

MASTER

Bridging the Boundary: Boundary Spanning in Emerging Companies

Explorative Case Study Research on Boundary Spanning Practices and Processes in the Novel Empirical Setting of Start- and Scaleups

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Bridging the Boundary: Boundary Spanning in Emerging Companies

Explorative Case Study Research on Boundary Spanning Practices and Processes in the Novel Empirical Setting of Start- and Scaleups

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Preface

Dear reader, before you lies the thesis '*Bridging the boundary*' for the completion of my Master in Innovation Management at the Eindhoven University of Technology. This is the final step in my life as a student. I enjoyed my time at the TU/e but now I want to put the education into practice and begin my professional life.

First, I would like to thank my supervisors from the Technical University Eindhoven, Sharon Dolmans and Bob Walrave for the guidance, input and constructive feedback during the complete process. It was a very pleasant and educational experience to uncover the boundary spanning process in startups. A special word of thanks to my company supervisor Roger de Rouw for facilitating the thesis project and giving some great insights from the perspective of an experienced professional. Because of you I got the opportunity to observe some very promising and interesting ventures from the inside. I also would like to thank all the interviewees for their collaboration and insights.

I believe that a pleasant working environment is crucial for successful results. For this I would like Stefan Lemmens, Michael Neefs and Sharon Schonkeren. You introduced me to the rollercoaster of startups with ups and downs and that you have to enjoy the ride and not only the destination.

Finally, I want to thank Frédérique, my sister and parents for supporting me in the rollercoaster of my thesis. Your mental support helped me through stressful times.

I hope you enjoy your reading,

Joris van Tongerloo

Management Summary

Knowledge is becoming an ever increasingly important intangible asset. For technology-based companies the acquisition, storage and subsequent implementation of knowledge is crucial for the development of their value proposition. This is especially true for startups because most of the knowledge that these emerging companies need is external from the company because there are little knowledge domains present within the company. The knowledge domains present in these companies are often very distinct because they have to span a wide range of business processes with less employees. This often proves a challenge for the transfer of knowledge because specific knowledge needs to be translated for it to be communicated. Whereas most studies on boundary spanning in technological innovation context focus on large and/or multinational corporations there is surprisingly little work on boundary spanning in the context of startups.

Research Questions

Following the notion that little is known about boundary spanning in a start and scaleup setting, the main research question in this study focusses on the factors that characterize the boundary spanning process in a technology-based startups.

MQ: What dynamics characterizes boundary spanning processes in a technology-based startup company context to create and exchange new knowledge?

Prior to exploring boundary spanning in this novel setting, it is important that the current state of the art is analyzed. So first the boundary spanning antecedents, theories and mechanism currently known in the literature are analyzed using the following research question:

SQ: What is the state of the art in current boundary spanning literature that focusses on the development of technical innovations?

Empirical Context and Methods

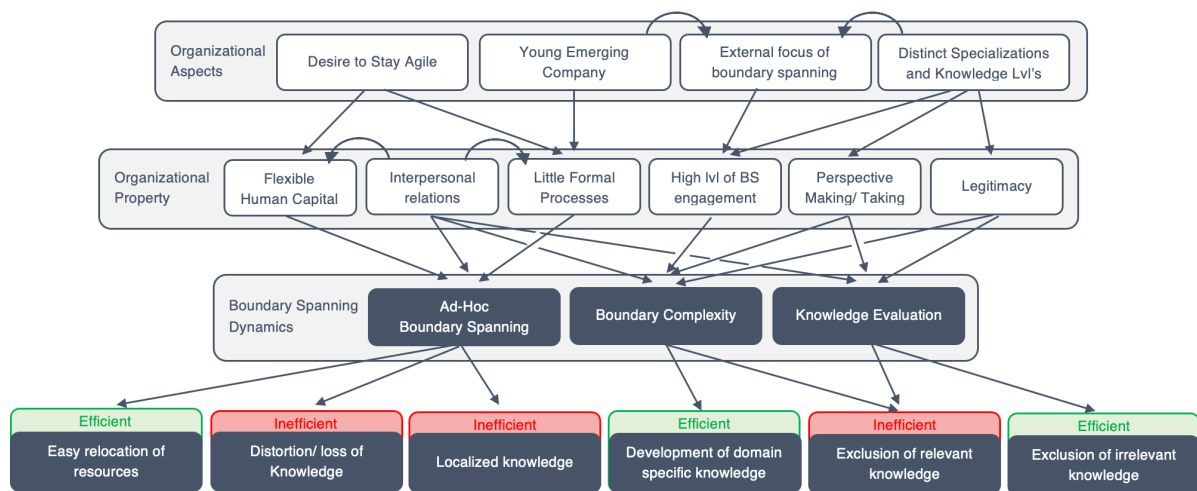
The study is performed at Fimavest B.V. which is a private equity investor that actively take place in the management of their ventures. Four of their ventures are selected for case study research. The cases are observed using 13 semi-structured interviews and fieldnotes. The interviews are loose guided with topics instead of prepared questions following the Gioia methodology. The interview data is transcribed and analyzed using 'MAXQDA' software. The coding resulted in first order concepts, second order themes and aggregate dimensions to form grounded theory.

Results and Discussion

A theoretical analysis is done to uncover the main topics of boundary spanning and their antecedents. The academic field of boundary spanning can be divided into five main topics.

Next to these factors, some antecedents and beneficial conditions are found that influence the effect that the factors have on boundary spanning performance. What strikes the eye is that all of the literary sources considered in this study focus on the empirical context of corporations or even multinational corporations. No study is considered with the empirical context of startups.

The empirical analysis concluded that boundary spanning in startups is characterized by three dynamics namely ad-hoc boundary spanning, boundary complexity and knowledge evaluation.



The ad-hoc boundary spanning is a result of the desire to stay agile and the young and emerging nature of startups. There is a low level of formality which implies that boundary spanning processes are not structured and communication between certain knowledge domains is not planned. This increases the effect that interpersonal relationships have on boundary spanning. The positive effect of this ad-hoc style of boundary spanning is the ability to allocate resources towards boundary spanning when it is most needed because resources are not fixed to predefined tasks. The downside is that boundary spanning does not take place at structured frequencies and information that is beneficial but not vital to business success at that moment in time is not shared between actors in the companies. Over time the information gets distorted or lost and becomes less beneficial for the startup. Because of the lack of scheduled boundary spanning practices and documents knowledge can be stuck and localized in a few employees or the founders of the startups.

The complexity of a boundary can be increased by several factors within a start- and scaleup. Next to the already theorized factors of difference, dependence and novelty boundary complexity is also determined by the social force of interpersonal relationship. It has an effect on the threshold for boundary spanning and will therefor increase or decrease the knowledge boundary. Legitimacy can also affect the boundary complexity because it can prejudice the usefulness of knowledge based on the education or job title of the knowledge source or boundary spanner. Increasing the boundary complexity for that specific person.

Following the notion that the relationship between actors in the startups can have an effect on the concept of boundary size, it also has an effect on the concept of knowledge evaluation. How actors perceive the quality of knowledge to include into their boundary spanning process is affected by the interpersonal relation with the knowledge source. This is also influenced by the perceived legitimacy of the knowledge source based on job title or education level for the development of their own knowledge domain development or decision making. This knowledge evaluation is also affected by a strong presence of perspective taking efforts by actors in a start- and scaleup because they are constantly monitoring and assessing the knowledge level of their conversation-partner so they can communicate as efficient as possible.

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1. Introduction

In the current knowledge-based economy, as argued by Drucker (2011) knowledge is a, if not the, most valuable intangible asset a company has in building and sustaining their competitive advantage (Grant, 1996). So, knowledge is undoubtedly an important driver for corporate success. Ahn and Kim (2017) argue that knowledge sharing is a critical driver for knowledge creation and innovation capability within firms when viewed from a social capital perspective. New knowledge can be created and exchanged by sharing knowledge across boundaries of specialized disciplines or knowledge domains (Leonard, 1995). But, if two or more knowledge domains intersect a boundary rises. This boundary is the result of a difference between specialized knowledge disciplines who all have their own terminology, tools, practices and incentive (Carlile & Rebentisch, 2003). This discrepancy makes the communication between specialized knowledge domains difficult (Carlile, 2003; Carlile & Rebentisch, 2003; Carlile, 2004; Tushman, 1977).

The academic field that is concerned with the migration of knowledge between different knowledge domains both internal and external of a company or innovation system is called 'Boundary Spanning'. The term first was used by Tushman (1977), but the concept dates back from the late 1950's with the work of March and Simon (1958). Since the initial publication of Tushman (1977), the term gains interest from academics ever since. The factors that affect the boundary spanning process are well theorized and extensively studied. Nevertheless, these are results from studies in the empirical context of large, often multinational companies where organizational departments are well defined and where these departments are made up of employees who specialize in the similar knowledge domains. Little empirical studies have been performed to map the factors that influence boundary spanning processes and outcomes in a smaller start-up or scale-up setting.

Smaller and emerging organizations like start- and scale-ups are less likely to have formal processes in place to facilitate knowledge exchange between domains. Next to this, it is even arguable that start- and scale-ups have clear organizational departments while employees or founders often are specialized in a specific knowledge domain (Freeman & Engel, 2007). This makes it assumable that start- and scale-ups differ from a large/ multinational company context. Therefore the antecedents and propositions resulting from empirical studies in large companies might not hold true in a start- and scale-up setting because they are not empirically proven. So, this master thesis will address this gap by studying the factors that influence the boundary spanning process in a start and scale-up setting.

1.1 Research questions

Following the gap from the academic field, the current study will therefore focus on the creation and diffusion of new knowledge in start- and scaleup companies using boundary spanning. First the factors that characterize the boundary spanning process in a technology-based startups get explored. Therefor the main research question for this study is formulated as following:

MQ: What characterizes boundary spanning processes in a technology-based start- and scale-up company context to create and exchange new knowledge?

Before the exploration of this novel empirical environment the current state of art of the academic field needs to be analyzed. So, the boundary spanning antecedents, theories and mechanism currently known in the literature are analyzed. So, the sub question for this study is as following:

SQ: What is the state of the art in current boundary spanning literature that focusses on the development of technical innovations?

1.2 Empirical Context and research set-up

The master thesis project is performed at Fimavest B.V. a private equity investment company that actively invests in start-ups to develop them to profitable companies and keep substantial interest in them. The focus lies on technical innovation with a clear environmentally sustainable goal. The study is conducted in four of their ventures.

What each of the four companies have in common is their strong scientific or R&D focused core. They all originate from a scientific invention which is at the core of their competitive advantage. The companies expand through the next phase of the lifecycle and need other knowledge domains besides purely technical ones to improve the product market fit and to develop and implement a business case. There is a discrepancy between these different knowledge domains. This discrepancy creates a boundary. To increase the likelihood- and accelerate the process of successful commercialization, new knowledge needs to be created and exchanged by spanning the boundary between the different knowledge domains.

This study focusses on observing the boundary spanning processes that take place in the four companies of Fimavest B.V. By doing so, the study explores the avant-garde topic of boundary spanning practices in small and emerging companies like start- and scale-ups to add to the state of the art of boundary spanning theory. Using this knowledge an advice can be formulated to improve boundary spanning in this novel empirical setting.

To answer the sub-question, an in-depth literature review is done. This gives a clear view of the current knowledge available in the academic field. This can be used as a frame of reference when considering the explorative nature of the thesis study. After that the empirical

analysis is conducted using four case studies of the four companies of Fimavest B.V. The interactions between the scientific and technical knowledge domains and the business-oriented knowledge domains get explored. This exploration is done with semi structured interviews. Next to that, use is made of a data structure to visualize the relations between first order concepts, second order themes and their aggregated dimensions. These findings will be synthesized to form a grounded theory.



Figure 1 - Research setup

The next chapter gives an overview of the most important academic constructs concerning this study. Thereafter the methodology of the study is discussed. After this, the findings are presented using a data structure. After that, the research questions get answered with conclusions that are drawn based upon the results of the study. Multiple possible perspectives on the conclusion are discussed and directions for future research are presented. Finally, theoretical and managerial implications of the study are proposed and a critical reflection on the study results in its limitations.

2. Theoretical Background

For product development to happen as effective as possible it is important to acquire and synthesize knowledge from different parties internal and external to the organization. These external organizational departments possess specialized and often more in-depth knowledge that the new product development team does not have access to. But to access this knowledge obstacles and organizational boundaries need to be bridged. This requires skill and effort in order to mobilize the knowledge and resources. How the boundaries between specific knowledge domains are best bridged is well researched in large companies and firms (Appendix A). The focus often lies with new product development teams and their antecedents and obstacles to effective boundary spanning.

Based on the work of Freeman and Engel (2007) there is a significant difference between small and emerging companies and large corporations, certainly when it comes to innovation and product development. Corporations have more capital, more scientists and engineers, more legitimacy, more brand presence, more strategic alliances and, already present business processes. Nevertheless, not all market opportunities are absorbed by large corporations.

