Examining engagement and network activity in opening up innovation within and across the manufacturing industry

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List of abbreviations:

ALFED	Aluminium Federation
AT	activity theory
CAD	Computer-Aided Design
EEF	The Manufacturers' Organisation
EU	European Union
ICT	information and communication technology
IP	intellectual property
IT	information technology
MOU	memorandum of understanding
NDA	non-disclosure agreement
NPD	new product development
OECD	Organization for Economic Cooperation and Development
OI	open innovation
RAND	Research ANd Development corporation
SNA	social network analysis
SME	small and medium enterprise
UK	United Kingdom
US	United States

Abstract

Recent years have seen a renewed focus on the importance of the manufacturing sector to the future growth of the UK economy. Most critically perhaps, governance studies have linked the UK's strength in manufacturing to its ability to innovate. However, these studies also imply that to be more competitive, UK manufacturers must develop new products and processes across both emerging and established industries, availing themselves of new knowledge and solutions. This renewed emphasis on innovation requires effective engagement with a variety of actors and firms in the local, national, and global economy. Adding complexity, following Brexit, manufacturers will still have to outsource business activities and rely on existing EU suppliers and customers to help to drive innovation. Thus, in this unstable new situation, to be successful in creating novel products and services will require organisations to cultivate strong relationships. Therefore, this thesis examines how and when manufacturing firms can engage stakeholders more effectively across the innovation funnel, uncovering how those relationships affect development and decision-making and how they define courses of action and creative output. To this end, an ethnographic study was conducted at a manufacturing company in the UK that decided to make its innovation activities collaborative to develop a novel quality-inspection technology and new strategic framework. The underlying processes of engagement are understood under the framework of AT, through which the study offers a thorough analysis of how engagement evolves in practice, when this work is effective, and what consequences the promoted relationships have on stakeholders' creativity and performance. As a result, this thesis establishes a stronger link between stakeholder engagement and open innovation discipline. It demonstrates also that for stakeholders to be meaningfully involved in innovation processes, they must first disengage from the norms, places, and situations that hinder their concentration and creativity. Drawing upon its analysis, this paper proposes for professionals a framework that can be applied to organise the engagement process in an open innovation context. Finally, thesis suggests that scholars investigate diverse industries and how organisations can tie stakeholder engagement to innovation strategies that, as the results explain, remain on periphery of manufacturers' organizational activities.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Tomasz Witkowski

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Dedication

Tę prace dedykuje mojej najukochańszej rodzinie:

Gosi – mojej najwspanialszej żonie i przyjaciółce – za wyrozumiałość, kiedy jej potrzebowałem, za okazała cierpliwość, kiedy mi jej brakowało, za wsparcie jakie mi dajesz przez ostatnie lata, a przede wszystkim za wspólne spełnianie marzeń.

Zoe – mojej najukochańszej córeczce, dziękuje Ci za dzień, w którym przyszłaś na świat, za radość jaka mi dałaś w życiu, i za to, że nauczyłas mnie żebym każde nowe wyzwanie traktował jak przygode. Dziękuje ci za twój uśmiech, który sprawia ze słońce świeci nawet w burzliwy i deszczowy dzień.

Mojej mamie, tacie i bratu — za to, że wierzyliście i dalej wierzycie we mnie, za motywacje na każdym szczeblu mojej edukacji, za wasze rady; dziękuje wam że jesteście.

"The mind is like a parachute.
It does not work if it is not open"

Frank Zappa

Chapter 1 Introduction

In recent years, the UK government has renewed its focus on the importance of the manufacturing sector for the growth of the national economy and the creation of new jobs. A post-Brexit plan detailed in the Building UK Industrial Strategy (2017) envisages ambitious goals to develop new world-leading cars and the UK aerospace industry, as well as the roll-out of investments to majorly upgrade its energy and transportation infrastructure. At the same time, to be more competitive, the industry expects to be more innovative. This demand requires the industry to open up even more to new knowledge and solutions from across established and emerging industries, for example information technology, 3D printing, and renewable energy. That calls for more effective engagement with a variety of actors and firms present in the local, national, and global economy to create a new product or service. Additionally, following Brexit, the manufacturing industry will still be required to outsource some of its business activities and rely on existing EU suppliers and customers to help to drive innovation in new products, but it will also have to find a new method of working across borders, to minimise the effect of new trade tariffs on their profits.

This thesis therefore will examine how stakeholders, namely firms' employees, suppliers, customers, contractors, and consultants, together create and sustain relationships to develop a new technologies and processes; it considers how those relations between various people affect decision making and define courses of action, accountability, and creativity. Based on this examination, this thesis develops a process-based framework for stakeholder engagement in an open innovation (OI) scenario. While drawing upon innovative input from external sources may offer considerable benefits, it requires sufficient stakeholder engagement to promote their substantial interest in the innovation being considered. Adequate dialogue is also needed to minimise the risk of knowledge misappropriation and to manage tension related to the divergent interests and perspectives of various innovation contributors. Therefore, this thesis examines how stakeholder engagement is conducted across the innovation funnel within and across a manufacturing firm—through the stages of ideation, development, technology implementation—and the when such process becomes effective, generating benefits beyond the acquisition of specific information.

The focus of manufacturing firms' innovation processes has traditionally been on closed and protected activities, for instance internal research and development (R&D) departments or through patenting of novel solutions. Today, in contrast, manufacturing organisations feel pressure to involve external actors such suppliers, customers, contractors, universities, and governing institution to advance even more innovation process by exploring knowledge outside of the firm and delivering products or services that allow them to compete globally. Such broadened input is becoming an increasingly important component of companies' innovation capabilities and is further explain in more details in section 2.5 (chapter 2). Thus, currently, innovation is rarely conducted in isolation and development of relationships to support knowledge exploration is one of the primary drivers to integrate OI, as presented by Chesbrough (2001). Open innovation provides a framework in both the private – firms with non-public ownership and public sectors – owned and operate by government, to involve various stakeholders from inside and outside of a firm in the firm's service-and-product innovation process. In this context, the OI process can be considered a co-creation process facilitating the engagement of various actors from inside and outside of an organisation, exploiting their ideas to collaboratively develop and commercialise new services or products. Moreover, as explained in section 2.4 (chapter 2) the OI process requires a demand-based and user-orientated approach in which particular attention is paid to the needs of the partners (i.e. stakeholders) involved in a shared innovation process. As such, the process requires the involvement of various stakeholders in the innovation, idea-generation, and design-and-creation processes of new products or services. Thus, sourcing of innovation activities from outside of a firm's boundaries facilitates 'democratic thinking' and engages actors in relationships, where those actors are rather seen as co-creators of value rather than passive participants of goods and services.

Although much work has been devoted to refining the conception of stakeholder engagement across the organisational literature, considerable focus has been placed, in particular, on prescribing how to select the right partners for development rather than explaining when stakeholders become effectively involved across the innovation funnel (section 2.6, chapter 2, introduce to engagement subject). For professionals, the pursuit of openness is about engaging with the varied interests and values of stakeholders and ensuring that those activities are effectively used to bridge a variety of perspectives and overcome organisational and pervasive obstacles when co-developing a new product or service. This thesis considers how this engagement process can be more effective to stimulate creativity and knowledge transfer but also to support the implementation of innovative solutions. Its analysis endeavours to distil this underlying process, guided by Engestrom's (2000) framework of activity theory (AT) (see also Nicolini, 2012). This analytical framework (explained in more details in chapter 3, section 3.5) provides the basis for this thesis to investigate more thoroughly the interactions and contradictions in daily work in intra-organisational context and to track the process (rather than only the outcomes) of developing stakeholder relationships. With the use of AT, this report responds to Eskerod and Huemann's (2013) call to move beyond the superficial treatment of stakeholder issues in the management literature. It also examines conditions (within AT) that may allow for more effective stakeholders dialogue to find new solutions to existing problems and to realise the full potential of collaborative innovation.

This thesis offers a study of a manufacturing company in the United Kingdom (UK) that decided to open up its innovation activities. The name of the company due to confidentiality issue has been omitted in this thesis and in chapter 4 (section 4.3.) I provide more detailed information about this researched organisation. By observing this process, this research was able to hone in on OI implementation. Ethnographic research methods specified also in chapter 4 (section 4.4) were used to examine how this manufacturer dealt with the involvement of stakeholders in the process, how it exchanged information required for the invention, how it communicated when problems occurred and what it did to overcome inherent tensions in divergent requirements when innovating in intra-organisational settings. The ethnographic method that was chosen because it provides the most insight and detailed knowledge around a firm's unmet and unarticulated needs, applications, and problems during the ideation process (see Cooper and Edgett, 2008) and allows one to understand better the reality of OI implementation.

1.1 Thesis context and research background

In the past decade, management in the field of innovation has devoted its attention to the OI paradigm, among both professionals and researchers (Dahlander and Gann, 2010; West et al., 2014). Open innovation is defined as 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively' (Chesbrough, 2006b, p.1). It offers to improve R&D for firms. At the same time, OI requires a substantial organisational change, often subject to significant internal forces (Chiaroni et, al., 2010) and tensions related to the differences between the motives and requirements of various innovation participants (Mahr et al., 2010). How such opening up of innovation is implemented in relation to individuals' routines plays an essential role in its success, and to make full use of the OI approach (Foss et al., 2011; Alexy et al., 2013b; Lakemond et al., 2016). Thus, while OI may offer considerable benefits, it requires effective stakeholder engagement to promote their interest in the proposed innovation, to reduce internal obstacles during OI implementation and to minimise the possibility of knowledge misappropriation (Lindegaard, 2010; Gould, 2012)—for instance, obtaining novel ideas during the process of knowledge exchange amongst the participants and using of those ideas for one's own benefit, without consent (Greenwood et al., 2011).

The original concept of stakeholder engagement offered by Freeman (1984) considers the importance of a person(s) with an interest in the value-creation process (i.e. stakeholders) as a strategic in nature, securing the strategic and ethical benefits of authentic interaction with a different range of actors inside and outside of an organisation. In this view, strategic and moral concerns cannot be separated if an organisation and the involved stakeholders want to produce 'value for all stakeholders' (Noland and Phillips, 2010, p. 40). Thus, the process of stakeholder engagement can promote collaboration and shared goals (Svendsen, 1998; Andriof and Waddock, 2002) rather than discrete plans for innovation activities and goals to protect against uncertainty. Interaction with stakeholders has been identified as crucial to access information, as is necessary in the OI model, and engaging the relevant stakeholders develops key relationships (Smith, Ansett, and Erez, 2011) for creating more value (Baden, 2010) through exchange of knowledge. Stakeholder engagement also fosters a goal-orientated network of relationships both inside and outside of the organisation and allow the discovery and refinement of new ideas and solutions. Such a network supports the transfer of knowledge and know-how between individuals, but also helps to capture and implement ideas.

For researchers and managerial professionals, the questions that arise from this process regard how to make stakeholder engagement more effective, especially across the innovation funnel (i.e. ideation, development, and technology implementation), to generate benefits from OI beyond the acquisition of specific information: in other words, how to navigate this process to stimulate creativity, information exchange between participants, trust, unified purpose and real value for all parties involved. Although many researchers (Svendsen, 1998, Zadek, 2001; Noland and Philips, 2010) have highlighted stakeholder engagement as central to OI, this process can still benefit from study in greater detail. To understand not only how stakeholders are involved in OI, but also when they are engaged in a way that promotes the discovery of new ideas, the implementation of novel solutions, problem solving, and the co-creation of value. For professionals, the pursuit of openness is about engaging with the varied interests and values of stakeholders and ensuring that those activities are effectively used to bridge a variety of perspectives and overcome organisational and pervasive obstacles. Therefore, research effort is needed to explain such process work form both a theoretical and from practical point of view.

The advantages of opening up innovation in the manufacturing industry are widely noted in the organisational literature (Laursen and Salter, 2006; Dodgson et al., 2006). The literature highlights a number of significant challenges related to the implementation of OI in small and medium enterprises (SMEs), which comprise most companies in the manufacturing sector (Gassmann et al. 2010, p. 219; see also Wynarczyk et al., 2013). One of the today's most discussed problems in this sector is the great effort required for knowledge protection (e.g., cost of patents), which discourages companies in this industry from applying the OI model (Brunswicker and Vanhaverbeke, 2011, Spithoven et al., 2010; van de Vrande et al., 2009). Additionally, issues related to SMEs minimal (in contrast to multinational firms) capabilities for networking and engagement in collaborative projects has also contributed to delaying the implementation of OI (Brunswicker and Ehrenmann, 2013) in this sector. Moreover, understanding how OI adoption effects firm performance remains an open area of investigation within field of innovation studies both for high-tech and large organisations and for SMEs (Mazzola et al., 2012). Thus, with minimal guidance how to implement OI in this sector from the organisational literature or industrial cases, manufacturing firms have become reluctant to take the risk of OI, since they remain unsure of how to implement the OI model (Idrissia et al., 2012). In these regards, scholars and professionals could benefit from better understanding how multiple stakeholders can connect to create and sustain OI to increase the success of their innovation efforts (Mahr et al., 2010).

1.2 Research justification and motivation

The key motivations for this thesis were primarily practical and personal. As an employee working in the manufacturing industry, I have supported new products and process development projects, conducted with different participants from various organisations. Some of those projects had positive results and appreciable impacts for the concerned organisations and individuals. However, other projects did not turn produce the expected benefits. This variance arose because every single project in an intra-organisational scenario carries unique problems. For instance, in the implementation of OI, employees often did not have the required capabilities or skills to make valuable contributions to innovation processes, or they lacked the motivation to do so. Also, significant internal forces (Chiaroni et al., 2010), related to an inherent lack of control in both the innovation process and the potential results of this process (Mahr et al., 2010), can distance collaborated partners and result in the termination of the collaboration. Additionally, the number of incoming ideas in the innovation process is sometimes too great (or too conflicted) to suit the effective implementation of new products or services. These experiences instigated my further interest in innovation studies, an especially the concept of OI, to understand how to conduct such processes more effectively.

Furthermore, this innovation model cannot be executed by a single individual, but demands relationships and active dialogue with others, to explore new ideas and get support for this idea implementation. However, the innovation literature does offer many examples of how such dialogue is perform and how relationships to support innovation processes are created but not necessary explain when stakeholders are effectively engaged at the different stages of innovation funnel. In summary, the innovation literature highlights at length the need to study the OI engagement process in more detail (Chesbrough 2017, de Vrande et al., 2009), and the same is true of organisational and management studies (see DeFillippi and Sydow, 2016).

The existing studies on the broader issue of OI implementation do not suggest that researchers probe the internal activities of innovation process. Often, these studies, suggest models and frameworks for companies to conduct OI, but are less interested in exploring how such work emerges and how conditions within specific work environments affect it. Thus, OI studies tend to focus on the organisational level at the expense of the practical activities of those who execute the process. In contrast, one of the strongest themes that has emerged in the organisational literature and manufacturing practice (explained in more details in chapter 2, section 2.6) is the fact that 'real' stakeholder engagement is more complex and unpredictable than represented in in models and approaches. If we want to extend our understanding of what constitutes effective stakeholder engagement in OI processes, we must analyse the actual work that makes up the processes. Thus, in comparison, to the usual research tendencies in innovation and OI studies, this study addresses the need to consider the entire work or activity system beyond just one actor, and the need to account for the environment, culture, tools, and complexity that shape this interaction.

While some studies have focussed on OI process in the manufacturing industry, they have primarily been associated with food production (Tsimiklis et al., 2015), electronics (Parida et al., 2015; Christiansen et al., 2005), and the automotive sector (Cano- Kollmann, Awate, Hannigan, Muabi, 2017) less often with more mature sectors, particularly producers and assemblers of metal components. From that point, little attention has been paid to what actually goes on at firms like these and what those firms do in the context of OI. Companies in this sector remain very capital intensive, leaving them vulnerable to changing and unpredictable market conditions. Additionally, stricter environmental regulations, enforced by the UK government, can put such firms at a disadvantage. Moreover, a recent reduction of UK corporation taxes reduces this low-margin sector's competitiveness, as compared to European firms. At the same time, companies in the metal sector are pushing towards a more circular economy, which is also an opportunity as the process of recycling metals mitigate the need of mining that reduce metal cost, that I describe more in chapter 2, section 2.5. Different components used in the processes such as metals (aluminium in particular) are endlessly reusable and recyclable, and because of that, they become more attractive for downstream users in terms of costs and environmental impacts. This circularity gives the industry a competitive edge in building closer relationships with its customers. However, to build these relationships, a forward-thinking, collaborative approach to R&D will have to be embedded in innovation throughout the industry, from the smallest firms to the largest, as directed by customers' needs (Vision 2030, The UK's metal industry's new strategic approach report, 2017). Chapter 2, section 2.5.4 elaborate on this aspect in greater details. Therefore, as this industry become opening up its research activities, an apparent research gap remains to be filled to better understand what such firms practical strategies to enable such R&D collaboration.

1.3 Research aims and objectives

The main aim of this study is to explore one effective stakeholder's engagement in the OI scenario and to use this exploration to develop a framework that incorporates specific responses managers can use to improve creativity output, control specific tasks and create value propositions in the OI process.

To support achievement of this aim, six key objectives have been developed, as described below:

1. to define effective stakeholder engagement through evaluation, analysis and synthesis of knowledge from innovation and management literature;
2. to explore how manufacturing firms engage in practice with external stakholders when developing new products or services;
3. to identify stakeholders who participate in innovation processes conducted within and across a UK manufacturing firm;

4. to understand what constitutes effective relationship development in the OI context and, in practical terms, to explain how to create and sustain such relations to generate benefits beyond the acquisition of specific information sought from external experts;
5. to examine how stakeholder engagement activities comprise a goal-directed network that connects the inside and outside of an organisation and how this network evolves and affects different phases of the innovation process; and
6. to investigate how divergence both in stakeholder's interests and in their perspectives on what is essential while discovering and developing new solutions is handled and is perceived in the participants' everyday experiences.

Additionally, the results of this thesis are addressed primarily to those people who participate in the decision-making process at a firm level, both strategically and operationally:

- **a.** those in senior management roles or those advising innovation strategies,
- **b.** those who enable, make and implement operational decisions at the firm,
- **c.** internal and external stakeholders who want improve innovation process performance, and
- **d.** those involved in the design and implementation of engagement as a process, including facilitators or professionals such as project managers, technologist, engineers and/or managers that works in the industry.

Also, based on the experience from the study, some organisations in the manufacturing industry may be compelled more than others to understand the engagement process within OI, including the following:

- **a.** sectors with high social and environmental impacts, such as metal producers and metal processors in the UK;
- **b.** the service sector, such as chemical treatment firms, electronic-device producers, and consulting firms; and
- **c.** manufacturing professional organisations in the UK, such as the Manufacturers' Organisation EEF, the UK Metal Federation and the Aluminium Federation (ALFED).

Finally, this thesis should appeal to those interested in or already committed to OI development. This report is not just about engagement; it is about engagement that supports more effective innovation processes in the inter-organisational setting.

1.4 Research questions

The primary research question for this thesis is as follows:

What can manufacturing firms do to engage stakeholders effectively in open innovation activities when stakeholder relations involve supporting the creation of new ideas, advancing a new development, and balancing divergent interests?

The question directs this study to examine a broader spectrum of stakeholder engagement activities during the OI process by focussing on the following sub-questions:

1. *What are the specific characteristics of effective stakeholder engagement in open innovation (OI)?* – This question is addressed in chapter 2

2. *How and when do (or should) stakeholders engage in OI?* – This question is addressed in chapter 5

3. *How does a network of relationships evolve during the innovation process, and how in turn does that evolution affect the discovery, invention, and creation of innovative options?* – This question is addressed in chapter 6

4. *How ought value(s) be prioritised when various stakeholders are engaged in OI*? – This question is addressed in chapter 7.

1.5 Novel contributions of the study

This research offers three main contributions, applicable to both professionals and researchers:

1. ***The first contribution*** is the integration of stakeholders' engagement processes into the OI model, advancing innovation and management scholars understanding of current innovation-process-based models. This integration helps to indicate how to accept the inherent tensions related to OI actives outside of a firm's boundaries, at the same time characterising stakeholders' engagement to maximise OI benefit. The general aim is to clarify how dialogue and relationships with stakeholders during the innovation process support decision making, define courses of action, avoid disputes, and improve accountability and creativity. This thesis has further elaborated how individuals create relationships when they have to interact with the various conditions related to the environment, history, culture, motivation, artefacts and the complexity of real life during the innovation process. With its focus on context, the thesis offers an understanding of stakeholder engagement based on Missonier and Loufrani-Fedida's (2014) suggestions to consider the relational ontology of stakeholders. In explaining these relationships, this thesis examines what an effective stakeholders' engagement process means in practice in the OI context, responding to Achman (2013) and Eskerod et al.'s (2013) recommendation to study the process in more detail.

2. ***The second contribution*** of this thesis is a view of how a network of relationships changes during the innovation process, affecting this process. Previous organisational and innovation literature has focussed primarily on a project's early stages, or the so-called front end (Matinheikki et al., 2016; Leenders and Dolfsma, 2016; Hellgren and Stjernberg, 1995) in which value creation occurs (Aaltonen et

al., 2015; Edkins et al., 2013; Morris, 2013). This thesis, by contrast, explains that while a project's front end is important, such a network changes over time, impacting development performance and creativity over the life cycle of the innovation process. This aspect of change has not been sufficiently addressed in the management and innovation literature.

3. ***The third contribution*** of this thesis is its in-depth examination of the activities of everyday organisational life in a mature manufacturing firm introducing an OI model. This examination is supported by rich and fruitful accounts explaining how the relationships between various individuals were created and sustained and how these affected the innovation process. This thesis offers first-hand experience and a better understanding of how and when individuals engage with one another when innovating in a manufacturing firm, along with the results of this process.

This research's location at a UK manufacturing firm has allowed study of how to effectively support communication and relationships developed between stakeholders involved in the intra-organisational process. This subject, in turn, allows professionals at the company to understand the significance of this interaction, which shapes the development process, and to use apply that knowledge in practice. As a consequence of improved knowledge about stakeholders' engagement, a firm begins to be more effective in innovation projects. Based on my contributions, I was promoted four times in the space of seven years at that, firm and the organisation become to increase number of collaborative R&D projects.

Organisation of this thesis

This thesis is structured as follows (see also figure 1 below):

- **Chapter 2** presents a literature review to establish a background against which the main research question can be answered. The chapter begins with an explanation of innovation processes. It reviews managerial approaches that have been used to manage the innovation process and explains the benefits that innovation brings to firms. It then explains the concept of OI and how it can increase these benefits, along with the external influences that support intra-organisational R&D. Following, the risks inherent to OI are identified and explored to further explain this innovation model. The chapter then establishes what is known about the OI process in the manufacturing sector, how is conducted, and how due to a lack of innovative capabilities (e.g., knowledge of how to innovate with other firms) the process is difficult to implement by SMEs in this sector. Finally, this chapter identifies current knowledge about stakeholders' engagement and establishes what effective relationship-creation means in the context of intra-organisational development projects.

- **Chapter 3** establishes a theoretical framework for this study, explaining the need to develop a process perspective to study stakeholder engagement in OI in more detail at the level of day-to-day activity. It then explains AT as a primary method by which this thesis analyses day-to-day innovation processes. It provides more information on how AT could be used in an intra-organisational context. In this chapter, the thesis also informs how analysis of activity has been expanded and adapted to study networks with use of a network ethnography. Finally, this chapter proposes how to use network ethnography to study temporary networks and their evolution.

- **Chapter 4** outlines the methods by which this thesis examines stakeholder engagement during intra-organisational development projects. It explains the research methods and data-collection techniques adopted for this study and justifies these methods. The chapter also explains where the research was conducted and how projects to examine engagement and network activity were selected for this study. Furthermore, it provides information about the ethnographic processes enacted in the study and the ethical considerations considered prior to and during the research.

- **Chapter 5** details how and when stakeholders become engaged across the entire innovation funnel (i.e. ideation, development, and technology implementation). Data for this examination was taken from a project conducted by a research manufacturing firm, an analytical instrumentation technology firm, and external R&D centres to create a novel technology that enables ultra-fast testing of metal components. To explore stakeholder engagement practices, AT to track the process (rather than only its outcomes) of developing stakeholder relationships has been applied. The results of this investigation reveal that different forms of engagement observed in the process have various effects on innovation, such as the development of incremental work relationships that enhance problem resolution and increases in radical idea generation that affects technology design. Additionally, the results imply that to be effective, stakeholder engagement requires the initial disengagement of stakeholders from established rules, normal work sites, and negative perceptions towards innovation precipitated by process problems.

- **Chapter 6** examines how daily joint activities for two different new product development (NPD) projects create a goal-directed network that connects the inside and outside of an organisation. Data for this chapter were collected for two projects (product and process development) conducted at a research manufacturing firm in cooperation with external collaborating firms from Europe. In this chapter network, ethnography is applied to analyse activities and their impacts on their networks to explain how structuration contributes to discovery, invention, and the creation of novel options. The results explain how project network patterns affect NPD and highlight the struggle with the co-creation process, which involves trade-offs for project advancement.

- **Chapter 7** explains whose values are prioritised when various stakeholders, not necessary from this same firm, are engaged in the innovation process. The data for this examination, as in Chapter 5, derives from the project conducted between a research manufacturing firm, an analytical instrumentation technology firm, and external R&D centres to create a novel technology that enables ultra-fast testing of metal components. Using AT, I describe how individuals and firms change the activity system to embrace paradoxical tensions stimulated by a different logic of worth. The results suggest that engagement in OI does not necessary lead to win-win situations that allow all involved parties to continually benefit while developing new technology. Instead, results in this chapter demonstrate that innovating with multiple stakeholders leads to many trade-offs, which may cost stakeholders 'small losses' while they pursue novel solutions.

- **Chapter 8** highlights the thesis's key findings and introduces the reader to a framework of stakeholder engagement proposed for OI professionals, developed on the basis of this study's various findings. The chapter also explains the theoretical contributions of this thesis offers for an academic audience. Additionally, it discusses several limitations of the research, and finally, it suggests further research that might advance our knowledge of the OI process.

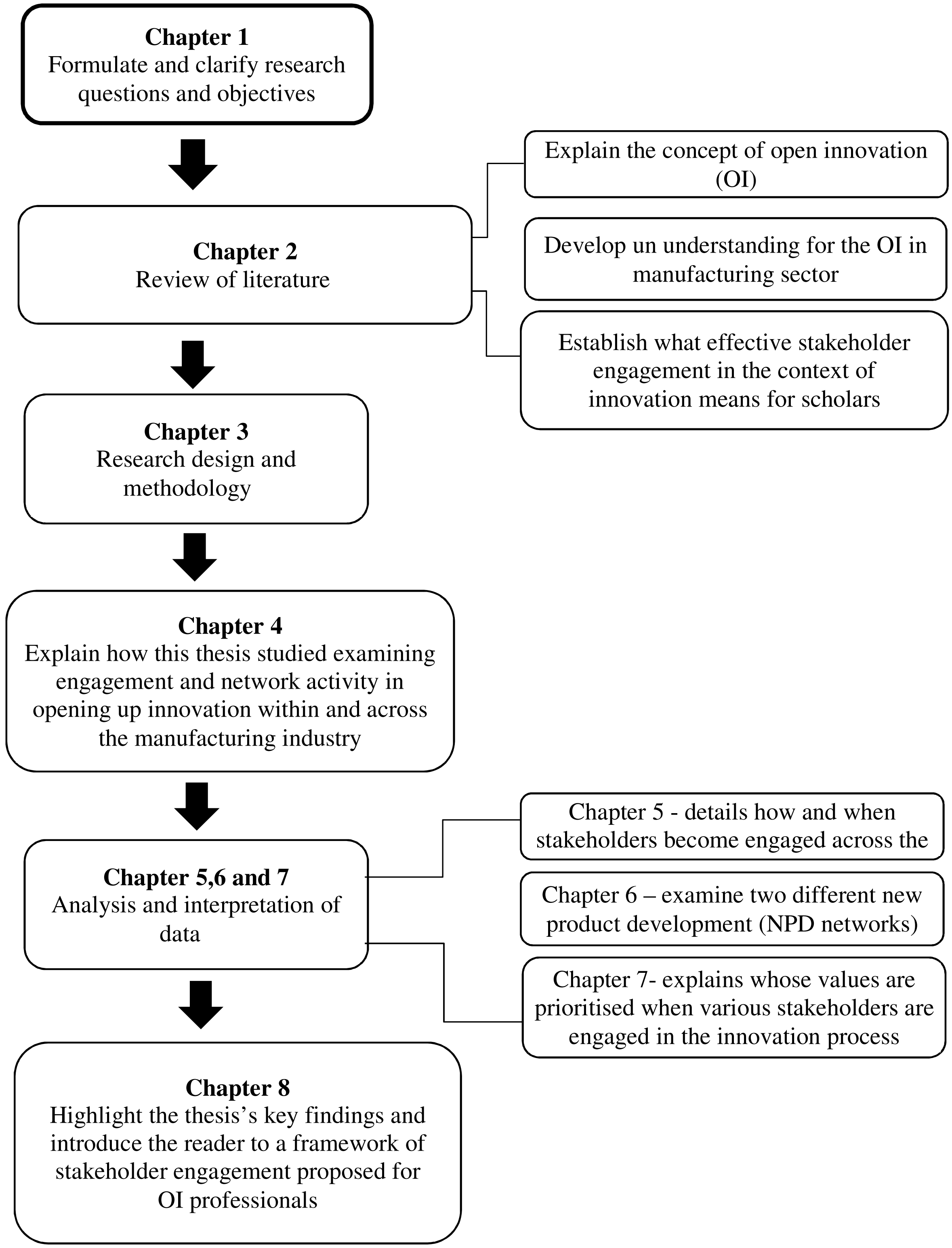


Figure 1 Conceptualisation of research process

Chapter 2 Opening up innovation in the manufacturing industry

2.1 Introduction

Stakeholder engagement is necessary for innovation, particularly for executing OI in the context of UK manufacturing firms. Defining the primary concepts of this subject, this chapter has two main objectives: the first is to explain the concept of innovation, how it can be managed, and the paradigm of OI, which this thesis examines in subsequent chapters. The second is to establish what effective stakeholder engagement in the context of innovation means for scholars (answering sub-question 1, as noted in Section 1.4).

Therefore, the chapter has two main parts. The first part (Section 2.2–2.5) is based on a review of the innovation and management literature; it explains to the reader the concept of innovation and the management of innovation processes. It explains the activities that comprise the innovation process and then fully explains the OI paradigm, its benefits, and its risks related to knowledge misappropriation. The first part of this chapter also explains to readers the challenges of the UK manufacturing industry and discusses how scholars and professionals could benefit from better understanding how to engage in OI to support an effective broadening of innovative collaboration within and across the manufacturing sector. In the second part (Sections 2.6–2.7), the chapter synthesises knowledge about the engagement process from the innovation, management, marketing, and psychology literature to define what effective stakeholder engagement means in the innovation context for scholars, but also in the context of the manufacturing industry.

Following that, Section 2.8 summarises the chapter's findings and concludes that the following is required of stakeholder engagement to be effective in the context of OI requires:

- to stimulate stakeholders' concentration, creative thinking, and ability to make good decisions when co-creating value;
- to promote channels of communication between stakeholders to motivate involvement and sustain interest, remove initial barriers, and assist with the understanding of development problems;

- to assist in the development of pervasive networks that increase knowledge exchange and connect the inside of the organization with its outside to find and refine new ideas; and
- to handle divergence in the interests of various actors engaged in the OI activities.

Based on these findings, the chapter further explains that to advance knowledge of OI, stakeholder engagement must be studied at the applied level, in terms of fully contextualised activity, rather than through analysis of selections stakeholders or their influence.

The chapter is constructed as follows:

- Section 2.2 introduces the reader to the concept of innovation and its benefits for organisations, society and the environment. It describes the different forms of innovation and provides examples of successful innovation.
- Section 2.3 explains how management of innovation helps to organise innovation activities with a selection of tools and techniques that increase the focus of internal participants on idea-finding and the planning of the innovation process.
- Section 2.4 discusses the background and premises of OI. It clarifies how through the externalisation of innovation activities, organisations can more quickly find new solutions to problems, but also how they can increase profitability by selling knowledge. Section explains the importance of intellectual property (IP) management and the consequences of absent or poor knowledge protection mechanisms, which may affect firms' engagement with the development of new products or service. Section also highlights how the global environment has evolved sine last 15 years, making it possible for individuals and organisations to engage with the external world more easily in order to find new opportunities for knowledge exchange, for capital, and for collaborative work to develop new products and services across industries. Additionally, Section summarises the value of engaging in OI innovation processes, and explains what can stop OI implementation at organisational level, specifying which organisational elements and issues negatively affect the engagement process
- Section 2.5 introduces the current situation of the manufacturing industry and the industry requirement to increase work with external actors, firms, and institutions.

Its highlights to the reader the challenges and opportunities facing the UK metal manufacturing sector, and demonstrate how these opportunities can be affected by firm expansion in this industry's collaborations for innovation.

- Section 2.6 answers sub-question 1: To be effective requires an appropriate stakeholder engagement process to manage the risk related to inherent conflicts between knowledge sharing and protection within OI activities, as well as the tensions that organisations experience when introducing OI. Section details how stakeholder engagement theory and OI are connected. Additionally, based on examples from the organisational literature, defines engagement and highlights theories that could make the stakeholder-engagement process more effective.

2.2 Innovation and its benefit

Innovation—from the Latin root of the word *novus* (meaning 'new')—implies newness and novelty. According to O'Sullivan and Dooley innovation is a 'process of making changes to something established by introducing something new that adds value for customers' (O'Sullivan and Dooley, 2009, p. 1.). Innovation plays a continuous role in every aspect of the organisational experience. In the project and business management literature, an innovation is often described as a something that is effective than what is presently available, be that a product, process, service, technology, or business model. In practical terms, 'innovation' is often used in reference to novel technological devices (e.g., bagless and cordless vacuum cleaners or the first model of iPad) that are the result of a process bringing together various experiences and ideas to create something new, which then is commercialised.

However, innovation may also focus on the introduction of new types of products and services (Kamien and Shwartz, 1982, Elster, 1983), which is also often described as product innovation. Depending on the level of novelty, such an innovation can take one of three forms. The first is radical product innovation, in which a wholly new product or service is introduced to firm, industry, or market. The initial development and commercialisation of transistor technology by Bell Labs is an example of radical product innovation (Luecke, 2003). The second one is innovation that differentiates a product (see

Shaked and Sutton, 1987), whereby an existing product or service is adapted to offer something unique to stand out from competition, such as compression ignition engines offered to reduce carbon dioxide emissions and allow greater fuel efficiency (Pandian and Krishnasamy, 2017). Finally, product innovation can be described by market differentiation, by which an existing product or service is extended to a new group of consumers, for instance the introduction of luxury cars (e.g., Bentley) that are seen as a status of a symbol because of their quality and price to the Asian market (Hill and Jones, 2009).

Innovation also refers to new *process* development. This form of innovation describes new or significantly amended methods, equipment or skills used to produce a product or to perform the service (Elster, 1983). Thus, process innovation can range from changes in the equipment and technology used, through improvement of supply chain and delivery systems, to changes in strategy formations. A ground-breaking example of process innovation is Henry Ford's oft-referenced invention of the world's first vehicle assembly line, which shortened the time necessary to produce a car from 12 hours to 90 minutes (Casey and Dodge, 2010).

Innovation can also be described through business model change that does not necessarily imply changes to products or process, but is about a fundamental re-arrangement of the organisation around one explicit requirement (e.g. customer needs) to realign resources, processes, and the firm's profit formula with a new value proposition (see Zott, Amit, and Massa, 2011). Whereas both product and process innovation can be incremental and moderate, business model innovation is predominantly radical, risky and transformative (Lindgardt et al., 2009). A good example of such business transformation is IBM, which managed to change its customer offers from mainframe production to personal computer and technology services (Harwood, 2011).

Innovation in the organisational context is linked to positive changes in efficiency, productivity, quality, competitiveness, and market share (see Freel and Robson, 2004, Eggert et al., 2011, Baron and Tang, 2011). Thus, innovation can be seen as a catalyst to growth that is key to the future success of a business (Christensen, 2001) (see also Table 1). Today, it is widely accepted that innovation is required for organisations to succeed, from privately owned firms, universities, and local governments to non-profit bodies. At the firm level, in the recent years, the most iconic innovation has been presented by Tesla Motors and their autonomous driving technologies (Gordon and Lidberg, 2015). Graphene production commercialisation by Manchester material school is an example of innovation perused by a university (The University of Manchester Intellectual Property, 2016). Also, on the level of local governance, the Klimastrasse project initiated and conducted by City of Cologne in Germany has introduced sustainable streets via optimised building insulation, connecting streets to renewable energy and to intelligent energy-management software that optimises energy usage (Manville et al., 2014). Even not-for-profit organisations have begun to innovate. For example, the American not-for-profit charity called Water has developed an application that allows financial contributors to track their contributions from pocket to project.

Table 1 Positive effect of innovation on a firm's growth (source: base on Horizon 2020)

To gain competitive advantage	To stimulate staff with interesting and challenging work
To make life easier for their customers and help them improve their business	To attract and retain higher calibre staff
To protect market share	To reposition an organisation and raise its market profile
To encourage those with good ideas to approach the company	To lead the market and reinforce a reputation as market leader
To attract alliance partners	To open new horizons so as to get out of a rut or avenues with milted potential
To attract extra funding	To comply with legislation (actual or anticipated)
To raise margins and profitability	To reduce competition and/or the influence of competitors
To drive total shareholder returns	To provide stability for the workforce

Organisations also are encouraged to innovate by national governments that see innovation as a tool for leveraging economic suitability and growth. The UK Department for Innovation, University, and Skills states that innovation is critical to the UK's further economic prosperity and quality of life (Innovation Nation, 2008), leading to discussion about a new policy known as ‘Patent box’ that relieves a substantial amount of corporation taxation which can be invested in technological development. In the United States (US) in a similar project, conducted under the auspices of the White House Office of Sciences Technology and Policy, seeks to build an infrastructure to integrate information on R&D inputs and outputs to investigate the impact of innovation on the lives of the citizens, called the STAR-METRICS project. In the European Union (EU), research and innovation are at the top of the agenda for growth and for creating new jobs. Member countries have been encouraged to invest 3% of their GDP in R&D by 2020 (1% public funding, 2% private-sector investment), which is estimated to create 3.7 million jobs and increase annual GDP by nearly €800 billion (Research and Innovation Performance in the EU, 2014). Therefore, innovation has been seen as an essential element not only for purely economic reasons, but also from a social point of view.

Consequently, manufacturing companies' leaders from around the world have seen innovation as a strategic priority. According to Dobni, Klassen, and Nelson’s (2015) study of Fortune 1000 firms’ top executives, 26% cited seeing innovative projects as a top priority, and an additional 45% ranked it as in the top three priorities for achieving business success. At the same time, scholars and professionals have been trying to better understand innovation processes in order to maximise them and deliver greater value. In the following sub-sections, I highlight areas of the management literature to describe how innovation is proposed to be managed.

2.3 Management of innovation processes

Innovation can occur as a result of focussed effort by various actors, but sometimes also as results of mistakes within a project (see Cobb 2010). Therefore, innovation can be achieved in many different ways, for example through formal R&D activities but also through less formal and small on-the-job modifications of a company’s own production process (sometimes called ‘incremental innovation’). To innovate, organisations require not only a recognised need but also resources such as expertise, knowledge, skills, financial support and premises for concept testing (see Engelberger, 1982). To develop and commercialise new opportunities, companies often need to explore and exploit new ideas, such as unexpected market anomalies, weak spots in processing, industry and market-structure changes (e.g., regulations), demographic changes (e.g., human capital—education), new insights, changes in perception and meaning, and sometimes even customers' moods.

Thus innovation in the management literature is often considered a process rather than merely an outcome that generates or captures value. Consequently, such a process requires defining value, which could range from particular functions of the specific features of an artefact (e.g., specification) to more abstract ideas about how to use it (see Bowman and Ambrosini, 2000). Thus, the importance how do we understand innovation lies not only in the definition of value but also in the purpose of the innovation outcome, labelled as a value-in-use (table 2). An innovation process can also be categorised according to its focus. Hence, the management literature often categorises innovation types according to product, performance, efficiency, market, services and strategy.

Table 2   Different types of value (based on Mele, Colurcio and Russo-Spena, 2014)

	Value-in-use	Value-in-context	Value-in-exchange
Value conceptualisation	A customer outcome or objective that is achieved through provider's process of using its resources	A Customer value delivered by set of unique actors with unique reciprocal links among them	New added value exchanged through new goods and services or new processes
Firm role	Co-innovator and value co-creator	Innovator and value creator	Main innovator and value creator
Customer role	Co-innovator and value co-creator	Recipient and source of knowledge	Recipient of value
Stakeholder role	Co-innovator and value co-creator	Source of knowledge and recipient	Functional contribution (supplier, distribution, etc.)
Network role	A meta-actor for value innovation and mutual value creation	Context for sources Stakeholders as partners	Context for competition
Locus driver	Opened-ended value and consider larger eco-system	From outside to inside for ideas generation	Inside the firm, technology market information and R&D department
Process model	Open and co-creation ("Co-s": cooperation, collaboration, co-development and coordination)	Sequential and collaborative	Sequential and linear

Because each phase of the innovation process has different aims (e.g., idea generation, testing, implementation, and commercialisation), the management literature divides these activities according to their use. For instance, one large group of techniques is used solely for the purpose of generating ideas through analysis of differences between existing and alternative conditions, so-called gap analysis. This group covers techniques used in quality management but also convenient for solving problems through creative thinking, including brainstorming (Osborn 1942) that allows different perspectives on opportunity to be expressed, diagramming that is useful to gain maximally broad of the system within which the opportunity is situated, benchmarking (McNair and Liebfried, 1992), the theory of inventive problem solving (i.e. TRIZ, acronym from Russian language "Theory of Inventive Problem Solving") (Altshuller, 1986), the SCAMPER method (Eberle, 1982), and opportunity-seeking through experimentation, as in the Taguchi (from inventor surname; statistical method to improve manufacturing product) method (Cullen and Hollingum, 1987) or quality function deployment (Akao, 1990).

To improve decisions about key attributes of innovation, the nature or amount of demand, and cost estimation management, the literature often promotes the use of forecasting techniques. For example, technology adoption curves (so-called S-curves, Slocum, 1999) are used to identify changes in particular market trends, known as 'leading indicators' to track effort over time for key areas of new product and process solutions. Additionally, an important exploratory technique to improve decision making within the innovation process is scenario planning. By considering the various scenarios, managers may make decisions, goals, and plans for the future in the light of the predicted situation (Schoemaker, 1995, Chermack et al., 2001). Also, more sophisticated brainstorming techniques with 'experts' from specific fields (e.g. the Delphi method) to establish a long-term perspective on technological development are popular in management literature (de Loe, Melnychuk and Murray, 2016). Less common techniques involve technology road-mapping that assist firms in identifying their future product, services, and technology needs (Barker and Smith, 1995).

The innovation process may bring with it many different techniques and tools—in fact, Smith (1998) identified more than 170 techniques and tools just for idea-generation—during its various process phases, such as concept development, industrial testing, or commercialisation. Each of them brings its own related sub-activities, categorised as a techniques, tools, methods, and resources, to manage the development of new ideas that can become practices within an organisation, if implemented regularly (Hidalgo and Albors, 2008). Additionally, it is common in the management literature that the project management framework becomes a dominant model for managing innovation (Lenfle et al., 2016). That framework include various tools and techniques to initiate, execute, control, and close the work of a team to achieve specific goals and meet specific success criteria are used to manage the process and make it transparent for its sponsor(s). Various alternations of project management techniques, tools and concepts and their selections can be found in the innovation literature. For instance, one may concern derivative projects, characterised by specific modification of a product or service and the way it is made or delivered. Another may concern platform projects, which involve design for manufacturing and commercial exploitation activities. A third might focus more on the generation of a creative ideas or concepts for a new product or service, often referred to AS breakthrough projects.

Also, it is common when talking about innovation inside of firms to relate it to internal R&D activities and the company's management process (see Roussel, Saad, and Erickson, 1991). Those internal R&D departments undertake projects either at the request of individuals from the different area of the business or may support broader company goals. Such departments aim to involve rest of the organisation in searching for novel solutions and integrating these solutions into the business. Therefore, projects run by such department tend to have tighter and more define objectives and are subject to greater financial scrutiny (Roussel, Saad, and Erickson, 1991). These projects usually lead to engagement in series of activities that enable the creation of novel solutions, products or services and are responsible for innovation adoptions that come from outside of the organisation (OECD, 2005).

However, according to researchers (Santamaria, Nieto and Barge-Gil, 2009), many activities that lead to innovation are not R&D based. Moreover, despite the heterogeneity of innovation management studies, scholars (Rothwell, 1992) have highlighted that there is no generally accepted prescription or recipe that guarantees success in the innovation process. Instead, Rothwell (1992) (see Figure 2) suggests innovation models that describe key factors reducing the risk of innovation failure. Such as the establishment of excellent internal and external communication, treating innovation as a corporation-wide task by involving all departments, implementing project management to control resources and efficiency in development work, promoting strong market orientation, introducing technological gatekeepers to the process, and committing to the development of human capital (see Rothwell, 1992). Therefore, as et al. (2001) also Tidd and Bessan (2014) have correctly highlighted, innovation management can help in organising innovation activities and within a selection of tools and techniques needed in the process to lower the risk of failure. One of these models that has gained the particular attention of scholars and professionals in the last decade is the OI model.

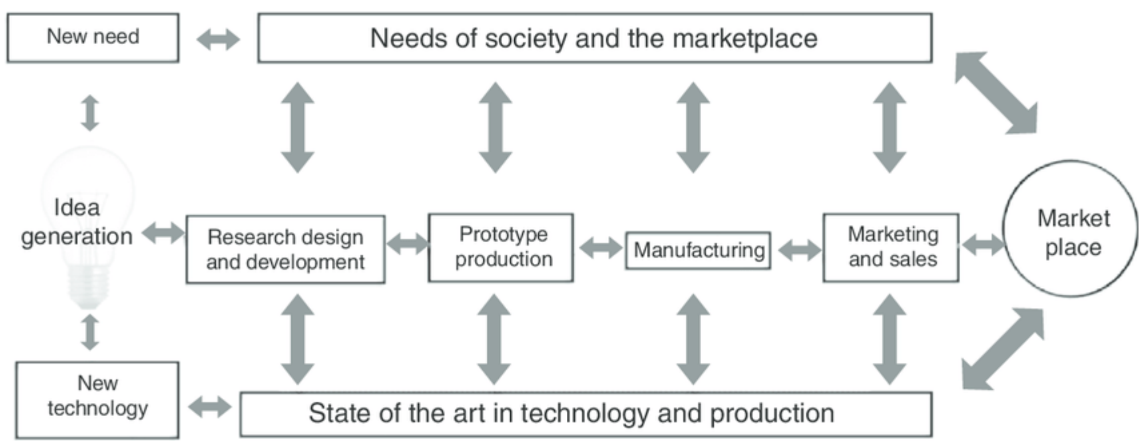


Figure 2 Rothwell's interactive innovation model (source: Rothwell, 1992)

2.4 The background and evolving conception of open innovation

For organisations, the innovation process is key if they want to grow, increase profits and operate sustainably in the long term (Elmquist et al., 2009). Hence, as explained in the previous section, scholars have examined many tools and techniques over the years that are useful for managing innovation, but most of them concern managing innovation within an organisation. Thus, often researchers follow innovation management activities within close and specialised units (West, 2002) such as internal R&D departments to understand how they could drive the research and deployment of new ideas more successfully. In one of these studies, Roussel, Saad and Erickson (1991) noticed that those units must be more than a ‘black box’ within the organisation and rather than being isolated need to increase interaction with the rest of the firm, allowing them to find new ideas faster and spend money on innovation more effectively. Following this argument, this same group of scholars have advocated that innovation processes can be even more productive when undertaken through a tightly defined contract with universities or other sustainable organisations, such as government research bodies.

A decade later, Chesbrough (2001) asserted that such an opening up of innovation activities to external parties became common practice in the information technology industry (Table 3), and firms have started to search for novel ideas and solutions not only with research agencies but also with suppliers, customers, and sometimes even competitors. This engagement with the external world has been allowing organisations to explore know-how, technological novelty and solutions to common problems even faster than offered was possible with traditional, in-house managed innovation activities. Furthermore, globalisation allows for greater knowledge exchange and collaboration (to complement resources) between firms to reduce innovation costs (Gassmann et al., 2006). Such an opening up of innovation processes has been conceived with the use of traditional techniques, tools, and methods and then improved by organisations to embrace intra-organisational innovation processes.

