and credibility	Knowledge platform	Innovative products	R&D services	Funding	Education and training programs	Innovation management services
ASML	Manufacturing company	✓	✓	✓	✓		✓		✓			✓	✓			
DSM	Science-based company	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓
IMEC	Research center	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
IMI	Public-private partnership	✓	✓			✓	✓		✓	✓	✓			✓	✓	✓
KULeuven	University	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
NanoNextNl	Dutch research consortium	✓	✓	✓	✓		✓		✓		✓	✓	✓		✓	

Case	Type	Value capturin g			Challenges													
		Agreements	Contribution rights	Incentives	Objectives of organizations	Mindset of organizations	Developing relationships	View on research time frame	IP protection issues	Funding issues	Withdrawal of partners	Public image	Risk sharing	Government contribution and interference	Government requirements	Reporting and monitoring	Internal financial problems	Inter-organizational problems
ASML	Manufacturi ng company	✓		✓		✓	✓	✓						✓	✓			
DSM	Science-based company	✓	✓			✓			✓	✓	✓							✓
IMEC	Research center	✓	✓		✓	✓	✓	✓				✓	✓	✓			✓	✓
IMI	Public-private partnership	✓		✓	✓	✓	✓		✓	✓	✓	✓		✓				
KULeuven	University	✓	✓		✓	✓		✓							✓			
NanoNextNl	Dutch research consortium	✓	✓	✓	✓		✓	✓		✓	✓			✓	✓	✓		

Referring to the table 9, indicate that the building blocks are crucial in understanding the value creation and value capturing of the six innovation ecosystems. However, it is still not clear how blocks are connected with each other. According to the informants, value drivers are the initial block that actors in the innovation ecosystems consider in joining the value creation process. Second, they apply various value creation mechanisms and third they investigate procedures to capture some of the value created. During this search, innovation ecosystems face different challenges where orchestrators and government agencies could manage and resolve some of the issues. To better understand the connection between the building blocks, the analysis of the results on each block (i.e. value driver, value creation, and value capturing) – from open coding to theory generation (See appendix C tables i to iv) - is integrated to generate the theoretical model of figure 9 (i.e. the red section of figure 2). The model illustrates the value drivers in the rectangular shape that is connected with dashed arrow line to a rectangular box consists of several drivers. These drivers are the themes generated from the coding analysis in appendix C, which is also illustrated under value drivers in table 9. Value drivers such as access to external knowledge and flexible strategies encourage partners to join the value creation process. As such, value drivers are connected to value creation block with a solid arrow line[12]. The rectangular box of value creation is linked to different value creation mechanisms with a dashed arrow line. These mechanisms are presented in a rectangular box and correspond to the main themes generated from the coding analysis in appendix C. Table 9 similarly illustrates these mechanisms across case studies. As already mentioned, while actors join ecosystems to create value they seek for various ways to capture some of the value created. Hence, value creation box is joined to value capture oval rectangular box with solid arrow line. Considering that actors repeat the value creation and capturing process to properly benefit from the interaction the value-capturing box is also connected to value creation block with a solid arrow line. Different value capturing mechanisms such as agreements, incentives and contributions rights are presented in a rectangular box and connected to the value capturing block with a dashed arrow line. These mechanisms reflect the main themes generated from the coding analysis as shown in appendix C. Table 9 also shows the mechanisms across cases. Based on what has been explained in the literature section, partners face potential challenges during the search for value. As such, both value creation and capturing box are connected to the rectangular shape of challenges with solid lines. Challenges as presented in table 9 and appendix C are determined through the coding analysis.

[12] Solid line is used to connect the building blocks to each other. Dashed line is used to link each building block to its relative identified components.

Different challenges are illustrated in rectangular box and connected with dashed line to the challenges. Diversity in organizations' objectives, funding issues, withdrawal of partners from the ecosystem and internal problems among organizations are some of challenges identified and presented in the model 4.1. Reflecting from the literature and what has been discussed both the orchestrator and the government as two crucial ecosystem actors in the nano-electronics industry could manage the innovation ecosystem challenges. Thus, the orchestrator and the government in oval shapes are connected with solid lines to the management of innovation ecosystem. These activities that both may apply to manage the challenges are derived from prior studies and my conversation with a Dutch government representative (See table 9). These tasks are shown in rectangular boxes and are joined to the orchestrator and the government box with dashed lines. Based on the figure 9, by creating and reshaping the environment and managing the relationships the orchestrator could manage the ecosystem challenges. Similarly, the government could offer financial support and support startups to indirectly resolve the conflicts and manage the tensions. Resolving the conflicts and managing or orchestrating the challenges leads to maximization of the value creation. This development of value creation is illustrated with a solid line that connects the ecosystem management to the value creation block of the model.

In the following sections, I examine each building block (i.e. value drivers, value creation, and value capturing) and the challenges that emerged from the analysis of the results.

4.4.1 Value drivers

Results of the study show that partners join innovation ecosystems for nine main reasons (See table 9). First, they join in order to gain access to external knowledge. Three elements—networking, collaboration and research opportunities are different aspects of gaining access to external knowledge. In other words, organizations join ecosystems to expand their network, collaborate with other partners, and enhance their future research opportunities. Rohrbeck et al. (2009); Vanhaverbeke and Cloodt (2006) have also discussed some of these elements. Second, organizations join an ecosystem to have complementary assets (Amit & Zott, 2001; Vanhaverbeke & Cloodt, 2006), high-tech infrastructure, and competencies (Rohrbeck et al., 2009). In addition, interaction with technical people and access to business mentality and project management services such as monitoring creates a unique platform for partners to access other competences and regulate research projects. Third, ecosystems enable organizations to enhance their technology. The complementary product that is offered through the collaborative innovation facilitates the access of organizations to technology enhancements.

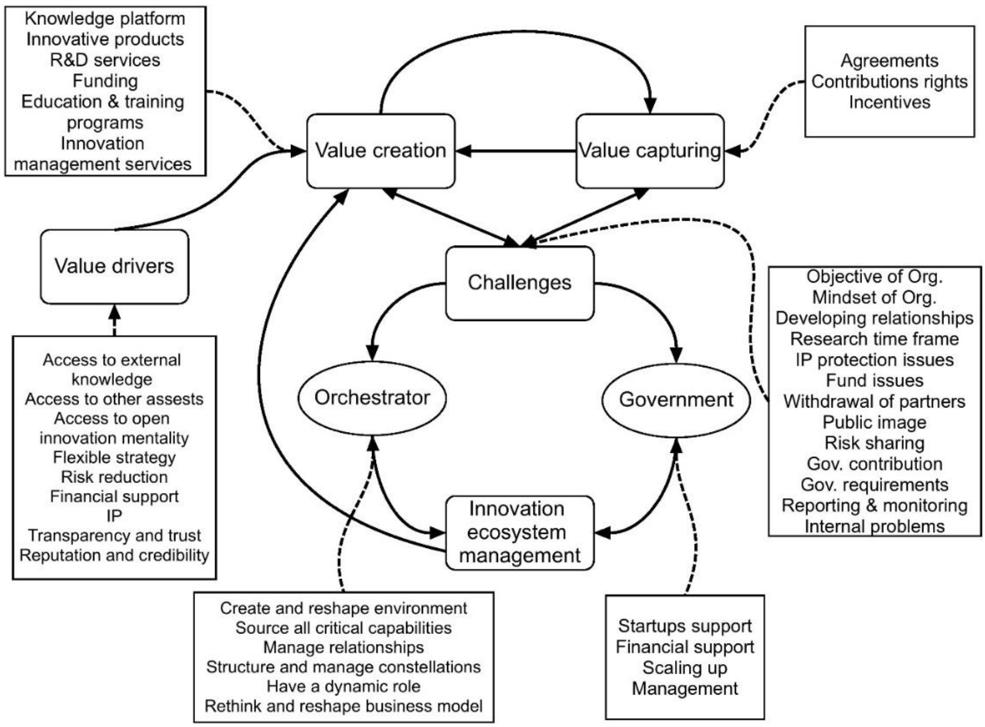


Figure 9 The theoretical model for value creation and value capturing mechanisms within the nano-electronics innovation ecosystem

Fourth, ecosystems offer an opportunity to access the open innovation mentality. Results show that nano-electronics organizations join ecosystems to access the open innovation culture and mentality of others. In addition, the flexibility that organizations provide to partners encourages them to join the ecosystem. Access to open innovation mentality is a new value driver that was not discussed in prior studies. The fifth reason is the transparency and trust between organizations. Communication and trust between partners and transparency in research activities are important reasons why organizations join ecosystems. Trust and communication have been emphasized in strategic alliance literature (Agarwal et al., 2010; Capaldo, 2007) and have less been concentrated in innovation ecosystem literature. Sixth, organizations join ecosystems because of interesting intellectual property (IP) available in other organizations (West & Wood, 2008).

Nano-electronics organizations join innovation ecosystems to access other organizations' IP, to create joint IP agreements, and to be able to protect their IP during the research projects.

Seventh, organizations enter the ecosystem to reduce the risk and cost of the collaboration (Vanhaverbeke & Cloodt, 2006; West & Wood, 2008). The results suggest that organizations in the nano-electronics industry join an innovation ecosystem to reduce their risks and networking costs (since developing a network may require high costs) and to enhance their R&D expertise. This is more obvious in organizations that concentrate on clinical trials and diagnostic tests, where the high cost of research projects can lead to financial challenges for the partners involved. Moreover, organizations join in order to deliver faster results. The eighth reason that drives organizations to join innovation ecosystems is to receive financial support (Iansiti & Levien, 2004b). Finally, analysis suggests that organizations in nano-electronics join because of previous successful collaborative experiences or the reputation that specific partners have created in the industry.

4.4.2 Value creation

My analysis suggests six mechanisms that organizations use to jointly create value: knowledge platforms, innovative products, R&D services, funding, education/training programs, and innovation management services. However, organizations have unique objectives and therefore their value creation approaches also vary.

First, organizations create value through generating knowledge platforms, ensuring that technology reaches the ecosystem partners that then have the opportunity to use it and co-develop projects and create value. Second is providing innovative products. It is suggested that organizations in nano-electronics ecosystems create value through application-oriented high-tech products, equipment, and solutions. It is important to note that mainly industrial partners and R&D manufacturing companies create value through this mechanism. Third, this study suggests that organizations create value through R&D services. In other words, they provide research to external partners in different phases of feasibility, development, and prototyping. This enables partners to align their projects (e.g. personalized medicine, developed drug tests, and enhancing the quality of healthcare) according to the research time frame. Fourth is providing funds to partners. This is one of the important mechanisms that organizations employ to create value in the ecosystem. Fifth, analysis shows that training/education programs are utilized to create value among partners. Indeed, this can assist partners in utilizing the knowledge spread through joint research projects. A sixth approach to create value is through providing innovation management services to ecosystem partners. The results indicate that organizations create value with their partners through project management services, creating a collaboration environment, and business development consulting. In order to further clarify the concept of value creation in innovation ecosystems, I illustrate how partners in an ecosystem jointly create value using two case studies, i.e. IMEC and IMI.

4.4.2.1 IMEC - interuniversity micro electronics center

In IMEC, value is mainly created through offering a knowledge platform, R&D services, innovative products, and education/training programs. IMEC as an orchestrator and leader in the ecosystem has built a successful reputation in nano-electronics and life sciences. Many organizations in this industry join IMEC not only to gain access to knowledge and technology, but also to access the "knowledge infrastructure" and IMEC's skills to work in an open manner. The complexity, high costs, and risks associated with R&D projects in nano-electronics have encouraged organizations to join the IMEC innovation ecosystem. In this respect, IMEC jointly creates value by offering research platforms for technological collaboration. As partners join IMEC's platforms, they gain access to state of the art knowledge and technology and are able to expand their network with other partners and share R&D costs.

In addition, IMEC creates value by providing an innovative infrastructure to its partners. The advanced high-tech equipment and research labs at IMEC encourage partners to join the ecosystem and save costs by co-using the infrastructure. IMEC offers pharmaceutical companies diagnostic tools and disposable or microscopic chips where the chip has the complexity of the clinical labs but in a portable way. The disposable chip can save costs on diagnostic tests compared to regular microscopes. "The Dual Core model"[13] of IMEC enables excellent research partners such as Johns Hopkins University to join, share IP, and create innovative products in collaboration with IMEC. IMEC also offers R&D services. Research at IMEC is conducted in three phases: early science, feasibility studies, and development. Thus, the range of research that is offered goes from theoretical study to developing prototypes. The knowledge platforms at IMEC and its collaboration with some of the best high-tech universities and researchers around the world have allowed IMEC to offer personalized medicine solutions and improve the quality of healthcare. Finally, IMEC provides knowledge expertise and training/education programs for its partners. Through different networking events, partners meet and exchange ideas and share their know-how. The

[13] IMEC has generated the Dual Core Model to enter the life science innovation ecosystem. IMEC and Johns Hopkins are the two cores of the model.

"Partner Weeks" is an example of an event where IMEC brings all partners together to share ideas. These events initiate a learning platform for all partners to complement each other's capabilities and create value. Indeed, the education/training programs create an open environment where IMEC and partners can interact and share technological problems, find suitable solutions, and create value.

4.4.2.2 IMI – innovative medicines initiative

Compared to IMEC, IMI uses similar but slightly different value creation mechanisms to benefit from the collaboration with partners. This is due to the fact that IMI is an insourcing agency that trains and educates individuals and partners so they can interact with other organizations. IMI creates value by providing knowledge platforms, funds, innovation management services, and education/training programs. In this respect, organizations are encouraged to interact with IMI to gain access to external knowledge and complementary products, reduce risks/costs, and receive financial support. Unlike IMEC, which receives 80% of its revenues from industrial partners, IMI is initiated by the European Union and the European Federation of Pharmaceutical Industries and Associations (EFPIA). This adds to IMI's credibility among the partners in the ecosystem and gives it a strong funding base. Similarly, the funding model of IMI during the two phases of research (See section 3.4 case box 6) clarifies how partners are financially supported and how they can benefit from collaboration with IMI. Moreover, partners believe that the government's financial support of IMI can reduce the risk of project failure. IMI also provides innovation management services to its partners. As partners join IMI and interact with partners on similar projects, they receive several project management services. In this respect, IMI's legal manager states *"IMI is supporting, monitoring, and managing the projects. On specific topics, we invite all stakeholders to meet, exchange information, and develop collaborative initiatives."* IMI not only supports research projects, but also provides different types of training/education programs. Through this mechanism—as just one example—IMI addresses the skills, knowledge, and behavior that are required for researchers' safety in using medical devices. It also creates an educational environment for partners to discuss their technological problems and come up with solutions. By offering these different value creation mechanisms, IMI can achieve its objectives as set by the European Union and the EFPIA.

4.4.3 Value capturing

Organizations in nano-electronics ecosystems use three approaches to capture value: arranging legal agreements, assigning contribution rights, and defining incentives.

First, legal agreements correspond to any legal contracts arranged between partners to protect and secure their IP and collaboration rights. Results show that organizations arrange different types of legal agreements to capture value. IP frameworks, bilateral, consultancy, and project agreements are some of the agreements identified. With regard to IP agreements, ecosystems offer IP protection and provide a single policy for all participating partners. In this respect, partners that join the collaboration benefit and own the IP. For instance, IMEC invites partners to acknowledge a bilateral agreement on the new IP generation. This agreement clarifies how the new knowledge could be shared among partners. SMEs and KULeuven sign the consultancy agreement. This enables KULeuven to offer SMEs different advises on technology know-hows and facilitate them to benefit from the joint collaboration. Through the legal agreements, ecosystem partners realize their benefits and share the value at organization or project levels. Second, contribution rights relate to the entrance fees and royalty fees that organizations may assign to partners. Indeed, this procedure differentiates partners from each other and in addition indicates how organizations can precisely contribute to the ecosystem. Interestingly, this approach is a common attitude that occurs in research centers and R&D companies. In this respect, NanoNextNL partners have 50% contribution (i.e. money or kind) and the government covers the rest. These contributions are clarified in Memorandum of Understanding (MOU) between partners and results or the value generated are shared among partners. DSM partners however, all have equal contribution rights. In other words, SMEs, large and MNE and academic institutes follow similar contribution rules. In IMEC innovation ecosystem, partners contribute differently. This means that, if partners financially support the project they would have certain rights compared to non-funding partners. Third, incentives are generally offered from the government or are structured internally to encourage collaboration between partners. They can be in forms of corporate allowances. For instance, NanoNextNl offers partners of the same program free patenting options. While this incentive encourages them to join the collaboration it allows them to benefit from the value creation process and reduce the patenting cost. In ASML innovation ecosystem, the Dutch government encourages partners to collaborate with academic institutes. Through employee tax reduction policies enforced by the government, ASML ensures that partners will be able to capture value.

In order to illustrate how partners in an innovation ecosystem can capture value, I describe in greater detail how the KULeuven and ASML ecosystems form value-capturing mechanisms for the ecosystem members.

4.4.3.1 KULeuven - katholieke universiteit leuven

Central to KULeuven's ecosystem activities is the KULeuven Association, an open and dynamic network linking university colleges across Flanders. This association's knowledge and technology transfer office is the Leuven Research and Development (LRD) center, which captures value by arranging legal agreements and assigning contribution rights. The fact that the KULeuven Association consists of different participating actors (universities, research centers, industrial partners, pharmaceutical companies, and hospitals) implies that the rules are customized for partners. KULeuven arranges different types of agreements with its academic and industrial partners. Generally, when industrial partners request collaboration, academic researchers enter into services or research contracts with companies. In addition, they interact with industrial partners in cooperative research projects. In this respect, the Legal Service of KULeuven supports researchers in drafting, negotiating, and monitoring the agreements. These agreements can be in various forms such as consultancy or laboratory tests. KULeuven also provides different services to industrial partners. The Flemish region (the Dutch region of Belgium) is mainly occupied by SMEs, which contribute to the regional economy to a large extent. Most of the large and multinational companies (e.g., Philips, Siemens, Royal Dutch Shell) are located in the Netherlands. This highlights the important role of the KULeuven LRD in establishing research and project contracts with partners in the ecosystem and facilitating the transfer of knowledge. In this respect, through KULeuven, the government offers financial support to R&D companies and SMEs' innovation projects and feasibility studies. This enables SMEs to use the link with KULeuven as a network platform and connect with other partners in the ecosystem. LRD at KULeuven also provides various legal services, IP protection rights, licensing agreements, cooperation agreements, and financial protection to spin-off companies during their startup phase. This support encourages spin-off companies to interact with pharmaceutical and medical research centers in different projects. With regard to IP, the LRD's manager governs the IP portfolio of the KULeuven Association. KULeuven has a flexible IP policy vis-a-vis some of its partners. Thus, when a technology does not belong to the core technology of LRD projects and the initial IP owner handles it. This encourages partners that are concerned about IP to join the KULeuven ecosystem. However, if the technology that is offered by a partner belongs to the core of the research group and can be reused for other applications, KULeuven arranges more broad-based IP frameworks that promote sharing. KULeuven assigns different contribution rights to ensure that partners can capture the value. The LRD general manager mentions the following in this respect *"If we license out to an SME, the proposition that we make will be a smaller upfront fee and a higher royalty fee later on. Because we know the SME does not have the money right now. While, if we license out to a large corporation we may say that it pays a little bit more up front and we will reduce the royalty rate later on."*

4.4.3.2 ASML

Compared to KULeuven, ASML uses a different type of IP policy with its partners. In some projects, ASML may collaborate with technical universities and some of the SMEs for as long as 10 years. In this situation, it is crucial that technical universities continuously provide well-educated people to work on the project. As ASML offers an IP framework agreement, it clarifies the financial terms and the context of the research projects for the partners involved in the program. In addition, it indicates how different components are subsidized in the projects. As ASML's strategic technology program director put it: *"We would like to get first access to inventions. The invention is then funded by us for at least half or a third of the costs. The Dutch government also initiates some funding."* Besides IP agreements, ASML defines incentives that are assigned by the Dutch government. These incentives enable partners to capture value in the ecosystem. Analysis suggests that the Dutch tax structure facilitates ASML product development. In other words, whenever ASML has a high income from a new product development, the Dutch government offers a very low corporate tax rate to R&D employees at ASML. In general, ASML spends more than one billion euros per year on R&D. Considering the corporate tax incentives from the government, ASML is able to save around 40 million euros per year.

4.4.4 Management of challenges

As mentioned previously, the search for value creation and capturing in innovation ecosystems can create potential conflicts. The results indicate that organizations face two major categories of challenges: inter-organizational challenges and intra-organizational challenges.

My analysis highlights twelve sources of inter-organizational challenges: differences in objectives and mindsets, different views on the research time frames of projects, IP protection issues, funding issues, partner withdrawal, public image, risk sharing, developing relationships, government contributions and interference, government requirements, and reporting and monitoring. In terms of intra-organizational challenges, financial problems and inter-departmental issues are the two major contributing elements.

Differences between organizational objectives and mindsets can create conflicts among ecosystem partners. For example, variations in organizations' demands or unrealistic expectations of universities from industrial partners can create tensions among partners. Similarly, lack of confidence in new technologies within pharmaceutical companies can create a defensive wall in such organizations that interferes with their collaboration in an open innovation environment. In this regard, developing effective relationships in joint projects could create tensions and be time consuming. The next inter-organizational challenge factor stems from different partner views on research time frames. Variations in organizations' objectives lead to different research time frames. For instance, SMEs tend to spend more time on delivering research projects because they have less R&D infrastructure and this can cause challenges when they work with large partners. IP protection is another type of inter-organizational challenge. When organizations interact to create new products or to develop existing ones, lack of IP protection or lack of clarity in the IP contract can create tensions between partners. Another challenge identified in this study is a lack of sufficient funding and financial stability of ecosystem partners. As such, partners seek contracts that offer reasonable funding amounts, which enable them to proceed with the research project and deliver the deliverables on time. Indeed, lack of funding may lead to the withdrawal of partners from research projects. The analysis shows that withdrawal of partners can result in not just delay in delivery time but actual project failure. It can further create a bad public image of the partners. Uncertainty in relation to customers' demand creates risks in organizations. Due to lengthy project delivery time frames, customers are uncertain or may change their requirements at the time of project delivery. Another challenge identified is that of government contribution and interference. The study shows that whenever the Dutch government contributes to projects, it monitors the activities and this creates a tense situation among partners.

In addition to inter-organizational challenges, results also suggest a few intra-organizational challenges that create tensions between departments. First, financial problems between organizations' departments can create tensions and may further result in inter-organizational challenges. For instance, the high costs of clinical trials, diagnostic tests, and the final FDA approval in pharmaceutical companies can generate problems that delay the work process and collaboration with partners. Second is the tension that is created by the lack of communication and negotiation among internal departments. Notably, in pharmaceutical companies, negotiations with the IP department can potentially trigger intra-organizational challenges.

I selected two case studies, DSM and NanoNextNl, to explicitly describe and compare the challenges and management procedures within innovation ecosystems.

4.4.4.1 DSM

Differences in the mindsets of DSM partners can create conflicts among ecosystem partners. As DSM interacts with pharmaceutical, medical, and chemical companies, their objectives and mindsets in performing business can have a significant impact on value creation and capturing mechanisms within the innovation ecosystem. DSM's vice president of open innovation spoke about biomedical organizations' perspective towards open innovation: *"The people in the biomedical materials companies are very afraid of open innovation. Therefore, people in my position and the CIO have to convince them."* IP protection is also a challenging task for DSM. The legal and IP agreements that DSM provides to its partners enable them to capture some of the value. Along the same lines, DSM seeks contracts that can guarantee similar protections for DSM. Since the various partners focus on their individual benefits in the innovation ecosystem, this may be a challenging task for DSM. DSM furthermore indicates that they continuously look for contracts that can provide sufficient funding for proposed research projects. Lack of funding may lead to partner withdrawal, which poses challenges. Intra-organizational hurdles at DSM emerge because of inconsistencies between departments. With respect to human resources, for example, one issue relates to frequent mobilization of personnel in departments, which often occurs in venturing teams as well as in management boards of startups. Personnel mobilization reduces trust within organizations and creates unreliable management.

In order to manage these challenges, DSM in the first instance serves as an orchestrator, welcoming manufacturing companies that are willing to participate in the Chemelot ecosystem.[14] Secondly, it supports R&D and innovation activities and continues to do so. In addition, whenever required, DSM changes some of the performance measurements and managerial strategies to reach common ground with its partners. For instance, DSM enforces rigorous IP-ownership policies to prevent a partner's withdrawal from the ecosystem. This leads to a win-win situation for DSM and the remaining partners as they are assured that their contributions in kind and money are protected.

[14] Chemelot is the name of DSM's innovation ecosystem that concentrates on different innovative collaborations.

4.4.4.2 NanoNextNl

Compared to DSM, NanoNextNl faces more challenges in the search for value creation/capturing processes. Challenges are mainly related to the relationships with external partners. The NanoNextNl ecosystem consists of different types of actors. Academic institutes seek research and science-based projects whereas industrial organizations look for developmental activities. As NanoNextNl concentrates on both research and development activities, the difference between the objectives of various organizations can create tensions within the innovation ecosystem. According to the NanoNextNl program director *"NanoNextNl is an R&D program. Companies are specifically focusing on development whereas academic institutes are concentrating on research. They have a problem in who is going to lead. It is our task to really bring them together and balance it."* The long research time frame (i.e. seven years) in NanoNextNl creates a challenging situation for SMEs, as they cannot afford to invest large amounts of money in long-term projects. Hence, attracting SMEs can be a challenging task for NanoNextNl. Additionally, developing inter-organizational relationships within the programs may take up to two years. Continuous effort is required to build, develop, and maintain relationships. NanoNextNl considers communication as a key parameter to developing relationships and personal involvement. In spite of these efforts, results show that NanoNextNl faces challenges in bringing partners together and aligning them towards a common goal. Results furthermore reveal that NanoNextNl faces different financial challenges at the start of programs. While partners are already involved in projects, the funding may take time. This can create a challenging situation for SMEs and other partners that have less financial means, to the extent that partners may even withdraw from the program. The government's contribution and interference and its related requirements with respect to research projects are other challenges within the NanoNextNl ecosystem. As the NanoNextNl program director comments: *"It is interesting for companies to receive funding to develop new products. So all partners invest 50% and receive 50% governmental funding."* While the government contributes financially, however, it also requires collaboration between partners and further monitors the activities, thus creating tensions within the ecosystem.

The results indicate that NanoNextNl, as a coordinator and supporter of research projects, applies flexible strategies to manage tensions, customizing its approach according to research programs and individual research projects. With respect to partner withdrawal, unlike DSM, NanoNextNl looks for flexible solutions and other alternatives to substitute these partners with similar ones.

4.5 Discussion and conclusions

The purpose of this chapter was to explore how ecosystem members jointly create value, and capture some of that value, and determine the type of challenges they face during these processes. The inherent tension between the smooth collaboration in order to create value together and the need for each partner to appropriate part of that value may lead to serious management challenges within nano-electronics innovation ecosystems. In order to study the strategic functioning of innovation ecosystems, it is necessary to look at value drivers, co-creating and co-capturing mechanisms, and ecosystem management challenges in a holistic approach. Therefore, this chapter develops an encompassing view of value drivers, value creation and capturing mechanisms, and ecosystem management challenges (Adner & Kapoor, 2010; Lubik et al., 2013; Nambisan & Sawhney, 2011; Vanhaverbeke & Cloodt, 2006).

With respect to value drivers, this study shows that nano-electronics organizations join innovation ecosystems not only to access external knowledge, but also to have an opportunity to access partners with an open innovation mentality. Openness and flexible collaboration strategies motivate partners to join innovation ecosystems and benefit from the interactions. Two common value creation mechanisms are "providing knowledge and collaboration platforms" and "offering education/training programs". Partners share their knowledge, expand their networks, gain access to manufacturing capabilities, and reduce their R&D costs through knowledge platforms. Similarly, through education programs, organizations create a shared vision to organize their collaborations and recognize their roles and that of other ecosystem partners. While organizations collaborate to create value, they also try to capture some of that value through different mechanisms. The findings of the interviews indicate that, although organizations mainly use legal agreements such as IP and bilateral agreements to capture value, some use "contribution rights" as a more novel approach. This implies that the value an organization in an ecosystem can capture depends on its contributions to the project and its negation skills to convince other ecosystem partners about its contributions. The interactions among partners and the search for value this lead to several challenges.

Results suggest that organizations face two major categories of challenges in innovation ecosystems, i.e. inter-organizational and intra-organizational challenges. One of the novel challenges identified in the first category is partner withdrawal. Lack of financial means, which can lead to withdrawal of partners from the collaboration, is an important issue that requires an effective management strategy. In the second category, inconsistencies between organizational departments in an organization are crucial to identify as they may impact the project performance and delivery time and hence lead to ecosystem challenges. To manage these challenges and resolve tensions, an ecosystem orchestrator can provide financial support, integrate expertise, and build strong and trustworthy relationships (Adner & Kapoor, 2010; Amit & Zott, 2001; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011; R Normann, 2001; Vanhaverbeke & Cloodt, 2006). Similarly, governments (who were involved in many of the studied innovation ecosystems) can facilitate the management of these challenges.

Innovation ecosystems entail several challenges for managers. They should attempt to try to understand the complexity of innovation ecosystems through comprehensively examining how "value is created and captured in innovation ecosystems". Ecosystems are neither firm nor market centric and therefore require a multilevel approach of value creation and capturing. Managers should recognize that an in innovation ecosystem, the interconnection and integration of resources and competencies among actors determine the innovation potential (and thus the value creation potential). While value is co-created and co-captured, managers need to move away from firm-level business models to ecosystem-focused business models to study the interdependence of the activities of the actors in an appropriate way.

The results of this chapter further offer different implications for public authorities. First, governments can play a role in creating the blueprint of innovation ecosystems. By bringing relevant partners together and financially encouraging them, governments have the power to create effective ecosystems. Governments can for instance ensure cross-disciplinary research by stimulating the involvement of research centers with different areas of expertise in ecosystem projects. Rather than through direct interference, which may create tensions within ecosystems, governments should financially encourage research centers and publicly supported organizations to collaborate with large and small companies. Second, governments can actually get involved in setting up ecosystems and financially supporting research projects. In general, if governments are involved in establishing an innovation ecosystem, the process will take more time because of administrative and bureaucratic functions. This implies that it is better for the government to define rules and objectives and financially support activities, but manage them indirectly. In this respect, governments can set up regulatory boards to monitor research activities and project milestones. Lastly, governments need to support and manage SMEs. Lack of financial means and expertise in SMEs forces them to withdraw from innovation ecosystems. As such, governments can financially support and stimulate SMEs to join innovation ecosystems and protect them from the consequences of potential ecosystem failures.

Although this study identifies new value creation and value capturing mechanisms and thus adds to the body of knowledge on innovation ecosystems, it has a number of limitations that open the door to future research directions. While I identified the richness and complexity of different mechanisms behind the ecosystem by focusing on the building blocks and the challenges, it would be interesting to explore in greater detail how different building blocks interact to achieve a successful innovation ecosystem. Next, considering the mechanisms identified in the theoretical model, it is worthwhile to measure the impact of challenges on value creation and value capturing activities—in other words, to explore how conflicts between organizations can influence the content, functioning, and effectiveness of value creation and value capturing mechanisms. Further, more studies from other industries can be used to increase the external validity of my results. Moreover, it would be interesting to explore similar aspects in other industries and conduct comparative research. Despite these limitations, this chapter shows how different partners create and capture value in ecosystems. It highlights that this phenomena, "ecosystem-based innovation", needs further research to understand how ecosystems are essential in the contemporary innovation landscape: therefore I encourage other scholars to explore this phenomenon in more detail.

Chapter 5

5 The roles of different actors in the Belgian and Dutch nano-electronics innovation ecosystems

5.1 Introduction

An innovation ecosystem is a system of interdependent firms whose performance is shaped by their interactions (Adner & Kapoor, 2010; J. F. Moore, 1993) and by the presence of an ecosystem-level objective (Adner, 2006; Ranjay Gulati, Puranam, & Tushman, 2012). The performance of the individual players in an ecosystem influences the overall performance of the ecosystem (Iansiti & Levien, 2004b). Acknowledging the interdependency of actors in the innovation ecosystem highlights first the importance of having different types of actors that play a specific role in an innovation ecosystem and, second, how these different actors need to interact with each other in the ecosystem in order to reach the targeted objective. Selecting the right type of partner to join the ecosystem and assigning suitable roles impacts the value creation and capturing process in an innovation ecosystem. As actors play different roles, it is important to align and manage these roles in order to realize the overall objective of the ecosystem. In this respect, an orchestrator usually plays a key role. By recognizing the type and role of actors, an orchestrator can shape and structure the ecosystem to optimize its performance. This aspect in explaining the success of ecosystems has been studied by several scholars (Adner, 2012; Bosch-Sijtsema et al., 2014; Dhanaraj & Parkhe, 2006; Hu, 2011; Iansiti & Levien, 2004a; Leten et al., 2013; Nambisan & Sawhney, 2008, 2011; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006).

The role of non-orchestrators has been less explored and scholars that focused on the role of orchestrators primarily examined leading firms with respect to establishing an innovation ecosystem (Rohrbeck et al., 2009), ecosystem strategy and partnership (Basole, 2009; Bosch-Sijtsema et al., 2014; Vanhaverbeke & Cloodt, 2006), and orchestration strategy (Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004a; Leten et al., 2013; Nambisan & Sawhney, 2011). Considering that in the innovation ecosystem all actors (orchestrators and non-orchestrators) collaborate with each other, it is important to examine the role of both, and not only the orchestrator's role, as has been done previously.

Reflecting on the interdependence of actors in innovation ecosystems, scholars have mainly examined their technological interdependence (Adner & Kapoor, 2010), the interdependency of evolving ecosystem strategies (West & Wood, 2013), the interdependence of ecosystem risks (Hogenelst et al., 2014), and in the business ecosystem literature, authors have mainly focused on the interdependency of actors' business models (Hellström, Tsvetkova, Gustafsson, & Wikström, 2015). Studies that analyzed the role of actors in innovation ecosystems failed to observe their interdependency in such ecosystems (Hu, 2011; Nambisan & Sawhney, 2008, 2011).