For startups it is easier to mobilize and relocate resources because these are not part of the day-to-day operations (Freeman & Engel, 2007). Corporations often need to change the original deployment of the resources. Startups have an organic structure and formal processes are absent employments are filled with tasks that are indispensable for direct business continuity. Lines of authority are muddled and often the founder/ inventor or the most technically experienced member is the informal leader of the startup. This makes the startup flexible and agile and therefore able to change and adapt to often dynamic market demands. Next to the mobilization of resources, the alignment of incentives is an important property that comes naturally to startups compared to corporations. This implies that the parties that provide the resources also share in the profit if the startup is successful (Freeman & Engel, 2007).

2.1 Boundary spanning

Information often resides in specialized knowledge domains. These domains can be internal or external from the focal company. The act of acquiring and synthesizing knowledge and resources from these external domains is defined as boundary spanning. Tushman (1977) coins boundary spanning as '*the linking of the organization's internal networks with external sources of information*'. The linking of the internal and external networks presents a challenge

because knowledge is 'sticky' to its invested knowledge domain. This implies that the knowledge needs some sort of decoding and translating in order to move it to another knowledge domain (Nonaka & Takeuchi, 1995). Edmondson and Nembhard (2009) state that boundary spanning skills are an important tool in improving new product development team effectiveness.

A companies boundary spanning can be focused both internally and externally based on the organizational departments involved. Nevertheless, external boundary spanning is coupled to internal boundary spanning because external uncertainty and changes must be internally absorbed by internal boundary spanning. So, internal boundary spanning is always present (Morash, Dröge, & Vickery, 1997). Nevertheless, it is argued that startups will have relatively more external boundary spanning than corporations because of the smaller organizational size. There is less information internal to the company to develop the knowledge domains of the startup knowledge needs to come from an external domain.

Companies can engage in boundary spanning in multiple ways. Bullinger, Neyer, Rass and Moeslein (2010) define proactive and reactive boundary spanning as a result of their study of the effect of competition and cooperation on innovation. Proactive boundary spanning is defined as active search for ties or links to knowledge. On the other hand, reactive boundary spanning is achieved when someone positively engages with boundary spanning activities of others. Startups need to actively develop their value propositions for business continuity, therefor they need to actively search for new information. Therefor it is expected that they will span boundaries in a proactive manner.

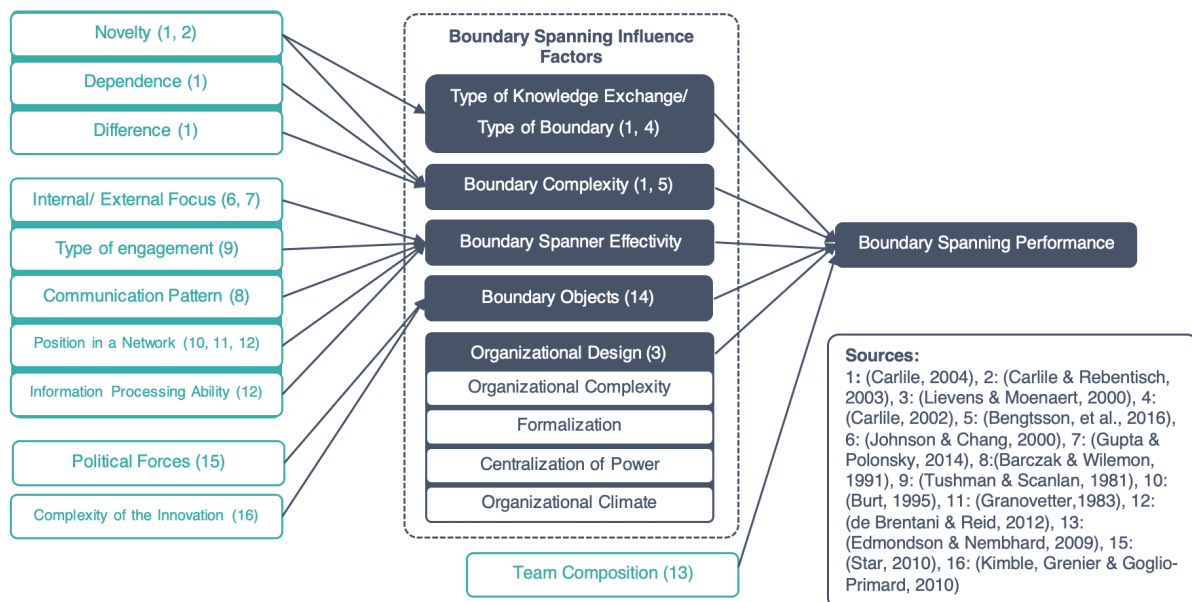


Figure 2 - Boundary spanning influence factors

Figure 2 further details boundary spanning and the factors that influence the boundary spanning process and their underlying relations. Current academic literature on boundary spanning describes 11 factors that have a relationship to the boundary spanning process

may it be through a higher-level construct. These are higher level factors that are build up out of two or more smaller factors that influence their performance. The figure depicts which sources describes which factor. There are 10 factors that combine into five higher level factors that have an impact on the boundary spanning process. One factor influence boundary spanning process directly. The following sections will elaborate all factors and their underlying relation with boundary spanning performance.

2.2 Knowledge domains and their boundaries

Leonard (1995) stated that most innovation happens at the boundaries between disciplines or specializations. This implies that working across knowledge boundaries is crucial for developing competitive advantage, but also why innovation proves so difficult to foster and maintain. So, to develop innovative new products and services communication between various departments within a company is necessary. This communication is the transfer of knowledge from one department or knowledge domain to another and therefor knowledge is crossing boundaries.

2.2.1 Knowledge boundaries

A knowledge domain contains information that is specific and specialized to a certain discipline. The knowledge is so domain specific it is often challenging to understand for outsiders. Because of this a boundary rises when knowledge is transferred to another domain. Carlile and Reberich (2003), state that these knowledge boundaries are established by the use of unique terminology, tools, practices and incentives. They also mention that the introduction of new knowledge disrupts the current relationships between specialized knowledge domains. The dependencies between the knowledge domains need to be rearranged and redefined through the process of knowledge integration from different sources. This process results in the creation of new knowledge which can be the genesis of innovation.

Carlile (2002, 2004), argues that there are three **types of knowledge boundaries** based on the amount of **novelty** (Figure 3). The first, syntactic boundary assumes the existence of a shared syntax (common knowledge) at the knowledge boundary. The shared syntax specifies and agrees on differences and dependencies in the knowledge that crosses the boundary. When too much novelty is introduced, the syntax is inadequate and a new boundary rises. The semantic boundary accepts the existence of differences. In contrast to the syntactic boundary, individuals have different interpretations of a word or term and do not share the same syntax. Both knowledge domains surrounding the boundary need to develop shared meanings. If more novelty is introduced the pragmatic boundary rises. The pragmatic type sees that knowledge is localized, embedded and invested in practice. Novelty introduced disrupts known dependencies and interest among actors at the boundary. To solve this, both common knowledge and domain specific knowledge need to be transformed.

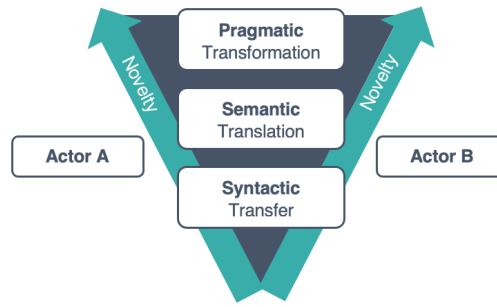


Figure 3 - Framework for managing knowledge across boundaries (Carlile, 2004)

Nevertheless, **novelty** is only one of the three factors that determine the complexity of a boundary. Carlile (2004) has developed a framework for the assessment of **boundary complexity** by examining the **difference**, **dependence** and **novelty** of domain specific knowledge among people attempting to communicate across a boundary. **Difference** refers to the number of unique knowledge domains of the people at the knowledge boundary. So, if the people at the boundary poses the same domain specific knowledge, there is no communication difficulty. If the people at the boundary have completely different domains of knowledge, communication will require a greater effort. **Dependence** is the perception of people working at the boundary about the inclusion of others perspective in order to achieve their goals. Finally, **novelty** is assessed by the lack of common knowledge because of different specialties, cultures and contexts of people working at the boundary. But, lack of common knowledge can also be caused by advances in technology of new scientific findings.

2.3 Process of transferring knowledge

The knowledge from the knowledge domains can be integrated to develop new knowledge. Therefor the boundaries between the domains need to be bridged.

2.3.1 Knowledge sharing at each boundary type

When novelty is introduced, the common knowledge is no longer adequate for describing the dependencies and discrepancies and therefor a boundary emerges or enlarges. There are three **types of knowledge exchange** processes for knowledge management across boundaries. These processes each belong to their own knowledge boundary typology as previously mentioned in chapter 2.2.1. If the boundary is syntactic, knowledge has to be transferred using common lexicon and domain specific knowledge is managed across the boundary. But when novelty is introduced, the common lexicon is not sufficient anymore and a semantic boundary arises. Learning about and translating domain specific knowledge into common meanings that actors can use to assess their knowledge is necessary to manage knowledge at the boundary. When this semantic response is not enough, the pragmatic boundary is faced, which requires the transformation of both common and domain specific

knowledge. Next to that, common interests need to be developed in order to share and assess knowledge.

2.3.2 The evolution of the three-part cycle

To integrate the knowledge from distinct domains Hargadon and Sutton (1997) have developed a cycle for understanding the integration of knowledge in companies. They propose a three-part cycle for knowledge transfer where knowledge is first acquired from external domains, then is stored in organizational memory where it is retrieved from for use. Concluding from two empirical studies on international joint ventures and a product development challenge, Carlile and Reberntisch (2003) state that the linking of knowledge storage and retrieval need a repeated cycle that can have both positive and negative effects on following cycles. They have addressed the process of knowledge integration that otherwise is deemed as '*the black box*'. They have evolved the three-part cycle of Hargadon and Sutton (1997) to start at the '*storage phase*' because they believe that stored knowledge is the genesis of path dependency or constrains of any retrieval effort. Next to that, Carlile and Reberntisch (2003) prefer transformation over acquisition because of the more active effort required with new knowledge (Figure 4). Carlile and Reberntisch (2003) focal point of research was the processes that resolved the negative consequences of the repeated three-part cycle.

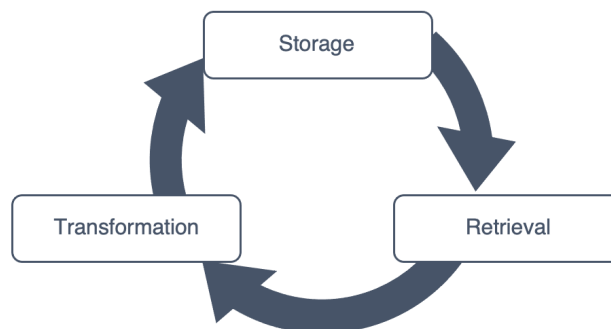


Figure 4 - The knowledge transformation cycle (Carlile & Reberntisch, 2003)

There are three challenges that can lead to negative effects in the repeated three-part cycle. The introduction of novelty to the context of the knowledge domain between knowledge storage and retrieval results in a core knowledge integration challenge because it disrupts the relation between specialized knowledge sources. Sources of novelty are often changing customer needs or actors who are unfamiliar with common knowledge used to describe the differences and discrepancies surrounding domain-specific knowledge (Carlile, 2004). The mismatch that occurs between retrieval of knowledge when there is a change in the context after knowledge is stored results in reduced usefulness of the knowledge because the stored knowledge did not evolve with the changing context. Next to this Carlile and Reberntisch (2003) argue that the number of interdependent sources of knowledge involved with the transformation process increase the difficulty of knowledge integration. The inter-group dependencies that come from the involvement of multiple knowledge sources increases the knowledge integration complexity. When there are many knowledge sources, and the context of the knowledge changes, the focus of the process shifts from integrating knowledge from

multiple sources to agreement on whose knowledge is most relevant for solving the task at hand and therefore needs to be integrated. Finally, specialization and differences in knowledge between sources of knowledge can form a challenge for the knowledge transformation process because of knowledge boundaries that occur as a result of the difference in language and practices between different knowledge domains. So, novelty, dependence and specialization propose challenges for knowledge integration processes. To overcome these challenges Carlile and Reber (2003) propose that boundary objects can be used to specify dependencies across specialized domains.

2.3.3 The communication between specific knowledge domains

One way through which specialized knowledge domains develop and translate their knowledge in common meanings is through perspective making and taking (Boland & Tenkasi, 1995). The development of knowledge within a specialized domain is called perspective making. The perspective complexifies which signifies a movement from general naming and terms to specific and more precise meanings.

It is important for the interlocutors to understand each other's knowledge level. This enables the interlocutors to take each other's point of view into account when transferring knowledge through narratives. The adoption of the others' view point and knowledge level in communicating complex specialized knowledge to other distinct domains is called perspective taking. This implies that they adapt the language, terms and naming used in the narrative to their interlocutor. The dynamic that comes up here is that the distinct knowledge held by the individuals need to maintain its uniqueness, but also needs to be made accessible for the other in the narrative.