From such experience, the OI concept emerged and falls directly in the gap between business and academia. The model envisages the use of ‘purposeful inflows and outflows of knowledge to accelerate innovation internally while also expanding the markets for the external use of innovation’ (Chesbrough 2006). It involves management of information exchange with actors outside of an organisation’s boundaries and aims to integrate resources and knowledge into a company’s own innovative process (Figure 3). The conception of OI has been attributed to Henry Chesbrough (2003a; 2003b), a professor at UC Berkeley’s Haas Business School who argued for the usefulness of a more distributed, more participatory, more decentralised approach to innovation than those offered by traditional (closed) views. Open innovation, he argued, is especially useful when knowledge is widely distributed, and no company, no matter how capable or big, could innovate effectively on its own. Quickly, the OI model received uptake beyond the private sector, becoming widely applied in other sectors, such as not-for-profit.

Open innovation is grounded in the recognition that organisations can harness knowledge from multiple sources to enhance innovation and thus deliver additional value. Moreover, the OI model assumes that an organisation does not strive to generate the best ideas entirely by itself, but rather requires one to utilise internal and external ideas in an optimal manner to effectively manage risks and costs to accelerate the innovation process. The sources of knowledge to identify the gap and find solutions often include suppliers, research centres, universities, customers, competitors or companies with complementary offerings (von Hippel, 1988). In recent years, new ideas finding have also been promoted by crowdsourcing (e.g., through innovation challenges), where an organisation may come to innovate with a broad range disperse actors from around the world. Despite this call for a holistic approach, the OI model is usually researched through examination of various processes' components (e.g., idea generation, King and Lakhani, 2013), capabilities (employee skills e.g., Podmetina et al., 2015), or tools used to manage the flow of knowledge inside and outside an organisation (e.g. West and Bogers, 2013). Such a fragmentation of the study of OI within the management literature has defined the field (West et al., 2014).

Interestingly, initially OI definition focusses management activity on balancing internal and external sources of knowledge, as well as methods:

'*… firms can and should use external ideas as well as internal ideas, and an internal and external path to market…*' (Chesbrough, 2003a, p. 24)

By contrast, the next definition focusses only on activities that balance the two existing knowledge flows, and explaining that OI

'… is the use purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively' (Chesbrough, 2006, p. 1)

Later definitions stress that OI requires simultaneous focus on practices and models:

'…exploring a wide range of internal and external sources for innovation opportunities … and broadly exploiting those opportunities through multiple channels' (West and Gallagher, 2006, p. 320)

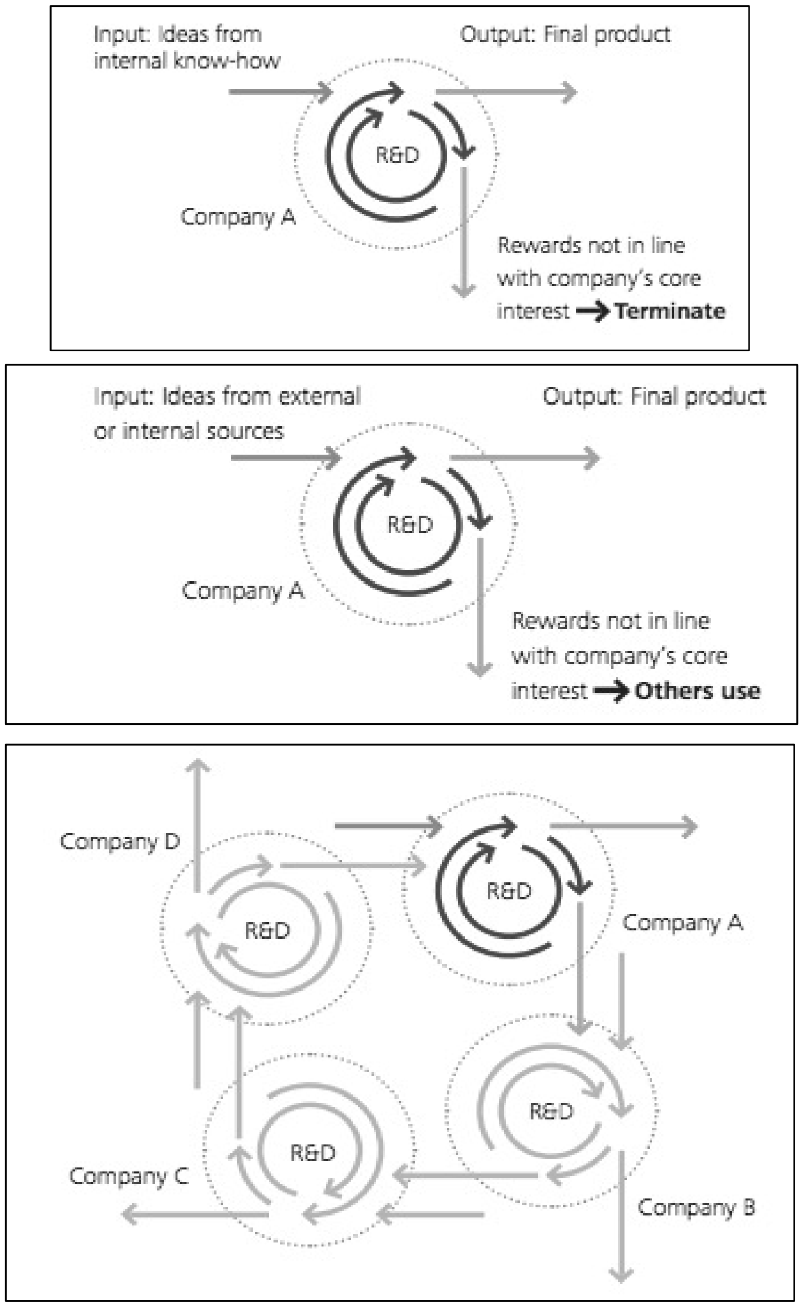


Figure 3 Open innovation paradigm (Source: Chesbrough, Vanhaverbeke, and West, 2006)

Moreover, more recently, Chesbrough and his colleague have been redefined OI as a

'*…process based on purposively managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model.*' (Chesbrough and Bogers, 2014, p. 12)

All of these definitions, as well as others that were not quoted here but are used in management literature, offer an initial understanding of OI. Firstly, these definitions highlight that a concept used significantly within innovation literature may have different labels. Secondly, various definitions of OI have been mostly developed over the past decade (West et al., 2014), suggesting that theoretical perspective has been developed over past 10–15 years. Thirdly, the definitions suggest that the concept today is still evolving, and new definitions of OI are proposed. From the quoted definitions, it seems that the essence of the OI model considers three key organisational components: culture, structure, and business model (Chesbrough, 2003a). Thus, it is important to mention them, especially when talking about OI practices, since the practices are a common to all these elements (Chesbrough, 2003a).

Table 3 Examples of OI projects (Source: adopted from Lindegaard, 2012)

OI Project	**Description**
Audi Production Award	In this competition, Audi asks questions such as follows: How will people work in production? What qualification concepts or kinds of cooperation will the future of production require?
Akzo Nobel Open Space	This open space allows Akzo Nobel, a producer of paints, coatings and chemicals, to reach out to individuals, companies and the academic world on a non-confidential basis.
Baden Aniline and Soda Factory (BASF) Future Business	An entry site for getting in touch with BASF with regards to joint innovation efforts

Dutch State Mining (DSM)	DSM provides a good example of how a business to business (b2b) industry such as a chemical manufacturing can develop with more OI mind-set. DSM has also been a driving force in developing Chemelot as a community for the chemical industry.
Hawlett-Packard (HP)	HP Labs' team pursues and coordinates collaborations with researchers and entrepreneurs in academia, government and business.
Nokia	The company turns to consumers with their Ideas Project.
Philips	To increase innovative effort, the company has committed to working with external partners on new product development.
System Application and Product (SAP)	The Global SAP Co-Innovation Lab (COIL) Network enhances the capabilities of SAP's partner and customer ecosystem through an integrated network of world-wide expertise, and best-in-class technologies and platforms.
Xerox	Open Xerox is the place where it is possible to experiment with technologies being developed in Xerox labs around the globe.

2.4.1 Open innovation, external interactions, and appropriation

Adoption of the OI model requires a firm to engage in proactive IP management in order to exploit its own knowledge and innovations in a strategic manner, as well as those of other firms (Herzog 2008). Often, this management is accomplished through registered rights to solutions with the use of patents, or unregistered rights with use of non-disclosure agreements (NDAs), to clarify ownership and control over resources that will be shared with external actors. Additionally, an organisation may establish a knowledge-management process to ensure that expertise is shared outside in controlled way. Base on that management literature, three ways for organisations to use OI model can be identified:

A. The first is inbound innovation, which refers to the use of the external source to innovate within the organisation: for example, using in-licensing to develop a new technological component elsewhere and then integrating that component into the firm's own technology solution rather than developing an equivalent in-house.

B. The second is an outbound innovation model that refers to the use of external partners for the purpose of developing and commercialising innovations (Chesbrough and Crowther, 2006). For instance, an organisation may out-source its product to another firm that can be used further to develop the product, obtain necessary market approvals, or to evaluate pricing.

C. The third form, so-called coupled innovation, combines the inbound and outbound dimensions, so rather than sharing existing resources and know-how, organisations work together to develop new knowledge and solutions (Gassmann and Enkel 2004). This is a form of OI involves closer integration, for instance through a joint venture or various forms of loose affiliation, such as new product or process development projects or engagement through competition.

Huizingh (2010) and Penin et al. (2011) have explained that knowledge integration from outside of an organisation's boundaries, especially in the context of product development, has almost always been practiced to some extent. For example, Edison's Invention Factory at Menlo Park, which introduced electric lighting in the 19th century, relied on multi-disciplinary teams' efforts (Penin et al., 2011). Hence, in practice, the distinction between the OI model and the traditional 'closed' approach to innovation is not as clear-cut as sometimes presented in the management literature. In fact, some scholars (Dahlander and Gann 2010; Lichtenthaler 2011) have pointed out that businesses frequently employ hybrid approaches. Therefore, the OI model can be reconsidered as a continuum of openness rather than balancing act between closed and OI approaches. Because organisations can use different forms such as bilateral collaboration, networks and innovation 'ecosystems' in which actors exchange their know-how and collaborate informally (Williamson and De Meyer 2012), the OI model is flexible.

Such flexibility promotes a variety of ways in which ideas can be developed and commercialised, such as explained before in-licensing, out-licensing, but also cross-licensing, joint research, and development (R&D) agreements, corporate investment capital, joint investment, and inorganic growth through acquisition (Table 4).

Table 4 Forms of technology sourcing in the OI model (Source: Herzog, 2008)

Technology sourcing method	***Typical duration***	***Method strength***	***Method weakness***
Internal R&D	Long term	Absorptive capacity, exclusiveness of technology, and knowledge exploitation	May not always be sufficient to keep pace with speed and complexity of technological developments in high technology industries, high commitment,
Licensing	Fixed term	Fast technology access, lower development costs, less technology and market risks, low commitment and high reversibility	Loss of control over decision-making due to contract constraints, competitive advantage may depend on exclusive licence
Joint R&D agreements	Medium to long term	Exploration of emerging technologies, defined and established standards, access to public funding, reduced risk, capacity to exploit established technologies, development of system solutions	Potentially limited flow of technological knowledge, knowledge leakage, risk of opportunism
Innovation challenge	Short term	Crowdsourcing broadens base of potential collaborators, cost-effective, reduced risk due to arm's length affiliation	In-house, follow-up R&D may enhance control over technology developed, IP management may be more complex with many contributors
Corporate venture capital	Flexible	Window on technology, option to defer high commitment of resources, high reversibility,	Information asymmetries between new venture and investing firm, modest control over development of technology

Joint ventures	Long term	Technology convergence, defined and established standards, smoother information flows, coordination and control, exclusivity of technology ownership	Organisational risk, high commitment,
Acquisitions	Long term	Hierarchical control over new technology, know-how, shortcut to new technologies	Highest degree of commitment

2.4.2 The evolving environment for open innovation

In the recent years, the external environment for innovation has changed significantly, affecting various organisations in both the private sector and the non-profit sector, but also governing entities and local and national communities. Thus, the business and management literature highlight several factors, in particular, that may induce the organisation to adopt the OI model:

- The integration of economic activities at the international level reduces barriers to international cooperation and allows for global competition, defined in the organisational literature as a process of globalisation. Globalisation has increased innovation rates rapidly and forced organisations to adopt more skilfully to new opportunities (Gassmann, 2006). At the same time, the continuing globalisation process allows greater higher mobility for skilled labour, which fosters knowledge distribution. Thus, firms may benefit from access to varied knowledge and experience, along with the best experts and talent, regardless of their location (Herzog, 2008).

- Also, as product complexity has increased to the point that even bigger organisations can no longer afford to do everything alone and in-house (Gassmann 2006, Penin, et al., 2011), dependence on others' expertise has become an integral part of today's business. A classic example is an automotive sector where an estimated 80% of innovation has been based on electronic and software components (Wallin and Von Krogh, 2010) developed by (and with) subcontractors. At this same time, to be more efficient, organisations focus on their core competencies and partner with others (firms, individuals, etc.) to obtain the necessary know-how and resources without the complexity and cost increase related to attempting in-house innovation (Wiliamson and De Meyer, 2012).

- Advancements in information and communication technology (ICT) allow companies to reduce the distance between disparate actors, thereby enabling the integration of new actors into the innovation process (Gassmann, 2006). Information and communication technology makes distance communication more manageable, but also allows one to identify potential innovation partners and pursue collaboration across borders (Penin et al., 2011). With the use of ICT, organisations may more effectively involve external actors in their internal processes, so they can directly collaborate with various staff within the organisation but also remotely test new solutions (e.g., remote technology software modification). In addition to greater higher connectivity, ICT has given rise to new approaches for conceptualisation research, such as crowdsourcing and innovation competitions (Wallin and Von Krogh, 2010).

- The increase of financing that is provided by firms or funds to small, early stage, emerging firms (private venture capital) like a start-up firms with high growth potential have increased the possibilities for commercialisation and invention for their products and services (Herzog, 2008). Small organisations that can overcome sized-related liabilities are more likely to collaborate, especially during the commercialisation stage (Enkel et al., 2010). Additionally, the possibility of financing allows start-up firms to become active on the international stage, where they offer their intellectual assets in order to engage in the development of new solutions more successfully than more prominent firms (see Enkel et al., 2010).

- Industry convergence, defined as ‘blurring of technical and regulatory boundaries between sectors of the economy’ (OECD, 1992), has in the past decade given rise to new inter-industry segments such as nanotechnology, genetic engineering and bio-computers. Thus, to compete in those new segments, organisations are required to combine expertise from different entities across industrial sectors. Moreover, so far, the management literature evidence has indicated the OI model is most common in the sectors that are characterised by joint-technology development (fusion), globalisation, and technology intensity, such as biotechnology (Huizingh 2010) and high tech-industries such as electronics and IT.

- Changes in IP law in the last 20 years have simplified the exploitation and tradeability of knowledge and investment in innovation (Granstrand, 2011). Thus, organisations and individuals can more easily exchange knowledge for other values, such as financial gain. Also, the same actors as in the past can secure know-how with use of patents, but also with others methods, such as copyrights or trade secrets. Intellectual property becomes a strategic asset for organisations; if it is not in use, it can be out-licensed to another organisation and commercialised for profit. With the OI model, the unused output from innovation process, rather than be written off, could be sold or monetised through licensing.

2.4.3 The value of opening up the innovation process

Working with others to develop a novel solution may be particularly useful in today's' globalised, interconnected and innovative market environment. The organisational literature proposes several advantages that may accrue for organisations engaging in OI:

- Their products may enjoy a shorter time to get to market with fewer costs and risks, through acquiring complementary skills and know-how from external sources, reducing investment needs in all innovation input, and thereby minimising the costs and risks associated with development and commercialisation of new solutions (Huizingh 2010; Wallin and Van Krogh 2010). Such situations allow companies to work on innovation at a faster rate than normal through collaboration.

- Innovation rates may increase over the long term; the early integration of diverse actors (e.g., suppliers, customers, etc.) across the industry or market into innovation process has been found to enhance innovation performance (i.e. produce more novel solutions) (Hagedoorn 1993, 2002). Additionally, expertise and skills that organisations do not already possess can stimulate creativity and the development of new and better products, processes or services (OECD, 2008).

- New business opportunities may be exploited by connecting diverse expertise across organisations and allowing industries to identify new market opportunities (Dahlander and Gann, 2010). Engaging in OI can enable an organisation to access new marketplaces by gaining them exposure to new distribution channel;, also, by working with others, small companies may be able to gain access to mature markets.

- Organisations' adaptability may be increased, since OI permits organisations to be more flexible by adapting their knowledge according to shifting commercial needs (Penin et al., 2011), particularly in rapidly changing market conditions. Organisations can decide to attract actors with required know-how or technological expertise on a temporary basis when required and to disband collaboration as necessary.

- The quality of a product, process, or service can be improved through integrating into innovation processes downstream and upstream partners (suppliers, customers), which may enable an organisation to better plan innovation efforts. Moreover, the integration of users into innovation processes, especially in the design stage, allows organisations to capture customers' latent requirements and hidden application knowledge (Von Hippel 1986). Open innovation may also help companies to overcome the tendency to problem-solve in only one particular way, with the same people in an organisation, thus increasing the likelihood of generating disruptive innovation.

- An organisation's ability to identify, assimilate and transform external knowledge (absorptive capacity) may be improved through experience in creating, retaining, and transferring knowledge within and outside of organisation boundaries, generating long-term advantages in innovation processes. Also, when engaged in OI, organisations can profit from their partners' assets, including their reputations and their investor relationships. Both over time improve the exploitation and exploration of new knowledge within a company, allowing innovation processes to be further improved and fine-tuned (Lichtenthaler, 2011).

- Open innovation may stimulate technological advancement by combining complementary resources and expertise to push the technological frontier more quickly. Better and more effective technological solutions can benefit a wider group of customers at the macroeconomic level. Accelerated technology development can also improve disaster response (Shklovski, Palen, Sutton, 2008) and help people to improve their lives.

- Finally, it can provide an opportunity for niche actors to participate in the commercialisation of new solutions. The OI model is particularly relevant for SMEs, which may develop novel technology or service although they have less (or no) expertise in bringing this technology or service into the market. The OI model is further underpinned by greater connectivity and globalisation that allows SMEs to participate in global innovation networks (Penin et al., 2011). Additionally, today's global trends in opening up of innovation processes offer more new openings for engagement with non-commercial organisations in innovation networks (Enkel et al., 2010) such as universities, non-profit research institutes (e.g. Max Plank Society) or governance research corporations (e.g. Research and Development [RAND] corporation that support policy ideas and analysis).

2.4.4 Prerequisites for successful open innovation integration

The business and management literature explains that to adopt OI successfully, organisations require a number of supporting elements, such as commitment from the firm's leadership, investment in organisational learning, and effective risk management in collaborative relationships. Another critical element described by scholars (Cohen and Levinthal, 1990) is absorptive capacity sufficient to identify and integrate valuable external information into innovation processes, which than can be exploited commercially. This ability of an organisation to find and transform relevant information from outside is usually related to technology and market knowledge (Broring and Leker, 2007). Recognition of value from new information allows organisations to expand their internal R&D capacity, general knowledge base, and market knowledge (Rosenberg, 1990). Thus, an organisation that possesses better absorptive capabilities may expect to extract more value from OI. At this same time, engaging in OI can benefit those organisations that do not have enough absorptive capacity on their own, because collaboration provides an opportunity to gain the necessary knowledge and expertise through the formation of an alliance with others who possess the desired capacities (Chesbrough, 2006).

Additionally, the management literature as highlighted that OI requires significant changes in how organisations operate. These changes may include establishing new strategies, decision-making pathways (e.g., from individual to shared), and frameworks to allow management of the intellectual assets of different partners (Lichtenthaler, 2011; Hagedoorn and Ridder, 2012). To make this change effective, organisations must first to identify the knowledge necessary for each stage of the innovation process, such as market trends and technological or process know-how, and then they must integrate that new knowledge into the organisation through collaborative efforts (Gassmann, 2010, Wallin and Von Krogh, 2010). Often, this integration is achieved through joint steering committees. Those committees manage every aspect of the innovation process, from concept development to manufacturing, IP management, and commercialisation, and therefore they also require significant, long-term investment (Huizingh, 2010).

To be successful, the OI model further requires an organisation to develop trust-based relationships with external partners to enable actors to share most valuable knowledge. As explained in management literature, one way to institutionalise an OI approach is to establish an innovation group between firms that combine internal and external experts with the aim of solving problems (Wallin and von Krogh, 2010). Also, an organisation must overcome the 'not-invited-here' syndrome, which is explained as cultural reluctance to develop and implement external solutions (Lichtenhaler, 2011). This mindset has been reported to harm innovation processes because it creates a negatively perception among actors towards working with external entities (Piller et al., 2015), which may lead to the termination of cooperation or of necessary know-how exchange. Whereas internal changes often are described in the management literature as essential steps towards supporting relationship development with partners, the external environment in certain respects may help with OI implementation. For instance, trade-secret protection may facilitate effective knowledge sharing among partners (Chiaroni et al., 2010).

Additionally, the OI model entails, therefore, some transactional costs, including effort to find the right partners and to exchange know-how, but also extra effort to manage complexity and risk in the innovative endeavour (Enkel et al., 2009). Specific investment also is needed to establish coordination processes for knowledge and IP management but also to develop trust with partners over time (Penin et al., 2011). Certain scholars (Dahlander and Gann, 2010; Enkel et al., 2009) have highlighted additionally that OI introduces to the organisation a particular difficulty when co-innovate in terms of valuation of knowledge. Assessing value of knowledge is a key process for any productive activity, and within the OI scenario, managers must estimate value of knowledge before is exchanged. Moreover, because the OI model invites an organisation to engage in multiple interactions with various partners during the innovation process, collaboration may be particularly challenging for resource-constrained organisations, such as SMEs (Huizingh, 2010). Survey data from the Organisation for Economic Cooperation and Development (OECD) (2008) describe that large companies with more resource as four times more likely than SMEs to collaborate on innovation. Thus, in practice, an organisation with multiple innovation interactions represents costs for all organisation that try to embrace OI.

Another challenge associated with the integration of OI is the appropriation of risk related to knowledge misuse. Opening up the flow of knowledge inherently exposes an organisation to risk of its technological and commercial know-how being misappropriated by others (Chesbrough 2006). Lichtenthaler and Frishammar (2011) note that even conscious decisions to disclose knowledge to competitors, for instance through licensing the proprietary technology, may carry the risk of strengthening these competitors. Thus, the management literature suggests that managers require guidance on how much know-how can be shared with relevant partner(s) and under what conditions to control knowledge spillover, either as positive (to allow to exchange necessary know-how) or negative (to avoid knowledge being commercially exploited outside of the project and to control the involved companies) (Mohamed et al., 2007). In knowledge the management literature, various mechanisms that managers can use to control this phenomenon have been described, like for example judicious use of registered rights, trade secrets, and patents or design complexity (West, 2006). Each of these mechanisms allows an organisation that sells the technology or expertise to disclose and trade their know-how in a controlled manner without losing control over these assets. A mechanism (e.g. registered rights) is especially useful in a situation where an organisation is reluctant to share expertise despite, this being necessary for successful collaboration (Arrow, 1962).

The management literature, also highlights that the OI model is not necessarily suitable for every firm in every situation (Gassmann et al., 2010). Depending on company needs and projects, closed innovation conducted with use of internal R&D may be preferable because it allows for streamlining and controlling innovation processes through the internal organisation of multi-disciplinary teams (Dahlander and Gann, 2010). Additionally, the OI model may be ineffective if an organisation lacks adequate knowledge-management processes (Huizingh, 2010). Dahlander and Gann, (2010) explains that for firms to receive OI benefits, far-reaching organisational changes must be introduced, for example re-organisation, the introduction of a new generation of ICT, or investment in extra resources to manage knowledge exchange. Furthermore, OI is not preferable when fear of the adverse impacts of knowledge leakage is present within an organisation, because such an organisation may develop an excessive focus on secrecy and legal protection strategies, sometimes called a ‘myopia of protectiveness’ (Laursen and Salter, 2006, p. 7). Such an experience may drive the organisation to avoid interaction with the external world (Myers and Cheung, 2008) and stop OI integration.

2.4.5 Overview of open innovation

This section has explained the OI paradigm, starting with the information that OI model considers three key organizational components: culture, structure, and business model, which differ for each organisation. Because of such differences, it can promote a variety of ways in which OI can be approached: In-licensing and out-licensing, but also cross-licensing, joint research, and development (R&D) agreements, corporate investment capital, joint investment, and inorganic growth through acquisition, are possible ways of engaging with external actors. Working with others to develop a novel solution may be particularly useful in today's’ globalised, interconnected, and innovative market environment. However, to be successful, the OI model further requires an organisation to develop trust-based relationships with external partners to enable actors to share most valuable knowledge. Furthermore, it concludes that OI is not preferable when fear of the adverse impacts of knowledge leakage is present within an organisation, because such an organisation may develop an excessive focus on secrecy and legal protection strategies, which may drive the organisation to avoid interaction with the external world. Thus, based on the above literature review, companies can usefully develop relationships with those who could offer new ideas, perspectives on problems, or solutions to make this process more effective, beyond the application of new information and communication technologies.

2.5 Opening up innovation within and across the manufacturing industry: Perspectives on how companies gain by widening their innovation focus

It is easy to fall into the trap of associating novel product and process development only with start-ups or fast-moving sectors such as IT or the pharmaceutical industry. Competitive advantage gained from innovative solutions also plays a crucial role in more mature, commodity-based industries, however, such as manufacturers producing metal components. Global companies such as Tata, Alcoa or Hydro Aluminium have achieved some success in managing projects that have revolutionised the metal market. Examples include a novel ironmaking process that cuts both carbon and costs (see Research Excellence Sustainable Future in metals, 2017), the development of a mixed methods for creating aluminium structures that can be used in lightweight cars production, or the achievement of electricity consumption of 12.5 kWh per kilogram aluminium, compared to an average of 13.8 kWh (Aluminium, about Hydro and technology, 2013), to cut bills and greenhouse gas emissions.

Demand for metal products and new uses of these products drive innovation on a constant basis in this field. New patents for metal alloys, welding technologies, methods of defect and cost identification, and environmentally friendly processes demand metal with properties suitable for spaceflight and new generations' of electric and lightweight cars or structures that require super-tensile, corrosion-resistant materials for modern infrastructure development. Today, metals must therefore possess the strength and functionality required of extensive innovative solutions for downstream industries.

2.5.1 The challenges and opportunities facing the UK manufacturing metal sector

According to UK Metals Federation (2017), by 2030, a modern and progressive UK manufacturing industry will be supplying high quality, innovative and competitively priced products to a wide range of customers. Following the Brexit, domestic companies in this industry will be the principal suppliers of the UK's foremost manufacturers and infrastructure projects and will take a leading role as global exporters.

However, currently international changes and globalisation have caused global market share to decline significantly, and even domestic demand has been increasingly met by imports. Consequently, important parts of the supply chain are located overseas, and some key markets now seem inaccessible to smaller UK firms. At the same time, the metal industry shows positive trends with technology developments that make production more effective in terms of costs and environmental concerns. Although developing new products or processes is becoming a high priority for metal companies, the industry remains capital intensive, leaving its companies vulnerable to changeable and unpredictable market conditions. Additionally, stricter environmental regulations enforced by the UK government can put metal firms at a disadvantage, as can the recent reduction of corporate taxes that have diminished competitiveness for low-margin metal companies in the UK, as compared to European firms.

On the other hand, according to the current UK government, a post-Brexit plan (Building UK Industrial Strategy, 2017) is to focus on the manufacturing industry. With the government's ambitious goals to develop new world-leading cars and its aerospace industry, as well as the roll-out of investments in a major upgrade to its energy and transportation infrastructure, extra demand for metals is expected in the coming years. This reshoring and increased production in the UK automotive sector, for instance, is expected to provide around £2.5 billion per year of additional opportunities for the industry, while the UK's latest national infrastructure plan includes some £466 billion of investment up to and beyond 2020 (Building UK Industrial Strategy, 2017). Therefore, this plan is reliant on the manufacturing industry, and if the demand for metals is not met domestically, a substantial part of their value will be lost to the economy (Vision 2030, 2017).

That pushes manufacturing industry towards a more circular economy, which is also an opportunity. Different components used in manufacturing processes, such as metals, are endlessly reusable and recyclable, so they become more attractive for downstream users in terms of both financial and environmental costs. This cyclical nature of the products' lifecycles gives the industry a competitive edge in build closer relationships with its customers. However, to foster these relationships, a forward-thinking, collaborative approach to R&D will have to be embedded in innovation development throughout the industry, from the smallest firms to the largest, directed by customers' needs (Vision 2030, 2017).

2.5.2 Metal product and process innovation and growth

Projects that concern innovation in the metal manufacturing sector have a significant impact on everyday life. For example, the processing of the liquid metal with the use of the high-tech alloys is set to make the next generation of batteries recharge faster and store more electricity, and aluminium alloys used to build light, recyclable, and eco-friendly cars are at heart of the design. Applications of other metals such as platinum, used in catalytic converters to reduce pollution, are also being discovered to improve our (society) lives.

Therefore, a novel solution to metal production processes and applications is now becoming even more important for the industry and the general market. The PricewaterhouseCoopers (PwC) report (Making innovation go further in metals, 2014) based on the senior executive survey, highlights innovation in this sector is as a key activity. What is more important, nearly half (47%) see innovation as 'a competitive necessity' now, and even more (53%) believe it will be so in five years' time. In this same report, on average, the metal companies are said to spend a slightly smaller percentage of their revenues on development projects than do companies across the sample as a whole (7.25% vs. 8.57%). According to a Booz & Co report (acquired by PwC) (Global innovation 1000, 2015), five of the top 20 R&D spenders in 2012 were automotive industry OEMs, and seven were healthcare companies (including pharmaceuticals companies). Not one was a metals company, however. The main reason for this conspicuous absence, according to board level senior executives from metal sector, is a too narrow focus on innovation, mainly on internal processes and products (Making innovation go further in metals, 2014).

According to a UK metal industry report (Vision 2030, 2017), this happens due to a restricted view reported by metal sector on the demand of OEMs and Tier 1 suppliers, which enable metal firms to fully engage with them and compete with their overseas suppliers. Furthermore, the UK government mechanisms to support the development of new products and processes across the manufacturing industry do not fully support smaller companies and make it challenging for them to participate in signature programmes such as Catapult, introduced to form a network of world-leading R&D centres and designed to transform the UK's capability for innovation in specific areas (United Kingdom: HVM Catapult, 2017).

2.5.3 An emphasis on strategy and innovation processes

Successful development projects organised between companies have to be built on the foundation of a clear strategy. To initiate such work, metal companies like others start by assessing the capability of the company and the market. Starting in 2015, a standard tool called Readiness for Innovation Diagnostic (R4I) has been promoted by the UK metal federation (Vision 2030, 2015) that help firms from the sector to understand problems with running innovative projects across the industry. According to the same report, metal manufacturers when creating a strategy for an innovative project should also put more emphasis on reducing risk aversion towards collaborative R&D. Consequently, a well-defined and widely accepted process for running innovative projects is an important component of a successful OI strategy, as highlighted by manufacturers.

Strategies in the metal sector are mostly too narrow and focus too much on internal activities; they virtually do not promote information exchange through the supply chain or provide expertise and guidance on how to work collaboratively across the industry. Mostly, these strategies hinder the development of regional clusters of associated industries that can cooperate on cross-industry innovation. Therefore, with this comes the opportunity to develop new strategies for innovation and R&D within the metal manufacturing sector.

2.5.4 Expanding collaboration to spur the innovation process

The advantages of opening up innovation in the manufacturing (metal) industry are widely commented upon in the organisational literature. The literature highlights a number of pressing challenges related to the implementation of OI into SMEs that are the largest number of companies in this industry (Gassmann et al. 2010: 219; see also Wynarczyk et al., 2013). Some of the today's most discussed problems include limited absorptive capacity, policy constraints, and risk management related to the misappropriation of information (Brunswicker and Vanhaverbeke, 2011, Spithoven et al., 2010; van de Vrande et al., 2009). Another issue related to the implementation of OI is the adoption of OI practices that require sustained effort from firm to allow them to motivate and maintain better performance (Brunswicker and Ehrenmann, 2013).

Moreover, understanding how OI adoption affects firm performance is still investigated, by scholars, both for high-tech and large organisations and for SMEs (Mazzola et al., 2012). Thus, with no available evidence from the organisational literature and industrial cases, SMEs will be reluctant to risk OI if they are not entirely convinced that some of the resulting practices can improve firm performance (Idrissia et al., 2012). In these regards, scholars and professionals could benefit from better understanding how to engage in OI to support an effective broadening of innovative collaboration within and across the manufacturing sector (De Backer and Cervantes, 2008; Frishammar and Ake Horte, 2005; Schroll and Mild, 2011).

2.5.5 Section summary

This section has introduced the challenges of the UK manufacturing industry. It explains that the competitive advantages gained from innovative solutions play a crucial role not only in high-tech and pharmaceutical firms but also in more mature, commodity-based industries, such as manufacturers producing metal components. This is especially true for metal manufacturing, as demand for metal products and new uses of these products drive innovation on a constant basis in this field. In post-Brexit plans, domestic companies in this industry will be the principal suppliers of the UK's foremost manufacturers and infrastructure projects and will take a leading role as global exporters. Additionally, industry will be driven into a more circular economy, and the cyclical nature of metal products' lifecycles gives the metal manufacturing industry a competitive edge in building closer relationships with its customers. To maximise this advantage requires from the industry a forward-thinking, collaborative approach to R&D that will have to be embedded in innovation development throughout the industry, as the current approach focusses too narrow on innovation, mainly on internal processes and products. In this regard, this section concludes that scholars and professionals could benefit from better understanding of how to engage in OI to support an effective broadening of innovative collaboration within and across the manufacturing sector.

2.6 What is missing in open innovation models?

Since 2007 (as noted in Section 2.4), the concept of OI has been modified and extended. However, theoretical modelling of OI in this period has been limited, and when it occurs in the organisational literature, it concerns mostly the structural categorisation of knowledge transfer, as is explained below, rather than the complex, unique, and unstructured nature of engagement mechanism, which is required to support an effective broadening of innovation collaboration within and across the manufacturing sector.

For instance, Dahlander and Gann (2010) separate inbound and outbound innovation processes and then subcategorise each of them based on their financial implications for the company. Similarly, van de Vrande et al. (2009) have divided the OI process into two categories, exploration and exploitation, to represent the process of knowledge inflow and outflow. Finally, Lichtenthaler (2011) explain the OI process as knowledge exploration, exploitation, and retention that can be applied internally or externally, depending on the innovation requirements. Such categorisation generates a total of six categories of organisational capacities. The internal element captures inventive (ability to create or design new things), transformative (materialise the idea) and innovative (produce and commercialise) capacities, and the external element refers to absorptive (recognise the value of new information), connective (connecting required know-how) and desorptive (exploitation of market knowledge) capacities.

However, because OI entitles knowledge sharing with various actors, it may generate significant uncertainty, tensions within organisations, and risk of knowledge misappropriation. Despite these potential drawbacks, the concept of risk-balancing within the theorisation of OI has not been adequately explained (Gould, 2012). In other words, explained above models do not prove particularly useful when evaluating issues related to uncontrolled knowledge leaks, especially when the risk occurs in the day-to-day activities of an innovation process. However, what follows from the OI literature is that researchers (Jarvenpaa and Wernick, 2011; Bogers et al., 2010) have considered the existence of paradoxical tension, as polarised conflicts between knowledge sharing and protection require resolution, but how to handle this resolution during the innovation process remains unclear. Therefore, similar to other scholars (Gould, 2012), I argue that the exploration of such process in greater details becomes essential for the evaluation of risks within OI when integrating collaborative process into the organisation.

Additionally, the literature of paradox theory (Lewis, 2000; Lewis and Smith, 2014) emphasises gaining more understanding of how paradoxes should be handled in extremely complicated operating environments such as OI. So far, we know from various scholars (Lewis and Smith, 2014) that to deal with various tensions, companies either follow a contingency approach (assume the most appropriate management for certain circumstances) and choose the most effective options, or they follow a paradox approach and accept the existence of tensions and multiple options. The latter approach is especially useful to understand complex and dynamic situations such as OI, which may raise multiple tensions. The OI literature distinguishes issues related to the distance paradox (Cohendet and Simon, 2007), where "…each party must maintain separate and distinctive identities and keep separate its activities so that one does not interfere and diminish the resource contribution of the others" (DeFilippi, Grabher and Jones, 2007, p. 516), organisation learning paradox (Bakker, Cambré, Korlaar, and Raab, 2011), which refers to the tension between knowledge creation and the difficulties of knowledge transfer or between crafting and standardised practices highlighted during inter-organisational cooperation (DeFilippi and Sydow, 2016). Thus, paradox theory provides an interesting perspective through which to study the process of OI, especially as emerging tensions are integral characteristics of an organisational system and set of social relationships that, if handled correctly, could be beneficial for participating stakeholders and organisation (Lewis and Smith, 2014). Thus, recognising and accepting the paradox when engaging in OI supports the understanding and management of inherently contradictory aspects in the organisation experience (Gould, 2012), and this possibility has not yet been fully explored by OI models.

2.6.1 Stakeholder engagement theory and open innovation

To manage the risk related to inherent conflicts between knowledge sharing and protection within OI activities, as well as the tensions that organisations experience when introducing OI, firms may rely on stakeholder engagement processes. The original concept of stakeholder engagement, offered by Freeman (1984), considers the importance of a person(s) with an interest in or concern for the value-creation process (i.e. stakeholders) as strategic in nature, capturing the strategic and ethical benefits of authentic interaction with a range of actors inside and outside of organisation. In this view, strategic and moral concerns cannot be separated if an organisation and the involved stakeholders want to produce 'value for all stakeholders' (Noland and Phillips, 2010, p. 40). Thus, the process of stakeholder engagement promotes the development of collaboration and shared goals (Svendsen, 1998; Andriof and Waddock, 2002), rather than plans of innovation activities and goals to protect against uncertainty. Interaction with stakeholders has been identified as important when accessing information that drives the innovation process. The engagement process with relevant stakeholders has been seen as a practical method for developing key relationships (Smith, Ansett, and Erez, 2011) for the implementation of value creation (Baden, 2010).

Thus, 'any group or individual who can affect or is affected by the achievement of the firm objectives' (Freeman, 1984, p. 25) must be considered when organisations face complex operating conditions, such as those of the innovation process. For instance, in the OI scenario, stakeholders can include communities, customers, employees, suppliers, and financiers, but also government, competitors, consumer groups, social interest groups, or even the media. Scholars (Bourne and Walker, 2005) have proposed to identify those stakeholders through the mapping of power, legitimacy, and urgency (Mitchell, Agle, and Wood, 1997) in order to plan interaction and relationship development. However, stakeholder theory proposes also that actors should evaluate the nature of multiple interactions and interdependencies between and among various groups and individuals (Frooman, 1999). Similarly, Rowley (1997) have linked stakeholder engagement model with a social networking approach to evaluate cooperation among multiple stakeholders. Lamberg et al. (2008) highlight that for deeper understanding of multiple-stakeholder relationships, one must identify the initial conditions of the engagement and the sequence of events that have developed this relationship. For instance, Zietsma and Winn (2008) argue that certain stakeholders link with others just to improve their relative position within network structure. Thus, a network of stakeholders' relationships can be complex and unpredictable, as stakeholders can interact outside of the control of the focal organisation (Lewrick, Raeside, and Pelsi, 2007).

By developing and managing relationships with various stakeholders, organisations can access expertise, sometimes even otherwise restricted information (Sharma, 2009). Such knowledge can impact idea generation, new product or process implementation, and its commercialisation, and in consequence, an organisation's profitability. Obtaining knowledge by creating stakeholder relationships may also stimulate organisational learning (Katsoulakos and Katsoulacos (2007). Similarly, scholars (Nelson and Zadek, 2000) have argued further that stakeholder engagement is responsible for relationship 'alchemy' that allows resources and knowledge to be combined and transformed to support value creation. Thus, according to researchers (Ayuso, Rodríguez, and Ricart 2006), stakeholder engagement is important for knowledge integration and should be recognised as an organisational competency. Freeman et al. (2010) advocate that 'a large cast of stakeholders is necessary to sustain value creation' (p. 282) and that ethical stakeholder engagement produces positive economic results. Thus, creating value is supported by developing as many win-win situation as possible with stakeholders, and the better the understanding of stakeholders' needs, the easier it is to create a win-win situation (Plaza-Úbeda, et al., 2009). An organisation by developing and managing positive relationships through stakeholder engagement may effectively pursue its own interests.

Stakeholder engagement and OI processes are therefore similar: Both efforts focus explicitly on accessing essential information by reaching outside of the organisation's boundaries in order to create value, as explained by Gould (2012): for instance, when an organisation opens up innovation processes for knowledge exploration to engage with various inside and outside stakeholders. Such a process requires an organisation to both offer outbound information and seek inbound information. The outbound information may leak into diverse stakeholders in unexpected ways to maximise the discovery of new solutions. Similarly, inbound information from different stakeholders may find unforeseen ways to cross-pollinate ideas and options that, when combined, offer new possibilities would otherwise remain unnoticed. Thus, dialogue and development of relationships with stakeholders has become an important element of the knowledge exploration and exploitation process, but also knowledge transfer that expands beyond the focus on information extraction. In the next section I review the concept of engagement in more detail to explain how the organisational literature describes relationship development and its effect on innovation processes.

2.6.2 Current state of knowledge about stakeholder engagement in the innovation context

In his seminal work, Freeman (1984) describes the role and importance of stakeholders in relation to organisations. Under complex conditions, such as OI, organisations are required to take account for multiple actors operating in the environment, not only to provide access to information and drive the innovation process, but also to enhance 'mutual understanding' (Gao and Zhang, 2006) to protect the firm against uncertainty. Thus, following Frank et al.'s (2004) definition, engagement in external pathways to knowledge creation and exploitation can be seen as the desire to focus discretionary effort on novel technological solutions, often spending extra energy on tasks that create value and minimise tension during innovative processes. Consequently, stakeholder engagement can be defined as a type of interaction that involves, at minimum, recognition and respect for the way in which one's action affects others (Noland and Phillips, 2010). We also understand stakeholder engagement as the impulse to communicate transparently with co-workers to build quality relationships (Antonacopoulou and Meric, 2005) and trust, allowing for uninhibited knowledge flow. In the OI context, stakeholder engagement can be used to develop confidence in co-operation and integrity and motivation to provide novels solution for the market (Appelbaum, 2001; Smith and Wallace, 2010; Heath, 2007), enabling collaborative development issues to be overcome. Engagement, then, can be seen as a practical method of developing relationships with relevant stakeholders (Smith et al., 2011) key to collaborative value creation (Baden, 2010).

Thus, a close relationship is maintained between stakeholder engagement and the OI process. As new ideas are rarely developed in isolation, OI requires stakeholder involvement and interactions to support the creation of new knowledge (Gould, 2012). However, to do that, the organisation has to reach beyond its boundaries, making an explicit effort to access essential information. Yet, to maximise innovation output, such a process not only relies on combinations and numbers of interactions, but also requires the ongoing relationships based on approaches that successfully impact operations and profitability, namely value creation (Gould, 2012). Such success is vital for the engagement process and is perceived as an integral part of innovation, where ideas can be controversial and where the regulation of relationships between parties is crucial in managing innovative output (Rizal et al., 2012). Thus, engagement is often researched in the organisational literature (especially in the context of NPD) to understand managerial actions that may lead to the development of relationships with stakeholders which increase a firm's ability efficiently to find solutions to problems, allow joint decision-making, and stimulate the effectiveness of collective knowledge development.

The OI literature provides examples of how such interactions occur at the firm level through disclosure of information with external parties. For example, Laursen and Salter (2006), Lee et al. (2010), and Love et al. (2011) describe through practical investigation the degree to which a firm's activities allow it to identify technological solutions or create a new applications for existing ideas (von Hippel, 1988; Alexy et al., 2013a). In the same literature stream, crowdsourcing (Afuah and Tucci, 2012), patent auctions (Fischer and Leidinger, 2014), and university-knowledge sourcing (Bruneel et al., 2010) have been identified as initial stimuli for interactions. Such processes may be spread out geographically (Laursen and Salter, 2006; Afuah and Tucci, 2012; Alexy et al., 2013a), and may differ from traditional (closed within an organisation) R&D activities, yet allow for knowledge flow across the boundaries of a firm (both inside and outside), with or without monetary incentives or IP protection (Dahlander and Gann, 2010). However, in order for OI to be effective, the organisation must have sufficient capability to successfully integrate any obtained information (Nonaka and Toyama, R. 2007), which requires stakeholder engagement to overcome the barriers of inertia and substantial costs. Moreover, for the process to be effective, it often requires additional redesign of managerial processes as well as the day-to-day job routines of R&D workers (Foss et al., 2011; Alexy et al., 2013b; Henkel et al., 2013).

While these examples offer a useful guide to explain the context of stakeholder engagement, they do not specify the activities that firms use to build the relationships that enhance competencies for knowledge retention and exploitation. Additionally, simply assuming that the same principles of stakeholder engagement that worked at the organisational level can be replicated successfully in the OI scenario will not necessarily help professionals in the effective management of such processes. In addition, the clear distinction in the literature between actions applied in different contexts of innovation and the actual methods of stakeholder engagement raises not only the question of *how* the engagement is carried out in practice, but also *when* such engagement is effective. To answer these questions requires an understanding of engagement itself.

2.6.3 The concept of engagement

Theory of engagement has its roots in the social sciences that include but are not limited to economics, marketing, political science, management, anthropology, psychology and sociology. The earliest use of the term 'engagement' has been traced to the 17th century, when it was used to describe a number of notions, including moral or legal obligations, ties of duty, betrothal, employment, or military conflict (Oxford English Dictionary, 2014). In the organisational and management literature, engagement is often associated with the concepts of 'stakeholder engagement' (Greenwood 2007; Noland and Phillips 2010) and 'employee engagement' (Catteeuw, Flynn and Vonderhorst 2007; Crawford, LePine, and Rich 2010). In last 15 years, the term 'engagement' has emerged in the business literature (e.g., Jennings and Stoker 2004, Frank, Finnegan, and Taylor 2004), including those addressing the notion of 'connection', 'attachment', ''emotional involvement'', or ''participation'', used to describe specific forms of engagement (e.g., London, Downey, and Mace 2007).

Most recently, the term ''engagement'' has been used extensively in fields including psychology, sociology, political science, and organisational behaviour, leading to a variety of conceptual approaches that highlight different aspects of the concept (Hollebeek 2011; Ilic 2008). For example, while ''civic engagement'' has been studied in sociology

(Jennings and Stoker 2004; Mondak et al. 2010), ''social engagement'' has been examined in the field of psychology (Achterberg et al. 2003; Huo, Binning, and Molina 2009). Furthermore, educational psychology has explored 'student engagement' (Bryson and Hand 2007; Hu 2010), while political science has examined the 'engagement of nation-states' (Kane 2008; Resnick 2001).

2.6.3.1 Defining engagement

Specifically, in the organisational literature, engagement often is associated with the interaction between an 'engagement subject' (e.g., employee, manager, individual actors or stakeholders) and an 'engagement object' (e.g., work, information, products, services, or people). However, engagement objects may also refer to values created by participants, groups or particular communities (customers values, employees values, e.g., Achterberg et al. 2003), as will be explained in subsequent sections 2.6.3.2.1 to 2.6.3.2.4.

Therefore, views on this form of interaction vary, which may have repercussions for how engagement is defined. Frank, Richard and Taylor (2004) define engagement in relation to work tasks, through the use of a behavioural lens, suggesting engagement to be an employees' desire to contribute discretionary effort in a jobs, often through spending extra time at work and energy in performing a task. Similarly, Macey and Schneider (2008a), propose seeing engagement as a form of behaviour that entails a blend of effective energy directed to others who work in an organisation. Following this conception of engagement, Noland and Phillips (2010) conclude that stakeholder engagement is used to recommend a type of interaction that involves, at minimum, recognition and respect of people's common humanity and the ways in which the actions of each stakeholder may affect the others. Andriof and Waddock (2002) describe collaborative behaviour as a foundation of stakeholder engagement. The tendency to communicate with co-workers helps to build firm-stakeholder relationship, as has been reported by Antonacopoulou and Meric (2005).

In addition, scholars in the organisational discipline define engagement with work tasks by the use of individual effort associated with a specific topic. Saks (2006) defines engagement as the amount of cognitive and physical resources an individual is prepared to devote to the performance of his or her work roles. Similarly, Luthans and Peterson (2002) refer to the degree of awareness of an employee's performance at a work task and their role in the work environment.