The extant literature shows two unexplored themes. First is the role of actors other than the orchestrator in innovation ecosystems. All the actors in innovation ecosystems jointly create value, participate, and simultaneously play different roles in the value creation process. Hence, the roles of different ecosystem partners should be considered simultaneously and not in isolation. Concentrating on the role of only one type of actor in the innovation ecosystem not only creates a biased view of the ecosystem, but it also undermines a full understanding of the value creation process in ecosystems. Recognizing the joint value creation process in the innovation ecosystem thus requires a holistic approach, and investigating the role of key participating actors is crucial to understanding how they jointly achieve their set targets. Second is the interdependency of actors in innovation ecosystems. Actors in the innovation ecosystem are interdependent with respect to resources, such as knowledge and technology expertise (Adner & Kapoor, 2010; Hogenelst et al., 2014). In addition, prior studies have shown that actors in search for value creation face different challenges; diversity of objectives, IP protection issues, and risk sharing are some of the challenges that call for ecosystem management. In this respect the orchestrator tries to align different objectives in the ecosystem. It is important to acknowledge that actors each have individual objectives and that their roles are not automatically performed in a way that will maximize the value creation potential of the innovation ecosystem. An orchestrator will help manage and solve possible conflicts arising in the ecosystem (Adner, 2012; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011). By understanding the resource complementarity of each actor in the ecosystem, the orchestrator can define the actors' roles with respect to their individual objectives and capabilities, interdependency of roles, and maximization of the joint value creation. This facilitates the orchestrator to interact with actors, shape their roles and structure the ecosystem to enhance its overall performance.

Following a qualitative approach, I investigated and collected data from seven nano-electronics innovation ecosystems in Belgium and the Netherlands. The theoretical analysis of the data enabled me to generate a model. This model reflects on the green section of figure 2 illustrated in the introduction chapter. The theoretical model illustrates that, in order to accomplish the ecosystem objectives, it is essential to understand the logic of creating an ecosystem, to identify the type of partners and the factors that motivate them to join an ecosystem, to specify the role of orchestrators in defining and managing partners' roles, and to examine how the actors may interact with each other.

By examining the diversity of roles and the interdependency among different actors in an innovation ecosystem, this research contributes to the literature in different ways. First, it adds to innovation ecosystem literature by considering the role of both non-orchestrators and orchestrators, and investigates how these different actors, who have specific roles, contribute to realize the overall objective of the innovation ecosystem (Adner, 2012; Bosch-Sijtsema et al., 2014; Dhanaraj & Parkhe, 2006; Hu, 2011; Iansiti & Levien, 2004a; Leten et al., 2013; Nambisan & Sawhney, 2008, 2011; Rohrbeck et al., 2009; Vanhaverbeke & Cloodt, 2006). Second, it adds to body of knowledge on the different types of actors and their roles in nano-electronics innovation ecosystems. By considering interdependency and exploring multiple roles of actors in the innovation ecosystem, this complements studies by Hu (2011) and Nambisan and Sawhney (2008, 2011). Third, the theoretical model offers a guideline for orchestrators to recognize the logic behind actors' roles in shaping and structuring the ecosystem and to enhance the ecosystem's performance. Finally, by emphasizing the importance of both the orchestrators' and non-orchestrators' roles, the model offers managers and policy makers a blueprint to maximize the joint value creation in their innovation ecosystem.

This chapter is structured as follows. First, the background literature on establishing an innovation ecosystem, the role of actors and the emergence of orchestrators are presented. Second, the research setting, data collection and data analysis are described. Third, the findings of the study and the theoretical model are presented. Fourth, key findings are discussed. Finally, concluding remarks followed by several theoretical and managerial implications are proposed.

5.2 Background literature

5.2.1 Establishing an innovation ecosystem

An innovation ecosystem is defined as "... the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution" (Adner, 2006, p. 98). An innovation ecosystem is thus a group of organizations that aim to create and capture value from innovation activities (Adner, 2006; Adner & Kapoor, 2010; Ritala et al., 2013). As firms and their knowledge partners adopt collaborative innovation practices, they create networks of collaborative agreements and ultimately expand their networks to create an innovation ecosystem (Adner, 2006, 2012; Chesbrough & Bogers, 2014; Dhanaraj & Parkhe, 2006; Gomes-Casseres, 2003, 2015).

Although innovation ecosystems vary based on the scope, structure, and nature of relationships and processes (Willianson & De Meyer, 2012), they all have common features. In this respect, Nambisan and Sawhney (2008) suggested shared goals, shared "world-view", social knowledge creation, and architecture of participation as common features of innovation ecosystems. First, it is critical that actors share a common goal and interact towards delivery of that specific goal. Second is sharing a "world-view", or their understanding about the external environment. This enables actors to capitalize on the potential synergies between the expertise and capabilities of different actors in the ecosystem. Third, the "social" knowledge creation principal in the innovation ecosystem indicates that as different types of actors interact with each other, new knowledge is created (Hu, 2011). Fourth is the architecture of participation, which addresses the work distribution among actors and their share of innovation rights. Using this principle, actors are provided with a suitable roadmap to join and innovate together (Nambisan & Sawhney, 2008)

5.2.2 The strategic logic behind creating an innovation ecosystem

In the first place, it is important to understand why innovation ecosystems are established. In other words, what is the strategic logic behind their establishment? Drawing from the resource-based view (Barney, 1991; Wernerfelt, 1984) and the knowledge-based view (Grant, 1996), it is assumed that a search for valuable resources - especially knowledge - is one of the important reasons to create an innovation ecosystem. As organizations collaborate with each other to expand their knowledge and expertise, they interact with variety of actors. This leads to the creation of an innovation ecosystem. On the same note, Brusoni and Prencipe (2013) have indicated that the emergence of different types of innovation ecosystems are based on the knowledge requirement imposed on the focal firm. Innovation ecosystems create a platform for the exchange of explicit and tacit knowledge (Hu, 2011). As such, access to external knowledge is one of the motivation factors that encourage organizations[15] to connect with external partners (i.e. universities and research institutes, government laboratories, and industry research associations). Motivation is defined as a psychological process that results in increase, direction, and persistence of voluntary actions that are goal-directed (Mitchell, 1982).

Besides knowledge, a lack of technology expertise, the high cost of R&D and the commercialization of products are other factors that motivate organizations to interact with external partners (Arvanitis, Kubli, & Woerter, 2008; Batterink et al., 2010; Håkansson & Ford, 2002; Kilian, Schubert, & Bjørn-Andersen, 2015; Y. S. Lee, 2000). Each organization has different motivation factors that encourage them to choose external partners and create a unique innovation ecosystem, based on its objectives (i.e. individual reasons for organizations to join an innovation ecosystem). This means that organizations’ objectives are the logic behind establishing an innovation ecosystem, thus they should be aligned together to avoid any conflicts and enhance the ecosystem’s performance.

A pharmaceutical company, for example, that creates innovative drugs has different types of external partners compared to one that generates enhanced diagnostics results. While they both operate in related industries, they are part of

[15] Organizations or actors in this research refer to industrial firms, universities, research centers and other entities that participate in value creation and capturing process in innovation ecosystems.

different innovation ecosystems. Their objectives drive them to join different innovation ecosystems or to create a new one.

Reflecting on the resource dependency theory (Pfeffer & Salancik, 2003), resources in innovation ecosystems create different interactions and determine the content of the innovation ecosystem organization. In other words, actors that provide complementary resources may create relational interdependences between them, whereas actors that share similar knowledge may construct a cluster or consortia among them.

The interdependency between actors is one of the important key features of an innovation ecosystem, implying that the performance of one organization is highly dependent on the assets that other organizations provide to the ecosystem (Iansiti & Levien, 2004b). Smooth collaboration between interdependent actors can strengthen their competitive advantage. However, it may also lead to potential challenges in the innovation ecosystem. One is the actors' dependency on the complementary products and resources. If the ecosystem is well structured, the challenges of interdependencies can be reduced or resolved. However, if the logic of interdependency becomes an opportunistic logic, the interdependency aspect of the ecosystem can undermine the health of the overall ecosystem. In other words, the interdependency of participating actors should lead them to structure and shape their role in a way that, while they complement each other in jointly creating value, they enhance the overall innovation ecosystem competency. Indeed, this will reduce the possibility of actors changing their roles or stepping down from their role, which may result in ecosystem failure. Thus, it is important to establish an innovation ecosystem where different actors with diverse capabilities and resources come together, interact, commit to collaborate and share ecosystem success (Frankort, 2014).

In summary, the interdependency of roles is a critical success factor in innovation ecosystems, but it can also undermine the success and even the survival of innovation ecosystems (Pfeffer & Salancik, 2003). In other words, if actors are not performing their roles in a properly defined manner it may negatively influence the performance of other actors and ultimately endanger the performance of the innovation ecosystem. According to Adner and Kapoor (2010), the interdependency challenges are based on the position of knowledge input flow (provided by the ecosystem actors) and the knowledge output flow (recipients of the knowledge) with respect to the focal firm. As such, considering firms' vertical integration could be one of the main strategy components to manage interdependencies.

5.2.3 Roles of actors – evidence from the literature

Nambisan and Sawhney (2008) assume that the characteristics of the innovation roles are based on the kind of activities that actors are involved in, or the type of innovative contribution that they are required to perform. "Roles in an ecosystem aren't static" (Iansiti & Levien, 2004b, p. 11) and thus organizations can have multiple roles simultaneously or over a period of time. For example, in an ecosystem an actor can play the role of an orchestrator and can perform as knowledge or infrastructure provider. On top of that, the interdependency of actors in the innovation ecosystems leads to an interdependency of roles. This implies that roles are recognized collectively and organizations' roles (current and potential) have to be designed to support the health and stability of the ecosystem. In this respect, it is essential to understand the role of different actors in an ecosystem (Iansiti & Levien, 2004b).

Considering the literature on innovation ecosystems and role of actors, Nambisan and Sawhney (2008) assume that actors can play three different roles in an innovation ecosystem. They can be an architect, an adapter, or an agent. An architect is responsible for providing the initial resources to create the innovation ecosystem and setting the innovation agenda. An adapter corresponds to actors who take the direction of the architects, and have a supporting role that is less central. An agent acts as a broker, a bridge or go-between in an innovation ecosystem. Thus, it can facilitate the transfer of innovation knowledge from one actor to another (S. Lee, Park, Yoon, & Park, 2010). Innovation ecosystem scholars have mainly focused on the role of orchestrators or hub firms (Dhanaraj & Parkhe, 2006; Gawer & Cusumano, 2002; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011). Although the orchestrators play an important role in innovation ecosystems, in my view it is crucial to understand the role of other, non-orchestrating actors in the ecosystem. In other words, in this chapter I intend to respond to the research question by understanding the logic behind the multiple roles that different actors play in innovation ecosystems.

5.2.4 Emergence of orchestrators

Studies in innovation ecosystem literature assume that inter-organizational collaborations that involve knowledge exchange and combination of complementary resources and capabilities are key drivers of joint innovation processes (J. H. Dyer & Singh, 1998; Kapoor, 2013). Possible conflicts of interest and the uncertainty generated by the existing interdependencies and complementarities call for precise ecosystem management (Adner, 2006; Kapoor, 2013), which leads to the emergence of orchestrators[16]. In "industrial architecture" and "industrial dynamics" literature scholars have similarly examined the role of the dominating firms (i.e. kingpin) and the interdependency of actors in innovation ecosystems (Jacobides & Tae, 2015). Considering both literature streams, orchestrators play a crucial role in innovation ecosystems. They bring firms together and define the innovation architecture of the ecosystems in such a way that firms can exploit the market opportunities (Nambisan & Sawhney, 2011).

In general, an orchestrator brings together different partners with various capabilities to interact toward common goals. By providing a set of common assets, it intends to enhance the overall health of the ecosystems and its stability (Iansiti & Levien, 2004b). The orchestrator builds the innovation ecosystem around core activities. To simplify complex problems, an orchestrator divides the tasks and distributes them to more efficient partners in the ecosystem. This increases the productivity of the innovation ecosystem. Moreover, the orchestrator strategically intends to maximize the alignment between various activities and actors, and optimizes the interfaces to reduce the risks, uncertainty, variability, and the transaction costs (Hsieh, Lazzarini, Nickerson, & Laurini, 2010). Notably, an orchestrator has two strategies to apply. One is to assure that value is created in the ecosystem, and second the orchestrator has to guarantee that there is a fair distribution of the value that is created (Iansiti & Levien, 2004b). However, what is really important it is the balance between these two strategies. If actors' expected benefits are not realized, they may not participate and the ecosystem will collapse. While roles determine how the value is distributed among the partners, Jacobides, Knudsen, and Augier (2006) suggested that firms put a substantial effort to not only define rules that indicate "who does what", but also more decisively address "who takes what".

In this respect, Nambisan and Sawhney (2011), have indicated that managing the innovation appropriability (value distribution) is one of the tasks that orchestrators should consider in innovation ecosystems. They assume that the orchestrators play different roles based on the orchestration model. They can be an innovation integrator in innovation-based model, or they can play a role as a platform leader in a platform-based model. As an innovation integrator, the orchestrator defines the basic architecture for the core innovation and welcomes actors to design and enhance the components for the core innovations. Later, the orchestrator integrates all the components to shape the core innovation. Unlike the innovation integrator, a platform leader defines and offers a basic innovation architecture,

[16] An orchestrator is the actor who participates, establishes and manages the ecosystem (Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011).

which later becomes the foundation for actors to create their innovation complementarities.

In this respect, Hu (2011) takes a different standpoint. He identifies various roles that a focal firm or a lead firm could play in an innovation ecosystem. In this study, network organization components (i.e. resources, actors, and infrastructure) at three levels of intra-organizational network, inter-organizational network, and the network itself were explored. He suggested that a focal firm, based on their power in the network, could have various roles ranging from a strong to a weak power[17] level. In intra-organizational levels with a high or intermediate power of hierarchy, the focal firm could manage or orchestrate different network actors. Whereas at an inter-organizational level, the firm is no longer within its boundaries, thus, its power is weakened by the other actors' power. Here the focal firm coordinates the network organization. If the power of focal firm is low, the focal firm participates in the network organizations, and if the power is too low to influence the network organization, the focal firm adapts to the environment. As such, the focal firm can play a role as a manager, orchestrator, coordinator, participator or an adaptor.

Although studies by Nambisan and Sawhney (2008, 2011) and Hu (2011) offer significant insights, they have a number of limitations. First, studies by Nambisan and Sawhney (2008, 2011) focus on the role of the hub firm or the orchestrator. While they identify different roles for the orchestrator, the role of other participating actors (i.e. non-orchestrators) in the ecosystem is left untouched. Second, studies investigate the role based on the network design, innovation design, nature of the innovation space, and structure of the network leadership. They do not examine the interdependency of actors' roles. Hu (2011) identifies the roles of actors based on an SME firm. While he takes a linear approach toward investigating different roles according to the firm's power level in the network, his findings are based on a single actor (i.e. SME) and they can thus not be generalized for other types of actors (i.e. academic institutes or large industrial firms).

In sum, despite a few studies having examined the role of actors, the interdependency of the roles of those actors – a key aspect of the innovation ecosystem - is not examined. By considering actors' interdependency in an innovation ecosystem it is possible to explore why actors join an innovation ecosystem, how they can have different roles that in the innovation ecosystem, and how they should interact with each other in the ecosystem environment.

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[17] Based on the resource dependency theory, if one firm processes resources that the orchestrator highly depends upon, then the firm has power over the orchestrator (Hu, 2011).

5.2.5 The benefits of an innovation ecosystem from the actors' perspective

A well-established innovation ecosystem gives benefits to the participating actors. Collaboration in an innovation ecosystem not only enables the actors to resolve complex problems, it also allows them to achieve their organizational objectives (Willianson & De Meyer, 2012). The benefits that the actors gain may vary, depending on their roles in the ecosystem. A number of studies have explored the benefits of the orchestrator's role, but the benefits of the non-orchestrator's role have yet to be explored. Therefore, it is important to explore how actors playing a specific role benefit from participating in an innovation ecosystem. In summary, understanding the types of actors and their different innovation roles is crucial to structure and direct ecosystems.

When mapping the innovation ecosystem literature, I found that the motivations behind the actors' interactions with regard to the roles they play in an innovation ecosystem have not yet been clearly defined. The diversity of actors and the interdependency of their roles in innovation ecosystems suggests that in order to recognize the types and roles of actors in an innovation ecosystem, it is important to investigate the motivations behind the interactions of specific actors, and the ways these interactions occur (Chesbrough & Brunswicker, 2013; Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004b; Nambisan & Sawhney, 2008; Tidd & Bessant, 2014).

As such, this research intends to concentrate on "established" innovation ecosystems, and to investigate the different types of actors and the roles they play in innovation ecosystems. Similar to the studies by Nambisan and Sawhney (2008, 2011), this research considers innovation ecosystems to be units of analysis. It further enhances their outcomes by identifying the multiple roles of an orchestrator in an innovation ecosystem. Moreover, it complements Hu (2011) approach by concentrating on the multiple types of actors in the ecosystems and examining their roles. Notably, it adds to the body of literature on innovation ecosystems by examining the logic behind establishing innovation ecosystems, the different roles of the actors, and the interactions between them. This has enabled me to realize how the roles of different actors such as the orchestrators, governments, and other participating actors, are shaped and joined together to ultimately deliver the ecosystem's objectives.

5.3 Method

This section describes the research setting and the methodology used in this thesis.

5.3.1 Research setting and sample

The research setting of this study is represented by nano-electronics innovation ecosystems. Below illustrates the methodology of this study (See chapter 3 for a comprehensive overview of the research setting and methodology).

5.3.2 Methodology

Considering prior studies, there is a need for a theory development approach to investigate different roles of actors in the innovation ecosystem (Adner, 2012; Adner & Kapoor, 2010; Hu, 2011; Nambisan & Sawhney, 2008, 2011). In order to explore different roles of actors in the ecosystem, it is essential to understand the opinion of the organizations in the nano-electronics industry (Miles & Huberman, 1994). As such, the most appropriate approach to investigate different roles of actors in the innovation ecosystem is the qualitative method. In this respect, I selected and examined seven innovation ecosystems (i.e. IMEC, ASML, IMI, Ridgetop, CTMM, TMC and CMOSIS) that comprehensively responded to the research questions and lead to theory generation (Corbin & Strauss, 2014; Eisenhardt, 1989a) (See section 3.4 for extensive case descriptions).

5.4 Findings

The coding procedure and the grounded theory development enabled me to identify different themes. The themes and their corresponding sub-categories as illustrated in appendix C are presented across the seven cases in table 11. Connecting themes in a specific logical order then led to the generation of a theoretical model. Using the steps in figure 10, I present a comprehensive overview (See table 11) of how the seven innovation ecosystems that I studied can be analyzed according to the different steps showed in figure 10. In the following section first three of the innovation ecosystems are comprehensively explained and an overview of the seven innovation ecosystems are presented. Second the logic behind different blocks of the theoretical model is illustrated and each block is explained.

5.4.1 Case studies

In this section, to avoid long case study descriptions I focus on three distinct innovation ecosystems of IMEC, ASML and CTMM illustrating how different actors play different roles in an innovation ecosystem, how their roles are linked to the overall objective of the ecosystem, and how orchestrators need to align the role of partners to achieve success with the ecosystem. I only describe these ecosystems as diverse examples on how the innovation ecosystem functions. Indeed, other four ecosystems could similarly be explicated using the table 11. Table 11 presents different elements identified across the seven innovation ecosystems.

5.4.1.1 IMEC

In 1982, the Flemish Government set up a major initiative in the field of microelectronics with the goal to strengthen the microelectronics industry in Flanders. Two years later IMEC, an interuniversity research institute was founded. More than 3 decades later, IMEC has become the world-leading R&D and innovation hub in nano-electronics and digital technology. Its research focuses on the next generations of chips and systems. IMEC's research bridges the gap between fundamental research at universities and technology development in industry to produce advanced products and improve the quality of health care. Its success is based on its Industrial Affiliation Programs (IAPs). An IAP represents an innovation ecosystem in which IMEC plays the role of a hub-organization and trusted partner for companies in the nano-electronics industry. An IAP starts with a research program written by IMEC researchers. Next, IMEC tries to convince large companies in the nano-electronics industry (e.g. NXP, Infineon, STMicroelectronics, Intel, Matsushita/Panasonic, Texas Instruments, Samsung and TSMC) to join the IAP to co-develop new technologies within the specs of the research program. The research is pre-competitive (3-7 years ahead of the market) and it is therefore relatively easy for industrial partners from the same industry to collaborate on new technological developments. This leads to a network of on average five to fifteen partners executing a research program over a period of several years. Each IAP partner works together with IMEC on a specific part of the program, but partners can use all the research outcomes developed within an IAP irrespective of whether they have contributed to it or not. IMEC inks bilateral agreements with each of the partners to structure the collaboration in an IAP.

Table 11 The summary of the innovation ecosystems and their identified specifications

Innovation ecosystem	Type	Number of partners	Objectives	Type of partners	Motivation factors	Orchestrators' role	Partners' role	Interaction ties
ASML	Manufacturing company	Around 700 Chip-manufacturing companies	- Establish ecosystem platform - Produce innovative products & solutions - Improve health care	- Academic institutes - Industrial firms - Customers - Suppliers - The Dutch government	- Access to knowledge & infrastructure - Financial matters & risk - Commercialization & incentives	- Orchestrator - Leader - Integrator - Facilitator - Supporter - Supplier - Motivator - Advisor - Monitor	- Project or program participator/ partner - Consultant/ advisor - Facilitator	- IP - Financial - Knowledge & information - Regulatory/ advisory - Contracts
CTMM	Public-private partnership	More than 100	- Establish ecosystem platform - Funding support - Monitor activities - Improve health care	- Academic institutes - Industrial firms - Pharmaceutical companies - Hospitals - Patients & Patient organizations - The Dutch government & regulatory agencies	- Financial matters & risk - Commercialization & incentives - Policy enforcement	-Orchestrator -Leader -Initiator -Intermediary -Supervisor -Monitor	- Project or program participator/ partner - Leader - Consultant/ advisor - Facilitator	- Power - IP - Financial - Knowledge & information
IMEC	Research center	More than 100	- Produce innovative products & solutions - Improve health care	- Academic institutes - Industrial firms - Pharmaceutical companies - Diagnostic companies - Hospitals - Patients - The Dutch government	- Access to knowledge & infrastructure - Financial matters & risk - Commercialization & incentives - Relationship history	-Orchestrator -Leader -Integrator -Project/ program leader	- Project or program participator/ partner - Associated partner - Facilitator - Regulator	- Power - IP - Financial - Knowledge & information

Innovation ecosystem	Type	Number of partners	Objectives	Type of partners	Motivation factors	Orchestrators' role	Partners' role	Interaction ties
IMI	Public-private partnership	More than 100 partners, 30 in pharma	- Establish ecosystem platform - Funding support - Monitor activities - Improve health care	- Academic institutes - Industrial firms - Pharmaceutical companies - The Dutch government & regulatory agencies - Consultancy / Advisors	- Access to knowledge & infrastructure - Commercialization & incentives	-Orchestrator -Leader -Initiator -Intermediary -Funding agent -Facilitator -Advisor - Monitor	- Project or program participator/ partner - Associated partner - Consultant/ advisor - Facilitator	- Power - IP - Financial
Ridgetop	Technology & Solution provider	More than 100	- Produce innovative products & solutions	- Academic institutes - Industrial firms - Customers - Suppliers - Semiconductor companies - Consultancy/ Engineering company	Access to knowledge & infrastructure Commercialization & incentives	- Program/ project leader - Market leader - Supervisor - Supporter - Project partner - Industry client - Solution provider	- Solution provider - Project or program participator/ - Partner - Consultant/ advisor	- IP - Financial - Knowledge & information - Regulatory/ advisory - Contracts
TMC	Insourcing agent	More than 200	- Establish ecosystem platform - Improve health care	- Academic institutes - Industrial firms - Diagnostic companies	Access to knowledge & infrastructure Commercialization & incentives	-Program/ project leader -Market leader -Facilitator -Supporter -Motivator	- Project or program participator/ partner - Consultant/ advisor	- Financial - Knowledge & information - Regulatory/ advisory
CMOSIS	Electronics part supplier	More than 300	- Produce innovative products & solutions	- Academic institutes - Industrial firms - Industrial digital & inspection camera manufacturers	Access to knowledge & infrastructure Financial matters & risk Commercialization & incentives	-Project or program participator/ partner -Supplier -Supporter	- Program or project leader - Project or program participator/ partner	- IP - Financial - Contracts

What is the role of different partners in an IAP? An IAP is a research program bridging the gap between fundamental research carried out at universities and technology development executed in leading nano-electronics companies. The different industrial partners finance an IAP by paying an entrance fee. An IAP starts with a research program, which is the result of IMEC's accumulated knowledge in the past and its continuous flow of PhD-theses, providing new scientific insights. Therefore, the background knowledge of an IAP is the outcome of IMEC's continuous interaction with universities in Belgium and around the globe. IMEC also selectively patent scientific insights from PhD studies conducted at IMEC or partnering universities.

Industrial partners further develop the foreground knowledge within the IAP: scientific insights are turned into useful technology that can be patented. An IAP focuses on pre-competitive technology so that industrial partners in the nano-electronics can easily collaborate with each other without being a direct competitive threat to other partners in the program. Industrial partners typically take different positions in the value chain of the nano-electronics industry, such as equipment manufacturers, foundries, integrated device manufacturers (IDMs), system providers, materials suppliers, etc. New technologies affect all segments of the value chain in the nano-electronics industry and therefore it is important that most – if not all – important players in the industry collaborate in an IAP.

Why are the companies interested in joining an IAP? Collaborating in an IAP offers participants a number of advantages. First, an IAP offers the possibility to perform research at a fraction of the price of in-house R&D. Nano-electronics research is extremely expensive and costs have been increasing exponentially in the last two decades. In-house R&D is becoming too expensive for most organizations in the nano-electronics industry. By leveraging IMEC's world-class infrastructure and ecosystem of diverse partners across a multitude of industries, IAP members can continue to perform world-class research. Second, early stage technology is also very risky. By collaborating with partners and combining expertise, an IAP can lower the risks for the partners. Third, an IAP offers a technology trajectory that may be an alternative for a technology developed in an in-house program of a (large) partner. Firms can apply a hedging strategy in case the in-house technology does not prove to be viable. Finally, IMEC can easily get access to diverse scientists across a multitude of scientific disciplines via its relations with universities. This is interesting for IMEC's industrial partners, who are at a disadvantage to get access to teams of scientists with different backgrounds. Summarizing, there are different drivers that attract industrial partners to join IMEC's IAPs. Partners jointly create knowledge in an IAP at a fraction of the cost of an in-house project, and collaborating with IAP partners at a research lab such as IMEC offers a number of additional advantages compared to a typical internal corporate R&D setting.

How do IMEC and its partners capture value within IAPs? Each partner in an IAP has to contribute to a specific part of the research program, but has the right to use all the foreground knowledge developed in the IAP, i.e. the research output and technology developed within the context of the joint research program. Participating in an IAP is interesting because partners contribute to a part of the IAP agenda, but they can benefit from all the scientific and technological progress made in the IAP. This way of working is made possible by the unique IP-model IMEC uses in its IAPs. IMEC collaborates with a partner on a specific topic of the IAP, and technological discoveries are co-patented. Other partners in the program have the right to use the technology through a non-exclusive and royalty-free licensing agreement. The licensing agreement is not transferable so that only IAP partners benefit from the joint research efforts. IMEC too benefits from these IP-arrangements. First, IMEC appropriates value from its IAPs via the program fees that are paid by IAP partners and co-ownership without any accounting on foreground IP. Second, co-ownership of patents also allows IMEC to use the newly developed technology as background knowledge in future research programs. This in turn increases IMEC's future attractiveness as a technology partner for potential industrial partners.

What are the challenges in managing the IAPs? IMEC orchestrates the IAPs as innovation ecosystems and it has to assume different tasks as orchestrator to manage IAPs effectively. First, IMEC sets the objective by writing the research program for each IAP. This is a first step in building the ecosystem of IAP partners. By writing the research program, IMEC takes a considerable risk as the quality and industrial relevance of the program determine its attractiveness for potential industrial partners. Second, IMEC also has to be skillful in designing agreements with each IAP partner. These are bilateral agreements, which have to be carefully co-aligned with each other to avoid overlapping claims of and conflicts between the partners. Third, IMEC is responsible for creating a cooperative mindset among the IAP-partners. IMEC uses its experience and expertise in open innovation to successfully manage its partners in IAPs.

An ecosystem orchestrator should not only guarantee the current ecosystem's success, but also seek new ways to prolong its orchestration role in the future (Leten et al. 2014). In this respect, IMEC is exploring a new way to apply its innovation ecosystem approach by leveraging the IAP model to the life sciences industry in search of nano-electronic applications in that industry. The life science industry faces similar problems as the semiconductor sector in the late eighties, when vertically integrated firms could no longer face the technical challenges and costs of R&D, and gave way to a disintegrated and networked model of technological innovation. Nowadays, pharmaceutical companies have to change their vertically integrated R&D approach into one based on collaboration in innovation ecosystems. As IMEC's Senior Vice President of Strategic Development stated, *"Pharma companies have learned a lot about the capabilities of nano-electronics in communicating with us. They see that the "business as usual" mode is outdated and they have to focus on open innovation. In reality, this is very hard for them to implement but they are looking for success stories."* For this purpose, IMEC's nano-electronics expertise will have to be combined with expertise in life sciences. Therefore, IMEC has teamed up with John Hopkins University, with top competences in life sciences, as the second orchestrator to create a dual-core, dual-site innovation ecosystem where two innovation ecosystems are integrated. The IP rules that IMEC developed previously can largely be leveraged to the dual-core model. The IP agreements between IMEC (or the second orchestrator) and its ecosystem partners will remain the same, but additional IP arrangements between both orchestrators are needed. In this way, IMEC is not only playing a role as orchestrator to secure the success of the current IAPs, but it is also crafting a new and larger ecosystem to become a leading force in the life sciences technology developments of the next decade".

5.4.1.2 CTMM

As a Dutch public-private partnership, CTMM's objective is to perform translational research. The essence of translational research is primarily to apply new biomedical developments to medical practice in order to enhance patients' health. According to CTMM's communication manager: *"The main objective of CTMM is to translate the knowledge of academics into practical clinical practice. CTMM aims to become a leading, Dutch-based innovator of Molecular Diagnostics and Molecular imaging technologies".* In other words, it transfers basic research into clinical development and clinical development into clinical practice, which can then be implemented more quickly, more widely and more cost-effectively among patients and in society (i.e. bench-to-bed and back) (Ortiz, 2015).

Why companies are interested in joining CTMM? Previously, organizations used to preform projects independently. This meant that they had to perform different tasks in-house and thus spent large amounts of money on R&D to realize their objectives and deliver a product. This led to high research costs and long product delivery time to market (and thus also "to the bed of the patient"). The growing complexity of research projects and the need for faster delivery times of clinical developments to patients necessitates joint research and development. Through collaborations, partners could not only increase their productivity by sharing complementary knowledge, but they could also deliver faster results to treat patients.

The Dutch government has a long tradition in subsidizing individual organizations to conduct research projects. As subsidizing individual organizations was becoming less and less effective, the government had a strong incentive to invite different organizations with the right expertise to join forces to conduct important, yet unexplored research. The Dutch government established CTMM to structure the funding of the research and development in high-priority research areas that patients required the most. Through the establishment of CTMM, the government could not only force the relevant parties to work in a collaborative way, but also enhance and monitor society’s healthcare development.

In order to achieve its objective, CTMM requires a variety of actors that have to combine different skills and resources in this process. To gather the best expertise from different fields, CTMM first creates a tender, based on a call for proposals. CTMM invites consortia of partners to submit proposals and the best proposals get (public) funding after a tough review process. Through the tenders CTMM not only brings diverse partners together, but it can also select high-quality proposals that involve the best partners. Second, partners that are interested in participating in the project create a consortium and submit their proposals. Third, through a critical evaluation process, CTMM reviews the proposals and distinguishes the high-quality consortiums that provide the best expertise to realize the objectives. Only proposals displaying the right knowledge across the value chain to realize the objectives (i.e. transferring basic research to improved outcome), can receive financial support from CTMM. At an organizational level, the Dutch government and scientific advisory boards play a crucial role in CTMM. However, at a project level, only partners that contribute to project objectives interact with CTMM. Joining the CTMM innovation ecosystem and participating in its consortium offers different advantages for partners. First, the government’s financial support that they receive through CTMM enables them to develop their R&D expertise and enhance their knowledge. Second, it reduces their risk of failure in projects and technology development. By collaborating in the consortium, partners share their R&D risk. Finally, it provides them a chance to commercialize and market their products. For instance, hospitals and medical centers use the collaboration in consortium as an opportunity to present their expertise in different research fields and expand their credibility.

What is the role of different partners in creating and capturing value in the CTMM consortium? In a typical approved proposal, partners create a consortium and bring their unique knowledge and expertise together. First, industrial partners such as pharmaceutical companies offer their biomedical products and technical skills through the precise identification and development of small molecule drugs. Second, researchers in labs and academic institutes use their scientific knowledge and develop new methods for diagnostics tests. They analyze the clinical results, assess the effect of the test in clinical practice and investigate its cost-effectiveness. The joint collaboration enables both academic and industrial partners to benefit from the complementary knowledge and expertise. Third, clinicians or doctors further collaborate and, through hospitals and health care clinics, implement the clinical development at an accelerated pace. Industrial partners further develop the solutions and commercialize them for the market. They need to equally invest in kind and money. The commercialized products are then distributed in hospitals. Fourth, hospitals deliver the new medicine or treatment to patients and conduct faster clinical and diagnostic treatments. Fifth, patient organizations, with the help of hospitals, create clinical reports based on the patients' information, feedback and satisfaction of the treatment and their further clinical requirements. These reports enable all partners, such as researchers and government institutes, to identify and prioritize society's healthcare needs. Sixth, funding agencies support CTMM in different ways. For instance, the Dutch Cancer Society helps the dissemination of the results and equally enhances CTMM's reputation in the industry. The Dutch Heart Foundation creates a committee of end-users consisting of patients, nursing staff and clinicians, who closely follow the development process and offer advice. In order to turn basic research into improved outcomes for patients (i.e. the objectives), these different partners (from research to the commercialization of products) are all required and they have to work together in a specific way. The incentives that they receive to submit joint proposals to CTMM, such as governmental funds, complementary expertise and knowledge, and product commercialization allow them to collaborate effectively on the projects.

What are the challenges in managing a CTMM consortium? The success of clinical research does not automatically lead to an improvement of patients' health. The diversity of the partners' objectives and business models creates tensions between partners and potential delays in marketing the successful solutions (Ortiz, 2015). CTMM's partners further create different challenges. One is the different viewpoint of research time frames between industrial and academic partners. In this respect, CTMM intends to communicate with partners and makes their requirements explicit at the start of the project in order to reduce potential tensions. Second is the lack of financial means, which creates a barrier for partners to join the collaboration or may lead to their withdrawal from the consortium. In this regard, CTMM aims to provide sufficient governmental funds to partners and encourages them to join the collaboration. This is an important issue for hospitals which usually don't have the financial means and consequently see no benefit in joining CTMM projects. With respect to partners that exit the consortium (e.g. SMEs), CTMM creates a backup plan at the beginning of the project, and allows the partner to re-contribute to the project again or replaces them with a new partner. A third challenge is the licensing and share of IP. CTMM attempts to resolve IP issues through its IP framework. This allows partners to decide on how and with whom knowledge will be shared, and it determines the financial benefits that every partner will receive for their efforts. Fourth is the tension that is created through monitoring the activities. While CTMM regularly reports to the government, it needs to carefully monitor the research activities so that partners do not underperform. To resolve this challenge, CTMM, as an orchestrator, uses a software system (i.e. back office) to record the activities for future monitoring procedures.