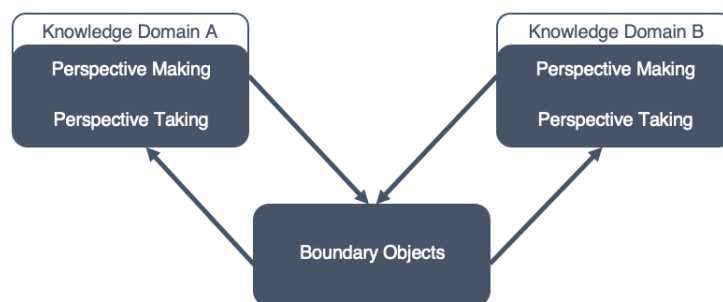


Figure 5 - Perspective making and taking and boundary objects

Boundary objects can aid in the communication between distinct knowledge domains (Figure 4). The process of perspective making shapes the boundary objects and the process of perspective taking is facilitated by the boundary objects. Section 2.5 will go more in depth about these boundary objects.

2.4 Actors who span boundaries

People play an important role in the integration of knowledge through the previously mentioned knowledge integration processes. These actors are called boundary spanners or boundary spanning employees. They translate their domain specific knowledge to integrate with other knowledge domains so that potential users can understand and use it. The term broker is also frequently used. Boundary spanners are different from brokers in the sense that brokers strategically use information they possess in structural holes in order to leverage a better position (Bergenholtz, 2011). Boundary spanners are actors who distribute information within and outside the company (Flemming & Waguespack, 2007). So, for the sake of this study, a broker without the ambition of personal gain or getting a better position themselves is assumed to be a boundary spanner.

Boundary spanning individuals are seen by their colleagues as technically competent and have the background and skills to communicate with different external knowledge domains (Tushman & Scanlan, 1981). Williams (2002) defines a boundary spanner as an individual who is focused on the management of interdependencies. These individuals rely more on relational and interpersonal attributes to build social capital rather than knowledge-based attributes.

There is a stream of literature that argues that boundary spanners are employees who only interact between the company and the external environment and do not focus on interaction between domains within a specific company (Johlke, Stamper & Shoemaker, 2001; Matous & Wang, 2019). Like general boundary spanning practices, a boundary spanner needs to bridge internal and external domains to gain, create or distribute knowledge. So, boundary spanners can be both **focused internally and externally**.

Tushman and Scanlan (1981) argue that boundary spanning is more than a formal status because work related competence is a better determinant of boundary spanning role than formal status. Leivina and Vaast (2005) distinguish between two **types of engagement** namely nominated boundary spanners and spanners-in-practice. Nominated boundary spanners are appointed with symbolic capital but do not actually engage in boundary spanning activities. Boundary spanners in practice are engaged in boundary spanning activities relating one knowledge domain to another, thereby creating a shared field of knowledge between the two domains. This shared field of knowledge is called the shared semantic space by Tushman and Scanlan (1981).

Barczak and Wilemon (1991) argue that boundary spanners are often team leaders and that the effectivity of new product development process communication is pendent upon the communication of the team leader. They specify two types of boundary spanner **communication patterns** namely, '*operating*' and '*innovating*'. Where the type of communication pattern is governed by the informational demand of their project. The operating type of communication pattern will be directed between team members and

focused on product features and schedules. On the other hand, the innovating type of communication pattern focusses more on customer needs (Barczak & Wilemon, 1991).

Following one of Gupta and Polonsky's (2014) propositions that internal boundary spanners are more effective within a network and that external boundary spanners are more efficient coordinating new information into the network. Nevertheless, Johnson and Chang (2000) state that internal and external boundary spanning can best be done by the same person, the so called '*communication star*'. These actors can better integrate internal and external information so they are mutually reinforcing (Johnson & Chang, 2000). Thus, the most effective boundary spanning employees focus on both the external and the internal environment of the company so they can better integrate both information streams.

2.5 Artifacts to Span Boundaries

Boundary spanning employees can make use of artifacts to help them bridge the gaps between knowledge domains. Carlile and Reberich (2003) state that boundary objects (Star, 1989) can be used for the development of an effective shared context between specialists of different knowledge domains. The boundary object develops shared language, provides a method for learning about differences and dependencies and therefor facilitates the process of transforming knowledge. Gideon, Markman and Wright (2008) argue that boundary spanners produce boundary objects to acquire knowledge from one domain and deploy it in other domains.

Star (1989) initially developed the concept of boundary object as a result of a study done on artificial intelligence. During this study she further evolved the notion of Hewitt and Kornfield (1981) that science uses objects to create a central authority on how robustness of findings is achieved. Star (1989) found that boundary objects enable scientists to cooperate without having good models of each other's work. Next to this, boundary objects let scientists cooperate while having different goals, time horizons, and audiences to satisfy.

A boundary objects are made up of three components (Star, 1989), the first being interpretive flexibility. This enables different actors to aggregate different types of information from the same artifact because of interpretation they make from their perspective. The second component being the structure of informatic and work process needs and arrangements and finally, the third component is the dynamic between ill-structured and more tailored uses of the objects.

Boundary objects also prove to be a method for solving heterogeneous problems which are weakly structured in common use but strongly structured in individual use (Star, 1989). At least two or more actors with different viewpoints need to be involved in the process of developing and using boundary objects.

Boundary objects need a certain scale to be most useful, for boundary objects this is the organizational level. Next to a certain scale, the scope of a boundary object dictates its usefulness. A certain level of specificity is needed to make a boundary object useful for the target group but not so specific that the interpretive flexibility is compromised. Next to that exclusion of certain objects from being boundary objects Star (2010) notices that only the component of interpretive flexibility is cited and used in describing boundary objects. The latter two are rarely used.

The selection of boundary object is determined by the **complexity of the innovation** (Kimble, Grenier, & Goglio-Primard, 2010). The selection of boundary object is a technical choice that depends on the informational need of the innovation process. Kimble, Grenier and Goglio-Primard (2010) also state that there is a second force in the selection of boundary object. This being **political forces**. This often translates in the leader of the group selects a boundary object based on the degree of diversity the group is willing to accept. The selection of boundary object can also be a political tool to manipulate the direction of group activities. This is why a strong relation between the boundary spanner and the boundary object is assumed.

Bowker and Star (1999), expanded the research to go from single boundary objects to a system of boundary objects known as a boundary infrastructure. A boundary infrastructure is an interplay of multiple boundary objects which enables any community of practice to aggregate information from the infrastructure. Boundary infrastructures are not perfect constructs when compared to unified and universally applicable information systems. Nevertheless, they respect the diverse needs of any community of practice that utilizes them because of the play they propose for localized differences. The recognition of different information objects that different communities of practice have is the main benefit of boundary infrastructures over traditional information systems. Next to that, boundary infrastructures have sufficient structure to allow the use of bureaucratic tools to be applied (Drucker, 2011).

2.6 The antecedents of boundary spanning

The previous sections explain different aspects of the boundary spanning process. Definitions are formed and the main topics of the boundary spanning literature are discussed. This section will elaborate on that by discussing factors that influence the effectivity of the boundary spanning process or its outcome.

2.6.1 The knowledge boundary

In the previous section knowledge domains and boundaries are discussed. There the influence of novelty at the knowledge boundary is discussed.

The complexity at the knowledge boundary has an inverted U effect on the proposed novelty of the innovation it creates (Bengtsen, Lakemond, Laursen, & Tell, 2016). Because novelty

effects the complexity of the boundary, the work of Bengtsson et al. (2016) can be coupled to the boundary typology of Carlile (2002, 2004) where a syntactic boundary consists of low levels of novelty. Current syntax will be adequate to manage the boundary. Therefore, little new knowledge is created in the translation of knowledge. So, it will result in a less novel innovation. The semantic boundary has enough novelty to result in new useful knowledge and therefore a novel innovation. The pragmatic boundary consists of a more than optimal level of novelty. The knowledge domains will be too distant from each other that will result in a less novel innovation.

Bengtsson et al. (2016) states that the relationship between boundary complexity and innovation novelty is moderated by the artifacts used to cross boundaries and the context of knowledge integrations. The artifacts aid in the creation of shared understanding, translation and transformation knowledge between domains. These artifacts can be seen as boundary objects (Star, 1989).

2.6.2 Team and organizational design

The composition of a team or organization influences the performance of the boundary spanning process. Edmondson and Nembhard have found that knowledge domain diversity within the **composition of a team** has influence on the effect of boundary spanning. High knowledge domain diversity within a team will result in a more positive effect of boundary spanning on new product team performance. They also found that there is a positive relation between cooperative orientation and boundary spanning. So, when companies are open for cooperation, more information will interchange between knowledge domains. When teams are composed of multiple knowledge domains, a wide variety of perspectives and specialized knowledge is transferred and shaped into new innovations.

The process of transferring knowledge can also be improved by the design and composition of the organization where it is practiced. There are four aspects of organizational design that influence boundary spanning effectivity (Lievens & Moenaert, 2000). The first is **organizational complexity**, which refers to the number of specialists in the organization. More specialists in an organizational design have a positive relation with boundary spanning effectiveness. Next to this, the importance the organization attaches to the idea of following rules and procedures when performing one's job, also called **formalization**, is argued to have a curvilinear relationship with boundary spanning effectiveness. Formalization may inhibit the search of new information, on the other hand (Zaltman, Duncan, & Holbek, 1973), formalization could be beneficial in the implementation of an innovation (Rogers & Agarwala-Rogers, 1976). The level of **centralization of power** in the organizational design and the absence of participation in decision making leads to lower boundary spanning performance. Finally, the **organizational climate** surrounding the project is curvilinearly related to boundary spanning performance. But what a good or bad project climate entails is not specified by Lievens and Moenaert (2000). They only refer to the "too-good friends" syndrome which means that very close team members may impede the boundary spanning process.

The organizational design of a start- and scaleup is likely to differ from the organizational design of a corporation. The aspects of complexity, formalization and centralization of power are argued to differ in startups compared with corporations. Therefore the influence of organizational design on the boundary spanning process of startups will be an interesting topic for the empirical research.

2.6.3 Boundary spanner

For boundary spanners to engage effectively in knowledge sharing they need to be spanners in practice rather than 'nominated' boundary spanners. Levina and Vaast (2005) found that an individual needs to be involved and create an understanding of both knowledge domains so they can participate in both domains. Next to being involved as a participant in the different knowledge domains, an individual needs to be a negotiator between the knowledge domains he represents. This is effectuated by gaining symbolic capital so that others perceive the individual as capable of influencing the practices between the knowledge domains. The last condition is that boundary spanning individuals need to develop an inclination to span the boundaries each domain.

De Brentani and Reid (2012) argue that the efficacy of a boundary spanning individual depends on three key factors namely: Characteristics of the innovation, the boundary spanning individuals' **information processing ability** and, the **position in the network** of the boundary spanning individual. Following these key factors are coherent propositions (de Brentani & Reid, 2012). Concerning the characteristics of the innovation, high levels of discontinuity of the innovation as well as sequential and uneven availability of information impacts boundary spanner effectiveness negatively. Concerning the abilities of the boundary spanning individual. Higher need for cognition leads to greater breadth and depth of search which lowers speed of information flow, but increases quality of information. Greater technical integration capability leads to better information filtration which results in faster speed of information flow and better information quality. Women compared with men have a greater breadth and depth of search effort and less information filtration which lowers information flow speed but increases information quality. Greater cosmopolitanism leads to greater breadth and depth of search and better information filtration which increases information flow speed and improves information quality.

Concerning the position of boundary spanning individual, networks with a greater breadth, centrality and lower cohesion have a positive effect on boundary spanner effectiveness (de Brentani & Reid, 2012). This is due to the structural holes theory (Burt, 1995). This implies that a network full of indirect weak ties is richer in information than a dense network because weak ties are less likely to possess redundant information (Granovetter, 1983). Nevertheless, indirect relations communicate information through one or more intermediaries. The information can get intentionally or unintentionally get disturbed between the intermediaries due to misunderstanding, forgetting details, failing to mention everything or intentional secrecy (Hansen, 2002).

So, the antecedents for boundary spanning individuals are that boundary spanners need to be work-related competent because this is related with colleague consultation. This colleague consultation improves the individual's chances on a promotion to a better formal status. This formal status facilitates in boundary spanning activities by gaining of symbolical capital. Next to that, a boundary spanning individual needs to be internally and externally connected. They need to be able to translate equivocal information from outside sources to less equivocal information for internal communication. This requires specific knowledge to link these internal and external domains. It is also beneficial for a boundary spanner to be central in a network rich in structural holes where they link multiple sub-networks to each other.

2.7 The absence of startups as empirical context

Out of all the sources consulted to form an overview of academic literature, none were concerned with boundary spanning in startups or small and emerging companies (Table 1). 12 of the sources reported on purely theoretical studies, 19 studies focus on large multinational corporations with clearly defined organizational departments, and five studies are concerned with governmental- and publicly financed services or universities.

A specific search is done to validate the absence of boundary spanning studies in emerging startups (Appendix A). This resulted in an article that focused on so called '*entrepreneurial firms*', nevertheless these were studied when they were listed on either European or American stock exchanges (Zott & Amit, 2007). Next to this there is an article that focusses on spin-offs which implies that these emerging companies have their origins in larger corporations (Hayter, 2016).