Another view on of engagement is expressed by scholars who study marketing and customer behaviour. A firm, as an engagement subject, is related to customers, and this relationship is often developed based on emotional attachment, including confidence in the brand, belief in its integrity, pride in the brand, and passion to provide a service or product (e.g., Appelbaum, 2001; Smith, and Wallace, 2010; Heath, 2007).

However, the engagement between parties (i.e. product or service providers and customer) has also been described by marketing scholars as a series of value-exchange transactions (e.g., financial). Those interactions occur over time and increase both the consumer's value to the company (product or service recipient) and the value of the company to the consumer (e.g., trust in the quality) (Peppers and Rogers, 2004).

Consequently, the definition of engagement relies on the engagement subject, engagement object, and context. As such, the nature of engagement is perceived differently as it emerges from various perspectives. In the next section, I propose to look more specifically at engagement, following these three components of engagement: subjects (who participate in the relationship), objects (what motivates or bonds parties), and context (where this relationship take place).

2.6.3.2 Source of engagement in innovation studies

Through study different approaches to engagement, scholars describe how the relationship between partners can be strengthened. To this end, they use different theoretical lenses and explain engagement in pluralist terms. How the approach is perceived depends on from where it is observed, how it is interpreted, and its particular context. Therefore, researchers have developed various ways of analysing engagement, without changing the fact that they were talking about the same phenomenon. It follows that engagement strategies, especially in the context of an organisation, have been described in the business and management literature quite broadly. Below I will try to focus on the major aspects of engagement to offer an analysis through the lenses of diverse interests.

2.6.3.2.1 Attention

The most tangible source of individual engagement with task or work explained in the organisational literature (table 5 and 6) is the source of people's attention (e.g., Holbeche and Matthews 2010, Anderson, 2004, Ocasio, 2011). Attention is defined as the behavioural and cognitive process of selectively concentrating on one aspect of the environment while ignoring others (e.g., Anderson, 2004). This mental faculty of considering or taking notice of someone or something is seen as an impulse that may lead individuals to exert greater effort to one task, relative to other tasks, by persisting in the process over time (e.g., Ocasio, 2011).

In the innovation management literature, engagement attention-base theory is commonly used to explain how actors engage with a task. Li et al. (2013) explain in their study of top management teams (TMTs) that such excitation of attention is more effectively achieved through use of unfamiliar information from outside of the company and when a range of sources are utilised to acquire that information. In other words, information to which TMTs have never been exposed and a diversity of sources from outside of the industry, such as, consultants, competitors, government, or universities, capture the attention of top management when they search their environment to develop new products. Therefore, in the search process novel, vivid, and salient information and knowledge are more likely capture the attention of top management and engage them in a persistent search. To that point, Li et al. explain that an indirect effect of attention to an engagement process describes the process as emergent. However, one conclusion of their work stresses the importance of understanding how attention is developed, so that TMTs can expand and delegate their initial search efforts to include others in the process. To conclude, their study, based on a mixed-methods approach, captures a more holistic view of engagement and explore the effects of TMT engagement on the introduction of new products, but leaves unexplored how attention-seeking could be develop beyond TMT group.

Table 5 Stakeholder engagement propositions in innovation context based on organisational literature review, Part-1,

Engagement proposition	*Stakeholders*	*Relationship enhancement tools*	*Research Context*	*Benefit of the action on innovation*	*Authors*
Attention seeking	Managers and firm staff	Attention to new information, task, notes, equipment; attraction to novelty during idea screening process	New Product Development, Organisational and Management Studies	Improve chance to find solution to problems faster, produce energy boost that leads to close work between individuals	Anderson (2004), Holbeche and Matthews (2010), Ocasio (2010), Li et al. (2013), Metiu and Rothberg (2013)
Exchange	Suppliers, manufacturing firms, individual customers	Value: money, goods, service, value of support, freedom, desirable choice, doing something right	New Product Development, Marketing, Online Marketing, Environmental Studies	Increase join decision making process, increase openness, help to exchange information	Nix and Zacharia (2014, Phillipson et al. (2012), Ernst et al. (2011), Kothandaraman and Wilson (2001), Vargo (2009b), Brodie et al., (2011), Verheof at el. (2010)

Table 6 Stakeholder engagement propositions in innovation context based on organisational literature review, Part-2

Engagement proposition	*Stakeholders*	*Relationship enhancement tools*	*Research Context*	*Benefit of the action on innovation*	*Authors*
Institutionalization	Engineering, technical, commercial and marketing staff and managers	Organisational arrangement, common language, job description, transformation leadership	Human Resource, Organisational Studies, Education Management, Government Studies	Enable resolutions to the problem, increase commitment to improvement from community, help with development of collective vision and increase collective actions	Driscoll and Lynton (1999), Ward (2003), Peters et al. (2005), Bloomgarden and O'Meara (2007), Thornton and Jeager (2008), Lagner and Seidel (2009), Vogelgesang et al. (2010), Thurgood et al. (2013)
Cohesion	Employees within the firm, individual customers	Selection of team members base on social skills, involvement of team members in goal settings or facts, e.g. industry localization, age, nationality, level of education, work position	New Product Development, Management, Sociology, Networking Studies	Higher interaction between individuals, help solve the problem quicker, increase effectiveness of collective knowledge transformation, increase mobilisation, of individuals, positively influence work, performance between organisations	Hoegel and Gemuendem (2001), Currarini et al. (2009), Hirunyawipada et al. (2010), Golub and Jackson (2012),

Metiu and Rothbard (2013), for example, investigate more deeply than Li et al. the relationships between attention and engagement processes. Same authors, based on ethnographic research from two teams that develop new software, conclude that mutual focus of attention on a shared task leads to group engagement. In their research they explain in more depth how attention is built through the use of interaction ritual theory (see Collins, 2004). A first important factor in maintaining mutual focus of attention, as explained in their research, was related to what they call the ‘task bubble'. The interaction of a small number of software developers whose interaction remained uninterrupted led to focus on the task until they decided they could not solve the problem. The second interesting finding demonstrated by researchers was related to task-related artefacts’ such as computer screens, code, or notes, which helped them maintain their intense mutual focus of attention. Thirdly, episodes where developers shared the success of a breakthrough led to positive shared emotions that gave an energy boost to developers. The authors’ observations emphasised also that the process of group engagement was more likely to unfold in the presence of several enabling conditions, such as frequency and informality of interactions and compelling directions.

2.6.3.2.2 Exchange

Another example of engagement stimulation emphasised in the marketing literature was the value exchange approach between parties. In simple term, the act of giving one thing and receiving another in return is perceived as a bonding or bridging agent between partners, often with specific rules or regulations. As the exchange is developed between actors, the object or medium of exchange is referred to product and/or service functionality, usability, reliability, reputation on monetary value. However, value exchange in the process may takes various forms, beyond the material (e.g. money, goods, or services). As explained by Higgins (2006), value may depend on context and have various forms such as opposition to interfering forces or resistance (e.g. value of freedom), dissonance when people are confronted with information inconsistent with their beliefs (e.g. value of support from others who share the beliefs), regulatory fit (e.g. value of desirable choice), and proper means (e.g. value in doing something right,). Therefore, the exchange process develops relationships that can be strengthening or weakened through different values.

Nix and Zacharia (2014), in their study of collaborative work between suppliers and firms, found that to engage in more joint decision-making processes and to exhibit greater openness to learning are necessary to enhance the exchange of information between partners. However, the object of exchange in this study is not limited to information, but includes exchange of values such as openness. In a similar vein, Phillipson et al. (2012) in his study of stakeholder engagement in environmental research reports that mutual benefits are gained from the exchange of staff between private, societal and public parties. This kind of exchange leads to greater relationship-building between stakeholders.

Practices of engagement through exchange are also widely remarked in marketing literature, especially in the context of customer engagement. The concept of customer engagement centres on how relationships between customers, a companies, and a brands are developed and maintained (e.g. Hoyer et al., 2010). Similarly, as in management studies, scholars referring to CE explain engagement by drawing on a service-dominant logic, which in contrast to a more traditional 'goods-dominant' perspective offers 'a transcending view of relationships' (Vargo, 2009b) (exchange beyond limits of economic norms, e.g. money or goods).

However, in contrast to management studies, scholars in the marketing discipline explain that to exchange 'values', a particular condition has to be met. Brodie et al., (2011a) directs them to 'the level of the customer's motivational, brand-related and context-dependent state of mind characterised by distinct levels of cognitive, emotional and behavioural activity in brand interaction.' Therefore such a process of exchanging not only requires a 'value' but at least three other components (Patterson, Yu and de Ruyter, 2006): Firstly, absorption; the level of concentration on the focal engagement object (e.g. brand or organisation) (Downer, Sara and Robert, 2007). Second, cognitive customer dedication, which corresponds to the emotional dimension (Catteeuw et al. 2007). Third, interaction, two-way communication between a focal engagement subject and object (Vivek, Beatty and Morgan, 2012). Therefore, the focal point here is that engagement with the object or value (e.g., the brand of ab organisation) creates exchange between the organisation and customer, but depends on a range of cognitive, behavioural, and emotional conditions.

While most of the research has concentrated on the characterisation of values and mechanisms of exchange or its effect on customer engagement, Verheof et al. (2010) have explained where the exchange appears and it develops. With the growing role of Internet technologies, these researchers explain how social relationships are established via online social websites (e.g. Facebook, Twitter) through examples of word of mouth and blogging. 'Word of mouth' communication is defined as the act of exchanging marketing information among consumers and plays an essential role in changing consumer attitudes and behaviours towards products and services (Katz and Lazarsdeld 1995), and blogging here represents the expression of customers' views or observations about particular products or brands on a weblog or website. In both situations, Ahuja and Medury (2010) express that organisations can build relationships with their prospective and current customers through posts on blogs and social websites and encourage them to participate by commenting on the blog and exchanging opinions, thereby stimulating consumer engagement.

2.6.3.2.3 Institutionalisation

Langner and Seidel (2009) have investigated collaborative practices developed between suppliers and customers in the automotive industry. In this context, using a case study, the authors state that the collaboration process has three phases: exploration, competition, and engagement. Engagement between supplier and firm is seen the final phase of collaboration, where joint activities after a process of creative conflict and compromise on specifications enables the resolution of problems and the optimisation of the design concept.

In this study, the firm's relationship with a supplier was established through new organisational arrangements. The deployment of the supplier's resident engineer, who facilitated communication between the firm and other supplier engineers, was found to support the interaction and exchange of information's between firms. The other finding was related to the development of a common language as a part of developing the relationships, again increasing the flow of information between firms. The effect of both elements was noted when problem-solving began to happen collaboratively (between firms), and teams sat jointly at the Computer-Aided Design (CAD)and tried to resolve problems and provide solutions.

This example illustrate another practice that may lead to engagement, namely institutionalisation. The *Oxford Dictionary* defines institutionalisation as 'establishment of practice or activity as a convention or norm in an organisation or culture.' How that can be achieved has been explained by Thurgood et al. (2013), who propose that engagement may be considered at an organisational level as enacted into organisational systems through job-design characteristics, high-performance work systems (e.g. high involvement and performance through people), and transformational leadership (leaders and their followers raise one another to higher levels of morality and motivation, e.g. Burns 1978). In addition, employee engagement is aligned toward strategic objectives valued by the organisation.

The concept of employee engagement has been developed based on the relationships between different actors and structural arrangements that can be observed in every organisation (e.g. hierarchy). Thus, the engagement subject in this context concerns actors, but the engagement object is related to the authority or legitimacy that flows from hierarchical structuring. Edelman (1964), a management theorist, explain that if legitimacy can be created for individual actions, it greatly reduces the chance of opposition to them because it creates a meaningful context in which they can be accepted and justified.

Where practices of engagement through institutionalisation exist in organisational studies, the literature concerning public, community, and higher education has discussed this matter at length. Moreover, scholars (Bloomgarden and O'Meara 2007, Driscoll and Lynton 1999, Peters et al., 2005, Thornton and Jaeger 2008, Ward 2003, Vogelgesang et al., 2010) have explained how the members of an institution integrate engagement into teaching and research by embedding mutual expectations for university staff and partners in schools statements; establishing rules for reappointment, promotions and tenure; and using the scholarship on engagement criteria in preparing documentation for faculty, staff and student programs and activities.

The effect of institutionalisation on engagement has been examined by Vogelgesang et al. (2010), who analysed the responses of faculty members participating in the 2004-2005 High Education Research Institute faculty members survey. The author and his colleagues found that faculty members for whom engagement was institutionalised (i.e. two-year colleges, public four-year colleges and Catholic four-year colleges) perceived their commitment to engagement to be greater than did faculty members from other institutional types. Alternatively, it was reported that, a lack of rules and regulations in the institutional system often deters faculty engagement (Driscoll and Sandmann, 2001, O'Meara and Rice 2005, Sandmann 2007, Ward 2003).

The institutional context often emerges when community engagement is investigated. Compared to other engagement strategies, the process of community engagement is one of outreach rather than individual relationship-building. Its main focus on the individuals that build ongoing, permanent multiple relationships for the purpose of creating a collective vision for the benefit of the community, organisation or group.

2.6.3.2.4 Cohesion

In the organisational and management literature has emerged another view on how relationships can be strengthened, one related to cohesion. The cohesion concept is defined as a 'dynamic process, reflected in the tendency of a group to stick together and remain united in the pursuit of instrumental objectives and/or the satisfaction of member affective needs' (Carron, Brawley, and Widmeyer, 1998, p. 3). Moreover, in discussion of group cohesion, scholars (e.g., Dyaram et al., 2005, Wheelan, 2010,) have explained that such a state is achieved when its members possess a connection linking them to one another and to the group as a whole. In social science, this bond (i.e. the engagement object) is related to social relations (i.e. any relationship between two or more individuals, based on actions, behaviours, or contacts) (Forsyth, 2010).

Hirunywipada, Beyerlei, and Blankson (2010) have explored the role of such relationships during their study of the cross-functional integration of various individuals when developing a new product. A key conclusion of their work support view that cross-functional integration promotes the engagement of people from different disciplines. However, the enrichment of this engagement is accomplished through a socialisation phase. Using previous studies (Hoegl and Gemuenden, 2001), they hypothesise that a cross-functional integration team needs a sense of camaraderie and affinity to engage its members and maintain intensive collaboration within the team. To promote team cohesiveness, the authors suggest a careful selection of members to the team who possesses, for example, skills that facilitate communication and interaction with others to help enrich socialisation, as well as the wider involvement of team members in decision-making and goal-setting. Based on their literature review of cross-functional integration and adopting socialisation theory, they argue that cohesiveness reduces barriers and unifies task orientation. Therefore, the authors propose socialisation as a stimulus for team engagement, which increases the effectiveness of collective knowledge transformation.

The organisational and management literature also promotes other views of socialisation, such as homophily (i.e., love of the same). The concept concludes that people are more likely to interact with individuals similar to themselves in respect to a variety of qualities and characteristic (McPherson, Smith-Lovin, and Cook, 2001; Monge and Contractor, 2003). The research on this subject has mostly been conducted in the social sciences and has investigated how humans develop relationships in the context of age, race, education level, occupation, and values (McPherson et al., 2001). Thus, in the case of organisations, the concept of homophily was often researched with the use of demographic characteristics such as age, gender, or race (Mollica, Gray and Trevino, 2003). More recent studies have used the theory to investigate the social factors that may affect organisational decisions. Typical examples of these factors include location, membership, or industry. Moreover, homophily theory has received widespread support in network research, especially in the context of the development of network ties. Recent studies in this area provide a number of examples. The work of Currarini, Jackson, and Pin (2009) has focussed on the relationship between group size and homophily, rather than on network structure. Golub and Jackson (2012) investigate the effect of homophily on learning and knowledge diffusion in organisational networks. Additionally, the concept has also been used to explain mobilisation in networks of organisations, to solve start-up problems. Centola (2013) indicated that as the mobilisation effort becomes more ‘complex', homophily becomes increasingly important for organisational collective action. The theory of homophily has also been adapted to analyse business alliances and trade relationships. In the study of Maoz (2012), researchers revealed strong evidence that alliance relationships are affected by homophily. However, what is more interesting is the tendency of international relations to evolve according to such a process over time. Consequently, the concept of homophily has been adopted to understand how ties bind or bridge relationships among organisations with similar or different characteristics, consequently improving performance (Yuan and Gay, 2006). Thus, overall the current literature offers the conclusion that similarity facilitates interaction and that differences may obstruct cooperation.

2.6.4 Engagement and divergence of stakeholders interest and values

Base on the examples above, engaged stakeholders during innovation process may generate different value in many different ways for many different targets: business owners, employees, customers, and end-users, for example, but also a society at large (Leapak et al., 2007). Therefore, the meaning of value has been conceptualised differently. In the innovation management literature, value creation and capture remains largely focussed on the exchange of social values exchange (mutually contingent and rewarding processes) between partners, for example through exchange of resources and capabilities (Vargo and Lusch, 2008) and through interaction and knowledge sharing (Ranjan & Read, 2014). Additionally, value can be generated through financial exchange (Du et al., 2014, Belderboset et al., 2004), such as exchange of goods or financial benefits during and after the innovation process.

However, a systematic and integrative approach to examine value and valuation has not been finished (Lamont, 2012; Vatin, 2013), especially on the level of a new product and process development. Assessing value is a key process for any productive activity and is inherently social (Vatin 2013), because actors justify their actions differently (Boltanski and Thévenot 2006). Additionally, valuation during development of a new product or process raises another difficulty with which that managers must contend, namely estimation of the worth of the created value before it is exchanged. Thus, when it comes to the process of value definition and assessment, individuals' and firms' justifications will differ and, as Boltanski and Thévenot (2006) explain, may stem from six self-enclosed 'orders of worth': civic, inspired, domestic, fame, market, and industrial (Blokker, 2011, 253). In the case of inter-organisation projects that concern the development of new products, this framework can be extended further to environmental and project-orientated orders (see Thévenot, Moody and Lafaye, 2000; Boltanski and Chiapello, 2005a). Thus, something that is valuable on one of these orders of worth may be considered worthless on another. Due to the complexity of inter-organisational projects and the nature and different logics of worth that actors respond to, assessment of value in the innovation activity may require various judgements and corresponding tensions to be addressed to maintain collaboration (see Smith and Lewis 2011).

In the manufacturing context, the orders of inspiration (driven by passion), industry (encompassing efficiency), project (defined by the goal) and the civility (rooted in the collective or general will) are closely interrelated. While value can be attributed to originality and creativity based on the logic of novelty from industry benchmarking and new technological discoveries, the control of the development process in industry (i.e. institutionalisation) is necessary to reduce activities that are not worthwhile, productive, or efficient and to control the process, so that important business information is not disclosed. Furthermore, civil logic plays an important role in manufacturing, as generating ideas requires a wider and more diverse set of actors (diversity), whereas project logic is characterised by a desire for described goal delivery with certain resources, specifically time and costs (shared goals). This situation makes it difficult to talk about value, as such projects are unique and continuously involve the various logics, perceptions, and interests of stakeholders. This study therefore, propose to close that gap and to study how requirement divergence express by different stakeholders during OI activities is embrace (chapter 7); this same answer to research sub-question 4 (section 1.4)

2.6.5 Section summary

This section has explained that the OI model concerns mostly the structural categorisation of knowledge transfer, rather than the nature of the engagement mechanism and its consequences, despite that the latter is required to effectively broaden innovation collaboration within and across the manufacturing sector. For that reason, this section proposes that the OI concept could be extended, with the integration of stakeholder engagement discipline. The next sub-sections have explained stakeholder engagement discipline in more detail and provided examples of engagement approaches that have been captured from the innovation, management, and marketing literature. For stakeholder engagement to be effective in the innovation context requires the stimulation of stakeholders' concentration, creative thinking, and ability to make good decisions when co-creating value. Communication channels should be promoted between stakeholders to motivate involvement to sustain interest, remove initial barriers, and assist with the understanding of development problems and alternatives. Furthermore, the engagement process may draw upon theories concerning psychological attention, institutions, social exchange and group cohesion.

However, further exploration in this area is needed to understand how professionals can apply such theories in an intra-organisational context rather than only within an organisation, and to follow when these theories support the creation of new ideas, assist with development progress, and allow the reduction of tensions related to various stakeholders' engagement requirements. In addition, studies so far have focussed predominantly on particular conditions that help to engage stakeholders at a particular time in a particular task and not fully elaborate on what exactly can be done differently in such conditions to increase the chances of developing more effective relations. Finally, because of that static approach, the mentioned studies do not fully explain how those relations between stakeholders evolve during various activities in social networks and what consequences these networks have on the creation of new ideas and development progress.

2.7 Networks and their impact on product and process development

By engaging with diverse partners external to an organisation, those organisations begin to collectively innovate in networks of intra-organisational relationships (Bessant and Tidd, 2014).

These connections in such networks, also called 'ties', arise from the daily interactions between stakeholders (or actors), such as the knowledge exchange and joint activities that create a social structure. Actors in such networks, also called 'nodes' or 'vertices', represent individuals or organisations. Ties, either 'edges' or 'links', explain how pairs of actors are connected by the measure of their strength, intensity, or capacity (Barrat et al., 2004; Horvath, 2011) by examining their arrangement. The structure of the ties that a set of actors generate (i.e. 'patterns') can determine how the exchange process develops between various actors and what the outcomes of this exchange will be. Researchers assessing a given network structure's impact have often referred to a social network analysis (SNA), which can be performed at the following levels: individually, such as with individuals during development; at the team level, such as with the teams working together on a specific project; or at the formal organisational level, including firms and the market. Social network analysis can even include the coalition level (e.g. with lobbying alliances) or regionally (e.g. with members of the EU). This analysis is used to identify a range of variables that affect business, including social influence (Erickson, 1988; Festinger, 1954); power (Daveni and Kesner, 1993; Padgett and Ansell, 1993); knowledge diffusion (Burt, 1992; Coleman, 1988; Rogers, 1995); social exchange (Cook and Emerson, 1984); economic exchange (Granovetter, 1985; Uzzi, 1997); social cohesion (Friedkin, 1993); and knowledge management (Carley, 1999; Contractor and Bishop, 2000; Hansen, 1999).

Subsequently, projects that bring a new product or process into the market are not only embedded in the firm or its industry, but may also become a connections in the search for new solutions with other actors, such as end users or even competitors. This kind of connection creates a situation with an open network, in the sense that no definite criteria are used to identify and control the network's boundary (Hellgren and Stjernberg, 1995). These temporary structures are often called 'project networks' (e.g., DeFillippi and Sydow, 2016; Hellgren and Stjernberg, 1995; Sydow and Windeler, 1999). These networks emerge in a project's early front-end stages (e.g., Artto et al., 2016; Matinheikki et al., 2016; Morris, 2013) or design phases (e.g., Hellgren and Stjernberg 1995), where value creation occurs (Aaltonen et al., 2015; Edkins et al., 2013; Morris, 2013). Project networks provide the opportunity to exploit solutions and ideas and to more effectively manage innovation through the high degree of freedom granted to multiple actors and non-hierarchical ways of working (e.g., Artto et al., 2011; Davis, 2004; Kim and Wilemon, 2002).

Although project networks allow for the exploration and exploitation of new ideas, they may also introduce disturbances, stimulated by the different project practices offered by various individuals and firms. For example, scholars including DeFillippi and Sydow (2016) have highlighted that project networks experience tension between accepted practices, which minimise risks, and crafted solutions, which address unique, unexpected, and innovative tasks and challenges, but are typically riskier. As both of these elements are necessary to support innovative tasks and progress, project networks are often based on trust and reciprocity rather than contractual and administrative forms of managing economic activity (Powell, 1990). Thus, the network's structure and the quality of its ties may define how a project is conducted.

Hence, these factors have been studied to understand their usefulness in project performance and their support for innovation progress (Jones et al., 1997; Jones and

Lichtenstein, 2008). For example, Hossain and Wu's (2009) work reveals an actor's central position in a project network's ability to coordinate support. Phelps (2010) explains how technological diversity in a firm's NPD alliance network positively affects firms' exploratory innovation. Further, resistance or even conflict with network actors—caused by poor connections or a lack of due interaction—may adversely affect project delivery and undermine the project's outcomes and values (Aaltonen, 2011; Zheng et al., 2016). However, a negative aspect exists, in the substantial amount of information from network actors that may decrease the ability to search for new alternatives (Koka and Prescott, 2002). Additionally, Brooks et al. (2006) have indicated that extended project networks negatively impact decision-making times and knowledge transfer. Iacobucci and Hoeffler (2016) uses an innovation perspective to explore how tapping surrounding networks increases firms' ability to develop radically new products. Finally, Hemphala and Magnusson (2012) explain that diverse network structures are required for the acquisition of ideas, knowledge, or resources, and more dense networks support engagement toward effective project execution.

Thus far, with the exception of a few studies (Lu et al., 2016), project management research regards such networks as formal and stable relationships. Therefore, in analysis of the connective structure between actors, they are perceived as present or absent at one point in time, and researchers describe the network as static, rather than in a dynamic relationship-development process. As delivering innovation requires combining functions and knowledge bases at different points in the development process—such as idea generation, concept testing, or commercialisation—the connection between diverse actors may break and reform multiple times as a relationship is ended and re-established. Thus, networks can evolve, and consequently offer different patterns that may produce different functions in the project and its innovative tasks (Pittaway et al., 2004). Thus, this thesis will explain how and when stakeholders engage and follows a network's evolution over time to examine how outcomes, performance, and creativity change over the project's life cycle.

2.8 Chapter summary

This chapter has briefly described the OI model and various definitions of innovation from the management and organisational literature. It has highlighted the conceptual and practical challenges to implement innovation processes, especially when they are carried out with multiple stakeholders in an intra-organisational context. It has explained the benefit for firms that decide to implement such processes. At the same time, the aim of this chapter has been not only to explain current OI knowledge, but above all to highlight areas of inquiry that might enrich our understanding of the OI process. Thus this chapter concludes that for OI to be effectively implemented at an organisation level requires the stimulation of stakeholder interests in the exploration of novel solutions, ideas and know-how from outside, but also encouragement to introduce this new information in an organisation. This stimulation is especially important to overcome issues related to "non-invited-here" syndrome at the organisation level, improving the recognition of possible value in new information, but also supporting the implementation of such value.

Moreover, to be effective, the OI process requires the development of trust between involved stakeholders to disclose relevant information during the innovation process. That is achieved not necessarily through contractual agreements but through creating and sustaining strong social relationships with those involved in the process. Additionally, creating and sustaining relationships with innovation process participants may also reduce risks related to knowledge misappropriation and the loss of advantages of their efforts to other participants in the network (Wadhaw et al., 2011). Finally, for OI to be effective requires the network to facilitate truly 'democratic thinking' that is open to ideas and solutions from all innovation participants, not only those involved in the process because of their status or position within the firm or market.

The OI literature has focussed on techniques and methods that can improve OI management, explaining strategic approaches that can make OI more adaptable for the firms and introducing new methods of knowledge protection to reduce concern about innovation misappropriation. This chapter has attempted to integrate stakeholder engagement theory with OI. Relationship building can support OI integration at the firm level, promote real interest in the innovation being considered, assist in the reconciliation of inherent structural and pervasive risks, and therefore enhance the value-creation process. Thus, this chapter informs also how stakeholder engagement is defined and described in the organisational and management literature. This chapter has explained various schools of thought about stakeholder engagement, which understand such engagement to arise from stimulation of attention to collaborative tasks, exchange of values, institutionalisation, and group cohesion. While this has been explained throughout this chapter, more research remains is required to explain how and when stakeholders create and sustain social relationships in OI context and what consequences those relations have on the process of strengthening our knowledge about effective innovation processes in an intra-organisational scenario.

Additionally, this chapter has introduced reader(s) to the manufacturing industry, especially to its SMEs producing or assembling metal products, explaining that this sector has some characteristics that may be particularly interesting for a study of innovation. Many of the environmental, financial, and social challenges these sectors face cannot be resolved at the firm level and instead require a collaborative approach with suppliers, customers, and local and national governing bodies to address these challenges. Moreover, firms in this sector require forward-thinking initiatives that improve current technology and manufacturing processes to compete with overseas suppliers. These initiatives can be established through cross-industry knowledge exchange, especially in the context of novel IT and energy solutions. Furthermore, the demands to improve the properties of metals (e.g. as required by aerospace, electric and lightweight cars) make these firms open to external knowledge (e.g., from universities) now more than in the past, in order to advance their products. While recent innovation activities have emerged strongly in this sector, it appears theoretically and practically useful to focus upon that industry to understand how to make collaborative R&D effective.

Chapter 3 An activity perspective to study engagement in open innovation

3.1 Introduction

The previous chapter discussed the notion of innovation and the OI paradigm in the relevant literature. It outlined also stakeholder engagement theory and established what effective stakeholder engagement means the in context of innovation. The chapter results highlight also the importance of stakeholder engagement research at the level of application and sophistication rather than of the basic premise of the discipline, through offer either stakeholder identification or influence analysis.

This chapter summarises the present research's approaches to studying stakeholder engagement and the OI process. Based on this summary, it proposes to avoid the relational perspective on stakeholder-engagement analysis and focus on how relations emerge in different stages of the innovation process. It then explains and justifies an analysis based on activity as the unit of analysis, encompassing social, cultural, and historical dimensions as origins of consciousness rather than following peoples' interpretations of the activity. This practical framework can be used to understand who is doing what, why, and, when, allowing holistic consideration of how various actors actually engage with various activities in different contexts of the innovation process. Additionally, the chapter explains that the network ethnography approach guides further research of this thesis to understand how goal-directed networks are enacted and in turn how network structure affects the creation of new ideas and process performance, such as completion of activity on time and on budget. Finally, the chapter contributes to the OI field by introducing an activity-based approach to study innovation.

In more detail, Chapter 3 is constructed as follows:

- Section 3.2 summarises the approaches previously used to study stakeholders and engagement in the field of innovation and management. This discussion suggests applying the lens of relational ontology rather than relational perspective to study stakeholder engage in inter-organisational innovation processes, focussing on activities.

- Section 3.3 introduces AT as the theoretical framework for this research. It explains that this theoretical framework maintains the idea that social structures such as rules, norms, and power resources are best expressed and researched via socially embedded and recurrent activities that constitute a bridge between agency and structures. Section then explains the fundamental tenets of this theory, highlights the relevance of AT to OI. And finally, introduces to the reader how AT can be used to explain how value-related tensions are handled during innovation activity.

- Section 3.4 discusses how studying activities during OI might allow one to understand how those activities enact the inter-organisational network and how they hold their members. Section elaborates on network ethnography, which allows one to transpose and explain OI activities at the network level by applying ethnographic fieldwork and social network analysis. Additionally, Section explains how social network analysis in such a scenario can be used to validate, for example, the centrality of different members of an innovation process during different development phases, and ethnographic exploration may allow the deepening of such findings by showing how participants create this position in the network through various activities.

- Section 3.5 considers how an activity-based approach can be used to pinpoint different parts of innovation processes—ideation, development, testing, and technology implementation—which this thesis proposes to analyse separately.

- Section 3.6 summarises the activity-based approach for the study in this thesis. It reflects on AT’s benefit for the study of stakeholder engagement in the OI context and explains how current knowledge about both subjects can be extended with the activity-based approach, by better understanding how relationships in innovation are made through day-to-day activities that include mediated interactions between individuals, communities, rules, divisions of labour, objects, and tools.

3.2 From a relational perspective on stakeholder engagement to relation ontology

Starting with the work of Freeman (1984), the organisational literature has concentrated on the dyadic relationships between individual stakeholders and organisations, where interactions with stakeholders have been seen as independent relationships. A significant contribution to this view is a salience framework and stakeholder identification (see Mitchell et al., 1997, but also Rowley, 1997) that allows the classification of stakeholders according to their power and legitimacy and explains how organisations react to stakeholder influence. However, this view, is limited because not allow to analysis 'interaction of multiple influences from the entire stakeholders set' (Rowley, 1997, p. 890). In other words, such analysis does consider how identified stakeholder responds and what consequences these individual responses have for the specific activity, but not analyse influence or input on decision non identified that management literature call secondary stakeholders. Thus, analyses of stakeholder engagement in the organisational literature have sought other approaches that integrate the complex arrangement of multiple and independent relationships in stakeholders' environments, moving from a dyadic perspective (Freeman, 1984) to a relational perspective based on a network perspective (Pouloudi and Whitley, 1997; Rowley, 1997).

Consequently, researchers (Granovetter, 1973; Rowley, 1997) have applied social network theory to examine how centrality affects response to stakeholder demand. Centrality in social network, identify focal vertices in graph such as the most influential stakeholders in the in an organisation. Density in social network theory measures the relative numbers of ties across the whole network that links various actors. When the network density increases, the same Granovetter, (1973); Rowley, (1997) found that communication becomes more efficient because it facilitates the voluntary diffusion of norms and shared expectations (see also Missonier and Loufrani-Fedida, 2014). By contrast, a centrality, because implies a position of power and status have been argued (Rowley, 1997) support resistance to stakeholder pressure, especially when actors are less densely interconnected. Base on this work, numerous scholars (e.g., Walsham, 1993, Coakes and Elliman, 1999, Bourne and Walker, 2005, Cova and Salle, 2006) have acknowledged that stakeholder relationships do not occur in a vacuum of dyadic ties but in the more complex network of intertwining connections. Moreover, rather than analysing stakeholder characteristics and behaviours as arising from the social structure, they emphasise the role of research into stakeholder interactions in better understanding how they emerge and evolve in different context.

Furthermore, the extant research examining the relational perspective in this context has considered the process of engagement, the network, its elements, and its characteristics as stable and innate properties, overlooking the co-evolution of the stakeholder engagement and innovation processes over time. Thus, despite the previous richness of the research in this field, this thesis proposes that the relational approach should be extended to integrate the dynamic and emergent nature of stakeholder engagement, an area that remains understudied (Yang et al., 2009a,b, Missonier and Loufrani-Fedida, 2014). In particular, this research focusses on the context of the inter-organisational innovation process, where stakeholder relationships emerge and are difficult to identify.

Consequently, this thesis proposes to avoid the relational perspective on stakeholder-engagement analysis, adopting instead a ‘strong relational ontology’ (Slife, 2004). Rather than recognising stakeholder engagement and network activities as a stabilised entities, this thesis assumes that people's actions are always locally defined and emergent, and this local emergence shapes both material and the social structures and processes (Orlikowski and Scott, 2008). This perspective thus emphasises an understanding of OI through unpredictable and emergent innovation features, integrating human behaviour and materiality in the analysis. Anchored in this relational ontology, this thesis suggests applying this mode of thinking to stakeholder theory in inter-organisational innovation processes by analysing innovation activities and the ways actors create and maintain relationships during these activities. Thus, this thesis proposes to use AT as main theoretical and methodological framework to study stakeholder engagement in the inter-organisational innovation process.

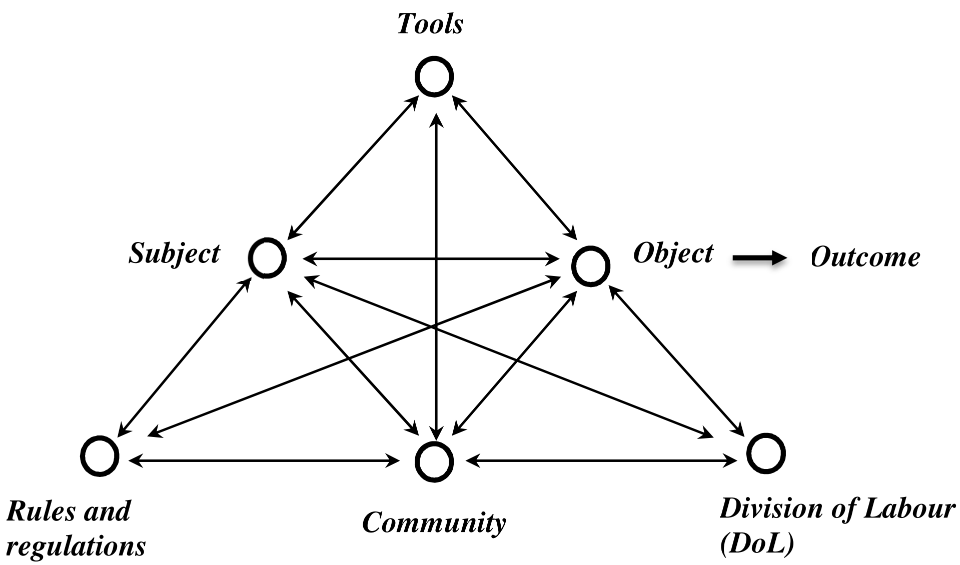
3.3 Activity theory

The concept of AT, developed in the Soviet Union by Vygotsky (1978) and enriched by Cole and Engenstrom (1993), considers work systems as a relationship of an individuals, with the entire sociocultural complexity (e.g., environment, history, culture, the role of the artefact and/or motivation) of real life. The theory was initially used in research aimed to develop psychological theory based on Marxist theory (Bendy and Karwowski, 2004; Blackler, 1993, 1995). Following that view, AT advances the understanding of work in terms of its purposive and social character (Bedney et al., 2004). Vygotsky (1978) explored the socio-cultural nature of mental operations as interactions and language as a cultural tool, each playing primary roles in the development of the mind:

'… internal development processes … are able to operate only when the child is interacting with people in his environment and in cooperation with peers.' (p. 90)

This author suggests that knowledge develops through the acquisition of culture and stems from historical and contextual processes that occur through interactive work (Roth and Lee, 2007). This so-called cultural-historical AT also initiated the exploration of activity in terms of actions and operations in work of Leont'ev (1978), who examined the dynamic relations of activity between actions, goals, and motives. In this view, activity is goal-directed and motives underpin the goals. Activity as the unit of analysis encompasses social, cultural, and historical dimensions as origins of consciousness rather than following peoples' interpretations of the activity (Blackler et al., 1999).

This view has been expanded upon by Engestrom (2000), who suggests that activity systems consist of mediated relationships between the individuals, communities, rules, divisions of labour, activities, objects, and tools required for activity transformation (see figure 3). Activity theory therefore allows the exploration of conditions whereby the work activity can be segmented into seven interrelated analytical components. Figure 4 presents the AT framework and its components.



Components of the Activity System

Subject: Stakeholders involve in activity – e.g. manufacturer and analytical instrumentation technology representative

Tools: The artefacts that mediate social actions in the activity

Object: The purpose of the activity system (e.g. ideas screening, development and/or technology commissioning)

Outcome: The desired outcome of the activity

Division of Labour: Relational and hierarchical structure governing individuals within activity system

Community: All individuals and groups involved in the activity system

Rules and regulations: Process, procedures and regulatory rules

Method of analysis

Define activity ⟶ Define outcome of the activity ⟶ Identify contradiction ⟶ Determine action taken

Figure 4 Activity Framework

Activity theory proposes that changes within activity systems are triggered by contradictions, such as a paradoxes within a given segment of the activity system between its different elements or between different activity systems (Kutti, 1996). The subjects have to work to change the activity system to resolve the issues and problems that originate from these contradictions so that they do not interfere with the materialisation of the desired outcomes. That negotiation allows a researcher to capture the contradictions that emerge as an activity system unfolds, the steps taken to address them, and the outcomes of those actions. Activity theory analyses can thus be used to capture the progression of OI by envisioning each step in the process as a series of adjustments in various activity systems.

Activity theory as a theoretical and methodological framework was chosen for two main reasons. Firstly, AT highlights the practical element of stakeholder engagement during OI. Through the identification of the actions of individuals and the community, alongside a variety of mediators within the cultural (social) system, AT enables one to see the changing nature of interdependent relations, rather than observing an activity's output. For example allow to pinpoint who, how, way and when was immerse (absorption) in the activity from community participants and division of labour. Secondly, using AT we explore the tensions between different system components (tools, communities, objectives, or rules and regulations) during activity. Such an approach allows to unpack the multiple and divergent values that must be considered (see Hemstberger and Reinhard, 2009; Jarzabkowski, 2003; Engenstrom, 2002) during the activity by the individuals. Activity theory therefore enables us to approach management through interdependent interactions and mediations (Blackler, Crump, and McDonald, 1999, 2000; Prenkert, 2006).

3.3.1 Fundamental tenets of activity theory

- **The hierarchical structure of activity**

  Activity theory suggests that activity has three layers, which form the hierarchical structure. The top one is reserved for activity that is orientated towards an object. Such an activity is encountered by the collective needs that shape and embed the object of the activity (Engstrom, et al., 1999). This level, therefore, is collective and object-driven (Engstrom et al., 1999). The next layer relates to individual and conscious movements (i.e. actions). The actions are an integral part of activity and concern individual performance with a sense of collective enactment. Activity theory, then, conceives actions as sub-units of activities. Finally, the lowest-level unit is an operation that relates to routines and compromises ‘automatic’ tasks. This hierarchical structure of activity allows the examination of collective goals, individuals values, and operational routines during the opening up of the innovation process. Such analysis of activity, action, and operation can inform researchers as to why stakeholders engage in OI and collective activity and how they execute this activity.

- **Mediate action**

  As was explained above, the activity system is represented by different objects of transformation (segments) that mediate the approach to the object of activity. Thus, this system reflects the structure of the material and non-material world, which both allows and constrains various activities. Actions taken by the subject to change this complex system (or one of them) in order to achieve the activity object are therefore mediated actions (Engestrom, et al., 1999). Tools and concepts are often used as an element of mediation in the subject-object interaction. For instance, the subject (e.g. a researcher) approaches the object (e.g. the writing of a research paper) using instruments (computer) and communities (other researchers’ ideas) as mediators. Also, rules mediate the interaction of the subject with the community by constraining (or allowing) actions as they consist of norms, standards, conventions and regulations (Engestrom and Sanino, 2010). For example, a researcher seeking to publish in peer-reviewed journal must to meet the journal’s standards. Additionally, a division of labour, referring to the distribution of tasks (e.g., Ph.D. researchers, supervisors, professor, etc.) and power relations between members of an organisation, generates multi-voicedness (Engestrom, 2001). The principle of multi-voicedness relates to multiple interests stem from the different positions and histories of participants.

Also, AT is useful when the aim is to analyse tensions and paradoxes during day-to-day work and how they are embraced. Whereas for example theory of negotiation focus on actors who maintain incompatible goals and considers how they should and could make joint-decision, AT allow to explore intervention in an activity process and this intervention effect on the activity objective. Thus, AT allow on formative experience which combines active participation with monitoring of the developmental changes of the study participants (Kaptelini and Nardi, 2006), something that for example stakeholders' theory that focus on stakeholder identification and salience or principal agent theory (explain how interest of various actors can be aligned) can't offer.

- **Development**

  In AT, development refers to a process of resolving difficulties related to tensions within an activity. Dilemmas, day-to-day problems, difficulties, and tensions are a source of transformation and learning (Engestrom, 2000). Such contradictions are 'historically accumulating structural tensions within and between activity systems' (Engestrom, 2001, p. 137). Based on Engestrom's research, significant learning and transformation emerge when contradictory relations are resolved. According to the same author, that can be done through learning by expansion (Engestrom and Sannino, 2010) of the collective envisioning of new potentialities, through a reconceptualisation of the motive of the activity and the object of collective attention. Such an approach can provide a basis for understanding contradiction-resolution during OI and learning during the process of co-creating value.

- **A network of activity systems**

  Developments in AT in recent years have also included the perspective of the activity system interacting with other activity systems. This analytical focus shifts from single activity systems to the network of interacting systems of activity (Engestrom and Keruso, 2007). In such a scenario, networks of activity systems require partially shared motives and shared objects. A share object represents the focus of attention (e.g., product innovation) and motivates activity among two or more interconnected activities (e.g., ideas development or commercialisation) (Yamazuni, 2009). The network of interacting activities systems embeds mutual needs and shares the envisioning of potential benefits, but also multiplies multi-voicedness (Engestrom, 2000).

3.3.2 The relevance of activity theory to open innovation research

In summary, AT is appropriate for OI research for four main reasons:

Firstly, scholars (Hasan and Kazlauskas, 2014) describe AT as practical framework that can be used to understand 'who is doing what, when, why and how' (p. 9). Additionally, as Huizingh (2011) explains,

'Open innovation requires managers to make new decisions in developing and exploiting innovation activities. When, how, with whom, with what purpose, and in what way should they cooperate with outside parties?' (p. 6)

As such, AT can be used to explore OI activities to fully understand how and when participants and their collaborators engage and with what purpose.

Secondly, the opening up of innovation activities includes formal but also informal interactions between various actors (King and Ockels, 2009) that can affect the innovation process. For instance, employees can develop solutions outside of the formal rules and regulations to deal with daily work problems, which might lead to innovation (Macpherson and Clark, 2009). From that standpoint, scholars (Cash, Hicks and Culley, 2015) have emphasised the significant role of AT in the analysis of 'unconscious' data, which can help researchers to reveal the obscure parts of the OI process.

Thirdly*,* AT is a significant framework for the observation of complex environments such as modern organisations (Cash et al., 2015; Hasan and Kazlauskas, 2014). The theory allows for multi-dimensional (allow to make connections between different activities, segments of activity) analysis as explained in previous sections (3.5.1). As this thesis examines the complex (practical) mechanisms of OI, the AT framework allows it to explore these mechanisms in greater detail.

Fourthly*,* as the objective of OI activity is the motive and focus of collective action, value can be examined through the lens of AT. In such a view, value is the motive of collective activity and is constituted and transformed through interaction with other elements of the activity system. Therefore, AT can explain how value is created in practices through adjustments or changes within activity systems.

3.3.3 Creating an activity theory framework to explain how value-related tensions are handled

In chapter 7, this thesis review also difference between value and value-related goals expressed by various stakeholders. Such experience is a natural phenomenon within innovation activity, because the process constantly changes in response to the evolving ideas and demands of various stakeholders (see Smith and Lewis, 2011). To deal with these tensions, companies can follow either a contingency approach (assuming that no one method can apply to the circumstance) and choose the most effective options, or they can follow a paradox approach and accept the existence of tensions and multiple options to support the collaborative venture. The latter approach is especially useful in complex and dynamic situations, such as innovation, where multiple version of ideas are scaled to suit different types and risks levels to achieve goal. Thus, paradox theory provides an interesting perspective to study the process of value creation, especially as emergent tensions are integral characteristics of organisational systems and social relationships. Paradoxes are defined as 'contradictory yet interrelated elements that exist simultaneously and persist over time' (Smith and Lewis 2011) and can be beneficial if handled correctly. They seem to be logical when various elements of an activity system are viewed separately, but do not make sense in relation to all elements of the activity system. Such contradictions reveal opposing options, and these oppositions are not to be eradicated but embraced, to generate value.

Therefore, at the organisational level, four examples of strategic responses to organisational paradoxes have been identified (Poole and Van de Ven, 2004, Jarzabkowski et al., 2013): splitting, suppressing, opposing, and adjusting. The first strategy involves separating elements temporally or spatially. The second leads to pursuing specific elements over others. The third is used when opposing responses emerge and support contradictory elements. The last involves people accommodating each other's requirements by recognising the needs of both parties are important and interdependent. The first three strategies are used to address short-term performance issues, and the last enables lasting relief from the negative aspects of contradictions.

To identify those contradictions and methods of resolving them, this thesis propose to use an AT to outline emerging tensions and disturbances in OI work. The proposition of AT is that changes within activity systems are triggered by contradictions, such as paradoxes within a given segment of the activity system between different elements or between various activity systems (Kutti, 1996). The subject (actors) must work to change the activity system to resolve the issues and problems that originate from these contradictions so that they do not interfere with the materialisation of the desired outcome. Thus, we seek to capture the contradictions that emerge as an activity system unfolds, the steps taken to address them, and the outcome of these actions. I use AT, because it allows to track the transformation process rather than only the outcomes of the work activity (see Blackler, 1993 and Engestrom, 2000).

Systematic examination of contradictions within AT allows insight into different aspects of value and their interdependencies from a various stakeholders' perspectives. The logic of worth can then be identified by capturing the diverse points of view that came together during the activity and then observing the justification process that allows change in the activity system to meet activity objective. Thus, AT allows us to examine how stakeholders embrace tensions with multiple justifications in order to advance the object of a given activity. Such analysis allows us to uncover the underlying aspects of negotiation practices used by stakeholders to deal with emerging tensions when involved in OI. Thus, AT analyses can capture how value comes into existence when actors innovate by envisioning each step in the process as a series of activity system components adjustments. By analysing those adjustments within particular activities and across innovation funnel activities, AT makes it possibly to unpack what it really means when stakeholders have to handle contradictions and then prioritise values.