The fact that the government has initiated CTMM gives CTMM power over its partners. By generating rules and regulations for the consortium partners, it controls and monitors the activities. In addition, the governmental funds that CTMM offers to consortia of partners creates financial ties. Besides financial ties, the research and knowledge that are created in the projects lead to IP generation. Through its IP agreement, CTMM provides partners access to the knowledge created.

Reflecting on how CTMM organizes the innovation ecosystem and how it establishes a consortium, illustrates that CTMM resolves challenges and successfully delivers an innovation ecosystem's objective by aligning the objectives of all partners, monitoring the activities, and orchestrating the research projects. This allows CTMM to improve the collaborative innovation activities of all partners involved, and ensures partners receive financial benefit from their collaboration in the research projects.

5.4.1.3 ASML

ASML is one of the world's leading manufacturers of chip-making equipment, and was established in 1984 to produce lithography and printing equipment to enhance the quality of life of patients through producing affordable microelectronics equipment. To realize this objective, ASML strives to invent, develop, manufacture and service advanced technology for high-tech lithography, metrology and software solutions for the semiconductor industry. In order to reach this objective ASML has set up an ecosystem of innovation partners, and the collaboration with these partners has lead to entirely new products and solutions in a variety of industries such as healthcare, communication, technology, energy and the entertainment industry.

Why are companies interested in joining ASML's innovation ecosystem? The complexity of industrial projects and high cost of R&D have forced organizations to cooperate. The broad perspective of ASML's objective requires a large number of partners from different industries (i.e. around 700 partners) to collaborate with ASML. In a typical research and manufacturing project, ASML interacts with partners to receive knowledge and technical expertise to produce advanced complementary parts and products. Later, it integrates the parts and supplies into end-manufactured products for its customers. As partners join ASML's innovation ecosystem, they receive different benefits. First, partners are exposed to a great number of companies in different disciplines. Through this they can present their expertise and commercialize their products. Second, partners have access to complementary knowledge and infrastructure. This enables them to reduce their in-house R&D cost. In this respect, SMEs can greatly benefit from the collaboration with ASML. Finally, as partners collaborate within ASML's innovation ecosystem, they can share their risk in technology development. While projects are divided into small work packages and each company offers specific components, the risk of losing the project is reduced.

What is the role of different partners in ASML's innovation ecosystem? Each partner that joins the innovation ecosystem plays a different role. First, the industrial partners participate in projects and provide their technical expertise and supply materials. In this respect, SMEs interact and offer their design and service expertise. Second, ASML collaborates with academic partners such as universities (e.g. University of Amsterdam) and research centers (e.g. Philips) and receives the results of their fundamental research. Third, PhD researchers interact with ASML through industrial projects that are defined by ASML. The research scholarship that ASML offers the PhD researchers enables researchers to focus on practical and more essential industrial projects. Moreover, it offers them knowledge and technical expertise. Last are the customers (i.e. the world's top chip manufacturers) that receive the final integrated product.

How do ASML and its partners capture value within the innovation ecosystem? When partners join the ASML innovation ecosystem, they sign legal agreements and recognize their roles and IP protection. Similarly, academic partners and PhD researchers interact with ASML through knowledge and information. In exchange, ASML covers the cost of the products and components that partners bring to the project, and provides industrial research grants for PhD researchers. As a market leader in lithography equipment and point of contact with The European Commission, ASML has a unique opportunity to interact with the Dutch government and it can offer regulatory and advisory services. In the interaction with the Dutch government, ASML benefits from a reduced corporate tax rate that the government offers in exchange for technical and innovative consultancy information.

What are the challenges in managing the ASML innovation ecosystem? Although the joint collaboration is beneficial for partners, it can create different challenges. The diversity in partners' objectives, the difference in project delivery times and difficulty in establishing relationships are some of the main conflicts that ASML's partners face during their joint collaboration. In order to resolve the challenges, ASML, as an orchestrator, applies several strategies. First, it creates an open environment where partners can easily communicate with each other. Second, it provides different problem solving sessions so partners can join and exchange their technical knowledge, negotiate and come to an agreement. Finally, based on the partners' requirements, ASML customizes strategies and contracts. This ensures partners that their expectations are met and considered during the project. The Director of Strategic Program of ASML says: "*Here at ASML we have an open culture and we offer opportunities to experts in the field to join and contribute. At time of conflicts between partners, we manage to negotiate and communicate with partners to come to an agreement".*

ASML's innovation ecosystem encourages diverse partners to join ASML, as it provides access to advanced knowledge and infrastructure, represents a commercialization potential and reduces the in-house R&D cost of its partners. Each partner joins and brings their specific technical and knowledge expertise to facilitate ASML in developing and integrating the ultimate product. The open and transparent environment that ASML creates for its partners, the flexible strategies that it applies to resolve the challenges and the benefit that it offers to its customers ensure participating partners a successful joint collaboration.

5.4.2 The overview of the seven innovation ecosystems

Although the model or figure 10 (i.e. the green section of figure 2) clearly presents different steps (from setting the objectives to defining the role of partners, creating different interaction ties and delivering the final objectives) that are essential for delivering innovation ecosystem objectives, it is important to understand the logic behind each step. First, for the purpose of establishing a joint collaboration, organizations need to understand their objectives and what they need to achieve in the joint collaboration. Factors such as establishing ecosystem platform and seeking for financial support are some of the identified objectives. List of objectives are presented in table 11 and are shown in the first step of the figure 10. Second, to achieve the objectives, organizations need to interact with right type of partners that could bring relevant knowledge and expertise (i.e. research centers, industrial partners or government agencies). Hence, second step of the model is identifying the type of partners (non-orchestrators). This step is connected to the fist one with a solid arrow line. Type of partners is presented in the second step of the figure. Third, in order to bring partners to the joint collaboration, it is crucial to recognize their motivation factors or what benefits they desire for. Factors such as the opportunity to commercialize the products and access to open innovation mentality are two of the identified motivation elements among Belgian and Dutch nano-electronics ecosystems. Through a solid arrow line step three is connected to step four. In this step, an orchestrator takes the lead. The orchestrator plays different roles (i.e. integrator, leader, supervisor, initiator or facilitator) in the innovation ecosystem. These roles are shown in the forth step of the figure 10. Based on the capabilities and expertise of the partners, the orchestrator defines the role and assigns them to each partner. Roles such as facilitator, advisor, and program partner are some of the identified roles for partners in this study. The complete list is presented in step five. These are also reflected in table 11 and the appendix C. Since, defining type partners, identifying their motivation, the role of orchestrator, and defining the role of partners continues during the ecosystem life cycle, these steps are connected to each other with solid arrow line[18] in a cycle shape. As partners get familiar with their responsibilities in the ecosystem, they need to understand how to interact with each other to accomplish the task. Thus, the sixth step is "connecting through suitable interaction ties". In this stage, the orchestrator reshapes and restructures the interaction between partners in the ecosystem. This enables actors to optimize their interaction and collaborate in a tension-free ecosystem environment. Interaction for IP, exchange of knowledge and information and financial means are some of identified type of ties among Belgian and Dutch nano-electronics innovation ecosystems. For instance, creating suitable IP policies and regulations could reduce the potential challenges among partners. The list of interaction ties is illustrated in step six of the figure 10. Indeed, following each step leads the ecosystem partners to the final step, which is delivering the ecosystem objectives. Considering the steps of the model (See figure 10) suggests that delivering the objectives at an ecosystem level is only possible when the role of all actors (i.e. orchestrator and non-orchestrators) is considered in the analysis.

Reflecting on the IMEC, ASML and CTMM innovation ecosystems and different elements identified in the table 11 show the complexity of innovation ecosystems by revealing differences in the objectives, types of partners, motivation factors, orchestrators' roles, partners' roles, and the interaction ties. In order to create value, an innovation ecosystem has to be well established, the roles of partners should be well defined, and it should be strategically managed. Notably, the

[18] Solid arrow lines connect the blocks together and indicate the relation between them.

orchestrator has an important role in positioning all the ecosystem components together and integrating them to accomplish the desired results.

5.4.3 The building blocks of the theoretical model

The following section explains how each block of the theoretical model (figure 10) is derived from the analysis of the data.

5.4.3.1 Setting the objectives

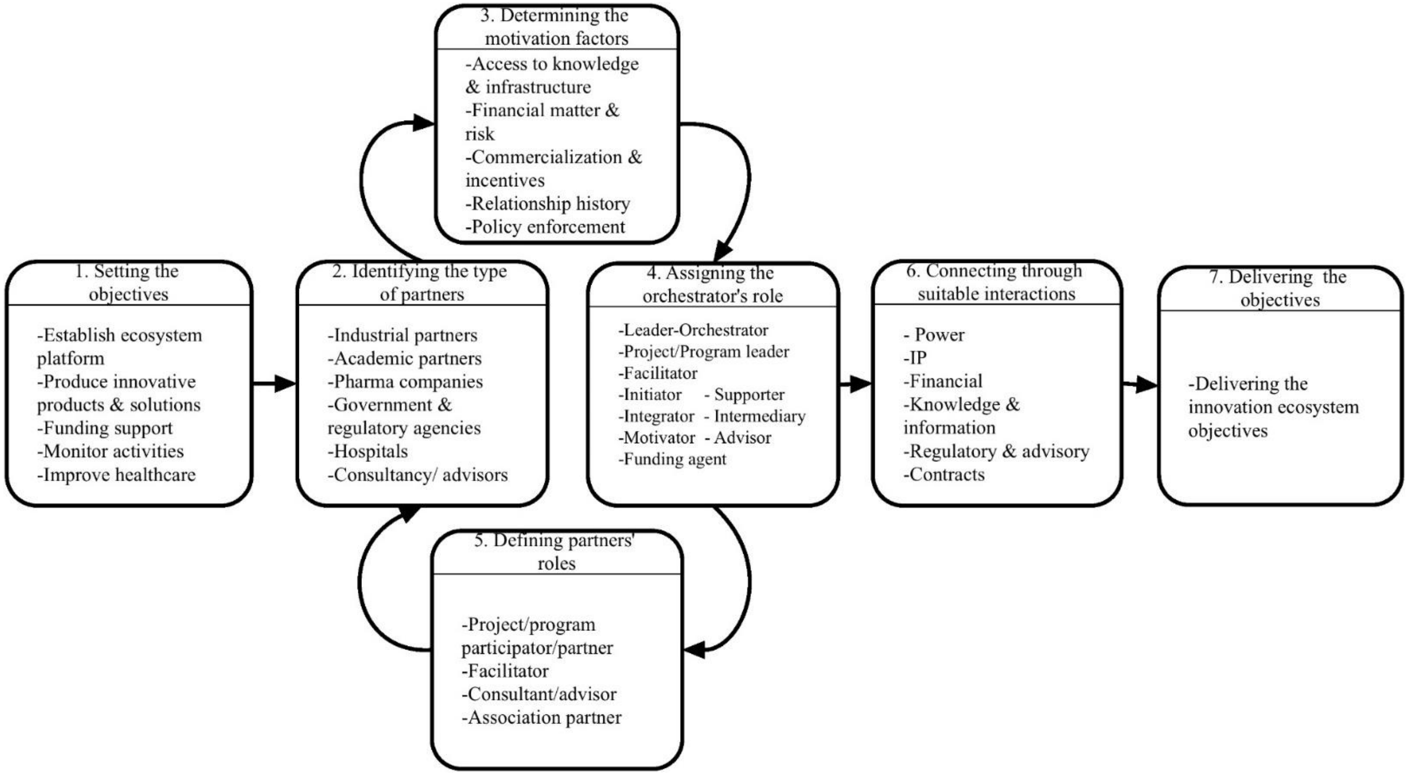
The results of my empirical research show that nano-electronics innovation ecosystems are established based on five different objectives. They aim to create an ecosystem platform, produce innovative products and solutions, receive financial support, monitor activities, and improve the healthcare sector (See appendix C table v).

First, ecosystems platforms are established as a specific governance mode to bring all relevant people, knowledge and expertise together to realize a particular innovation objective. Each of the innovation ecosystems I studied in the nano-electronics industry had a particular governance structure designed to deliver the objective in the most effective way. IMEC's IAPs are a great example: an IAP is structured and organized in such a way that it can bring relevant partners (and expertise) together. Its organization also facilitates collaboration (e.g. through bilateral agreements and IP rules).

Second, one of the common objectives to jointly create value within an innovation ecosystem is to improve the quality of healthcare that results in enhancing the patients' quality of life. In this respect, CTMM as a public-private partnership aims to create a technology platform to bring people, expertise and knowledge together to provide financial assistance to partners, and to control and monitor project activities. In addition, it aims to provide precise diagnostics and personalized medicine to reduce the impact of diseases, offer fast patient care, and ultimately improve the quality of life of patients.

Similarly, with its IAPs IMEC is advancing the technical progress in the nano-electronics industry while making research and development affordable for its partners. Another example is TMC, an insourcing agency that provides its customers technical and knowledge management expertise so they can be successful in their project and business activities. Although CTMM, IMEC and TMC create different innovation ecosystems, they bring partners into an ecosystem in order to improve the healthcare sector.

Figure 10 The theoretical model for type and role of actors within the nano-electronics innovation



The third objective is to produce innovative products and solutions. In a high-tech industry such as nano-electronics, products are made of a variety of components that are high in price and advanced in technology. As such, it is essential to source some of the components from other partners. In this respect, ASML produces lithography products that are energy-efficient. Similarly, IMEC offers nano and bio products and solutions. Hence, different partners interact with ASML and IMEC to benefit from their advanced products.

Fourth, ecosystems are established to provide financial support to different organizations in a specific way. The high cost of R&D and research infrastructure has led many organizations to create or join an innovation ecosystem. In this regard, public-private partnerships such as CTMM and IMI that are initiated by the Dutch government offer financial support to their partners. CTMM, for instance, assists universities in receiving funds required for the research and indirectly offers a salary to PhD researchers so they can accomplish their projects. Similarly, IMI as a funding agency creates a financial platform so that SMEs and other academic institutes can receive the funds required.

Finally, innovation ecosystems also have the specific objective to monitor activities of partners. Results show that CTMM and IMI carefully monitor the activities of different partners. The fact that both organizations are initiated and monitored by the government indicates that the outcome of the projects needs to be successful. Thus, through defining different milestones and designing back office department to monitor project activities, CTMM monitors partners' activities. On the same note, IMI supports and monitors research areas by offering different training programs and evaluating the partners' performance.

Once the objectives are defined, it is key to find the right partners with complementarity assets and expertise in order to jointly create value in the ecosystem (i.e. objectives of the ecosystem). This leads us to the second block of the model, which is identifying the type of partner.

5.4.3.2 Identifying the type of partners

Jointly creating value at the ecosystem level requires the participation of different partners that complement each other's expertise and resources. Results show 17 different types of partners that collaborate in the seven Belgian and Dutch nano-electronics innovation ecosystems studied (See table 11). Actors can be classified into six main categories: industrial firms, academic institutes, pharma and life science companies, the government and regulatory entities, hospitals, and consultants.

First, industrial partners join the innovation ecosystem and offer their technical expertise. In this respect, Ridegtop as a technology and solution provider offers a variety of advanced products to other ecosystem partners. In this regard, it plays a role as a supplier in the nano-electronics innovation ecosystem. Second, academic partners such as academic researchers, PhD graduates and research centers also join the ecosystem and provide their scientific knowledge and research infrastructure. IMEC as a nano-electronics research center provides world-class research labs and advanced research infrastructure. Industrial companies and academic institutes are two common types of actors in the nano-electronics innovation ecosystem. By playing different roles in the innovation ecosystem, they complement each other and create value (e.g. innovative products). Third, pharmaceutical companies further participate by exchanging information, data and knowledge, and expertise. IMI's legal manager states that; *"Pharma companies will provide biomarkers or compounds upon which clinical trials have to be carried out by some academic partners.... Companies that carry out research also provide expertise in terms of project management".* In the IMI consortium, pharma and life science companies play a crucial role as they participate in projects to improve the healthcare of the patients. Fourth, the Dutch government joins the innovation ecosystem and offers financial support to facilitate the interaction. In addition, with the help of regulatory agencies, government authorities monitor the research activities to ensure the best possible outcome. Through CTMM, the Dutch government monitors the research activities and provides financial support to other partners. Fifth, hospitals are partners that join the nano-electronics ecosystem. They are the patient's point of contact and therefore deliver the clinical tests and advanced diagnostic equipment to patients. Together with patient organizations, they collect patients' clinical information and facilitate ecosystem partners with patients' requirements to develop further research projects. Finally, consultancy companies that join innovation ecosystems offer their advice and expertise on a variety of research areas and technology know-how.

In this respect, Ridgetop as a solution and technology provider selects the most suitable actors that can offer the required and essential skills and technologies for their customers. The complementarity of partners in the Ridegtop ecosystem is crucial. Hence, universities, research centers, large industrial firms, SMEs, and other consultancy and engineering companies support Ridegtop to produce innovative products and solutions. This interaction resolves some of the challenges that the Ridegtop ecosystem partners may face during their value creation and capturing procedures.

In sum, innovation ecosystems need different types of partners. These partners have complementary roles to play in the ecosystem. In other words, different partners with diverse expertise need to join and collaborate to create value.

Taking one type of partner out of the process (e.g. research centers), would lead to a lack of resources and capabilities on a specific area, and low performance, which could result in project failure and ultimately the collapse of the innovation ecosystem. Hence, it is really critical to interact and wisely select partners that are capable and fit the value creation process in the innovation ecosystem. In order to attract partners, it is important to understand which factors influence their decision to join the ecosystem. This introduces the third block of the model, which is determining the motivation factors of partners joining the innovation ecosystem.

5.4.3.3 Determining the motivation factors

Actors join an innovation ecosystem if they receive specific benefits in return. The analysis (See appendix C table vi) shows five motivation factors: 1. Access to knowledge and infrastructure, 2. Financial issues and risks, 3. Commercialization opportunities and incentives, 4. Relationship history and developing trust, and 5. Policy enforcement. These factors encourage actors in the nano-electronics industry to join the innovation ecosystem.

The first factor is the high cost of research and infrastructure in nano-electronics projects, which drives companies to join ecosystems to benefit from the knowledge and infrastructure that they cannot provide alone. IMEC as a world-class research center offers advanced research infrastructure and equipment. In this respect, while ecosystems partners interact with IMEC, they benefit from the collaboration and reduce their cost. Second is the lack of financial means and high risk of projects that motivates organizations to join innovation ecosystems. A lack of financial resources for organizations, especially startups and SMEs, encourages them to join ecosystems such as CTMM. By joining CTMM innovation ecosystem, organizations benefit from the financial support that is offered by the Dutch government and similarly reduce their risk of failure in projects. The third factor is the commercialization opportunities and the incentives that organizations benefit from, when joining the innovation ecosystems. The opportunity to commercialize products, and to expand their market into healthcare encourages both IMEC and its partners to interact with each other and create ties. *"I would say [what attracts partners] is the path toward commercialization for research institutes. So we don't only do technical development, we also do business development together with partners."*[19]. Fourth is the good and positive relationship history and developing trust, which motivates organizations to join the nano-electronics ecosystems. The good reputation of IMEC and its public image in the nano-electronics industry encourages organizations to join the IMEC

[19] IMEC Senior Vise President of Strategic Development

ecosystem and benefit from the open innovation interactions. In addition, the chance to expand their network, communicate and develop trust among partners motivates organizations to join the TMC insourcing agency. Similarly, the clear research directions at Ridegtop motivate organizations to join the ecosystem and benefit from the transparency offered to them. Finally, there is the policy enforcement that drives organizations to join innovation ecosystems. For instance in CTMM, the Dutch government enforces innovative collaboration between industrial firms and academic institutes by providing governmental funds.

In summary, in an innovation ecosystem complementary partners are brought together to jointly create value. Although joining the innovation ecosystem is in theory beneficial for all parties joining the value creation process (i.e. reducing cost on R&D, risk, and access to expertise), in practice it has several drawbacks. It limits for instance the freedom of partners' performance. Since partners jointly create value, they need to align their objectives and negotiate their expectations of the joint collaboration. This may slow down the innovation process and lead to an increase in R&D expenditures. In addition, the IP protection, which is crucial in high-tech innovation ecosystems such as nano-electronics, needs to be considered. A lack of IP protection or confidentiality issues in addition to the other challenges calls for a suitable actor who can orchestrate the ecosystem. This leads us to the fourth block of the model.

5.4.3.4 Assigning the orchestrator's role

Orchestrators in the innovation ecosystem have significant roles. Based on the interviews with managers in the nano-electronics industry, I found that orchestrators could play 10 different roles in the nano-electronics innovation ecosystems. They act as an orchestrator, project or program leader, facilitator, initiator, integrator, motivator, supporter, intermediary, funding agent or as an advisor.

An orchestrator is an actor who leads the innovation ecosystem. Project or program leader is an actor who not only participates in projects, but also leads the activities in the projects. For instance, ASML plays the role of a leader in some of the projects. Next is the facilitator. A facilitator is an actor who helps and assists the collaboration activities. In this respect, TMC and the Dutch government play a role as facilitators. By providing technical expertise, TMC and the Dutch government expedite the collaboration between ecosystem partners through funding schemes. An initiator is an actor who initiates the innovation ecosystem. In other words, it establishes the ecosystem. IMI, for instance, is an initiator in the nano-electronics innovation ecosystem. The European Union (EU) has initiated IMI to concentrate on specific research projects. Another role that an orchestrator can play in the ecosystem is to act as an integrator. ASML is a system integrator. It receives different components of a specific product from ecosystem partners and integrates them together. Moreover, an orchestrator can also be a motivator. In this respect, the actor not only leads the ecosystem but also motivates the ecosystem's partners to join the value creation process. TMC and ASML both motivate and stimulate their ecosystem partners to join, interact and collaborate toward a unique goal.

Moreover, an orchestrator can also be a supporter. This indicates that while an orchestrator leads the ecosystem, it also supports the interaction between ecosystem partners. This is acknowledged as one of the most significant roles of an orchestrator. Moreover, the orchestrator resolves conflicts, governs different challenges that partners face during their collaboration and supports them. On the same note, ASML supports its ecosystem partners by providing different problem solving sessions that partners can join to exchange their technical knowledge. Next, an orchestrator can play a role as an intermediary. An "intermediary" means that the orchestrator is mainly positioned between the ecosystem partners and the government. In this respect, CTMM acts as an intermediary. It orchestrates the ecosystem partners and simultaneously connects the Dutch government with ecosystem partners. Through CTMM, the government enforces its research projects and provides governmental funds to support the project partners. Notably, compared to other orchestrators, orchestrators that simultaneously intermediate between the government and ecosystem partners have tougher responsibilities in resolving challenges and leading the ecosystem. They need to properly manage the project and reduce any delays in delivery time.

Furthermore, an orchestrator can play the role of a funding agent. This means that it not only leads the ecosystem, but also offers financial assistance to ecosystem partners. IMI is an example of a funding agent or a funding orchestrator. IMI distributes the governmental funds that it receives for each consortium to its participating partners, which has motivated many partners to consider the IMI ecosystem as an innovative collaboration platform. Last is the advisory role that an orchestrator plays in the ecosystem. Generally, when the government enforces some of the collaboration policies and regulations and provides research funds, it monitors the activities. This enforces orchestrators such as IMI to monitor the ecosystem activities and offer advisory sessions to resolve issues. This highlights the significance of an advisory role of an orchestrator. While the orchestrator intends to advise and consult the partners, it ensures that project milestones are achieved. This allows the orchestrator to demonstrate its leading capability to the government and maintain its strategic position in the innovation ecosystem. This can lead to the financial stability of the ecosystem.

In summary, reflecting on the interaction of complementary partners and the diversity in their individual goals, ecosystem partners cannot automatically take a role and play these roles efficiently. Their interdependency indicates that all partners need to perform well so that the whole ecosystem value creation would be successful. This is more evident in a complex, high-tech environment such as nano-electronics innovation ecosystem where incompetency of several actors' performance may increase the cost, create IP protection problems, and ultimately lead to a breakdown of the ecosystem. As such, presence of an orchestrator in such ecosystems is crucial. By taking multiple roles simultaneously, orchestrator could participate in different ecosystems and observe actors' capabilities and performance. This would allow the orchestrator to define role of the ecosystem partners in a way that reduces or eliminates potential challenges that they may face during the value creation and capturing process. This introduces the fifth block of the model.

5.4.3.5 Defining the partners'[20]roles

The analysis of the interviews indicates that partners in the innovation ecosystem mainly have five different roles. They act as a solution provider, project or program partner, associated partner, advisor, or facilitator. First, a solution provider refers to partners that offer products and technology solutions. Generally, technical companies take on this role and participate in projects by providing different advanced innovative solutions to their ecosystem partners. For instance, Ridgetop plays the role of a solution provider and offers different advanced technical solutions to its partners.

Second, a project or program partner refers to actors that collaborate in innovative research projects. This is one of the most common roles among the nano-electronics innovation ecosystem partners. Mainly industrial firms (large and SMEs), academic institutes (universities and research centers), and pharma companies play as a project partner. In this role, partners contribute in kind and money. In IMEC's innovation ecosystem for instance, the Industrial Affiliated Partners (IAP) take part in a variety of projects by providing their knowledge and expertise. Similarly, pharmaceutical companies such as Johnson & Johnson, together with several European and non-European universities collaborate and participate in drug discoveries and other research projects. Third is the role of an associated partner. This means that partners are connected, however, their

[20] Partner refers to an actor who participates in the innovation ecosystem and has a non-orchestrating role.

contributions are defined and evaluated through a specific committee or independent experts. Non-EFPIA (The European Federation of Pharmaceutical Industries and Associations) partners in the nano-electronics innovation ecosystem mostly play this role. Compared to project partners, associated partners are indirectly connected to research projects. For instance, in IMI's innovation ecosystem, associated partners (i.e. any pharmaceutical or life science companies that are not a member of EFPIA) participate in projects by providing their expertise and knowledge.

Fourth, besides the associated partnership role, ecosystem partners act as advisors. Advisors are partners that offer consultancy services or participate on an Advisory Committee. In the nano-electronics innovation ecosystem, this is one of the common roles among government and regulatory agencies and consultancy companies. Government agencies generally interact with ecosystem partners and regulate the activities. For instance, in the ASML innovation ecosystem, several consultancy companies as well as the government authorities interact within the ecosystem and advise ASML on a variety of research and technical areas. Last is the facilitating role, which corresponds to partners that facilitate the interaction. Patient organizations and consultancy companies are examples of partners that play the role of facilitators in the innovation ecosystem. The patient information that is offered through patient organizations to pharma companies and research centers within the CTMM ecosystem facilitates their clinical trials and diagnostics research projects.

In short, ecosystem actors play different roles in the innovation ecosystem. Comparing prior literatures and the findings of this chapter, it is clear that this study complements the findings of Hu (2011); Iansiti and Levien (2004a); Nambisan and Sawhney (2008) by identifying various novel roles for orchestrators (i.e. leader, facilitator, motivator, initiator, integrator, and advisor). Moreover, it adds to the literature of innovation ecosystems by identifying different partner roles (i.e. participator, facilitator, consultant, advisor and regulator). Drawing from the evaluated innovation ecosystems, one can anticipate that, while partners play multiple roles, they complement each other with respect to resources (knowledge and infrastructure). This means that their roles are interdependent on each other. The knowledge and capabilities that partners offer in the joint value creation process certainly influences the outcome of the project and ultimately the objectives of the innovation ecosystem. Hence, an orchestrator such as CTMM or IMEC strategically selects partners and defines their roles based on the partners' capabilities to achieve the best result. This signifies the importance of actors' interaction and how the orchestrator is required to shape them to enhance the delivery of the ecosystem objectives. This introduces the next block of the model; connecting through suitable interactions.

5.4.3.6 Connecting partners through suitable interactions

As partners join the innovation ecosystem, they connect and interact with each other. How they interact is important as it may influence the outcome of the value creation process. A careful analysis of the interviews shows that partners in the nano-electronics innovation ecosystems mainly connect to each other through six types of interactions: power, IP, financing, knowledge and information, regulatory and advisory, and formal contracts (See table 11)

First, financial interaction appears to be the most common type of collaboration in all seven ecosystems I studied in the nano-electronics industry. Receiving financial support is one of the major aspects in ecosystem partners collaborating with each other. In CTMM's innovation ecosystem, the financial support that partners receive during their collaboration with CTMM creates the financial interaction. Second is the power interaction. This type of interaction occurs between the orchestrators and the partners, or between the government and the partners. For instance, ASML as an orchestrator and system integrator has power over other partners in its ecosystem. This enables ASML to bring other partners to join the ecosystem, define their roles and shape their interaction ties. Third is the IP interaction, which mainly occurs between industrial firms and academic institutes. The IMEC Dual Core Model is a clear example of how a research center defines the IP protection rules for its participating partners. By participating in the IMEC innovation ecosystem, partners are aware of their IP rights and their gained benefit of the knowledge creation.

Fourth is the interaction through knowledge and information, which mainly occurs between academic and other ecosystem partners. As partners join the TMC partnership programs, they benefit from the knowledge and information that the TMC technical team offers in exchange for financial contributions. Fifth is the regulatory and advisory *tie*. This type of interaction mainly appears between government authorities, regulatory agencies and consultancy companies. In this respect, ASML as a market leader in lithography equipment and point of contact with European commission has a unique opportunity to interact with the Dutch government through regulatory and advisory ties. In this interaction, ASML benefits from the reduced corporate tax rate that government offers in exchange for technical and innovative consultancy information. Last is the interaction that occurs through formal contracts. This type of interaction generally appears between industrial partners to generate a transparent collaboration outline between partners. For instance, as partners join the CMOSIS innovation ecosystem and collaborate on different projects, they sign a contract that clarifies their role and the required technical and knowledge expertise. Formal contracts facilitate the value creation process by determining the objectives of the organization and the benefits that organizations may gain from the collaboration. On the same note, the Ridegtop innovation ecosystem partners sign contracts to receive various after sale services.

Considering the above, it is evident that partners have to interact in specific ways through suitable ties to jointly create value in the innovation ecosystem. The interaction mainly occurs as a co-creation and transfer of knowledge and information in exchange for financial support. The high cost of R&D, knowledge and research infrastructure in the nano-electronics research projects forces companies to join innovation ecosystems such as ASML and TMC to benefit from the collaboration and the ultimately created value. This leads to the final block in the model: delivering the objectives of the ecosystem.

5.4.3.7 Delivering the objectives

Delivering an innovation ecosystem's objective is a step-by-step process. The first is setting objectives. In this initial stage, it is crucial to identify the organization's goal and set shared objectives. This enables organizations to realize the required expertise and technology infrastructures. Second is to select suitable partners. According to the project's requirements, potential partners that can contribute and complement each other's capabilities and skills are identified. Identifying the right partners can reduce potential challenges during the value creation process. Third is to determine factors that motivate ecosystem partners; offering financial support and providing the access to knowledge and research infrastructure could encourage partners to join ecosystems. This step enables organizations to attract suitable partners that are willing to effectively participate in the ecosystem. The fourth step is to determine a leader who can orchestrate, define other partners' roles and intermediate between partners. The orchestrator could resolve the challenges and conflicts between partners. Fifth is to determine partners' roles. In this stage, by acknowledging the roles' interdependences, the orchestrator is required to wisely define and determine partners' roles in the innovation ecosystem. This enables individual partners to recognize their role and what is required from them in each specific research project. Sixth is to connect partners with suitable ties. This enables partners to interact in a tension-free environment. Last is to deliver the ecosystem objectives. By thoroughly applying each step, organizations can jointly create value and deliver the final ecosystem objectives.

5.5 Discussion and conclusions

In this chapter, I investigated different types and role of actors in the innovation ecosystems. Although, prior literature explains different elements of the innovation ecosystems, it does not provide a solid base to evaluate such ecosystems empirically (Hu, 2011; Nambisan & Sawhney, 2008, 2011). As such, through an in-depth analysis of seven innovation ecosystems in the European nano-electronics industry, I identified different elements of such ecosystems. The crucial aspect in understanding how innovation ecosystems function is to determine roles of different actors (both orchestrators and non-orchestrators) and to investigate how these roles are mutually dependent. The theoretical model proposed in this chapter offers a distinct overview of different building blocks in an innovation ecosystem. Some of the elements identified with respect to the role of orchestrators are inline with the prior literature on innovation ecosystems (Nambisan & Sawhney, 2008, 2011) but the detailed analysis of innovation ecosystems in this chapter provides a broader and deeper perspective on the ecosystem by focusing on the role of different types of actors and on the interdependency of these actors in the innovation ecosystem (Adner, 2012; Hogenelst et al., 2014; Hu, 2011; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2008, 2011; West & Wood, 2013). The major contribution of this chapter is to develop an understanding of the logic behind the role of actors in innovation ecosystems by decomposing the different elements that are required to make an ecosystem successful in attaining its objectives: these elements include setting of the objective, the need for attracting different types of actors with different and complementary assets or competencies, the motivation factors of the participating actor to join an ecosystem, the definition of their multiple roles in the ecosystem, the need to align partners through specific actions of an orchestrator, and the understanding of how the actors interact with each other via different types of relationships.

The potential benefits of innovation ecosystems have been studied in the literature in the last five to ten years. The complexity of their functioning has been underestimated and managing an ecosystem could be captured in a set of guidelines for a single organization that operates as an orchestrator. In this study – based on in-depth qualitative research of seven innovation ecosystems – I can conclude that innovation ecosystems are more complex than previously thought. The functioning and success of innovation of ecosystems can only be understood by connecting an ecosystem’s overall objective to incentives of actors to join the ecosystem, their different roles, the management of the orchestrator and the different ways the partners are linked to each other in the ecosystem.

First, actors complement each other with respect to resources, knowledge, and expertise, and their performance influences the performance of others and the overall innovation ecosystem. Partners are valuable for the ecosystem based on their assets or competencies and they will play a different role in the innovation ecosystem depending on their potential contribution to the ecosystem. Innovation ecosystems in the nano-electronics industry are mainly established to produce innovative products, receive financial support from the government, and enhance the quality of healthcare. In this respect, different industrial partners, academic institutes, pharma companies, and government regulatory agencies are selected according to their capabilities and expertise and invited to join the ecosystem. Despite the benefits of joining an innovation ecosystem (i.e. access to open innovation mentality, saving R&D cost, and reducing project failure risks), IP protection issues, long research times, low expected benefits, and other shortcomings of collaboration in the innovation ecosystem might prevent actors from joining. Given these potential drawbacks, it is critical to determine factors that motivate actors to join the ecosystem: offering financial support, IP protection, and commercialization incentives could encourage actors to join the innovation ecosystem. Actors who are motivated to join an ecosystem will help to realize the objectives of the ecosystem, but they also have their own objectives and expect to reap benefits for their own organization. This search for value capture by different actors in the ecosystem will automatically lead to inconsistencies between actors and to suboptimal performance of the ecosystem. Therefore, a central actor will have to take the lead and orchestrate the ecosystem. An orchestrator has a critical role in creating a balance between the need to align partners in creating joint value within the ecosystem on the one hand, and their inclination to seek individual profits from that collaboration on the other hand. Because of this balancing act, an orchestrator will actively define and manage the roles of the partners involved. An orchestrator has multiple tasks to perform in an ecosystem. An orchestrator attempts to support partners, facilitate the value creation processes, and manage and stabilize the innovation ecosystem.