Because startups are likely to possess only the minimal necessary knowledge domains for their core value proposition, they need to consult internal and external resources to gain new knowledge to further develop their company. Therefore, boundary spanning in emerging companies like startups proves to be an interesting topic of study.

Table 1 - Analysis of empirical focus

Author	Year	Research focus	Empirical focus
1 Barczak & Wilemon	1991	Empirical	Differences in communication style of leaders in new product development teams
2 Bengtsson, Lakemond, Laursen & Tell	2016	Theoretical	
3 Bergenholtz	2011	Theoretical	
4 Bowker & Star	1999	Theoretical	
5 Bullinger, Neyer, Rass & Moeslein	2010	Empirical	Innovation contest in German Universities
6 Burt	1995	Theoretical	
7 Carlile	2002	Empirical	The use of boundary objects in new product development between primary functions for a high volume product within a automotive corporation
8 Carlile	2004	Empirical	Research program on a computational fluid dynamics tool in the third largest automotive company in the world
9 Carlile & Rebentisch	2003	Empirical	Knowledge flow in technology and product development settings in international joint venture and product development firm
10 Drucker	2011	Theoretical	
11 Edmondson & Nembhard	2009	Theoretical	
12 Fleming & Wwaguespack	2007	Empirical	Longitudonal analyses of careers within the internet engineering task force community on brokerage, boundary spanning and leadership
13 Gideon, Markman & Wright	2008	Theoretical	
14 Granovetter	1973	Theoretical	
15 Gupta & Polonsky	2014	Empirical	Study on inter- firm learning in multinational pharmaceutical networks
16 Hansen	2002	Empirical	Effect of knowledge networks 120 new product development projects in 41 large multinational companies
17 Hargadon & Sutton	1997	Empirical	Ethnographic study of technology brokering in a large multinational product design firm
18 Hewitt & Kornfield	1981	Empirical	Study on problem solving in an artificial intelligence laboratory
19 Johlke, Stamper and Shoemaker	2001	Empirical	Study of boundary spanners perception of organizational support of sales employees in four B2B companies
20 Johnson & Chang	2000	Empirical	Boundary spanning in a national cancer information service
21 Kimble, Grenieer & Goglio-Primard	2010	Empirical	Political effects on brokers and boundary spanners in two groups of IT-professionals and a network of healthcare professionals
22 Leivina & Vaast	2005	Empirical	Study on boundary spanners in an insurance company and an professional services firm
23 Leonard	1995	Theoretical	
24 Lievens & Moenart	2000	Empirical	The communication flows in innovation projects of four European multinational corporations
25 Love & Roper	2001	Empirical	The effect of location and network effects in UK German and Irish manufacturing plants
26 Matous & Wang	2019	Empirical	Boundary spanning and leadership in 16 remote agricultural communities
27 Morash, Droge & Vickery	1997	Empirical	Interactions between logistics, production, marketing and new product development departments
28 Nonaka & Takeuchi	1995	Empirical	Japanese automotive and electrical companies
29 Patnayakuni, Rai & Tiwana	2007	Empirical	Knowledge integration in information systems departments of manufacturing and service firms
30 Star	1989	Theoretical	
31 Star	2010	Theoretical	
32 Star & Griesemer	1989	Empirical	Management of divergent viewpoints in the Museum of Vertebrate Zoology
33 Tushman	1977	Empirical	Communication activity of R&D facility of a large U.S. corporation
34 Tushman & Scanlan	1981	Empirical	Study on boundary spanning antecedents in a North-American high-technology medical instrument corporation
35 Williams	2002	Theoretical	

3. Method

To aid Fimavest B.V. in improving the creation and exchange of new knowledge the process of boundary spanning in startups is first observed using multiple case studies. The findings resulting from these observations analyzed and synthesized to gain insight into the boundary spanning processes in the context of startups. This chapter will give further insight into the methodological setup of the master thesis study. The research design, data source selection, data collection- and analysis methods get discussed.

3.1 Research Design

Resulting from the problem diagnoses and literature gap, the master thesis study is concerned with exploring the properties, characteristics and qualities of boundary spanning in the empirical context of startups. The research will be conducted using a qualitative approach because, as stated in the research question, it is concerned with exploring the properties and characteristics of boundary spanning in start- and scale-ups (van Aken & Berends, 2018).

The empirical analysis will be conducted using case study research encompassing the companies depicted in Table 2 as four separate cases (Eisenhardt, 1989). These are typical cases because of the absence of exceptional behavior on behalf of boundary spanning processes or performance. The case study research strategy focusses on developing grounded theory using data collected from empirical settings. The theory will be developed in an inductive manner where observations from the empirical environment get generalized to form a grounded theory that predicts certain behavior for other companies within the empirical scope. The process of conducting case study research is depicted in Figure 6.

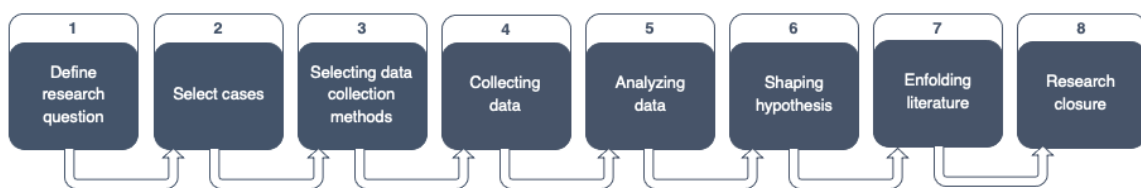


Figure 6 - Process of conducting case study research (Eisenhardt, 1989)

The problem diagnosis is done using informal interviews with the company supervisor and other partners of Fimavest B.V. The research question is formulated in a cooperative manner with the company supervisor and TU/e supervisor.

3.1.1 Data sources

As previously mentioned, the empirical analysis will be conducted using case study research. The cases are selected based on their business type which resulted in the inclusion of all technology-based startups in the portfolio of Fimavest B.V. The cases range from the

very front end of the startup lifecycle to the scaling phase (Passaro, Rippa, & Quinto, 2016). Next the that, the technical value proposition of the startups are different as well. This improves generalizability of the findings because the cases span a wide range of technology-based startups based on lifecycle phase and area of application.

These companies consist of several actors being employees, shareholders, founders and partners. These are divided into two main categories based on their knowledge domain, namely ‘*technical*’ and ‘*business*’. This is a very generic categorization, but this is the only distinctions that can be clearly made from the composition of the startups. Table 2 gives a description of each of the cases and depicts the number of actors that are interviewed relative to the total number in their knowledge domain in their startup.

Table 2 - Cases for theory development

Case name	Plastic-Cycle	Bacteria B.V.	ECOating	Agri-Improvement
Description	Development of a radically new way of recycling polypropylene and polyethylene plastics so that 90% of the resources that go into the process are reusable as either gas, naphtha or paraffin.	Production of patented bacteria that can upcycle waste streams into useful components for the chemical industry. The R&D department of BACTERIA B.V. is still exploring which useful enzymes their bacteria produces and therefore which practical applications the bacteria have.	ECOating is a company that develops applications for a patented water and dirt repellent coating that resists UV radiation and corrosion. Examples of applications are water repellent treatment of sport clothing and corrosion resistance of aluminum cool roofing panels.	Agri-Improvement is a company that co-produces and distributes a patented soil enriching substrate. The added value of the substrate is a reduction in the need for water and more crop production per meter squared because of the moisture and nutrient retaining properties of the product.
Startup lifecycle phase	Scaling	Fitting product to market	Minimum viable product	Scaling
Established	2011	2015	2016	2018
Employees Interviewed/ total	5/35	2/4	5/5	1/1
Technical	3/30	1/3	3/3	0/0
Business	2/5	1/1	2/2	1/1

In total there are 13 interviews conducted. This consist of seven technical/ scientific actors and six business related actors. Appendix B depicts all functions that are represented in the interviews.

3.1.2 Interview Design

Data will be collected using interviews and observations about the process of boundary spanning in emerging startups. The interviews are semi-structured following the Gioia-methodology (Gioia, Corley, & Hamilton, 2012). This methodology implies that interviews must be loosely guided by the predetermined interview protocol, and that this protocol must be focused on the research question without any ‘*leading-the-witness*’ questions. When the

research progresses and some findings become increasingly clear the interview protocol must be revised in order to follow the dynamic nature of discovering grounded theory (Glaser & Strauss, 1967). To capture the empirical picture with the least amount of disturbance, the interviews are conducted using the interviewee's terms and native language. Using the native language has the downside that the researcher can get too close and loses his higher-level perspective needed for grounded theory development (Gioia, Corley, & Hamilton, 2012). Next to that, most of the interviews are conducted and transcribed in Dutch. Some information can get lost or distorted in translation to English.

The interview protocol is designed to analyze the boundary spanning engagement and process of the employees and founders of the startups selected as cases. The boundary spanning influence factors from the theoretical background are indirectly included in the interview as well as novel factors specific to startups. Throughout the interview, the interviewee is asked to link his personal beliefs and impressions to practical examples in order to make them as tangible and objective as possible. Nevertheless, the interview questions will change as the research develops (Gioia, Corley, & Hamilton, 2012). The protocol consists of three parts.

The first part of the interviews is focused on getting to know the interviewee's perspective on boundary spanning and knowledge sharing. This gives the interviewer more insights in possible discussion topics to extract more information. The interviewees are asked about the startup they work in, their function within the startup, the actors and parties they cooperate with and, their educational and professional background. This part of the interview also enables the interviewer to recognize the boundary spanning influence factors. This gives an impression of the organizational design, if they engage in boundary spanning activities, their position in a network and, their field of focus (internal/ external).

The second part of the interviews is focused on gaining insight on the interviewee's own way of boundary spanning. The term boundary spanning is never used, this is too distant from the interviewee's native language. Knowledge sharing is used instead of boundary spanning. Questions are focused around formal versus informal processes, meeting culture, hierarchy within the company, documentation, certification and, how the interviewee personally is engaged in sharing knowledge.

The final part of the interview is concerned with the interviewee's opinion and impressions about the current performance of boundary spanning within the start- or scaleup. The questions first focus on the factors that positively influence the boundary spanning process. Then the protocol is focused on factors that negatively influence the boundary spanning process. Finally, the development of the boundary spanning processes and engagements over time are discussed. How did this evolve during the lifespan of the startup and was this evolution for the better or for the worse.

3.2 Data analysis approach

The five phased cycle for data analysis (Figure 7) is used as a framework for analyzing the data collected (Yin, 2011). First, data is created by transcribing the audio files from the interviews. For these audio recordings written permission was asked and anonymity was promised. The observations outside the interviews are transcribed in an MS Excel file as fieldnotes. The transcriptions and the fieldnotes are collected in one folder to aid in easy access later in the data analysis process.

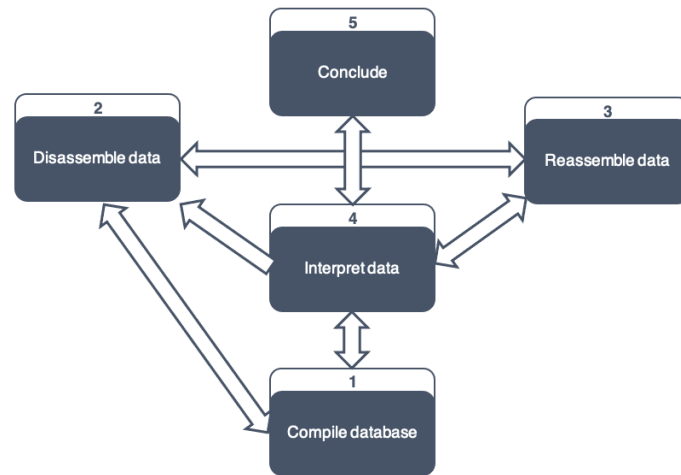


Figure 7 - Five-phased cycle of analysis and their interactions (Yin, 2011)

After this the transcriptions need to be coded in the disassemble phase. A computer assisted qualitative data analysis software program called 'MAXQDA' will be used to aid in the coding of the transcripts. The software aids in the three phased coding method necessary for the grounded theory approach (Gioia, Corley, & Hamilton, 2012).

The first order analysis is called open coding and is focused on selecting emerging concepts. In recognizing and selecting these concepts, the analysis adheres to the native language of the respondents. The results of the first round of open coding are depicted in the data structure as first order concepts. Appendix C depicts an overview of all first order concepts with a description and exemplary quote. The open coding evolves into the second order analysis when similarities and differences between the first order concepts are found. These second order concepts are more abstract and theoretical compared with the first order concepts. Because of continuous iteration between open coding more conceptual second order themes and current literature the interviews not only resulted in new second order concepts but also lead to the recognition of the existing theoretical concepts. These concepts are already known in the literature but to avoid conformation bias the literature is not known in detail before analysis. Nevertheless, during the analysis process the findings are constantly iterated with and reflected on the literature. The interviews resulted in some first order concepts concerning the communication and development of specialized knowledge between actors in the startups that were best explained by the work of Boland

and Tenkasi (1995) on perspective making and taking. Next to this, some evaluative and judgmental actions of certain actors in the startups indicated the prolific presence of legitimacy (Suddaby, Bitektine, & Haack, 2017). The second order concepts are distilled further to aggregate dimensions. These are abstracts of the second order themes. A number of concepts centered around ad-hoc boundary spanning approach because of the low level of formal processes, agility and flexibility that are inherent to startups. Next to that, multiple judgmental processes are distilled further into knowledge evaluation. Further iterating with the literature concluded that perspective making, legitimacy and the distinction in knowledge domains and specializations lead to a further expansion of the concept of boundary complexity by Carlile (2002). Figure 8 displays the so-called data structure to visualize the relationships between the three coding orders (Gioia, Corley, & Hamilton, 2012). This gives a clear picture of the reasoning behind the theory development which aids in demonstrating the rigor of the study. Table 3 is an overview of all second order themes with their definition and an exemplary quote to support the data structure.