3.4 Applying activity-based view in inter-organisational settings

This thesis also examines the effect of network activity on OI in an intra-organisational context – provide explanation to sub-question 3: How does a network of relationships evolve during the innovation process, and in turn how does that evolution affect the discovery, invention, and creation of innovative options? To do that, it proposes to combine the SNA with established ethnography methods to address the missing practice-turn element in inter-organisational network research (Berthod, Grothe-Hammer, and Sydow's 2016).

Research into inter-organisational relations is a common topic in organisational studies and has found application in various disciplines, such as strategic management (Jarillo, 1988), public administration (Provan and Milward, 1995), and financing (Powel et al., 2002). While the effect of inter-organisational relations on organisations has been researched extensively, studies that focus attention on whole networks are comparatively rare (Provan et al., 2007). The whole network is a 'group of three or more organisations connected in the ways that facilitate achievement of a common goal' (Provan et al., 2007, p. 482). Such whole networks are governed through specific formal (e.g. contracts) and informal (e.g. trust) structures that are developed collectively over time, sometimes supported by a dedicated network administration organisation (Provan and Kenis, 2008). Relations in this inter-organisational context imply broad autonomy loosely distributed over the network and non-hierarchical flows of information that go beyond formal contracts, including even the development of a network identity among members (Raab and Kenis, 2009).

According to scholars (Provan et al., 2007), research on a whole network should focus mostly on the structural features of the network, to understand the rights of an organisation that are embedded in it. From that point of view, SNA (explained in chapter 2, section 2.7) is a an obvious, well-established analytical tool (Scott, 2000) that provides an overall picture of a network and its attributes via quantitative measurement of network members, ties, the density of network relationships and clustering tendencies within the network (Borgatti et al., 2009; Wasserman, 1994). Social network analysis works with relational data that is filled into a matrix, which can be reproduced using dedicated software applications to illustrate and calculate the network. In this thesis, NodeXL has been used, but researchers have other choices, such as UCINET and NetDraw. Such analysis expresses network attributes as dependent or independent variables for multivariate statistics, or both. For instance, scholars (Owen-Smith and Powell, 2004) explain how information spillover in networks are developed by geographical concentration and the central position of the organisation(s) within the network. However, Provan and Milward

(1995) have shown that network effectiveness is a function of the network structures' stability over time. However, researchers (Windeler and Sydow, 2001, Sydow and Windeler, 1998) have reported that for network evaluation and management, the recursive emergence of structures requires more detailed and activity-related investigations, which are difficult to conduct using SNA alone (see also Berthod, Grothe-Hammer, and Sydow's 2016).

Thus, the activity-based view has not often been adopted in research of inter-organisational networks (Proven et al., 2007, Pratt 2000, Knights, Murray and Willmott, 1993). In this thesis, the theoretical framework maintains the idea that social structures such as rules, norms, and power resources are best expressed and researched via socially embedded and recurrent activities that constitute a bridge between agency and structures (Shatzki, et al., 2001, Shatzki 2007, Feldman and Orlikowski, 2011). Therefore, this thesis proposes to study daily activities during OI to understand how those activities enact the inter-organisational network, how they hold their members together in the process of innovation, and how they provide their relations with meaning and legitimacy. Building on the idea that daily activities are used to create, develop, and maintain relationships, this thesis proposes to observe how inter-organisationality is produced and how these activities create meaning and allegiance to the broader network and its brokers. Such an activity-based approach of organisational coordination (Kellogg, Orlikowski and Yates, 2006) could be transposed and expanded at the network level to explain the network structure, as well as its existence and effect on the innovation process. The limit to this promising avenue of research is methodological in nature but can be overcome via network ethnography (Berthod, Grothe-Hammer, and Sydow's 2016).

3.4.1 Network ethnography: Method to transpose and expand activity at the network level

To transpose and expand OI activities at the network, we need, in addition to SNA, techniques and tools derived from ethnographic fieldwork (further detailed in chapter 4, section 4.4). This combination allows us to unpack, firstly, through ethnographical research, the activities that cultivate network integrity (boundary objects) at various sites during OI and, secondly, through SNA, how these activities relate to the structural development of whole network. Such an approach in the organisational studies is often referred to as network ethnography. This integration of SNA and ethnography (detailed in chapter 4, section 4.6) is especially valuable to address specific research questions that have remained unexplored in the study of inter-organisational networks. For instance, the process by which participants of goal-directed networks contribute to the structure and enactment of specific modes of network governance remains poorly understood (Provan and Kenis, 2008, Provan et al., 2007).

Triangulation in network ethnography was assured through the use of multiple methods of data collection (cross-references), such as photographs, descriptions of sites locations and space (Appendix E and F). Actor description (notes) and goals that people try to achieve (notes also appendix E and F) during observation. Recording the sequencing of events that occur (time) and accessing email messages sent by various actors in different time periods (Appendix G). Also, description of researcher feeling (example in Appendix E and F) when observing company events, meetings and rituals. Additional data also comes from a review of historical documents such as project documentation and powerpoint presentations as well as through ordinary informal conversation with employees of the research company.

3.4.2 Using network ethnography to study temporary networks and their evolution

In this thesis, network ethnography is applied to understand how two new development projects (introduced in more detail in chapter 4, sub-section 4.3.2) with a temporary character, often referred to as 'project networks' (e.g., DeFillippi and Sydow, 2016; Hellgren and Stjernberg, 1995), evolve and with what consequences for innovation process. From innovation and project management literature, we understand that such networks emerge in a project's early, front-end stages (e.g., Matinheikki et al., 2016; Morris, 2013) and design phases (e.g., Hellgren and Stjernberg 1995), where value creation occurs (Aaltonen et al., 2015; Edkins et al., 2013; Morris, 2013). However, scholars also argue (Snijders, van de Bunt, and Steglich, 2010) that the arrangement of connections between actors evolve and change over time while they perform different activities (Bodin and Crona, 2009; Carlsson and Sandstrom, 2008). Thus, while a project's front end is important, a need also exists to follow the network's evolution over time and examine how outcomes, performance, and creativity change over a project's life cycle. Social network analysis in such a scenario can be used to validate, for example, the centrality of different members of an innovation process during different development phases, and ethnographic exploration may allow the deepening of such findings by showing how participants create this position in the network through various activities.

3.5 The process-oriented approach to studying open innovation: Towards an activity-based view

To study how stakeholders engage in the innovation context, there is also a need to identify innovation sequences (e.g. ideas screening, testing, implementation etc.) and how during these sequences stakeholders create and sustain their relationships. This thesis thus proposes to process-oriented approach.

Since the 1970s process research (i.e. process-oriented study that tries to explain regular patterns or sequences) has made substantial contributions firstly to the fields of strategy (see Mintzberg, 1973, Mintzberg et al., 1996, see also Jarzambowski, 2003), management process, and innovation studies (Barley and Kunda, 2001, Greenhalgh et al., 2004;

McMaster 2005 and May, 2013). Such an approach has helped to explain the internal dynamic of an organisation, such as its internal politics (Pattigrew, 1987) or organisational tensions (Normann, 1977) that significantly affect the effectiveness of organisations' decision-making processes. This field of research also 'humanised' (Pettigrew et al., 2002 p. 12) the business and management field and shed light on key organisational phenomena, such as the role of the top teams in strategy formation and innovation. With the application of relational perspectives, process research has demonstrated the potential to capture a micro-aspect of decision making made by human beings that could explain what affects company actions and why. Those studies with close observation of organisational processes became a source of rich and enduring insight into managerial work (Mintzberg, 1983). Such a process-oriented view allows one to develop a holistic and contextual understanding essential to unpacking the complex forces that drive change and stability within an organisation (Melin, 1992)

However, careful examination of the studies that applied this lens, especially in the context of innovation, shows limitations that can inform the application an activity-based perspective to study engagement and networks within OI processes. There are four points to be made in this context.

The tradition of process research, as well as the current OI literature, does not obligate researcher to probe the details of an activity. Often, process research describes the overall sequence of organisational decision-making and organisational change, but is less interested in the practical activities necessary to execute these processes. Thus, process research tends to fix upon the organisational level at the expense of the practical activity of those who constitute the process. If we want to extend our understanding of what constitutes effective stakeholder engagement, we must delve deeper into the actual work that makes up the process.

The process approach has also been reluctant (in innovation studies) to investigate the role of individual agency to explore further whether and in what way individuals make a difference. For instance, when the process view is applied, innovation studies exaggerate the importance of managers, particularly those at the strategic centre, whereas activities at the periphery of an organisation are less often identified, even though they can have crucial effects (Johnson and Huff, 1998) on innovation. That does not aid the exploration of whether micro-activities (conducted by individuals) affect macro-organisational (i.e. group) decisions or vice-versa, and in what ways. Applying an activity-based view allows the research to remain neutral on the question of agency.

Studies that employ the process approach generally provide rich descriptions of the innovation process, but mainly leave to the reader the hard work of interpreting the results in practice (Johnson, Melin, Whittington, 2003). Especially in the context of OI, a process-oriented is useful for theoretical reflection, but difficult for professionals to digest. To make the insights of process research more accessible, activity-based research can transform descriptive contributions into more important management models.

The traditional process research framework is also separate from all social situated phenomena's such as history, space, situation of individuals etc. For instance, when demonstrating that managers communicate or make decisions with others participants, studies that apply a process-oriented view do not necessary count all of social phenomena to answer how, when and where that communication was apply to understand its effectiveness (Bruhn and Ahlers, 2017). In OI context, that element is especially important, as the interface between internal and external stakeholders' interests and the quality of the dialog affects the generation of new ideas (Ayusi, Rodriquez and Ricart, 2006) and the effectiveness of development processes. Thus, activity-based research can be useful to unpack process dichotomy, where the content (history, places, people and/or tools used) is regarded as an inherent and indissoluble part of the ongoing process (Johnson, Melin, Whittington, 2003).

An activity-based view therefore offers an agenda worth following, but also introduce challenges that must be addressed. Explaining how micro-activities are linked to macro-phenomena (e.g. intra-organisational innovation performance), for example, is difficult. Not having a link in such a situation leaves a researcher without a clear sense of how the activity-based can be applied. Moreover, in some cases the micro- and macro-level cannot be directly linked, but the activity-based view may be then used to demonstrate how the configuration of such innovation process take shapes through the actions of either individuals or groups.

Additionally, activity analysis concentrates on the effectiveness of activity and the individuals who perform the activities (e.g., what do individuals have to do to make a difference, and what is their impact?). In such analysis, the appropriate measure is not economic performance (e.g., profit, success of the development, etc.) but the effectiveness of management or the right assortment of tools achieve a certain objective. That result could be difficult to translate into what benefits an organisation performance and what does not. Also, the activity-based view requires 'close engagement with practice' (Johnson, Melin, Whittington, 2003), rather than being premised on retrospective accounts of the process by the actors involved. Thus, the onus on the researcher is to provide convincing evidence that the activities have been captured as accurately as possible (Johnson, Melin, Whittington, 2003).

3.6 Chapter summary

This chapter has outlined the theoretical framework for the thesis. It explains the need to research the daily activities that individuals and organisations undertake to understand the OI process better. The pursuit of openness is about engaging with the varied interests and values of stakeholders and ensuring that joint activities are effectively used to bridge a variety of perspectives and overcome pervasive organisational obstacles. Therefore, the analytical endeavour to distil these underlying processes in this thesis is guided by Engestrom's (2000) framework of AT (also Nicolini, 2012). This analytical framework provides the basis to investigate more thoroughly the interactions within the OI process and to examine how and when those interactions happen. Thus, this thesis argues that such study is required to learn how stakeholder engagement takes place at the level of practice, especially looking at how they engage over time, but also when facing inherent OI paradoxes related to openness and control, resulting in tensions both structural and pervasive (Remneland-Wikhamn, 2013).

Our knowledge of how innovation occurs, change in OI paradigm, and the theoretical understanding of such a model's organisation require further research and review. While the opening up of innovation is perceived as complex and risky, the connection between the people and their ideas needs to be made to minimise knowledge misappropriation, but also to explore new solutions to existing problems more effectively. The primary aim of this research is not to diminish existing models of OI, but to better understand how these connections are made through day-to-day activities that include mediation interactions between individuals, communities, rules, divisions of labour, objects, and tools. Thus, this research emphasises the integration of activity based research in examining OI over time.

Chapter 4 Studying open innovation in the manufacturing industry

4.1 Introduction

The previous chapter has presented the activity-based approach as the theoretical framework for this study's investigation of stakeholder engagement in OI context. It has also proposed AT to study how relations emerge in different stages of innovation process. This chapter presents how and where the study of engagement and network activities was conducted. It begins with explanation of the benefits of the manufacturing industry for OI research, discussing research organisation(s), the project-selection process, and the ethnographic approach applied to conduct the investigation. The focus of this chapter is to explain the research process used to address the sub-questions 2–4 (see Section 1.4).

The chapter discusses also the ethical considerations taken into account prior to and during this thesis research to protect the organisations and people who participated in the study. It explains a number of actions taken to protect sensitive business and personal information that could damage the participating organisations' business reputation and to protect participants' identities. This chapter also explains how the network ethnography analysis was conducted. As network ethnography proposes to combine SNA with established ethnographic techniques, this chapter explains how qualitative and quantitative data was analysed to define network characteristics with the creation of new ideas and with project progress. The chapter concludes that the ethnographical method is valuable in its ability to explain the daily activities that emerge in the course of actors examining unexpected problems or issues during the innovation process.

In more detail, the chapter is constructed as follows:

- Section 4.2 identifies the characteristics of the metal manufacturing industry that may be of particular interesting for a study of OI, as this sector's innovations are usually incremental, and not radical, since the market has already been established

(Caiazza, 2015). This section thus suggests that organisations operating inside of this industry could use OI to differentiate their innovations and value propositions.

- Section 4.3 introduces the host organisation, a metal-processing company based in the Midlands of the UK. It briefly explains the company history and how and when the company was accessed by the researcher in order to obtain permission to conduct this study. Additionally, Section explains how two projects for the research were selected and further describes them in more detail: 'Project A' aimed to develop a new testing technology to improve its production of defect-free novel coated products, and 'Project B' aimed to develop a new strategic framework for the manufacturer. Finally, Section informs the reader about the approach taken by the researcher to access individuals from the different organisations who took part in these two projects

- Section 4.4 discusses the ethnographic method as a method of inquiry to map out and disclose relationships between various stakeholders taking part in the two projects. In more detail Section explains to the reader both the challenges and benefits of the insider position during the research. Section details how the observation method allowed me to share the everyday lives and activities of the people involved in both projects in the chosen setting. It also describes to the reader how documents such as budget information, work descriptions, memos, contracts, NDA, letters of cooperation and meeting minutes were collected, along with the data collection methods for electronic communication (emails) and interviews.

- Section 4.5 highlights the ethical considerations applied to protect the organisations and people who participated in the study. In this section a number of actions are explained that minimised potential risks of the research for the host business and protected research participants' identities.

- Section 4.6 explains the network ethnography approach to study networks that emerged between stakeholders involved in the NPD project. In more detail, this section introduces the network ethnography method and explained how data from multiple sources of evidence—such as observatory notes, interviews, project documents, and electronic communications—were merged with social network analysis to analyse network patterns over project time and those patterns' influence on the discovery, development, and implementation of new ideas.

- Finally, Section 4.7 summarises how this thesis pursues the remaining research questions. It condenses for the reader the context of this research and how the researcher carried out the ethnographic methods at the host manufacturing firm and involved in selected projects firms. This section highlights ethnography as an appropriate scientific method to explain the daily activities that emerged in the course of actors examining unexpected problems or issues during the innovation process.

4.2 Manufacturing industry as context for innovation research

It will remain a primary challenge for the manufacturing industry to meet modern societies' growing demands and reduce the industry's overall environmental impact in the coming years (see Liu and Muller, 2012, Strezov et al., 2013), especially for metal producers. With increasing demand for more innovative products (e.g. 'smart' and flexible packaging or lighter but stronger materials) and reduction of specific emissions and wastes from plants (e.g. greenhouse gas emission), those firms are part of the wider solution to climate change (see Kumar, Fujii and Managi, 2015) improvement in transportation, aerospace, and construction. While improving environmental and market demand is at the top of the agenda, metal manufacturers like other businesses have been associated with market-driven competition and price fluctuations related to macroeconomic conditions (e.g., uneven cost of labour, transportation, uneven energy price and industry regulations). In this competitive and unforgiving environment, metal producers have made complex decisions to adapt to their diverse environmental conditions. Leverage energy, carbon footprint, and processing costs are some examples of current challenges requiring innovative solutions in the industry. Metal manufacturers, therefore, currently represent organisations useful for the study the innovation processes.

Moreover, the metal manufacturers have certain characteristics that may be particularly interesting for a study of OI. Firstly, most of the firms in this manufacturing sector are categorised as SMEs, which often 'are under-researched in the open innovation literature'

(Gassmann et al., 2010, Wynarczyk et al., 2013). Thus, many of those companies are constrained by a lack of resources, knowledge, and the crucial capabilities required to manage innovation processes (see Maylor et al., 2015). Secondly, manufacturing firms, as compared to emerging and growing industries (e.g., IT, pharmaceutical), have had to deal with saturated and slow-growing demand, consolidated competitors, and eroded margins and returns (Forbes and Kirsch, 2011). Because of these obstacles, when their innovations are usually incremental, and not radical, as the market is already established (Caiazza, 2015). These dynamics and constraints in the manufacturing industry suggest that organisations operating inside of this industry could use OI in order to differentiate their innovations and value propositions.

4.3 Identifying research participants

To examine engagement and network activity in OI, the research took place in a metal-processing company (as explained in introduction company name has been omitted due to confidentiality issue) based in the Midlands of the UK. This company was a natural choice for the research, as the researcher worked full-time in the company for the duration of the study. The firm has a long tradition in the production of metal foil products, produced from aluminium ingots, which after casting are rolled with use of different mills into various products with different thicknesses and characteristics. Initially, the firm's products were produced for the packaging industry for products such as confectionaries, pharmaceuticals, and cooking and storage items. Because the firm can produce the foil at a range of thicknesses to suit customers' needs, over the years their product has found applications in many industries, including shipbuilding, electronics, and engineering construction. In the last five years, the average profit per year for the firm was estimated at around £9 million. In the last four years, the firm also spent heavily on capital investments into new machinery to maximise production output and achieve better quality.

Today, the company is a leading producer of high value-added metal sheets to various industries that are supply worldwide. The firm is also the UK's only manufacturer of specialised material for the packaging industry and one of only four producers of this type in Europe. The company invests continuously a high-tech, dedicated production centres to produce best-in-class product. With facilities integrated all at one site, the firm attempts to reduce the costs in the supply chain and increase recycling performance. Therefore, the company is well positioned in the market and provides exceptional lead-time, product quality, and knowhow for its process and products. The strategic mission of the company is to grow strongly, build the experience, and offer the best product quality, service, and strategic support to customers. The company has placed special attention on its technology and process innovation activities to continuously enhance product value and to discover additional sources of revenue and growth.

4.3.1 Accessing organisation

As a full-time employee of the firm, the researcher obtained permission to research the premises of the company on 11 November 2012. In this report, that firm is described as a manufacturer. That permission includes innovation work done in the company with the cooperation of other departments, manufacturing units, suppliers, customers, and contractors. As the company had already begun to cooperate with various external partiers to develop new products and processes, it offered a wide range of opportunities for examining OI activities and evaluating them across the innovation funnel (i.e. from idea-generation to production). Additionally, a confidential NDA was signed to outline confidential material, knowledge, and information related to company technology shared with researcher during the research, but restricted for third parties (Appendix B). Moreover, access to business information was granted on 27 March 2014 and was signed by the operation manager responsible for the plant (Appendix A). As such, approval was granted to allow on access sensitive information, such as NDAs and financial contracts between the firm and other parties, which was not initially accessible. The research procedures were also been outlined to the company to inform management of the study's methods and tools. The method of ethnographic inquiry (detailed in the sections 4.3.2 below), was verbally accepted by the company. Finally, a number of projects to be selected for the study were discussed between the researcher and company.

4.3.2 Projects selections for the research

Five projects were initially selected to research and examine engagement and network activities. These particular projects were chosen based on their innovative context (novel for the firm) and inter-organisational arrangements in accordance with the following definition of OI: 'Open innovation is 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, 2003a). Additionally, selected projects were required to have minimum risk of strategic technological and financial knowledge loss, which could cost the company in terms of profit and its reputation as a technological leader. These criteria resulted in two of the initial five projects being selected for investigation in this research. The company rejected the other three due to the substantial business risks. The firm's privacy was secured, and confidential material, data, information, and knowledge were protected from publication with an NDA signed by the firm, the university, and me, the researcher.

4.3.2.1 Development of a novel testing method for metal products

The first project, called 'Project A' in this study, aimed to develop a new testing technology to improve its production of defect-free novel coated products, which were financially and technologically more attractive for the company's manufacturing customers and end users of the product. Initially, the material-testing method required expensive and time-consuming metallurgical investigation and laboratory simulation to understand the defect mechanism. Three years of internal research allowed the firm to identify a potential source of the problem inside the production's metal-matrix composition. Unfortunately, identification of the defect at this stage was time-consuming, error prone, and expensive; consequently, identification of the problem was unreliable in manufacturing production centres. Further plans to develop this new product depended on inventing a more sensitive, reliable, and cost-effective method of material testing at these centres. As this project addresses the complete process of bringing a new technology (equipment) to the industry and market, this study describes the phase-gate methodology as an NPD project.

The manufacturer decided to rectify the aforementioned issues by opening its R&D activities to multiple organisations. The first company that engaged to develop the new technology was an electronics firm, with a tradition of developing quality-testing equipment for the metal, pharmaceutical, and food industries. This firm's product portfolio included equipment designs for nano-technology research and instruments required to solve complex analytical challenges and improve laboratory productivity.

The second partner to participate in the project was a private technology consultancy consortium that has specialised over the past two decades in offering processing knowledge to different manufacturers worldwide. It has also been involved in over 20 collaborative R&D project consortia over the last 10 years, funded by the UK government's Innovate UK program. Most of these projects have either focussed on aerospace or have involved exploiting the unique properties of various materials. Opening up this development also led to closer work with the external R&D divisions from the manufacturer's Asian metal-processing company. This external R&D division specialises in metal-processing research using a variety of advanced technologies, which range from materials development to product evaluation, including process design, processing, and manufacturing. Its technology development has also been supported by a manufacturing R&D centre, which has worked closely with manufacturing facilities to produce a coherent development plan to test its methods and to analyse and interpret results. Additionally, the company decided to work on its testing method in its own R&D facilities, including the novel processing of an ultra-clean metal with a leading UK university in the materials research field. The work began with the university's specialisation in materials, device materials, polymers, and nanomaterials fields, as well as processing, manufacturing, and computational material modelling and research.

4.3.2.2 Development of a new strategic framework for the company

The second project, which I call 'Project B' for the purposes of this study, aimed to develop a new strategic framework for the company that not only clarifies the new revenue streams, but also to connect individual efforts and team tasks to new requirements to achieve optimal outcomes within and across five separate manufacturing units. The program, created by the company's senior shareholders, matched and optimised the firm's available strategic tools and techniques, as explained by the firm's strategy manager, 'to establish clarity of direction for each employee at the firm level and ensure that they can constantly relate what they do, to where business is driven.' The firm envisioned the strategic framework's development as taking place over a two-year period, during which the project would combine tools and techniques into one improved method of strategy development and implementation within the business. As this project concerns the implementation of a new and significantly improved strategic framework for the company through divided phases, this study describes this as a new process development project.

Similar to Project A, the firm decided to work with other parties external to the organisation to develop its framework. Hence, a small privately owned consultancy firm was approached to offer business strategy advice without long-term commitment. This consulting firm specialises in the manufacturing industry and had a positive record in creating custom strategies to fit companies' needs. The second organisation that became involved in this development was a manufacturing association supporting manufacturing excellence across the industry and encouraged education in both management and strategy development. This organisation also provided a benchmarking opportunity with other firms by offering its partners an extensive metric database at both the operational and industrial levels.

4.3.3 Accessing individuals

Once company access was granted, there was a need to convince the individuals within the firm and those who took part in both projects about the relevance of the research. As individuals' participation in this study was voluntary, it had to be negotiated separately, by the researcher. Initially, the participants had a number of reservations towards qualitative research, which had never happened in the organisation. Questions often arose concerning why they should participate and why they should be interested in talking to a researcher who is also a company employee about the problems and advantages of innovation within and across the company (or companies). To convince them to participate, researcher informed participants that the study aimed to provide an answer to the question of how the business could grow more profitable by recognising and clarifying effective ways of working together when innovating. Additionally, participants were offered access to the insights of the study concerning what can be improved when they work across the firm boundaries.

To inform participants of the research project, adequate information was prepared about what participation entails in practice. A participatory information sheet was developed in accordance with Manchester University standards (Appendix C) to inform participants about the title of the research, who will conduct the research, the aim of the research, why they were chosen, what they would be asked to do if they took part, what would happen to the collected data, how confidentiality would be maintained, what would happen if they did not want to take part or if they changed their mind during the research, the duration of the research, and where the research would be conducted. Each participant received such information prior to the start of the research, including individuals from outside of the organisation who took parts in both projects.

4.4 Using ethnography as a method of inquiry for both projects

For this thesis, ethnography has been selected as a method of inquiry to map out and disclose relationships between various stakeholders taking part in the two projects. Ethnography method "refers to the doings of individuals as 'work' that is, activity that people do at work that requires time and effort and has intent" (Prodinger, Rudman and Shaw, 2013, p. 74, based on Smith, 2005). In this thesis, I use the term 'activity' to refer to anything that people do in their day-to-day work; the term is meant to capture objective, naturally occurring human actions. From that point, ethnography supports the extrapolation of a detailed descriptions of the social context necessary to understand how daily activities are accomplished through people's actions. Furthermore, the method tracks how those day-to-day activities are orchestrated by influences and other factors not visible to the participating individuals. Thus, ethnography as a method of inquiry allows one to understand how the actions of individuals are socially organised through evaluation of the experience of everyday life as it happens in real time, situated in a specific place (Smith, 2005). The benefit of ethnography was especially appreciable for this thesis in examining how and when stakeholders are (or ought to be) engaged in OI. The method supports the exploration of the process of gaining access to people's knowledge, that is 'known in the doing, and often yet discursively appropriated' (Smith, 1997, p. 394), for instance how to deal with unexpected problems when they arise, where to get information or how to apply know-how during tasks. This method allowed the research to better understand the practice of individual activities (Smith, 1999), to identify discrepancies between what people say they do and what they actually do. In ethnography, 'the individual is not the analytical end but rather the entrance point into the context in which people go about their daily activities' (Prodinger et al., 2015. p. 75).

The study of stakeholder engagement during OI activities, across time and space, also suggests that ethnography is an appropriate method of inquiry because it offers an approach to make the social visible (Smith, 2005), something that cannot be captured through other research methods, for instance case studies or discourse analysis. Social links (relationships) indicate that 'social exist and is experienced in actualities of everyday life; experience is shaped, structured, known socially' (Griffin, 1998, p. 369). Seeing relationships development between stakeholders offers ways to conceptualise engagement as a social process that is an emerging, rather than something studied in retrospect. Additionally, ethnography allows one to capture social acts or communication used to develop or maintain relations in particular settings, for instance an organisation's norms (rules and regulations) as instantiated in office rooms (space)—the situated nature of people's actions. This level of detail supports the analysis and development of social relations in the settings in which they are embedded, explaining how people respond and how they restore social relations by changing these settings. Therefore, ethnography as a method of inquiry is well suited to understand the social organisation of day-to-day work in intra-organisational innovation.

By making social relations, ethnography allows one to see the development of social relations as a sequence of actions that coordinate the activity of various people in different locations. For example, when a quality engineer foregoes his day-to-day responsibility for product inspection so he can attend a product-development meeting outside of the firm with an external organisation, his or her work is then coordinated with the firm (to a find replacement) and the collaborative effort (to arrange meeting, for instance, to discuss new ideas). This examples shows how the activities of various stakeholders are related, without the social relations necessarily being visible. Thus, capturing social relations with use of ethnography enables one to address how and when stakeholders engage when opening up innovation activities are organised across different settings. As such, acknowledgment of individuals' actions and capturing the social relations in which they operate during day-to-day work supports a comprehensive view of the complexities of individuals' occupations and organisational processes (Townsend, 1996; Townsend, Langille, and Ripley, 2003).

Ethnographic inquiry was also chosen because of its ability to capture and analyse the language used by individuals in the daily work (Smith, 1999, Bakthin, 1986, Volosinov 1973). Language is a powerful tool in defining the concepts which become substitutes for reality and organise peoples' consciousness (Emerson and Holoquist 1981):

'Language is not a neutral medium that passes freely and easily into the private property of the speaker's intentions of others. Expropriating it, forcing it to submit to one's own intentions and accents, is a difficult and complicated process'. (p. 294)

For instance, the procedures of reporting and assessing new technology to analyse metal components, the procedures inherent in performing tests to estimate technological analysis parameters, the performance of joint work, and so on are parts of the innovation process that allow for the arrangement of individuals' experience and can be used as a reference points to trace innovation activities across different stakeholders, locations, and times. Additionally, capturing, the language that individuals use during the innovation process, through for instance the assessment of testing protocols or written (electronic) communication aids in understanding how individuals' roles are organised across settings (DeVault and McCoy, 2002, 2006) and who does what during OI. For example, to get additional financing for tests, the lead engineer would have to fill in a requisition form which references the company's expenditure system. This form, along with the justification from the engineer, explains why the test is required in this particular setting and his or her part in the process.

4.4.1 Challenges of the insider position

My ability to be close to the people involved in the study from one site was beneficial, because it allowed easier access to the individuals (and organisation) and increased my chances of forming close relationships with participants. As insider, I had a better understanding of cultural norms and social relationships, which informed me of issues, problems and situations within the company and between companies. Such information would have been difficult for an outsider to secure. On the other hand, close relationships with people involved in the study can also be a challenging to a research project, especially for novice researcher (Glesne, 1999, 26-27). For me, as the main researcher during the study, a common problem arose: confusion of what I know (or think that I know) intuitively and what I know on the basis on my research evidence. Such confusion required of me a long time to reflect critically upon my presumptions.

Because the topic (innovation process) and the environment (the company) were familiar to me, I also followed scholars' (Eriksson and Kovalainen, 2008) advice and developed a way to view my research evidence in an unusual manner. For example, because during the time of the research I had an engineering role in the company, I tried to look at both projects from the position of a manager. Also, to study 'engagement and network activity within and across the company', I tried to view things from suppliers', partners' and customers' perspectives. Such attempts to develop an outsider's view (Glesne, 1999) enhanced my ability to be analytical with regard to the organisations, problems, and situations that I was examining. Such experience allowed reflection on different power relationships between me as a researcher and other participants, which might affect the study results if not critically examined in terms of my attitudes, thoughts, values, assumptions, and prejudices. Being reflexive about power relationships has been especially important to understand network evolution, as positions and roles change during the innovation process.

4.4.2 Doing ethnographic fieldwork

'Fieldwork' refers to the activities that researcher needs to carry out 'in the real world' in to collect data (Wolcott, 1999, Coffey, 1999, Amit, 2000). The main fieldwork of this study was conducted, as explained above, in a Midland manufacturing plant, which delivers metal based products for the variety of customers for different market segments. However, this research also applied multi-sited fieldwork (Marcus, 1995) to examine engagement and network activity across the organisations involved in both new product and process innovation projects selected for this research. As explained, my insider position in this research allowed me to travel to different partners involved in the innovation process and do research in more than one place to make comparisons between local subcultures. Ethnographic fieldwork research materials can consist of observation, interviews and site documents.

4.4.2.1 Observation

Observation allowed me to share the everyday lives and activities of the people involved in both projects in the chosen setting, and it is the most widely used method of collecting data in ethnographic research (DeWalt and DeWalt, 2002). Being an 'insider' (i.e. a company employee) allowed me to completely immerse myself into the daily activities of both selected projects. This experience was necessary for participant observation to enable a understanding of the studied culture (Rosen, 1991:16). During the observation, special attention was placed on spaces, actors, activities, objects, events, goals and feelings (Spradley, 1980) (see Table 7).

Table 7 Descriptive Question Matrix for observation (Spradley, 1980)

	Space	*Object*	*Act*	*Activity*
Space	Can you describe in detail all the places?	What are all the ways space is organised by objects?	What are all the ways space is organised by acts?	What are a the ways space is organised by activities?
Object	Where are objects located?	Can you describe in details all the objects?	What are all the ways objects are used in acts?	What are all the ways objects are used in activities?
Act	Where do acts occur?	How do acts incorporate the use of objects?	Can you describe in detail al the acts?	Can you describe in detail all the activities?
Event	What are all the places events occur?	What are all the ways events incorporate objects?	What are all the ways events incorporate acts?	What are all the ways events incorporate activities?
Time	Where do time period occur?	What are all the ways time affects objectives?	How do acts fall into time periods?	How do activities fall into time periods?
Actors	Where do actors place themselves?	What are all the ways actors use objects?	What are all the ways actors use acts?	How are actors involved in activities?
Goal	Where are goals sought and achieved?	What are all the ways goals involve use of objectives?	What are all the ways goals involve acts?	What activities are goal seeking or linked to goals?
Feeling	Where do the various feeling states occur?	What feelings lead to the use of what objects?	What are all the ways feelings affect acts?	What are all the ways feelings affect activities?

The observation includes also collocated meetings (e.g., formal with agenda and participants invitation), informal and ad-hoc meetings, project management activities (e.g., review of tasks, financial aspects or progress of activity) (see Table 8 and 9 on the end of the section). A total of 236 hrs of meetings (284 meetings) observations were conducted between various stakeholders with different positions and roles within the company and varied knowledge, skills, and nationality. Meetings observations typically lasted 50 min and were conducted over three years of data collection, 2013–2016. The data from the observations concerned meeting spaces, stakeholder profiles, mediating tools used for engagement, logs of activities, stakeholders' opinions and the researcher's feelings about the process. Background information to enhance the interpretation of observations was accessible through meeting minutes and informal discussion with participants.

Whereas for day-to-day observations, field notes were written following Spradley's (1980) guidance (see Table 7, also Appendix E and F), formal meetings were recorded with the approval of the participants (before starting recording) and then transcribed into notes.

4.4.2.2 Site documents and electronic communication

A variety of documents were relevant to the research and were collected, including budgets, work descriptions, memos, contracts, NDA, letters of cooperation and meeting minutes. This data, in form of electronic files (.docx, pdf, .ppt) over a period of 72 months (2013–2016), was collected with the approval of the research company. The documents were used to support both real-time data from observations and event reconstructions (see Eriksson and Kovalainen, 2008). Those documents were collected to learn about general issues which might affect departments (company) and to understand how the participants involved presented themselves to others during the innovation process. Additionally, those documents were collected to learn about demands that were placed upon the people involved in innovation process, the privileges they have, and the reconstruction of the innovation process.

To enrich the site documents and observations, electronic communications (emails, calendar appointments) from various stakeholders were collected. The data were collected to understand how stakeholders wrote their messages and how they expressed content while facing the limitations of text-based communication. The email typically consisted of a receiver's name, a sender's name, a brief greeting, substantive content, the time, the date, and a brief situation. In a message, stakeholders generally wrote issues related to the project and asked questions and expressed concerns about collaborative activities and project results. The data was accessed from the company's main server with company approval, and before being downloaded it was filtered to catch only emails key words related to projects in the body text, instance technology specifics or the names of the companies involved. The downloaded emails and calendars also had attached files, with additional information such as plans for innovation activities, financial information and technological data.

4.4.2.3 Ethnographic interviews

To supplement what was learnt through participant observation, site documentation, and electronic communication (emails), interviews were used. These interviews were open-ended, which scholars (Rooke et al., 2004) often refer to as 'ethnographic interviews'. The interviews were particularly helpful when the participants finished one stage of the innovation process and started another—for instance after the ideas-generation phase and before prototyping—to learn how people involved in the innovation reflected upon their behaviours, circumstances, identities, and the surrounding events (see Eriksson and Kovalainen, 2008). Such insight was valuable in fulfilling the main goal of ethnographic research, gaining the perspectives of insiders. The interviews were conducted in settings where participants were most relaxed and could talk openly (i.e., their offices). Before the interview, consent forms were sent to participants to explain that the interview was voluntary and would be audio recorded, and participants were informed that they were free to withdraw at any time without giving a reason; after reading the attached information about researcher's project, interviewees could ask questions of the interviewer, and to protect privacy and confidentiality, all recorded information was anonymous. In total, 13 interviews were conducted, with various participants (see Table 8).

Table 8 Interviews summary

Interviewees Type/Function	*Interviewees Position*	*Data of interview*	*Interview Length (Approx.)*
Operations (Manufacturing company)	Participant 1: Head of manufacturing business unit with technical expertise and experience metal casting production	Oct-13	92 minutes
Technical (Manufacturing company)	Participant 2: Quality and product engineer with experience and expertise in quality assurance and product development in metal sector	Mar-13	82 minutes
Engineering (Manufacturing company)	Participant 3: Head of engineering with mechanical engineering know-how in casting and rolling technology	Jul-14	85 minutes
Technical (Electronic company)	Participant 4: Head of UK new product development in area of testing technology	Apr-14	74 minutes
Technical (Electronic company)	Participant 5: New product engineer with electronic and software development knowledge in chemical testing technology area	Jun-13	82 minutes
Operation (Electronic company)	Participant 6: EU Director of new product development and marketing with extensive technical knowledge in rapid testing technology but also marketing responsibilities	Mar-13	71 minutes
Strategy (Manufacturing company)	Participant 7: Senior Manager with responsibility for developing a new strategic framework ***interviewed twice**	Jan-13, Oct-15	85 minutes, 91 minutes
Operations (Technology Consulting company)	Participant 8: Director with technical expertise on metal technology process	Mar-13	78 minutes
Operations (Consulting company)	Participant 9: Director with strategy development expertise	Mar-13	72 minutes
Technical (external R&D centre)	Participant 10: R&D engineer with knowledge about metal production and new alloys development	Apr-14	85 minutes
Technical (external R&D centre)	Participant 11: Senior R&D engineer with metallurgy and material science expertise	Jun-14	80 minutes
Operations (Consulting company)	Participant 12: Director with technical and business expertise	Oct-15	70 minutes

I then conducted a secondary analysis of 50 interviews that investigated the original 'interests of middle management toward innovation activities' at the manufacturing site to understand actors' perspectives on innovation activities within the business; Originally the interviews were, recorded, and conducted by the manufacturing firm's strategy manager. Tables 9 and 10 illustrates in further detail the interviews' frequency and the number of actors who participated. The incorporation of secondary data in the analysis of the interviews facilitated research into the wider population, unaffected by the researcher and the established relationships with employees and project actors. Access to the data from these interviews was negotiated separately with the strategy manager.

4.4.2.4 Writing field notes

Scholars (Emerson et al., 1995) have highlighted a number of issues to be considered when making a field notes. The general advice is that the field notes should be written either during the stay in the field or as soon as possible after leaving the field site (Eriksson and Kovalainen, 2008, p 147), to ensure that all relevant details are recorded. Writing field notes is also time-consuming, therefore to make the process more effective (less time consuming) the followed approach was taken:

- Based on Spradley's (1980) guidance (also explained above), brief phrases (jottings) were written out to remind me of things that should be included when more completed notes could be written (Emerson et al., 1995). That helped in various research situations, such as having conversations over coffee with a technical officer, to capture the key phrases that would allow more complete notes afterwards.
- Descriptions were recorded (i.e., notes on everything about specific events during the research but also pictures of the settings, if approved and appropriate) to reduce the time taken in writing. Pictures representing employees during the activities related to both projects were not approved either by individuals or by the company.

Table 9 Data source summary, part 1

Data source	*Collocated meetings*	*Informal and ad hoc meetings*	*Written communication*
Approach	*Recording in logbook; electronic recording of*	*Work diary*	*Electronic file capture, meeting notes*
Overview and references	*Meeting notes and audio conversation*	*Meeting notes*	*Email messaging activity via computer, electronic files*
Avg. number of participants per activity	3.86	2.3	3.3
Max. number of participants per activity	13	4	14
Min. number of percipients per activity	2	2	2
Number of employees at Manufacturer (host) site	240	240	240
Consulting firm 2	9%	11%	4%
Consulting firm 1	6%	7%	26%
Manufacturer	85%	82%	70%
Number of unique participants involved in	117	28	126
Total number of participants involve in all	234	40	308
Total number of recorded data	124	63	432
Avg. number of participants per activity	6.38	3.6	4.9
Max. number of participants per activity	13	5	9
Min. number of percipients per activity	3	2	2
UK university	4%	0%	5%
Technology consulting firm	8%	5%	5%
External R&D centre	23%	15%	37%
Electrical firm	27%	30%	49%
Manufacturer	38%	50%	54%
Number of unique participants involved in	26	20	41
Total number of participants involve in all	83	53	332
Total number of recorded data	*39*	*58*	*163*

Table 10 Data source summary, part 2

Data source	*Project management activity*	*Participant details*	*Other*
Approach	*Data logging*	*Work diary*	*Interviews*
Overview and references	*Detail of work carried out during project, electronic files*	*Notes, visual demeanour, conversation*	*Interviews*
Avg. number of participants per activity	1.9	2.5	Include secondary data from interviews
Max. number of participants per activity	3	7	
Min. number of percipients per activity	1	2	
Number of employees at Manufacturer (host) site	240	240	63 *interviews*
Consulting firm 2	6%	22%	4%
Consulting firm 1	6%	28%	9%
Manufacturer	88%	50%	87%
Number of unique participants involved in activity	16	60	62
Total number of participants involve in all activities	28		63
Total number of recorded data	47	92	63
Avg. number of participants per activity	1.8	5.5	
Max. number of participants per activity	3	8	
Min. number of percipients per activity	1	1	
UK university	0%	6%	
Technology consulting firm	0%	6%	
External R&D centre	8%	25%	
Electrical firm	75%	31%	
Manufacturer	17%	31%	
Number of unique participants involved in	12	32	
Total number of participants involve in all activities	24		
Total number of recorded data	*60*	*32*	

4.5 Ethical considerations

To protect the organisations and people who participated in the study, a number of actions were taken to explain the potential risks of the research and to protect their identities:

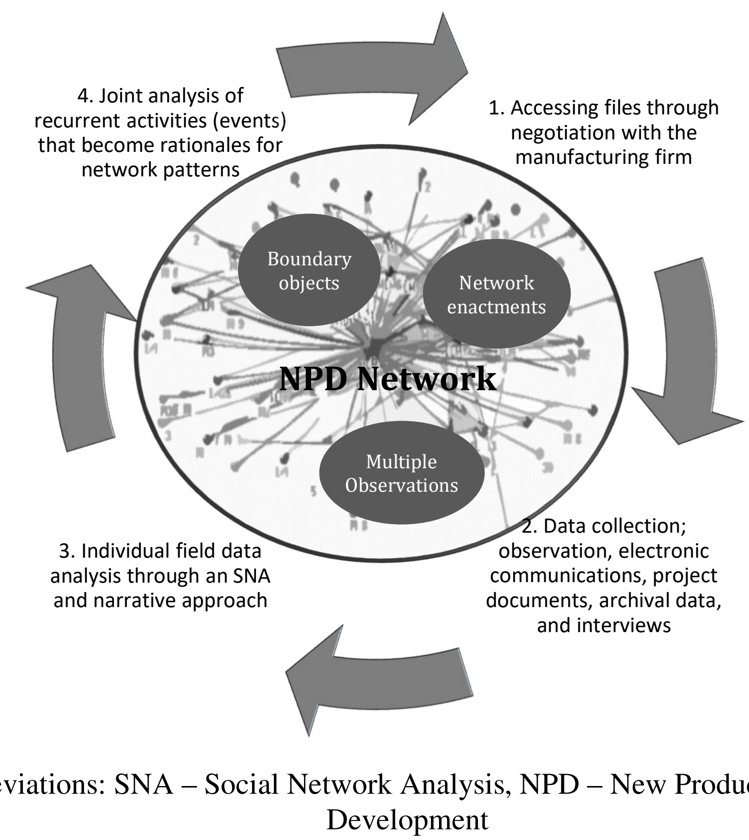
- Organisational confidentiality has been addressed through NDAs signed by all three parties who took part in the research (the organisation, the university, and me, the researcher).
- As a consequence of confidential disclosure agreements, all participants' identities and institutional names have been omitted from any documentation. The data and interview records have been encrypted, as per the university's research data analysis guide. All were stored on my computer and erased according to university data management policy guide. Any data related to the individual names of persons or institutions have been anonymised.
- As this study has involved participants from other parties than the manufacturing company (as explained in Section 3.2.2), additional approval for the research from the employing company has been agreed upon (Appendix C). Also, participants representing other parties have been reassured, as part of gaining informed consent, that they can share whatever they feel comfortable with and should not feel coerced into disclosing information they are not comfortable with sharing.
- The information sheet and consent form were also presented to the employing company for approval before confidential disclosure agreement confirmation.
- The data was stored in Microsoft Excel and Word as password-protected files.
- It was explained verbally but also through a participant information sheet form that analysis of the research data would be undertaken by the researcher with the support of his Ph.D. supervisor.
- Information from the observations and the interviews was protected by a password and not passed to the participants during the research.
- The interviews were conducted at the firm site, on a one-on-one basis. Before each interview, a participant information sheet was provided each interviewee. Prior to the interview, the researcher asked for permission to audio-record the interview

proceedings. The audio recordings were encrypted and transcribed *verbatim* with identifiers removed to anonymise the interview data and protect the identities of the interviewees. Permission was granted to interview key stakeholders, and the interview data was not disclosed to any other party but the research supervisor.

4.6 Adapting network ethnography to study practices in an inter-organisational new-product-development project setting

This thesis also adapts network ethnography to explore how networks emerged between stakeholders involved in the NPD project. Thesis introduced network ethnography through multiple sources of evidence—such as observatory notes, interviews, project documents, and electronic communications (Berthod et al., 2015; Daft and Lewin, 1993; Edmondson and McManus, 2007; Molina-Azorin, 2012)—to study how daily activities create a project-directed network and explain network patterns' impacts over time, as related to the discovery, development, and implementation of new ideas (example appendix E and F) We accomplished this by examining how social contexts influence the 'difference paradox' (DeFillppi and Sydow, 2016) between creativity and performance. As aforementioned, the development of both a new testing technology and a strategic framework for a UK manufacturing company were established in an inter-organisational relationship setting, which included such third-party organisations as customers, suppliers, contractors, consulting companies, and expert groups. The application of network ethnography as a research method with multiple sources of evidence allowed us to observe the network's daily functions in more detail than could be gathered from only the analysis of practices, people, or objects (Zilber, 2014) using standalone organisational ethnography (Figure 5).

To understand the NPD project settings organised with external actors, my fieldwork focussed on common reference points for conversations between actors, such as project documentation, frameworks, meetings, and conflicts (Forgues, 2010). Technological artefacts used in both projects and technology-in-practice (Orlikowski 2000, p. 403), such as actors' roles and skills, were also maintained to record the artefacts and working groups used in both projects. Our fieldwork also recorded the various spaces in which many heterogeneous actors met to discuss projects (Star, 2010; Stange et al., 2016). According to Star and Griesemer (1989), these objects could be regarded as boundary objects that stabilise networks (Star, 1991); therefore, these objects became our unit of analysis. Additionally, I collected information by capturing network activities through the identification of joint relationships, such as organised or unplanned meetings, as well as virtual electronic communications regarding common project goals. Finally, one of the researchers employed by the research organisation participated in both project cases. Thus, I could maintain a constant team-based dialogue and reflect on differing views and interpretations to broaden our view and network understanding (Jarzabkowski et al., 2015b). Adopting this method led to an analysis of the entire NPD project setting and explained 'how things worked' in inter-organisational settings. This approach helped to address the paucity in the NPD management literature on practice-based network research (Berthod et al., 2016).



Abbreviations: SNA – Social Network Analysis, NPD – New Product (Process) Development

Figure 5 Approach to study activities and network in NPD project settings

As network ethnography proposes to combine SNA with established ethnographic techniques, our research design collected and analysed qualitative and quantitative data both separately and simultaneously (Creswell and Plano-Clark, 2011). Thus, first research step involved accessing the company explained in the previous section, which plays a central role in both projects. After the organisation granted us access, I began our second step of data collection by following objects of interest, conducting intensive field studies, and collecting exhaustive relational data on the network and its actors. In the third step, I began SNA and analysis of ethnographic data in parallel, with many iterative loops, as each analysis required more data. Finally, I conducted a joint analysis complementing the SNA method with ethnographic observation (Appendix E,F,G and H). Ultimately, such a combination implies macro- and micro-data interpretation reflecting the entirety of the projects' networks, the actions within each network, and their effect on NPD project realisation.