Finally, collaboration between partners in an ecosystem is shaped through suitable interactions between them. My research of innovation ecosystems in the nano-electronics industry reveals that interactions between actors can take different forms - power, IP, financing, knowledge and information, regulatory and advisory, and formal contracts. Shaping these ties in the right way facilitates the value creation process. In this respect, the orchestrator has to shape the interactions between partners to maximize the value creation process and in this way strengthen the innovation ecosystem.

This study has several implications for managers and policy-makers. In order to maximize the value creation in innovation ecosystems, organizing and managing the different partners in the ecosystem is essential. Managing ecosystems is a difficult process because of the complex objectives that initiators want to achieve and due to the number of actors involved. I provide a number of reasons why ecosystem management is far from trivial and needs close attention from managers and policy-makers. First, in some ecosystems I studied, there was also no single entity that has all the power and can direct the ecosystem single-handed. In the case of IMI and CTMM for instance, the government initiated the innovation ecosystem in order to spend public R&D more effectively in healthcare. Ecosystems such as IMI or CTMM are set up with the objective to provide grants to consortia of partners through tenders, realizing the government's objective in this way. The management of IMI and CTMM orchestrate the whole process, but they do that according to pre-specified rules. In reality, the situation is even more complex, as other entities – such as the advisory board – play a part in the management of these ecosystems. In sum, innovation ecosystems are not always led by one well-defined orchestrator, but sometimes, different actors play a role in initiating, leading and managing an innovation ecosystem. Understanding the interplay between these leading actors is important for the effectiveness of an innovation ecosystem.

Second, the innovation ecosystems can only realize their objective effectively if the orchestrator understands how roles of partners are complementary to each other and how they are interdependent. Roles are complementary to each other, and this implies that they can only be effective if all relevant partners are included in the ecosystem. Roles are also interdependent and the ecosystem's management therefore has to keep in mind that affecting the position of one type of actor in the ecosystem is likely to have an impact on all other types of actors. Because of these interdependencies, ecosystems are characterized by non-linear dynamics in which small actions of the ecosystem management can lead to disproportional changes in the ecosystem's performance. Hence, considering complementarity and interdependencies in establishing the innovation ecosystem is crucial. The implications are that management has to clearly define the objectives of the innovation ecosystem at the outset, it has to identify all types of partners with complementary resources and capabilities required to realize the ecosystem's objective, and it has to develop as set of rules, agreements, and routines that set the context of how partners can and should interact with each other in the ecosystem.

Third, ecosystem managers have to understand the factors that encourage potential partners to join the ecosystem. Each type of actor has a different motivation to join the ecosystem and looks for its own way to profit from it. Understanding these motivations can greatly reduce conflicts and facilitate the collaboration process. Moreover, even with good management, conflicts between ecosystem partners cannot be avoided. The leading actor(s) have to orchestrate, facilitate and support other actors in the innovation ecosystem, design, and shape the roles so that partners can perform and maximize their value.

Finally, innovation ecosystems can greatly facilitate policy makers. Governments are expected to support R&D activities of universities, research labs and companies, and innovation ecosystems are constructs that can greatly help to achieve better results with the limited government budgets. Policy makers thus have a lot to win by relying on innovation ecosystems, while at the same time, innovation ecosystems represent a new way of dealing with science, technology and industrial partners in providing public funding for R&D. The government as a funding organization initiates the ecosystem and helps to set the rules, but once the ecosystem is up and running, government control is indirect. In the case of CTMM, the Dutch government does not interfere with tenders, and it only checks whether the initial objectives are met. This is a new way of realizing a policy objective, which requires a different way of selecting projects and partners and a different stance from the policy makers.

While this chapter contributes both to theory and managerial practices, it has number of limitations. First, I limited the empirical research to seven innovation ecosystems in the European nano-electronics industry. More research in other industries has to be done to proof the external validity of this study. Second, this research concentrated on "established" innovation ecosystems. It is interesting to consider the evolution of innovation ecosystems and explore the impact of the ecosystems' dynamics on the role of actors. Similarly, innovation ecosystems emerge or have been set up by initiators and it would be of great interest to understand how success of innovation ecosystems depends on the way they have been established and developed. Third, I have examined how innovation systems can be decomposed into their constituent components and how roles of different partners are crucial in understanding the functioning of ecosystems. However, partners' roles do not explain entirely their actual behavior. Future research should focus on behavior of ecosystem partners when for instance distrust emerges among them, when market or technology uncertainty increases, or when an orchestrator is changing rules or incentives for the ecosystem partners.

Chapter 6

6 Orchestrating Belgian and Dutch nano-electronics innovation ecosystems: Internal preparation and external governance

6.1 Introduction

Nowadays, innovative collaborations are organized in ever more complex forms of governance, i.e. innovation ecosystems. In innovation ecosystems, organizations or research partners are generally specialized in different technical and scientific activities. Their long-term collaboration within such collaborative structures is indicative of how ecosystem partners depend on each other's expertise and complementary products and infrastructure. Despite many studies on innovative collaborations, only some scholars have concentrated on collaborations within innovation ecosystems (Adner, 2012; Chesbrough, 2003; Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011; Vanhaverbeke & Cloodt, 2006). In comparison with other forms of collaboration, such as strategic alliances and networks, in innovation ecosystems partners join forces to create value at the level of the ecosystem and contribute to a joint innovation strategy process. Indeed, some of the distinctive characteristics of innovation ecosystems are the joint strategizing and longevity of collaborations within these ecosystems (Borgh, Cloodt, & Romme, 2012). As each partner's performance is dependent on the strength of other members of the ecosystem, each actor has to deliver vigorous products so that the ecosystem as a whole is robust (Iansiti & Levien, 2004b). In this respect, effectively managing an ecosystem is crucial as this will stimulate shared development of novel ideas and technologies and lead to enhanced joint innovative performance (Chiang & Hung, 2010). In the context of ecosystem management, orchestrators have a significant role in managing and structuring their ecosystems for the purpose of maintaining long-term stability and continuity in joint collaboration success (Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011). Though understanding the role of orchestrators in managing innovation ecosystems is important, few scholars have investigated this issue with respect to network theory and design elements of ecosystems (Dhanaraj & Parkhe, 2006; Nambisan & Sawhney, 2011) or have concentrated explicitly on the managerial perspective (Iansiti & Levien, 2004a). These studies have mainly focused on networking, conflict resolution, and partner interaction strategies and discussed these strategies from different perspectives. Only one study elaborates on the provision of exit routes for partners in ecosystems as a means to resolve conflicts (Borgh et al., 2012). While these studies have explored some strategies, other strategies that may typically occur in nano-electronics innovation ecosystems are yet unexplored. For this reason, this chapter intends to fill this gap and contribute to the innovation ecosystem literature by identifying the orchestration strategies that organizations (orchestrators) use in the nano-electronics industry.

Complexity and high costs of nano-electronics R&D and its diverse applications in the pharmaceutical industry have stimulated innovative collaboration among organizations within innovation ecosystems. European governments, similarly to other regions, have concentrated on the development of nano-electronics research projects. Considering the importance of the nano-electronics industry and its crucial applications in the pharmaceutical sector (e.g. with respect to developing the quality of patient care), in this research I focus on the Dutch and Belgian nano-electronics innovation ecosystems active in the pharmaceutical sector. Through a qualitative approach using multiple case studies, I inductively generate theory from eight different innovation ecosystems (Corbin & Strauss, 2014; Eisenhardt, 1989b; Yin, 2013). All the ecosystems selected for evaluation of this chapter are orchestrators in their innovation ecosystems. Nvivo content analysis software has enabled me to create a theoretical model explaining the orchestration approach to innovation ecosystems in the nano-electronics industry. In this chapter I cover the blue section of the figure 2 of the introduction chapter.

The remainder of the chapter is structured as follows. First, in the literature review section, I clarify the evolution of collaboration, what has already been explored with respect to orchestration, and what needs further investigation. In the method section, I illustrate the research setting and the methodology applied. In the analysis section, I present the key findings on the basis of the cross-case analysis and the generated theoretical model. Finally, I discuss the findings and present several implications for managers and policy makers.

6.2 Background literature

This section illustrates prior research on the evolution of collaboration and the lessons learnt about ecosystem orchestration.

6.2.1 The evolution of collaboration: innovation ecosystems and previous forms of collaborative innovation

Collaboration for innovation is evolving; with experience, companies have engaged in ever more complex and comprehensive cooperative relations to reach their goals, i.e. increased innovative performance. Currently, we are witnessing the most extensive form of collaboration to date, i.e. the innovation ecosystem. To understand this new form and distinguish it from previous forms such as networks, we need to examine these earlier forms and describe how they are different from the ecosystem and how the ecosystem has naturally evolved from its predecessors.

In the early days of innovative collaboration, two companies would temporarily combine their technological resources and efforts to reach their strategic, innovative goals. These early dyadic strategic technology alliances were mostly driven by the self-interested behavior of the partners involved and joint strategizing was usually not the case; alliances were new tools to reach firm-level, innovative goals and they would typically be discontinued once the partners had reached these goals (usually within five years after the start of the joint research project). Companies made up for their lack of experience with this new tool by drawing up extensive contracts to control the other party as much as possible; some firms would even make a habit out of taking an equity stake in their technology partners for the sake of having a substantial say in the joint research projects and making sure their individual interests were taken care of.

As companies engaged in ever-increasing numbers of longer-lasting dyadic strategic R&D alliances with a growing variety of technology partners, the need arose to manage synergies across these many cooperative relations or technology alliance portfolios. Firms began to extract best practices from their alliance experiences and started to spread them throughout the organization; more mature firms would set up alliance departments that were in charge of collecting and disseminating this type of management knowledge for the purpose of optimizing companies' R&D collaborations. While firms were still acting as ego firms, trying to organize alliances in such a way as to best serve their own individual (competitive) interests, more mature companies were increasingly realizing that they needed to view their research alliances as strategic relations rather than one-time market transactions. As alliance portfolios and technology partners became a more structural element of doing business, high-tech firms started to treat their partners better and incorporate them into the strategic innovation process, leading to better results in the long term. Mature companies also increasingly began to organize their portfolios on the basis of more flexible, looser, trustful relations with strategic technology partners, not trying so much to control them anymore, but treating them as equal, valuable partners in the innovation process whose interests also need to be taken into account.

As R&D alliances proliferated in many different kinds of high-tech sectors such as biotechnology and IT, dense network structures started to emerge. While portfolios are characterized by direct connections between research partners and an ego firm that manages synergies within the technology alliance portfolio, R&D networks consist not only of direct relations between many different kinds of technology partners and an orchestrator, but also comprise interconnections among partners. With growing alliance portfolios of diverse innovation partners (e.g. suppliers, complementors, competitors, customers) many technology firms began to grasp the fact that the boundaries of their alliance portfolios were not clearly defined and that technical information was potentially traveling further than their direct research partners. Through their research partners they were able to tap into technological resources and know-how being created beyond their portfolios. As such, mature technology firms began to manage their collaborative arrangements to optimally position themselves for access to research and technology in the long term. Depending on their innovative strategies, companies started to be part of different research networks specialized in various technologies. In networks mainly used to scan for state-of-the art technologies, technology firms typically held a peripheral position. In other more crucial networks, focused on developing strategic technological resources, they commonly maneuvered themselves into more central positions, sometimes acting as orchestrators, actively determining the research agenda. Most of these networks would have long life spans, where technology partners with changed objectives would leave and new ones with necessary skills would come in, thus ensuring the continuity of the network as a whole. More and more, these research networks, which tended to be stable in the long term, would start competing with other networks, thus outgrowing the focus on the specific competitive positions of individual partners. Technological resources were increasingly being created at the level of networks, benefiting the network as a whole, and technology partners were engaged in joint long-term strategizing lead by an orchestrator, actively facilitating interaction and stimulating network continuity.

Recently, innovative collaboration has matured even further to what is termed innovation ecosystems. Innovation ecosystems have come about in different types of high-tech industries, such as nano-electronics, and they typically unite various kinds of technology partners in the long run. Several scholars have described innovation ecosystems as being very similar to biological ecosystems (Ranjay Gulati et al., 2012; Iansiti & Levien, 2004a; Vargo & Lusch, 2016). Through the technological resource-integrating interactions between R&D partners, innovation ecosystems create value at the level of the ecosystem, which ultimately benefits all partners. In other words, partners apply their technical resources for the wellbeing of the ecosystem and ultimately the wellbeing of all partners involved (Thomas & Autio, 2014; Vargo & Lusch, 2016). Within the innovation ecosystem, partners typically specialize in the technological activities they are good at and rely on other research partners to provide them with access to complementary resources. As such, partners depend on each other and the innovation ecosystem as a whole for survival and mutual effectiveness (Iansiti & Levien, 2004a; Nambisan & Baron, 2013). The role of the leading partner or orchestrator is usually to initiate and manage the innovation ecosystem so that it can survive in the long term (even though individual research partners may leave and new ones may come in).

To this end, they establish formal and informal rules, cultivate a shared logic guiding partners' behavior, stimulate trust among partners and actively manage conflicts, and facilitate optimal interaction between research partners. Besides being orchestrated structures, ecosystems also evolve on their own to some extent as research partners interact and co-evolve in the long run based on the shared logic underlying the collaboration (Ranjay Gulati et al., 2012; Mars, Bronstein, & Lusch, 2012; Thomas & Autio, 2014; Vargo & Lusch, 2016). More so than any previous form of collaboration, innovation ecosystems are about joint strategizing and longevity. Research partners that can contribute valuable technological resources are brought together to create value at the level of the ecosystem and to provide their input to the joint innovation strategy process. Orchestrators are focused on managing the ecosystem as a long-term, stable structure that continues to create innovative value despite the withdrawal of some research partners and the entry of new ones over time. In the past, several scholars within strategic alliances and alliance networks have disseminated crucial lessons with respect to the management of collaboration that we need to build on for the sake of gaining a comprehensive understanding of the orchestration approach used in the innovation ecosystems under study. The next section summarizes these insights.

6.2.2 The ecosystem orchestration: lessons from the existing literature

In order to acknowledge what has been identified with respect to collaborative management in the past literature, I have reviewed papers appearing in top innovation and management journals that have contributed to three related literature streams: strategic technology alliances, innovation networks, and innovation ecosystems. In total, I identified 35 journal papers from the Strategic Management Journal, Academy of Management journal, R&D Management Journal, Strategic Organization Journal, International Journal of Management, California Management Review, Harvard Business Review, Organization Strategy, Organization Science, Industrial Marketing Management, and Administrative Science Quarterly. Appendix D illustrates these papers and presents the authors' names, the literature stream to which the paper contributes, the underlying strategic theme, and collaborative management insights organized in two categories: internal preparation (how the company prepares the internal organization for managing collaborations and guarantees a smooth relation between the collaborative partners and the internal personnel) and external governance (how the company manages its external relations). Despite the growing importance of managing more complex forms of collaboration, previous studies have mainly contributed to the strategic (dyadic) alliance literature (21 papers). Only 14 papers have added insights to the innovation network and innovation ecosystem literature. This highlights the crucial need for more research on innovation ecosystems and the management strategies used by the orchestrators of such ecosystems. Below, I summarize the most important lessons from the existing literature on internal preparation for ecosystem orchestration as well as the external governance element of the orchestration approach.

6.2.2.1 The Internal preparation

Scholars within the strategic technology alliance literature have mainly focused on how firms develop strong partner relationships (8 papers) and only few have discussed the importance of organizational structures and internal communication within strategic alliance partners. With respect to developing successful partner relationships, papers have illustrated that building strong trustable relationships can enhance confidence among partners and create a reliable environment for interaction between strategic alliance partners (Das & Teng, 1998; R. Gulati, 1995; Ranjay Gulati, Lavie, & Singh, 2009; Kale, Singh, & Perlmutter, 2000; Madhok & Tallman, 1998). In this respect, past successful collaborative experience with a particular partner can increase trust between partners and may increase the intensity of interaction in new strategic alliances (Anand & Khanna, 2000; Hoang & Rothaermel, 2005; Kale, Dyer, & Singh, 2002).

Besides this focus on trustable partner relationships, few scholars have emphasized the significance of internal communication and collaborative structures within partnering organizations for the benefit of the alliances these companies engage in (Agarwal et al., 2010; Sarkar, Aulakh, & Madhok, 2009). It is purported that suitable internal structures that provide economic incentives and facilitate communication and trust between employees can prepare strategic alliance partners for more effective interaction with each other. Similarly, within the innovation network and ecosystem literature, scholars have emphasized the importance of developing trustful, open internal relationships between employees as well as strong, open internal communication. Researchers have highlighted that creating trustable relationships and efficient communication among employees within partners can assist and prepare organizations with respect to successful interaction within innovation ecosystems (Lorenzoni & Baden-Fuller, 1995; Rampersad et al., 2010b; Zaheer, McEvily, & Perrone, 1998). Moreover, it is mentioned that trust plays a central role at the level of the individuals interacting within the ecosystem. Not only can it prevent and more easily resolve conflicts occurring among partners, but it can also positively influence the performance of organizations in interaction with other firms (Zaheer et al., 1998). As such, partners with internal organizational cultures stimulating trust and openness in their employees are better equipped for managing their relations with ecosystem partners.

6.2.2.2 The external governance

With respect to external governance, researchers within strategic technology alliances have mainly emphasized the significance of partner selection techniques and criteria (11 papers) (See appendix D). The complementarity of resources, skills, and decision-making strategies as well as a shared vision, mutual commitment, and dependability of partners are some of the main selection criteria that have been identified as crucial for alliance success in the prior literature (Adegbesan & Higgins, 2011; Dussauge, Garrette, & Mitchell, 2000; J. H. Dyer & Singh, 1998; Gomes-Casseres, 2003; Holm, Eriksson, & Johanson, 1999; Inkpen & Beamish, 1997; Lippman & Rumelt, 2003; Mindruta, 2013; Sarkar et al., 2009; Saxton, 1997; Wassmer & Dussauge, 2011). Furthermore, few researchers have indicated that applying strategies to resolve or even prevent conflicts among technology partners and creating knowledge exchange channels can reduce tensions and enhance strategic alliances' governance efficiency (J. H. Dyer & Singh, 1998; Kale et al., 2002).

While scholars studying innovation networks and innovation ecosystems have similarly indicated the importance of partner selection and conflict resolution strategies (Adner, 2006; Dhanaraj & Parkhe, 2006; Leten et al., 2013; Willianson & De Meyer, 2012), they have introduced different perspectives on these strategies. The complexity of innovation ecosystems and the high interdependency among ecosystem partners highlights the importance of selecting partners strategically and for a long term. For instance, within innovation ecosystems, selecting complementary partners may expand to different types of industries and sectors. Similarly, it is suggested that resolving conflicts at the level of ecosystems may involve complex activities such as facilitating innovation processes, creating innovation communities, and applying customized orchestration strategies (Borgh et al., 2012; Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004b; Leten et al., 2013; Nambisan & Sawhney, 2011; Ritala et al., 2009; Vanhaverbeke & Cloodt, 2006).

Besides these lessons, scholars have identified two distinct strategies that uniquely correspond to the innovation ecosystem environment. First, building networking channels that relate to strategies (Jeffrey H Dyer & Hatch, 2006; Jeffrey H Dyer & Nobeoka, 2000; Lorenzoni & Baden-Fuller, 1995; Willianson & De Meyer, 2012) enabling partners to flexibly exchange knowledge and share their expertise. It is assumed that different networking channels enhance communication and interaction between partners within innovation ecosystems. Second, they have identified strategies that partners use to interact with each other within ecosystems. In this respect, IP models and other value capturing mechanisms such as contributions rights could effectively facilitate ecosystem governance (Leten et al., 2013; Nambisan & Sawhney, 2011).

Drawing from these reviewed papers, it is clear that the strategic alliance literature and studies on networks and ecosystems address several common strategies, such as trust building, collaborative experience, internal communication, partner selection, and conflict resolution strategies. However, more so than strategic technology alliances, innovation ecosystems are complex phenomena with a clear strategic focus that have long-lasting characteristics. This increases the level of tactics that are required to orchestrate partners within innovation ecosystems for longer periods of time (Borgh et al., 2012). In this respect, this study intends to extensively focus on innovation ecosystems and shed light on and investigate various strategies that orchestrators apply to prepare their firm for long-term collaboration and manage their strategic external interactions for continuity (See appendix D).

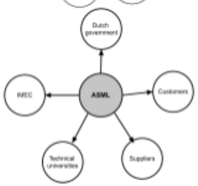
6.3 Method

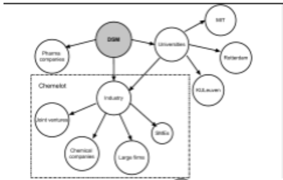
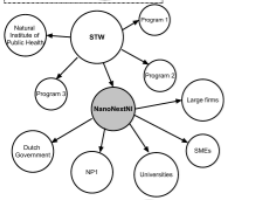
6.3.1 Research setting and sample

Considering the importance of innovation ecosystems and targeting nano-electronics for innovation and development in the pharmaceutical industry, and the importance attached by many governments to this technological growth, I focus on Dutch and Belgian nano-electronics ecosystems in the pharmaceutical sector. In total, I selected eight innovation ecosystems (i.e. IMEC, IMI, KULeuven, ASML, DSM, NanoNextNL, CTMM, and TMC) to investigate the strategies that orchestrators use to govern the innovation ecosystem (See section 3.3.1 for comprehensive data collection description). The selected cases orchestrate their innovation ecosystem. Table 12 illustrates these innovation ecosystems and presents a map of each ecosystem, the year of foundation, the number and type of partners involved, the name and type of orchestrator, and the value created by these ecosystems. I briefly describe this table below.

The largest Belgium-based nano-electronics research institute in the world, IMEC, established its ecosystem more than 30 years ago. Over 100 different types of partners such as private firms, hospitals, and other research institutes interact with each other on the basis of knowledge platforms to create advanced products in life sciences. IMI as a public-private partnership established its ecosystem in Belgium at a much later date than IMEC, i.e. in 2008. In this ecosystem, more than 100 partners, around 30 of these pharmaceutical companies, engage with each other to create improved and faster clinical trials as well as translational approaches to disease therapies.

Table 12 The ecosystems’ demographic specifications

Ecosystem map	Year of foundation	Number of partners	Type of partners	Orchestrator	Type of orchestrator	Value creation
	1984	More than 100	• Academic institutes • Industrial firms • Pharmaceutical companies • Diagnostic companies • Hospitals • The Dutch government	IMEC	Research center	• Life science (intelligent bioreactors, advanced diagnostics research on brain diseases, implantable neural microsystems) • Electronics (thin film electronics, ultra thin chip packages) • Silicon solar cells (cost effective, high efficiency and industry relevant)
	2008	More than 100 partners, 30 in pharma	• Academic institutes • Industrial firms • Pharmaceutical companies • European Union	IMI	Public-private partnership	• Improved, faster, and more reliable clinical trials of priority medicine (antibiotics, osteoarthritis, etc.) • New and approved diagnostic markers in biological heterogeneity and tumor variations • Translation approaches to disease therapy
	1972	More than 100	• Academic institutes • Industrial firms • Pharmaceutical companies • Hospitals • The Dutch government	KULeuven	University	• Collaboration services (legal services and EU advice) • IP (biological and bioengineering sciences, medical sciences, engineering, and applied sciences) • Spin-off support • Financial monitoring
	1986	Around 700 chip-manufacturing companies	• Academic institutes • Industrial firms • Customers • Suppliers • The Dutch government	ASML	Manufacturing company	• Customized products and systems • Ultraviolet lithography products • Mature products and services (thin-film heads/LED, radio frequency)

Ecosystem map	Year of foundation	Number of partners	Type of partners	Orchestrator	Type of orchestrator	Value creation
	1945	More than 100	• Academic institutes • Industrial firms • Pharmaceutical companies • Joint ventures	DSM	Science-based company	• Medical devices (biomedical, stereo- lithography) • Electronics (smaller, thinner, and greener components, thermoplastics) • Animal nutrition products
	2009	130	• Academic institutes • Industrial firms • Government agencies • The Dutch government	NanoNextNL	Dutch research consortium	• Nano-medicine (3C molecular imaging, 3B Nano-fluidics for lab-on-a-chip) • Bio-nano (projects in miniaturization) • Energy (projects in cost efficient, renewable energy)
	2008	More than 100	• Academic institutes • Industrial firms • Pharmaceutical companies • Hospitals • The Dutch government	CTMM	Public-private partnership	• Diagnostic tools for Alzheimer's disease • Rapid and accurate information generation tools for cancer patients • Advanced imaging techniques
	2000	More than 200	• Academic institutes • Industrial firms • Startups • Diagnostic companies	TMC	Insourcing agency	• Nanostructures optochemical sensors • Developing innovative products (manicure acute system) • Electric variable transmissions

The LRD center of the KU Leuven, a Belgian university, started to collaborate in 1972 with academic institutes, pharmaceutical companies, hospitals, and the Dutch government and began to form an ecosystem. Through funding, education, and training programs, the ecosystem provides legal services, IP protection advice, spin-off support, and financial monitoring for partners.

Similar to the ecosystem established by IMEC, ASML, a Dutch chip-machine manufacturer, founded its ecosystem around 30 years ago. Over the past three decades, ASML has interacted with around 700 chip-manufacturing companies to create customized products and systems in lithography and mature products (See table 12).

The oldest innovation ecosystem in this study is the one established by DSM in 1945. DSM, a science-based, specialized chemicals and pharmaceuticals company located in the Netherlands, interacts with academics, industrial firms, pharmaceutical companies, and joint ventures. Through R&D services and financial support it offers innovative medical devices, electronics components, and animal nutrition products. NanoNextNL is the youngest innovation ecosystem in my study and was initiated in 2009 as a Dutch research consortium. This ecosystem, joining around 130 partners of various types, conducts a variety of collaborative research projects in nano-medicine, nano-fluids, and energy.

CTMM, a Dutch orchestrator grounded in a public-private partnership, has, since 2008, engaged over 100 partners in academia, industry, healthcare, government, etc. in its ecosystem to create diagnostic tools for specific diseases and advanced imaging techniques.

Finally, in the year 2000, TMC, a Dutch insourcing agency, founded its innovation ecosystem that currently unites more than 200 partners. Through different R&D services, training, and education programs, this ecosystem develops innovative products such as nanostructures sensors, electric variable transmissions, and manicure acute systems (See table 12).

6.3.2 Methodology

Only a few studies provide insights on ecosystem orchestration strategies (Iansiti & Levien, 2004a; Nambisan & Sawhney, 2011) and a clear theoretical grounding is lacking for this topic. To address research questions in areas where viable theory and empirical evidence is lacking and where there is a clear need for in-depth understanding of a phenomenon, a qualitative research design should be used (Miles & Huberman, 1994). In this respect, I used grounded theory development on eight case studies that orchestrate their ecosystems (Corbin & Strauss, 2014; Eisenhardt, 1989a). This allowed me to have a clear view on how ecosystems are managed by orchestrators. The analytical procedure was based on coding to generate theories. Moreover, the Nvivo content analysis software facilitated the coding procedures in this research (See chapter 3 for complete methodology descriptions.).

6.4 Findings

The coding analysis of the eight innovation ecosystems has enabled me to draw the table 12 and the figure 11 (i.e. the blue section of figure 2). The table 12 shows the final themes of internal preparation and external governance as two main orchestration strategies that Belgian and Dutch nano-electronics orchestrators apply in their ecosystems. Their sub-categories are also shown across the cases. These strategies are reflected in appendix C tables vii and viii. Considering the logic behind the sequence of both main strategies and their relative components enabled me to generate the theoretical model. According to figure 11 and what I have already discussed and evaluated in chapter 4, the challenges among actors in the innovation ecosystem calls for suitable orchestration strategies. As such, the challenges block in figure 11 through a solid arrow line [21] is connected to the big rectangular block that presents the ecosystem orchestration. This block consists of two individual components that each corresponds to the internal preparation and external governance of the ecosystem. The ecosystem orchestration block shows that orchestrators both prepare for the orchestration task internally (through creating an open organizational culture, ensuring effective internal communication, and recruiting/training staff that will exhibit the necessary skills and attitudes to effectively partner) to create an optimal connection between the organization and the ecosystem, as well as focus on managing or even preventing tensions among ecosystem partners to ensure the long-term viability of the strategic collaboration (through e.g. instigating conflict resolution and partner withdrawal strategies and actively facilitating partner interaction through venues such as platforms). During this process trust development and financial support are important. As such, the rectangular block of trust and financial support is connected to all three external strategies with solid arrow lines. Since both internal and external governance strategies are interrelated to each other they are linked together with a solid arrow line. Through this process, the orchestrator resolves the challenges and orchestrates the ecosystem. Thus, the ecosystem orchestration block is connected to the rectangular shape of the "orchestration of the ecosystem" block.

In the discussion of the findings below, I elaborate on those items in figure 11 that are characteristic for orchestration approaches and were not identified in the

[21] Solid line is used to connect the building blocks to each other.

existing collaboration and ecosystem literature (thus excluding the importance of establishing inter-partner trust and experience with respect to partnering, selecting the right partner, and allocating dedicated budgets to collaborative relations). For each orchestration item in table 13, pairs of cases exhibiting similarities and differences in their approaches to the same item are discussed. By comparing and contrasting identified orchestration approaches in pairs of cases, it is possible to cover examples in relation to all eight cases in our discussion (ASML and TMC for internal preparation; IMEC and KULeuven for networking and conflict resolution; CTMM and DSM for partner withdrawal; IMI and NanoNextNl for interaction) (See section 3.4 for overall case descriptions).

6.4.1 The internal preparation

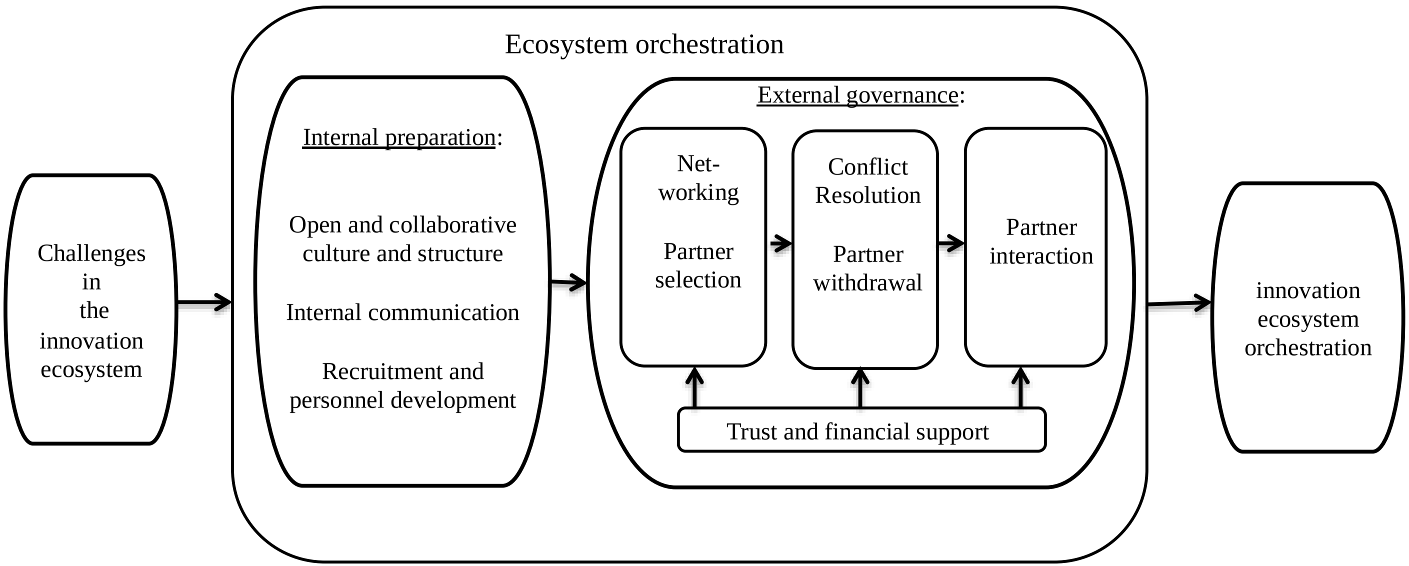
With regard to internal openness, the interviewee from ASML indicates that an open culture creates a platform for personnel to communicate and clarify their understanding of the challenges the company faces. It also enables employees to resolve technical or scientific issues. In the words of the strategic technology program director: *"ASML has an extremely open culture. There is no saying of "that's my area and nobody else knows about it". Or what you sometimes hear "it is not invented here"… there is a very clear and general understanding in the company of what the problems are at the moment."* Moreover, ASML looks for bright ideas. This means that the organizational structure of the company allows all employees to openly propose ideas and play an equal role in collaborative research. The company actively recruits and trains its employees to be entrepreneurial and show initiative. Through networking events, ASML furthermore stimulates its employees to interact with other experts and discuss technical problems.

TMC similarly has an open culture and informal structure in place. TMC's chemical and nanotechnology director notes that *"we are an open company, even board members walk around in the company and you can address your issues with them. We are always available. That's basically the atmosphere of TMC, it's very informal."* This open environment stimulates employees to collaborate in an effective manner and provide their innovative services to others. In addition, TMC actively invests in leadership programs so that employees are trained to create collaborative value for the company: *"investing in our people is very important and we hear from employees that they really appreciate that not only do we say that we invest in our people, but also we actually do it.*

Table 13 The cross-case analysis of the ecosystem orchestration

		Internal preparation			External governance									
					Conflict resolution			Partner withdrawal			Partner interaction			
Case	**Type**	Open and collaborative culture and structure	Recruitment & personnel development programs	Networking channels	Negotiation and communication	Creating balance	Project management services	Adopt and be flexible	Backup and upfront agreement	Replace by a new partner	Open and transparent strategy	Adaptive and customized strategy	Similar and standardized strategy	Platform strategy
IMEC	Research center	✓	✓	✓	✓		✓	✓	✓	✓		✓		✓
IMI	Public-private partnership	✓		✓		✓			✓	✓	✓		✓	✓
KULEUVEN	University	✓	✓	✓		✓			✓			✓		
ASML	Manufacturing company	✓	✓		✓		✓			✓	✓	✓		
DSM	Science-based company			✓			✓	✓	✓	✓			✓	
NANONEX TNL	Research consortium	✓		✓		✓		✓				✓		✓
CTMM	Public-private partnership		✓	✓	✓		✓		✓	✓	✓	✓	✓	
TMC	Insourcing agency	✓	✓	✓			✓	✓				✓		

Figure 11 The theoretical model of the orchestration approach used within the nano-electronics innovation ecosystems



We hear from clients that we are able to provide people that can make us proud". Similarly, necessary skills and attitudes with respect to partnering are taken into account when hiring new staff: *"I am a sales director here, not doing any technical work, but I do have a physics background. That really helps in talking to partners. For instance with ASML we understand their problems and if the program manager or the group leader explains his work, I can relate to these issues."*

6.4.2 The external governance

The results indicate that orchestrators in nano-electronics innovation ecosystems apply four main external governance strategies in relation to networking, resolving conflicts, coping with partner withdrawal, and ensuring effective partner interaction that are specific to ensuring long-term value creation within innovation ecosystems. I discuss networking and conflict management in one category, handling partner withdrawal and strategies to stimulate partner interaction in separate sections and provide examples from the cases.