The last two phases are about interpreting findings and drawing conclusions. In the fourth phase the data from the reassemble phase gets arranged to extract interpretations on how boundary spanning is characterized in startups. The data structure proved a convenient tool in streamlining the thought processes that went in to the findings of the research. Nevertheless, the grounded theory looks different from the data structure because it is a more dynamic picture that the static combination of first and second order themes and the aggregate detentions. There were many iterations necessary to get the underlying relations between the concepts and aggregate dimensions right. The grounded theory also considered the effects that the aggregate dimensions had on the boundary spanning process. The last phase focusses on drawing a conclusion for the whole study by answering the main research question on the characteristics of boundary spanning in startups using the data derived from the interviews. Next to that the implications for managers are given and the implications for theory are given by reflecting the grounded theory on already known literature.

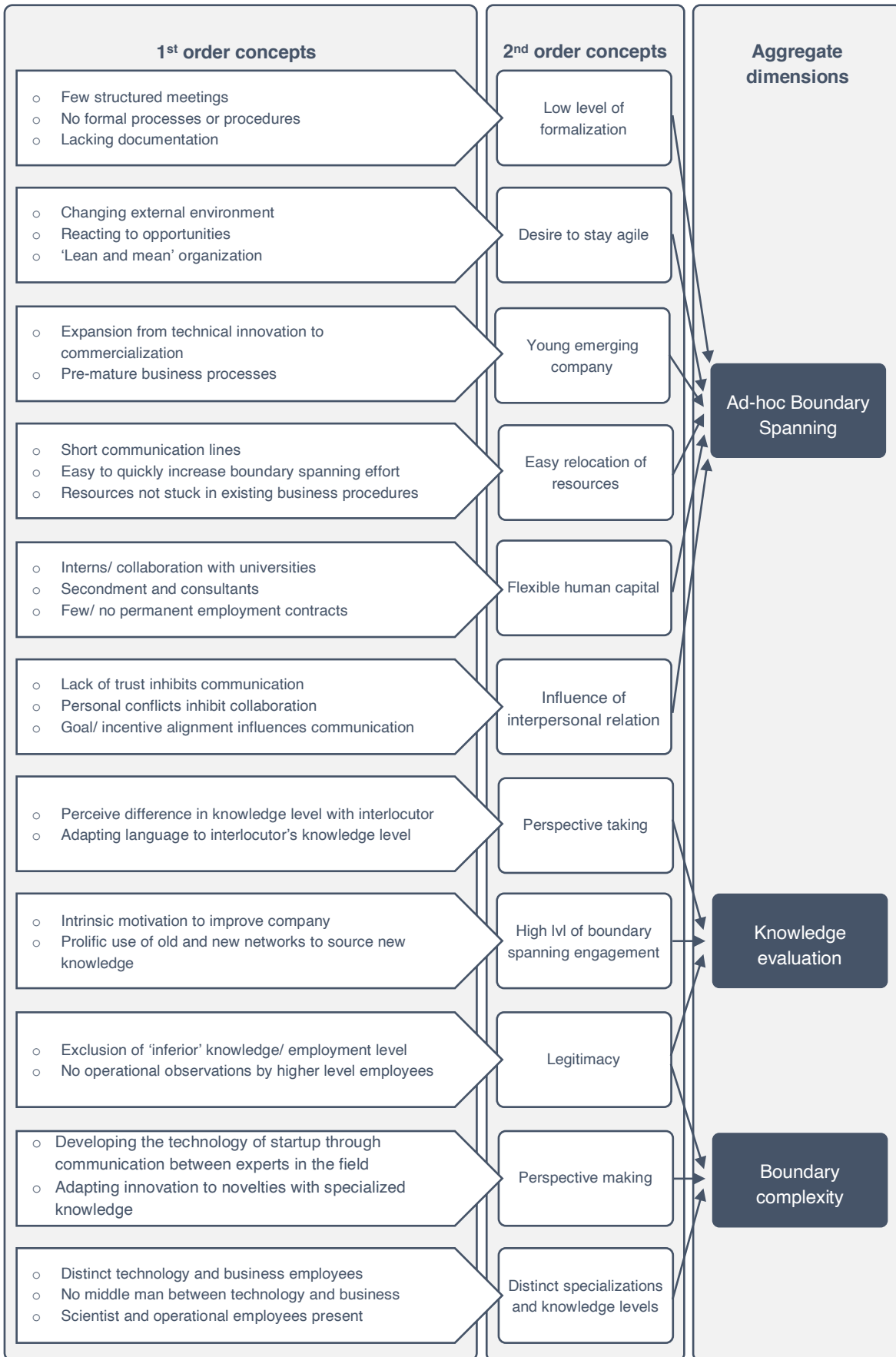


Figure 8 - Data structure

Table 3 - Description of second order concepts

2 nd order concept	Definition	Example quote
Low level of formalization	No or few processes in the start- and scaleups are preplanned, structured or documented. This includes documentation, meetings, operational processes and reporting hierarchies	<i>"There are no fixed processes here, we do everything in the way we think is best. It is a small organization so we get it managed."</i>
Desire to stay agile	The start-and scaleups want to be able to react to external changes with a flexible internal organization	<i>"I see a market that is moving and we must continue to respond to that dynamic, so we must remain flexible."</i>
Young emerging company	Start- or scaleup gaining presence and prominence in competitive market landscape	<i>"We have developed the technology and are now making the first step to the market. All those business processes have yet to get underway."</i>
Easy relocation of resources	The start- or scaleup can rearrange its resources with little impact on the current organizational actions	<i>"Yes we are just opposite each other, the lines are short so we switch quickly and just talk to each other."</i>
Flexible human capital	Actors active in the start- and scaleups have flexible employment terms	<i>"We also work with interns, technically but also in the marketing field."</i>
Influence of interpersonal relation	The effect that the quality of the interpersonal relationship between actors surrounding the boundary have on the boundary spanning process	<i>"Let's keep the ball flat, the communication between management, sales, feed and so forth was poor. It has a personal aspect. I do not like mister [...] he does not like me. It does not work."</i>
Perspective taking	Adjustment of language to communicate domain specific knowledge to another knowledge domain	<i>"I talk to them in a very different way when I talk to [...], for example."</i>
High level of boundary spanning engagement	Almost all, if not all employees in a startup engage in boundary spanning activities to improve the technical value proposition	<i>"Everyone is very hands-on involved in developing the product."</i>
Legitimacy	Judgement of information quality of the input from actors based on educational background or job title	<i>"But nothing is shared when they are innovating. Nothing is discussed with us and decisions are made within their own club. And then they simply don't take certain things into consideration, which we know from our expertise."</i>
Perspective making	Using information from other knowledge domains to improve own knowledge domain	<i>"But because I am very closely involved in many actions and decisions. I also learned a lot from [...] from chemistry. Which also helps me understand the business better."</i>

Distinct specializations and knowledge levels	The specializations, knowledge levels, and job titles active in the start- and scaleup are distant from each other because they span the same width of tasks with less employees	<i>“But often I think they have understood it, but then they often don't understand it yet. Our knowledge is simply too far apart there.”</i>
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3.3 Validity and reliability

To make sure the master thesis study covers the intended topic and its results are reproducible, reliability is discussed next to construct-, internal- and external validity (Yin, 2003; Swanborn, 1996).

The study makes use of three systematic processes to collect and analyze data (Appendix A, Figure 6 and 7). These processes are well used and proved themselves in other studies. They also ensure reliability because the processes are repeatable and therefore improve the likelihood of reproducing the results.

Semi-structured interviews are used to uncover unknown factors of boundary spanning in the unknown context of startups. To assure internal validity multiple actors from a single case get interviewed. Unfortunately, this was not possible in the Agri-Improvement case because the actors responsible for technical innovation were not present in the company during the time of the study. The internal triangulation makes sure that the concepts and aggregate dimensions and their underlying relationships concerning the boundary spanning process are justified and complete. The number of cases in which a code was present is depicted in the codebook (Appendix C).

To avoid conformation bias, the literature study was not used to form a complete overview of the academic field, but not to form any validating questions like propositions of hypotheses. But, to assure academic rigor the literature was iteratively used in combination with the data to search for already existing patterns, theories and concepts. This led to the inclusion of some second order concepts and the expansion of on aggregate dimension. The interviews were conducted by one researcher, this increases the risk of hot-/ cold biases and personal interpretation of qualitative data. This risk is tackled during the analysis of the interviews with the use of a data structure to clearly visualize the reasoning behind the relations between first and second order concepts and their aggregate dimension.

The coding of the interviews followed a three-step process (van Aken & Berends, 2018). Open coding results in first order concepts by labeling phenomena from the interviews staying loyal to the interviewees terms. No existing coding scheme is used to reduce the risk of conformation bias. Thereafter the interviews are analyzed using theoretical coding which resulted in the second order concepts. Finally, selective coding was applied to the data to

crystalize the relationships between the results from the previous steps to come up with the aggregate dimensions.

External validity refers to the generalizability of the study results. This is ensured by incorporating four companies is the empirical analysis who are in a different phase of the start-up lifecycle and who are active in different markets ranging from very early minimum viable product phase to the scaling phase and from bio-chemistry to.

4. Findings

The analysis of the 13 interviews has uncovered some interesting dynamics concerning the boundary spanning processes of startups. In particular, the findings below highlight various factors that play an important role in boundary spanning processes in the four empirical cases. Some interesting dynamics are discovered on how the technology focused startups engage in boundary spanning processes.

As demonstrated in the remainder of this section, findings explain how various organizational aspects of startups influence the boundary spanning process. The desire to stay agile, the emerging nature and the distinction between actors in the startups have a significant effect on the way knowledge is shared and developed within the companies.

Prominent is the ad-hoc and intuitive way of initiating tasks, actions and collaborative efforts. Next to this, startups engage in more externally focused boundary spanning processes because the knowledge that is demanded is external rather than internal from the company.

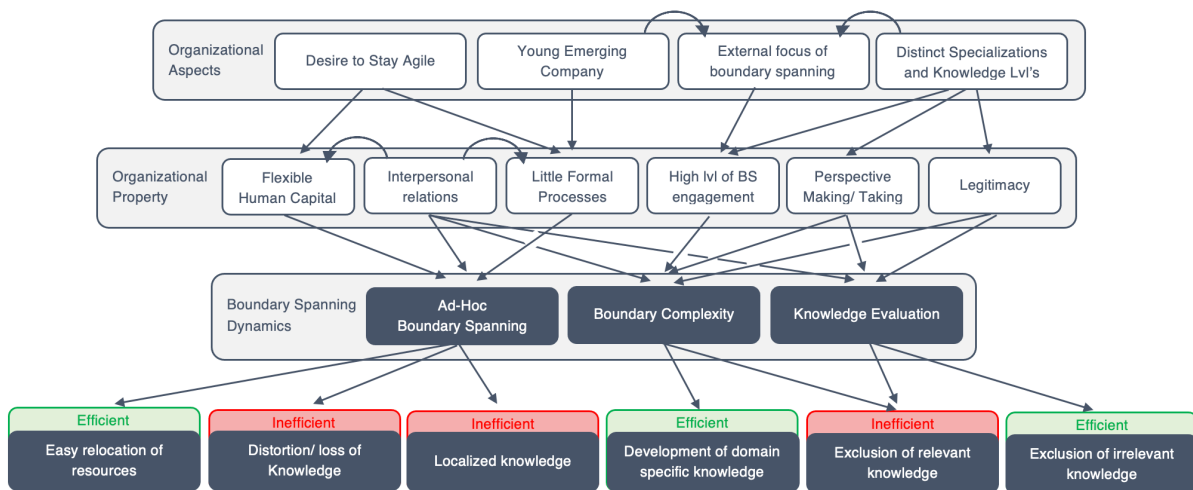


Figure 9 - Model of influence factors of boundary spanning in startups

The following sections will give a more detailed look into the dynamics and elaborates how they affect the boundary spanning processes of startups. This will be accompanied with quotes directly taken from the interviews.

4.1 Ad-hoc boundary spanning

This section discusses the dynamic between the agile and emerging nature of startups and the boundary spanning process. This is considered the left side of the model (Figure 9). It is to be argued that this has both positive and negative effects on boundary spanning.