I conducted data collection for both case studies predominantly at a manufacturing firm in the Midlands (in the UK), but also at external firm sites in Europe that collaborated during both ventures selected for study. Data was collected from five primary sources: observation, electronic communications, project documents, archival data, and interviews. These multiple sources provided the information for a holistic picture of activities within the two NPD networks. During the 36-month data collection period, I conducted over 300 hours of meeting observations on spaces, project-actor profiles and opinions, project activity logs, and researchers' (actors') opinions on this process. The background, which enhanced the interpretation of my observations, was accessible through meeting minutes and informal discussions with project participants. I collected ethnographic data and electronic communications, such as e-mails and calendars, from various project actors. I then conducted a secondary analysis of 50 interviews that investigated the original 'interests of middle management toward innovation activities' at the manufacturing site to understand actors' perspectives on project activities; The secondary data's incorporation into the analysis facilitated research on a wider population, unaffected by the primary researcher and the established relationships with employees and project actors.

The data sources provided a rich qualitative data set subject to SNA. I coded the participants' names in Microsoft Excel using the replace function, and used SNA to visualise the group and individuals' interactions within this group. I then copied the coded data, which had been prepared in an Excel spreadsheet, into the NodeXL application for a graphical visualisation and network calculation (Aldhous, 2012) of such graph characteristics as density, closeness centrality, and total edge calculations (Table 11). This analysis examined density and network centrality to determine the relational patterns of researched project networks (Leenders and Dolfsman, 2016). The members who originated the meetings and communication were placed in the first column and represented the edge's first vertex. Set actors, which received an invitation to interact (representing the edge's second vertex), were placed in the second column. Consequently, I selected a direct graph type to differentiate between various edges, such as initiator versus participant actors. A Harel-Koren fast multiscale algorithm was used to lay out the graph and network data (Aldhous, 2012). The central analytical questions at this point examined how density, ties, and centrality changed over time in each project to examine the networks' evolution.

Table 11 Graph network measures (Based on Everett and Borgatti, 2005)

Graph Metric	Definition	Function
Vertex	The number of vertices within network	Basic measures
Unique edges	The number of unique edges within network	Connectivity measures
Edges with duplicates	The number of edges with duplicates within network	Connectivity measures
Total edges	Total number of edges in network	Basic measures
Graph density (%)	Describes the portion of the potential connections in a network that are actual connections	Strength of ties measures
Average degree	Measure of most trusted actors. Counted for the number of 'connections' that link to the actor	Trust measures
Median closeness centrality	Measure of who has faster access to information in the network	Centrality measures
Median clustering coefficient	Measure if median degree to which nodes in a graph tend to cluster together	Isolation measures
Betweenness centrality	High number means that the person is in a central position in the graph	Importance measures
Reciprocated vertex pair ratio	Ratio between ingoing and outgoing connections (only valid in directed graphs)	Reciprocity measures
In degree	The number of edges coming into a vertex in a directed graph	Trust measures
Out degree	The number of edges directed out of a vertex in a directed graph (most trustful)	Trust measures
Maximum geodesic distance (diameter)	The distance between two vertices in a graph is the number of edges in a shortest path	Distance measures

In parallel to the SNA analysis, I analysed statements and descriptions from field notes, electronic communication, and interviews potentially associated with the activities within the selected NPD projects based on transparency, accountability, and defined roles; Table 11 displays analytical code examples. This data was coded into key themes and subthemes using a thematic analysis (Corbin and Strauss, 2014). During the analysis, I mapped the events and activities during the projects as expressed by project actors during my observations and used collected documents to divide the information into events and phases to arrange them in chronological order. Our empirical analysis included such micro-level entities as activities and choices, as well as the meanings given to those entities by individual project actors. The analysis focussed on the concepts of ‘boundary object’ and ‘enactment moments’ to write stories, which I compared within and across selected projects to ‘extract general or invariant proprieties’ (Bourdieu and Wacquant, 1992, p. 233). This process eliminated ‘radical doubt’ (Bourdieu and Wacquant, 1992, p. 235) or ‘suspicion’ (Klein and Myers, 1999), which is crucial for theorising on the basis of field data. I used this stage to understand the consequences of network activities on project performance through a focus on delays, design problems, and project-cost-related issues when comparing them with an agreed upon plan (i.e. for project performance) over time.

Table 12 Coding process – examples (see also Appendix J)

Data snippet	**Initial coding**	**Focussed coding**	**Axial coding**
The installation that I attempted in the Industrial Computer we supplied you with, which is intended to be utilised for the new technology, was not complete on time, as not all information required for the successful setup of software was initially available to us. I feel disappointed with installation progress and therefore, I would kindly like to invite you to take the necessary steps towards the information exchange - *email between project engineers recorded on 1/5/2014*	Installation delay Pursuing installation performance improvement Feeling not good because not what was originally planned was not accomplished	Installation delays through lack of set-up procedure, progressing strongly on goal, feeling disappointed	Project performance: delay, Affect: disappointed Focus: on information Activity: technology installation
Business director shows interest in the project and asks 'how long it takes to deliver something useful from it'. Lead technologist answers, 'Uhhh, I don't know. I don't expect any results quickly because we need to build a lot of information. I will be looking towards the end of this year possibly before I get significant useful data, but may be quicker.' When he finished, colleague of his enters conversation and explains to director, 'We start to prepare more samples now, so we can reduce the (developing) time by two-to-three months' - *Projects review meeting recorded on 2/3/14*	Business director interested in technology development plan Technologist feels that he cannot give a detailed answer but optimistic about delivering positive results for the business; ached of plan that would allow reduction in development time	Sharing information, feeling positive about development, progressing strongly on goal	Affect: motivated Focus: positive Activity: project review, Project performance: positive ached of goals
'I'm starting to think about the discussions with the middle management, I'm hoping from this to get some good feedback so I can start to gauge understanding and appetite in the company, particularly in these critical areas (strategy); For me it's where the top down approach would reach the bottom up approach so it's the key battleground!' - *interview strategy coordinator during project 'B' initiation, recorded on 12/12/13*	Thinking about the improved performance for strategy alignment through one-on-one discussion with various stakeholders within the business Feeling that debate about strategy development requires consensus between various actors within organisation Feeling energetic about it, wanting to do more and understand different perspectives	Realising positive performance, feeling enthusiastic about his role in this project	Feeling: energetic Project performance: proactive, Activity: project initiation

The last part of the analysis focussed on actors' interactions to capture when they promoted novel ideas which the network actors recognised and used over time (Nijstad and Stroebe, 2006; Somech, 2006; Tang and West, 2004). These ideas, how network actors responded to the ideas, and whether they decided to implement them were recorded in notes during meeting observations and extracted from interviews and communications to measure creativity. I used such data to analyse the number of suggested ideas per relationship and their novelty to distinguish between incremental (mostly improvement) or radical ideas (starting a new thread of ideas), as well as the promotion and use of ideas by either their encouragement or criticism. I began to inductively identify creative output with network attributes at this stage. Finally, I compared the two projects and evaluated how this interaction between creativity and structure affected selected projects.

4.7 Summary

This chapter has provided an account of how this thesis set out to pursue the research questions. It provides details, about the context of this research and how the researcher carried out the ethnographic methods at the manufacturing firm in the Midlands. In some detail, ethnography and network ethnography methodology has been explained, along with the justification developed for the method to study stakeholders' engagement and network activity. It was explained that the method would be valuable in its ability to explain the daily activities that emerged in the course of actors examining unexpected problems or issues during innovation process. Access to the manufacturing site and its individuals has been explained, along with the challenges related to my insider position. The aspect of reflexivity was briefly raised and discussed to highlight its influence on the study and its results. However, as there are no clear and obvious social and psychological views on reflexivity, this chapter has primarily considered how the researcher collected the data and what ethical considerations were applied to protect organisations' and participants' identities in this research.

Chapter 5 Examining how and when stakeholders are engaged (or ought to be) in open innovation

5.1 Introduction

The previous chapter has explained ethnography and network ethnography as the main methods chosen for the examination of engagement and network activities during the OI process within and across the manufacturing firm. It has also explained in detail how the data for the research in this thesis was acquired. This chapter provides the reader with results from the new testing technology development (i.e. Project A) and explains of how relations between various stakeholders emerged during this process. It describes also what people and organisations do when facing tensions and problems related to knowledge protection and sharing (Section 5.2.2), differences when applying standardised and crafting actions (Section 5.2.3), and pressures related to temporary organisation activities (concerned with accomplishing innovation activity goals) and permanent organisation (concerned with the long-term efficiency of the business process) (Section 5.2.1). The chapter then identifies when stakeholder engagement became effective, according to findings from Chapter 2, and allowed the advancement of OI despite differences, emerging problems, and unanticipated tensions. Consequently, the main purpose of the chapter is to answer the second research sub-question: How and when do (or should) stakeholders engage in OI? The chapter concludes that stakeholders are engaged more effectively in the innovation process when they first disengage from established rules and places where their normal work occurs. In separating stakeholders from organisational norms and moving them to other work sites, they can freely offer their ideas and skills for the OI development.

5.2 Results

5.2.1 Company focus on stakeholder involvement in screening ideas: Promoting inbound relationships

The decision to pursue collaborative work between the companies has stimulated various ideas concerning the testing capabilities the new equipment might deliver in the future. Thus, such a requirement brought into the discussion a need for idea screening, which then became the object of the activity system. The first objective of the activity system was to set specific criteria for screening technology, such as detection limits required for the future, operational requirements, and return on investment. The second objective was to make a decision regarding the ideas that should be continued or dropped at that point, requiring the involvement of numerous stakeholders from across various technological, commercial, and organisational disciplines from both organisations. Their knowledge and expertise were key to better understanding the current and future requirements that could be used for initial specification development and for determining compatibility with the businesses' overall objectives. To this end, the representatives from both firms (senior managers) decided to go back to their firms and involve their key stakeholders in the process to identify the required information.

Although the evaluation of ideas was agreed upon as an important part of the NPD process, the different rules and regulations at the two firms began to contradict with the objectives and led to disturbances and dilemmas occurring in the routines of their daily collaborative activities.

Initially, the manufacturing firm wanted to control the outflow of novel product technological information (it did not want to share details with the electronics company) and limit stakeholder involvement to production engineers and managers, with no direct involvement of R&D projects the firm conducted with customers. Employees who were located at the site where the technology may be deployed, by virtue of production expertise, became part of the screening committee. Each was asked to join the group by a direct line manager, either through verbal communication during the technological meetings or through email. On the other hand, the electronics company decided at this stage to involve only commercial engineers based in the UK to evaluate the costs of the potential ideas and ensure that selected ideas fit the planned budget for technology invention (e.g. development and tests). However, as it turned out, this decision became problematic for cost estimation, since the commercial scientists initially underestimated testing complexity and manufacturer requirements related to testing sensitivity. Similar to the manufacturer's approach, at this point, the electronics company's European R&D centre was not asked to participate in establishing the criteria or the selection of ideas for the design stage. In both examples, this planned isolation of stakeholders was used initially in order to control the process: outflow of information by manufacturer and control of innovation costs by the electronics company.

This situation conflicted within the labour division at the manufacturing firm, where the technical and R&D departments worked closely with customers and understood future customer requirements; these employees became naturally interested in offering their views on what the new testing equipment should deliver. Because of a lack of transparency as to who was actually making the decisions about idea selection and on what basis those ideas were selected, the tension between departments turned into numerous informal discussions about both firms' employees' roles and responsibilities in this process and created conflict between the manufacturer and its R&D department. With no forum for describing ideas, two R&D engineers decided to visit the manufacturing division and express their proposals for detection requirements and potential plans for equipment use in the future. Below is a summary of a reported observation at manufacturer site on February 2014:

'*The R&D engineer enters the office as always in the last four weeks and starts to talk with the site manager about the number of customer issues that were recently reported. During the talk, the site manager becomes interested in the new chromatography analysis project that the R&D engineer is part of, explaining the importance of this project for the future possibility of the crosscheck with the new technology that the company would like to develop. He then explains the technical rationale and logic behind this new concept. When he finishes, the R&D engineer admits: 'this is why I am coming here, I want to be part of that project', suggesting over another hour further ideas related to development'.*

Informal meetings between the R&D engineer and site manager, when both discussed the alignment of requirements for this new technology, became more frequent and longer, and the R&D engineer began to propose bolder ideas regarding what the technology should test. As a consequence, one of the R&D engineers, by virtue of his involvement in the subject, was co-opted to the committee and began to inform the rest of the team about recent and future customer requirements that the technology should be able to help with. At this point, the process of involvement became more ‘fluid’, and other members at the manufacturer’s site began to express their interest in the matter. One particularly interested employee was a senior manufacturing manager representing the factory where the technology may be tested, who was not included in initial discussions. Below is a summary of a reported observation at production office (figure 6) after initial discussion between firms about various ideas concerning the testing capabilities of the new equipment, between process technologist and production manager:

‘…impatient manufacturing manager asks him (technologist): ‘I would like to see them (results), can you show them to me?’. Site manager looks at him with a smile and says ‘yes (technologist) I have them on a memory stick, but we need software to open them’. The process technologist pulls out from his pocket the memory stick and gives it to the manufacturing manager who quickly sticks it into his computer. After that, he impatiently tries to open the data from the stick. During the process, the process technologist again explains to the manufacturing manager that he needs to have special software to open the data, but the manufacturing manager shows his impatience and turns to the site manager and asks, ‘where is the IT specialist, he can do it’…. Later on, the technologist with the printed version of the results comes back and the manufacturing manager stops work and spends a good hour studying the results, suggesting at the end: ‘this is interesting; when you get more results, send them to me please.’

Observed at Manufacturer Production Unit Office on March 2014

Figure 6 Production office at manufacturers (production unit) sites

After spending time on the data analysis of the initial results from the laboratory, the manufacturing manager formed an opinion about the potential benefits of the new venture for his department in the form of sampling-time reduction and material-cost-cutting. Thus, he offered his opinion to the committee in terms of the venture's viable return on investment. However, the manufacturing manager did not stop with his initial data analysis but began to formulate many questions around the implications of the new ideas presented by the electronics company in terms of faster and more reliable sample results. From that point onwards, the manufacturing manager supported the lead process technologist in the evaluating product ideas and participants in the discussions with the electronics company representatives.

Table 13 Activity system – new testing technology idea screening

Object of the activity system	**Contradictions and system tension**	**Actions (engagement mechanisms)**	**Result(s) of the activity system**
Idea screening for new testing equipment development to determine compatibility with overall businesses objectives	*Tension between the temporary and permanent organisation Highlighted by firms' control over stakeholders' involvement in the venture and requirement to encourage stakeholders' autonomy to bring new ideas and passion to minimise disturbance from the environment and subsequent obstacles to implementation*	*Opening up to inbound ideas from stakeholders by spreading the word about value of the technology promoting informal stakeholder visioning. (e.g. involves asking various participants to appraise where technology is now and where they can realistically expect to be in the future)*	*Further laboratory tests to be conducted to test new ideas offered by R&D engineers.*
		Representatives from both firms, technical and non-technical professionals (e.g. production manager) offer advice and detailed information about development status and idea selections and form an advisory committee	
		Explore issues related to the lack of a forum for idea expression and identify solutions that allow discussing and promoting them effectively; achieved through basic activity research method applied by two R&D engineers	

As a result of the idea screening process, both companies selected key technology capabilities that constitute objectives for concept development and testing. The effectiveness of this process, I observed, required artful stakeholder involvement to start an effective discovery process. One site manager established selective involvement of stakeholders in order to control the decision process, but another had to encourage stakeholders' autonomy to bring the creativity and passion required to this temporary endeavour. As explained in Table 13, I posit that this tension between permanent and temporary organisation can be embraced through a relationship-building exercise (stakeholder visioning), a mechanism that enables information to be distributed to different stakeholders' groups (i.e. the advisory committee) and an approach that allows the identification and testing of solutions to obstructions in the innovation process (action research). This process helped the companies, first, to discover the various requirements for the technology, and second, to allow for the alignment of ideas so these ideas could become development objectives. In those examples, the process required that stakeholders had to first withdraw from their normal tasks delineated by the organisation to gain the status of participants; however, once they achieved that status, they created a stronger bond for idea evaluation. This bond then led to a commitment to the activity, but not to their original tasks and goals set by their organisations. In some form, they came to work outside of the organisational rules; however, this work method turned out to be equally effective in terms of development and increased the open communication of information. Ultimately, the organisations learned that to continue further development, laboratory tests needed to be conducted.

5.2.2 Stakeholder availability for information exchange during concept development and testing: Improving outbound relationships

Once the committee reached a decision to steer the project towards proof of concept, it organised discussions to forward plans for the necessary tests. Concept development and testing thus become the object of a new activity system for the firms, and increased requirements for more detailed information exchange about product(s) and instrumentation specifics, such as metallographic defect characteristics and measurement of spectral content of light, as well as interpretation of results from such a measurement. The aim was to understand whether laboratory outcomes correlated with the manufacturer's processes, showing trends for chemical elements within the manufacturer's products that could may indicate defects. At this point, the process required from the manufacturer and the electronics company was the disclosure of defect type and the understanding of algorithms that were not protected by patents or any other form of agreements, thus securing both firms' IPs. Therefore, to control the transfer of sensitive information between the firms, it was decided that stakeholders who represented the manufacturer's site would first seek approval to disclose the required information for the development. Below is a summary of a reported observation at Electronic firm in EU, May 2014.

'… (Manufacturer's employees in the committee) speak with senior management to see if they can constitute a work group inside of the company to open the information exchange for the next level …. "so that if we want to be of help to them, we need knowledge of their expectations in different steps in the process, and after that we would like to use that as a kind of generic information … so everything confidential we leave alone, and we sign confidential agreements"'.

Despite this plan and future non-disclosure agreement (NDA) exchange between the firms, the whole process to test the concept was delayed due to the slow exchange of information between the involved stakeholders working on the tests separately, in two different countries. The delay also occurred because of the stakeholders' beliefs that the decision process still required approvals from departmental managers for information disclosure to ensure such exchange was more secure. Additionally, due to the lower positions of the technicians and scientists taking part in the tests in the company hierarchies, their knowledge was limited as to what could or could not be disclosed, as the NDA was not circulated across all organisational levels. Finally, information for the tests required the manufacturer's customer approvals before externalisation, and the whole process of approval took longer than initially estimated. Furthermore, at this point, the committee did not see the need to establish a formal position that would develop the exchange of information, because the concept was not yet proven. Therefore, not having required information led to disturbance within the community by barring basic understanding of the requirements necessary to make sense of the detailed version of testing for the technology idea.

Table 14 Activity system – new technology concept testing

Object of the activity system	**Contradictions and system tension**	**Actions (engagement mechanisms)**	**Result(s) of the activity system**
Concept development and testing to obtain initial feedback about selected technology ideas	*Contradiction between knowledge protection and sharing, highlighted by increased requirements for more detailed information exchange between the firms and problems with disclosure of sensitive information about manufacturer's product specifications*	*Constitute a small group of technicians, technologists, and scientists (expert panel group) from across the disciplines and from both companies to test the concept separately from their normal day-to-day work*	*Develop the tests rapidly and spend rest of time evaluating solutions to technology problems discovered during tests that may allow for even further concept improvement*
		Facilitate ownership of testing problems, provide exercise aim, length of engagement, and required outcome by establishing a new space for expert panel group	
		Increase exchange of status reporting and new information presentation through feed-forward type meetings	

To improve the situation and progress the tests, the committee decided to create a small group of technicians, technologists, and scientists from across the disciplines and from both companies to test the concept in one place at the electronics company's lab in Europe. The key goal for that group was to understand whether the concept worked and met the required objectives selected for development during the idea-screening process, but also to exchange the required information and understand the results in the context of the manufacturer's process and customer requirements (tolerances) in terms of product imperfections. Five employees, two from the manufacturer site and three from the electronics company, spent a week testing the concept together and providing feedback to the committee about the results to help with further decisions about the development plans. The laboratory and offices where they worked on the task were located in a different building from other offices and offered the small team a space to elaborate on the test results (figure 7).

Figure 7 Office create for inter-organisational team to work together on concept testing

The physical separation from other employees and company regulations allowed this team to move the tests forward rapidly and to spend the time evaluating solutions to technology problems discovered during the tests, inventing additional testing methods for even more precise material verification beyond the original concept. Such initiative was welcomed by the senior managers, who soon began to formulate the next development objectives based on these more frequent status reports and further action plans. Below is a summary of a reported observation at Electronic firm in EU, July 2014.

'Director of marketing and product manager in a short chat on a previous day concluded with the team to have at the end of the visit a short meeting to discuss developed solutions…. During a walk to the meeting room, the director of marketing changes the plans and invites the team into the director of operation's room, where technicians, technologists, and scientists testing the concept could explain to the director what can be done to meet the technology objectives…. After introductions, one of the process technologists kicks off the discussion by talking to the director of marketing about a number of people who should be involved at the manufacturer's site during the next steps of development… and explains enthusiastically their roles within the technology development. During that short chat, all participants stand around the table; nobody sits. The director of marketing waits until the technologist finishes and concludes by suggesting further actions by explaining to the director of operations, "so, step one is to accomplish work (referring to technology test), right? And then after that research scientists will go (referring to manufacturer site visit) to help with industrial tests" … "the second step we are to offer them as the part of collaborative agreement is off-the-shelf algorithms… advanced algorithms for defect analysis that they and their customers need"'.

After that, technicians, technologists, and scientists from the team began to work closely with each other on the invention. They exchanged information often directly with each other through conference calls, electronic communications, and site visits. Through their contact, they also offered to support technological queries from other employees involved in the development to allowed faster and more reliable knowledge transfer between the firms. Interestingly, during those interactions, firms came to balance the transfer of sensitive information with their knowledge protection. Stakeholders could offer their ideas and skills above and beyond organisational rules and regulations and allow the temporary transfer of sensitive information within small expert panel groups entrusted to do it by firms. However, increased exchange of status reports (feed-forward type meetings) allowed as well to control for both firms and adjust what knowledge could be transfer between stakeholders. In consequence, this allowed both firms to progress to the next development phase – the technology-commissioning plan.

5.2.3 Effect of transparent stakeholder communications during commissioning planning: Creating a coupled relationship

After the concept-testing phase, the development of the commissioning plan became the object of a new activity system. The purpose of the plan was to provide direction for the technology commissioning process during equipment installation and provide resolutions for issues such as scheduling, roles, and responsibilities, lines of communication and reporting, approvals, and coordination. In this stage, the committee decided to select two engineers, one from each firm, to lead the preparation of the plan. Both firms also declared that the commissioning plan was required to ensure that the technology performed according to the intended design and specified operational requirements. Additionally, the plan needed to specify all information technology necessary to support equipment and systems according to the best practices and standards within the industry. During the commissioning planning stage, the nominated engineers worked with various stakeholders (e.g. managers, other engineers, contractors) to achieve consensus on acceptance-testing protocols for the technology installation and where the technology would be installed. The participation of stakeholders in the commissioning activities was expected to follow the requirements defined in the specifications.

Although the aim of the commissioning plan was clear, work with various stakeholders who were not part of the design stage, such as contractors or IT personnel, created a disturbance in the process due to their different perceptions of best practices and installation standards. This disturbance led to problems with acceptance of tests and stakeholder acknowledgment of responsibilities. However, the main disturbance was caused by the fact that the nominated engineers did not deliver needed information to stakeholders about detailed design requirements, especially in the context of the new facility where the technology was to be installed. The problems relating to the lack of exact design specifications for the facility became apparent after one of the meetings between nominated engineers, external contractors, managers, electrical engineers, and the manufacturer's fire system co-ordinator. Below is a summary of a reported observation at electronic firm in Europe during commissioning pre-planning meeting, Oct 2014.

'(Nominee engineer) starts the meeting by explaining where the new technology should be installed. At the same time, presented to participants is the drawing that he received from the project office. He gives all participants one copy of the drawing and additional information about technology specification. Once he does that, one of the industrial managers begins to re-design the facility on the drawing using a pencil, and then he stops the nominee engineer's introduction by asking him detailed questions about wall types and doors that the building was required to have. When that happens, other participants join the discussion and comment on the fire doors that in their opinions should not be named "fire" because they should be able to open in other ways. The engineer becomes confounded but repeats that the drawing was only an indication of the technology installation. However, the participants in the room start to comment that all of them require more than just a basic drawing to accept responsibility for the job that has to be done. After that, the electrical manager looks suspiciously at the engineer and asks, "I don't mean to be funny, but does somebody know if the drawings are up to scale?"'

A delay in the planning of the commissioning stage was caused by a lack of standardisation in such scenarios and instructions expected by contractors for the facility where the technology was to be installed. Contractors did not want to acknowledge full responsibility for the technology installation before design information was provided to them. At this stage also, the nominee engineers required from contractors customised crafted solutions for the building to avoid issues related to vibrations that affected technology reading's sensitivity, as was discovered during earlier phases. Therefore, the discussions of the commissioning plan were not seen as transparent, and stakeholders involved in the planning from both firms avoided responsibility for managing the situation. To resolve such an impasse, the management team from the manufacturer's site proposed to have more frequent and structured meetings with stakeholders, where they could discuss specific requirements and 'calibrate' perceptions about installation design, practices, and roles that could become part of the commissioning plan. Such solutions received the support of stakeholders, and a week later, the first meeting was organised.

The meetings were organised and led by an operational manager at the manufacturing site in one of the meeting rooms. The meetings had formal agendas to discuss engineering issues related to design requirements, technical problems with IT system support for the technology integration, and potential problems with scheduling that could affect the commissioning stage. However, the meetings became uncomfortable, because they were often confrontational and overly formal. This discomfort led to awkward conversations between stakeholders and contributed to a distinct sense of unease and a notable lack of openness, which caused stakeholders to express their thoughts indistinctly. However, at the third meeting, stakeholders became distracted from the meeting objective. Below is a summary of a reported observation at manufacturer site, October 2014:

'… (Nominee engineer) asked the others what else was needed to be clarified. After a few seconds, the IT manager asked if the building where the technology was going to be installed should have swipe card access because if that was the case somebody had to organise an external firm to install it. That clearly moved the manufacturing manager that sat opposite him, who asked, "If we do that, can we also change the thing in our office, please?" The IT manager looked at him and answered, "They are too expensive", adding afterwards, with a smile on his face, "…also, from my experience it is faster to change managers than this type of swipe card equipment". When he said that all in the room chortled with laughter, including both the IT and manufacturing managers, and the lead participants began to talk about jokes and completely moved away from the subject…. 10 minutes later, in a more relaxed atmosphere, the engineer that was leading the meeting asked openly, "so, what are we doing with this swipe card equipment?" … The IT manager then said, "I suggest that we work together on this with (manufacturing manager), what do you think?" The manufacturing manager responded with a smile on his face, "Well, I agree we should; let me get the quotes"'.

Table 15 Activity system – new testing technology commissioning plan

Object of the activity system	**Contradictions and system tension**	**Actions**	**Result(s) of the activity system**
Development of commissioning plan to outline the scope and define the responsibilities, processes, and requirements of technology installation for industrial testing	*Tension between crafting and standardising practices, emphasised by different perceptions on best installation standards and requirements for customised solutions needed to avoid technological issues*	*Introduction of more frequent and structured meetings with stakeholders where they could discuss specific requirements and openly work on problem solving*	*Commissioning plan completed and stakeholders engaged as a team with installation phase where together they overcome further issues related to IT specification changes, such as modification of the integration system and problems between the two firms related to technology calibrations*

From that point onwards, meetings either began with personal conversations between stakeholders, or during the meetings, the stakeholders found ways to divert to other subjects unrelated to the agenda. Such positive distractions allowed open conversations to be maintained and allowed stakeholders to feel comfortable and positive, thereby reducing negative emotions. This spurred all stakeholders to elevate their ability to communicate and collaborate more effectively, even outside of the meetings (through informal chats, emails, and phone calls) to offer help in resolving technology-installation issues. As a result, the installation discussion came to follow a sequential (non-iterative) process in which progress was identified as flowing steadily downwards from one element to another to eliminate changes that would be costly if not implemented at the design stage. That kind of discussion allowed the group to complete the commissioning plan, and the team was engaged in the installation phase, where together they replicated the same sequential ‘protocol’ to overcome further issues related to IT specification changes, such as the modification of the integration system and problems between the two firms related to technology calibration.

5.3 Sub-question 2 conclusions and managerial implications

Sub-question 2 contains two questions—*how* and *when* are stakeholders engaged in the OI process—to capture, in practice, how firms can enhance OI beyond acquiring information.

The results suggest that stakeholder engagement during OI activities may take three forms, defined by three different relationships. The first is inbound relationships, with such engagement generally occurring during the technological options discovery phase, established through promotional initiatives that make OI visible and discoverable so that stakeholders can see the solutions that bring development benefits. This first relationship form is needed to motivate involvement to sustain interest and remove initial barriers to collaboration related to the selection of technological options, such as the lack of manufacturer openness around key product information. The second is outbound relationships (promotion of new relationships between selected stakeholders) to assist with the understanding of development problems, alternatives, and further opportunities during the invention phase. Finally, the third form is coupled relationships focussed on collaboration to promote pervasive networks that increase knowledge exchange. These relationships can be fostered through a regular shared meetings where stakeholders complement each other’s knowledge and resources to address (in this case) the problematic technology installation process.

As a consequence of this study, I demonstrated that the application of different forms of stakeholder engagement allow actors to embrace the contradiction and tension that are inevitable in the OI process (e.g. Mahr et al., 2010 and Remneland-Wikhamn, 2013). Thus, for managers to be effective requires to choose between involvement, consultation and cooperation mechanisms in order to balance OI paradoxes during the discovery, invention, and creation phases of the process. I also suggest that creating an urge is the most effective way to gain more concentrated feedback from stakeholders and attract them to the innovation process. However, rather than waiting for individual stakeholders and their ideas, in this case, managers should actively promote their inclusion in the process through an schedule of open co-designed meetings in which large and diverse groups can be involved. Additionally, to improve information availability and exchange, a balanced, objective, and enhanced alignment of work with others inside and outside the firm is required. To be fruitful, such a process requires that managers spend time researching and motivating their target audiences (an expert panel, in this case), but also that they ensure the relevant audience has an environment in which they can move beyond the original concept. I also believe that the benefits in these scenarios can be maximised through information sessions and fact sheets that document and summarise developed 'facts' and can be used for further idea stimulation. Moreover, issue resolution in the design of the commissioning plan could be improved through participatory editing, where stakeholders co-write the plan and endorse the final document. I believe that in this way, mistakes could be identified earlier in the process and dealt with in a cooperative manner initially.

One obvious implication is that stakeholders are engaged more effectively in the innovation process when they first disengage from established rules and places where their normal work occurs or from negative perceptions formed by process problems. In the study, I demonstrate that such disengagement can be achieved by withdrawing stakeholders from their tasks, as delineated in the organisation to gain status as an innovation participant. In separating stakeholders from organisational norms and moving them to other work sites, they can freely offer their ideas and skills for the OI development. In addition, by offering a positive distraction that allows for transparent conversations and builds trust, collaboration is stimulated. This experience suggests that managers should consider that innovation needs to focus on activities to be productive. Therefore, to move forward with our understanding of stakeholder engagement, as called for by Achman (2013) and Eskerod and Huemann's (2013), scholars should explore not only how stakeholders are involved, consulted, or collaborated with in those activities, but also how they can be effectively disengaged from norms, places, or situations that block their ability to concentrate, think creatively, and make good decisions when co-creating value.

I believe, therefore, that to make the OI process effective, managers should focus not only on visible activities, such as managerial processes and routines (as explained by Foss et al., 2011; Alexy et al., 2013b; and Henkel et al., 2013), but should also turn their attention to spaces in which facilitation, negotiation, communication and synthesis of information can happen. Such spaces include decision-making areas and forums for actions, but also, as the results suggest, other ‘spaces’ that are seen as opportunities, moments, and channels where stakeholders can act to potentially affect the development discourse. Effective engagement that drives OI is promoted by informal communications in natural spaces, where stakeholders gather to discuss ideas outside of the institutionalised arena to stimulate the co-innovation pursuit. The inter-relationship of the spaces also creates challenges for the stakeholder engagement process. To challenge OI barriers, managers may serve in the role of advocate, arguing for greater transparency to build trust or exchange ideas between stakeholders by creating a new space. As these newly invited spaces emerge, scholars and managers may need to consider other engagement mechanisms to maximise the benefit of bringing various stakeholders together.

However, results imply that effective stakeholder engagement in the context of OI not only relates to improvement in engagement methods or ways of overcoming creativity blocks, but also to how and when those relationships blend together to generate value. Therefore, perhaps a more challenging question arising from this finding is, what are the potential consequences of different forms of engagement on social structure that connects the inside of the organisation with its outside, and how does this pattern of relationships affect capacity to produce different types of innovations? Managers should be aware that structures created by relationships between and among stakeholders could have different management implications for the direction of the innovation. As illustrated in the examples, collaboration promotes the development of more incremental work relationships between stakeholders during the installation phase that allowed for effective resolutions to the technology installation issues, whereas sourcing ideas during the screening process from stakeholders not involved at first in the process (such as R&D engineers) offered an increase in new options that affected the technology design. Therefore, through an improved understanding of the impact of various forms of stakeholder engagement practices on radical or incremental innovation processes, managers could plan the direction of innovation even more effectively.

Chapter 6 Effect of network evolution on creativity and performance of new product and process development projects

6.1. Introduction

The previous chapter has explained the conditions for effective involvement of stakeholders in an intra-organisational innovation process by answering the first of the four research sub-questions, concerning when stakeholders are (or ought to be) engaged. The focus in this chapter is to explain how these joint activities in an OI a scenario generate a network of relationship ties that stimulate idea generation and innovative culture. Moreover, this chapter traces the network's evolution over time and examines how its outcomes, performance, and creativity change over the life cycle of an NPD project—an aspect that has not yet been sufficiently addressed in the organisational literature. The chapter thus answers Sub-questions 2: How does a network of relationships evolve during and innovation process, and in turn how does that evolution affect the discovery, invention, and creation of novel options?

Section 6.2 describes and compares the network results of two projects selected for this research to give to the reader an overview of both cases. More specifically, Section 6.2.1 details how the network for new testing-technology development (Project A) was set up, and Section 6.2.2 describes the effects of new testing invention-and-development arrangements. Section 6.2.3 explains how the relationships for the creation of a strategic planning framework (project B) were created, and Section 6.2.4 explains the consequences of that network form on idea generation during the idea screening and implementation phase. Section 6.3 closes this chapter with a discussion of the findings.

6.2 Results

The SNA data obtained in the research suggests that networks created through engagement with various parties (manufacturers, electronics companies, R&D centres, and customers) to develop a new testing technology in Project A (Figure 8) had a more compact structure (13.3% density) than Project B, which focussed on the development of a new strategic framework (Figure 9; 2.76% density; Table 16). The first NPD venture had fewer vertices (29; Table 16) compared to the second case (78; Table 16) for the same 36-month research period, from 2013–2015.

Table 16 Graphs' metric (Calculated using NodeXL version 1.0.1.251)

Graph metric	Project A: Develop a new testing technology	Project B: Develop a new strategic framework
Vertices	29	78
Unique edges	18	114
Edges with duplicates	334	408
Total edges	352	522
Graph density (%)	13.30	2.76
Average degree	3.72	2.26
Median closeness centrality	0.016	0.006
Median clustering coefficient	0.333	0.179

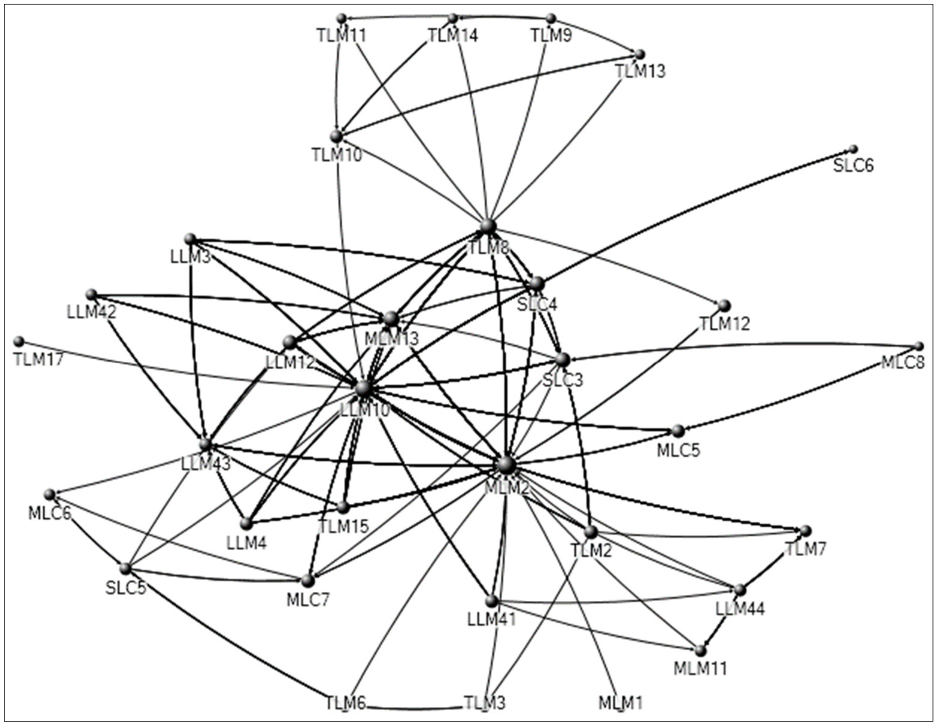


Figure 8 Project network structure established to develop a new testing technology (created using NodeXL version 1.0.1.251)

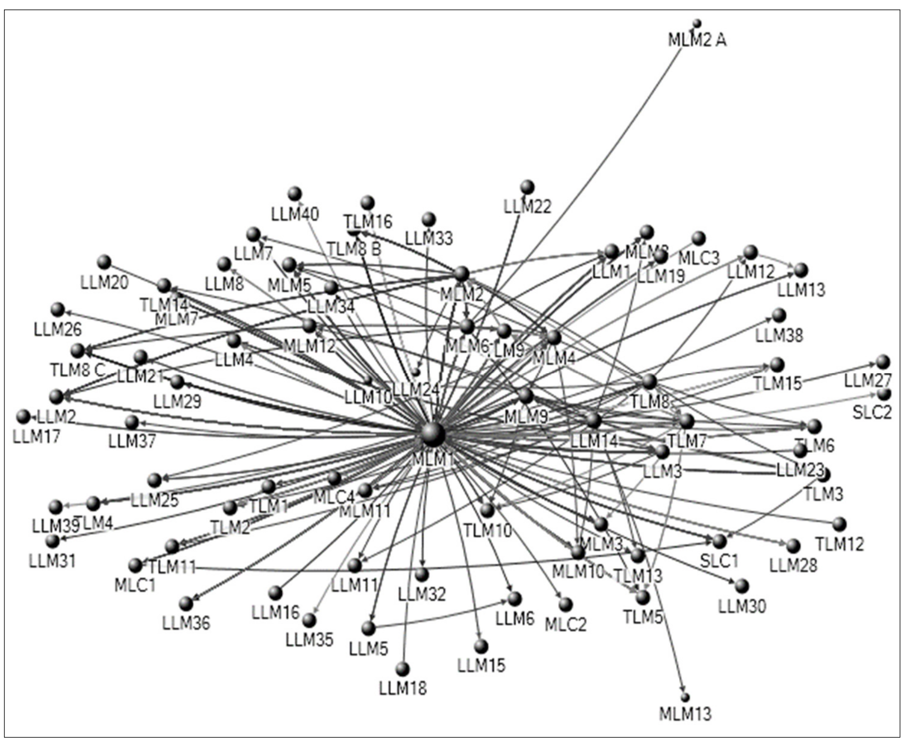


Figure 9 Project network structure established to develop a new strategic framework (created using NodeXL version 1.0.1.251)

6.2.1 Setting up the network for new testing technology development

During the initial idea discovery stages for the first case study (as illustrated on the end of this section Figure 11a), the network was characterised by the number of direct ties pointing towards the graph's central point. The development of the connections in the later stages of the same venture (Figures 11b–11g) were replicated, and the network pattern was defined. In practical terms, this connection arrangement occurred due to repeated attraction, facilitated through a discussion on new technological ideas in the relaxed social settings of the actors (nodes) who had already expressed their interests. This interest was also stimulated by the firms' strategic intent, as the manufacturer requires the advancement of technological solutions to rapidly identify product quality problems; this identification work can occur only through time-consuming, expensive laboratory tests. The electronics company sought partners to help them expand their analytical concepts for faster testing processes in a future market. A focus on market gaps led to network actors offering their expertise in the second case study. Their method was achieved through frequent and intensive face-to-face informal and spontaneous meetings, typically following technological exhibitions where actors could obtain qualitative information from these individual(s). These meetings add a personal dimension to the process, as the following observation notes indicate (observed after technology exhibition; Germany, Jan 2013):

'Participants enter the restaurant and sit down around a prepared table. Both of the manufacturer's representatives (a technologist and manager) sit opposite the product manager, who represents the electronics firm. The initial talk begins with the menu, but when participants begin to eat, the conversation turns to the difficulty of developing testing technology in the industry […]. The (product manager) explains that the instrument could work only if the measurement and results reflect the production process. Thus, from that perspective, it is necessary to have someone work closely with the process to develop it. The technologist commented: "It will take us 12 months to convince people […] as it seems they (other firms) do not have time for set-up and development, so it will work for their process and product." When he said that, the manager answered: "No, we are serious about it; we have a group of people from production, technical, and external R&D that will help us to develop it." Shortly after that statement, the technologist added, "I am very

excited about it." The product manager commented that the discussion demonstrated all parties' willingness to further understand the technology.'

Figure 10, Restaurant where representatives from manufacturing and electronic firms obtain information

Time is required for actors to develop meaningful relationships based on mutual respect and supportiveness, which facilitate the first stage of development: the discovery of technological options. With a lack of substitutes to hold and strengthen relationships, such as immediate financial benefits, actors begin to replicate known meeting processes to attract more actors, who become aware of new technical options and this technology's impact on the market. Thus, central network actors who become entrusted by firms lead both firms to the design stage, in which they communicate about the individual benefits of this technology's development, as well as expert ideas for manufacturers' product specifications, physics, programming, and construction design to determine prototype concepts. Technology ideas were shared through informal conversations and questions with chosen actors in the community. The interested actors then followed up on these conversations and utilised their skills and expertise to challenge development at various levels. It is noteworthy that discussing these ideas in relaxed social settings became a pattern in this project, rather than focussing on a comparative review of effective ideas by experts who could easily and more quickly identify the most promising technology options. Therefore, encouraging actors to share their ideas without intimidation led to intra-organisational group thinking, and built further personal relationships and a commitment to long-term development, as Figure 11 reveals.

'[…] The process engineer entered the operations manager's office. He greeted him, then sat down and asked: "So, how was the meeting?" "Very good," replied the manager, and he began to explain the details of process engineering. The process engineer listened carefully, and when the manager finished, he asked, "By the way, can you send me the last test results?" He explained that he would like to analyse the results, adding, "I didn't want to ask about them during the last technical review meeting because (name) had already questioned them […]." "Of course, I will send them to you now," the manager replied, "but let's look at them together, and you tell me what you think."' (observed at manufacturer site in UK, June 2014)

The results indicate that the project participants who accepted the benefit of developing long-lasting relationships offered more for both companies than those with short-term ambitions to run the process more effectively, even with a negative impact on relationships. Thus, actors became more involved in the network's development and the decision-making process within this network; consequently, the development process becomes more time-consuming and resource-intensive.

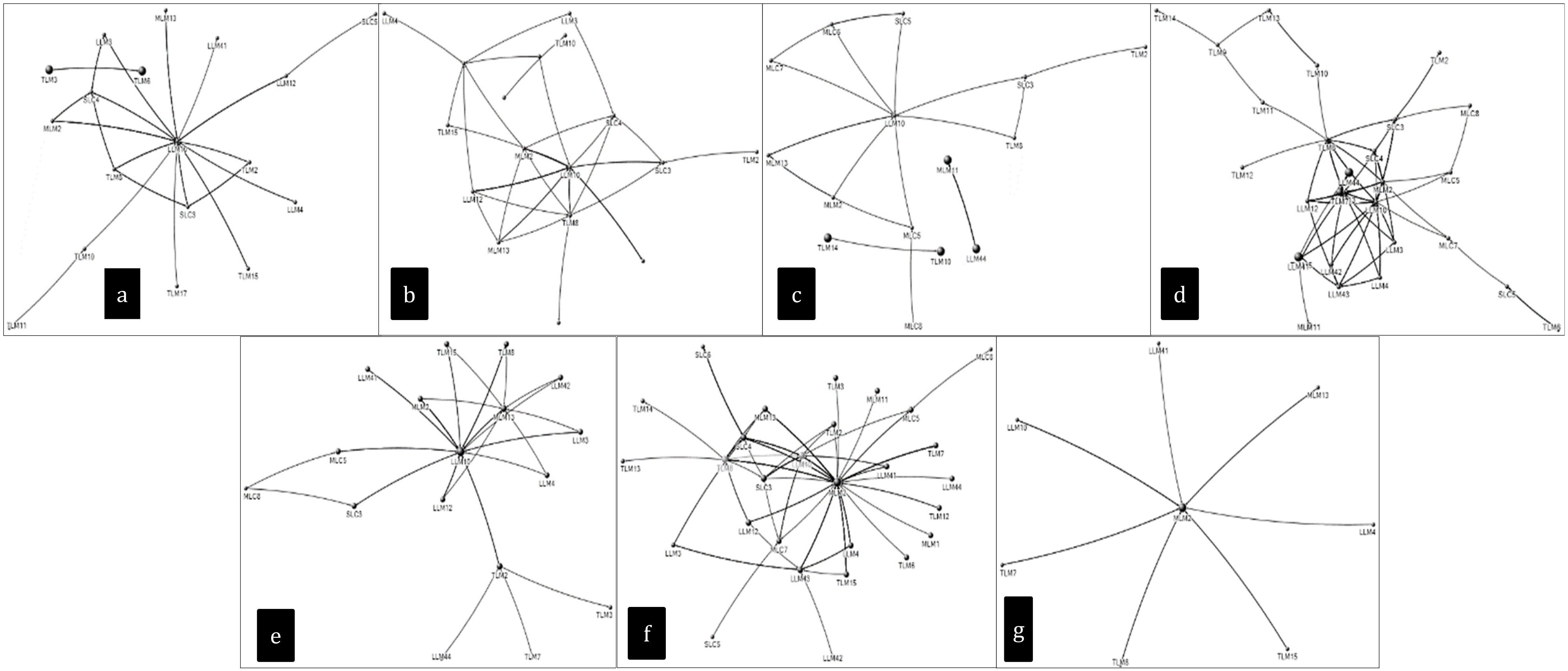


Figure 11 Evaluation of project network structure across the development of new testing technology in four-month intervals, November 2013 through November 2016(created using NodeXL version 1.0.1.251) – data in Appendix I

Table 17 Evaluation of project network structure across the development of new testing technology – types and characteristic

Figure		**Type**	***Characteristic***
10	**a**	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.
	b	Clustered Network (Community clusters)	Network with tendency of vertices to create a group with dense connections but sparser connections between groups. Indicate a existence of experts group.
	c	Fragmented Network	Ecosystem where network become fragmented e.g. breaking or being broken into fragments. Indicate existence of not connected and coordinated flow of information
	d	Clustered Network (Community clusters)	Network with tendency of vertices to create a group with dense connections but sparser connections outside of the group. Indicate a existence of experts group.
	e	Clustered Network (Community clusters)	Network with tendency of vertices to create a group with dense connections but sparser connections outside of the group. Indicate a existence of experts group.
	f	Clustered Network (Community clusters)	Network with tendency of vertices to create a group with dense connections but sparser connections outside of the group. Indicate a existence of experts group.
	g	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.

6.2.2 Network effect on new testing invention and development arrangements

While this inbound communication pattern dominated the network, it also established a central agency that influenced the idea-screening and development processes. The measure of the 'betweenness' centrality provided additional insights into this mechanism. One group, composed of more than eight experts from both firms (LLM10, MLM13, MLM2, SLC4, SCL3, TLM8), appeared to interact more frequently and tended to be more connected to all participants. This higher betweenness centrality for those actors, as compared to the second case study, had a significant information availability advantage over the peripheral actors. Consequently, the group with more frequent interaction and superior connectivity had more timely and complete information access than actors with lower betweenness but faster access to those in the network through a higher closeness centrality (0.016).