6.4.2.1 Networking and conflict management

With regards to networking, IMEC arranges different events for ecosystem partners to meet, interact, and search for joint value creation opportunities. The business development manager of life science technologies at IMEC states that, *"an important example of how we manage partners is the "partner weeks" that occur twice a year. Partners take part in technical presentations. New ideas are presented and contracts are signed. (...) There is a lot of enthusiasm among people that is very effective. (...) That creates the conviction that we can make new things."* Besides this event, IMEC also has a program for residents from partners such as Panasonic and Samsung that collaborate with IMEC researchers. *"The resident program ensures that the research scope and contribution is clear for all residents working in the labs. We have project meetings where information is translated into Japanese or Korean. As such, communication among partners is facilitated. Residents also pick up new research opportunities through these networking channels."*

In order to resolve conflicts, IMEC applies two different strategies. One is communication and negotiation with partners. Over the past years, IMEC has learned that communication with partners is crucial in understanding each other's capabilities and challenges. Hence, through open communication with partners and inquiring about their requirements and challenges, IMEC resolves misunderstandings and manages tensions: *"at first they [pharmaceutical companies] were unwilling to sit down and discuss the problem; later, they agreed to give it a try. That was a great format and we shared a lot with them. Then we have to show our flexibility, we have to listen to them, make sure we understand* *their fears. And then we have to help them and accommodate them, in the best way we can."* Besides communication and negotiation, IMEC offers project management services to resolve potential conflicts within the ecosystem. In this respect, IMEC tries to create a secure stage for business discussions by, among other things, ensuring confidentiality in projects and making sure project teams are staffed with parties that are authorized to make budget decisions.

Orchestration strategies in relation to partner networking at KULeuven similarly involve the facilitation of interaction and knowledge exchange among academic researchers and industrial personnel. Stimulating interaction among these different groups helps researchers and industrial partners to understand each other's visions and expectations, thus preventing potential tensions and misunderstandings. With regards to managing conflicts, KULeuven very much relies on the intrinsic motivation and willingness of partners to be part of the ecosystem and interact with each other. In this respect the LRD general manager states that, *"at the end of the day, there is no single collaboration that will be truly successful if the people from the company and the people from our faculty are not willing to interact with each other in a very smooth and good way, no matter how much we want to make it happen, it will not work."*

6.4.2.2 Handling partner withdrawal

In order to ensure the longevity of its ecosystem, CTMM actively manages partner withdrawal risks that the ecosystem may face as a result of its smaller partners' potential financial problems in relation to long research time frames, bankruptcy, acquisitions, etc. The orchestrator applies two strategies in this regard. First, it chops up its research projects into small work packages that make management and completion easier for smaller partners. In its upfront agreements with small partners, CTMM stipulates that these partners can finish one particular work package, temporarily leave the project, and return when finances allow. Furthermore, CTMM actively backs up its research projects where a potential replacement for a critical party is identified upfront should a partner withdraw from a research project prematurely. CTMM communication manager states that,*"this is the main responsibility of the program managers (…) to get another partner instead of the partner that has withdrawn from the project (…) or to rearrange work packages so that others take over (…) to make sure that the project is not endangered."*

In a similar manner, DSM actively manages partner withdrawal hazards by building flexibility into its ecosystem, where partners can compensate for loss of skills and by negotiating upfront agreements that particularly cover IP issues. DSM VP open innovation states that, *"In public-private partnerships, it happens* *sometimes that companies withdraw but if they withdraw they should leave the potential ownership of IP to the remaining partners; this is a way to keep them on board."* Even in cases where crucial partners withdraw, DSM ensures the continuity of the research project: *"in these cases it is very important to find a better host for what you are not going to pursue. Because you have created value and you should not discard it."*

6.4.2.3 Strategies to stimulate partners' interactions

In order to stimulate partners within its ecosystem to interact in an effective manner, IMI applies three main strategies. First, the orchestrator provides (new) partners with a code of conduct or a set of rules that apply to the collaboration and that are known and embraced by all partners. IMI legal manager states that, *"I would say that when partners enter the collaboration, they know exactly what the rules for collaboration are and they commit to them."* Second, IMI ensures that all partners are treated equally and have an equal role within the ecosystem, where all partners know exactly what they can expect from each other. Third, IMI facilitates efficient and effective partner interaction on the basis of a platform created and maintained by the orchestrator.

NanoNextNl also facilitates partner interaction through offering a technology platform in which partners can exchange ideas and jointly work on resolving technical issues. The orchestrator views this platform as crucial for effective collaboration. Program officer states that, *"If the platform did not exist or was not working properly, then we would have a problem as there is more risk involved."* Furthermore, as its ecosystem is highly diverse in terms of types of partners, NanoNextNl stimulates partner interaction by stressing the diversity and unique roles of different partners and treating them in a flexible, customized manner so they can effectively play their unique roles. Program director mentions that, *"We have major parties that are really big companies and they can invest a lot of money but also small companies that are really innovative and can make a difference. How these partners work can be very different and we are flexible in that regard."*

6.5 Discussion and conclusions

This chapter aimed to investigate the orchestration strategies that organizations (orchestrators) use in their innovation ecosystems in the nano-electronics industry. Considering prior innovative collaborations such as strategic alliances and networks, innovation ecosystems are distinctive collaboration environments. Comparing the analysis with prior studies on innovation ecosystems, it is clear that this study is in line with Adner (2006) and Iansiti and Levien (2004a) on the importance of resource management and the role of orchestrators to the longevity of innovation ecosystems. Similarly, results complement findings of Dhanaraj and Parkhe (2006) and Nambisan and Sawhney (2011) on orchestration strategies by identifying other novel strategies in networking, conflict resolution, and partner interaction. Notably, this study contributes to the literature on orchestration strategies by identifying internal preparation strategies, partner interaction strategies, and strategies to resolve partner withdrawal.

Through collaborating in innovation ecosystems, organizations can not only create and capture value, but also reduce their R&D costs. Moreover, the joint strategizing and longevity characteristics of the innovation ecosystem enable partners to apply precise strategies to collaborate with their external partners for longer periods of time. Indeed, this adds to the complexity of the innovation ecosystem. Considering the complexity of innovation ecosystems and the fact that firms' inter-firm ties or their strategic networks may significantly influence their performance (J. H. Dyer & Singh, 1998; Zaheer et al., 2000), it is important to apply suitable and distinctive orchestration strategies. Orchestrators, as leaders in innovation ecosystems, have a crucial role to play in managing these ecosystems. Through orchestrating external and internal coherence, orchestrators can enhance innovative output (Nambisan & Sawhney, 2011).

The case analysis showed that orchestrators in nano-electronics innovation ecosystems not only externally govern the collaboration activities, but they also internally prepare the organizations to collaborate with their external partners. An open and collaborative organizational culture and communication enables personnel to better comprehend each other and recognize the organizations' ultimate objectives. Moreover, a clear understanding of the objective by different departments is crucial as it can enhance external collaboration. Similarly, frequent networking events with external partners enable organizations to meet each other and exchange knowledge and expertise. This interaction will not only increase transparency and trust between partners, but it will also facilitate them in identifying potential partners. On the same note, the enthusiasm among partners within the IMEC ecosystem generated by the orchestrator stimulates other partners to join and all partners to exchange knowledge.

Furthermore, my findings suggest several strategies that orchestrators can apply to enhance their orchestration activities. One is to create an open and collaborative organizational culture where employees can internally communicate and be supported for external collaboration. Second is to hire knowledgeable people for the research projects. Certainly, appropriate regular education and training programs can enhance the technical and scientific capabilities of personnel. In this respect, the open environment within TMC and their investment in personnel development has not only enhanced their skills, but has also increased customer satisfaction. Third is to create a networking platform for partners to join, build trust and exchange ideas. Different networking events at IMEC have led to existing and potential partners interacting and exchanging ideas. Fourth is to select suitable external partners. It is crucial that partners can complement each other in technical expertise and innovative infrastructure. Due to the high costs of R&D in nano-electronics research projects, it is crucial that partners from different disciplines with a variety of expertise join and collaborate within the ecosystem.

Next is to communicate and offer project management services to manage conflicts. Another aspect is to arrange backup and upfront agreements, and bring new partners in at the time of a partner's withdrawal. In this respect, sufficient financial assistance can resolve such issues, especially for SMEs. On the same note, the orchestration strategies that CTMM have applied to resolve this issue have reduced the chance of project failure and of the disintegration of the ecosystem as a whole. Last is to customize the interaction strategy with different partners. In this context, the customized ecosystem agreement that IMI arranges with its partners clearly defines the rules and expected benefits of research projects. Certainly, this strategy enables IMI to reduce potential conflicts among partners. I therefore anticipate that government, by supporting academic and industry collaborations, initiating funding agencies and facilitating monitoring and regulation policies through orchestrators in innovation ecosystems, can indirectly manage the collaboration activities and devise policies to effectively stimulate orchestrated ecosystems.

Chapter 7

7 Conclusions

7.1 Discussion

In recent decades, the advancement of technology has increased the complexity of projects. The high costs of R&D and the significant risks of failure have forced many organizations, especially in high-tech industries, to look beyond their R&D and technical expertise and interact with external partners. In the past, organizations tended to collaborate in dyads and groups of firms in networks or clusters. More recently, they have realized that by opening up and joining an innovation ecosystem and bringing together more partners and resources, they are not only able to benefit from the interactions, but they can also accomplish something that they could never achieve alone. The popularity of the open innovation paradigm and its beneficial impact on organizations' performances, especially in high-tech industries, has encouraged scholars in different disciplines of business, knowledge management, and strategy to focus on this concept, and to investigate its various aspects (Adner, 2006; Chesbrough, 2003; Chiaroni, Chiesa, & Frattini, 2011; Enkel & Gassmann, 2010; Lichtenthaler, 2011; Nambisan & Sawhney, 2011; Van de Vrande et al., 2009; Vanhaverbeke & Cloodt, 2006).

Despite the increasing number of studies on open innovation, the majority of research has examined this concept at the dyad and firm levels, and has focused less on the ecosystem perspective. Considering a firm as a unit of analysis in evaluating its innovative collaborations creates a biased view of that firm and fails to provide a clear picture of the partners' objectives and interaction mechanisms, as well as of the most common managerial solutions for conflict resolution. Compared with firm level analysis, ecosystem level analysis presents an unbiased and comprehensive view of organizations' objectives. From an ecosystem's perspective, it is possible to investigate value creation and capture mechanisms where the partners openly interact with each other to jointly create value and benefit from their collaboration. In this respect, recognizing the interaction mechanisms may also lead to better identification of the challenges, and ultimately strategically managing the ecosystem for optimal results.

Considering the importance of innovation ecosystems and the previously mentioned research gaps, this thesis is the first attempt to explore innovation ecosystems from a comprehensive perspective. Figure 12 shows the topic areas that were investigated in this thesis. The color of each topic area corresponds to the relevant section of the figure 2 that was introduced in the introduction chapter of this thesis.

Using a qualitative inductive approach, this thesis examines 10 Belgian and Dutch nano-electronics innovation ecosystems that offer products in the pharmaceutical sector. By concentrating on the nano-electronics industry, a typical high-tech industry, and considering that ecosystem develops in a dynamic manner, this study explores the innovation ecosystem by analyzing three broad research questions in three separate chapters (See chapters 4 to 6). First, by considering industrial firms, academic institutes and other profit and non-profit organizations, it explores the different mechanisms that organizations use to jointly create and capture value. In addition, while these two activities are interrelated in an innovation ecosystem and may pose challenges, this thesis investigates the potential challenges that organizations may face during this process. Moreover, this study emphasizes the importance of value drivers in inducing organizations to participate in joint value creation processes. Second, this thesis identifies and explores the roles of actors (orchestrators and non-orchestrators) in innovation

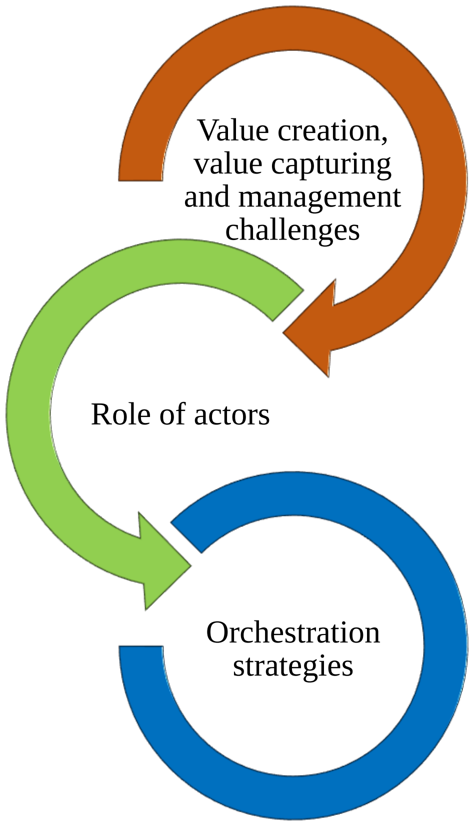


Figure 12 The topic areas investigated in each research question

ecosystems. The joint value creation mechanisms and interdependency of the actors in innovation ecosystems indicate that actors establish an innovation ecosystem to jointly create and capture value, and to achieve their goals. During these processes, they need to interact with different types of actors and may simultaneously play multiple roles that require the orchestrators to manage the roles and resolve conflicts. Third, it explores the orchestration strategies that are used to manage innovation ecosystems. In this respect, this thesis examines the different strategies that various type orchestrators in the nano-electronics ecosystem use to resolve their inter-organizational and intra-organizational challenges. The NVivo content analysis software facilitated the theoretical analysis of the data (i.e. from code generation to theory development) in three research questions, and resulted in three distinctive theoretical models. While each model responds to individual research questions, it reflects the richness of the data of the nano-electronics innovation ecosystem and the analysis procedure, and offers a well-defined guideline.

Reflecting on the nano-electronics theoretical model (See figure 2) that was introduced earlier and was covered through out the thesis, it is assumed that, organizations have specific objectives and follow clear logic when establishing an innovation ecosystem (See the green section of figure 2). Actors mainly establish an ecosystem to exchange knowledge, produce innovative products, receive financial support, and improve the quality of healthcare. In this respect, industrial firms (e.g. semiconductor, electrical, diagnostics, and industrial design companies), pharmaceutical companies, academic institutes (universities and research centers), hospitals, patient organizations, and government agencies (e.g. the Dutch government, The National Institute of Public Health) join together. They connect not only to access knowledge and infrastructure, but also to achieve an open innovation mentality. An open innovation mentality means that organizations have an open and friendly mindset when interacting with external partners and exchanging knowledge. An open and transparent collaboration environment motivates organizations to join an ecosystem, and jointly create and capture value. The interdependency of the actors leads to an interdependency of the roles. In other words, the performance of one actor can impact the performance of the others, and the overall performance of the ecosystem. Results show that by providing knowledge platforms, R&D services, and education and training programs, actors mainly serve as project partners, and jointly create value. They simultaneously play the role of facilitator or consultant in different research projects. Although joint value creation is the main objective of the actors in an innovation ecosystem, their return in benefits from the interaction is equally important (See the red section of figure 2). Through legal agreements, especially IP frameworks and contribution rights, actors acknowledge each other's capabilities and roles, and ensure they capture some of the value created. The diversity of actors' objectives in the search for value creation and capture in an ecosystem may cause tension. Our findings indicate two main types of challenge that organizations face in innovation ecosystems. One is the challenge of aligning the interests of external partners, and the other is what they face internally when interacting with different departments. Inconsistencies between departments with respect to an organization's objectives and lack of financial resources may lead to external tension. This is very apparent in SMEs where there are sometimes limited knowledge and financial resources. The analysis reveals that when SMEs face financial problems, they tend to withdraw from research projects, and ultimately from the ecosystem. This may lead to the failure of a project and eventually jeopardize large multinational companies' credibility and public image in the market.

The negative impact of these challenges on organizations and ecosystems' performances highlights the importance of the orchestrator's role in an ecosystem. Batterink et al. (2010) suggested that the orchestrator's role varies, depending on their innovation ecosystems. This means that the orchestrator can play multiple roles in different ecosystems. At the initial stage, to establish the ecosystem, the orchestrator aligns the objectives of all the actors, and distributes their roles, so that not only can the actors jointly create and capture value, but they also encounter fewer tensions. By applying different inter-organizational and intra-organizational orchestration strategies, they aim to manage the ecosystem (See the blue section of figure 2). When reflecting on the interdependency of the actors in an innovation ecosystem, the internal preparation of organizations is crucial. In this respect, an orchestrator generates an open and collaborative culture where personnel can openly communicate with each other, and develop their skills and capabilities. Moreover, the orchestrator can facilitate external collaboration by providing different networking sessions (with wisely selected potential partners that have the right technical knowledge and fit the research projects) where the actors meet, exchange knowledge, and resolve their technical problems. This enables the orchestrator to reduce potential problems. Importantly, it applies customized strategies to interact with partners. This allows the orchestrator to carefully manage the actors' roles in the ecosystem, and to shape their interaction in order to maximize the value creation process. Besides the orchestrator, our case evidence shows that governments can play a critical role. The Dutch government has indirectly attempted to integrate and manage ecosystems. By initiating agencies and financially supporting various institutes, the government enforces its regulations and monitors research activities, which may also create tensions between actors.

Consequently, it is clear that establishing and managing an innovation ecosystem is a very complex task that asks for a variety of actors to strategically collaborate toward a specific goal. It further requires an actor to not only orchestrate and facilitate other actors, but also to shape and structure their roles in order to successfully deliver the ecosystem's objectives.

7.2 Managerial implications

This study offers several managerial lessons for large and multinational companies, small and medium enterprises (SMEs), intermediaries, academic institutes, and the government agencies involved in the nano-electronics industry

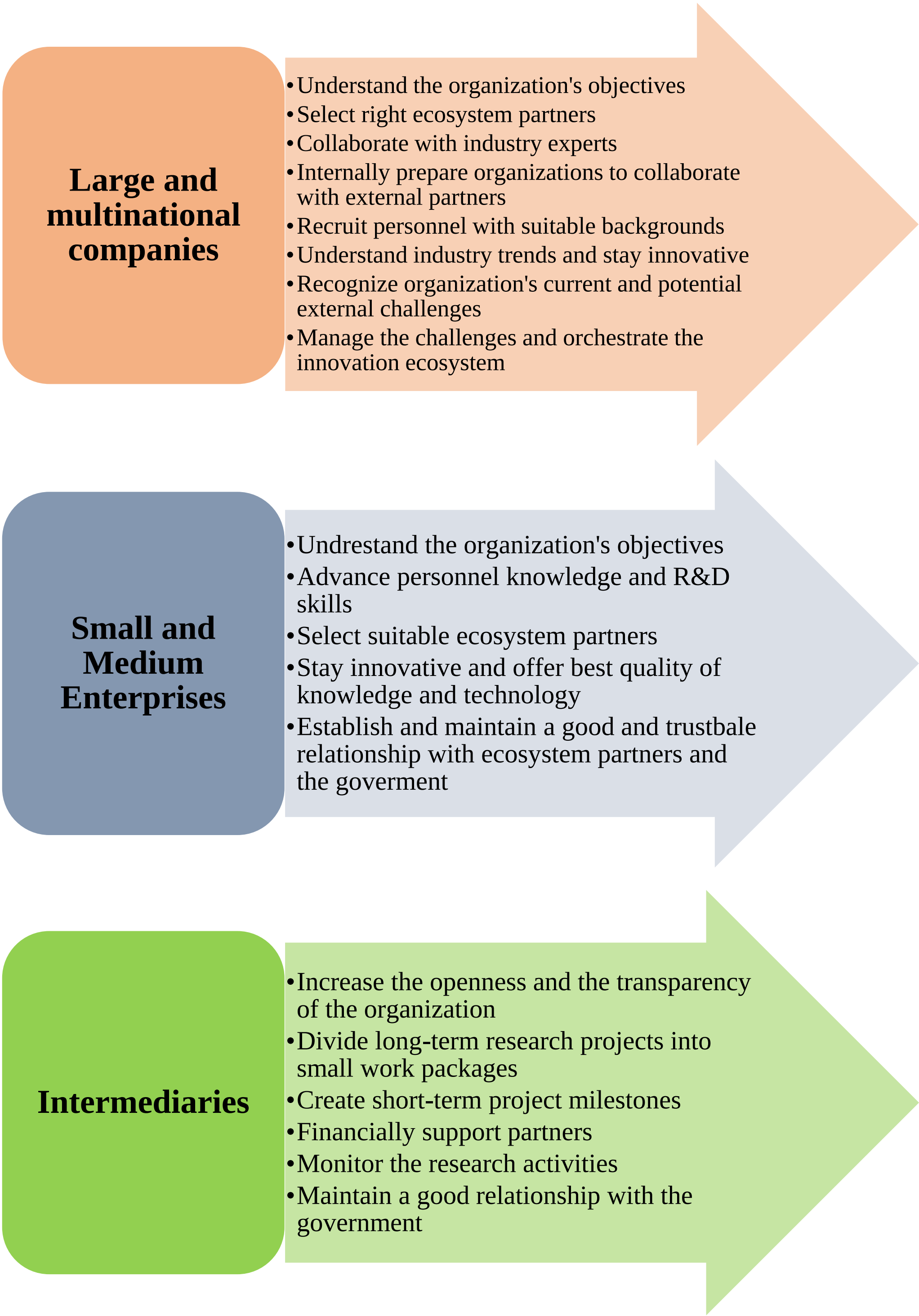
(See figure 13). Figure 13 illustrates the managerial implications for these categories. The implications mentioned below can also be extended to similar high-tech industries. The following section concentrates on each category of implication, and offers relevant strategies drawn from the investigated case studies.

7.2.1 Implications for large and multinational companies

This research clearly illustrates the important role of industrial firms in innovation ecosystems' performance. Notably, large and multinational companies contribute to nano-electronics innovation ecosystems by providing advanced resources, infrastructure, technical expertise, and financial means. Although they have mainly succeeded in achieving their objectives, there are a few lessons that would allow them to maximize their value and optimize their performance in an ecosystem. The first is to clearly understand their objectives. Recognizing objectives can allow companies to wisely establish their innovation ecosystem, identify the right types of partner, and assign their roles. The second is to select partners wisely. While partners are interdependent and their performances influence each other, large companies should invest in partners that have the right expertise and are willing to collaborate and participate in their projects, and ultimately in the ecosystem. In this respect, understanding their partners' objectives and motivations can genuinely assist large companies in attracting partners. By providing the expected benefits from their collaboration, partners can comprehend clearly the added value in the collaboration. The third is to collaborate with industry experts. The consequences of unfinished projects, or those that have failed to deliver their objectives are very severe, especially for large and multinational companies. It may endanger their public image and credibility in the industry. Creating trustworthy relationships is time-consuming, so damaging one's reputation in a high-tech industry such as nano-electronics may result in losing trust in existing and potential partners.

The fourth is to internally prepare organizations to collaborate with external partners. In this regard, creating and maintaining an open and collaborative culture within an organization allows the personnel to openly communicate with each other and between the departments, to resolve their conflicts, and to recognize their goals. The fifth is to recruit personnel with appropriate backgrounds. This can reduce the technical problems that may occur during projects. In this respect, investing in training and education programs to enhance the personnel's technical expertise can be very constructive. The sixth lesson is to understand the industry's trends and remain innovative.

Figure 13 Managerial implications



Academic institutes

- Understand the institutes objectives and their capabilities in different scientific disciplines
- Recognize the objectives of other partners in the ecosystem
- Select suitable academic and industrial partners
- Create an open culture and open innovation mindset
- Concentrate more on applied projects
- Motivate researchers to collaborate through incentives and contribution rights
- Support university spinoffs
- Develop and maintain trustable and transparent relationship with the government

Government

- Develop relationships with ecosystem partners
- Provide long-term financial commitment
- Support startups and SMEs (financially & non-financially)
- Offer government collaboration incentives and rewards
- Indirectly manage the ecosystem

By participating in industrial forums, seminars, and workshops, the personnel of large companies can not only develop their own knowledge and expand their networks they can also recognize future technological trends in the industry. This enables large companies to expand their ecosystems into game-changing industries. In this respect, the pharmaceutical and healthcare sectors are two fast-moving industries that have developed hugely in recent decades, and continue to look promising. The seventh is to recognize an organization's current and potential challenges with its external partners. Challenges such as their mindsets, IP protection issues, financial problems that may result in the partners' withdrawal from the ecosystem, and a clear project timeframe all enable large companies to plan ahead and design suitable strategies. The final lesson is to manage the challenges and ultimately orchestrate the ecosystem. Through different networking and technology platforms, large companies can act as orchestrators, create trustworthy relationships, and identify the needs of their partners and customers. Accordingly, they can customize their interaction strategies, design clear and transparent contribution policies that determine IP protection, provide financial support to resolve conflicts, apply their designed strategies, monitor their activities, and finally govern the ecosystem.

7.2.2 Implications for small and medium enterprises (SMEs)

This research shows that SMEs participate in innovation ecosystems. In general, a lack of financial resources, R&D's ability to develop and apply technologies, and the risk of technology and knowledge leaks all encourage SMEs to join innovation ecosystems. Although SMEs join in the success of the ecosystems, they have little or no power over the ecosystems' partners. In this respect, there are a few actions that could enhance SMEs' participation and performance in innovation ecosystems. The first is to understand their objectives and what they are really interested in. This facilitates SMEs to prioritize their demands and accordingly develop their capabilities. The second is to advance their personnel's knowledge and R&D skills based on their identified objectives. The third is to select suitable ecosystem partners and to establish trustworthy relationships with them. In this respect, joining a strong and successful ecosystem partner could not only enhance an SME's credibility in the market and expand its network, but it also could provide it with external knowledge and technology infrastructures. This does indeed allow SMEs to reduce their R&D costs and risk of failure in projects. The fourth is to remain innovative and offer the best quality knowledge and technology know-how. This is a crucial aspect for SMEs, as it could create a platform for other ecosystem partners (i.e. large and multinational companies) to frequently contact them for specific technological expertise. The fifth is for SMEs to establish and maintain a good relationship with all their ecosystem partners. Participating in regular meetings and social events held by their ecosystem partners could lead SMEs to openly communicate with them, acknowledge their objectives, and resolve any potential challenges. The last is to establish and maintain a trustworthy relationship with the government. In this regard, by joining public consortiums and offering innovative and technological expertise in national research projects, SMES can establish strong relationships with government agencies and benefit from their financial support.

7.2.3 Implications for intermediaries

Intermediaries are institutions that operate between governments and other organizations. Governments may also initiate organizations and institutes to act as intermediaries. For instance, CTMM and IMI are two public-private partnerships that act as intermediaries and simultaneously orchestrate ecosystems. Intermediaries generally connect governments with industrial firms and academic institutes. Exploring the nano-electronics innovation ecosystem has shown the important role of intermediaries in facilitating collaboration in this kind of ecosystems. In order to improve the performance of intermediaries in ecosystems, a few managerial lessons should be considered. The first lesson is to increase the openness and transparency of organizations so that more partners join technology and knowledge platforms, and exchange knowledge. The second lesson is to divide long research projects into small work packages, and to assign each work package to a suitable, skilled partner. This can reduce the chances of project failure. The third is to create short-term project milestones and reward systems. This encourages partners to work more efficiently to accomplish their tasks in shorter periods of time.

The fourth is to financially support partners. The government funds that are received for projects need to be clearly distributed and managed. Government funds are one of the main drivers that encourage organizations to join intermediaries and interact with other partners. A clear and transparent contribution agreement can reassure partners about how much they are contributing, IP protections issues, and the financial support they will receive during the project. The fifth is to monitor research activities. Due to research project delivery times and the limited amounts of government funds, it is crucial to regularly monitor your partners' project performance. In this respect, frequent meetings and networking sessions can allow partners to join their project leaders and directors to negotiate and resolve any potential issues. In this regard, by engaging in projects, intermediaries can consult with their partners on possible technical solutions, economize on spending, reduce possible delays in project delivery times, and stabilize their projects. The final lesson is to maintain a good relationship with the government. As intermediaries are initiated and funded by the government, they similarly enforce the research projects. This implies that intermediaries are actually required to respect government policies and regulations. As such, intermediaries can take the initiative to regularly generate reports on their projects' and partners' performances and financial spending. This develops trust in their relationship with the government.

7.2.4 Implications for academic institutes

This thesis emphasizes the important role of academic institutions such as universities and research centers in the nano-electronics innovation ecosystem. By providing their scientific knowledge and expertise for a variety of research projects, researchers can contribute to open innovation activities. In order to establish and enhance their role and participation in a successful innovation ecosystem, several issues should be considered. The first is to clearly understand their objectives and capabilities in different disciplines. This enables academic institutions to carefully differentiate between research projects and select the most feasible one. The second is to recognize the objectives of the other partners involved in the collaboration. In this respect, creating networking channels and social events where partners can meet and exchange ideas could clarify the innovation ecosystems' goals. The third is to select suitable academic and industrial partners that not only complement their expertise, but also facilitate the value creation process. The fourth is to create an open culture and open innovation mindset where researchers and industrial partners can openly interact with each other and develop their ideas. In this regard, creating university science parks and research labs could facilitate collaboration between technical engineers and academic researchers in order for them to concentrate on innovation and product advancement.

The fifth lesson is to concentrate more on applied projects. By understanding the industry's trends and the social issues, academic institutions can maximize their value in innovation ecosystems and financially benefit from their active participation in these types of projects. The sixth is to motivate individual researchers to collaborate with their industrial partners. Through offering attractive research incentives and contribution rights, academic institutions can encourage researchers and graduates to join their innovative collaboration. Travel grants and financial assistance for academics and PhD researchers are some of the research incentives that academics could gain when collaborating with industrial partners. The seventh is to support university spinoffs. University spinoffs enable researchers to develop their scientific and technological expertise, and to participate in innovation ecosystems. Academic institutions could create various networking sessions (i.e. scientific forums) where industrial partners (i.e. SMEs and startups) and financial institutions can offer their resources to support university spinoffs. This allows the spinoffs to participate in innovation ecosystems. The final lesson is to develop trust and maintain a transparent relationship with the government. By participating on government scientific advisory boards or other platforms, academic researchers can offer their scientific expertise and advice to policy makers, and establish their relationship with the government authorities. Notably, this creates a firm foundation for future academic-government collaborations.

7.2.5 Implications for government policy makers[22]

This thesis shows that the Dutch government participates in the nano-electronics innovation ecosystem. Their direct and indirect participation through intermediaries influences the performance of research collaborations and the ecosystem's objectives. By providing financial support for research projects, they encourage numerous startups and SMEs to join the innovation ecosystem. Similarly, their support for industry-academic collaborations through TTOs (Technology Transfer Offices) motivates academic researchers to step outside of their comfort zones, trust their industrial partners, and jointly create value. Governments can indeed play a crucial role in innovation ecosystems. The consideration of the following issues could enhance this role in innovation ecosystems. The first role of a government is to develop its relationship with its industry partners and academic institutions. By participating in industrial and academic seminars, workshops, and discussion forums, government representatives can develop their networks with their ecosystem partners, build trust, and understand the real-life challenges of people in society. This facilitates the government to support and financially assist where it is really essential. The second issue is to indirectly manage ecosystems. By assigning people to directory boards, government officials can indirectly engage in research projects and the ecosystem value creation process. In doing so, not only can governments recognize the challenges that organizations face in carrying out projects, but it also forces governments to initiate possible solutions and to manage innovation ecosystems. The third is to provide long-term commitment through financial assistance. The instability of government funds in research projects creates a challenging situation for intermediaries that include both industry and academic partners. Short-term financial support can act as a barrier against collaboration and result in the partners' withdrawal from their projects.

[22] Some sections are developed based on the interview (dated: Dec 11th, 2015) with the Senior Advisor of the Clusters and Business Networks from the Dutch government.

The fourth is to allocate more government funds to startups and SMEs. Governmental financial assistance can greatly support startups' and SMEs' performances and decision-making in ecosystem collaborations. Besides current companies, prospective startups can also observe their market potential in order to advance their business. Notably, governmental support for startups and SMEs could lead to advanced economic development. The final issue is to offer governmental collaboration incentives and rewards to large and multinational companies, pharmaceutical companies, academic institutions, hospitals, and other partners that are involved to encourage them to participate in ecosystems. Reducing companies' corporate tax, increasing the numbers and amounts of research grants for researchers and PhD students, and providing science parks and government research labs are some of the policies that governments can apply to motivate and facilitate innovative collaboration.

An additional role or goal of governments is (could be) that they should learn from the performances of the ecosystems that they have already instigated. Prior experience should be used to improve decision-making processes and ecosystem designs in order to improve collaboration between partners.

7.3 Limitations and future directions

Although this thesis offers novel and unique contributions to the innovation ecosystem literature, it has some shortcomings. The first two limitations are related to the nature of the qualitative methodology. The first is data collection. In general, collecting data from interviews is subjective, and they only reflect the interviewees' experience. Similarly, an interview can be regarded as a "self-report" where the informant responds to the research questions based on his or her beliefs or attitudes on the subject matter (Bazeley, 2013; Corbin & Strauss, 2014; Dey, 1993). The second is the interview environment. The researcher could not control the impact of environmental factors, or of the social, psychological, and organizational conditions of the informants during the interviews. This may have influenced the interviewees' responses to the interview questions. The third limitation is the internal validity of the theoretical models, which are generated from Grounded Theory development. While the reliability and validity of the coding procedure and theory development are achieved, the internal validity of theoretical models is not investigated in this thesis. However, their external validity has been confirmed by other innovation ecosystems. The fourth limitation is related to the generalization of the findings. While this study analyzes the nano-electronics innovation ecosystem and concentrates on Belgian and Dutch ecosystems, it is anticipated that similar results will be generated in other high-tech industries, although, this has not been examined here.