4.1.1 The flip side of agility

From the empirical analysis it became clear that startups want to stay agile because they want to react fast to changing market demands and requirements. This helps them to develop products quicker with the least amount of risk and resources needed. This agility is often established in little formality concerning processes as business employee 1 of Plastic-Cycle states.

"But what's also going on here, which I think is typical of small and developing companies, is the lack of structure and the ad-hoc, action-reaction approach. This allows us to respond to market dynamics with a limited number of people." (Business employee 1, Plastic-Cycle)

The desire to stay agile embodies itself in a low level of formal processes and agreements. The reason for the informal organizational style is the belief that the formalization of organizational processes is not necessary because of to the small organization size. The span of control of the founders and managers in the startup is more than enough to encompass the startup even without strict organizational processes. The effort needed to initiate, implement and maintain the formalization does not outweigh the benefits it brings as business employee 2 from ECOating B.V. states.

"Because we already work very close together every day and because we work here with three people for ECOating, and then we have [Technical employee 1] and the two interns. So we are a small organization. So that formalization takes more time and effort than it generates profit." (Business employee 2, ECOating)

So, informality results in a low amount of or even absence of processes, procedures, documentation, document management and meeting structures. When less human capital is allocated to predefined tasks and processes, more capital is free to be allocated where it is needed the most in that moment in time. Thus, increasing the agility of the startup. Next to this, the daily operations and activities of the startup can be sufficiently managed without these formal structures. That implies that the formalization of the startups would cost more time and effort than what it would spare. Nevertheless, the informal structure of startups causes some interesting dynamics concerning the boundary spanning process.

Next to the informal way of organizing the startup, there is another way in which startups make their organization more agile and that is flexible human capital. Three of the four cases work with interns and university projects and one case made use of secondment as can be seen in the quotes below. The reason for this kind of employment is that it takes market dynamics and uncertainty of business continuity into account. If external changes from the market have a negative effect on the startup, flexible human capital can be discarded more easily than permanent employments, keeping the organizations agile.

"Yes I also have a permanent employee and two interns." (Technical employee, Bacteria B.V.)

"In addition, we work with interns, both technically and in the field of marketing. But we are a small organization and this way we still get things done." (Business employee 1, ECOating)

"She supervises interns and graduates and they have carried out tests for us." (Business employee 1, Agro-Improvement)

"The production people are not employed by Plastic-Cycle, they are from [Secondment bureau]."
(Technical employee 2, Plastic-Cycle)

decided there, who was there. We must now rely on what we hear from [technical employee 2]." (Business employee 3, Plastic-Cycle)

4.1.2 Interpersonal relations affect the boundary spanning process

During the empirical analysis it became clear that the absence of formal processes and structured documentation makes the collaboration between different actors more subjective to personal interpretation. As business employee 1 of ECOating states below, this personal interpretation has an effect on the task content and execution. Because of the personal interpretation, interpersonal aspects have greater influence on the collaborative efforts used to execute a task. This implies on who to collaborate with, how in depth is the collaboration is and what knowledge to share in the collaboration.

"You notice that a lot depends on the atmosphere in the team. From my previous job at [...] I am used to having all input for innovation processes fixed and structured. Everyone is responsible for their own part of the R&D process and supplies predetermined documents or specific parts. Here it is not so fixed and what is done and how effectively team members work together depends on how they interpret the tasks and how the atmosphere of the team is. [...] The relationship you have, to be very open and honest and quick to enter into a dialogue with each other is super important in developing a product. If your relationship with your colleague is not good and distant, you are not so inclined to share things. While that is super important in a startup because your structured processes that would normally streamline this are not there yet. [...] How well you get along doesn't even matter that much, because you really don't have to be the best of friends, but that you trust each other and that you work towards a common goal. No double agendas and no annoyances. You have to have a collaboration where you can communicate transparently and honestly with each other so that you can solve the annoyances instead of making them worse." (Business employee 1, ECOating)

The relationship between different actors of the startup needs to facilitate collaboration by decreasing the threshold for sharing knowledge. This also holds true for the flexible employments. Because there are no coordinating processes for sharing and transferring knowledge, the relationship between the flexible employments has an effect on the willingness to share knowledge, frequency and intensity of knowledge transferring events. This implies that transparency and a close relationship is crucial for the development of a startup. To create this relationship, trust and honesty are crucial factors. Misalignment of goals and incentives causes political forces which undermine trust between team members. As technical employee 1 of Plastic-Cycle states, personal aspects like disliking someone is detrimental to the sharing of knowledge and the spanning of boundaries.

"Let's keep the ball flat, the communication between management, sales, feed and so forth is poor. It has a personal aspect. I do not like [...], he does not like me. It does not work." (Technical employee 1, Plastic-Cycle)

Thus, the quality of interpersonal relationships effects the relation between informality and the boundary spanning process. Actors with a good interpersonal relation will therefor benefit from the low level of formalization because they do not need to allocated to a fixed schedule

to collaborate successfully. Therefore they are more flexible to allocate their time and resources to attain their goals without the need to engage in possible redundant coordinating efforts. Nevertheless, actors with a bad interpersonal relationship need structure to force them on delivering the minimum viable input to the boundary spanning process.

4.1.3 The effects of ad-hoc boundary spanning

Because of the informal organization style, actors in the startups are not tied to bureaucratic structures and fixed reporting procedures. This enables them to allocate their resources to the boundary spanning efforts when this is needed. If there is no or little demand for boundary spanning, the efforts are easily scaled down resulting in minimal time lost to redundant processes and structures.

“But formalizing everything now comes at the expense of flexibility. If we suddenly have to discuss and collaborate more intensively, we now choose to visit each other more frequently in an informal manner. And if we had everything structured, we had to cancel regular meetings when times are less busy. You often get those meetings where nobody really has anything to say and that waste your time” (Business employee 2, ECOating)

The low level of predefined coordinating efforts and procedures, coupled with their compact size leads to the startups having very flat hierarchical structures. This shortens the communication lines to a situation where everybody is approachable by each actor in the start- and scaleup. These short communication lines increase the amount of knowledge domains that engage in the boundary spanning process which have a positive effect on the boundary spanning process.

“Everyone talks to each other and that is super useful, everyone has a different perspective on things which often provides new insights and ideas. That was much less at my previous employer, where everyone worked on their own piece of the project in their own little bubble.” (Technology employee 1, Bacteria B.V.)

We notice a synergistic effect. An example, if [...] joins the R&D meetings. He looks more from a business perspective, but because of his experience over the past four years with technology and science, he can often ask very specific questions concerning the business case that also trigger me as CEO. [...] can sometimes get stuck in the technical truth-finding. But [...] can reason very well what is really important for the customer. This also challenges me. (Business employee 1, ECOating)

The ad-hoc nature of boundary spanning processes only incorporate the information and subjects which are absolutely necessary of the business continuity. Because of this, information that could be beneficial, but is not crucial to include into the boundary spanning process is left out. Over time, this information can get lost or distorted.

“Well, we hardly ever sit together because the majority just goes over the table with [...] and with [...] we then talk for 10 minutes and then he is on the same page again. To discuss everything in scheduled meetings, the organization blunts off. Then I may have to wait a few days before I can ask or discuss something, then the focus will be gone. [...] Then things are also forgotten.” (Business employee 1, Agro-Improvement)

The flexible employments work for a limited time on a predefined task. Because of this limited timeframe, they do want to start up their project as efficiently as possible. To start it is important that they have access to the information necessary for their project. During the empirical analysis it became clear that not all information was accessible for the new employees or interns. The information often localized in the founders/inventors of the startup. The boundary objects to transfer the knowledge to the other actors in the startup are not present or are poorly organized. The latter was the case in ECOating as an intern states below. There the knowledge of the founder was uploaded in a cloud where everyone can access the data. Nevertheless, the information was poorly structured and the sheer number of documents was so overwhelming that the interns and even permanent employees could not find the information they needed or were demotivated to start their search. This resulted in delays in their projects and the execution of tests that were already done.

"I still find things and then I think "wow that would have been nice if I had found that out six months ago". That really slowed me down in the beginning." (Technical intern 1 ECOating)

Because of the ad-hoc organizational character, the knowledge transfer processes and structures are not in place yet. So, next to the absence or lacking structure of boundary objects, there are no or little meetings to share and transfer knowledge from the founder/inventor to the employees. Because the resources of the founder/ inventor are allocated towards running and developing the startup, there is little room for additional meetings for knowledge transfer. So, the knowledge is and stays centralized into one or a few actors in the startup.

"But we have just entered a transition in which [...] is just starting and in which we are working with interns and graduates who start a new projects. There is also no transfer of knowledge from intern to intern. There is no transfer at all at the moment, so that can be a lot better and more efficient." (Business employee 1, ECOating)

4.2 Boundary Complexity

Next to ad-hoc boundary spanning, the analysis of the interviews resulted in a number of factors that affect the concept of boundary complexity.

4.2.1 High level of boundary spanning engagement

Due to the smaller size of the companies they tend to have limited human capital and therefore limited internal knowledge. This is why the emphasis of boundary spanning in emerging companies like startups is more on external boundary spanning than on internal boundary spanning because most of the knowledge domains needed for innovation is external from the company.

"In this company everyone is very externally focused because there is simply not enough knowledge internally to solve the problems or to further develop the product" (Business employee 2 Plastic-Cycle)

Because of the limited amount of human capital present in the start- and scaleup companies every employee plays a vital role in the development of the business. That is the reason why all employees search externally for information to improve the company they work in. They have a high level of external boundary spanning engagement. This high level of boundary spanning engagement is caused by an intrinsic motivation to improve the company.

"Everyone is very hands-on developing the product, everyone is always looking for information or opportunities from old employers, competing products or academic journal. [...] This involvement in the development of the business comes mainly from intrinsic values of continuously wanting to improve. These are qualities we pay attention to during application procedures." (Business employee 1, ECOating)

Because each actor within the startups has a distinct knowledge background, they are likely to have a distinct network. This makes their networks rich in structural holes so their networks have less redundant ties (these are multiple ties that provide the same information).

"Network is crucial, especially in a small business because you don't have all the knowledge in-house to run your business." (Business employee 1, Agro-Improvement)

The distinction in knowledge domains opposes a challenge for actors to communicate with each other. It requires a collective effort to create a shared semantic space and mutual understanding. This is only possible with a frequent and in-depth collaboration. This is affected by the interpersonal relationship between actors in the start and scaleup.

"Everyone here has such a different background and comes from a completely different world. Therefore, there is very little overlap in the networks of the people here. [...] Sometimes it is a challenge to transfer each other's professional knowledge because I have 30 years of experience with coatings and [...] with financial aspects. [...] We still manage to share that knowledge because we work very closely together. [...] A good atmosphere in the team is certainly essential for the success of the business." (Business Employee 2, ECOating)

The external boundary spanning often opposed by the secrecy that is used to protect the intellectual property that is the basis for the start-ups competitive advantage. This limits the freedom that employees have in their communication with external parties because there is the risk of revealing technical details that enables the competition to develop similar value propositions which lowers the added value and potential of their own company.

4.2.2 Perspective taking and making

Technology-based startups originate from purely technical knowledge domains. After the technical development the companies evolve and want to commercialize their product. Because less employees are present in startups whilst spanning a broad range of knowledge domains, the knowledge gaps between these actors are large. Because of the specialized nature of the internal knowledge domains, much of the knowledge that is attained externally is distant from the currently present knowledge domains. Perspective taking and making are therefore prolifically present in startups to develop the internal knowledge domains and to communicate internal knowledge with external parties.

But sometimes I notice that s they don't get it. I really have to bring it back to simple language. You have to leave biology behind, you have to tell it in clear and simple language." (Technical employee 1, Bacteria B.V.)

The translation to make the domain specific knowledge understandable for external knowledge domains requires a communicative effort from the employees. Because of this translation certain technical details can get lost. Therefore it is important that the employees have the communicative skills to translate the domains specific knowledge in such a manner that important technical details remain present without making the communication too difficult for the conversation partner.

Because I can't put it into a business case. That is the knowledge I am again lacking." (Technical Employee 1, Bacteria B.V.)

Sometimes the knowledge gaps are of such a magnitude that new human capital is needed to close the gap. Perspective taking does not seem to be enough to transfer the knowledge from one knowledge domain to another and an intermediary knowledge domain needs to be attained.

"What the organization needs for the future? [...] is the CEO but has a very strong technical orientation. But [...] is also a marketing expert. But what I think we're missing is a technical salesperson who's in between those worlds. A sales-oriented person who enters the market together with [...]." (Business employee 2, ECOating)

4.2.3 Boundary complexity and its effects

The concept of boundary complexity has two main effects on the boundary spanning process. On one hand an increase in boundary complexity because of perspective making results in the development of domains specific knowledge. But, on the other hand, this increase of the boundary complexity because of the distinction of knowledge domains can make the knowledge too specialized for actors to understand each other with the result that actors cannot communicate effectively. This lack of communication can lead to the exclusion of relevant knowledge from the boundary spanning process.