Thus, the process of absorbing, verifying, and decoding knowledge from different actors also led to the natural establishment of various roles and responsibilities, which were mutually accepted by the companies and network individuals involved in the project. This volunteered affiliation to the project was observed during design meetings, in which the network's central actors led the participatory design process and demonstrated information exchange between actors (through e-mails), as illustrated by a higher clustering coefficient in the network (0.333, Table 16). Consequently, when a new idea was proposed from outside the central network group, actors preferred to jointly evaluate it through their pre-established relationships. They perceived this as leading to a predictable development path, with a shared understanding of development goals. Additionally, the actors did not force a discussion with these external connections on any new ideas, as they focussed on using the current actors' competencies and capabilities. This prioritisation is explained in the below correspondence between network actors:

'After discussing with (name), our new product development director, I confirmed that you have direct access to our factory through me for technical issues regarding the initial design specifications. Do not hesitate to contact me with any questions […]. I will search for R&D or tech support if I do not have the answer. […] Before any of our resources can be assigned, we need some type of joint development agreement for (the technology

subcomponent) document, or at least a memorandum of understanding (MOU). Such a document should cover not only the scope of the work on the technical side, but also all commercial and financial issues."' (from email correspondences, April 2015)

The joint management arrangements for development, such as the MOU, ensure that development projects for new testing technology involve actors from both companies and that various expertise and practices were recognised and considered. However, accepting technical options from peripheral actors becomes apparent in the specific selection of ideas prior to designing the stage problem, as noted in the following example:

'After a few minutes of explanation, the technical engineer stopped him and started to explain why he would like to have the option to transfer data between new equipment and planning systems. The IT specialist became nervous and began to gesticulate with his hands, raised his voice, and explained that he did not want any new ideas because processes become more complicated. When he had finished, the technical engineer asked him, "So what is the problem?" The IT specialist replied, "Listen. Of course I can do that, but first, I must speak with (names) […]. We have a good relationship with […], and for them, that requires further software modification."' (from observation at manufacturing site, UK, May 2015)

This example demonstrates that new ideas from peripheral actors could disturb initial development concepts by enabling their rejection from further investigation. Therefore, rather than risk options that may provide future value, the actors decided not to disturb established relationships that supported their network's position. Thus, an inability to debate the trade-offs between new and viable options, or the poor performance of these options, as our results indicate, led to the acceptance of pre-established options. This experience was influenced by the network's central agency and led to more collective work between central actors, which was favoured by network closeness; the median closeness centrality was 2.4 times higher than in the second case, and the median clustering coefficient was 1.8 times greater (Table 16)

Table 18 Testing of technology activity and its effect on network

<table>
<tr><th>Actions</th><th>Implications of network structure patterns</th><th>The network structure's effect on the innovation process</th></tr>
<tr><td>Focussing on technology envisioning or a technological gap analysis, which required diverse actors' input and expertise during the idea-generation stage, rather than an evaluation matrix, in which a narrow expert group compares ideas with a set of organisational criteria</td><td rowspan="4">Bring in temporary project actors between organisations and separate them from institutional logic, creating a 'virtual' organisation.

Allow them to form more connections between ideas to produce a denser network structure.

Elevate the importance of actors' knowledge and their perspective on what is important to develop compared to the initial specifications.</td><td rowspan="4">Ideas and technological options have been jointly evaluated in detail by the network's central actors to steer the project into a more iterative, incremental, and evolutionary process. More connections in the network establishes a pattern of relationships, and the actors' instead focus on detailed technology propositions rather than the further exploration of novel options.</td></tr>
<tr><td>Opening volunteer affiliations (partner of choice) to attract new members that are not (or should not be) related to the development subject, rather than restructuring to bring a more effective idea-screening process from technical experts</td></tr>
<tr><td>Promoting casual conversation between individuals to present and discuss ideas, rather than legitimate joint meetings between firms to evaluate the acceptance of new technology options during concept testing</td></tr>
<tr><td>Partnering development using embedded actors' competencies and capabilities, rather than new expertise from peripheral actors during the technology installation process</td></tr>
</table>

As Table 18 summarises, this network infrastructure promoted information-sharing and collaborative work across the firms and parts of the businesses, with a higher ratio of reciprocated vertex pairs in the network. The central actors co-owned the solutions that created more velocity in the execution of their work and the cross-pollination of ideas. However, the network also promoted locking in their preferences for new ideas from peripheral actors and novel solutions from outside the network centre, which led to the implementation of ‘safe’ technological options that did not further maximise project value.

6.2.3 Opening new relationships for the creation of a strategic planning framework

The second case contrasts the first case study, in that the former was directed from the start by the company's senior managers and shareholders. The manufacturing firm changed its organisational structure to support the development of a new strategic planning framework and created a new managerial position, development coordinator. The person in this role reported directly to the managing director responsible for plan formulation and implementation (Figure 12a, placed on the end of this section). With additional time, resources in the form of an external consultancy firm established external links with industrial organisations, which could incorporate more knowledge into the process and maximise its benefits (Figure 12b). The development coordinator officially announced this initial OI venture stage through information sessions, e-mails, newsletters, and meetings to a large number of actors both inside and outside the firm, including divisional managers and union representatives involved in the joint activity.

The development coordinator discussed the initial concept with a greater number of actors to generate commitment and a greater number of ideas for the venture (Figures 12c to 12e) and to expand the network. The development coordinator individually e-mailed a larger group of management and staff-level actors within five different divisions and two senior consulting groups, suggesting a one-hour meeting to discuss ideas. The individuals received a list of questions to guide the discussion a few days before the meeting to understand how firms establish direction, build capability, manage performance, and execute strategy, as the development coordinator explained:

'I'm starting to think about the discussions with shareholders, consultants, and management, down to the shop floor's supervisory levels […]. As a part of these meetings, I want to conduct a verbal questionnaire. I'm hoping to obtain some good feedback so I can begin to gauge understanding and appetite, particularly in these critical areas […].'
(from interview with strategy coordinator, Jan 2013)

The attendees at this meeting prepared an agenda and questions—such as 'How can we better align the business?'—and invited discussion on limiting and restricting solutions or discovering potential new options that could become a part of the framework development. However, the conversation in practice often shifted toward actors' future requirements and generated radical ideas for the business, such as a plan to be developed around employees' well-being, and not just growth. This began to shape initial proposals for a new strategic framework. After nearly 50 individual meetings, the proposal offered a greater number of diverse options, but at the expense of a competent selection to keep pace with this increase in options. Thus, actors' opinions across the network were polarised, which hindered the creation stage. Too little attention was paid to the holistic quality of the strategic framework proposal, which was urgently required, as the development coordinator explained:

'We need this clarity, as without it I will go mad and become disillusioned; I totally agree, but feel a little lost just now!'(from interview with strategy coordination, October 2013)

However, the circulation of new ideas produced more direct outbound network connections toward its peripheral actors (Figures 12c to 12e), with actors' increased commitment to work on idea selection and implementation. As this process did not produce better results, the development coordinator decided to improve the situation by organising a consultation group. This included firms' management personnel and representatives from two consulting firms (Figure 12f) to screen the ideas generated in the previous process. This would decrease the number of connections within the network, but increase network density compared to the previous stage. The development of new connections would be similar with the use of electronic communication. The coordinator explained the primary goals:

'The initial proposal for the agenda concerns a review of the existing content and the filtering of new suggestions […]. I am sure the agenda will develop over time, but it's a start. The idea is to have short, regular meetings to review where we are with this new process and where we can go with it.' (from email correspondence between strategy coordinator and external consultants, May 2014)

The decision to engage with only a small group of chosen actors (TLM6, TLM3, MLM5, TLM7, MLM10, and MLM5) led to fewer network nodes (Figure 12g). However, an increase in the network density correlated with an increase in the number of weekly meetings, in which participants were assured that all of the development plan's aspects were addressed before any work was executed. These frequent sessions began with listing existing and new suggestions, narrowing them down to propositions, and evaluating them through questions as to the 'who', 'what', 'where', 'when', and 'why'. However, this type of meeting creatively solved issues unrelated to the framework, such as specific technological issues or challenges within human resource departments. The mechanism increased central actors' commitment to the development project and the exchange of information, and particularly between the firm and one of the consulting companies, but left previously engaged actors on the network's periphery. Consequently, only a few actors contributed to the framework's creation at the implementation phase (Figure 12h) as they were external in origin, as explained in an interview with a production manager:

'*The plan takes place in areas that had not been agreed upon and advised by the actual owner of that area. […] There was no asking of 'What needs action in your area?' or 'What matters to you?"'* (from interview - secondary data – conducted by strategy manger, March 2014)

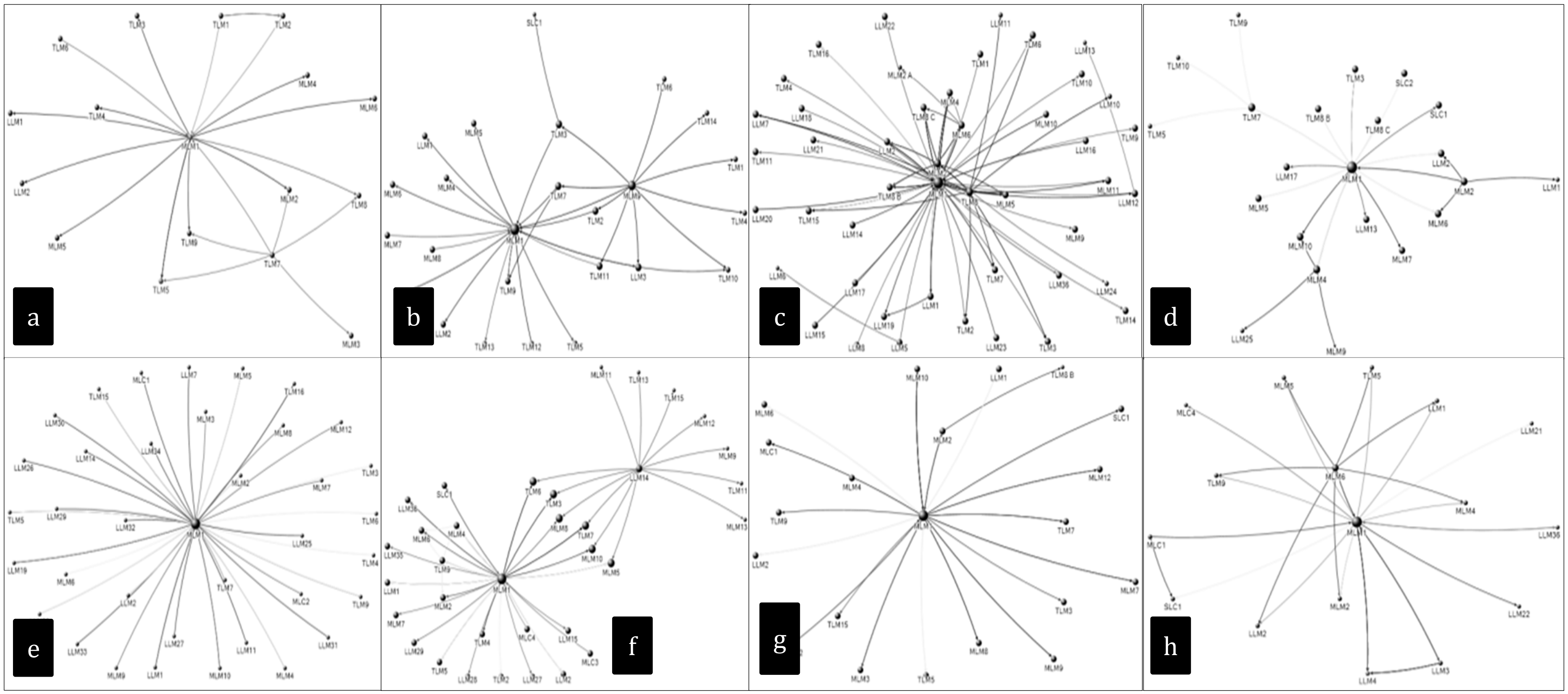


Figure 12 Evolution of project network structure across the development of a new strategic framework in four-month intervals, December 2012 through December 2015 (created using NodeXL version 1.0.1.251)

Table 19 Evolution of project network structure across the development of a new strategic framework - types and characteristic

Figure		***Type***	***Characteristic***
11	**a**	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.
	b	Polarized Crowds Network	Ecosystem where network become divided e.g. breaking or being broken into two or more groups. Indicate existence of controversial topics and ideas but do not connect to actors in the "other" group.
	c	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.
	d	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.
	e	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.
	f	Polarized Crowds Network	Ecosystem where network become divided e.g. breaking or being broken into two or more groups. Indicate existence of controversial topics and ideas but do not connect to actors in the "other" group.
	g	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.
	h	Support Network (out-ego and spoke)	Ego type network - consist a focal node ('ego') and the nodes to whom ego is directly connected to (called 'alters'). This type of network support coordination of information that is delivered by focal node to alters.

6.2.4 Consequences of the network pattern on extreme idea-seeking and connection during idea-screening and implementation

As the development coordinator's outbound communication became prevalent in the network, participants tended to wait for the coordinator to initiate discussions and further development steps, instead of generating and stimulating interaction by participating to connect new ideas and options. This did not mean that actors in the network were not engaged in the development process, as they offered their ideas in isolation when requested. Our observation suggests that when the network's 'owner' did not support an idea, the actors did not exchange their opinions because it was easier for them to explain what could be done to the coordinator and leave their ideas for someone else to materialise, as explained below:

'Participants come to the weekly meeting […], and after a few minutes, the development coordinator and one of the consultants begin to explain a number of issues to participants that require management. The participants listen for over 10 minutes, and after that, a manager changes the subject and asks participants: "So, where is he? Is he coming?" Then, one of his colleagues replies: "He is still on the phone. I think he has an urgent call from (name). He said that we can start without him by reviewing the progress following the agenda, and he will join us when he is finished." A manager suggests, "Well, let's wait for him; he will tell us what he wants us to do."' (from observation, June, 2015)

This arrangement created difficulty in stimulating relationships between participants that could lead to more trusting and open conversations. Network actors could not problem-solve in real time, but switched to thinking only about big ideas. Ideas offered in isolation promoted major changes to the initial framework concepts, as they would constantly reinvent often overlooked business areas, such as sustainable issues or intangible assets, including patents and business methodologies. While these were important for individual actors, they disturbed the framework-development process. This disturbance naturally increased divergence between network actors' goals, which required trade-offs between their interests (for example, consultants delivering solutions in the required time period versus the firm searching for a correct solution).

Thus, the ethnographic results for this case suggest that limited personal contacts impede the trading of development options (ideas). As a result, choices were not made, such selection and realisation of ideas, which led to unintended network reduction (Figures 12a to 12h). It is noteworthy that the development coordinator, as the network's central actor, could not influence decisions regarding the ideas to be implemented, as most of the network's actors had different opinions and did not want to support new, externally available options. Ultimately, the development coordinator decided to terminate the project after discussion with the managing director and company shareholders, as he explained to the network actors:

'Thanks go to a number of you who have attended each week; the enthusiasm and commitment you have demonstrated is appreciated, but we seem to end up having the same conversations. We are attempting to propose a number of great options, but there is the feeling that we are pushing against each other's ideas, such as what we want and what we believe is important. I am acutely aware that this is neither an efficient use of your valuable time, nor is it moving our project forward.' (from email correspondence between strategy coordinator, internal and external actors taking part in the project, July 2015)

In summary, such an egocentric network pattern was not conducive to idea connections, but promoted idea discovery. Most ideas were far-reaching and required more effort from actors, and particularly from the development coordinator, to connect them in one comprehensive strategy. As with the first project, our observation revealed that a compromise between different interests and new valuable development options became the chosen tactic and resulted in a reduction in the available options and a smaller network.

Table 20 Actions within a new strategic-framework-development project and their effect on the network

<table>
<tr><th>Actions</th><th>Implications of network structure patterns</th><th>The network structure’s effect on the innovation process</th></tr>
<tr><td>Amendment of the manufacturing firm’s organisational structure to support the effective coordination of knowledge transfer between firms and individuals</td><td rowspan="4">The development coordinator effectively becomes the network’s central knowledge broker to develop relationships with the firms’ management, staff, experts, and consultants.

This coordinator connects with a significant number of actors over a short period of time for their experience, knowledge, skills, and ideas to design a new strategic framework model.</td><td rowspan="4">Promotes more control over the project’s conceptual and technical feasibility phase, and favours an outcome-oriented environment in which the focus is on results, rather than on the process

Allows for the generation of ideas and options for new strategic planning in framework development

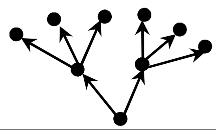
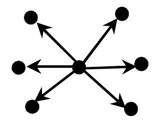
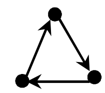
Steers the process toward a more disruptive path to find novel solutions and options</td></tr>
<tr><td>Frequent circulation of information about project objectives to selected actors during the idea-generation stage</td></tr>
<tr><td>Promotion of reflection-type meetings, in which individuals consider their most relevant options, issues, or challenges that require change during the project’s idea-screening phase</td></tr>
<tr><td>Mobilisation of actor attachment to develop an implementation plan by forming a consultation group</td></tr>
</table>

6.3 Sub-question 3, discussion and conclusions

I have explained in this study that project networks change over time, but they are likely to evolve in a predictable pattern. By observing two NPD project cases, I distinguished three different strategies that could lead to the development of those patterns (Table 21) and potentially offer distinct benefits to explain how similarly embedded NPD projects could function in practice. Therefore the findings contribute to recent project network studies (Artto et al., 2016; Matinheikki et al., 2016; Hellgren & Stjernberg, 1995), which have so far examined networks only at one point in the time, by studying network formation (evolution) as a process. I first propose a replication strategy; I define replication as a project network-formation strategy, in which actors embed themselves in the network and recreate the same interaction formula to attract more actors. These actors become aware of the detailed requirements for new technology, and maximise their use of expertise and the skills necessary for idea connection. These actors also stimulate joint activities when problems arise.

First case study involved technology envisioning with a focus on partnering and small-talk, which led to a denser project network. This encouraged the development of personal ties and more frequent conversations through favoured spaces outside of institutions. Additionally, project actors were temporarily separate from the institutional logic promoting the 'virtual' organisation and some degree of organisational autonomy. Various actors could contribute their specialised expertise to the project. This structure developed and was supported during the idea-screening and development stages, which established links between different technology options that were further evaluated by a greater number of project actors. I observed in these stages a more iterative, incremental, and evolutionary process. However, such a participant-governed project can reduce the inflow of new ideas. This reduction was apparent during the technology testing's industrial implementation phase, which maximised projects by linking a complete set of controls and tests offered by new technology with the planning system.

Table 21 Strategies affecting project network structure

Replication	Dissemination	Affiliation
		

Second proposition involves a dissemination strategy; I explain dissemination as a project network-formation strategy in which development activities and information are tailored and targeted for an intended and identified audience. This was explained in the second case by the development coordinator, who was the central actor. This strategy was enacted by intensifying information, holding joint reflection meetings, and stimulating individual electronic e-mail conversations that flowed from one source to a number of actors across firms and disciplines. Additionally, this strategy is supported by observation of frequent network actor mobilisation through the arrangement of pre-contact meetings, surveys, and procedures; the allocation of responsibilities; and the creation of lines of communication during the project's implementation. The lead actor (i.e. the network ego) governed the network and connected the internal organisation with the external environment; this was particularly effective during the idea-seeking stage and for new strategy framework options. However, the strategy did not offer benefits regarding the verification of new knowledge and further implementation, as the exchange of information did not allow for the effective combination of different options between various network participants.

Finally, last proposition involves an affiliation strategy ensured through an official research agreement, such as a joint development agreement. This created possibilities for individuals to join the project, which was technically unrelated to the subject of technology development and testing. This strategy promoted the development of responsibilities and involvement within the network for increased reciprocity between actors. The first project's exchange of an MOU between the manufacturer, the electronics firm, and external R&D centres ensured the arrangement of resources and knowledge between these firms. Opening up volunteer affiliations with the project during its establishment attracted various actors. Such an experience increases the involvement and energy of actors to drive more evolutionary development processes, as the prioritising of ideas and determining what to develop will jointly evolve as the project progresses. However, I believe that solely focussing on this strategy can offer an increase in small, close-knit groups within the networks (cliques) that do not readily allow others to join, and thus, may degrade the value of emerging options at the expense of simplicity in the process, decreasing the benefits of OI.

Based on those findings, I suggest that NPD projects networks should start with an ego-centric pattern to boost creativity and generate new ideas and should then be changed to more dense structure that allows creativity to be enhanced. I also explain that a project network is an important tool to connect the inside of the organisation (i.e. intra-network) with its outside (inter-network), something that is rarely discussed in studies that examine the impact of social networks on innovation and NPD (Leemders & Dolfsma, 2016). In other worlds, successful process and project development requires effective arrangement of external ties and a smooth internal network to allow the firm to integrate the externally acquired knowledge into its own process. I find that in practice this integration is achieved by a project network facilitated by activities such as technology envisioning, strengthening volunteer affiliation, promoting casual conversation, amending organisational structure, and establishing a consultation group. The results show also that once the network is created in the front-end stage, actors on the network have difficulty modifying it to make it more effective.

Therefore, based on this findings, I explain that the innovation process has more potential when the project network's relational and structural elements match the NPD project's distinct needs. I add to the project network literature by suggesting that actors should activate different network characteristics at the appropriate moments in the NPD project's daily activities. Such an arrangement should also reduce tensions between project control activities and *ad hoc* solutions (as identified by DeFillppi & Sydow, 2016). For example, managers who intend to support radical innovation should focus on preventing the formation of sub-groups that may accept ideas in favour of generating development options that challenge and change initial requirement perceptions. This intention can be realised by establishing a network that activates a formal position. Additionally, managers who intend to support the incremental process should consider activities that support informal networks, such as partnerships using embedded actors' competencies and capabilities to encourage links across formal, conventional channels. However, managers should consider activities that promote the legitimation of responsibilities and involvement to promote a network formation that exchanges mutually beneficial expertise and skills. Thus, I recommend that future studies should focus to understand better not only how but also when network structure must be changed to bring knowledge, ideas, finances, and other resources from ‘the outside’ into the firm, where they need to be routed to the right place at the right time.

The study also highlights that OI naturally increases the likelihood of divergence between the goals of actors within the network who try to connect the inside of the company with its outside, as they are unlikely to be perfectly aligned. However, remarkably, we did not observe a jointly produced, mutually valued outcome (co-creation) in the value-creation process for either of the studied projects, even in the case of an emergent, denser network. I instead experienced a process affected by many trade-offs between actors’ interests or the traditional notions of competition and value capture, and their perceptions of what is important for NPD ventures, such as their expectations for value creation and distribution. Thus, the illustrated ‘ego’ network form did not result in the lead actor (development coordinator) obtaining precisely what was needed from the project. For example, the manufacturer’s employees collaborated with the electronics firm’s teams to incorporate planning elements for a new testing technology to increase development value. Therefore, I add that future project network studies should consider investigating how value is generated in project networks. Determining how different perspectives on values are accommodated and which values should be prioritised is critical to predicting how managers will respond to NPD projects and the maximisation of OI benefits (Bresnan, 2015; Morris, 2013).

7. Examining how values are priorities when opening up innovation activities

7.1 Introduction

Whereas Chapters 5 and 6 have explained when stakeholders are engaged in OI and how they develop a network of relationships, this chapter highlights the reality of the OI process and the divergence of interests (traditional notions of competition and value capture) and perspectives on what is important while seeking the new solutions (expectations of value creation) (see Adner, 2016) offered by various employees, contractors and third-party firms involved in the process. Thus, as the future of OI is more extensive, more collaborative, and more inclusive of a wider variety of participants (Chesbrough 2017), there is a growing need to understand how tensions related to different values (see Zobel and Bogers, 2014) can be handled. Hence, this chapter aims to explore such processes and discuss how they can be improved to realize the full potential of OI (see Reypens et al., 2016, and Kazadi et al., 2016).

Therefore, Section 7.2 discusses three different strategies to apply in these processes: accommodating requirements during concept testing (Section 7.2.1), designing a mutually beneficial outcome during technology-testing optimisation (Section 7.2.2), and pursuing the unique development of effective technology implementation during the integration phase (Section 7.2.3). The final section in this chapter presents a summary of findings revealing that value prioritisation can be achieved through a series of trade-offs and analyses between stakeholders that allow them to identify relative gains and losses in the implementation of different options.

7.2. Results

7.2.1 Accommodating requirements variation(s) during concept testing

The beginning of the joint-development-work between the electronics firm and the manufacturer created contradictions related to rules within the activity system and its objectives. The conflicts were brought to the fore by disturbances and dilemmas occurring during technology-concept tests, stimulated by the different requirements of various project actors (Table 22 and 23, Figure 13).

The manufacturer designated a working group including process engineers, a technical manager, a operational manager and a purchasing manager to establish initial criteria for technology development (i.e. technology specification). The group came to work with a high-tech electronics company offering expertise related to the design and engineering of testing equipment. The same company, by virtue of its business type and experience, promoted effective technology design and integration. Thus, the project manager and product manager who came to work with the group forced a structured project management approach with clearly assigned roles, deadlines, and objectives for the development of the specification for the tests. With confidence from previous projects, such a method of project management has was seen appropriate and was implemented by the electronics firm, due to resource constraints for the project. this approach, combined with the manufacturer's processes and material expertise produced initial development responsibilities for the concept testing. Therefore, the electronics firm role was to guide the development and build the technology. The manufacturer's role was to bring its product and process expertise to interpret the results and later to understand how the technology could be further improved to analyse nano-impurities within the produced material. However, the manufacturer, in contrast to the electronics firm, had more resources from across different disciplines dedicated to the project, and this variety of expertise influenced what and how testing would occur to assess whether technology would advance the current testing process.

From that point, the whole collaborative process was affected by divergence in perspectives on what is really important for the various parties. The conflict began when external R&D consultants from another form, involved in the project by the manufacturer, began to advocate more bolt options for wider range of defects to be identified through the testing. This proposition expanded the venture's goals and increased the cost the electronics firms had to agree to if it wanted to continue to participate, but it also increased the duration of the development, because it required more work to improve testing sensitivity and further technology calibration methods for various materials, not before envisaged by either party. From the other side, the manufacturer opted for the low-risk option of focussing on very precise and quick identification of limited defect types that was needed to improve the production process. This scope for the collaboration required less development work and lower costs but did not generate enthusiasm among R&D experts towards working on something that would not give them research value. Thus, this controversy impacted activity progress to the point that individuals representing the electronics firm began to complain about their partners' unstructured approach to development. Such tension caused delays in activity. Hence, deciding upon the technology specifications to prove the concept was a challenge for the group and created disturbance among its members. The electronics firm decided to delay the design and development of the project plan in order to wait for the manufacturer's specification to try to balance R&D requirements with existing process needs. As a consequence, running the project through the electronics firm with the aim to keep everything on track conflicted with the existing working arrangements between the manufacturer's firm and the external R&D firm.

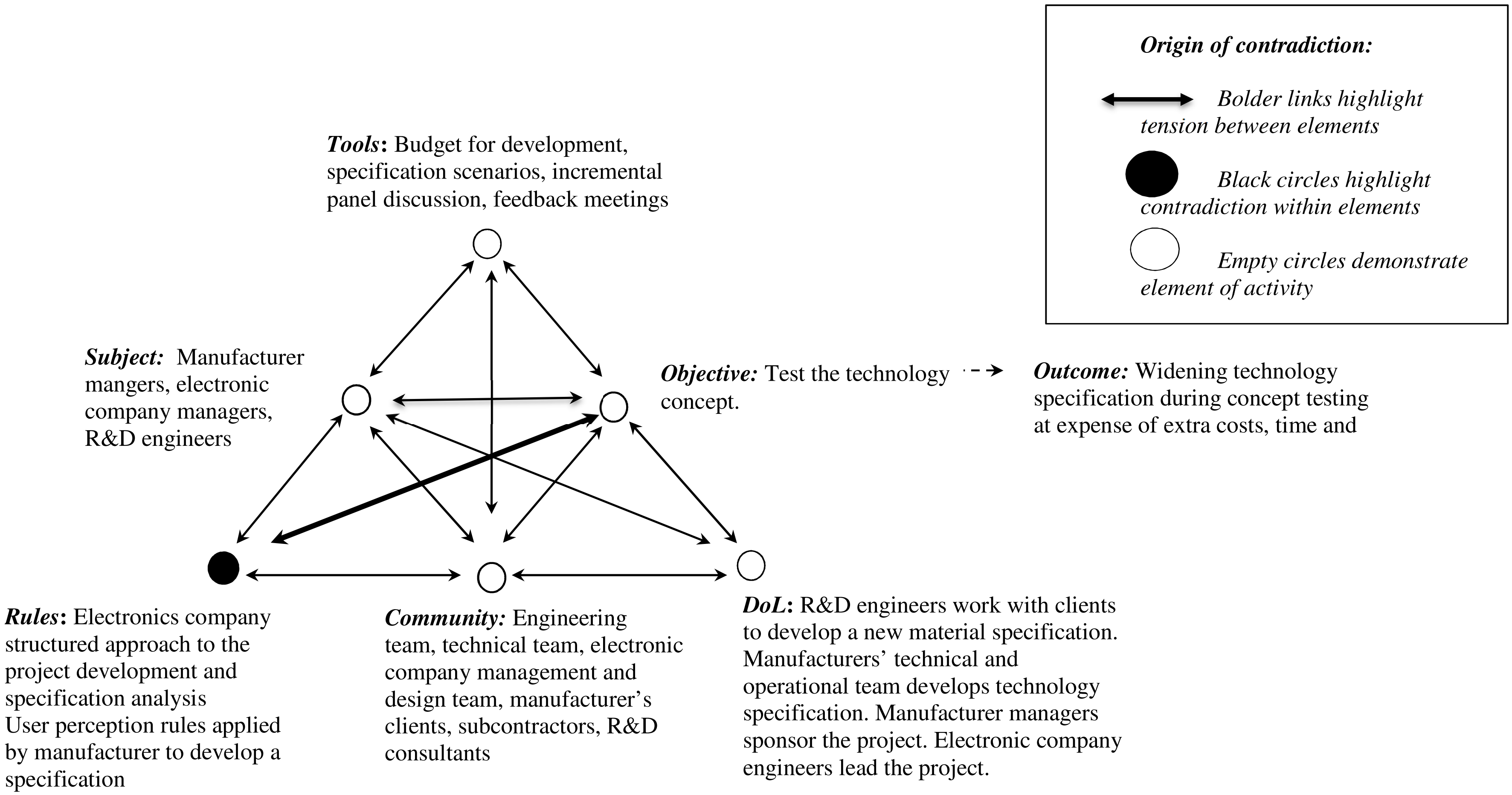


Figure 13 Challenges and responses in concept testing

To improve the situation and organise development work, both firms decided to work together to develop specification scenarios, which helped both sides to choose and agree on technological options to be used to evaluate the acceptability of a new technology idea. This strategy was use to embrace the conflict through promotion of incremental panel discussion between the interested parties, helping to clarify and organise the decision-making process. Although the intent of this form was clear, opening up the discussion allowed more actors within the manufacturer's site to express their opinions about technological specifications. For example, the manufacturer's technical department defined quality categories and detection limits required to be identified by the technology and engineering department to propose a place for equipment installation. However, from such experience emerge another tension within the activity. The building offered by the engineering department was affected by transportation-related source vibration, however, so the sensitivity of the technology measurements meant may affect test results. Therefore, the plans for technology installation required further investigation to find alternatives. In consequence, the electronics firm propose to lower (due to lack of specification) technology reading sensitivity, to test the concept on time.

Table 22 Results of values trade-off process during new technology concept-testing activity, part 1

<table>
<tr><th>Activity</th><th colspan="2">Tensions</th><th>Value example from manufacturer's point of view</th><th>Value example from Electronics firm's point of view</th><th>Value example from R&D point of view</th><th>Value component</th><th>Value foundation and logic of worth</th><th>Action</th><th>Results</th></tr>
<tr><td rowspan="3">New technology concept test</td><td rowspan="3">Within activity rules</td><td rowspan="3">Difference between electronics firm management approach to run the project and manufacturer process that promoted users' perception to lead the development</td><td>Work agreement with R&D group to improve own product</td><td></td><td></td><td>Commercial Relationships</td><td>Economic</td><td rowspan="3">R&D experts lead the decision-making process and prepare plan for concept test</td><td rowspan="3">Widening equipment specifications during concept test at expense of extra costs, time, and resources</td></tr>
<tr><td></td><td>Role of electrical firm to solve designing issues and guide the development process as a leader in the field</td><td></td><td>NPD Know-how</td><td>Functional</td></tr>
<tr><td></td><td></td><td>Objective to contribute to new technology development in order to guarantee work continuity</td><td>Collaboration continuity</td><td>Economic</td></tr>
</table>

Table 23 Results of values trade-off process during new technology concept-testing activity, part 2

Activity	Tensions		Value example from manufacturer's point of view	Value example from Electronics firm's point of view	Value example from R&D point of view	Value component	Value foundation and logic of worth	Action	Results
New technology concept test	Between Rules and Activity Object	Difference between electronic Firm requirements for concept test and R&D request to widening technology specification for initial technology evaluation	Bringing metal product and process expertise into the project			Material Know-how	Functional	R&D experts lead the decision-making process and prepare plan for concept test	Widening equipment specifications during concept test at expense of extra costs, time, and resources
				Desire to minimise cost of technology development and maximising profit by collaborate with manufacturer and R&D group		Cost reduction	Economic		
					Desire to develop technology that improve understanding of particular defect formations and allow on further material improvement beyond market requirements for everyone involved	Appreciation	Emotional		

Concerns and tensions occurring during specification development activity were finally addressed by allowing R&D experts to lead the decision-making process and prepare the plan for concept testing. When guiding the decision about technology specification for the test, R&D experts still based their opinion on intuition (e.g. future customers' demand); however, they also have the vocabulary to rationalise those intuitions better than any other parties involved. They became more active and often promoted their options as best for development directly to various stakeholders. That allows those experts to prepare and test the concept according to theirs reqirments. However, such decisions meant that R&D experts led the activity and amended the initial agreement of responsibilities between the electronics firm and the manufacturers within the project. The electronics firm had to accept 'small losses' such as development delays and extra costs related to design, but also the role of project co-ordinator. The manufacturer had to accept similar changes to specifications, which eventually reduced the speed of defect identification. For R&D, then, this situation was allowed to extend work agreement with the manufacturer and widen the technology specifications for further material testing.

7.2.2 Design a mutually beneficial outcome(s) during technology concept optimisation

The decision to enter collaborative work with a precise idea of what has to be developed generated multiple conditions within the activity systems, triggering new issues to which both firms had to conform (Table 24 and 25 on the end of the section). Work to develop the technology to the point that it could be industrially test first required improvement of its detection sensitivity and method of calibration. Both of these adjustments required more detailed plans for how to avoid signal overflow to measure required materials' impurities, setting-up new algorithms to produce reliable results and calibration samples for the initial technology set-up and testing to prove the concept. The developments of those elements enabled future technology implementation within the manufacturer's operational process, which allowed the concept to be moved forward to the pilot stage.

In this context, increased detection sensitivity and the method of calibration were crucial for both firms and became a new object of the activity system (figure 14). However, to make progress towards the objective, the electronics firm envisaged further requirements for detailed information from the manufacturers' products, under the scope of the firm's intellectual property (IP) rights. At this point in the process, the team that represent manufacturer was not keen to disclose the required product know-how to protect genuine business assets integral to the core services of the business and its overall long-term viability. Also, partners who assisted the electronics company with research and development of the technology explicitly began to avoid producing samples required for the calibration due to uncertainty about the materials' specifications. Calibration of the new technology done on the inexact samples produced by the firm could affect the reputation of the firm, which depends on its products' quality. Additionally, to understand fully the technology calibration, the electronics company was required to share with manufacturers' team the latest solutions for algorithm calculations that, when combined with the manufacturer's expertise, could lead to testing improvements. As those were not yet protected by any form of IP rights, however, the electronics firm decided to not share it. The firm did want to dilute the value of new features by giving such options to its partners and not get anything in back. These experiences generated less enthusiasm toward optimising the technology, but also gave rise to another contradiction with regards to division of labour within the activity system.

The manufacturer's team was split, on the one hand, into technologists who opted for formalising the venture by introducing further joint-agreement contracts between the firms and, on the other, the management team who decided to avoid shared ownership and control of the project. The technologists' explained that joint-intellectual agreement is a fair solution for all parties involved in the technology calibration activity to share the costs and risk of the research and development work and its results during technology optimisation. By contrast, the management team argued that signing such agreement at this stage of the process would not have any value, because the technology had not yet demonstrated its ability to measure the required defects, and they would like to avoid detailed product information disclosure at this stage. Therefore, to embrace the situation, the team of technologists was asked to plan an alternative method of materials testing that, in comparison with the initial lab tests, could demonstrate potential capability of the equipment and constitute a platform for opening up the transfer of know-how between parties.

However, six months later, the technologist's team representing the manufacturer travelled to the electronics company's R&D headquarters to discuss potential technology capability and mitigate risk related to further investment in the development, in light of new tests results achieved by an alternative verification method. During the series of technology presentations and technical and marketing meetings, both companies focussed firstly on technological strengths that were attractive for the manufacturer in the first place, such as the possibility to detect material defects faster than currently accessible methods. During those meetings, a technologist, with the approval of his manager, decided to communicate sensitive information: material critical for improvement of detection sensitivity would be offered by the manufacturer in return for advanced algorithm to measure the size of the defects, which might allow a better understanding of particular defect formation during the production process. These value exchanges of technology subcomponents allowed the project to remain attractive for further development. The manufacturer received additional testing options in exchange for sensitive information that would allow electronics company to optimise equipment optic system, which could be applied to their other products.

A further compromise was struck to keep working collaboratively on the development when manufacturer agreed to consider sharing knowledge and expertise from industrial testing that, in the longer term, might lead to possibilities for publications that the electronics firm could use to market its product. These exchanges gave clearer ideas to both parties about where the development might be going to and helped build trust and relationships between the partners. Such exchange of values also accelerated work between parties towards increasing technology detection sensitivity and preparing the calibration method for initial tests.

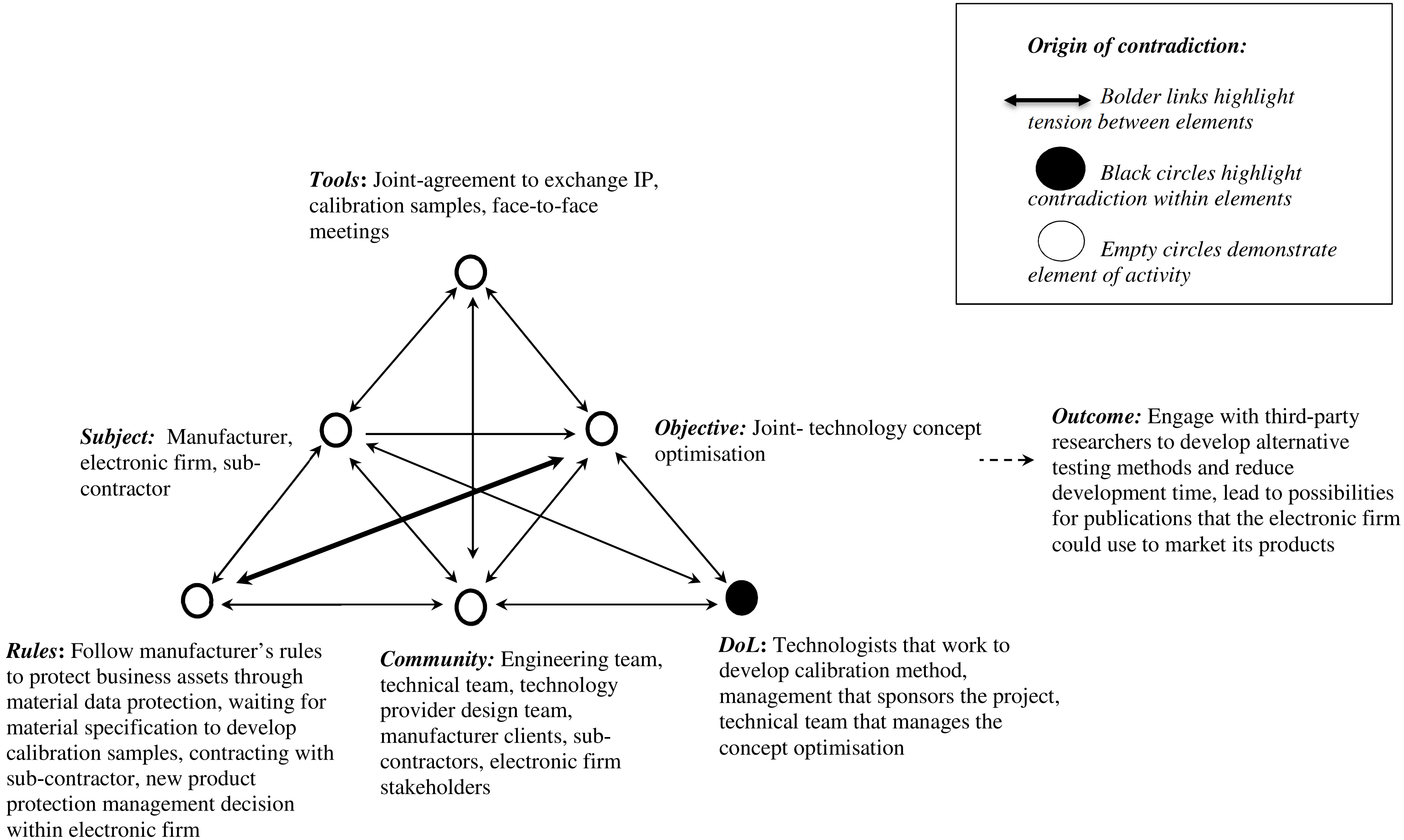


Figure 14 Challenges and responses during work towards increasing technology concept optimization

Once value of joint-technology development for the both companies was re-defined, further action was taken to finalise the proof of concept. The manufacturer established a lead project engineer role to test the equipment and organise its implementation in the industrial process. The role had multidisciplinary character, to understand other issues related to the development that were either overlooked or not seen in the front-end stage of the project. To save time, the manufacturer also decided to seek expertise outside of the organisation to develop an alternative laboratory-method of material testing to prove the technology concept. Subsequently, two other separate links were established, one with the external technical consultation group and another with a UK university to accelerate technology-concept optimisation. Furthermore, the electronics firm created a new position for a research scientist to work more closely with the manufacturer's team to understand its expectations and provide necessary solutions for concept optimisation. Both companies formulated and signed an NDA that allowed them to separate the different parties' control of IP concerning technology, based on their vested interests.

Finally, achieving mutually beneficial outcomes allows them to complete the concept optimisation process. Once detection sensitivity and calibration was improved and technology testing finished, the new object of the activity system was to design technology integration with the manufacturer's industrial software and hardware systems. A key point at this stage was to get archiving capabilities from the technology software and hardware to allow the off-line backup of a large store of analysis results. Not having these capabilities would block full introduction of technology in the industrial testing phase. Due to the high number and frequency of industrial tests and a lack of data storage for the results, this become problematic for both firms, because of the requirement for technology modification and accommodation of extra costs. Recognising this issue, manufacturer began to leverage its own industrial IT capability to find a solution.

Table 24 Issues and actions during works towards increasing technology detection, part 1

<table>
<tr><th>Activity</th><th colspan="2">Tensions</th><th>Value example from manufacturer’s point of view</th><th>Value example from electronics firm’s point of view</th><th>Value example from sub-contractor’s point of view</th><th>Value component</th><th>Value foundation or logic of worth</th><th>Action</th><th>Results</th></tr>
<tr><td rowspan="3">New technology concept optimisation</td><td rowspan="3">Between rules and activity object</td><td rowspan="3">Following organisational rules and regulations did not allow for effective know-how transfer in order to improve the concept</td><td>Long term business viability more important than short-term gains from collaboration</td><td></td><td></td><td>Profit</td><td>Economic</td><td rowspan="3">Exchange is critical to improve detection sensitivity: materials’ characteristics exchanged for advanced algorithm measuring size of the defects; a lead project engineer role is established to optimise the equipment and organise implementation in the industrial process; a non-disclosure agreement (NDA) is formulated and signed.</td><td rowspan="3">Concept optimisation leads to discussion of sharing expertise and knowledge from the industrial testing, leading to possibilities for publications that the electronics firm could use to market its products</td></tr>
<tr><td></td><td>Desire to make profit on new algorithm when collaborate</td><td></td><td>Profit</td><td>Economic</td></tr>
<tr><td></td><td></td><td>Realise calibration samples that fit requirements and lead to concept optimisation</td><td>Reputation</td><td>Symbolic</td></tr>
</table>

Table 25 Issues and actions during works towards increasing technology detection, part 2

Activity	Tensions		Value example from manufacturer's technical team's point of view	Value example from technologists' point of view	Value example from manufacturer's management point of view	Value component	Value foundation and logic of worth	Action	Results
New technology concept optimisation	Between rules and activity object	Lack of agreement within manufacturer DoL on working arrangements with electronics firm	Develop further agreement to share increasing costs and risk of concept optimisation and its results.			Relationship management	Economic	Exchange is critical to improve detection sensitivity: materials' characteristics exchanged for advanced algorithm measuring size of the defects; a lead project engineer role is established to optimise the equipment and organise implementation in the industrial process; a non-disclosure agreement (NDA) is formulated and signed.	Concept optimisation leads to discussion of sharing expertise and knowledge from the industrial testing, leading to possibilities for publications that the electronics firm could use to market its products
				Keep the technology development attractive for involved partners		Personal driver	Emotional		
					Aim for stable and low-risk assignment to maintain project costs	Profit	Economic		

7.2.3 Pursuing unique development over effective technology implementation during integration phase

Working alone in this area, the manufacturer created an improved design that also assists the firm in efficient determination and selection of the most appropriate production order. Such an amendment to original plans allowed the manufacturer to maximise the utilisation of its machines and increase process yields. However, this benefit required further work to integrate the planning software with the new testing technology. Therefore, the manufacturer's requirements became conflicted with the original technology development plan, which did not offer such capacity. This new option required software modification by the electronics firm to accommodate testing technology integration with the manufacturer's planning system and consequently gave a rise to contradiction between subject and tools (Figure 15). The manufacturer's industrial IT and planning teams clearly saw the potential benefits of technology software modification as an additional source of value for its own business, but the electronics company's management was not prepared to modify already pre-developed software due to the minimal potential benefit (in their eyes) and extra development costs associated with such a unique design.

Furthermore, such an extra development option was not covered in the MOU exchange by the firms and lead to another impasse. To address this new manufacturer requirement, electronic management agreed to offer additional direct access to the factory in order to assist with technical issues related to the software integration and to extend this access to the IT division group to answer information about its design. However, the manufacturer's management also requested to explore and explain what commercial and financial gains they can expect from such design, before entering specific improvement talks. Thus, the proposal for further technology improvement became a new outcome of the activity system, targeted to suppress the pursuit of the manufacturer's design. Shortly after this development, however, the manufacturer requested detailed instructions and the passwords for the correct installation of all software instances, including servers, to begin its own work on integrating the technology. That decision increased cost of development, since the manufacturer absorbed the costs of external resources to facilitate the integration of both technologies.