The fifth constraint is related to the types of innovation ecosystem analyzed in this thesis. This research analyzes "established" innovation ecosystems. This limits the analysis of the innovation ecosystem establishment and its evolution over time. The sixth is the analysis of established innovation ecosystems; this thesis uses multiple case studies to generate theory. Using multiple case studies in a longitudinal study would have enabled me to examine the dynamics of innovation ecosystems over a period of time, and to measure the changes in these ecosystems. Similarly, through a historical research design, I would have been able to investigate past occurrences of collaboration activities in order to test the hypothesis concerning the causes, effects, or trends of the events, and to predict similar future activities. The final limitation is related to the general shortcomings of qualitative methodologies. Although applying a qualitative methodology enabled me to investigate the "how" and "why" decision making in each research question (i.e. concepts related to theoretical explanation) from the primary data, it limited me when quantifying variations, predicting casual relationships, and describing the characteristics of the study population, which could have been achieved through using a quantitative methodology (i.e. statistical analysis).

7.3.1 Future directions

While this research analyzes Belgian and Dutch nano-electronics innovation ecosystems, and addresses several research gaps, there are also a number of potential research directions that emerge from this thesis. I encourage researchers and scholars of innovation ecosystems to consider the following research avenues.

7.3.1.1 The big picture

First, in this study I identified several value drivers that encourage organizations to create and capture value. It would be interesting to focus on one specific driver such as IP or funding, and observe whether IP protection, for instance, leads to a specific type of value creation and capturing mechanism. Second, I mainly focused on the key actors (i.e. pharmaceutical companies, universities, research centers, and industrial firms) that participate in the nano-electronics industry and offer products in the pharmaceutical sector, and I collected proportionally less information on other actors such as hospitals and patient organizations. In this respect, it would be worth exploring other types of partners in innovation ecosystems such as hospitals and patient organizations, and evaluate their value creation and capture mechanisms, the challenges they face, and the strategies that they apply to resolve their issues. Third, I identified different orchestration strategies. Although the ecosystems examined here are successful, it would be interesting to measure the impact of orchestration strategies on ecosystems' performance, and determine which strategies lead to better performances. Why is this the case? Perhaps this could be explored through using a quantitative methodology (i.e. creating questionnaires). Fourth, in this study, I indicated that a lack of financial resources is one of the reasons that could lead to the withdrawal of SMEs from innovation ecosystems. This could be further developed and other factors investigated that result in the withdrawal of SMEs from innovation ecosystems in order to determine possible resolution strategies.

Fifth, while this study explored successful innovation ecosystems, it would be interesting to analyze ecosystems that have failed to deliver their objectives, and to determine the contributing factors. This would not only expand the innovation ecosystem literature, but it would also offer practitioners lessons to learn from. Sixth, with respect to cases of failure, it would be worth further determining which factors mainly contribute to the breakdown of ecosystems and how failures can be prevented. Seventh, in this thesis I explored "established" innovation ecosystems. By considering the dynamics of ecosystems' settings and their evolution over time, it would be interesting to explore the establishment of innovation ecosystems and analyze their evolution over time. This indeed would open a new horizon in the "innovation ecosystem dynamics" literature. Eighth, to further explore "the evolution of the innovation ecosystem," one could focus on the dynamics of the roles within ecosystems, and understand under what conditions actors play different roles. This could be achieved through using the Fuzzy Set (Ragin, 2000) approach. Adner (2012) has examined the evolution of ecosystems with respect to large-scale adoption. Finally, it would be useful to expand this research to other European countries. This research investigated Belgian and Dutch ecosystems. It would be interesting to examine similar aspects of innovation ecosystems in other European countries and to compare the findings.

7.3.1.2 Innovation ecosystems and its promising future

Collaboration has been a major driver in economic growth and, as such, many organizations have already established innovation ecosystems and expanded their collaboration with external partners. In this respect, considering the rapid development of nanotechnology and the increasing number of innovation ecosystems, first, it is crucial to further explore other areas of this industry. For example, exploring nanotechnology applications in the food industry or nano-medicine would help both researchers and practitioners. Second, assuming that the mindsets of pharmaceutical companies are gradually shifting from the traditional view to the ecosystem view, it would be worth focusing on this industry and conducting an in-depth analysis on their collaboration approach. Third, in this study, I analyzed nano-electronics innovation ecosystems as a "high-tech" industry. Considering that there is a gap in the “low-tech” industry innovation ecosystem literature, it would be worth concentrating on a specific type of “low-tech” industry and examining similar lines of research. Recently, Vanhaverbeke (2017) published some research on ecosystem development in small firms in “low-tech” industries. This research could be further developed with comparing the “high-tech” innovation ecosystems to “low-tech” ones. Finally, knowing that governments participate in innovation ecosystems, it would be interesting to conduct a comprehensive study exploring the roles of governments in innovation ecosystems. This could be developed in two directions, one in a comparative study that examines the role of governments in a “high-tech” and a “low-tech” innovation ecosystem. The second would be to compare the roles of governments in different regions, such as Europe and North America.

8 Appendices

Appendix A Summary of the reviewed studies

No.	Industry	Title of study	Authors	Year of publication	Country of study	Concept	Research question	Methodology
1	Software intensive	Aligning innovation ecosystem strategies with internal R&D	Bosch-Sijtsema, Petra M Bosch, Jan	2014	Northern Europe and North of America	Ecosystem strategy and ecosystem model	Align the innovation ecosystem strategy with the internal R&D.	Qualitative: empirical study, 4 case studies.
2	Nano-electronics	IP Models to Orchestrate Innovation Ecosystems: IMEC, a public research institute in nanotechnology	Bart Leten, Wim Vanhaverbeke, Nadine Roijakkers, André Clerix, Johan Van Helleputte	2013	Belgium	Orchestration model	Present what is the IP model of IMEC and how it has enabled IMEC as an orchestrator to successfully lead the innovation ecosystem?	Qualitative: empirical study, case study
3	Electronics, IT, health care, semiconductor	Wide lens a new strategy for innovation	Ron Adner	2012	Not mentioned	Innovation and strategy	Address the difference between the innovation that succeed and innovations that fails, although customers' needs are identified. Also indicates on execution of some blind spots in the ecosystem.	Mix methodology
4	Aerospace, IT	Orchestration Processes in Network-Centric Innovation: Evidence From the Field	Satish Nambisan and Mohanbir Sawhney	2011	USA	Managing the ecosystem	Investigate the shift from firm-centric innovation to network-centric innovation	Qualitative: empirical study, number of case studies + social network concept
5	Textile	Open innovation in Networks: Building a network perspectives and the role of firms in Networks.	Yimei Hu	2011	Denmark and China	Ecosystem strategy	Identify what is the difference between innovation network and network organization? Investigate weather the focal firm can always manage the ecosystem and what is the relating factor?	Qualitative: empirical-exploratory study-1 case study
6	Semiconductor lithography equipment	Value creation in innovation ecosystems: how the structure of technological interdependence affects firm in new technology generations	Ron Adner and Rahul Kapoor	2010	Not specified	Strategy and ecosystem	Identify how do the challenges faced by external innovators affect the focal firm's outcomes?	Qualitative: empirical study, case study, statistical analysis
7	Agricultural	Orchestrating innovation networks: the case of innovation brokers in the agri-food sector.	Maarten H. Batterink, Emiel F.M. Wubben, Laurens Klerkx and	2010	NL,GR,FR	Managing the ecosystem	Determine how orchestrators successfully orchestrate innovation ecosystems of SMEs?	Qualitative: empirical study, semi-structured interviews and inductive approach

No.	Industry	Title of study	Authors	Year of publication	Country of study	Concept	Research question	Methodology
			S.W.F. (Onno) Omta					based on case studies
8	Information technology, nanotechnology and biotechnology	Managing innovation networks: Exploratory evidence from ICT, biotechnology and nanotechnology networks	Giselle Rampersad Pascale Quester and Indrit Troshani	2010	Australia	Managing the ecosystem	Investigate the key management processes for an effective management strategy in innovation ecosystem from perspectives of various actors in the ecosystem.	Qualitative: empirical-exploratory study-interview and quantitative: survey questionnaire-descriptive and casual research.
9	Telecommunication	Opening up for competitive advantage- how Dutch Telkom creates an open innovation ecosystem?	René Rohrbeck, Katharina Hölzle and Hans Georg Gemünden	2009	Germany	Creating an ecosystem	Analyze to what extent the open innovation paradigm has been embraced inside Philips multinational company.	Qualitative: empirical studies based on case study
10	TV mobile services	Innovation orchestration capability – defining the organizational and individual level determinants	Paavo Ritala, Leila Armila and Kirsimarja Blomqvist	2009	Finland	Orchestration, creating and managing ecosystem	Investigate the determinants of orchestration capabilities in building and managing innovation ecosystems in multilevel.	Qualitative: empirical studies based on in-depth case study
11	Mobile	Visualization of inter-firm relations in a converging mobile ecosystem	Rahul C Basole	2009	USA	Ecosystem strategy	Understand the complexity and structure of inter-firm relationships in mobile ecosystem.	Quantitative: exploratory study-databases: alliance and joint venture and Social network analysis
12	Electronics & IT	Creating and Evolving an Open Innovation Ecosystem: Lessons from Symbian Ltd.	Joel West, David Wood	2008	Not specified	Creating an ecosystem	Study how to create an ecosystem in high tech industry and explore how the ecosystem is evolved over time?	Qualitative: empirical study, case study
13	Biopharma	Towards technological rules for designing innovation networks: a dynamic capabilities view	Palie Smart, John Bessant and Abhishek Gupta	2007	Europe, UK and USA	Designing ecosystem	Produce design-oriented knowledge for configuring inter-organizational networks as a means of accessing such resources for innovation.	Qualitative: empirical studies based on literature (systematic review) and interview
14	Electronics	Match Your Innovation Strategy to Your Innovation Ecosystem	Ron Adner	2006	Not specified	Strategy and ecosystem	Investigate management strategy in high-tech innovation ecosystem, based on 3 fundamental risks and evaluate the performance expectations.	Qualitative: empirical study, number of case studies
15	Pharmaceutical	Orchestrating innovation networks	Charles Dhanaraj and Arvind Parkhe	2006	Not specified	Innovation and managing ecosystem	Explore how hub firms are orchestrating the innovation ecosystem?	Qualitative: empirical studies-descriptive

No.	Industry	Title of study	Authors	Year of publication	Country of study	Concept	Research question	Methodology
16	Agribiotech	Open innovation in value networks	Wim Vanhaverbeke and Myriam Cloodt	2006	Not specified	Managing the ecosystem	Role of inter-organizational networks on commercialization of new products offerings based on technological breakthroughs	Qualitative: empirical studies, case study
17	Biotech and internet services	Strategy as Ecology	Marco Iansiti and Roy Levien	2004	USA	Strategy and managing ecosystem	Investigate Wal Mart and Microsoft' innovation ecosystem	Qualitative: empirical study, case study
18	Digital production	Managing Innovation Networks: Exploring Competition Dynamics in Innovation Ecosystems	Vasili Mankevich	2014	Sweden	Managing the ecosystem	Explore the dynamic of the orchestrator's involvements in developing innovation ecosystem.	Qualitative-empirical study based on case study and interview
19	Dutch PV (solar energy)	Innovating in interdependent contexts: Applying an ecosystem perspective to the innovation process of small and medium-sized enterprises	Hogenelst et al.	2014	The Netherlands	Managing ecosystems and innovation risks	Investigate how innovative SMEs can apply the innovation ecosystem approach to their innovation process?	Qualitative-exploratory-descriptive study based on case study- interview
20	Telecommunication	Orchestrating innovation ecosystem: a case study of telecom wholesaler growing into a global hub for cross-innovation	Diana Catalina, Botero Marin	2012	Spain	Managing the ecosystem	Identify practical management and orchestration process strategies and fir the findings to the study case.	Qualitative-empirical study based on case study and deductive reasoning analysis

No.	Variables	Findings	Contribution	Limitation	Future studies / gap
1	*Ecosystem strategy * internal perspectives: company strategy, technology platform, organizing. * External dimensions: ecosystem strategy, ecosystem technology and ecosystem organizing.	Study presented ESTO model (ecosystem strategy and technology platform organizing) in order to analyze and present 4 types of approaches on how firm can align the ecosystem strategy with its internal R&D.	Applied ecosystem strategy analysis model to align the internal R&D on different cases. * Identified 4 different ecosystem strategies.	* Study is industry specific. * ESTO model cannot be generalized or applied in other industries or ecosystems.	*More in-depth study of different types of ecosystems and their model. *More details investigation on the influence of the context and the role of firms plays in the ecosystem in relation to the different innovation ecosystem strategy. * Investigate other actors and their role in the ecosystem.
2	*IP model, *Orchestration model, *Value appropriation	* Presented the IP models and orchestration model of IMEC. * Discussed the open innovation management practices in IMEC. * Explained how based on the presented models IMEC is successful.	*Presented an IP model and orchestration model in Nano-electronics innovation ecosystem	* Study is based on one case study. * Does not evaluate other partners and their role in the ecosystem.	*Develop classification scheme of innovation ecosystems with different governance structures
3		*Presented various tools through 3 phases of seeing the ecosystem, choosing your position and winning the game. Such as innovation risk framework, value blueprint and 5 levelers.	*Created a 3 step toolkit as "wide-lens toolbox" while used in iteration will provide managers and their team to create a best strategy and continue on success path.		
4	*Ecosystem design factors (ecosystem embeddens and openness), *innovation design factors (modularity) and *orchestration processes (managing innovation leverage, managing innovation coherence and managing innovation appropriability)	*Presented network orchestration processes reflect the interplay between elements of innovation design and network design. *Illustrated orchestration processes model and their possible practical strategies	*Presented framework for orchestrations processes based on innovation design and network design attributes	*Study concentrates on some of the orchestration processes, and design factors. *It is mainly focused on social network analysis perspective of the ecosystem.	*Consider other orchestration processes, organizational design factors, characteristics of focal firm and their impact on ecosystem orchestration. *Focus on ecosystem and orchestration processes from managerial aspect and NOT social network analysis.
5	* Key components of network organizations: actors, resources, commonality, activates and infrastructure. * Different levels of ecosystem: inter-organizational, inter-organizationally and the network level. * Focal firms power.	*Showed that based on the strength of a firm's power, its role may varies in the ecosystem from manager to adaptor. *Illustrated a conceptual model of focal firm's role in different levels of network.	*Presented a conceptual model for strategic managers to recognize the importance of power in the role of firms in different levels of ecosystem.	*Study focuses only on one case study. *Considers only SMEs can have an impact on the findings. *Also considers the linear conceptual model for a dynamic network is inappropriate. *Moreover, the different in network levels is not suitable since the levels are overlapping and cannot be classified in 3 levels.	*Consider more case studies. *Investigate the study with other actors in the ecosystem, such as R&D centers and universities. Also count other firms sizes such as large and multinationals.
6	*Dependent: generation share *Independent: technology leadership, component challenge, complement challenge, vertical integration, and technology maturity. *Control variables:	*Proposed that the effectiveness of vertical integrations a strategy to manage ecosystem interdependence increases over the course of technology life cycle.	*Presented a framework for the effect of ecosystem challenges for the innovators to organizational theory literature.	*Study did not consider core challenges of focal firm.	*Considering ecosystem approach is crucial for researchers and managers hence areas such as business model, value chain configuration, customer expectations, positioning and coordination choices will become

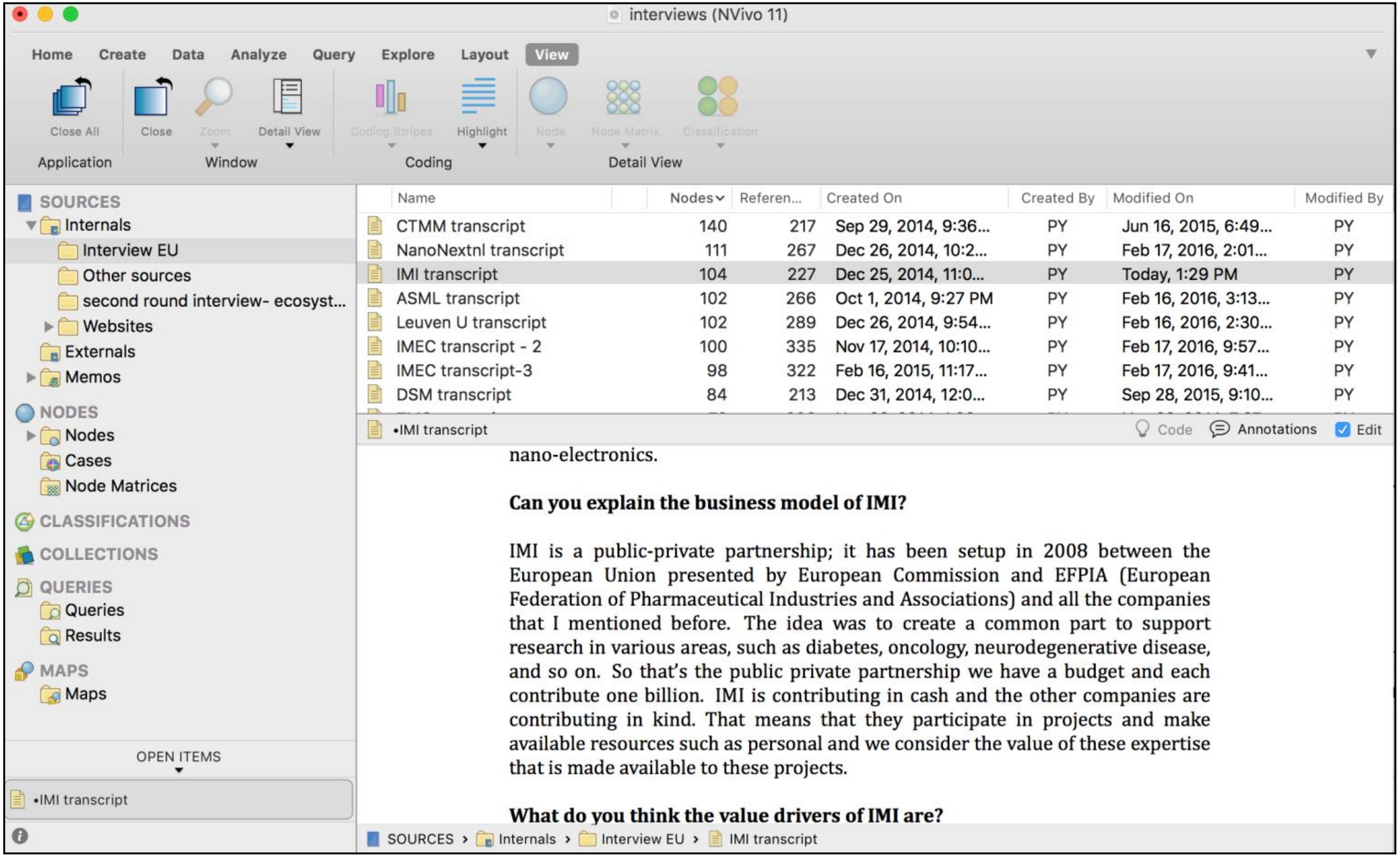
No.	Variables	Findings	Contribution	Limitation	Future studies / gap
	incumbent, conglomerate, and generation sales growth, number of firms.				more important in ecosystem context.
7	*Innovation design activities (membership, structure and position) and on going management processes (resource mobility, value creation and appropriation and ecosystem stability and development).	*Showed that orchestrators have added value to the ecosystem, especially with the orchestration processes such as innovation initiation, ecosystem, composition and innovation process management. *Presented the best practices for the orchestrators.	*Presented a framework for successful orchestration processes by orchestrators in SMEs based on 4 cases.	*Study concentrates only on SMEs and few orchestration processes. *It does not consider large corporates or other actors in the ecosystem. *Also it is specific to agriculture (food) industry.	*Compare the orchestrators in various organizations settings and countries. *Consider other multifaceted orchestration processes in the ecosystem with regard to SMEs.
8	*Power distribution, *trust, *coordination, *harmony, *communication efficiency, *R&D efficiency on network effectiveness.	*Indicated that all factors considered has an impact on the managerial implications of the ecosystem and trust is the most crucial factors. Some factors have direct and others have indirect effect the management implications.	*Presented various management factors that should be considered and have an impact on the ecosystem management in 3 different industries.	*Study used insufficient sample size (124). * Considered some of the factors. *Did not concentrate on orchestration role or the focal firm. *Investigating one specific country (i.e. Australia)	*Consider larger sample size. *Obtain more rigor method to improve reliability and considering within organizations and among other type of organizations. *Hypothesis testing among non-universities, firms and government. *Concentrate on the cultural aspects and cross-country perspective in to the study.
9	*Open innovation instruments based on 4 phases of idea generation, research, development and commercialization. *Also 3 OI processes outside-in, inside-out and coupled.	*Identified 11 open innovation instrument and their contribution. * Mapped the innovation ecosystem of Dutch Telekom	*Presented the open innovation activates of Philips and its activities. *It also indicates that by opening up the innovation process Philips has enhanced their innovation capacity. *Showed that multinational companies such as Philips can enhance their innovation capabilities.	*Study obtained small sample size for the interview 15 amongst 240,000 employees, hence the open innovation activates are limited	*Enlarge the sample size of the study and also *Consider various case studies evaluating SMES as well as other actors.
10	*Orchestration processes: stability, mobility and innovation appropriability on 2 levels of individual skills and organizational capabilities	*Identified the 15 determinants of orchestration capability and proposed that there is an interplay between individual and organizational capabilities. This interplay is presented in 4 mechanisms. *It showed that in absent of capabilities; individual efforts can drive the innovation ecosystem.	*Presented elements to understand the innovation orchestration capabilities, which can facilitate managers to consider at individual levels and on organizational capability stand point. The case orchestrates a complex innovation ecosystem.	*Elements identified are specific to the case study. * Did not consider other actors perspectives. * Specific to one country	*Investigated various cases to identify elements that facilitate managing the ecosystems.
11	*Network measurement: density, degree centralization, closeness, betweenness of current mobile ecosystem and emerging ecosystem.	*Indicated that many firms in the mobile ecosystem have started partnering with firm from other segments for manufacturing, development and new mobile	*Concentrated on entire mobile ecosystem. *Provided a mean for decision makers to understand firms' competitive position in	* Used incomplete database of alliances *Mainly concentrated on large, public companies, startup and SMEs were not considered. *Results were biased: for simplicity reason only considered	*Differentiate the ecosystem by their purpose and investigating the relationships of the actors. *Compare between the ecosystems based on their purpose and

No.	Variables	Findings	Contribution	Limitation	Future studies / gap
		services. *Also showed various network measurement of the ecosystem, which changes as an ecosystem merges with another ecosystem and converts to new ecosystem. *Moreover presented that mobile ecosystem has more than one orchestrator.	the ecosystem. *It illustrated the importance of the relationships in new converging ecosystem. *Also concentrated that business model should adapt the network-centric idea of the firm.	one relationship and avoided multiple relations. *It only concentrates on the social network analysis of the ecosystem- a static approach on dynamic ecosystem* did not focus on management aspect of the ecosystem.*did not include end-customers, universities or research centers. Only firms.	relationships. * Compare different alliances such as Android, Windows mobile and so on. *Identify the candidates for cartelizing the ecosystem. * Use more enhanced visualization techniques.
12	The case ecosystem was based on *3 phases of An ad hoc Ecosystem Strategy, *Symbian Platinum Partners and *Symbian Partner Network	*Identified challenges of managing the innovation network, hence the importance of leaders in managing the innovation networks.	*Indicated that the technical structure is important than the business structure. *Also through proposing the challenges in managing the ecosystem, it facilitated orchestrators to prioritize the need conflicts.	*Considers single case study, and specifically mobile phone industry.	*Investigate on value added complementary supplies. *Define the operationalization of ecosystems with multiple leaders.
13	Based van Aken's design oriented knowledge for innovation. *Considering two view of resourced-based view and *dynamic capabilities view.	* Identified 7 theoretically and empirically grounded rules associated with effective interorganizationally networking innovation. * It highlighted the importance of dynamic capabilities that addresses the renewal of network specific resources, which tackles at the network level.	*Represented set of rules a tentative taxonomy, a means to classify design principals that can facilitate managers in directing their decision-making processes.	* Study is specific to biopharmaceutical industry.	*Consider other industry context
14	3 fundamental risks: *interdependence risks, *initiation risks, *integration risks	*Introduced the importance of IE through reduce in coordination cost, *Formulated an ecosystem strategy based on three fundamental risks of IE, * Mapped the IE based on innovation strategy.	*Presented a framework to managers of organizational strategies to implement more effective profitable innovation	*Concentrated on large multinational companies. * Focused on risk aspects in the ecosystem. *Does not cover other factors.	*Consider various cases and other factors in the ecosystem.
15	Orchestration processes: *managing knowledge mobility, *innovation appropriability, and *network stability, *innovation ecosystem output	*Proposed that hub firms are at the center of many ecosystems and they have crucial role in formation, growth and success of the ecosystem.	*Proposed an orchestration framework in innovation ecosystem, on network management	* Ecosystem was oversimplified by considering as dichotomy of orchestrator and peripheral actors. *Large innovation ecosystems were the focus of the study.	*Consider other orchestration processes. *Investigate how hub firms create and extract value from their ecosystems or how they orchestrate?
16	Value constellation based on new business model *Value drivers * value creation	* To manage the value constellation, understanding how value is created and distributed is crucial.	* Contributes to open innovation in value constellation and business models	* Study concentrates on specific case study in one industry.	*Study open innovation in other industries and at multiple layers (e.g. individual or unite level Vs. innovation and system level). *

No.	Variables	Findings	Contribution	Limitation	Future studies / gap
	* Value appropriation * value constellation management		development in mature businesses		Investigate dynamic of innovation networks. * Essential to integrate the theoretical frameworks
17	*Ecosystem health: productivity and robustness over time. *Level of turbulence and innovation and complexity of relationships	Presented the benefit attributes to ecosystem management of studied cases. * Emphasized on the health of the ecosystem. * Indicated the importance of keystone role in the productivity of the ecosystem. * Identified the 2 factors that contribute to success of keystone: 1. creating a platform and 2. Sharing the value. *Strategy that needs to be matched to the environment.	*Ecosystem presenting implication for managers in strategy, operation, policy and product design.	*Study only concentrates on 2 large multinational companies and it does not evaluate the role of SMEs or other actors such as universities.	*Investigate role of other actors in the ecosystem.
18	*Ecosystem design, *orchestration processes and *outcome framework of Dhanaraj and Parkhe (2006) study was used with 3 *developing phase of the case (open forum, externalization and fragmentation)	* Identified 3 stages of ecosystem development and investigated the development phase with the orchestration processes. * It indicated that orchestration processes are not carried out simultaneously but they tend to respond to the environment of the firm. * Illustrated the position of the orchestrator as the ecosystem develops (role dynamics of the orchestrator in the ecosystem).	Provided in-depth evaluation of the innovation ecosystem orchestration within the digital creative industry, including its development phases and the challenges related to it. *The application of competition notion to the innovation ecosystem context brings forward tensions that should be further considered in order to develop better management practices for such innovation networks.	*Specific industry was studied, therefore it can not be generalized to other IT companies or other industries.* the context of the sample case it was selected from an area where there is strong presence of academics and also economic crises were present.	*Study of such framework in other industries and other cases is needed for better understanding due to complexity of the orchestration processes.
19	*Innovation development phase, *Innovation risks and *ecosystem strategies.	*Showed that the process can be done in 3 step of ecosystem strategy of ecosystem path, ecosystem role and ecosystem product positioning. * It determined the innovation ecosystem risks and the relevant development phases that they encounter. * Identified 2 more ecosystem strategies messo and macro. Messo comes from the dominant regime and macro comes from the landscape	Added to the literature of innovation ecosystem evolution and how innovation ecosystem and its role is changing during the product development process. *Also it explores the risks that SMEs face during the product development process and their respond to it. *In addition presented a multilevel framework to better understand and manage SMEs during the	*A retrospective research resulted in a biased study. *Available data was not sufficient to detect a pattern for generalization; risk responses were too diverse to be generalized. *Concentrated on one specific industry. *Interviewed the CEO/founder can impact the innovation strategy applied and responses to risks. * The available resources to the case were not similar so can impact the responses to risk.	*Perform a longitudinal research on innovation ecosystem. * Consider other emerging industries for further investigation. * Choose similar respondent in terms of personality and experience.

No.	Variables	Findings	Contribution	Limitation	Future studies / gap
		factors. * Showed that more leaders often mitigate the risks.	product development process.		
20	*Orchestration processes based (Dhanaraj and Parkhe (2006) and Nambisan and Sawhney, (2011), *management tool kit of Adner, 2012)	*Illustrated orchestration strategy map of the case study based on the company's objectives. * Identified the key success factors of the case study, based on respondents and Adner's management tool kit.	*Created an orchestration strategy for the case studied so it can create a platform to orchestrate the ecosystem and deliver a new experience to the customers.	* Study only considers one specific case/ company. * Specific industry is studied. * Other actors in the ecosystem are not counted into the evaluation.	*Investigate the challenges that potential orchestrator might face. *Consider various case and other actors in the ecosystem. *Investigate other industries.

Appendix B Snap shot of the NVivo 11



Appendix C coding tables

Table i Theory generation procedure for value drivers

Case name	In vivo codes	Sub-categories/themes	Themes	Selective codes
IMEC	Opportunity to network with big companies	Networking opportunity	Access to external knowledge	Value drivers
IMEC	Opportunity to network with big pharma companies, designers, diagnostics companies (Nano-electronics and health care system)			
IMI	Networking with big leading pharma companies			
ASML	Expand network of good partners			
NanoNextNl	Access to the network and capacity of other partners			
KULeuven	Access to the network of partners			
DSM	Access to the network			
ASML	Interact with technical universities and research centers	Collaboration opportunity		
DSM	Access to the technology			
NanoNextNl	Interaction with other partners and stakeholders			
IMI	Access to platform to exchange knowledge			
IMEC	Chance of communication (partner week)			
IMI	Collaboration of all stakeholders			
ASML	Interesting subjects for research	Research opportunity		
ASML	Option for graduate students research topics			
DSM	Opportunity for research projects and graduate students			
IMEC	Co-development projects with pharma			
ASML	Entrepreneurship			
IMEC	Access to advanced facilities, tools and labs	Infrastructure and products	Access to complementary assets, infrastructure & competence	
ASML	Access to high-tech and advanced facilities, good equipment's and machines			
DSM	Access to world class labs			
IMEC	Interacting with an independent lab in the world (i.e. IMEC)			
DSM	Access to industrial parks			
IMEC	Access to new tests			
ASML	Access to innovative designed products			
ASML	Access to complex /unique products			
IMEC	Access to new technology			
IMEC	Access to research infrastructure			
IMEC	Complexity of the projects			
IMEC	Professional and highly technical people	Technical People		
KULeuven	Access to business mentality			
NanoNextNl	Access to innovation services (training and business plans)			
NanoNextNl	Access to project management services			
IMI	Existence of support and monitoring expectations	Monitoring		
IMEC	Existence of regulators in the projects with pharma			
NanoNextNl	Monitoring the research programs			
IMEC	Welcoming environment	Access to open innovation mentality		
ASML	Very open internal environment			
ASML	High tech environment			
NanoNextNl	Open environment			
DSM	Access to open environment			
IMEC	Adaptive strategy/ flexible strategy	Flexibility		
NanoNextNl	Flexible strategy			
KULeuven	Flexible strategy			
IMEC	Patience and flexible with SMEs			
ASML	Flexibility and space of supplier and partners to design products			
IMEC	Collaboration freedom			
NanoNextNl	Working freely			
DSM	Chance of residency in DSM for project			

ASML	Everybody is heard.	Communication and trust	Transparency and trust	
NanoNextNl	Consider partners feedback			
NanoNextNl	Existence of communication and trust			
KULeuven	Existence of communication and trust	Clarity		
KULeuven	Clarity of activities			
IMI	Clarity from the beginning			
NanoNextNl	Well organized consortium	Intellectual property		
IMEC	Access to IP			
NanoNextNl	Share of IP			
KULeuven	Handling the IP with out a problem			
DSM	Joint IP agreement			
IMEC	IP protection			
IMEC	Reduce failure risk in projects	Failure risk	Risk reduction	
IMEC	Safe environment/no fear of project failure			
IMI	Reduce failure risk in projects			
IMEC	Reduce cost / cost efficiency of products	Cost		
IMI	Reduce networking cost			
KULeuven	Cost efficient			
IMEC	Cheaper diagnostics tests			
IMEC	Clear path to commercialize			
IMEC	No upfront money for new projects			
DSM	Cost efficient analysis			
IMEC	On time/ faster results	Time		
IMEC	Funding projects	Funding opportunity	Financial support	
NanoNextNl	Investment opportunity/ funding for partners			
KULeuven	Opportunity to access to governmental funding			
DSM	Opportunities for funding			
IMI	Access to financial support			
IMI	Government contributions	Government support		
ASML	Government support / EC			
NanoNextNl	Government support			
IMEC	Satisfying past collaboration results	Collaboration history	Network credibility	
IMI	Successful and satisfying past collaboration projects			
KULeuven	Successful history			
IMI	Leader in the industry	Leadership		
KULeuven	Leader in the industry			
IMEC	Number one life science provider			
IMEC	Game changing in health care industry			

Table ii Theory generation procedure for value creation

Case name	In vivo codes	Sub-categories/ themes	Themes	Selective codes
IMEC	Offer research in three phases (early science, feasibility and developed stage)	Research	Provide R&D services	**Value creation**
IMEC	Offer personalized medicine			
NanoNextNl	Offer excellent scientific research			
IMEC	Developed technology in protein essays and DNA	Research and Development		
IMEC	Silicon drug developed test			
IMEC	Improve the quality of health care			
ASML	Offer R&D services			
NanoNextNl	Offer R&D services			
DSM	Offer R&D services			
IMEC	Offer a technology platform	Technology platform	Provide knowledge platform	
NanoNextNl	Create and develop a technology platform			
IMEC	Offer platform for life science projects	Research and collaboration platform		
IMEC	Offering platform to share cost and early insight			
IMI	Provides platform for research projects			
KULeuven	Create a collaboration platform for other parties			
IMEC	Offer application oriented products	Application oriented products	Provide innovative products	
NanoNextNl	Offer application of results in practice			
IMEC	Products with less energy consumption	High-tech products		
IMEC	Semiconductor products			
IMEC	Offering disposable chips			
IMEC	Creating and developing diagnostics tools			
ASML	Offer higher and innovative designed products			
IMEC	Offer downscaling transistors equipments	Equipment and solution		
ASML	Offer lithography and printing equipments for chips			
IMEC	Creating and developing diagnostics tools			
IMI	Funds organizations in contact	Provide funds		
KULeuven	Provide funding to KU Leuven			
DSM	Offer financial contributions			
IMEC	Knowledge expertise	Knowledge and expertise	Provide education and training programs	
NanoNextNl	Create a shared vision among partners			
KULeuven	Offer consulting agreements			
NanoNextNl	Offer education program and assistance in business development.	Training		
IMI	Provide education and training programs			
KULeuven	Offer regional development for Flemish region			
IMI	Support, manage and monitor projects	Projects services	Provide innovation management services	
KULeuven	Offer innovative projects			
IMI	Ensure all stakeholders collaborate	Collaboration environment		
KULeuven	Create an open environment to collaborate			
DSM	Offer business development	Business development		
DSM	Creating spin offs			
KULeuven	Creating spin offs			
KULeuven	Offer licensing			
DSM	Offer licensing			
DSM	Offer venturing			
DSM	Business acquisition			