Nevertheless, the increase in boundary complexity cannot only be accounted by a distinction in knowledge, but also to the effect of interpersonal relation. Interpersonal relation can increase or decrease the boundary complexity because it can influence the willingness to communicate and therefore the frequency and intensity of boundary spanning efforts between actors. Leading to less exclusion of knowledge and more development of domain specific knowledge. From the interview with business employee 1 of ECOating it became clear that prolific boundary spanning efforts made him able to understand domain specific knowledge better further enabling him to develop his own knowledge domain.

Because [...] took the time in the beginning to explain everything simple language to me until I understand it, I have to say that I can now easily communicate with [...] about it. So that I understand what is going on in commerce and I can judge that from a technological background." (Business employee 1, ECOating)

Next to that, legitimacy can increase boundary complexity because it can prejudice the input of employees based on educational level or job title and exclude it from decision making or innovation processes. Further distancing these actors from boundary spanning activities and therefor increasing the threshold for boundary spanning.

You can express your opinion but nothing will be done about it. [...] They think we are way too pragmatic and it doesn't match their theoretical or scientific approach. (Technical employee 2, Plastic-Cycle)

4.3 Knowledge evaluation

There are a number of evaluative practices present in the boundary spanning process of a startup with both positive and negative effects.

4.3.1 Legitimacy and interpersonal relations

During the empirical analysis it stood out that multiple respondents talked about the exclusion of certain information in the decision-making processes by higher ranked employees. After further questioning it became clear that these higher ranked employees did not consider the experiences and observations that the operators had during a trail run. These experiences and observations were structurally collected in a report after each trail run. Nevertheless, this information was structurally excluded from the decision making.

"Well, to put it briefly, they [...] do not stand with their feet in the clay. They do not experience what is happening here in terms of testing and trial production runs. They form their judgment of the situation entirely from their own reasoning and theories. The experiences gained by the people on the floor are hardly taken into account. [...] They think they know better." (Technical employee 2, Plastic-Cycle)

The higher ranked employees all shared one thing, an academic title. The other employees' perspective on this exclusion was that based on people's educational background, job title and knowledge of the project, input is deemed as superficial and therefor is not included in analyses and decision making.

"They think their knowledge is above that of others. They have a mindset, a philosophy and it's hard to get rid of that." (Business employee 1, Plastic-Cycle)

Thus, not all observations and experiences are evaluated as legitimate knowledge by the higher ranked employees. Nevertheless, the knowledge is structurally reported and offered to the higher ranked employees. The report as a boundary object, is not accepted because it consists of inferior knowledge in the eyes of the decision-making group. There is a formal structure in place to develop a shared semantic space, nevertheless it is not used. So, it is argued that procedures themselves do not oblige actors in a boundary spanning process to share and adopt knowledge but enforcement of the procedures does.

Interpersonal relations can also influence how actors perceive and evaluate each other's knowledge independently of the actual knowledge quality. A good interpersonal relation can

lead to a better evaluation of their knowledge and a bad interpersonal relation can have negative effects on the evaluation of their knowledge.

4.3.2 Perspective taking

The act of perspective taking as previously mentioned is the communication of domain specific knowledge to another domain. This requires some form of translation to make the knowledge understandable for the conversation partner. But before the domain specific knowledge can be translated to the knowledge level of the conversational partner, the actual knowledge level of the conversational partner needs to be evaluated. This increased awareness of the understanding from the conversational partner improves the overall view of their knowledge level and therefor the evaluation of the quality of input to the boundary spanning process.

4.3.4 The effects of knowledge evaluation

The evaluative practices mentioned above can have both positive and negative effects on the boundary spanning process. On the one hand evaluation of knowledge, and especially legitimacy can lead to the exclusion of relevant knowledge from the boundary spanning process. The input itself is not judged during this evaluative practice but rather the educational background or job title from the actor who wants to convey it. On the other hand, the evaluative practices can exclude irrelevant knowledge from the boundary spanning process to reduce the time, energy and resources invested in this redundant information.

5. Conclusion & Discussion

This study was conducted to explore the practices and processes that characterize boundary spanning for the exchange and creation of knowledge in technology-based startups. To answer this main research question, a sub-question was formulated. This section will elaborate on how the study answers these research questions, what implications it has for theory and practice, what aspects need to be researched more in-depth in the future and what the limitations of the study are.

5.1 Research questions answered

To answer the main research question, the sub-question needs to be addressed. The sub-question focusses on the current existing theoretical landscape of boundary spanning:

What is the state of the art in current boundary spanning literature that focusses on the development of technical innovations?

A theoretical analysis was performed to uncover the main topics of boundary spanning and their antecedents. The academic field of boundary spanning can be divided into five main topics, which are further divided into factors that influence a company's boundary spanning process. Two factors are found that directly influence the boundary spanning process and 14 factors that combine into five higher level factors that influence the boundary spanning process. Next to these factors, some antecedents and beneficial conditions are found that influence the effect that the factors have on boundary spanning performance.

It must be noted that all of the literary sources considered in this study focus on the empirical context of corporations or even multinational corporations. These have clearly defined departments and stable/ already present business processes. Therefore start and scaleups differ significantly from corporations. So, it is argued that boundary spanning processes and practices also differ between these empirical scopes.

To research how boundary spanning works in emerging companies like startups the main research question was formulated as follows:

What dynamics characterize boundary spanning processes in a technology-based startup company context to create and exchange new knowledge?

Boundary spanning in startups is centered around three dynamics namely, ad-hoc boundary spanning, boundary size and knowledge evaluation.

Ad-hoc boundary spanning

Ad-hoc boundary spanning is a result of the desire to stay agile and of the young and emerging nature of startups. There is a low level of formality of business processes and there is a high level of flexible human capital to keep risks down, which implies that boundary spanning processes are not structured and communication between certain knowledge domains is not planned. The unformalized organizational design increases the effect that interpersonal relationships have on boundary spanning. Actors are not formally inclined to communicate with each other and there is no or little structure in the frequency and depth of information sharing between them or in the documentation of these information sharing instances. The lack of knowledge sharing instances and documents also causes knowledge to stay localized in the founders of the startup. Actors could be unwilling to communicate due to relationship issues or suffer from the 'too good friends' syndrome, where communication is so intense that it makes actors blind for other perspectives.

The positive effect of this ad-hoc style of boundary spanning is the ability to allocate resources toward boundary spanning when it is most needed because resources are not fixed to predefined tasks. Communication lines are short which enables the startups to react quickly to changes in their dynamic external environment. The downside is that boundary spanning does not take place at structured frequencies and that it is not clear which actors or knowledge domains communicate with each other. Thus, information that is beneficial but not vital to business success at a specific moment in time is not shared between actors in the companies. Over time, the information may be distorted or lost and becomes less beneficial to the startup.

Boundary complexity

The complexity of a boundary can be increased by several factors within a start- and scaleup. Because of the distinction of the knowledge domains present in the start- and scaleup the amount of novelty at the boundary increases by which the boundary complexity increases. Next to this, the process of perspective making increases boundary complexity because specialized domain knowledge improves as a result of boundary spanning, further distancing the knowledge domains.

The boundary complexity can also be decreased by perspective taking and the high level of boundary spanning engagement present in the startups. Because these factors increase the effort that actors in the startups put into communicating their domain specific knowledge across other domains. The difference in knowledge domains decrease and therefor the boundary complexity decreases.

Next to the more informational factors argued above, boundary complexity is also determined by the social force of interpersonal relationship. It has an effect on the threshold for boundary spanning and will therefor increase or decrease the boundary size. Legitimacy can also affect the boundary complexity because it can prejudice the usefulness of knowledge based

on the education or job title of the knowledge source or boundary spanner. Increasing the boundary complexity for that specific person.

Knowledge evaluation

The relationships between actors in the startups can have an effect on the concept of boundary complexity but also has an effect on the concept of knowledge evaluation. How actors perceive the quality of knowledge to include into their boundary spanning process is affected by their interpersonal relation with the knowledge source. This is also influenced by the perceived legitimacy of the knowledge source based on job title or education level for the development of their own knowledge domain development or decision making. This knowledge evaluation is also affected by a strong presence of perspective taking efforts by actors in a startup because they are constantly monitoring and assessing the knowledge level of their interlocutor to communicate as efficient as possible.

The effect that the concept of knowledge evaluation has on the overall boundary spanning process is two-fold. On the one hand, it filters out redundant knowledge streams so that they are excluded early in the boundary spanning process, reducing time and resources that would otherwise be needed to process the redundant knowledge making the boundary spanning process more efficient. Nevertheless, knowledge evaluation filters out useful knowledge prematurely by excluding it from the boundary spanning process. The knowledge cannot be shared and used to develop the knowledge domains and ultimately the technical value proposition of the startup.

5.2 Theoretical Implications

This section reflects on the current theoretical field and the theoretical implications of this study (Figure 10).

This study advances current theory on the topic of boundary spanning because it is the first study that considers the empirical setting of startups. Boundary spanning is very externally focused because the internal knowledge useful to develop the technical value proposition of the companies is already applied. The remainder of the knowledge necessary to develop the value proposition thus is external from the start- and scaleup.

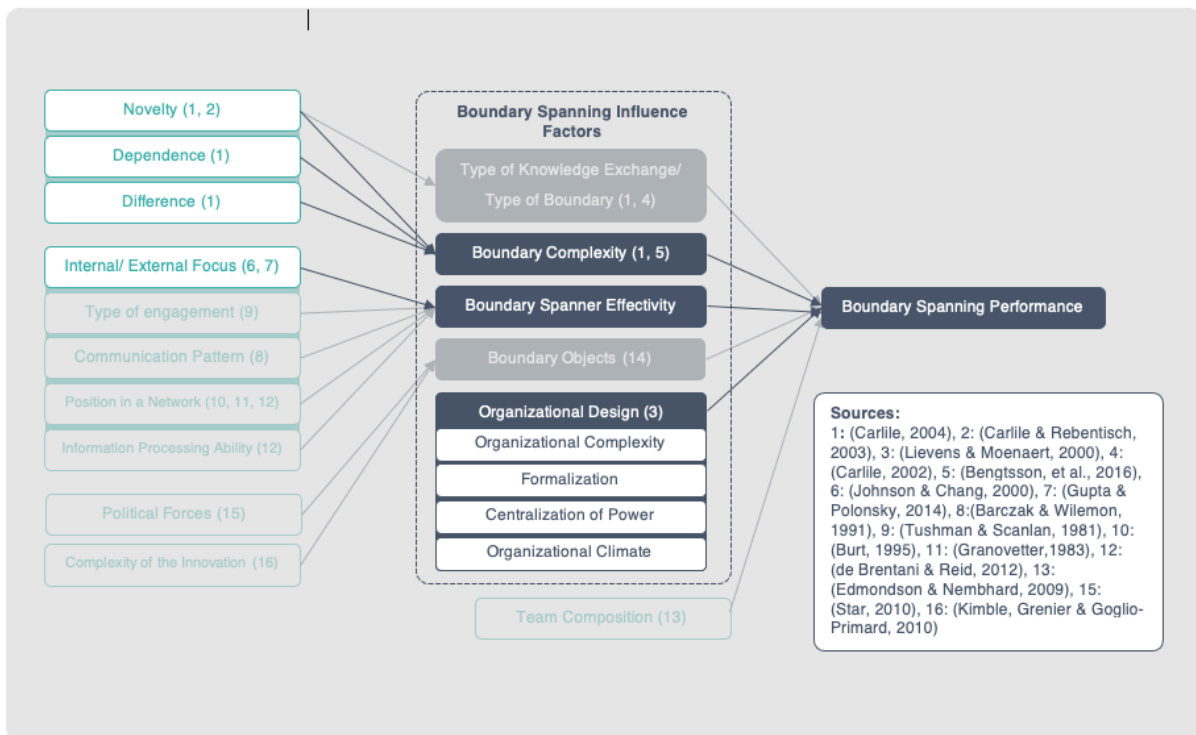


Figure 10 - Reflection on the current theoretical field

It is worth noting that the difference in organizational design (Lievens & Moenaert, 2000) between corporations and emerging companies such as startups has a significant effect on their boundary spanning and its results. The propositions of Lievens and Moenaert (2000) hold true, but this study advances them with specific argumentation for this empirical context and some additional concepts. The factor of formalization in particular, influences boundary spanning process because the low level of formalization enables the startups to conduct boundary spanning in an ad-hoc manner when it is the most needed. Nevertheless, the lack of formalization can cause knowledge distortion or even loss because knowledge that is not essential to business success at a specific moment is not shared with other knowledge domains. So, the statement of Lievens and Moenaert (2000) that formalization is curvilinearly related to boundary spanning effectiveness also holds true in a startup setting. This study validated the curvilinear relation and advanced the argumentation of it. Further the study advanced the negative effect that centralization of power has on boundary spanning effectivity with the concept of legitimacy. Legitimacy lowers the inclusion of information in the decision-making process further lowering the boundary spanning effectivity. Next to this, this study expands the concept of organizational climate with the observed effect that interpersonal relationship has on the boundary spanning process. Current theory only describes a curvilinear relationship and mentions the 'too good friends' syndrome. This study observed the negative effect that interpersonal relationships can have on the organizational climate and therefore the boundary spanning process especially given the low level of formalization.