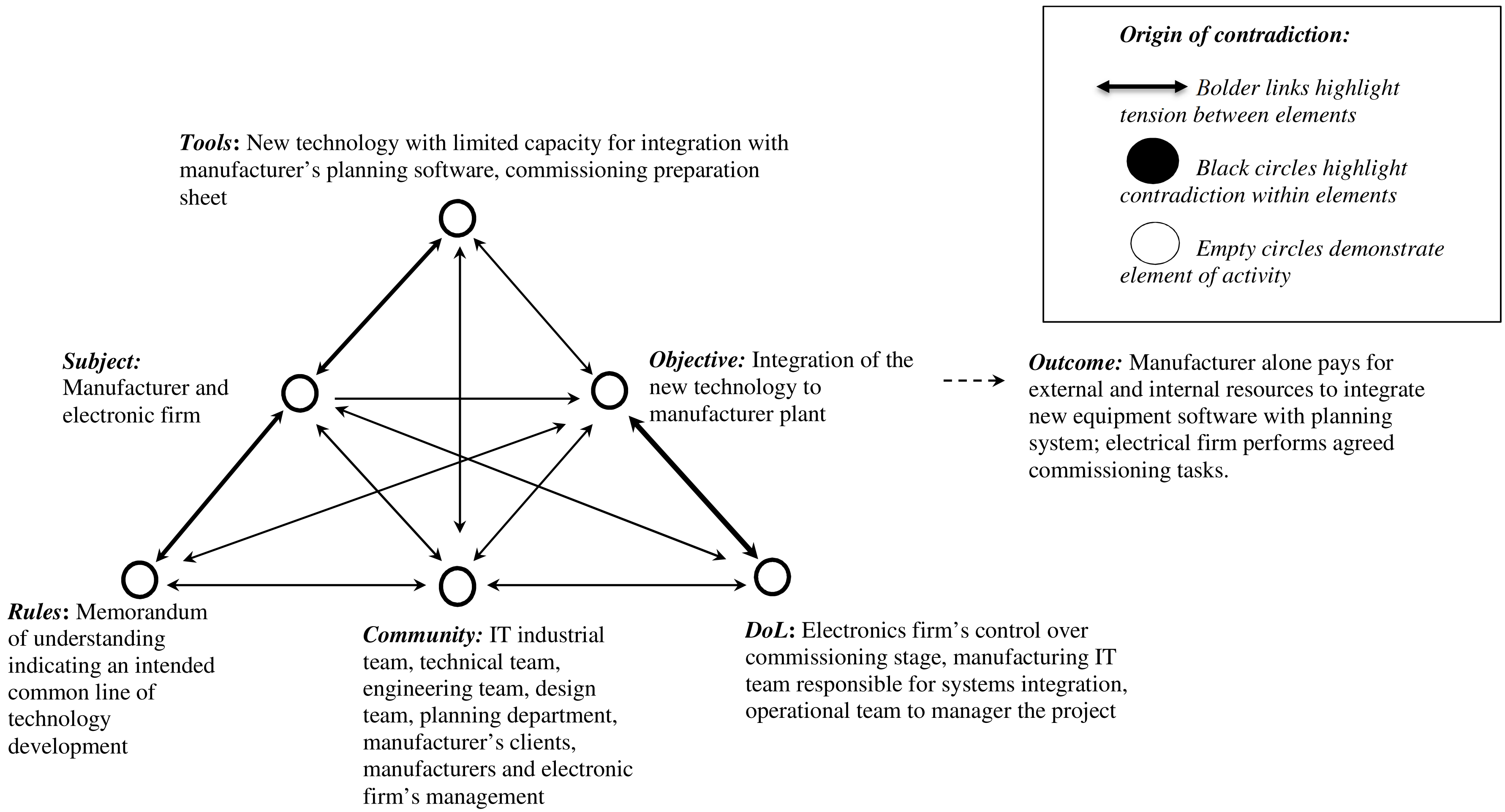


Figure 15 Challenges and responses during technology integration to manufacturing plant

The manufacturer's IT engineering team examined the specifications of electronic firm technology software and proposed to share the raw results from the technology directly to own servers. The results were then accessed by a prototype application developed by the manufacturer to create and optimal production order within the planning software. The manufacturer's IT team could thus simulate exactly the characteristics of their intended design, allowing the electronics firm to fully understand what the end user (i.e. manufacturer's planning team) expected when both technologies are integrated. Once demonstrated, the option became more attractive for the venture partners because it lowered modification costs (manufacturer already developed prototype) and was accepted to be driven by the manufacturer's experts. That allow the manufacturer to further improve business operations over the long term.

However, the decision to integrate both systems created another contradiction with regards to the activity system's division of labour (Table 26, placed on the end on this section). The standard design typically gives the electronics company full ownership and control of the effective process of assuring the systems and components of a newly developed technology are designed, installed, tested, operated, and maintained according to specifications. However, because an integration of testing technology with planning software was forced by the manufacturer, the specifications were altered to disallow the electronics firm full control of the commissioning process, as was initially planned. Although the firm acknowledged the manufacturer's wish to integrate testing technology with planning software, it remained sceptical about it and further delays occurred, related to integration tests and unclear responsibilities when problems arose with integration, especially those outside of the electronics firm's expertise. The firm then proposed to establish a commissioning phase with an engineering representative from manufacturer's IT group. To avoid delays and further issues, during the integration stage, the companies used a commissioning preparation sheet in which they clearly defined responsibilities during technology implementation, plans for pre-operational hardware, software and network testing, and escalation procedures when any technological issues occurred.

In consequence, the manufacturer's staff who worked during the commissioning stage became heavily involved in the process to resolve issues related to testing technology and planning-software integration. This increased involvement created additional costs related to longer working hours for IT and engineering staff and further technology software modification. Engineers from the electronics firm, however, limited their work only to agreed tasks and did not take active part in the integration of both systems, leaving that to the manufacturer's staff. Finally, because difficulties with this integration activity caused delays, the commissioning manufacturer decided to stop the work on systems integration in order to make the technology operational. This decision was welcomed by the electronics firm and allow to on following an original integration plan. Thus, our results suggest that, co-production of a new technology was not done through finding a shared solution or jointly resolving a problem but by suppressing the manufacturer's unique systems development to prioritise effective technology implementation.

Table 26 Issues and actions during technology integration within manufacturer's IT system

<table>
<tr><th>Activity</th><th colspan="2">Tensions</th><th>Value example from manufacturer's point of view</th><th>Value example from electronics firm's point of view</th><th>Value component</th><th>Value foundation and logic of worth</th><th>Action</th><th>Results</th></tr>
<tr><td rowspan="4">New technology integration within manufacturer's process</td><td rowspan="2">Between subject and tools</td><td rowspan="2">Manufacturer's requirement to integrate new technology to support planning system conflicted with intended equipment design</td><td>Realise technology integration that fits wider business context and can to improve manufacturer's operation</td><td></td><td>Recognition beyond initial project expectation</td><td>Symbolic</td><td rowspan="2">Manufacturer prototyping software application that allows demonstration of intended design and benefits for electronics firm</td><td rowspan="4">Manufacturer works alone on systems integration, and electronics firm limits itself to work specified in the agreement commissioning tasks</td></tr>
<tr><td></td><td>The unique option developed by Manufacturer is not a goal in the project but nice addition to technology that should not be continue due to higher costs and further project delays</td><td>Profit</td><td>Economic</td></tr>
<tr><td rowspan="2">Between DoL and object</td><td rowspan="2">Systems integration work conflicted with the commissioning rules</td><td>Desire to integrate systems that will be appreciate within manufacturer's business</td><td></td><td>Appreciation</td><td>Emotional</td><td rowspan="2">Creating commissioning preparation sheet to clearly define responsibilities during technology implementation</td></tr>
<tr><td></td><td>Objective to commission the technology effective on time and budget to have a reference plant</td><td>Reputation</td><td>Symbolic</td></tr>
</table>

7.3 Chapter summary

This chapter, demonstrated that both companies were required to invest much effort into working around different design expectations, team priorities, changes related to firms' interests, and technological limitations when jointly developing new testing equipment. Therefore, dealing with value-related tensions was a central challenge for both firms when working together on technology development. During such a process, extra benefits were created by widening the technological specifications that allow R&D firms to improve material analysis and maintain a work contract with manufacturer. Also, gaining access to the manufacturer's material and process knowledge allowed the electronics firm to optimise its engineering solutions for testing applications. This benefit also allowed the manufacturer to expand its knowledge about defect formation during the production process. Analysis of this process informs the current management literature on value creation during the innovation process and comprises compelling evidence that such a process is achieved through a web of interdependent social relationships.

Additionally, this study adopts AT to explain how value-related tensions have been handled in practice, by tracking activity transformation rather than analysing only outcomes. This emphasis on process has allowed to enrich recent studies from Reypens et al., (2016) and also Kazadi et al., (2016) to explore the value-creation process beyond the exchange of knowledge. The chapter conclude that tensions and contradictions related to value emerge not only during the initial stages but also across the innovation funnel. Those tensions are related not only to economic value but also to emotional, symbolic, and functional dimensions. Therefore, I argue that value (creation) in an innovation scenario means different things to different stakeholders. To be productive, stakeholders (organisations) should disclose how they define value and what steps can be taken to maximise value creation according to their conception of value. The results reveal that such a determination is achieved through series of trade-off analyses that allow participants to identify relative gains and losses in the implementation of different options.

However, such a process does not necessarily lead to win-win situations allowing all involved parties to continually benefit while developing new technology. Instead I demonstrate that innovating with multiple stakeholders simultaneously leads to numerous trade-offs that may cost them a 'small losses' while they pursue novel solutions. Accepting development delays and increased costs over development of additional technological features by electronics firms has been a prime example in this study. However, transparent processes that the involve loss of one value to gain another, we argue, can force firms and individuals to recognise new opportunities and value-assessment improvements that are not normally considered (e.g. systems integration). However, to fully benefit from such situation, managers must identify these trades-offs with care and approach them managerially rather than in an *ad hoc* manner, as I illustrated: for example through the use of more conscious choices based on a rational method of making compromises (e.g. concentrating on an objective's overall importance), conducting the easier swap first and seeking reliable information.

Moreover, explained case study shows that when value-related tensions begin to feel difficult for participants, most participants lower their expectations and consequently underestimate the benefit of innovation. For example, the challenge of widening technology specifications led the electronics firm and manufacturers to the decision to lower measurement sensitives that allow them to test ultraclean metal. However, as I point out in this same example, R&D employees who persisted with the proposed specification not only realised it, but also ensured that the sensitivity of the technology was improved. Similarly, during the planning of the industrial testing perseverance, the manufacturer and the electronics firm's exchange of critical knowledge led to benefits for both parties and increased innovation value. Additionally, clear persistence to suppress work on manufacturer's unique design during the integration phase allowed to finalise project according to original plan, so both firms could realise gains from it. Thus, how paradoxical tensions affect actions of various stakeholders during innovation process is an avenue for further research.

Finally, handling value-related tension generally requires a host of complementary changes to the rest of the activity system. In this study, the rules and division of labour were amended to allow the pursuit of activity. A company, department, or team without an ability to change the division of labour will not be able to make trade-off decisions and maximise value from OI. Thus, even with a clear OI strategy, but without the flexibility to change the activity system, different partners can easily halt the development process. Sales managers may focus on the pressing needs of the biggest customers. Operation heads may concentrate on their targets and on particular costs pressures. Scientists in R&D tend to see opportunity in new technologies. This divergence in interests and perspectives is critical to successful innovation. However, without embracing the tensions between those perspectives, the power of diversity is blunted or, worse, becomes self-defeating.

8. Thesis summary

8.1 Introduction

In this final chapter, I summarise (figure 16.) the key findings of the research contained in Chapters 5, 6, and 7, so the reader will understand the implications of engagement application during the OI process (see Section 8.2). The focus in this chapter is also to explain a resulting framework that can be use at the manufacturing firm to organise engagement processes with employees, suppliers, contractors, and third-party organisations (see Section 8.3). Sections 8.4 and 8.5 highlight the theoretical and practical implications of this study, respectively, offering more effective engagement approaches and thereby fulfilling a primary objective of this thesis. In Section 8.6, the limitations of the research are explained. Section 8.7 details opportunities for the future research and presents some concluding remarks, which explain the importance of stakeholder engagement for the manufacturing business's short- and long-term aims.

8.2. Key findings of the research

As explained in the previous chapters, the AT perspective on the engagement process in intra-organisational innovation not only addresses a critical management challenge in practice on the level of application but also embodies scholarly interest in improvement of open (or distributed and democratised) forms of innovation (Chesbrough, 2017; West et al., 2014) and co-creation (Payne et al., 2008; Ryepens et al., 2016; Kazadi et al., 2016) and thereby broadens the scope of innovation studies and stakeholder engagement (Gould, 2012). This thesis, contributes to the understanding of how and when employees, contractors, and external firms are (or ought to be) engaged in intra-organisational context and what consequences applications of different engagement approaches had during two examples of new product and process development. It explains how temporary (project) networks are created later influence the radical and incremental development process. It also highlights that engaged stakeholders promote different values during co-creation activities that are not necessarily related to purely economic benefits, but also to social values and individual requests that often require a trade-off approach for stakeholders to continue joint work.

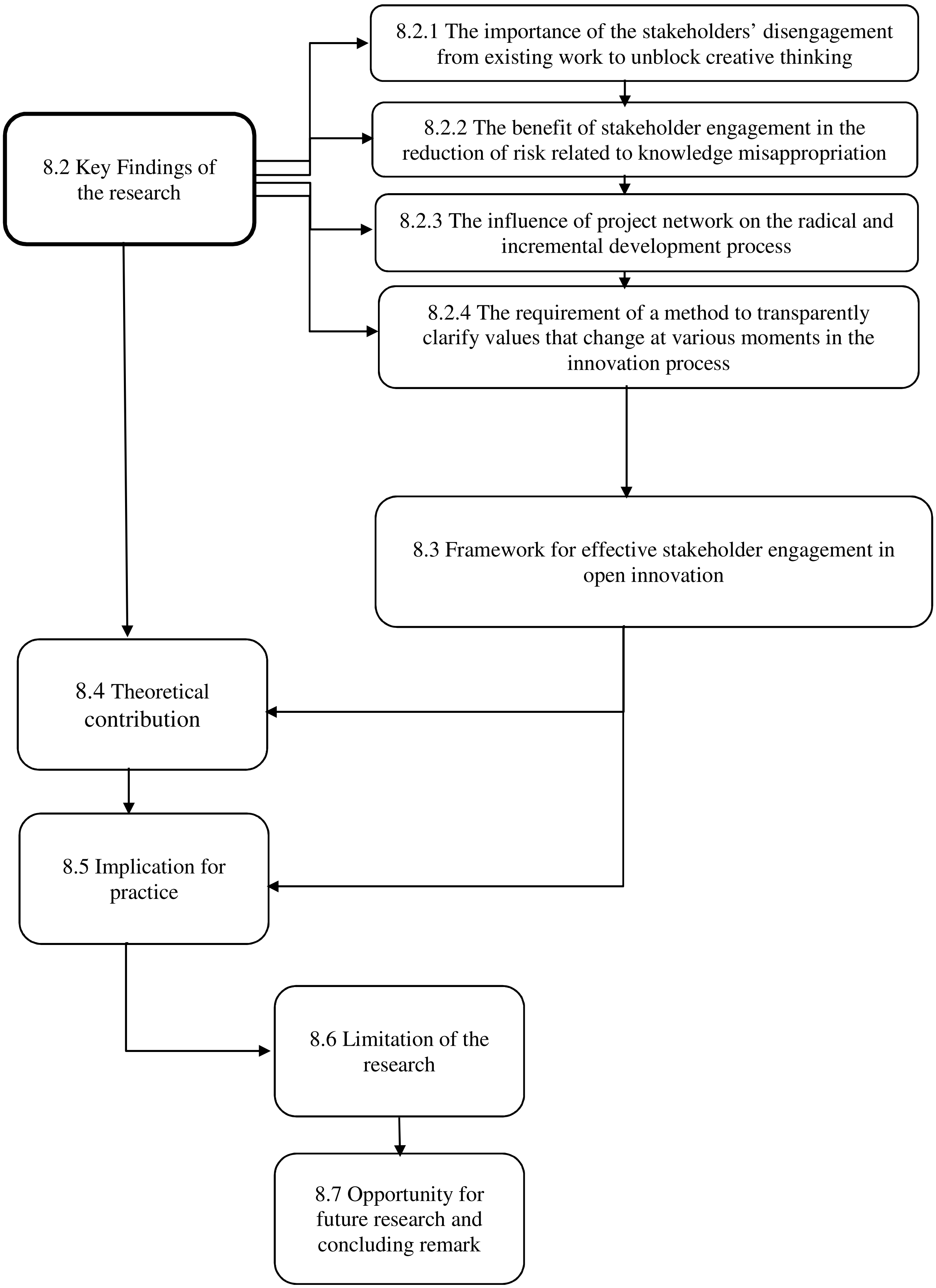


Figure 16 Chapter 8 overview

In conclusion, this thesis has argued that effective engagement in OI requires different elements: firstly, disengagement from existing work to unblock creative thinking; secondly, development of discourse channels to organise communication with stakeholders; thirdly, communication with network governance to clarify direction of relationship development; and finally, the requirement of a method to transparently clarify values that change at various moments in the innovation process. Below, I propose an elaboration on those key findings, so they can be fully understood in the context of a manufacturing organisation.

8.2.1 The importance of stakeholders' disengagement from existing work to unblock creative thinking

The importance of stakeholders' disengagement from the role, rules, and conditions that disallow them from creative and collaborative work implies that actors are more effectively involved in innovation activities when they are first disconnected from norms, places, and situations that block their ability to concentrate, think creatively, and make good decisions when co-creating value. The findings of thesis suggest that this disengagement could be achieved by creating 'places for innovation' where ideas can be turned into prototypes more effectively. Such 'places' should be open and accessible for the stakeholders during the innovation process. Thus, firms—especially SMEs—even through small alterations (and inexpensive changes) to the places where the development project is conducted can impact creative thinking, collaboration, and stakeholder satisfaction and facilitate the innovation process.

Additionally, such a 'disengagement' stage can also mitigate or resolve the 'non-invited-here' syndrome, because different physical environments from where the day-to-day work occurs encourage stakeholders to have more informal discussions. Such informal communication is free from the usual rules, regulations, and procedures and allows stakeholders to better understand their differences, consequently improving their relations and work as a group. Based on this observation, this thesis proposes that metal producers, and the UK manufacturing industry in general, pursue OI to invest their time and money, or at least to consider how the physical environment can be used by multi-disciplinary and inter-organisational teams during development projects. More specifically, these spaces can be foster more open conversation, idea generation, and relationship maintenance. The thesis also opens a new avenue for scholars who research innovation processes to consider other disengagement tools, such as humour, which allow actors to respond to paradoxes and tensions in everyday corporate life, as recently explained in an organisational study by Jarzembowski and Le (2017). Such tools can also be explored in maximising internal and external actors' creative thinking, involvement, and satisfaction when developing a new technology or services together.

8.2.2 The benefit of stakeholder engagement in the reduction of risk related to knowledge misappropriation

This thesis's findings also agree with the research of Gould (2012) **that assumes the benefit of stakeholder engagement in the reduction of risks related to knowledge misappropriation**. As this thesis suggests, when stakeholders are engaged, they build credibility through the transparent dissemination of data and knowledge. Thus, to reduce the risk of dishonesty or unfair use with regard to knowledge that can be taken advantage of in OI, an increase of relationships developed with augmented trust is needed. As explained in Chapter 5, efficient exchange of knowledge between stakeholders is not necessarily hindered by NDAs or letters of cooperation between involving firms, but rather by the slow development of social relations between stakeholders. Not having or not promoting such processes may reduce trust thus slow exchange of expertise between involved actors. Thus, business and technical knowledge characterises the relationship between stakeholders in the early stage of the development process (transactional relations), whereas the later stages of the same process are identified with stakeholder knowledge (social relations). As a result, companies with traditional business models that are less experienced with the OI process, such as metal producers, would benefit from investing in the training of their own staff beyond just technical know-how and skills. Moreover, it is beneficial to equip them with competencies that facilitate interaction and communication with others, where social rules and relations are created, communicated, and changed in verbal and nonverbal ways. As highlighted in this thesis, such engagement is usually not planned and rather happens on an *ad hoc* basis; such capabilities within an organisation are essential for innovation across firm boundaries, but they are often not recognised by firms that pursue and invest in technical knowledge.

8.2.3 The influence of project network on the radical and incremental development process

Temporary (project) networks are crucial, and as the analysis demonstrates, they connect the inside of the organisation with its outside. Such networks are created in the early stage of the development process, in idea seeking, but they may evolve through the process. As demonstrated in Chapter 6, promoting an ego-centred network quickly increases the number of ideas posed and the network's creativity, but denser forms of network lead to ideas verification and allow better control of the time and resources needed for the development process.

Consequently, this thesis argues that the innovation process has more potential when the project network's structural elements match the NPD project's distinct needs. For example, an ego-centred network should be promoted in the idea-seeking stage, whereas a denser network could be applied during the testing and implementation phase. Such findings add to project network literature by suggest that actors should activate different network characteristics at appropriate moments in the NPD project. Furthermore, those different network configurations may be applied to reduce tensions between project control activities and *ad hoc* solutions, as identified by DeFillppi and Sydow (2016).

In such a scenario, managers who intend to support radical innovation or maximise idea-seeking could focus on preventing the formation of sub-groups that may accept ideas, in favour of generating development options that challenge and change initial requirement perceptions. This can be realised by establishing a network that activates a formal position. Additionally, managers who intend to support the incremental process and focus on control of the process's performance could pursue activities that support informal networks, such as partnerships (participatory involvement) using embedded actors' competencies to encourage links across formal, conventional channels. To do that, managers should consider activities that promote the legitimation of responsibilities and involvement to form a network that exchanges mutually beneficial expertise and skills. Thus, we recommend that future studies should focus on better understanding not only how to govern the network but also when the network structure requires changes to maximise the effectiveness of idea generation or the performance of the innovation process and where the network's emphasis should fall at any given time.

8.2.4 The requirement of a method to transparently clarify values that change at various moments in the innovation process

Finally, the thesis explains how divergence of perspective is handled in practice, highlighting that engagement does not necessary promote a win-win situation for all stakeholders. Because the AT perspective tracks activity transformation rather than only its outcomes, it was possible to pinpoint in greater detail that the tensions within OI are not only related to economic value but also had emotional, symbolic, and functional dimensions, which can be either accommodated to continue joint-work or be dealt with by developing a unique requirements and reconciling differences through an exchange of one-value over another. Such an approach enriches, therefore, recent studies from Ryepens et al. (2016) and Kazadi et al. (2016) in exploring the value-creation process beyond the exchange of knowledge. The contradictions related to value emerge not only during the initial stages of ideas-generation but also are evident across entire innovation funnel. As a consequence, value creation in OI scenario, this thesis argues, means different things to different stakeholders. Thus, to be more effective in working with different actors, organisations and stakeholders could work to disclose how they define value and what steps they offer to take to maximise that value according to their definition. Better transparency in this aspect could be achieved through a series of trade-off analyses that allows one to identify relative gains and losses in the implementation of different options, which in practice are not clear and obvious, as the results in this thesis suggest. Additionally, managers should understand that such processes do not always lead to win-win situations that allow all involved parties to benefit while developing new technology continually. Instead, innovating with multiple stakeholders simultaneously leads to numerous trade-offs that may cost them a 'small losses' to continue pursuing a novel solution. For manufacturing companies, this sort of arrangement should be an essential element of innovation strategies, and therefore in such situation managers must identify these trades-offs seriously and approach them managerially rather than on an *ad hoc* basis. For example, managers can make more conscious choices, based on a rational method of making compromises (e.g., concentration on an objective's overall importance, making the easier compromises first, etc.).

In summary, the thesis explains how engagement between different actors occurs in practice, and how it is applied during OI both from theory and practice. Its key results contribute to better explaining stakeholders' engagement mechanisms and their effects on the innovation process. Moreover, those findings imply also that even if stakeholder engagement as an aspect of business has changed since Freeman's (1984) initial work, the changes in understanding effective engagement processes are in their application and sophistication rather than deviating from the basic premise of the discipline.

8.3 Framework for effective stakeholder engagement in open innovation

As identified by the analysis, to be successful, OI requires different application of engagement approach at different stages (figure 17, below illustrate the proposed framework). The engagement process involves listening, keeping stakeholders up-to-date with development information, and being clear about how their contributions are used. Clear expectations about ongoing work are also required, so a firmer understanding between stakeholders can be secured and so they can keep focus. Furthermore, transparency must be developed to reduce risk related to knowledge misuse. Thus, engagement with employees, contractors, and other external partners to develop new a new product, service or process is about shaping but also recognising and understanding the values, perceptions, and ideas, not just agreeing with stakeholders. Developing relationships that reflect this shared understanding enables differences to be acknowledged and expressed. As the objective of this thesis was to explain that more effective engagement in the OI context, in this section I propose, based on this thesis's results, a framework that may be used at the manufacturing firm where the research was conducted.

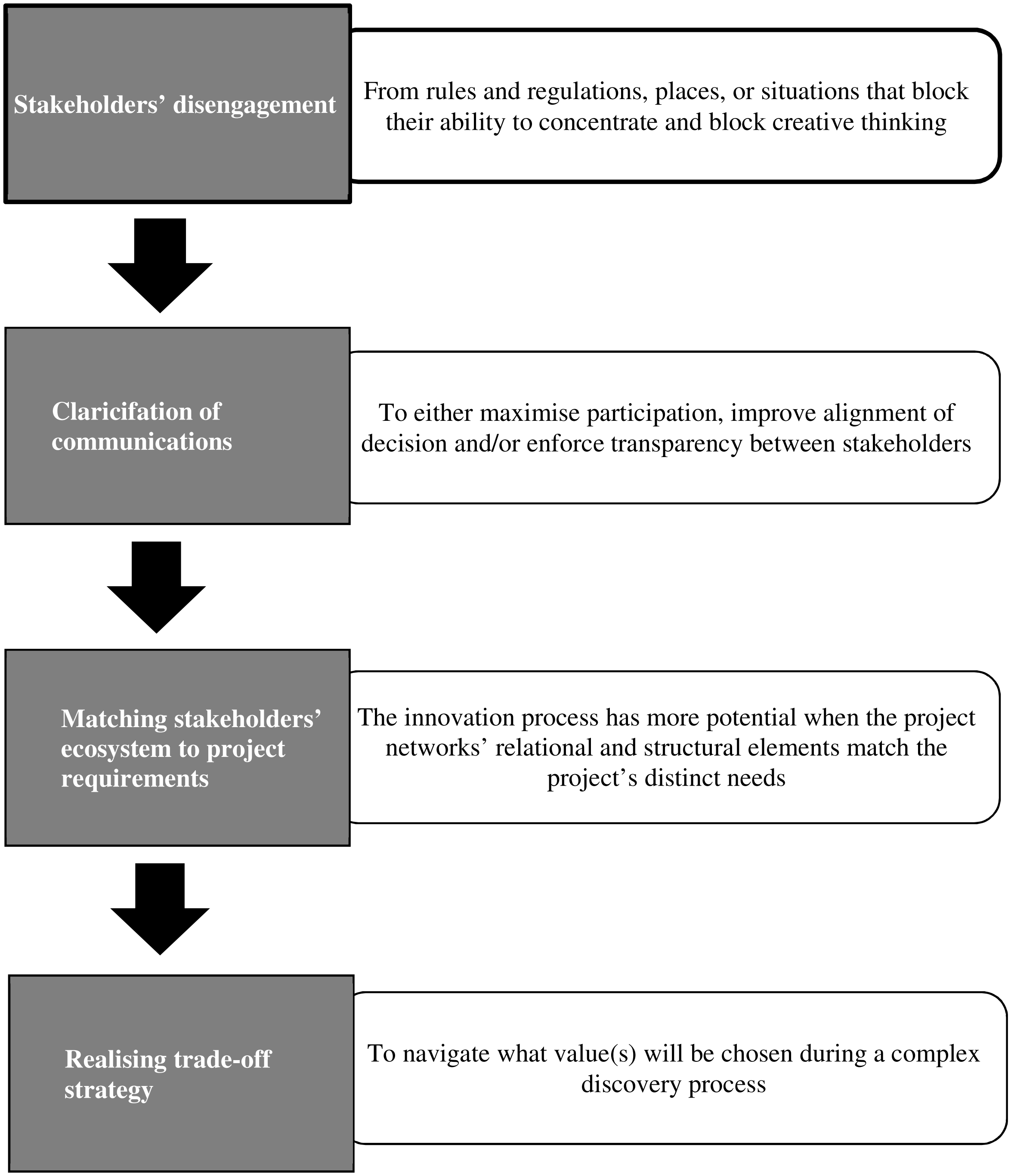


Figure 17 Illustration of the proposed stakeholders engagement framework

8.3.1 The framework

The framework below (Tables from 27 to 31) outlines how greater involvement of employees and external actors in discovering of new options can be achieved, including information about how communication with various actors can be developed, what tools can be applied to support communication, and how different arrangements of communication may benefit stakeholders' relationships. The framework also proposes various modes of network governance that allow managers to create a different temporary social system that may have various effect on different stages of OI. Finally, I explain trade-off strategies that can help managers to make better decisions when facing differences during the co-creation process.

The process includes four steps:

- The first, disengagement from rules and regulations that block creative thinking, can be achieved through distraction, rule changes, and the creation of a space for innovation.
- The second is development of discourse channels that help to clarify how stakeholders maintain relations. Evidence shows that such discourse can be developed either by participatory involvement, consultation, or collaborative information sharing, or some mix of the three.
- In the third step, network governance to coordinate the development of a temporary social system can be achieved by replicating interaction formula between stakeholders, disseminating information tailored to intended audience, and creating affiliations between selected stakeholders by establishing new rules and regulation before and during the development work.

Table 27 Stakeholder engagement framework summary, part 1

Engagement step	**Description**	**Engagement element (illustration from the case study)**		
Disconnection	To strongly involve actors in innovation activities is more effective when those stakeholders are firstly disconnected from norms, places, or situations that block their ability to concentrate, think creatively, and make good decisions when co-creating value.			
Develop discourse channels	Help to clarify the way stakeholders maintain relations. Promoting inbound discourse (involvement) allows loose affiliation of stakeholders with various development activities, so they can offer solutions and ideas periodically during the process. Outbound discourse (consultation) promotes stable contributions to the development process of targeted professionals. Coupled discourse (collaboration) promotes knowledge exchange and trust development.	**Involvement**	**Consultation**	**Collaboration**
		Tools: Open co-design meetings, information sessions, open distribution of development fact sheets, any ideas cards (encouraging and celebrating idea-sharing in teams), promotional initiatives such as a jigsaw event (problem is placed in public place and people can write what they can contribute or their ideas around)	Tools: Participatory editing, circulation for comments, formal meeting with stakeholders, set objectives and chose method and criteria for evaluating the process, use timeline, develop a budget	Tools: Web-based tools such as intranet, extension of CAD/CAM that allows member of a supply chain to work together to design, build and market product, email communication, calendar sharing tools, file-sharing (cloud) tools, evaluation dashboard, creating a new space for collaboration
		Benefit: Maximise participation and promote diversified decisions. Promote unique insight into development. Involving stakeholders can secure resources to assist with development decisions.	Benefit: Improve alignment of decision between stakeholders; help to build consensus for final decisions	Benefit: Enforce requirement in the development of transparency and trust, promote ideas refinement. Brings balance to decision-making (developing transparent communication with stakeholders can root out the occurrence of biased or partisan decisions because each stakeholder has a presence around the 'table').

Table 28 Stakeholder engagement framework summary, part 2

Engagement step	Description	Engagement element (illustration from the case study)		
Develop discourse channels		Disadvantage: Involvement of stakeholders may be inappropriate when establishing accountability in a supervisory setting. Asking for input, when decisive actions is needed to address supervisory issues, can give the appearance that the supervisor does not have solid leadership abilities. Additionally, if stakeholders become involved but their advice is do not taken, it raises an expectation that hasn't been met, which can lead to distrust and hamper morale.	Disadvantage: When more people need to be consulted before a decision can be made, the project lead times are extended to facilitate this extra consultation. Additionally, the cost of consolation may be high—the larger the number of individuals involved in the consultation efforts, the greater the costs of the exercise, both direct, from facilitating meetings and communication, and indirect, because of the time actors spend away from their duties.	Disadvantage: If the responsibilities of the different stakeholders are not clearly defined, their contribution may become ambiguous, and the result can be chaos. The benefit of having several different perspectives starts to decline after an optimum number of members is reached, and this number may vary from project to project. Further, promoting coupled discourse may also bring complexity in decision-making and loss of autonomy and, in consequence, divert energy and resources away from the development aims (i.e. risk of mission drift).

Table 29 Stakeholder engagement framework summary, part 3

Engagement step	Description	Engagement element (illustration from the case study)		
		Replication	**Dissemination**	**Affiliation**
Network development	Use to coordinate development of temporary social system. Replication allow stakeholders to embed themselves in the network and re-create initial interaction formula to attract more ideas and knowledge from diverse actors. Dissemination offers information that is tailored to an intended audience. Affiliation specifies rules of the joint development process, but also responsibilities and involvements of different parties during the process.	Tools: Technology envisioning, informal and small talk between actors, appreciative story telling (tool which encourages stakeholders to take a positive perspective by rediscovering and reorganising what is going well, rather than focussing on problems).	Tools: In-person communication, email distribution list, workshops, project documentation, research reports, data circulation	Tools: Letter of intent (LOI), non-disclosure agreement (NDA), joint-introduction of key performance indicators (KPIs), intellectual property (IP) rights (patents, trademarks, industrial designs)
		Benefit: Various stakeholders contribute their specialised expertise and support the generation of many ideas in a short period of time, and therefore this strategy leads to more incremental development process.	Benefit: New ideas can be dispersed from one place and person more rapidly and widely, which in turn triggers new research and investigation; it serve as an impetus for knowledge gain, since more stakeholders can see the results of the research and development, including those who would otherwise not be able to access the information due to their work commitments or location.	Benefit: Promote clarification of rights, roles, and responsibilities prior to and during development in order to further enhance the relationships between professionals. Reduce risk of knowledge misappropriation.

Table 30 Stakeholder engagement framework summary, part 4

Engagement step	Description	Engagement element (illustration from the case study)		
Network development		Disadvantage: Development process is shaped by opportunistic behaviour—opportunities for new ideas development are taken as they arise, regardless of planning or principle.	Disadvantage: Reduce cross-pollination of idea(s); high levels of information-sharing distract stakeholders from the core creative process. Instead of producing a solution to the problem, reviewing information consumes the time and the effort required to pursue one's goals.	Disadvantage: Limit the ability of either party to renegotiate terms (and relationship arrangements); may also limit the flexibility of work arrangements that have already been established (e.g., a time period needed for particular development phase) and ability to transfer ownership (stakeholders must agree and give consent any time a stakeholder's knowledge or expertise is transferred)

Table 31 Stakeholder engagement framework summary, part 5

Engagement step	**Description**	**Engagement element (illustration from the case study)**		
Realise trade-off strategy	Use to deal with value and preferences variability offered by various stakeholders during the process. Required to identify relative gains and losses in the implementation of different options.	**Accommodation**	**Persuasion**	**Reconciliation**
		Lose-lose scenario means that all parties end up affected negatively by the development performance: for example, accepting delays and cost increases due to the development of extra technological features.	Win-lose situation results when only one side perceives the outcome as positive: for example, in promoting stakeholders' subjective preferences over the planned objective.	Win-Win scenario when each side feels they have won. Usually achieved through exchange of different values, for example exchange of technology subcomponents that give extra features for sensitive information needed for further testing development.
		Benefit: May lead to discovery of novel solutions, not seen or considered during the ideas-screening stage.	Benefit: Can introduce different viewpoints during development and change stakeholders' opinions when a certain person has particular knowledge about the subject.	Benefit: Sharing of values, usually a win-win option
		Disadvantage: Expensive, which may lead to conflict and delays when applied during technology implementation stage.	Disadvantage: Reduce input of new options during ideas-seeking stage.	Disadvantage: Can be time consuming

- The fourth step is to develop a trade-off strategy that helps navigate what values will be chosen during a complex innovation process, something this thesis found to be overlooked. The results suggest three possible ways to take this step: accommodation, persuasion and reconciliation.

How this process is applied will be driven by the purpose and requirement of each different stage of the innovation process, as explained throughout the thesis. Tables 24-28 describes the tools, benefits, and disadvantages of each element, so professionals can understand the consequences of applying them in the various stage of the innovation process.

8.4 Theoretical contributions

The thesis offers a number of theoretical contributions:

- The main contribution of this thesis is to bring to the fore the social influence that shapes the OI process, namely stakeholder relationships. While the topics of OI and stakeholder engagement theory are well researched separately in the organisational and innovation literature, these two subjects are rarely combined. By researching both of them in context of a UK manufacturing firm and its suppliers and contractors, this thesis broadens both subjects and explains the benefit of engaging in OI.

- This thesis suggests AT to be theoretical lens for the study stakeholders' engagement in inter-organisational settings. This suggestion provides a fresh understanding of how engagement is applied during innovation rather than observing the output of such process. By using AT, the thesis contributes to stakeholder engagement theory and extends our understanding of the OI process in the complexity of its practical application, drawing on sophisticated approaches in different contexts, rather than only the basic premises of the discipline.
- The thesis also traces activity at the network level through the application of network ethnography, which has allowed the study to unpack, firstly (through

ethnographical research), the activities that maintain network integrity (boundary objects) at various sites during the OI process and, secondly (through SNA), how these activities relate to the structural development of network as a whole. Such analysis is not new in organisational studies, but is less explored in the context of OI. Therefore, the study adds to the current organisational literature that network ethnography could explain the consequences of various stakeholders' engagement practices on network formation and explain the effect of the kind of network on the innovation process.

- While the extant literature on networks has studied the qualities of the network structure in innovation projects (e.g. density, proximity etc), this thesis suggests studying a network's evolution during OI. It thus explains the impact of different network forms at different times on creativity, but also the corresponding performance of the OI process, a subject little-explored in the innovation and organisational literature.

- A key contribution would be to broaden the understanding of stakeholder engagement itself. Whereas, previous studies have centred mostly on stakeholder selection to control who should be involved in the process and strategies that could be deployed to increase participation, this thesis explains when stakeholders are engaged. It suggests that to secure stakeholders' creativeness and willingness to make innovation happen, the process requires the initial disengagement of stakeholders from established rules, normal work sites, and negative perceptions towards innovation formulated by process problems. This view has not drawn substantive attention in stakeholder engagement discipline.

- Thus, this thesis also indicates that to move forward with our understanding of stakeholder engagement, as called for by Achman (2013) and Eskerod and Huemann's (2013), scholars should explore not only how stakeholders are involved, consulted, or collaborated with, but also how they can be effectively disengaged from norms, places, or situations that block their ability to concentrate, think creatively, and make good decisions when co-creating value. Thus, the thesis offers a consideration of a psychical environment called a ‘place for innovation’ as an important aspect of stakeholders’ engagement process. IT therefore offers a new view on the process and indicates a new territory that should be explored in the context of engagement and innvoation.

- The thesis’s findings also suggest that NPD projects networks evolve, and the development of new processes and product has more potential when the project network’s structural elements match the NPD project’s distinct needs. The thesis add to current project network and innovation studies by explaining that networks should start with ego-centric patterns to boost creativity and generate new ideas, and then they should be changed to a denser structure that allows the enhancement of creativity and project performance. Consequently, this work extends recent project network studies (Artto et al., 2016; Matinheikki et al., 2016; Hellgren & Stjernberg, 1995) that have so far examined network only at one point in the time, instead considering network formation (evolution) as a process.

- Additionally, the thesis adds to the project network literature by suggesting that actors should activate different network characteristics at the appropriate moments in the NPD project’s daily activities. Such arrangement may reduce tensions between project control activities and *ad hoc* solutions required within the innovation process, as identified by DeFillppi and Sydow (2016).

- Another key contribution is that temporary networks created during OI process are an important tool to connect the inside of the organisation (intra-network) with its outside (inter-network), a connection that is rarely discussed in studies examining the impact of social networks on innovation and NPD (Leemders & Dolfsma, 2016). This thesis proposes that such an arrangement firstly requires a smooth internal network that allows the firm to integrate successfully acquired knowledge into its own process, and when that is achieved it can benefit from external ties.

- Another key contribution is that engagement in the OI process does not necessarily lead to only to win-win situations that allow all involved parties to immediately benefit while developing new technology. Instead, as this thesis demonstrates, innovating with multiple stakeholders simultaneously leads to numerous trade-offs that may cost them a ‘small losses’ in the pursuit of novel solutions; this insight has not been widely emphasised in innovation studies.

8.5 Implications for practice

In line with its theoretical contributions, this thesis provides implication for professionals in the manufacturing industry. The thesis informs decision-makers in an organisation, such as managers, on how to conduct the stakeholder engagement process to increase creativity, increase motivation to formulate novel solutions, and develop relationships that minimise knowledge misappropriation in a manufacturing firm. The key practical implications are as follows:

- When engaging with various stakeholders, companies should recognise that competing values or divergence of perspectives represents both a challenge and an opportunity. This difference may exist between those who lead the innovation process, external stakeholders, but also between various internal functions. The innovation process can produce greater insight and plot a path to success if stakeholders attend to and evaluate those divergences and evaluate them carefully.

- The implication for practice is that the OI process may involve the loss of one value in return for gaining another. Such a process, the thesis argues, can force firms and individuals to recognise new opportunities and improve value assessment. However, to fully benefit from such a situation, managers must identify these trades-offs in greater detail, for example through the use of more conscious choices based on a rational method of making compromise.

- Moreover, this thesis's findings suggest that when value-related tensions start to feel difficult, most participants lower their expectations and consequently underestimate the benefits of innovation. Therefore, an effective trade-off process in such a situation is important not only for increasing value, but also for ensuring that process is continued. Assessing value and appropriate communication of this assessment can help make this trade-off process more transparent.

- Organisations that engage in OI should also be aware that divergence in interests and perspectives is critical for the innovation process, because it stimulates discussion about alternative solutions that may satisfy all involve parties. However, without embracing those perspectives through stakeholder engagement, the power of diversity is blunted or, worse, becomes self-defeating.

- Organisations should also learn how and when to use various engagement techniques, such as technology envisioning, fostering volunteer affiliation, promoting casual conversation, amending the organisational structure, or establishing a consultation group to make the innovation process more effective (as explained in Section 8.3).

- This thesis suggests to managers who coordinate OI that effective engagement that drives OI is promoted by informal communication in natural spaces, where stakeholders gather to discuss ideas outside of the institutionalised arena to stimulate co-innovation. To challenge OI barriers, managers may serve in the role of advocate, arguing for greater transparency to build trust or exchange ideas between stakeholders by creating a new space.

- Additionally, this research highlights that especially for metal producers, technical skills and knowledge (e.g. of engineering and metallurgy) are more important than social skills in driving the innovation process. Therefore, to foster innovation collaboration across the sector, future manufacturing associations and organisations should recognise the value of competence in interactions and communications with stakeholders and should make such interaction a core element of training.

8.6 Limitations of the research

Several limitations of this thesis merit discussion.

One of the main limitations of this thesis is methodological: This thesis relies largely on observation as a key method of data collection, but stakeholder engagement in an intra-organisation setting requires multi-side observation that was not necessarily possible at all times in all of the physicals space where work was conducted. Thus, other data sources such as electronic communication were added to this PhD project to illustrate how people become involved in new product and process developments.

The thesis overlooks several macro-factors that may influence engagement and network formation, such as years of experience of certain actors who did not disclose this information, but also gender, economic factors (e.g. budgets for developments), or the nationalities of the involved firms (UK and EU). On the micro-level, factors such as power and politics were not discussed in this thesis; although data from the research indicates that this factor affects stakeholder engagement, this variable had to be overlooked due to the thesis's size limitations.

Furthermore, what constitutes the 'norm' during innovation within the researched manufacturing firm cannot be conclusively determined in this instance. To understand what the firm (and other firms involved in this research) 'normally' do when innovating would require a longer period of study (such as longitudinal research) to validate the day-to-day activities.

Additionally, due to an NDA, this research could not record all data and collected information and was allowed only to publish limited information (related to selected technology and process development), which makes it more difficult to depict the practical circumstances of the OI process.

This thesis also could not review fully the stakeholder selection process as key aspect of the stakeholder engagement process, something that can be added in the future studies, as the question remains open how to identify and select the right stakeholders when discover a new product or process.

8.7 Opportunity for future research and concluding remarks

This thesis responds to calls to better understand of how organisations can better integrate stakeholders' perspectives into the OI process, particularly in the context of the manufacturing industry in the UK. The thesis synthesises current knowledge about the approach to engagement in the innovation and organisational field, explores the reality of the engagement process at the manufacturing firm in midlands and proposes the framework for engaging stakeholders during the OI process. It concludes that for research firms to be more competitive (innovative), they may be required to integrate stakeholder engagement more deeply into their corporate strategies, across all functions and geographies, as the benefits of stakeholder-centred thinking are compelling. When organised well, it can help organisations to find and refine ideas more effectively, reduce the risk of knowledge misappropriation, and above all, ensure a more inclusive, disruptive, and transparent innovation process for the organisation.

Based on the thesis's examples, however, stakeholder engagement remains on periphery of manufacturers' organisation activities, and when it is performed, it is done *ad hoc*, managed by one team (or individually by the professionals), with few resources allocated to it. Thus, this thesis explains also the difficulties and struggles of building lasting trust-based relationships in intra-organisational innovation processes through light-touch engagement activities. In the end, the message is that poorly organised stakeholder engagement is worse than no-engagement, because it creates tensions and challenges between unmet stakeholders expectations. Therefore, future studies could also research how organisations could (and should) learn from engaging their stakeholders and embed this knowledge in their new product and process development projects, to deepen the internal stakeholder engagement capabilities. Also, scholars could investigate diverse industries and how organisations can tie engagement to innovation strategies, for example how they concentrate on the development of specific training to ensure that various units within the business are aware of their responsibilities in communicating with and responding to external stakeholders. To do that future research could assist with the examination of particular needs in this context across the industry, job specialisations, and individual levels of education.

Thus, both manufacturing companies and other businesses could in the future consider in-depth interactions among employees, suppliers, contractors and third-party relationships as a critical component of the innovation process—not as the optional mechanism to manage risks of knowledge misappropriation or to avoid a crisis, but as a fundamentally new way of thinking about how to structure innovation strategies, drive development processes, and understand value. From that point, the companies of the future will probably evolve to adjust to specific interactions with the external environment. Thus, businesses may include all stakeholders who can both help and harm the business, not just the top two or three of them. Such an approach will require from firms to think about their innovation plans but also to consider influence, impact, and unintended consequences. Thus, to move deeper into more strategic engagement, scholars could also explain more about power dynamics among stakeholders and recognise the different forms of power and their consequences on innovation that those stakeholders might hold when co-creating together.

Finally, stakeholder engagement as a business discipline has changed significantly since Freeman (1984) first identified what has been now recognised as stakeholder engagement theory. However, this thesis explains that the changes to our understanding of effective stakeholder engagement process are in its application and sophistication, not the basic premises of the discipline. Thus, many firms, such as Tesla and, in the metal and mining industry, RioTiton Alcan, that regularly practice stakeholder engagement are stronger and more profitable as a result. Thus, this thesis shows to professionals in the manufacturing sector and scholars who are interested in OI what we should already have known: Stakeholder engagement is not about shared values, corporate social responsibility (CSR), or responsible innovation that is socially desirable and undertaken in the public interest — it is just good business.

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Appendix A – permission to access business information

[redacted] 27th March, 2014

Dear Tomasz,

I confirm that you are permitted to conduct your research on new product development projects, specifically development of [redacted] product and Development of [redacted] Programme across [redacted] Ltd and our project partners. That includes related work that is done in the company with the cooperation of other departments, manufacturing units, suppliers and customers.

Yours sincerely,

[redacted]

[redacted]
Operation Manager
[redacted]

Appendix B – Non-Disclosure Agreement (NDA)

PARTIES

THE UNIVERSITY OF MANCHESTER of Oxford Road, Manchester, M13 9PL, United Kingdom, in this instance acting through the Faculty of Life Sciences (hereinafter referred to as "the University")

AND

TOMASZ WITKOWSKI of the School of MACE, The University of Manchester as supervised by Dr. Paul Chan (hereinafter referred to as "the Student")

AND

[redacted]
(hereinafter referred to as "Company")

BACKGROUND

i Company has developed and may continue to develop Company Technology.

ii Company wishes to exchange information connected with and / or relating to their technology to allow the Student to complete their PhD degree for the Project entitled "How Stakeholders Engage in Innovation" and for the University to supervise and examine the Student.

iii The University must be able to assess the quality of the Student's work on the Project. This is done by a University supervisor who visits the Company to review the Project on which the student has been working and the quality of the Student's work in connection with the Project.

iv In the course of point (ii) and (iii) above, certain proprietary information may be disclosed by Company to the University and the Student.

v The University, the Student and Company agree that any discussions and exchanges of any such information shall be governed by the following provisions:

OPERATIVE PROVISIONS

Definitions

a) "The Effective Date" shall mean the date of date of final signature.

b) "The Disclosing Party" shall mean Company.

c) "The Recipient Party" shall mean the University or the Student.

d) "The Parties" shall mean Company, the University and the Student collectively.

e) "Confidential Information" shall mean any and all knowledge, know-how, information and techniques disclosed by Company to the Student or the University in connection with this Agreement including in the Company Technology but not limited to research data, databases, software, bioinformatics tools, specifications, plans, drawings, prototypes, models, documents, recordings, instructions, manuals, papers, or other materials of any nature whatsoever. Any communications under this Agreement, including but not limited to telephone conversations, correspondence, memoranda, facsimile communications and e-mail communications shall be protected under the terms of this Agreement as Confidential Information.

f) "Company" shall mean certain valuable and confidential information related to the company name, address, financial results, specifications, technology and components use by the company and their contractors, subcontractors and customers.

g) "The Purpose" shall mean evaluation of the Company Technology by the Student in order to complete their degree, and the supervision and examination of the Student by the University in the course of the Project.

Terms and Conditions

1) The Disclosing Party shall disclose on a non-exclusive basis the Confidential Information to the Recipient Party to enable the Recipient Party to evaluate the same. The extent of such disclosure shall be at the sole discretion of the Disclosing Party.