Table iii Theory generation procedure for value capturing

Case name	In vivo codes	Sub-categories/themes	Themes	Selective codes
IMEC	IP framework, IP protection	IP framework	Arrange agreements	Value capturing
IMI	IP policy/ agreement (single policy for everyone)			
ASML	IP frame agreement (prices, share)			
KULeuven	IP protection			
DSM	IP agreement (joint IP)			
IMEC	Bilateral agreement on new IP generation	Bilateral		
NanoNextNl	Bilateral agreement with partners to use facilities			
IMEC	Consortium	Consortium		
IMI	Existence of projects consortium			
NanoNextNl	Program consortium agreement (IP right, cost, what to share at partner level)			
KULeuven	Consortium agreements for large firms			
IMI	Legal framework	Legal		
DSM	Legal agreement			
IMEC	Customized contracts for partners (based on cost and benefit)	Customized		
IMEC	Customized /flexible contracts for partners (based on partner, their offer in project.			
IMEC	Customized application projects (CAPS)			
KULeuven	Consultancy agreement for SMEs	Consultancy		
IMI	General framework for projects	Project		
NanoNextNl	Memorandum Of Understanding other partners (program level)	MOU		
KULeuven	Upfront fee and royalty from TTO	Entrance fee	Assign Contribution rights	
DSM	Upfront fee and royalty			
IMEC	Entrance fee on background IP			
IMEC	Equal and fair contribution (money and in kind)	Contribution types		
NanoNextNl	Financial contribution is clear (50% partner, 50% government)			
NanoNextNl	Results are shared			
NanoNextNl	All partners within the program are owners of IP			
DSM	Equal and fair contribution (money and in kind)			
IMEC	Funding partners have certain rights			
IMEC	Only funding partners have the right to select their CAPS			
NanoNextNl	Free patenting options (base on approval of partners)	Licensing	Define Incentives	
ASML	Government incentive (low corporate tax and employee tax)	Government		
IMI	EU- pharma co-lead projects			

Table iv Theory generation procedure for challenges

Case name	In vivo codes	Sub-categories/ themes	Themes	Selective codes
IMEC	SME take longer time in projects	View on research time frame	Inter-organizational challenges	**Challenges**
NanoNextNl	Time frame/ Period of research			
KULeuven	Expect firms accomplish complex task in short time			
ASML	Short term commitment			
NanoNextNl	Building relationship at time of program setting up.	Developing relationship		
NanoNextNl	Communication takes time and effort			
IMI	Convince partners and build relationship among them.			
ASML	Transparency and building trust			
IMEC	Co-development is hard.			
IMEC	Not into communication			
IMEC	Reaching to them is difficult			
IMEC	Only rely on special companies			
DSM	Withdrawal of partners	Withdrawal of partners		
IMI	At withdrawal funding stops so SME receive fund from IMI			
NanoNextNl	Withdrawal of partners/ SMEs bankruptcy			
DSM	Getting a good contract	Funding issues		
NanoNextNl	Funding of PhD students stops			
NanoNextNl	Receiving fund takes time			
IMI	At withdraw funding stops			
IMI	Receive fund from IMI			
DSM	Covering IP	IP protection issues		
IMI	Legal IP framework			
IMI	Create a network and expand	Diversity in Objectives		
NanoNextNl	Look for development			
KULeuven	Expect free services from universities			
NanoNextNl	Look for research			
NanoNextNl	Look for research for graduate students			
IMEC	Variation in demands			
IMEC	Want to have their own diagnostics			
IMEC	Independent of diagnostics companies			
IMEC	Finding a right biomarkers			
IMI	Ensure success			
DSM	Convincing partners of OI benefits	Diversity in Mindset		
ASML	Not having R&D regulators			
KULeuven	Idealistic expectations from partners			
IMEC	Don't see the reason to invest			
IMEC	Mindset is different			
IMEC	No trust on new technologies			
IMEC	Chip tech is not accepted yet.			
IMEC	Culture does not believe in OI			
IMEC	Possessive on IP			
IMEC	Do not look at mechanism of disease and side effects			
IMI	Large pharma: work very systematic			
IMEC	For large companies project failure creates bad image and public press, they have big budgets	Public image		
IMI	Create bad image at withdrawal			
IMEC	Uncertainty of customers	Risk sharing		
IMEC	Consolidation			
NanoNextNl	Invest in Nanotechnology projects and available funds for parties			
NanoNextNl	Dutch government funds 50% of the project cost			

ASML	Government funds part of projects	Government contribution & interference		
IMI	European Medicine agency leads many projects.			
IMEC	Creating research labs			
NanoNextNl	Collaboration between academics and industry partners to receive funding	Government requirement		
KULeuven	(KPI) key performance indicators, number of contracts & spinoffs			
KULeuven	Return on money and tangible results			
ASML	To satisfy government			
ASML	Show companies the generated result			
NanoNextNl	Monitoring the research programs	Report & monitoring		
IMEC	FDA approval is expensive	Financial problems	Intra-organizational challenges	
IMEC	Clinical trials are expensive			
IMEC	Diagnostics is expensive			
IMEC	Complexity of diagnostics			
IMEC	IP department - internal	Inter-departmental issues		
IMEC	Overcome internal hurdles			
IMEC	Internal negotiation			
IMEC	BM has to change (adapt to the BM and revenue model)			
DSM	HR. department/ high frequency of personnel movements			

Table v Theory generation procedure for objectives of the innovation ecosystems

Case name	In vivo codes	Sub-categories/themes	Themes	Selective codes
CTMM	Bringing all parties together	Bringing people together	Establish ecosystem platform	Objectives
CTMM	Building the relationships			
CTMM	Translate knowledge of academics to clinical practice	Bringing knowledge & expertise		
CTMM	Bringing knowledge to Netherlands			
CTMM	Precise diagnostic and personalized therapies			
CTMM	Have a practical role			
IMI	Establish collaboration among stakeholders	Create an ecosystem		
IMI	Create a sustainable ecosystem			
IMI	Facilitates collaboration			
ASML	Integrate systems components	System integrator		
ASML	Interact with other ecosystems/industries			
TMC	Insourcing agent create open innovation platform	Insourcing agencies		
TMC	Focus on technology			
ASML	Produce lithography/ printing equipment for computer chips	Produce lithography equipment	Produce innovative products & solutions	
ASML	Invent lithography products			
ASML	Produce energy efficient semiconductors			
Ridgetop	Developing new products	Produce advanced product & solutions		
CMOSIS	Supplier of CMOS image sensors			
CMOSIS	Produce electric parts for digital cameras			
CMOSIS	Manufacture light and measuring equipments			
CMOSIS	Provide industrial inspection cameras			
CMOSIS	Producing x-ray and dental images			
Ridgetop	Produce products			
Ridgetop	Interacting with niche market	Lead health and semiconductor industry		
Ridgetop	Provides advanced equipment solutions in health &semiconductor			
IMEC	Deliver products to increase the credibility	Produce advanced nano and bio products & solutions		
IMEC	Produce precise innovative chips			
IMEC	Deliver industry solutions			
IMEC	Develop bio-electronic tools			
IMEC	Offer nano-electronics products and solutions			
CTMM	Assist universities to get the required fund	Funding assistant	Funding support	
CTMM	The multiplier effect at CTMM			
CTMM	Indirect salary for PhD students			
CTMM	Earn more money			
IMI	Funding agency	Financial platforms		
IMI	Provide fund for academic partners			
IMI	Provide fund for SMEs			
IMI	Create legal and financial platform			
CTMM	Ensure that research is performed with movement guideline	Monitor and control activities	Monitor activities	
CTMM	Taking care of milestones and midterm revenue			
CTMM	Monitor contribution of partners in the project			
CTMM	Back office system monitors the projects objectives			
IMI	Support research on diverse areas	Support and monitor research projects		
IMI	Support and monitor and manage projects			
IMI	Educate and train partners			

CTMM	The benefit for patients	Lead innovative MD and MI	Improve health care performance and shape the future	
CTMM	Fast patient care			
CTMM	Precise diagnostic and personalized therapies			
CTMM	Reduce impact of disease and improve quality of life			
CTMM	Become a Dutch based leader in innovative MD and MI			
CTMM	Reduce death, unnecessary treatment, disease burden			
IMI	Secure international competitiveness	Secure Pharma competitiveness		
IMI	Improve health and accelerate development and patient access			
IMI	Develop vaccine and new treatment			
IMI	Resolve health challenges			
IMI	Offer efficient and effective treatment			
IMI	Create diagnostic markers			
IMEC	Offer expertise to solve genetic problems	Provide better quality of life		
IMEC	Provide better life			
ASML	Improve quality of life			
IMEC	Convince pharma to interact			
TMC	Facilitating company	Facilitate customers		
TMC	Add to customer success			
IMEC	Lead companies to success	Lead companies to success		
IMEC	Shape the future			
IMEC	Integrator in the ecosystem			

Table vi Theory generation procedure for partners' motivations

Case name	In vivo codes	Sub-categories/themes	Sub-themes	Themes	Selective codes
IMI	Lack of internal expertise	Lack of knowledge & expertise	Lack of research knowledge & Infrastructure	Access to knowledge & Infrastructure	Motivations
CMOSIS	Lack of knowledge				
IMI	Property of knowledge				
Ridgetop	Lack of research on patient knowledge or future product				
ASML	Limited capabilities				
IMEC	Lack of research materials	Lack of research infrastructure			
IMEC	Identify the problem immediately	Accelerated diagnostics & enhanced quality	Enhancement of knowledge & clinical trials		
IMEC	Early detection of dieses				
IMEC	Better understanding the disease mechanisms				
IMEC	Increase quality of clinical trials				
IMEC	Complementary products	Simplified products & solutions			
IMEC	Systematic solutions				
ASML	Simplifies design activities				
CMOSIS	Supply solutions				
Ridgetop	Products to the solutions				
Ridgetop	Innovate new idea and products	Innovative ideas & products			
IMI	Available resources and capabilities to offer				
CMOSIS	Exploring news ideas				
Ridgetop	Experience new research domain				
TMC	Fundamental research				
IMEC	Generate new ideas				
IMEC	Access to shared information	Share knowledge			
Ridgetop	Technology adaptation				
IMEC	Understand the concept of tech				
ASML	Save cost on research expenses	Save cost	Save cost, time & risk	Financial matter & risk	
IMEC	Save money on creating medical clouds				
CMOSIS	Outsourcing saves time	Save time			
IMEC	Joint effort and less risk	Reduce risk			
IMEC	Complex projects/ high risk	High risk	High cost, risk & complexity		
ASML	Complex products	High complexity			
ASML	Many different components				
IMEC	Requires a lot of money	High cost			
IMEC	Too costly research				
ASML	Lack of money				
ASML	Government investment institutes	Government investment	Funding scheme		
CTMM	Project funds opportunity	Funds			
Ridgetop	Generate sale				
TMC	Business development	Business development & Commercialization	Commercialization potential	Commercialization & incentives	
IMEC	Technical development/ commercialization				
Ridgetop	Commercialization of products				
IMEC	Opportunity to interact with industry partners	Market grow			
IMEC	Market grow in healthcare				
ASML	Graduate research				
IMI	Divers research team				
IMI	Same IP policy for all	Similar IP policies	IP protection policy		
IMI	IP protection from beginning				
CTMM	Similar IP rules				

IMI	IP clarity				
IMI	Similar IP rules				
ASML	Mutual interest on projects	Mutual interest	Beneficial situation		
IMEC	Mutual interest				
IMEC	Enthusiasm of partners				
TMC	Permanent contracts for collaborators	Contracts	Incentive structure		
IMEC	Chance of technical publications				
ASML	Trusting the partner	Innovation based on trust	Trust	Relationship history	
ASML	Trusting to deliver				
IMEC	Trusting the partner				
IMEC	Trust in experience				
IMI	Trust from the start to the end of projects				
TMC	Establish trust	Relationship based on trust			
TMC	Establish relationship on trust				
TMC	Good service creates trust				
IMEC	Word of mouth & company image	Good reputation	Good collaboration history		
IMEC	Good public image				
IMEC	Success stories	Collaboration history			
IMEC	Clear benefits	Clarity	Clarity & transparency		
IMEC	Clear contribution of residences				
Ridgetop	Clear research direction				
ASML	Transparency in projects	Transparency			
IMEC	Good communication channel	Communication channels	Communication		
IMEC	Communication event				
Ridgetop	Better customer interaction				
Ridgetop	Change the collaboration perception	Collaboration perception			
CTMM	Government requires innovative collaboration	Government enforcement	Policy enforcement		

Table vii Theory generation procedure for internal orchestration strategies

Case name	In vivo codes	Sub-categories/ themes	Theme	Selective codes	Theory
TMC	The atmosphere is very informal	Informal atmosphere	Open organizational culture	Open and collaborative culture and structure	**Internal orchestration strategies**
NanoNextNl	Within the program there is open environment people provide services and collaborate. It's an innovative buzz.	Open environment			
IMEC	Very flexible to adopt to our environment	Flexibility to adapt to environment			
TMC	An open company where all the Board of Directors communicates with email or telephone call.	Open Company			
ASML	Very open culture	Open culture			
ASML	Integration occur in the company	Integrator	Collaborative organizational structure		
IMI	Support the research carried out by stakeholders toward the end of the project.	Support research			
KULeuven	Policy to collaborate only with interested Academic processors	Collaboration policy			
TMC	Investment projects to leave and create value for the company	Invest in project leadership			
ASML	Very clear understanding of the problem and drive to be better	Clear understanding of problems			
ASML	Second-guessing the Dutch Government	Looking for bright ideas			
ASML	Nobody is the boss in the company	Decentralized structure			
ASML	Not a strong hierarchy	Weak hierarchy			
TMC	Flats hierarchy between managers and employeneure	Flat hierarchy			
CMOSIS	At the Highest level there are more strategic ideas top-down approach and at lower level more practical words and bottom up approach.	Strategically and practical levels	Internal collaboration	Internal communication	
IMEC	Different teams in project phases collaborate with each other	Collaboration in different project stages			
NanoNextNl	Executive board and business directors manage daily tasks	Different divisions for specific tasks			
NanoNextNl	International advisory committee and program and project leaders and coordinators supervise the work performance.	Supervisory board to monitor			
CTMM	Back office system for time registration and publication management	Back office system			
CTMM	Personal reminders through back office systems	Backbone			
CTMM	Where IP managers are responsible to check if the research topic of PhD students is uploaded before the publication	IP on publications			
NanoNextNl	Program director is involved form beginning	Involvement from the beginning	Meeting and communications		
NanoNextNl	Program offices work together	Group effort			
NanoNextNl	Communication is important	Communicate			
NanoNextNl	Program offices work with legal department	Work with legal department			
CTMM	All supervisors and directors meet	Meet other stakeholders			

ASML	Professor day to gather with academics and resolve technical problems	Professor day	Networking events		
TMC	The bar in the company to gather and meet	Socialize within the organization			
CTMM	Frequent meeting to build relationship and create trust	Frequent meetings			
ASML	Entrepreneurship drive	Entrepreneurship	Personnel recruitment	Recruitment and personnel development program	
IMEC	Technically good skills people to resolve problems	Good technical and engineering skills			
IMEC	Right people to understand customers	Understand customers			
KULeuven	Attitude of university management	Managers attitude			
CTMM	Program managers and project managers are in charge of projects	Different people for research projects			
TMC	Right background knowledge better to understand research team	Right background knowledge			
TMC	Personal development budget	Coaching and training budget	Training and development programs		
TMC	Different training in project leaderships	Project leadership training			
TMC	Software training for people	Software training			
TMC	Continuously stimulates people	Stimulate people			
TMC	Invest in people to be profitable	Invest in people			
ASML	Care for personnel performance optimization	Personnel performance optimization			
TMC	Exploring the innovation improvement processes	Improve innovation processes			

Table viii Theory generation procedure for external orchestration strategies

Case name	In vivo codes	Sub-categories/ themes	Theme	Selective codes	Theory
IMEC	Pharma companies consider IMEC as a safe place to negotiate and discuss research projects.	Open environment	Open environment and transparency	Establishing trustable relationship	External orchestration strategies
DSM	First open up to manufacturing, second to R&D and later to innovation.	Open environment			
ASML	Open to each other and very transparent with companies	Open and transparent			
IMEC	To gather with pharma companies and openly negotiate	Open negotiation			
DSM	First open up and welcome manufacturing and then consider R&D activities	Open up to manufacturing			
CTMM	Shifting the mindset of people from fundamental to translational research	Partners' mindset			
IMEC	Communication from both side is important and resolves other problems	Good communication	Trust and communication		
TMC	Importance of communication to build a trustable relationship	Trustable relationship			
NanoNextNl	Knowing the challenges and creating trust to create a solution	Trust on creating solution			
IMI	Creating trustable relationship	Trust between partners			
NanoNextNl	Communication and personal involvement are important	Communication as a key parameter			
CTMM	Establishing trust takes time	Establish trust			
CTMM	Networking days for academic and industrial partners to meet	Networking days	Networking events		
CTMM	On the networking days partners join in groups	Joining research groups			
KULeuven	Look for best partner that places the technology in the market	Best partner to commercialize	Right people internally	Identifying the right partner	
IMEC	Scientifically, engineering and technically good skills people	Good skilled partners			
IMEC	High technical people in the company better understand the customer	Right technical people			
NanoNextNl	Ideal situation that partners give and take benefits	Ideal situation	Right partner externally		
DSM	Look for partners that we feel the complementarity with them	Complementary partners			
NanoNextNl	Importance of involving major players of the Nano-electronics ecosystem in research programs	Major players			
IMEC	Approaching partners with certain technologies	Partner with right technology			
IMEC	Important to target the right people at right level in organizations	Levels of organizations			
TMC	Top down approach from managers	Top down approach	Systematic strategies	Strategies to interact	
TMC	Contacting at multilevel so a bottom up approach	Bottom up approach / multilevel			
TMC	According to the size of the partner both top-down and bottom-up approach are used	Combined approach/ based on size			
KULeuven	Basic strategy are both financially and in terms of collaboration are important	Bread and butter/ basic strategy			
IMEC	Have to adopt to the environment to create business	Adopt to the environment	Adaptive strategy		
IMEC	Different strategies for different regions	Adopt to the region			
IMEC	Importance of creating a deal and targeting the market demand	Target market demand			

Case name	In vivo codes	Sub-categories/ themes	Theme	Selective codes	Theory
TMC	Important to look outside of company border and target market demand	Out of box adopt to market demand			
IMEC	Adopt to life science business model	Adopt to business model			
TMC	Adopt to different organizations requirements	Adopt to partners' requirement			
IMEC	Adaptive culture at IMEC	Adaptive culture			
CTMM	Report to government what is actually achieved during the research projects	Report to government	Monitoring strategy		
CTMM	Midterm revenue and the ISAC compare the activities with objectives	Midterm revenue monitoring			
CTMM	Monitor the activities and compare with what is been registered in the back office system	Monitor the activities and deliverables			
CTMM	Practical role to monitor the activities so that they are achieved in a promised manner	Monitor the activities			
ASML	Establish meeting to align the research activities within the company and other partners	Monitored and audit			
IMEC	Importance of regulators at start of projects	Regulator at the beginning projects			
TMC	NED agreement with partners	NDAs agreements	Agreements strategy		
TMC	Not interested in IP, so NDA agreement is created with partners on innovation processes	NDA or no IP			
ASML	Frame agreement with technical universities	Frame agreement			
IMI	Projects are managed through set of rules and agreements	Project agreements			
CTMM	Offering different agreements	Different agreements			
TMC	Permanent or fix contracts that allow partners to switch jobs	Fix contracts			
CTMM	IP agreement with partners while they share knowledge	IP framework			
DSM	When required IP protection is taken to TLO	IP agreement			
NanoNextNl	MOU with other consortia construct a concrete linkage of knowledge	MOU			
NanoNextNl	Platform technology creates a stage to reduce risk and resolves some of the problems	Technology platform	Platform strategy		
IMI	A general platform that partners respects each other's business.	General platform			
IMEC	Customized application project gives a platform for customers to identify their strength	CAP			
IMEC	Each organization has specific CAP	Different CAPS for companies			
IMEC	A unique platform for life science and chip applications	Unique platform			
CTMM	New cost system accelerates the work	New cost system	Software strategy		
CTMM	Software system can store data other PhD students can also use it	Software system			
CTMM	Back office system to manage time and publication	Back office			
IMEC	Strategy with customers on no upfront fee	No upfront fee	Upfront strategy		
KULeuven	Different upfront fee for SMEs and large companies and the higher and lower royalty rate for them.	Different strategy/ upfront fee			
IMEC	Good tangible results retain customers	Good tangible results			

Case name	In vivo codes	Sub-categories/ themes	Theme	Selective codes	Theory
IMEC	Good results in life science shows that it works so customers come back	Show results	Tangible results strategy		
ASML	Flexible and easy environment at start	Flexible environment	Flexible strategy		
ASML	Tailor made strategies	Flexible strategy			
KULeuven	Impossible to use one strategy, have to be flexible	Flexible strategy			
NanoNextNl	Flexible on whom the contract is made and dealt with	Flexible based on research or project			
TMC	Holst center has flexible strategy	Flexible based on research topic			
CTMM	Importance of thinking out of the box when dealing with partners	Flexible / out of box strategy			
IMEC	Flexible with companies with different needs	Flexible based on needs			
NanoNextNl	Flexible toward the partners that are collaborating with	Flexible based on partners			
DSM	Similar strategy applied for different materials	Similar strategy	Similar strategy		
IMI	Same process for all stakeholders	Similar process strategy			
CTMM	All partners sign similar contract and there is no exception	Similar contracts for everybody			
CTMM	Similar rules for all partners involved	Similar rules for all			
KULeuven	There are some guidelines to follow and remember in selecting partners	Partner selection guidelines	Selecting partner strategy		
IMEC	Clear road map for semiconductor companies	Clear road map			
IMEC	For expensive products its hard to find the best partner, so we preached them	To preach			
TMC	Invest in companies that ensure that they will join the program	Right investment			
DSM	Work and agree on mutual benefit	Mutual benefit			
NanoNextNl	Different programs are available and always look for best program options	Best program			
IMEC	Understanding SMEs business model is important	Patient with SMEs	Unsystematic strategy		
DSM	Focus on the market and where actually	Go for action			
DSM	For profitable growth sustainability is important	Sustainability			
DSM	In order to grow it is essential to invest in R&D and innovation	Invest in innovation			
DSM	Partner with other companies for breakthrough and radical innovations	Partnership and acquisition			
KULeuven	Contact local organizations for the projects due to regional development objective	Regional development			
KULeuven	Different business modalities	Business modality			
IMI	Bringing partners and stakeholders together and ensuring that they collaborate	Diversity of partners			
IMI	Not a structured or systematic approach with partners	No systematic approach			
ASML	Transparency and continuation of R&D helps the business improvement	Transparency and Keeping R&D	Open and clear strategy		
IMI	Clear management strategies from the beginning and clear rules	Clear rules from the beginning			
CTMM	Partners are clear on their contributions	Clear contribution			
IMI	Open environment giving the access and specification to involved parties	Open environment strategy			
KULeuven	Impossible contracts and research projects are not acceptable	Feasible research	Feasible research strategy		

Case name	In vivo codes	Sub-categories/ themes	Theme	Selective codes	Theory
IMEC	In life science approach companies and research projects that are feasible	Feasible ideas			
TMC	Software programs to communicate	Software training	Software	Networking channels	
IMEC	Placing residences to contribute and work in labs	Resident program / corporate bonding	Networking event		
IMEC	Samsung and Panasonic have residents in IMEC	Allocate residence			
IMEC	Partners meet at partner week event	Partner week			
IMEC	INTEL uses exercise labs to control and fix data for diagnostic tests	Exercise labs			
DSM	On capital market day the board interacts with the stock exchange analysts and discuss the companies' development	Capital market day			
KULeuven	Creating circumstances for partners to meet and network	Networking events			
NanoNextNl	On stakeholder sessions all partners that are involved get together	Stakeholder sessions			
IMI	Regular meetings between stakeholders to exchange ideas	Regular meetings			
CTMM	Partners meet and cycle to interact and collect sponsorship	Sponsorship events			
DSM	Participate in money and kind	Financial and in kind support	Financial support	Strategies to financially support	
DSM	CTO budget to keep the competences in top shape	Supporting budget			
IMI	Providing funding for the partners	Funding the partners			
IMI	Offering research support to the partners	Research support			
NanoNextNl	Financially supporting the PhD research when industries stop the payment	Financial support of research			
CTMM	Financial formula of CTMM which is from the government supports partners and ensures they collaborate with each other	Financial formula from government			
IMEC	Financial sponsorship from medical institutes	Financial sponsorship	Financial sponsorship event		
CTMM	Cycling event to collect sponsorship	Fundraising event			
IMEC	Communication with experts to resolve technical problems	Communicate with right people	Negotiation and communication	Strategies to resolve conflicts	
ASML	Negotiation on how to spend R&D and make an agreement	Negotiate for agreement			
IMEC	Communication to learn about each other	Communication to know each other			
IMEC	Open communication to know the challenges	Open communication on challenges			
IMEC	Trusting IMEC facilitates the decision making	Building trust			
IMEC	Communicating with pharma companies can change their mindset	Communicate to change mindset			
CTMM	Discussion on filling the research gaps in projects	Discussion to resolve problems			
KULeuven	If university and companies don't work together we smooth the collaboration	To create a smooth path	Creating balance		
NanoNextNl	Balance between different demands	Balance between different demands			
IMI	To create a balance between coordinators and managing institutes	Balance partners			
DSM	Managerial changes required to ensure other companies can work	Managerial changes	Project management services		
CTMM	Managing the process of the projects	Managing project processes			
IMEC	Understanding who is deciding the budget	Knowing who decides on the budget			
CTMM	Projects are divided into work packages	Creating work packages			
ASML	When it is hard to get agreement we split the ways	Go your way			

Case name	In vivo codes	Sub-categories/ themes	Theme	Selective codes	Theory
ASML	Replace people where they can work better	Put people where they are better			
IMEC	Expand the ecosystem and increase the range of customers	Expand ecosystem			
IMEC	Importance of confidentiality in discussing the projects	Consider confidentiality			
TMC	The approach depends on what firms require	Client requirements			
NanoNextNl	Flexible solutions for key player innovation	Flexible solutions	Adapt and be flexible	Strategies to resolve partners' withdrawal	
TMC	Offering flexible forces to complete the job when partners withdraws	Flexible forces			
IMEC	When partners withdraw different things happen. The business model adapts to the new situation especially in financial applications.	Adopt the business model			
DSM	Setup a new business model	New business model			
TMC	Adopt to new workforce with partners that left the program	Adopt to new workforce			
IMI	Legal framework creates a backup plan for partners withdrawal	Legal framework as a backup plan	Back up and upfront agreement		
CTMM	Stop the work, but they can start and try to contribute again later	Be open			
KULeuven	Upfront agreement to contribute and use of materials	Upfront agreement			
DSM	The IP ownership remains with the loyal partners	IP ownership			
IMEC	IP generated during the contribution remains with the partner but the one after is not owned by the withdrawal partner	IP ownership			
DSM	At time of withdrawal is important to find a better host to not loose the created value	Find a better host	Replace by new partner		
CTMM	Enlarging the share, finding a new partner or rearranging the work packages at time of withdrawal	Enlarging the share, new partner, rearranging the work package			
IMEC	Inviting new partners to collaborate and finish the job	New partner			
CTMM	Replace the drop out partner in to the collaboration to compensate	Replace the partner			
IMI	Find the consortium and see if possible to have additional partner	Replacing the consortium			
IMI	Brining additional parties to join the consortium	Replace with additional parties			
ASML	Continuity of SMEs is important	Continue the project			

Appendix D Summary of the literature review on the orchestration

Authors	Journal	Literature stream	Theme	Internal preparation	External governance
Adegbesan and Higgins (2011)	SMJ	Strategic alliances	Partner selection strategy		Complementary resources and capabilities
Adner (2006)	HBR	Innovation ecosystem	Partner selection strategy		Complementarity of partners
Agarwal et al. (2010)	SMJ	Strategic alliances	- Open and collaborative structure - Internal communication	- Economic incentive - Communication	- Economic incentive - Communication
Anand and Khanna (2000)	SMJ	Strategic alliances	Relationship development		Learning experience
Borgh et al. (2012)	RDM	Innovation ecosystem	Conflict resolution		- Facilitate innovation process of partners - Creating innovation community - Provide exit routes for partners
Das and Teng (1998)	AMR	Strategic alliances	Relationship development	Trust and confidence development	Trust and confidence development
Dhanaraj and Parkhe (2006)	AMR	Innovation ecosystem	Conflict resolution		Orchestration strategies: - Knowledge mobility - Innovation appropriability - Network stability
Dussauge et al. (2000)	SMJ	Strategic alliances	Partner selection strategy		Complementarity of partners
Jeffrey H Dyer and Hatch (2006)	SMJ	Innovation ecosystem	Networking		Knowledge transfers
Jeffrey H Dyer and Nobeoka (2000)	SMJ	Innovation ecosystem	Networking		Orchestration activities: knowledge sharing and network identity
J. H. Dyer and Singh (1998)	SMJ	Strategic alliances	- Networking - Partner selection strategy - Conflict resolution		- Knowledge sharing - Complementarity - Effective governance
Gomes-Casseres (2003)	SOJ	Strategic alliances	Partner selection strategy		Organizational characteristics and resources
R. Gulati (1995)	ASQ	Strategic alliances	Relationship development	Reliability and trust between partners	Reliability and trust between partners
Ranjay Gulati et al. (2009)	SMJ	Strategic alliances	Relationship development	Trust based on collaboration intensity	Trust based on collaboration intensity
Hoang and Rothaermel (2005)	AMJ	Strategic alliances	Relationship development		Prior experience
Holm et al. (1999)	SMJ	Strategic alliances	Partner selection strategy		- Commitment - Interdependency
Iansiti and Levien (2004b)	HBS	Innovation ecosystem	Conflict resolution		Ecosystem management
Inkpen and Beamish (1997)	AMJ	Strategic alliances	Partner selection strategy		Dependency of partners
Kale and Singh (2007)	SMJ	Strategic alliances	Open and collaborative structure		Dedicated social structures

Authors	Journal	Literature stream	Theme	Internal preparation	External governance
Kale et al. (2000)	SMJ	Strategic alliances	- Relationship development - Conflict resolution	- Strong relationship building - Conflict management	- Strong relationship building - Conflict management
Kale et al. (2002)	SMJ	Strategic alliances	Relationship development		Past collaboration experience
Leten et al. (2013)	CMR	Innovation ecosystem	- Conflict resolution - Partner interaction		IP model to orchestrate
Lippman and Rumelt (2003)	SMJ	Strategic alliances	Partner selection strategy		Complementary resources
Lorenzoni and Baden-Fuller (1995)	CMR	Innovation network	- Relationship development - Partner selection strategy - Networking	Trust and reciprocity building	- Trust and reciprocity building - Selecting partners strategically with care - Share and exchange idea
Madhok and Tallman (1998)	OS	Strategic alliances	Relationship development	Trust building	Trust building
Mindruta (2013)	SMJ	Strategic alliances	Partner selection strategy		Complementary resources
Nambisan and Sawhney (2011)	AOM	Innovation network	- Partner interaction - Conflict resolution		Orchestration strategies: - Innovation appropriability - Innovation leverage - Innovation coherence
Rampersad et al. (2010b)	IMM	Innovation network	- Internal communication - Relationship development	Trustable and efficient communication	Trustable and efficient communication
Ritala et al. (2009)	IJIM	Innovation ecosystem	Conflict resolution		Orchestration processes: - Innovation stability - Innovation mobility - Innovation appropriability
Sarkar et al. (2009)	OS	Strategic alliances	- Open and collaborative structure - Partner selection strategy	- Structured formation - Management abilities - Knowledge management	Skills and complementarity of partners
Saxton (1997)	AMJ	Strategic alliances	Partner selection strategy	- Partner reputation - Shared decision making - Similar strategies	- Partner reputation - Shared decision making - Similar strategies
Vanhaverbeke and Cloodt (2006)	OI book	Innovation ecosystem	Conflict resolution		Ecosystem management
Wassmer and Dussauge (2011)	AMJ	Strategic alliances	- Partner selection strategy - Conflict resolution		Synergies between partners
Willianson and De Meyer (2012)	CMR	Innovation ecosystem	- Partner selection strategy - Networking		- Well-defined partner roles - Complementary investments - Flexibility and co-learning
Zaheer et al. (1998)	OS	Innovation ecosystem	Relationship development	Trustable relationship to resolve conflicts	Trustable relationship to resolve conflicts

Appendix E interview questions

Industrial firms questions

This interview aims to investigate

1. What is the open innovation ecosystem/ ecosystem of the firms?
2. What is the role of different nano-electronics actors in the OI ecosystem? Firms, universities/research centers and others (i.e. hospitals).
3. How firms are managing their relationships? What is the management procedure? Individual relationships and orchestrators' models
4. What are the success factors of nano-electronics firms or universities and research centers in maintaining their relationship and position in the ecosystem?

Demographic information

- Interviewee name:
- Position:
- Department/ division:

Background information of firms

- Organization name:
- Size:
- Number of employees:
- Number of R&D employees:
- Type of firm: Service Manufacturing Other

Section A- The Innovation Ecosystem

1. How many business partners do you have?
2. Who are the main business partners? And targeted customers?
3. What is the Business model behind the ecosystem?
4. What are the value drivers? Cost reduction, speeding and improving innovation or better quality of service or others?
5. How does your firm capture value for each of the members? Or what strategies they use?
6. How are the partners connected to each other through the ecosystem, and why?
7. Which practices are used? Technology exploitation (venturing, outward IP licensing, employee involvement), technology exploration (customer involvement, external networking, external participation, outsourcing R&D, inward IP licensing), joint venturing.
    a. What is the outcome of OI practices?
    b. What is the process (inside-out, outside-in and coupled)?
8. What are the challenges in industry-university collaboration?
9. How the Business Model of each partners/actors should change, when actors are loosing out from the ecosystem?