2) In consideration of the disclosure of the Confidential Information by the Disclosing Party the Recipient Party agrees at all times that it will treat the Confidential Information with all reasonable and practicable care to avoid disclosure of the same to any other person, third party, firm or organisation other than as is provided herein. The Recipient Party shall be entitled to use the Confidential Information only for preliminary evaluation purposes and to disclose the Confidential Information in confidence to such of its employees that need to know in order to carry out the Purpose. The Recipient Party shall have no obligation with respect to the Confidential Information or any part thereof which:

a) the Recipient Party can demonstrate is at the time of disclosure by the Disclosing Party already known to the Recipient Party other than from the Disclosing Party and the Recipient Party promptly so informs the Disclosing Party of the same in writing;

b) becomes known to the Recipient Party from a third party lawfully entitled to disclose the same and the Recipient Party so informs the Disclosing Party in writing within thirty (30) days of the receipt of such information;

c) is approved for release from the provisions of this Agreement by prior written authorisation from the Disclosing Party;

d) was at the time of disclosure by the Disclosing Party in the public domain or subsequently becomes the subject of public knowledge through no fault of the Recipient Party;

e) the Recipient Party can demonstrate has been independently developed by the Recipient Party;

f) is specifically ordered to be disclosed pursuant to an operation of law or an order of a court of competent jurisdiction but the Recipient Party is only released from its obligation to the extent of such requirement.

3 Any Party may terminate this Agreement by providing thirty (30) days' written notice to the other Party. Upon termination of this Agreement or otherwise at the written request of the Disclosing Party the Recipient Party will promptly return the Confidential Information together with any copies or extracts thereof which have been made, save for one copy which may be retained for the sole purpose of ensuring compliance with the ongoing obligations created herein.

4 The Parties hereby acknowledge that the Disclosing Party retains any and all right title and interest in and to the Confidential Information.

5 The Disclosing Party makes no representations or warranties either express or implied with respect to the Confidential Information and specifically disclaims any implied warranty of non-infringement or merchantability, satisfactory quality or fitness for purpose.

6 This Agreement shall expire one (1) year after the Effective Date. The obligations of Non-Disclosure and non-use set out in this Agreement shall subsist from the Effective Date and shall survive termination or expiration for a period of five (5) years.

7 No Party shall assign or otherwise dispose of any or all of the rights duties or obligations under this Agreement without the prior written consent of the other.

8 Nothing in this Agreement shall obligate any Party to enter into any further agreement relating to this matter.

9 Any notice or other communication to the University under this Agreement shall be sent to The Research Office at the address hereinbefore mentioned marked for the attention of the Director of Research and Business Engagement Support Services.

10 This Agreement is made under the laws of England and shall be subject to the non-exclusive jurisdiction of the English Courts regardless of place of execution or place of performance.

11 This Agreement may be executed in one or more counterparts each of which shall for all purposes be deemed to be an original and all of which shall constitute one and the same instrument.

12 Nothing in this Agreement is intended to confer on any person any right to enforce any term of this Agreement which that person would not have had but for the Contracts (Rights of Third Parties) Act 1999.

13 Nothing in this Agreement shall prevent the Student from submitting for a degree of the University a report based on their work under this Agreement and the examination of such a report by examiners appointed by the University (provided that such examiners are bound by obligations of confidentiality no less onerous than those contained in this Agreement in respect of the content of the report). A report may be placed in the University library in accordance with University policies provided it remains on restricted access for the duration of this Agreement subject to Clause 6.

14 Should during the performance of the Project the University and/or the Student disclose to the Company Confidential Information, the Company hereby covenants that it will treat such Confidential Information in like manner as provided herein in respect of the Agreement.

SIGNED for and on behalf of The University of Manchester

Name Dr Andrew Walsh

Title Director of Research and Business Engagement Support Services

Date 12/3/14

Dr Andrew Walsh

Director of Research and
Business Engagement Support Services

SIGNED for and on behalf of Tomasz Witkowski

Name Tomasz Witkowski

Title Mr

Date 7/2/14

SIGNED by [redacted]

Name [redacted]

Date 7.2.14

Appendix C – participant information sheet

The University of Manchester
MANCHESTER 1824

APPENDIX C

Title of Research

Understanding and managing engagement in new development projects across firm

Participant Information Sheet

You are being invited to take part in a research study [as part of a student PhD project]. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Who will conduct the research?

Mr. Tomasz Witkowski, School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, PO Box 88, Manchester, M60 1QD,
email: tomasz.witkowski@posgrad.manchester.ac.uk

Title of the Research

Understanding and managing engagement in new development projects across firm

What is the aim of the research?

The purpose of the study is to research how stakeholders engage across firms in the context of new product and process development. The research seeks to identify a range of engagement practices and examine their implications on the organization of new product and process development projects. In so doing, we hope to explain how people interact with one another within and across firm boundaries when developing new product or process.

Why have I been chosen?

You are selected due to involvement in the projects that are classified as a new product/process development venture.

What would I be asked to do if I took part?

The initial design of the study it to gather qualitative data in the form of ethnographical observations and interviews to analyse it for emerging themes. The first part will focus on observation of meetings, second on interviews of participants. During that stage question regarding engagement in innovation will be asked.

What happens to the data collected?

Data analysis will be undertaken by the researcher with support of PhD supervisor.

How is confidentiality maintained?

The data will be store in the researcher privet computer. Only researcher and his supervisor will have access to the data.

What happens if I do not want to take part or if I change my mind?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason and without detriment to yourself.

Will I be paid for participating in the research?

No.

What is the duration of the research?

18 months

Where will the research be conducted?

[redacted]

Will the outcomes of the research be published?

Yes, in the form of PhD publication.

Who has reviewed the research project?

The project has been reviewed by the University of Manchester Research Ethics Committee.

Contact for further information

PhD Researcher: Mr. Tomasz Witkowski, School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, PO Box 88, Manchester, M60 1QD,
email: tomasz.witkowski@posgrad.manchester.ac.uk, phone: +44 07809 483788

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Additional information

If there are any issues regarding this research that you would prefer not to discuss with members of the research team, please contact the Research Practice and Governance Co-ordinator by either writing to 'The Research Practice and Governance Co-ordinator, Research Office, Christie Building, The University of Manchester, Oxford Road, Manchester M13 9PL', by emailing: Research.complaints@manchester.ac.uk, or by telephoning 0161 275 7583 or 275 8093.

or

If a participant wants to make a formal complaint about the conduct of the research they should contact the Head of the Research Office, Christie Building, University of Manchester, Oxford Road, Manchester, M13 9PL. (Or emailing research.complaints@manchester.ac.uk or telephoning 0161 275 7583 or 0161 275 8093)

Appendix D – consent form

Project Title

Understanding and managing engagement in new development projects across firm

CONSENT FORM

Thank you so much for participating in this study. Your participation is very valuable to the project. Your help in the study is voluntary and you are free to withdraw at any time without giving a reason. The meetings and interviews selected for this project will be audio-recorded. Please find the time to read the attached information on the above project, and in case of your questions I will be happy to answer them. To protect your privacy and confidentiality, all recorded information will be anonymous. Once that happens any data collected during the project may be passed as anonymous data to other researchers.

I agree to take part in the above project

Name of participant	Date	Signature
Name of person taking consent	Date	Signature

Appendix E – observation of the meeting

Observation sheet [1] ver1

Date: 21/3/14
Time: 13.45-14.15
Participants: [redacted]
Place: [redacted]
Subject: End of the visit meeting, discussion of further cooperation plans,

Description of Space *First room after the reception. Big, long and bright room, with a desk next to the window that is situated opposite the entry door. In the middle of the room is meeting table, is wooden and painted on dark mahogany colour. Around the table, there are eight black chairs that seem to be made from high-quality materials. The walls are white; the two most extended walls have whiteboards that are symmetrically placed to each other; they are hinging opposite to meeting table. On one, is precisely written by green colour marker information regards production and sales figures. The room seems to be long and very well organized. There is minimal amount of furniture inside.*
Description of Actors [redacted] *something man, average height with dark hair. Work for the company last* [redacted] *years, doing different jobs and have various functions. He is* [redacted] *origin, and he works and lives in* [redacted]*. He is responsible for European market sales. Since the beginning of an investigation by* [redacted] *in new technology development, he was in contact with Process Technologist delivering quotes, answering the particular technical and commercial questions. So, far he is the first contact to communicate issues or queries about technology development, and commercial aspects. His directly reporting to* [redacted] *that is place at* [redacted] *offices.* [redacted]*), PhD educated person. Originally from* [redacted]*, but in* [redacted] *for the last 40+ years. He has the dark complexion, he is of average height and he has dark hair. He is wearing a casual but smart shirt and trousers. He also is wearing glasses and a pen and a black pad for taking notes. He is the most active person during the meeting, likes to joke and tell episodes from his live and professional experience. He is energetic, positive and speaking very fast. Reporting to the* [redacted]. [redacted] *something, originally from* [redacted] *Wearing a casual but smart clothes. He is tall, dark-haired but with some grey hairs. Quiet during the meeting. Responsible for the whole plant.* [redacted] *something PhD educated person. Born and live in* [redacted]*, working for* [redacted] *for last 20+ years. Very positive and always smiling person. Like to joke, speaking in English with a* [redacted] *accent, he is responsible for* [redacted] *data development, he reporting to the* [redacted]*, he works with the research scientist to develop the product. Also wearing casual but smart clothes.* *Research Scientific, PhD qualified female, originally from* [redacted]*, educated in* [redacted]. *Varying casual clothes. Small with dark hair. She reported to the* [redacted]*; she focuses on algorithm development in* [redacted]*. During the visit, she trains both* [redacted] *employees in algorithm setup and change. She is responsible for the development of new* [redacted] [redacted], [redacted] *something-year-old male. Working for the* [redacted] *for the last two years. Previous experience in copper pipe production and heat treatment. He has a metallurgical qualification. He reports to* [redacted] *and* [redacted]. *Working with the* [redacted] *provides quality assistance, manage product*

concession, analyse the process and product defects. Working also with [redacted] *and Senior development* [redacted] *to achieve strategic product development for the customers. He is responsible for the New Technology introduction. Not very familiar with this technology and process. Keen to learn. Wearing special protective trousers, boots, and a jumper.* [redacted], young adult, white male. Working for the company over the last 5 years. Before in [redacted] work as a [redacted]. He has metallurgical degree.. His is tall with Dark hair. He doesn't wear the glasses. Wear shirt, cover by jumper and casual trousers. Has protective boots with hard stand on the top. He is responsible for [redacted] (Production, People, H&S, Supply Chain, Quality). Also he is responsible for snagging of new production facilities. He reports directly to [redacted]
Description of Activities *Development of further plan related to the* [redacted] *investigation and initiation of cooperation between companies to progress the development.*
Description of Objects *Inside the room was a large meeting table, and impressive chairs that seem were made from the expensive material.*
Description of Events [redacted] *and* [redacted] *in short chat in previous day conclude with* [redacted] *visitors to have on the end of the visit a brief meeting to discuss further steps of product development and discussion related to ways of cooperation between firms. During the walk to meeting room,* [redacted] *change the plans, moving into* [redacted] *room with goal to introduce both* [redacted] *employees to company key man.* *After introduction,* [redacted] *kick of discussion talk to* [redacted] *about number of peoples that potentially will be involve in* [redacted] *during further development steps.* [redacted] *confirms that, and starts to talk looking on* [redacted] *about different sets of skills that company possess.* [redacted] *employees enthusiastically present* [redacted] *and company potential for development of technology. During that short information, all participants stand around the table, nobody sitting.* [redacted] *wait when* [redacted] *finish and conclude suggesting further actions, by explaining to* [redacted]*: "so, step one is to accomplish work (ref to technology) they bought for in the first place, right? And than after that research scientists will go (ref* [redacted] *and help with development of technology)", "the second step we are offering them as the part of collaborative agreement, we sign kind of brief collaboration agreement with them, we offer them the* [redacted]*", He stops their, because* [redacted] *explain to him:" they don't have it, I don't know why was not there (ref to lack of additional function in* [redacted]*)we need to add it" When he said that* [redacted] *express his surprise about it, but follow to the next issue of* [redacted] *that will be work on it further. The participants still stand around the table.* [redacted] *continue that* [redacted] *and* [redacted] *will 'speak with their management to see if they can constitute a workgroup inside of the company to open the information for the next level … so if we want to be a help for them… than we need a knowledge of their expectation in different steps in the process, and after that we would like to use that as a kind of generic information … so everything confidential we leave it, and we sign confidential agreement' All this time, he concludes to* [redacted]*, explain him a clear plan of action. When he finished* [redacted] *inform about support of* [redacted] *Management for this project, but when he said that* [redacted] *decided to explain more clearly that for this project it is also important to include more people from different part of the plant and that involve discussion with them, which 'we have to do somehow, even if we need to sign NDA between the firms'. When he said that,* [redacted] *that stay next to him, express his view on that, suggesting that NDA is not needed.* [redacted] *turn into him and explain that the results itself are not meaningful if they are separate from process and conditions that affected it. He continues to say that in such stage there need to be NDA, add: that 'definitely we (ref to both firms) find common ground in that terms'.* [redacted]

agrees with [redacted]) suggesting that it will be necessary to understand results in the context of the process. After that discussion they switch again into [redacted] preparation to develop the product ([redacted]). [redacted] explain who can be potentially involved from [redacted] to help with this. When he finished, Product Manager ask: 'if you would like to do, such as publication or presentations on [redacted]?' [redacted] listing that and answer with smile on his face: we did discuss it actually on plane with [redacted] we looking for things like that…but we have to basically find out of what exactly we can publish' [redacted] did not wait when [redacted] finish and add: 'don't need to publish much, because this is virgin territory' When he said that, [redacted] suggests: 'take your time… and validate it internally'.
Description of Goals *Exchange of opinions about further development plans and values from collaborative work*
Description of Feelings *During the meeting from both parties, excitement about this development was felt; all participants stand. [redacted] management was kind and especially in [redacted] words understand the position of [redacted] in this development project. There wasn't particular attention to the time for this development. Most of the discussion was about skills, possibilities, how other people see the product and what has to be done internally at [redacted]. [redacted] was trying to ask for publications that are important for technology recognition in the industry world. It seems it was an idea for exchange of particular technological function over data from the internal tests that could be sue for publications. Overall the meeting proceeded in the very friendly atmosphere.*

Appendix F - observation of informal brainstorming

Observation sheet [1] ver1

Date: 17/4/2014
Time: 11.20-12.50 (meeting planned to finished at 12.00)
Participants:, [redacted]
Place: [redacted] room
Subject: informal discussion about a new framework progress
Purpose: to exchange ideas, views on development process

Description of Space B10,CI meeting room
Description of Actors *[redacted], middle age, white male. Working for the company over the last five years. He has a metallurgical degree. His is tall with Dark hair. He doesn't wear the glasses he has protective boots with a hard stand on the top. He is responsible for unit operation (Production, People, H&S, Supply Chain, Quality). Also, he is responsible for the commissioning of new production facilities. He reports directly to [redacted]. The coordinator is in late middle age, tall with light brown hairs. He has previous experience with the supply chain. He works for the company more than ten years. Since Nov 2013 he becomes strategy coordinator with a direct reporting line to [redacted] of the company. [redacted] middle-age manager working for the company since the production centre was built (26 years), he also reporting to [redacted]. [redacted] is responsible for new product development, he manages four engineers and he has PhD in the material science subject.*
Description of Activities *After formal meeting cancelation, three participants left in the room engage by [redacted] that ask them the question about the view and opinion about company KPIs. Three of them start to discuss that and exchanging ideas.*
Description of Objects
Description of Events *There was a lengthy discussion about company KPIs for different departments and manufacturing units and after nearly one hour subject of discussion change. [redacted] start to explain his disappointment with lack of target for the development, suggesting that each: 'meetings without solid plan of what this group what to do...will be a waste of the time' He added after that:' we have to have something solid to discuss with senior management about that....we don't have a clear strategy ...until we do not develop a strategy for this development that we will still be in this grey area of discussion of what we can do and what we can't'. When he said that [redacted] suggests changing the meeting into work meeting where the manufacturing process will be discussed in more details and suggestion of where the potential bottleneck is which should lead to discussion...the [redacted] support that by comments: 'you are right, until we don't try we never will know what we can or can't do' After that [redacted] enthusiastically says: 'ok, so I will prepare flow of the process in more details for the next meeting'.*
Description of Goals

Description of Feelings

Informal talk about company KPIs issues that participants discuss turn into self-reflection about the the process that they develop. Consequently, problems that they highlight with lack of targets that will reflect better organization within the company were used as the platform to redefine the development process. Overall the participants were very interested in discussion staying much longer in the room. During the conversation inside of the room, it was felt high energy and motivation for change of the development process direction. It seems that participants were encouraged by subject to talk and explain their view.

Appendix G – an example of recorded email

From: [redacted]
Sent: 23 January 2014 17:13
To: [redacted]
Subject: RE: Progress update

[redacted] and a Very Happy New Year to you

The last update I had was back in December where the estimated "end of production" was to be second half of March.

We also need to consider that it was agreed that you would participate in customisation for the [redacted], so I will ask the factory for an update and a time-line so that we can think about scheduling a visit for you prior to the instrument shipment.

Regards
[redacted]

Appendix H – example list of observations, documents and communication records

No.	Engagement	Aim/Objective (coded)	Ref	Attachments	Date	Time [hh:mm]	Approx. Time Length [min]	Number of Participants
1	Collocated meeting	Framework development	P2CM1		05/07/13	10:30	55	3
2	Collocated meeting	Framework development	P2CM2		07/11/13	09:30	63	2
3	Collocated meeting	Coordinator Role Integration to the business	P2CM3		14/11/13	10:00	76	3
4	Collocated meeting	Program review	P2CM4		26/11/13	14:00	60	2
5	Collocated meeting	Meeting re: ideas development	P2CM5		27/11/13	10:00	120	2
6	Collocated meeting	Program review	P2CM6		27/11/13	14:00	45	7
7	Collocated meeting	Current strategic framework assessment - Information and next steps	P2CM7		28/11/13	09:00	65	1
8	Collocated meeting	Development: current state	P2CM8		28/11/13	10:00	61	2
9	Collocated meeting	Development team meeting	P2CM9		28/11/13	11:00	83	9
10	Collocated meeting	Framework development	P2CM10		29/11/13	14:15	50	2
11	Collocated meeting	Framework development	P2CM11		03/12/13	15:00	45	2
12	Collocated meeting	Development Direction Discussion	P2CM12		04/12/13	10:00	74	3
13	Collocated meeting	Framework development with consultants	P2CM13		06/12/13	10:00	240	3
14	Collocated meeting	Development Discussion	P2CM14		09/12/13	09:00	60	2
15	Collocated meeting	Framework development	P2CM15		10/12/13	11:00	60	2
16	Collocated meeting	Framework development	P2CM16		10/12/13	14:00	60	2
17	Written communication	Consultant review	W57		10/12/13	11:00	60	2
18	Collocated meeting	Framework development	P2CM17		11/12/13	12:00	60	4
19	Written communication	Short discussion regarding 'new strategic framework	W28		11/12/13	10:30	60	9
20	Written communication	Consultant	W57		17/12/13	11:00	90	12

21	Written communication	Consultant	W57		17/12/13	09:24	4	2
22	Collocated meeting	Review of previous ideas	P2CM18		18/12/13	11:00	60	3
23	Collocated meeting	Development team meeting	P2CM19		19/12/13	14:00	60	9
24	Written communication	Information from discussion today	W34		03/01/14	15:00	60	2
25	Written communication	Short discussion regarding 'New framework'	W56		03/01/14	13:00	60	3
26	Written communication	Short discussion regarding 'New framework'	W57		03/01/14	11:00	60	2
27	Written communication	Summary of current development process	W67	W67A1	03/01/14	15:00	60	2
28	Written communication	Short discussion regarding development problems	W56		03/01/14	16:30		2
29	Written communication	RE: Meeting with Company & LEAD	W50		06/01/14	14:30	60	2
30	Written communication	Short discussion regarding 'development stage'	W56		06/01/14	11:17	81	2
31	Written communication	Consultant	W57		06/01/14	14:00	120	13
32	Written communication	Meeting request - Current Status of the new framework development	W38	W38A1	07/01/14	10:00	210	3
33	Collocated meeting	FW: Development Review Meeting	P2CM20		09/01/14	11:00	60	2
34	Written communication	FW: Short discussion regarding 'new framework development stage'	W29	W29A2	09/01/14	14:30	60	2
35	Written communication	Short discussion regarding development	W52		09/01/14	09:38	10	2
36	Written communication	RE: Short discussion regarding the development	W52		09/01/14	13:30	60	2
37	Written communication	Short discussion about the development	W60	W60A1	09/01/14	10:00	60	2
38	Written communication	Short discussion about the development	W61	W61A1	09/01/14	14:00	60	2

39	Written communication	Short discussion about the development	W62	W62A1	09/01/14	14:00	60	2
40	Written communication	Short discussion about the development	W63	W63A1	09/01/14	11:00	60	2
41	Written communication	Short discussion about the development	W64	W64A1	09/01/14	11:00	95	5
42	Written communication	Short discussion about the development	W65	W65A1	09/01/14	11:00	130	8
43	Written communication	Short discussion about the development	W66	W66A1	09/01/14	13:30	150	10
44	Other	Phone Conversation	CM15		10/01/14	05:45	3	2
45	Written communication	RE: Short discussion about the development	W52		13/01/14	10:30	170	8
46	Written communication	RE: Short discussion about the development	W52		13/01/14	13:45	10	9
47	Written communication	RE: Short discussion about the development	W52		13/01/14	13:46	10	9
48	Written communication	RE: Short discussion regarding development problems	W55		13/01/14	14:00	60	3
49	Collocated meeting	Project - #58	P2CM21		14/01/14	14:00	60	3
50	Written communication	Short discussion regarding development problems	W29	W29A1	14/01/14	09:35	10	9
51	Written communication	RE: Short discussion regarding development problems	W53		14/01/14	13:30	60	3
52	Written communication	RE: Short discussion regarding development problems	W53		14/01/14	15:00	60	3
53	Written communication	FW: Short discussion regarding development problems	W28		14/01/2014			2
54	Written communication	Updated Charter	W76		14/01/2014	14:15		3
55	Collocated meeting	Development:current state	P2CM22		16/01/14	11:00	70	6
56	Collocated meeting	Framework development	P2CM23		16/01/14	11:01	10	9
57	Written communication	Framework development	W10		16/01/14	10:00	10	2

58	Written communication	Framework development	W12		16/01/14	12:01	10	9
59	Collocated meeting	Development:current state	P2CM24		17/01/14	08:28	10	9
60	Written communication	RE: Short discussion regarding development problems	W54		21/01/14	11.05	15	4
61	Collocated meeting	Development:current state	P2CM25		22/01/14	11:20	90	3
62	Written Communication	RE: Samples for SD set-up	P1WC82		22/01/2014	09:37		3
63	Written Communication	Samples for SD set-up	P1WC83		22/01/2014	09:51		3
64	Written communication	WMMC - Complimentary Festo Training	W30		23/01/14	14:00	60	2
65	Written Communication	Minutes for meeting - SD samples	P1WC62		23/01/2014	15:19		4
66	Written Communication	Samples for SD set-up	P1WC64		23/01/2014	13:30		3
67	Written Communication	RE: Progress update on new technology	P1WC72		23/01/2014	17:13		2
68	Written Communication	Progress update on new technology	P1WC73		23/01/2014	08:59		2
69	Written Communication	Progress update on new technology	P1WC80		23/01/2014	08:59		2
70	Collocated meeting	brainstorm samples required for SD setup and ongoing development	P1CM13		23/01/2014	13:30	30	3
71	Collocated meeting	Framework development	P2CM26		24/01/14	10:00	60	3
72	Written Communication	Installation of the new technology	P1WC2		24/01/2014	11:02		8
73	Written Communication	RE: Progress update on new technology	P1WC71		24/01/2014	09:23		2
74	Written Communication	FW: Progress update on new technology	P1WC77		24/01/2014	10:55		4
75	Written Communication	RE: Progress update on new technology	P1WC78		24/01/2014	09:23		2

76	Written Communication	FW: Samples for SD set-up	P1WC81		24/01/2014	10:53		2
77	Written communication	Cancelled: Development Discussion	W6		27/01/14	14:00	60	2
78	Written communication	Continuous Improvement Discussion	W14		27/01/14	11:11	119	5
79	Written communication	Continuous Improvement Discussion	W15		27/01/14	11:00	95	7
80	Informal and adhoc meeting	management of the development	CM13		28/01/14	11:07	81	4
81	Written communication	FW: WMMC - Complimentary Festo Training	W31		28/01/14	09:45	10	3
82	Written Communication	Current technology use for new manufacturing unit	P1CM		28/01/2014	13:30		4
83	Collocated meeting	Framework development	P2CM27		29/01/14	11:24	106	3
84	Written Communication	Minutes for technology meeting - 28.01.14	P1WC63		29/01/2014	10:47		5
85	Collocated meeting	To decide formula for product number sequence and its integration with IT system	P1CM2		29/01/2014	14:00	105	4
86	Collocated meeting	Operational meeting	P1CM11		29/01/2014	10:05	25	6
87	Written Communication	FW: Progress update on new technology	P1WC69		30/01/2014	10:57		5
88	Written Communication	RE: Progress update on new technology	P1WC70		30/01/2014	10:54		2
89	Infromal and adhoc meeting	program review			31/01/14	11:06	127	6
90	Collocated meeting	Operational meeting	P1CM12		31/01/2014	10:00	20	7
91	Collocated meeting	Business review	P1CM2		03/03/14	11:00	84	5
92	Written Communication	technology installation meeting	P1WC3		03/02/2014	17:27		14
93	Collocated meeting	Business Review Meeting	P1CM1		03/02/2014	14:00	120	11
94	Collocated meeting	Framework development	P2CM28		04/02/14	09:41	10	9
95	Collocated meeting	Framework development	P2CM29		05/02/14	09:51	10	9

96	Written Communication	technology installation meeting	P1WC65		06/02/2014	15:00		7
97	Collocated meeting	To decide needed connection point and allocation of new technology and PC	P1CM3		06/02/2014	15:00	60	6
98	Written Communication	technology meeting minutes and technology room layout	P1WC4	P1WC4A1, P1WC4A2	07/02/2014	14:47		8
99	Collocated meeting	Framework development	P2CM30		10/02/14	10:48	10	9
100	Collocated meeting	Framework development	P2CM31		11/02/14	10:00	90	3
101	Written communication	Meetings with Section Leaders re: development	W39	W39A1	11/02/14	14:00	70	2
102	Collocated meeting	Operational meeting	P1CM8		17/02/2014	10:05	20	4
103	Collocated meeting	Development: current state	P2CM32		18/02/14	13:00	240	5
104	Informal and adhoc meeting	To inform about recent development of new component shipping date	P1IM17		18/02/2014	11:40	65	2
105	Collocated meeting	Development: current state	P2CM33		19/02/14	09:00	420	2
106	Collocated meeting	Development: current state	P2CM34		23/02/14	10:00	420	2
107	Infromal and adhoc meeting	To communicate and decide the schedule of trip	P1IM10		19/02/2014	10:45	15	2
108	Collocated meeting	Updated: Discussion with CAC - and wider application?	P2CM35		24/02/14	14:30	60	3
109	Collocated meeting	Operational meeting	P1CM9		24/02/2014	10:00	30	5
110	Written communication	LEAD Limited - Intro session	W36		26/02/14	14:00	60	5
111	Written communication	LEAD Limited - Intro session	W36		26/02/14	11:29		2
112	Collocated meeting	Operational meeting	P1CM10		26/02/2014	10:05	23	6
113	Collocated meeting	Development: current state	P2CM36		27/02/14	15:25	46	2
114	Infromal and adhoc meeting	To talk about new technology calibtation	P1IM11		03/03/2014	14:40	35	3
115	Written communication	Revision for Business Map	W58	W58A1	04/03/14	16:36		8
116	Written communication	Follow up on the LEAD presentation from 26/2	W18		06/03/14	15:54		7
117	Written communication	Follow up on the LEAD presentation from 26/2	W19		07/03/14	09:43		2

118	Collocated meeting	Program Development	P2CM37		10/03/14	14:37	36	2
119	Infromal and adhoc meeting	reinforce lack of help from supplier	P1IM7		10/03/2014	10:00	5	3
120	Infromal and adhoc meeting	action for tomorrow installation of new spectro	P1IM12		10/03/2014	15:50	15	2
121	Collocated meeting	Operational meeting	P1CM7		10/03/2014	10:00	17	5
122	Collocated meeting	Program Development	P2CM38		11/03/14	11:23	50	3
123	Written communication	Requirement to carry out training	W27		13/03/14	09:25		3
124	Written communication	Re: Requirement to carry out training	W27		14/03/14	11:20		3
125	Written communication	Training	W31	W31A1, W31A2	14/03/14	12:21		2
126	Written communication	FW: Requirement to carry out training	W27	W27A1, W27A2	17/03/14			3
127	Written communication	Presentation - CI in the packing area	W41	W41A1	17/03/14			2
128	Collocated meeting	Consulting Group - program structure	P2CM39		18/03/14	16:16	84	2
129	Written communication	Consulting Group - program structure	W71		18/03/14			2
130	Infromal and adhoc meeting	chat about planned visit and recent activities that are associate with installation of new technology	P1IM16		18/03/2014	10:00	34	2
131	Collocated meeting	Program Development	P2CM40		18/03/14	10:30	45	2
132	Collocated meeting	Program Development	P2CM41		19/03/14	10:30	160	9
133	Written communication	Presentation as discussed	W42		19/03/14	14:54		7
134	Infromal and adhoc meeting	Informal dinner between companies representatives	P1IM20		19/03/2014	19:30	110	3
135	Written communication	1st draft - update	W1	W1A1	21/03/14	15:00		2
136	Written Communication	tech sys results from training	P1WC32		24/03/2014	18:11		4
137	Written Communication	tech sys results from training	P1WC76		24/03/2014	18:11		4

138	Infromal and adhoc meeting	Exchanging interest and opinion about development of SDa subject	P1IM3		24/03/2014	14:30	60	2
139	Infromal and adhoc meeting	Exchanging interest and opinion about development of SDa	P1IM6		24/03/2014	10:45	45	5
140	Collocated meeting	Program Development	P2CM42		25/03/14	13:30	90	5
141	Written Communication	FW: tech sys results from training	P1WC31		25/03/2014	16:06		2
142	Collocated meeting	Program Development	P2CM43		26/03/14	13:30	90	5
143	Written communication	Development the next stage	W43		26/03/14	11:55		2
144	Infromal and adhoc meeting	Exchange view points on new technology	P1IM5		27/03/2014	14:00	25	2
145	Written communication	Framework development - background and latest steps	W8		28/03/14	11:01		9
146	Collocated meeting	Framework development - background and latest steps	P2CM44		02/04/14	08:14	87	2
147	Written communication	Framework development	W44		03/04/14	11:04		2
148	Written communication	Program Development	W45		03/04/14	08:28	160	9
149	Written communication	Program Development	CM4		03/04/14	11:00	94	9
150	Written communication	Framework development	W11	W11A1	03/04/14	14:44		2
151	Written Communication	Installation of new technology	P1WC30		03/04/2014	15:09		9
152	Written Communication	RE: Installation of new technology	P1WC47		03/04/2014	16:15		2
153	Written Communication	Installation of new technology	P1WC48		03/04/2014	15:09		9
154	Written Communication	RE: Installation of new technology	P1WC60		03/04/2014	16:15		9
155	Written Communication	Installation of new technology	P1WC61		03/04/2014	15:09		9

156	Written Communication	RE: Installation of new technology	P1WC43		04/04/2014	09:41		5
157	Written Communication	FW: Installation of new technology	P1WC44		04/04/2014	09:27		5
158	Written Communication	RE: Installation of new technology	P1WC45		04/04/2014	09:25		3
159	Written Communication	FW: Installation of new technology	P1WC46		04/04/2014	09:22		2
160	Written Communication	FW: Installation of new technology	P1WC57		04/04/2014	09:27		5
161	Written Communication	RE: Installation of new technology	P1WC58		04/04/2014	09:25		3
162	Written Communication	FW: Installation of new technology	P1WC59		04/04/2014	09:22		2
163	Collocated meeting	Operational meeting	P1CM4		04/04/2014	10:00	35	8
164	Written communication	Framework development - background and latest steps - part 2 to complete	W7		07/04/14	10:59		14
165	Written communication	Framework development - part 2 to complete	W9		07/04/14	11:55		2
166	Written Communication	Arrival of T - 8.04.14	P1WC5		07/04/2014	14:37		10
167	Written Communication	RE: Arrival of T - 8.04.14	P1WC27		07/04/2014	15:06		14
168	Written Communication	Arrival of T - 8.04.14	P1WC28		07/04/2014	14:37		2
169	Written Communication	RE: Arrival of T - 8.04.14	P1WC36		07/04/2014	15:06		2
170	Written Communication	Arrival of T - 8.04.14	P1WC37		07/04/2014	14:37		8
171	Collocated meeting	Operational meeting	P1CM5		07/04/2014	10:00	30	8
172	Collocated meeting	Framework development - part 2 to complete	P2CM45		09/04/14	16:08	84	2
173	Collocated meeting	Framework development - background and latest steps - part 2 to complete	P2CM46		10/04/14	07:56	80	2
174	Collocated meeting	Operational meeting	P1CM6		09/04/2014	10:05	25	6

176	Collocated meeting	Program Development	P2CM47		10/04/14	11:00	70	6
177	Written communication	Program Development - updates	W46		11/04/14	14:45		6
178	Written communication	FW: Assessment sheets	W21	W21A1, W21A2, W21A3	11/04/14	08:44		2
179	Written communication	Summary of assesment	W47		14/04/14	08:57		2
180	Written communication	Summary of assesment	W48		14/04/14	16:01		2
181	Written communication	Continuous Improvement Meeting	W16	W16A1	14/04/14	08:50		4
182	Written communication	Hidden Factory Assessment	W32	W32A1	14/04/14	08:50		3
183	Written communication	Summary of interview process	W70	W70A1	14/04/14	12:01		9
184	Written communication	summary of interview process	W69		14/04/2014			2
185	Written Communication	FW: technology	P1WC24		14/04/2014	12:52		3
186	Written Communication	technology	P1WC25		14/04/2014	10:57		4
187	Written Communication	FW: technology	P1WC34		14/04/2014	12:52		3
188	Written Communication	technology	P1WC35		14/04/2014	10:57		4
189	Written Communication	technology	P1WC75		14/04/2014	10:57		4
190	Infromal and adhoc meeting	chat about possibilities of new machine	P1IM13		14/04/2014	15:10	35	3
191	Written communication	Summary of interview process	W23		15/04/14	15:14		3
192	Written communication	FW: MX Awards - final report	W24	W24A1	15/04/14	15:13		2

193	Written Communication	Set-up of existing technology for new manufacturing unit samples	P1WC19		15/04/2014	12:35		2
194	Written Communication	Set-up of existing technology for new manufacturing unit samples	P1WC50		15/04/2014	12:35		2
195	Written Communication	Conference call with T IT personnel	P1WC56		15/04/2014	12:41		2
196	Infromal and adhoc meeting	chat about problem related to lack of space on computer	P1IM14		15/04/2014	11:40	46	2
197	Collocated meeting	Re:Summary of assesment	P2CM48		16/04/14	11:40	43	2
198	Collocated meeting	Program Development	CM6		17/04/14	11:05	15	4
199	Infromal and adhoc meeting	Program Development	CM7		17/04/14	11:20	80	3
200	Infromal and adhoc meeting	RE:Summary of assessment			17/04/14	10:30	120	2
201	Written Communication	technology Posters	P1WC23		17/04/2014	12:51		3
202	Infromal and adhoc meeting	meeting organise by SDT to discuss process control	P1IM15		17/04/2014	09:58	37	3
203	Written Communication	RE: Conference call with T IT personnel	P1WC55		22/04/2014	11:55		2
204	Written Communication	RE: Conference call with T IT personnel	P1WC54		23/04/2014	09:56		2
205	Written Communication	FW: Conference call with T IT personnel	P1WC7		24/04/2014	13:40		4
206	Written Communication	Conference call with T IT personnel	P1WC8		24/04/2014	11:48		3
207	Written Communication	FW: Conference call with T IT personnel	P1WC52		24/04/2014	13:40		4
208	Written Communication	RE: Conference call with T IT personnel	P1WC53		24/04/2014	11:48		3
209	Written Communication	RE: Set-up of existing technology for new manufacturing unit samples	P1WC17		25/04/2014	09:29		2
210	Written Communication	FW: Set-up of existing technology for new manufacturing unit samples	P1WC18		25/04/2014	09:26		4

211	Written Communication	FW: Set-up of existing technology for new manufacturing unit samples	P1WC49		25/04/2014	09:26		5
212	Collocated meeting	Framework development	P2CM49		28/04/14	10:30	120	4
213	Written Communication	RE: technology Posters	P1WC21		28/04/2014	15:15		4
214	Written Communication	FW: technology Posters	P1WC22		28/04/2014	11:31		2
215	Collocated meeting	tracking and recording system	P1CM7		29/04/14	15:07	100	2
216	Written Communication	FW: technology Posters	P1WC20		29/04/2014	11:06		9
217	Collocated meeting	Framework development	P2CM50		30/04/14	11:08	120	2
218	Written communication	Interesting article from this months' Works Management magazine	W35		30/04/14	09:38		2
219	Collocated meeting	Program Development	CM8		01/05/14	11:11	119	5
220	Written communication	Potential training	W36		01/05/14	15:39		2
221	Written communication	Potential option for workforce training / development with a Lean bias	W40	W40A1	01/05/14	14:19		3
222	Written communication	OpEx_Turning_Strategy_into_Reality discussion	W75		01/05/2014	10:19		2
223	Written Communication	FW: Next visit to B	P1WC9		01/05/2014	13:18		5
224	Written Communication	RE: Next visit to B	P1WC10		01/05/2014	10:01		12
225	Written Communication	B - Issues discussed on Wed. 30-Apr-2014	P1WC51		01/05/2014	15:53		5
226	Written Communication	RE: B - Issues discussed on Wed. 30-Apr-2014	P1WC74		02/05/2014	16:39		3
227	Infromal and adhoc meeting	the sampling door not closing	P1IM8		02/05/2014	08:50	25	2
228	Written Communication	Creation of ID (product)	P1WC6		08/05/2014	10:10		3
229	Written Communication	tech sys set-up requirements	P1WC33		08/05/2014	16:39		2

230	Written Communication	RE: Creation of ID (product)	P1WC39		08/05/2014	16:04		3
231	Written Communication	RE: Creation of ID (product)	P1WC40		08/05/2014	15:53		3
232	Written Communication	Creation of ID (product)	P1WC41		08/05/2014	10:10		3
233	Written Communication	RE: Creation of ID (product)	P1WC42		08/05/2014	16:04		3
234	Infromal and adhoc meeting		P1IM1		08/05/2014	14:20	80	5
235	Written communication	Further information - Network	W20		09/05/14	12:14		2
236	Written Communication	Fwd: Creation of ID (product)	P1WC26		09/05/2014	08:57		2
237	Written Communication	RE: Creation of ID (product)	P1WC38		09/05/2014	08:17		3
238	Infromal and adhoc meeting	Design of the system	P1IM4		09/05/2014	09:35	12	3
239	Infromal and adhoc meeting	SCADA installation	P1IM9		09/05/2014	12:44	11	2
240	Written communication	RE: Mini Tab Software	W51		13/05/14	09:48		3
241	Written communication	RE: Mini Tab Software	W52		15/05/14	09:21		3
242	Collocated meeting	Program Development	CM10		15/05/14	11:00	105	6
243	Written communication	Trial Menu for Projects and Documents	W73		15/05/14	15:54		7
244	Infromal and adhoc meeting	One to one meeting to develop technology further plans	P1IM2		19/05/2014	09:19	3	2
245	Written communication	Trial Menu for Projects and Documents	W74		20/05/14	09:22		2
246	Collocated meeting	Disscusion of implementation	CM14		19/05/14	11:24	76	3
247	Collocated meeting	Disscusion of implementation	CM15		20/05/14	08:56	44	7
248	Collocated meeting	Program Development	CM12		21/05/14	11:06	137	6

249	Collocated meeting	Disscusion of implementation	CM16		22/05/14	09:24	47	2
250	Infromal and adhoc meeting	meeting to discuss development of new technology	P1IM19		22/05/2014	08:55	35	3
251	Written communication	LInk to CI projects men	W37		23/05/14	08:34		2
252	Written Communication	Error message on X	P1WC68		28/05/2014	16:54		2
253	Collocated meeting	Program Development	CM11		28/05/14	11:00	84	5
254	Collocated meeting	Disscusion of implementation	CM17		29/05/14	09:34	50	2
255	Written Communication	FW: Error message on X	P1WC66		29/05/2014	08:42		3
256	Written Communication	RE: Error message on X	P1WC67		29/05/2014	00:48		3
257	Infromal and adhoc meeting	friendly chat between manufacturing unit manager and ChemEng	P1IM18		03/06/2014	09:55	23	2
258	Written communication	Suspension of the weekly meeting	W77		04/06/14	09:51		9
259	Written communication	Suspension of the weekly meeting	W77		04/06/14	09:41		9
260	Written communication	Suspension of the weekly meeting	W77		04/06/14	09:56		3
261	Collocated meeting	Meeting with - Consulting	P2CM51		13/06/14	10:58	70	3
262	Written communication	2 day training - 15th and 16th July;	W3	W3A1, W3A2, W3A3	18/06/14	11:02		2
263	Collocated meeting	Updated: framework kpi's	P2CM52		27/06/14	16:17	90	2
264	Written communication	FW: Development Meeting	W23	W23A1	01/07/14	09:15		3
265	Written communication	Quick Intro for 2 day strategy training	W44	W44A1	01/07/14	13:18		3
266	Written communication	Draft intro	W49		02/07/14	10:44		3
267	Written communication	Ideas for dashboards	W33	W33A1	04/07/14	11:15		3

268	Written communication	Project 56	W43	W43A1	04/07/14	11:23		3
269	Written communication	RE: Draft intro	W49		04/07/14	21:31		2
270	Collocated meeting	Visit.	P1CM8		08/07/14	22:04	50	2
271	Written communication	Training	W48		17/07/14	16:18		2
272	Written communication	Re:Training	W48		18/07/14	10:44		3
273	Written communication	1st draft - next steps presentation	W2	W2A1	22/07/14	15:42		2
274	Written communication	Presentation to sharholders	W13	W13A1	04/08/14	16:50		2
275	Written communication	FW: Optimum Strategy for the process- Follow up	W25		18/08/14	09:08		2
276	Written communication	Optimum Strategy for the process- Follow up	W25		18/08/14	20:31		2
277	Written communication	FW: Optimum Strategy for the process- Follow up (I) - Follow up	W26		18/08/14	15:28		2
278	Written communication	4 day Improvement training	W4		19/08/14	16:15		2
279	Written communication	FW: Presentation to shareholders	W22	W22A1	19/08/14	09:57		2
280	Written communication	4 day Improvement training	W45		19/08/14	14:37		2
281	Written communication	4 day Improvement training	W5		20/08/14	09:07		4
282	Written communication	RE: 4 day Improvement training	W45		26/08/14	09:07		4
283	Written communication	RE: 4 day Improvement training	W46		26/08/14	09:08		4
284	Written communication	RE: 4 day Improvement training	W45		26/08/14	09:13		3

285	Written communication	Details from the interviews	W17	W17A1	04/09/14	09:14		3
286	Collocated meeting	Customer Visit - good element for the framework development?	P2CM53		10/09/14	09:15	45	3
287	Collocated meeting	Benchmarking visit	P2CM54		16/09/14	09:06	72	3
288	Written communication	Supporting article for NCE model	W70	W70A1	19/09/14	15:42		2
289	Collocated meeting	Project 58	P2CM59		22/09/14	09:59	50	2
290	Written communication	Discussion of implementation	W47		10/11/14	12:09		2
291	Written communication	Discussion of implementation	W47		11/11/14	13:30	150	10
292	Collocated meeting	Program development	P2CM60		12/11/14	10:29	40	9
293	Written Communication	RE: Installation of new technology	P1WC29		03/04/2015	16:15		9

Appendix I – data used to evaluate project network structure across the development of new testing technology

Graph Metric	Jan-14	Apr-14	Jul-14	Oct-14	Jan-15	Apr-15	Jul-15
Graph Type	Directed	Directed	Directed	Directed	Directed	Directed	Directed
Vertices	18	17	28	28	17	28	8
Unique Edges	14	23	21	21	19	29	2
Edges With Duplicates	40	25	148	148	28	139	11
Total Edges	54	48	169	169	47	168	13
Reciprocated Vertex Pair Ratio	0.381	0.071	0.135	0.135	0.125	0.283	0.000
Reciprocated Edge Ratio	0.552	0.133	0.237	0.237	0.222	0.441	0.000
Connected Components	2	2	2	2	1	1	1
Single-Vertex Connected Components	0	0	0	0	0	0	0
Maximum Vertices in a Connected Component	16	15	24	24	17	28	8
Maximum Edges in a Connected Component	52	47	159	159	47	168	13
Maximum Geodesic Distance (Diameter)	4	5	7	7	4	4	2
Average Geodesic Distance	1.90	1.89	2.48	2.48	2.06	2.16	1.53
Graph Density	0.09	0.11	0.08	0.08	0.10	0.08	0.13

created using NodeXL version 1.0.1.251

Appendix J – coding examples

Data snippet (examples from technology installation phase)	Initial coding	Focussed coding	Axial coding
Following his visit last week, he feels ([redacted]) that the current [redacted] setup may not be suitable for the large amount of data that the [redacted] analysis and the [redacted] will generate. He added: I am concerned by the lack of space available and how quick that will be used up by running several samples using the [redacted], I fear that you run lots of samples and then the system locks up due to a shortage of space [...]. Then he added: I would like to propose that in the short term a more standard [redacted] be made available so that we can reload the [redacted] software installed in a manner to which we are more familiar with. The database from the current [redacted] could then be copied across to the new [redacted]. This would take up a bit of time, but I am sure it would be worth it to help us understand if we do have any problems with the setup of the [redacted] software and to progress. We can of course then decide upon a suitable strategy for backing up data to an external or partition drive that fits with your [redacted] requirements. *Notes from the project review meeting recorded on 14/04/14*	The project engineer is worried about technical system problems at the manufacturing side that not allow progressing the testing phase. He proposes a short-term solution that would enable testing progress. Feels that long-term solution require manufacturer investment and change of the technical system strategy. Don't feel confident with the system provided by the manufacturer.	Attempt to clarify the problem that not allow on testing progress and has to be resolved by the manufacturer. Feeling confounded. Installation delays.	Project performance: unanticipated delay, Activity: integration of the [redacted] system in preparation for testing, Feeling: confounded
He explains that the errors all relate to the door safety not making (...) the protection breaks the source voltage and the high voltage and gives the security error. The engineer responsible for the mechanism is not sure why this still	The lead technology engineer explains the importance of the magnetic part on the functional error that	Progressing problem-solving, sharing information. The lead engineer is	Focus: on the problem resolution: Activity: instrument installation.

failing as it is a magnetic part that mates with a sensor when the door is closed. The magnet part is located on the right-hand side of the door towards the back hinge. After an explanation to the group of technicians he says: just, first of all, make sure the magnet is still in place. I will try and find a picture and send it over (...) *installation meeting between both firms group of technicians recorded on 29/5/14*	confuses the installation of the instrument at the manufacturing site. Feel that more information and knowledge about design is needed and require to be transferred to technicians that face installation difficulties.	very understandable and helpful.	Feeling helpful.
Also, apart from the [redacted] generation we also discussed the potential utilisation of your existing set of software applications to assist us in the most efficient determination and ultimately selection of the most appropriate production order, based on the currently achieved [redacted]. However, as we both agreed, in order to be able to progress further and make the above, both parties should commit and dedicate the necessary resources if we want these implementation attempts to be successful and any results useful and profitable for both organisations. Therefore, I would kindly like to invite you to take the necessary steps towards the initiation from your end of the required actions, so we can start discussing the projects in detail and set the framework and time needed (…) – *email between projects engineers recorded on 09/05/14*	Project Manager at the manufacturer site requests new sub-project - that change existing installation plans - but potentially can make manufacturer planning process more effective. He hopes that the modification of equipment system can benefit both companies. He requests the technology development partner to take actions towards the initiation of this sub-project.	Discovery of additional function (value-in-use) within newly designed technology during installation. Feeling existed about the new opportunities and energetic	Feeling: energetic and hopeful about the new idea. Activity: systems integration. Project performance: A new idea in the middle of the installation.