10. Which department is mainly responsible for innovation and collaboration and outsourcing knowledge?
11. What is the impact of open innovation on technology transfers?
12. What are the entities of the innovation ecosystem of your firm?
13. Do you lead or orchestrate the ecosystem?
    a. Yes: what strategies do you use in terms of value appropriation and equitable value distribution?
    b. No: Which actor has a major role in this innovation ecosystem or orchestrates the ecosystem?
14. Do you segregate partners or have different types of partners?
15. How is the ecosystem managed? Orchestrator's role?

Section B- Role of different actors in the nano-electronics ecosystem

16. What is the role of universities and research centers to your firm?
17. How your firm is benefiting from universities collaboration?
18. Which universities or research centers are your major partners?
19. What is the value proposition they can offer the orchestrator and other partners in the ecosystem?
20. Are they orchestrating the ecosystem?
21. What strategies they use toward your firm?
22. Do you believe that they have been successful to maintain their relationship with your firm?

Section C- Managing the ecosystem

23. Among each layers of individual, firms, dyads, inter organizational and regional how the management strategies vary?
24. How the relationships between entities of the innovation ecosystem are managed?
25. Is there different management strategies applied toward various types of companies (e.g. SMEs, orchestrate companies or research centers)?
26. Do they vary based on corporate, business and operational levels in the firm?
27. What is the role of orchestrators in managing the ecosystem?
28. What is the role of orchestrators in starting a new ecosystem?

Section D- Success factors of the nano-electronics ecosystem

29. What is the success factors in your opinion?
30. What managerial strategies /practices are applied?
31. What changes are required to be successful or more successful in the open innovation ecosystem?
32. As an orchestrator: how is it possible to achieve success? Success factors: performance, publications, patents, PhD students …
33. How do you ensure success and continue to orchestrate the ecosystem?

Final section

34. How do you scale the firm level of openness?
    Scale 1(not so open) to 5 (very open)

35. How do you see your firm in terms of open innovation in the next 5 years?
    Scale of 1 (decrease in OI) to 5 (increase in OI)
36. How important is open innovation to your corporate goal/ success?
    Scale 1(not very important) to 5 (very important)
37. What other companies or universities/ research centers do you suggest for our further interviews?
38. What other questions should we include in this interview?
    Would you provide us any document of the company (e.g. brochures, newsletters), which could help us in our research, please?

Academic institutes questions

Demographic information

Interviewee name:
Position:
Department:

Background information of the university or research center

- Organization name:
- Number of employees in the department:
- Main activity of university/research center:

Section A- The Innovation Ecosystem

1. How many business partners do you have?
2. Who are the main business partners? And targeted customers?
3. What is the Business model behind the ecosystem?
4. What are the value drivers? Cost reduction, speeding and improving innovation or better quality of service or others?
5. How does your firm capture value for each of the members? Or what strategies they use?
6. How are the partners connected to each other through the ecosystem, and why?
7. Which practices are used? Technology exploitation (venturing, outward IP licensing, employee involvement), technology exploration (customer involvement, external networking, external participation, outsourcing R&D, inward IP licensing), joint venturing.
    a. What is the outcome of OI practices?
    b. What is the process (inside-out, outside-in and coupled)?
8. What are the challenges in industry-university collaboration?
9. How the Business Model of each partners/actors should change, when actors are losing out from the ecosystem?

10. Which department is mainly responsible for innovation and collaboration and outsourcing knowledge?
11. What is the impact of open innovation on technology transfers?
12. What are the entities of the innovation ecosystem of your university or research center?
13. Do you lead or orchestrate the ecosystem?
    a. Yes: what strategies do you use in terms of value appropriation and equitable value distribution?
    b. No: which actor has a major role in this innovation ecosystem or orchestrates the ecosystem?
14. Do you segregate partners or have different types of partners?
15. How is the ecosystem managed? Orchestrator's role?

Section B- Role of different actors in the nano-electronics ecosystem

16. What is the role of this university/research center in the innovation ecosystem?
17. How universities are benefiting from firms collaboration?
18. Which firms are your major partners?
19. What is the value proposition they can offer the orchestrator and other partners in the ecosystem.
20. Are they orchestrating the ecosystem?
21. What strategies do you use toward firms?
22. Do you think that this university/research center has been successful in maintaining their relationship with other companies?

Section C- Managing the ecosystem

23. How the relationships between entities of the innovation ecosystem are managed?
24. Is there different management strategies applied toward various types of companies (e.g. SMEs, orchestrate companies or research centers).
25. Do they vary based on corporate, business and operational levels in the firm?
26. Do you have different phases of research?
27. As an orchestrator: How do you manage different processes of leverage, coherence, knowledge flow, membership, stability and appropriabillity?
28. What is the role of orchestrators in managing the ecosystem?
29. What is the role of orchestrators in starting a new ecosystem?

Section D- Success factors of the nano-electronics ecosystem

30. What is the success factors in your opinion?
31. What managerial strategies /practices are applied?
32. What changes are required to be successful or more successful in the open innovation ecosystem?
33. As an orchestrator: how is it possible to achieve success? Success factors: performance, publications, patents, PhD students …
34. How do you ensure success and continue to orchestrate the ecosystem?

Final section

35. How do you scale the university/research center level of openness?
    Scale 1(not so open) – 5 (very open)
36. How do you see your university/research center in terms of open innovation in the next 5 years?
    Scale of 1 (decrease in OI) - 5 (increase in OI)
37. How important is open innovation to your corporate goal/ success?
    Scale 1(not very important) – 5 (very important)
38. What other companies or universities/ research centers do you suggest for our further interviews?
39. What other questions should we include in this interview?
    Would you provide us any document of the company (e.g. brochures, newsletters), which could help us in our research, please?

We appreciate your time!

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9 Bibliography

Adegbesan, J. A., & Higgins, M. J. (2011). The intra-alliance division of value created through collaboration. *Strategic Management Journal, 32*(2), 187-211.

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard Business Review, 84*(4), 98-107; 148.

Adner, R. (2012). *The wide lens: A new strategy for innovation*: Penguin UK.

Adner, R., & Kapoor, R. (2010). Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in New Technology Generations. *Strategic Management Journal, 31*(3), 306-333.

Aeneas, & Catrene. (2012). *Innovation for the Future of Europe: Nanoelectronics Beyond 2020*. Retrieved from

Agarwal, R., Croson, R., & Mahoney, J. T. (2010). The role of incentives and communication in strategic alliances: an experimental investigation. *Strategic Management Journal, 31*(4), 413-437.

Alexy, O., & Dahlander, L. (2013). Managing open innovation. *The Oxford Handbook of Innovation Management*, 442.

Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic Management Journal, 22*(6-7), 493-520.

Anand, B. N., & Khanna, T. (2000). Do firms learn to create value? The case of alliances. *Strategic Management Journal, 21*(3), 295-315.

Arvanitis, S., Kubli, U., & Woerter, M. (2008). University-industry knowledge and technology transfer in Switzerland: What university scientists think about co-operation with private enterprises *Research policy, 37*(10), 1865-1883.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management, 17*(1), 99-120.

Bartunek, J. M., Rynes, S. L., & Ireland, R. D. (2006). What makes management research interesting, and why does it matter? *Academy of management journal, 49*(1), 9-15.

Basole, R. C. (2009). Visualization of interfirm relations in a converging mobile ecosystem. *Journal of Information Technology, 24*(2), 144-159.

Batterink, M. H., Wubben, E. F. M., Klerkx, L., & Omta, S. W. F. (2010). Orchestrating innovation networks: The case of innovation brokers in the agri-food sector. *Entrepreneurship and Regional Development, 22*(1), 47-76.

Bazeley, P. (2013). *Qualitative data analysis: Practical strategies*: Sage.

Binsfeld, N., Whalley, J., & Pugalis, L. (2017). Looking beyond official success measures: tales from the field of the complex forces shaping Luxembourg's ICT ecosystem. *Journal of Innovation Management, 5*(2), 15-25.

Birks, M., & Mills, J. (2015). *Grounded theory: A practical guide*: Sage.

Boari, C., & Lipparini, A. (1999). Networks within industrial districts: Organising knowledge creation and transfer by means of moderate hierarchies. *Journal of management and Governance, 3*(4), 339-360.

Borgh, M., Cloodt, M., & Romme, A. G. L. (2012). Value creation by knowledge-based ecosystems: evidence from a field study. *R&d Management, 42*(2), 150-169.

Bosch-Sijtsema, Petra, M., & Bosch, J. (2014). *Aligning innovation ecosystem strategies with internal R&D.* Paper presented at the Management of Innovation and Technology (ICMIT), IEEE International Conference.

Boschma, R., & Frenken, K. (2010). The spatial evolution of innovation networks. A proximity perspective. *The handbook of evolutionary economic geography*, 120-135.

Botero, M., & Diana, C. (2012). Orchestrating innovation ecosystems: a case study of a telcom wholesaler growing into a global hub for cross-innovation.

Bowen, G. A. (2009). Supporting a grounded theory with an audit trail: An illustration. *International Journal of Social Research Methodology, 12*(4), 305-316.

Brandenburger, A. M., & Nalebuff, B. J. (1996). Co-opetition: A revolutionary mindset that combines competition and cooperation in the marketplace. *Harvard Business School Press, Boston*.

Brandenburger, A. M., & Stuart, H. W. (1996). Value-based business strategy. *Journal of Economics & Management Strategy, 5*(1), 5-24.

Bruneel, J., D'este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. *Research policy, 39*(7), 858-868.

Brunswicker, S., & van de Vrande, V. (2014). Exploring Open Innovation in Small and Medium-Sized Enterprises. *New Frontiers in Open Innovation*, 135.

Brusoni, S., & Prencipe, A. (2013). The organization of innovation in ecosystems: problem framing, problem solving, and patterns of coupling. *Advances in strategic management, 30*, 167-194.

Buckler, G. (2013). Electronics Industry *The Canadian Encyclopedia*.

Capaldo, A. (2007). Network structure and innovation: The leveraging of a dual network as a distinctive relational capability. *Strategic Management Journal, 28*(6), 585-608.

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology*: Harvard Business Press.

Chesbrough, H. (2006). The era of open innovation. *Managing innovation and change, 127*(3), 34-41.

Chesbrough, H., & Bogers, M. (2014). Explicating open innovation: clarifying an emerging paradigm for understanding innovation. *New Frontiers in Open Innovation. Oxford: Oxford University Press, Forthcoming*, 3-28.

Chesbrough, H., & Brunswicker, S. (2013). *Managing open innovation in large firms*: Fraunhofer Verlag.

Chesbrough, H., & Di Minin, A. (2014). Open social innovation. *New Frontiers in Open Innovation*, 169.

Chesbrough, H., Vanhaverbeke, W., & West, J. (2006). *Open innovation: Researching a new paradigm*: OUP Oxford.

Chesbrough, H., Vanhaverbeke, W., & West, J. (2014). *New frontiers in open innovation*: OUP Oxford.

Chiang, Y. H., & Hung, K. P. (2010). Exploring open search strategies and perceived innovation performance from the perspective of inter-organizational knowledge flows. *R&d Management, 40*(3), 292-299.

Chiaroni, D., Chiesa, V., & Frattini, F. (2011). The Open Innovation Journey: How firms dynamically implement the emerging innovation management paradigm. *Technovation, 31*(1), 34-43.

Coenen, L., Moodysson, J., Ryan, C. D., Asheim, B. r., & Phillips, P. (2006). Comparing a Pharmaceutical and an Agro-food Bioregion: On the Importance of Knowledge Bases for Socio-spatial Patterns of Innovation. *Industry and Innovation, 13*(4), 393-414.

Constituent. (2017). Merriam-Webster.com. Retrieved June 24, 2017 https://www.merriam-webster.com/dictionary/constituent

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*: Sage publications.

Das, T. K., & Teng, B.-S. (1998). Between trust and control: Developing confidence in partner cooperation in alliances. *Academy of Management Review, 23*(3), 491-512.

De Bruijn, J., & Heuvelhof, E. F. (2008). *Management in Networks: On multi-actor decision making*: Routledge.

Denzin, N. (1978). The research act: A theoretical orientation to sociological methods: New York: McGraw-Hill.

Denzin, N., & Lincoln, Y. (1994). *Introduction: Entering the field of qualitative research*.

Dey, I. (1993). *Qualitative data analysis: A user friendly guide for social scientists*: Routledge.

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating innovation networks. *Academy of Management Review, 31*(3), 659-669.

Du, J., Leten, B., & Vanhaverbeke, W. (2014). Managing open innovation projects with science-based and market-based partners. *Research policy, 43*(5), 828-840.

Dussauge, P., Garrette, B., & Mitchell, W. (2000). Learning from competing partners: Outcomes and durations of scale and link alliances in Europe, North America and Asia. *Strategic Management Journal, 21*(2), 99-126.

Dyer, J. H., & Hatch, N. W. (2006). Relation-specific capabilities and barriers to knowledge transfers: creating advantage through network relationships. *Strategic Management Journal, 27*(8), 701-719.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal, 21*(3), 345-367.

Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review, 23*(4), 660-679.

Echeverri-Carroll, E. L., & Brennan, W. (1999). Are innovation networks bounded by proximity? *Innovation, networks and localities*, 28-49.

Eckstein, H. (1975). *Case Study and Theory in Political Science in F.I. Greenstein and N.W. Polsby (eds) Handbook of Political Science*.

Eisenhardt, K. M. (1989a). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

Eisenhardt, K. M. (1989b). Making fast strategic decisions in high-velocity environments. *Academy of management journal, 32*(3), 543-576.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: opportunities and challenges. *Academy of management journal, 50*(1), 25-32.

Elmquist, M., Fredberg, T., & Ollila, S. (2009). Exploring the field of open innovation. *European Journal of Innovation Management, 12*(3), 326-345.

Enkel, E., & Gassmann, O. (2010). Creative imitation: exploring the case of cross-industry innovation. *R&d Management, 40*(3), 256-270.

Etzkowitz, H. (2010). *The triple helix: university-industry-government innovation in action*: Routledge.

European, C. (2015). *Open innovation year book 2015* European Commision: Luxembourg.

Ferguson, A., & Moritz, M. (2015). *Leading*. Great Britain: Hodder and Stoughton.

Finch, J., Zhang, S., & Geiger, S. (2013). Managing in conflict: How actors distribute conflict in an industrial network. *Industrial Marketing Management, 42*(7), 1063-1073.

Frankort, H. T. (2014). Open innovation norms and knowledge transfer in interfirm technology alliances: evidence from information technology, 1980–1999. *Collaboration and Competition in Business Ecosystems (Advances in Strategic Management), 30*, 239-282.

Furr, N., O'Keeffe, K., & Dyer, J. H. (2016). Managing Multiparty Innovation. *Harvard Business Review, 94*(11), 76-83.

Gadde, L. E., Huemer, L., & Håkansson, H. (2003). Strategizing in industrial networks. *Industrial Marketing Management, 32*(5), 357-364.

Galatsis, K., Gargini, P., Hiramoto, T., Beernaert, D., DeKeersmaecker, R., Pelka, J., & Pfitzner, L. (2015). Nanoelectronics Research Gaps and Recommendations. *IEEE Technology and Society Magazine*.

Gardet, E., & Mothe, C. (2011). The dynamics of coordination in innovation networks. *European Management Review, 8*(4), 213-229.

Gawer, A., & Cusumano, M. (2002). Platform Leadership. *Harvard Business School Press*.

Ghemawat, P. E., Collis, D. J., Pisano, G. P., & Rivkin, J. W. (1999). *Strategy and the business landscape*. Reding MA: Addison-Wesley.

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research policy, 37*(10), 1717-1731.

Glaser, B., & Strauss, A. (1967). The discovery ofgrounded theory. *London: Weidenfeld and Nicholson*.

Glaser, B. G. (1978). *Theoretical sensitivity: Advances in the methodology of grounded theory*: Sociology Pr.

Gomes-Casseres, B. (2003). Competitive advantage in alliance constellations. *Strategic organization, 1*(3), 327-335.

Gomes-Casseres, B. (2015). *Remix Strategy: The Three Laws of Business Combinations*: Harvard Business Press.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*(S2), 109-122.

Gulati, R. (1995). Social structure and alliance formation patterns: A longitudinal analysis. *Administrative Science Quarterly, 40*(4), 619-652.

Gulati, R. (1999). Network location and learning: The influence of network resources and firm capabilities on alliance formation. *Strategic Management Journal, 20*(5), 397-420.

Gulati, R., Lavie, D., & Singh, H. (2009). The nature of partnering experience and the gains from alliances. *Strategic Management Journal, 30*(11), 1213-1233.

Gulati, R., Puranam, P., & Tushman, M. (2012). Meta-organization design: Rethinking design in interorganizational and community contexts. *Strategic Management Journal, 33*(6), 571-586.

Håkansson, H., & Ford, D. (2002). How should companies interact in business networks? *Journal of business research, 55*(2), 133-139.

Hellström, M., Tsvetkova, A., Gustafsson, M., & Wikström, K. (2015). Collaboration mechanisms for business models in distributed energy ecosystems. *Journal of Cleaner Production, 102*, 226-236.

Herriott, R. E., & Firestone, W. A. (1983). Multisite qualitative policy research: Optimizing description and generalizability. *Educational researcher*, 14-19.

Hoang, H., & Rothaermel, F. T. (2005). The effect of general and partner-specific alliance experience on joint R&D project performance. *Academy of management journal, 48*(2), 332-345.

Hogenelst, W. W., Treffers, T. T., Podoynitsyna, K. K., Stultiëns, R., & Smetsers, T. (2014). Innovating in interdependent contexts: Applying an ecosystem perspective to the innovation process of small and medium-sized enterprises.

Holm, D. B., Eriksson, K., & Johanson, J. (1999). Creating value through mutual commitment to business network relationships. *Strategic Management Journal, 20*(5), 467-486.

Hsieh, C., Lazzarini, S. G., Nickerson, J. A., & Laurini, M. (2010). Does ownership affect the variability of the production process? Evidence from international courier services. *Organization Science, 21*(4), 892-912.

Hu, Y. (2011). Open innovation in networks: Building a Network Perspective and the Role of Firm in Networks. *Open Innovation and New Business Creation 2011*.

Iansiti, M., & Levien, R. (2004a). The keystone advantage. *Harvard Business School Press, Boston*.

Iansiti, M., & Levien, R. (2004b). Strategy as ecology. *Harvard Business Review, 82*(3), 68-81.

Inkpen, A. C., & Beamish, P. W. (1997). Knowledge, bargaining power, and the instability of international joint ventures. *Academy of Management Review, 22*(1), 177-202.

Jacobides, M. G., Knudsen, T., & Augier, M. (2006). Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. *Research policy, 35*(8), 1200-1221.

Jacobides, M. G., & Tae, C. J. (2015). Kingpins, bottlenecks, and value dynamics along a sector. *Organization Science, 26*(3), 889-907.

Johanson, J., & Mattsson, L.-G. (2015). Internationalisation in industrial systems—a network approach *Knowledge, Networks and Power*: Springer.

Johnson, R. B. (1997). Examining the Validity Structure of Qualitative Research. *Education, 118*(2), 282.

Jones, O., Macpherson, A., Thorpe, R., & Ghecham, A. (2007). The evolution of business knowledge in SMEs: conceptualizing strategic space. *Strategic Change, 16*(6), 281-294.

Kale, P., Dyer, J. H., & Singh, H. (2002). Alliance capability, stock market response, and long-term alliance success: the role of the alliance function. *Strategic Management Journal, 23*(8), 747-767.

Kale, P., & Singh, H. (2009). Managing strategic alliances: What do we know now, and where do we go from here. *Academy of management perspectives, 23*(3), 45-62.

Kale, P., Singh, H., & Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic Management Journal, 21*(3), 217-237.

Kaplan, S., Milde, J., & Cowan, R. S. (2014). *Interdisciplinarity in Practice: A Case of a Nanotechnology Research Center*. Retrieved from

Kapoor, R. (2013). Collaborating with complementors: What do firms do. *Advances in strategic management, 30*, 3-25.

Kilian, T., Schubert, P., & Bjørn-Andersen, N. (2015). *Benefits and Barriers of University Industry Collaborations from a Researcher's Perspective: Development of Formative Scales and Cluster Analysis.* Paper presented at the 23rd European Conference on Information Systems (ECIS)

Klerkx, L., & Aarts, N. (2013). The interaction of multiple champions in orchestrating innovation networks: Conflicts and complementarities. *Technovation, 33*(6), 193-210.

Koch, T. (2006). Establishing rigour in qualitative research: the decision trail. *Journal of advanced nursing, 53*(1), 91-100.

Kroes, N. (2015). A European Strategy for Micro-and Nanoelectronic Components and Systems1). *The Nano-Micro Interface: Bridging the Micro and Nano Worlds*, 1-18.

Laage-Hellman, J., Lind, F., & Perna, A. (2014). Customer involvement in product development: An industrial network perspective. *Journal of Business-to-Business Marketing, 21*(4), 257-276.

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*(2), 131-150.

Lee, S., Park, G., Yoon, B., & Park, J. (2010). Open innovation in SMEs—An intermediated network model. *Research policy, 39*(2), 290-300.

Lee, Y. S. (2000). The sustainability of university-industry research collaboration: an empirical assessment. *The Journal of Technology Transfer, 25*(2), 111-133.

Leten, B., Vanhaverbeke, W., Roijakkers, N., Clerix, A., & Van Helleputte, J. (2013). IP models to orchestrate innovation ecosystems: IMEC, a public research institute in nano-electronics. *California management review, 55*(4), 51-64.

Leydesdorff, L. (2013). *Triple Helix of university-industry-government relations*: Springer.

Lichtenthaler, U. (2011). Open innovation: Past research, current debates, and future directions. *The Academy of Management Perspectives, 25*(1), 75-93.

Lijphart, A. (1975). The comparable-cases strategy in comparative research.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry* (Vol. 75): Sage.

Lippman, S. A., & Rumelt, R. P. (2003). A bargaining perspective on resource advantage. *Strategic Management Journal, 24*(11), 1069-1086.

Lorenzoni, G., & Baden-Fuller, C. (1995). Creating a strategic center to manage a web of partners. *California management review, 37*(3), 146-146.

Lubik, S., Garnsey, E., Minshall, T., & Platts, K. (2013). Value creation from the innovation environment: partnership strategies in university spin-outs. *R&d Management, 43*(2), 136-150.

Madhok, A., & Tallman, S. B. (1998). Resources, transactions and rents: Managing value through interfirm collaborative relationships. *Organization Science, 9*(3), 326-339.

Maine, E., & Garnsey, E. (2006). Commercializing generic technology: The case of advanced materials ventures. *Research policy, 35*(3), 375-393.

Mankevich, V. (2014). Managing Innovation Networks: Exploring Coopetition Dynamics in Innovation Ecosystems.

Mars, M. M., Bronstein, J. L., & Lusch, R. F. (2012). The value of a metaphor: Organizations and ecosystems. *Organizational Dynamics, 41*(4), 271-280.

Martini, A., Aloini, D., & Neirotti, P. (2012). Degree of Openness and Performance in the Search for Innovation. *International journal of engineering business management, 4*(Godište 2012), 4-37.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*: Sage.

Mindruta, D. (2013). Value creation in university-firm research collaborations: A matching approach. *Strategic Management Journal, 34*(6), 644-665.

Mitchell, T. R. (1982). Motivation: New directions for theory, research, and practice. *Academy of Management Review, 7*(1), 80-88.

Miyazaki, K., & Islam, N. (2007). Nanotechnology systems of innovation—An analysis of industry and academia research activities. *Technovation, 27*(11), 661-675.

Moller, K., Rajala, R., & Westerlund, M. (2008). Service innovation myopia? A new recipe for client-provider value creation. *California management review, 50*(3).

Moore, G. A. (1991). Crossing the chasm: Marketing and selling high-tech products to mainstream consumers. *New York: HarperBusiness*.

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard Business Review, 71*(3), 75-83.

Moore, R. (2007, June). *Nanomedicine - from the lab to the clinic, while gaining public acceptance.* Paper presented at the EuroNanoForum -

Nanotechnology in Industrial Applications - European and International Forum on Nanotechnology, Germany.

Nambisan, S., & Baron, R. A. (2013). Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self-Regulatory Processes and Their Implications for New Venture Success. *Entrepreneurship Theory and Practice, 37*(5), 1071-1097.

Nambisan, S., & Sawhney, M. (2008). The global brain. *Roadmap for Innovating Fast*.

Nambisan, S., & Sawhney, M. (2011). Orchestration processes in network-centric innovation: Evidence from the field. *The Academy of Management Perspectives, 25*(3), 40-57.

Nie, S., Xing, Y., Kim, G. J., & Simons, J. W. (2007). Nanotechnology applications in cancer. *Annu. Rev. Biomed. Eng., 9*, 257-288.

Nikalje, A. P. (2015). Nanotechnology and its Applications in Medicine. *Medicinal Chemistry*.

Nikulainen, T., & Palmberg, C. (2010). Transferring science-based technologies to industry—Does nanotechnology make a difference? *Technovation, 30*(1), 3-11.

Nohria, N., & Garcia‐Pont, C. (1991). Global strategic linkages and industry structure. *Strategic Management Journal, 12*(S1), 105-124.

Normann, R. (2001). *Reframing Business: When the Map changes the Landscape*. U.K: Wiley

Normann, R., & Ramirez, R. (1993). Designing interactive strategy. *Harvard Business Review, 71*(4), 65-77.

Ochekpe, N. A., Olorunfemi, P. O., & Ngwuluka, N. C. (2009). Nanotechnology and drug delivery part 1: background and applications. *Tropical journal of pharmaceutical research, 8*(3).

Ortiz, A. (2015). Translational nephrology: what translational research is and a bird's-eye view on translational research in nephrology. *Clinical kidney journal, 8*(1), 14-22.

Padgett, D., Mathew, R., & Conte, S. (2004). Peer debriefing and support groups. *The qualitative research experience*, 225-235.

Parida, V., Westerberg, M., & Frishammar, J. (2012). Inbound open innovation activities in high-tech SMEs: the impact on innovation performance. *Journal of Small Business Management, 50*(2), 283-309.

Parkhe, A. (1993). Strategic alliance structuring: A game theoretic and transaction cost examination of interfirm cooperation. *Academy of management journal, 36*(4), 794-829.

Payne, A. F., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. *Journal of the Academy of marketing Science, 36*(1), 83-96.

Perkmann, M., & Walsh, K. (2009). The two faces of collaboration: impacts of university-industry relations on public research. *Industrial and Corporate Change, 18*(6).

Pfeffer, J., & Salancik, G. R. (2003). *The external control of organizations: A resource dependence perspective*: Stanford University Press.

Pitelis, C. N. (2009). The co-evolution of organizational value capture, value creation and sustainable advantage. *Organization studies, 30*(10), 1115-1139.

Pittaway, L., Robertson, M., Munir, K., Denyer, D., & Neely, A. (2004). Networking and innovation: a systematic review of the evidence. *International Journal of Management Reviews, 5*(3-4), 137-168.

Porter, M. E. (1985). Competitive advantage: creating and sustaining superior performance. *New york*.

Provan, K. G., & Kenis, P. (2008). Modes of network governance: Structure, management, and effectiveness. *Journal of public administration research and theory, 18*(2), 229-252.

Ragin, C. C. (2000). *Fuzzy-set social science*: University of Chicago Press.

Rallet, A., & Torre, A. (1998). On geography and technology: The case of proximity relations in localized innovation networks. *Clusters and regional specialisation: On geography, technology and networks: Pion London*.

Ramirez, R., & Wallin, J. (2000). *Prime movers: define your business or have someone define it against you*: Wiley.

Rampersad, G., Quester, P., & Troshani, I. (2010a). Examining network factors: commitment, trust, coordination and harmony. *Journal of Business & Industrial Marketing, 25*(7), 487-500.

Rampersad, G., Quester, P., & Troshani, I. (2010b). Managing innovation networks: Exploratory evidence from ICT, biotechnology and nanotechnology networks. *Industrial Marketing Management, 39*(5), 793-805.

Reichman, M., & Simpson, P. B. (2016). Open innovation in early drug discovery: roadmaps and roadblocks. *Drug discovery today, 21*(5), 779-788.

Renn, O., & Roco, M. C. (2006). Nanotechnology and the need for risk governance. *Journal of Nanoparticle Research, 8*(2), 153-191.

Ring, P. S., & Van de Ven, A. H. (1994). Developmental processes of cooperative interorganizational relationships. *Academy of Management Review, 19*(1), 90-118.

Ritala, P., Agouridas, V., Assimakopoulos, D., & Gies, O. (2013). Value creation and capture mechanisms in innovation ecosystems: a comparative case study. *International Journal of Technology Management, 63*(3-4), 244-267.

Ritala, P., Armila, L., & Blomqvist, K. (2009). Innovation orchestration capability—Defining the organizational and individual level determinants. *International Journal of Innovation Management, 13*(04), 569-591.

Ritala, P., & Hurmelinna-Laukkanen, P. (2009). What's in it for me? Creating and appropriating value in innovation-related coopetition. *Technovation, 29*(12), 819-828.

Robson, C. (1994). *Analysing documents and records*: Paul Chapman London.

Rohrbeck, R., & Arnold, H. M. (2006). *Making university-industry collaboration work-a case study on the Deutsche Telekom Laboratories contrasted with findings in literature.* Paper presented at the The International Society for Professional Innovation Management Conference, Networks for Innovation, Athens, Greece.

Rohrbeck, R., Hölzle, K., & Gemünden, H. (2009). Opening up for competitive advantage–How Deutsche Telekom creates an open innovation ecosystem. *R&d Management, 39*(4), 420-430.

Saebi, T., & Foss, N. J. (2015). Business models for open innovation: Matching heterogeneous open innovation strategies with business model dimensions. *European Management Journal, 33*(3), 201-213.

Sarkar, M., Aulakh, P. S., & Madhok, A. (2009). Process capabilities and value generation in alliance portfolios. *Organization Science, 20*(3), 583-600.

Saxton, T. (1997). The effects of partner and relationship characteristics on alliance outcomes. *Academy of management journal, 40*(2), 443-461.

Shea, C. M. (2005). Future management research directions in nanotechnology: A case study. *Journal of Engineering and Technology Management, 22*(3), 185-200.

Smart, P., Bessant, J., & Gupta, A. (2007). Towards technological rules for designing innovation networks: a dynamic capabilities view. *International Journal of Operations & Production Management, 27*(10), 1069-1092.

Smits, R., & Kuhlmann, S. (2004). The rise of systemic instruments in innovation policy. *International Journal of Foresight and Innovation Policy, 1*(1), 4-32.

Stylios, G. K., Giannoudis, P. V., & Wan, T. (2005). Applications of nanotechnologies in medical practice. *Injury, 36*(4), S6-S13.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research policy, 15*(6), 285-305.

Tegart, G. (2003). Technology foresight: Philosophy and principles. *Innovation, 5*(2-3), 279-285.

Thomas, L. D., & Autio, E. (2014). The fifth facet: The ecosystem as an organizational field. *DRUID, Copenhagen, Denmark*.

Tidd, J., & Bessant, J. (2014). *Strategic innovation Management*: Wiley.

Traitler, H., Watzke, H. J., & Saguy, I. S. (2011). Reinventing R&D in an open innovation ecosystem. *Journal of food science, 76*(2), R62-R68.

Vale, M. (2011). Innovation networks and local and regional development policy. *Handbook of local and regional development*, 413-424.

Van de Vrande, V., De Jong, J. P., Vanhaverbeke, W., & De Rochemont, M. (2009). Open innovation in SMEs: Trends, motives and management challenges. *Technovation, 29*(6), 423-437.

Vanhaverbeke, W. (2017). *Managing open innovation in SMEs*. Cambridge: Cambridge University Press.

Vanhaverbeke, W., Chesbrough, H., & West, J. (2014). Surfing the new wave of open innovation research. *New Frontiers in Open Innovation*, 281.

Vanhaverbeke, W., & Cloodt, M. (2006). Open innovation in value networks. *Open innovation: Researching a new paradigm*, 258-281.

Vanhaverbeke, W., Vermeersch, I., & De Zutter, S. (2012). Open innovation in SMEs: How can small companies and start-ups benefit from open innovation strategies?

Vargo, S. L., & Lusch, R. F. (2008). Service-dominant logic: continuing the evolution. *Journal of the Academy of marketing Science, 36*(1), 1-10.

Vargo, S. L., & Lusch, R. F. (2011). It's all B2B and beyond: Toward a systems perspective of the market. *Industrial Marketing Management, 40*(2), 181-187.

Vargo, S. L., & Lusch, R. F. (2016). Institutions and axioms: an extension and update of service-dominant logic. *Journal of the Academy of marketing Science, 44*(1), 5-23.

Wassmer, U., & Dussauge, P. (2011). Value creation in alliance portfolios: The benefits and costs of network resource interdependencies. *European Management Review, 8*(1), 47-64.

Wauters, J. (2008). The importance of R&D alliances to sustain a nano-biotechnology ecosystem.

Welsh, E. (2002). *Dealing with data: Using NVivo in the qualitative data analysis process.* Paper presented at the Forum Qualitative Sozialforschung/Forum: Qualitative Social Research.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171-180.

West, J., & Wood, D. (2008). Creating and Evolving an Open Innovation Ecosystem: Lessons from Symbian Ltd.

West, J., & Wood, D. (2013). Evolving an open ecosystem: The rise and fall of the Symbian platform. *Advances in strategic management, 30*, 27-67.

Westerberg, M., Singh, J., & Häckner, E. (1997). Does the CEO matter? An empirical study of small Swedish firms operating in turbulent environments. *Scandinavian Journal of Management, 13*(3), 251-270.

Wild, A. (2017). *Europe Positioning in Nanoelectronics* (R. P. M. Van de Voorde, L. Baldi and S. E. van Nooten Ed.). Weinheim, Germany.: Wiley-VCH Verlag GmbH & Co. KGaA.

Willianson, P. J., & De Meyer, A. (2012). Ecosystem advantage: how to successfully harness the power of partners. *California management review, 55*(1), 24-46.

Winch, G. M., & Courtney, R. (2007). The organization of innovation brokers: An international review. *Technology analysis & strategic management, 19*(6), 747-763.

Winter, G. (2000). A comparative discussion of the notion of'validity'in qualitative and quantitative research. *The qualitative report, 4*(3), 1-14.

Wry, T., Greenwood, R., Jennings, P. D., & Lounsbury, M. (2010). Institutional sources of technological knowledge: a community perspective on nanotechnology emergence. *Research in the Sociology of Organizations, 29*, 149-176.

Yin, R. K. (2013). *Case study research: Design and methods*: Sage publications.

Zaheer, A., Gulati, R., & Nohria, N. (2000). Strategic networks. *Strategic Management Journal, 21*(3), 203.

Zaheer, A., McEvily, B., & Perrone, V. (1998). Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. *Organization Science, 9*(2), 141-159.