Carlile (2004) defines boundary complexity using three factors namely difference, dependence and novelty. The findings of this study indicate that there is one additional factor that effects the complexity of a knowledge boundary. This is the interpersonal relation between the people at the knowledge domain. During this study several observations were made where boundary complexity was increased or decreased because of interpersonal relation. When certain actors are technically competent enough to create a shared semantic space between their knowledge domains but are not willing to cooperate with each other, no single innovation is developed. It can be argued that the interpersonal relation affects the difference, dependance or novelty of the knowledge boundary. Carlile (2004) defines these as purely informational factors about the number of unique knowledge domains, the perception of the importance of including one's knowledge and the lack of common knowledge. But even when there are little knowledge domains present, the knowledge of the other actor is deemed useful and common knowledge is adequate, a bad interpersonal relation can still inhibit actors to span the boundary. So, the quality of interpersonal relation is crucial for the transfer of knowledge and therefor this study pleads for the addition of interpersonal relation in the concept of boundary complexity.

5.2.1 Further research directions

Following the statement that formalization is curvilinearly related to boundary spanning effectivity it is to be advised for future research to focus on finding the characteristics of an optimal level of formalization and agility. Afterall the low level of formalization might have positive and negative effects on other business processes next to boundary spanning.

5.3 Managerial Implications

This study it is to be argued that boundary spanning is crucial for technology-based startups because development of their technology-based value proposition is at the heart of their business success. Therefore, this study has a number of implications for managers in emerging technology centered companies.

This study finds evidence that the low level of formalization present in startups leads to ad-hoc boundary spanning and shortens communication lines. This makes resources within the companies flexible to be allocated to boundary spanning processes when they are needed the most. Nevertheless, the lack of structure in boundary spanning processes can cause a loss or distortion of valuable information. There is no need for startups to become bureaucratic and lose their agility, but most start- and scaleup companies could benefit from a slight increase in formalization of boundary spanning processes and boundary objects/infrastructures to create and attain new knowledge.

One of the main conclusions of this study is that certain social factors play a vital role in the effectivity of boundary spanning processes. The relationship between actors within the startups can literally make or break boundary spanning processes because actors can lose

their willingness to communicate or withhold information due to relation issues. Next to this, the proposed increase in formalization needs to be backed by legitimacy because otherwise the knowledge attained by the increase in formalized boundary spanning processes can be deemed as inferior and therefor does not get implemented in decision making. So, it is important to not only consider informational and organizational factors but also social forces that surround boundary spanning.

5.4 Limitations

The data for this study comes from four different start- or scaleup companies. Nevertheless, these companies have one thing in common. They all have a mutual shareholder who is active in the management of the companies. This might have an impact on the observations made during the empirical analysis because these can be caused by the management and therefor might reduce the generalizability of the study. Some findings that are present in the conclusion of this study only appeared in one of the cases. Which reduces the generalizability of the study.

The last 18 months are undoubtedly characterized by the global COVID-19 pandemic. Due to Dutch governmental advice, non-essential workers were requested to work from home as much as possible. This coupled with personal cases of COVID-19 for the employees, partners and other shareholders of Fimavest B.V. and its ventures has brought attendance frequency down. This has three negative consequences on the master thesis study. First, less observations were to be made of the natural behavior of the employees involved in the study. This results in fewer observations to be reported in the in the fieldnotes. Second, less opportunities occurred to get acquainted with the interviewees. This results in less knowledge of their 'native' terms which influences the conducting of the interviews. Finally, some interviews needed to be conducted using an online business communication platform MS Teams. This influences the interactions and non-verbal communications during the interviews.

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Appendix A: Systematic Literature Review Method

After the previous argumentation why boundary spanning is of significance to corporate performance regarding the domain of innovation management the methodology of this dissertation is argued. To make sure all relevant literature is included in the review without biases, a rigorous methodology is needed to search and select literature. The selection of the sources is described, then the included key terms are discussed. After this the development and formulation of the search string and the results of the search string are given. Finally, further detailing in the form of inclusion of literature via snowballing is discussed.

Search strategy

Scopus is selected as the library for the literature search. The reason for this is the possibility of including Boolean operators and field codes in the '*advanced search*' option. Next to the search possibilities, the access to the documents granted via the Technical University of Eindhoven is paramount in the selection of this database. After the selection of the libraries, the exploratory literature research is done based on the main review topic '*boundary spanning*' and one of the leading authors on this topic '*P. R. Carlile*'. These two search terms are derived from an interview with the supervisor. After reading the resulting articles the following key terms have emerged: *boundary spanning*, *boundary spanner*, *boundary object*, *knowledge boundary* and *product development*.

Article	Key Term
Carlile, P. R., & Rabentisch, E. S. (2003). Into the Black Box: The knowledge transformation cycle. <i>Management Science</i> , 1180-1195.	Boundary object, knowledge transfer
Carlile, P. R. (2003). A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. <i>Organization Science</i> , 442-455.	Boundary object, product development
Carlile, P. R. (2004). Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries. <i>Organization Science</i> , 555-568.	Boundary object, boundary management, product development

Search string development and snowballing

The key terms are searched for in the title and the abstract of the articles. So, the search string looks as following:

TITLE-ABS ("boundary spanning" OR "boundary spanner" OR "boundary object")

This resulted in 3.285 documents. To improve the quality of the results only documents about innovation or product development are considered interesting and therefore worth inclusion. This is done by adapting the search string so the results must include the previously used key terms and innovation or product development. This resulted in the following search string:

TITLE-ABS (("boundary spanning" OR "boundary spanner" OR "boundary object") AND ("innovation" OR "product development"))

The search string as depicted above resulted in 450 documents. After this, selection is been made to only include English sources on the subject areas of the social sciences, economics, econometrics and finance and, business, management and accounting. These inputs give rise to the following search string used in Scopus:

TITLE-ABS (("boundary spanning" OR "boundary spanner" OR "boundary object") AND ("innovation" OR "product development")) AND LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "SOCI") AND (LIMIT-TO (LANGUAGE, "English"))

This resulted in 332 documents divided over four source types; journal (267), conference proceedings (40), book (20), and book series (5). To narrow the results down the journals are included based on the quality of the journals. This selection is made using the Clarivate Analytics Incites Journal Citation Reports (JCR). Journals who are not included in this list are excluded from the search. From the 155 journals in the search, 100 journals are included in the JCR and thus are included in the systematic review. Appendix 1 shows a table with the evaluation of all journals. This evaluation includes the JCR ranking in their own niche and the 5-year impact factor. The five-year impact factor is preferred over the 2019 impact factor because it gives an impression of the quality of a journal based on the previous five years instead of a shorter period of 1 year. So, from the 267 journal articles, 168 journal articles remain.

The title and abstract of these documents get scanned using inclusion and exclusion criteria. First, only studies about the boundary spanning climate in a firm are included because of the interests in exploring boundary spanning processes in a business setting. Second, studies that focus around the cooperation between company actors surrounding boundary spanning practices are included. Third, boundary spanning must be the focal point of study and must be a primary study outcome. Finally, empirical studies with non-business contexts (e.g., natural- and computer science, healthcare) are excluded from the final selection because of the deviant empirical context the results are not applicable and might not be interesting to

the main research. Notably, no selection is made based on business size concerning the empirical studies. The final set contained 18 documents (Appendix 2).

Search string	Results
<i>TITLE-ABS ("boundary spanning" OR "boundary spanner" OR "boundary object")</i>	3.285 documents
<i>TITLE-ABS (("boundary spanning" OR "boundary spanner" OR "boundary object") AND</i>	450 documents
<i>TITLE-ABS (("boundary spanning" OR "boundary spanner" OR "boundary object") AND</i>	332 documents
<i>Selection on JCR ranking</i>	168 documents
<i>Selection on title</i>	112 documents
<i>Selection on abstract</i>	18 documents

To make sure the entire field is covered, snowballing is applied to the three orientating articles and the 18 articles that originate from the search. Snowballing is done with articles cited in the original articles when they contain interesting and useful information on the topic of boundary spanning.

Synthesis method

The research results will be combined using an integration research synthesis method (Rousseau, Manning, & Denyer, 2008). This synthesis methods focusses on triangulation of the findings through this evidence-based aggregation process in a specific context into one coherent framework (Rousseau, Manning, & Denyer, 2008). This framework takes the shape of a diagram summarizing the findings from the selected articles on which factors affect the boundary spanning process.

Appendix B: Respondents of the empirical analysis

	Case		Job Title
1	Agri-Improvement	Business Employee 1	Founder/ Partner at Fimavest B.V.
2		Technical Employee 1	Product and application Developer
3	ECOating	Technical Employee 2	Research Intern
4		Technical Employee 3	Research Intern
5		Business Employee 1	CEO/ founder
6		Business Employee 2	CFO/ partner at Fimavest B.V.
7	Bacteria B.V.	Technical Employee 1	R&D Director/ founder
8		Business Employee 2	Managing Director/ partner at Fimavest B.V.
9	Plastic-Cycle	Technical Employee 1	Process Engineer
10		Technical Employee 2	Technology Consultant
11		Technical Employee 3	Operations Director/ Senior Engineering Group
12		Business Employee 1	Plant Manager
13		Business Employee 2	Key Account Manager

Appendix C: Codebook

	Code	Description	Example citation
2 nd order theme	Legitimacy	Judgement of information quality of the input from actors based on educational background or job title	<i>"Ze denken dat hun kennis boven die van andere staat. Ze hebben een denkwijze, een filosofie en daar zijn ze moeilijk van af te brengen."</i>
1st order concept	Exclusion of 'inferior' knowledge/ employment level	Knowledge and experiences from operational employees is excluded from decision making processes because their knowledge level is deemed inferior based on their educational background or job title.	<i>"Ja we worden wel betrokken, we zijn ook wel eens bij die vergaderingen. Je mening kun je uiten maar daar wordt niks mee gedaan. [...] omdat je geen professor bent nemen ze niks van je aan."</i>
1st order concept	No operational observations by higher level employees	Higher level employees do not feel inclined to observe and experience the results of a trial run of the factory based on their believe that theory stand above experiences.	<i>"Als er ergens een probleem is moet je er met je snufferd bijstaan. En als iets open gemaakt wordt moet je er met je snufferd bij staan want een foto verteld jou niet wat je er dan bij ziet en ervaart en tegenkomt. Dat is iets wat [...] niet doen wat dat hoort niet bij hun academische aanpak."</i>
2 nd order theme	Perspective making	Using information from other knowledge domains to improve own knowledge domain	<i>Maar omdat ik heel nauw betrokken ben bij heel veel acties en beslissingen "heb ik van [...] ook een stuk chemie geleerd. Waardoor ik ook de business beter kan begrijpen."</i>
1st order concept	Developing technology of the startup through communication with another field	Actors communicate with other knowledge domains and transform the gained information to improve their own knowledge domain.	<i>"Dan ontstaan er trajecten waarin je samen de technische oplossing gaat zoeken. Door elkaars kennis samen te voegen en dat te testen."</i>

1st order concept	Adapting innovation to novelties with specialized knowledge	Adaptation of technology-based value proposition to changes in external market demands	<i>"We waren te technisch bezig, we moeten veel meer en eerder gaan kijken naar wat wil de markt. [...] door dat inzicht hebben we het product ook aangepast"</i>
2nd order theme	Perspective taking	Adjustment of language to communicate domain specific knowledge to another knowledge domain	<i>"Ik praat met hun op een heel andere manier als ik bijvoorbeeld met [...] praat."</i>
1st order concept	Perception of difference in knowledge level with interlocutor	Actor assesses the knowledge level of his interlocutor during communication	<i>"Maar dan merk ik nog dat ze het af en toe niet snappen."</i>
1st order concept	Adapting language to interlocutors' knowledge level	Actor adapts language used to the knowledge level of the interlocutor so the interlocutor understands the knowledge transferred during the communication. This might include leaving out technical details or simplifying/ highlighting parts of the story.	<i>"Ik moet het echt naar Jip en Janneke taal terugbrengen. De biologie moet je achterwegen laten, je moet het in een duidelijke heldere taal vertellen."</i>
2nd order theme	High level of boundary spanning engagement	Almost all, if not all employees in a startup engage in boundary spanning activities to improve the technical value proposition	<i>"Iedereen is heel hands-on bezig met het ontwikkelen van het product,</i>
1st order concept	Intrinsic motivation to improve company	Employees want to improve the start- or scaleup their work without external motivational factors or rewards.	<i>"Die betrokkenheid bij het ontwikkelen van de business komt vooral vanuit intrinsieke waarden om steeds te willen verbeteren"</i>
1st order concept	Prolific use of old and new networks	Employees actively use the network from their previous employment and their current employment to source information to improve the start- or scaleup without motivation or stimulation from their supervisor.	<i>"Iedereen zoekt naar informatie of mogelijkheden bij oude werkgevers, concurrerende producten of vaktijdschriften."</i>
2nd order theme	Low level of formality	No or few processes in the start- and scaleups are preplanned, structured or documented. This includes documentation, meetings, operational processes and reporting hierarchies.	<i>"Hier liggen geen processen vast, we doen alles op de manier waarvan we zelf denken dat het het beste is. Het is een kleine organisatie dus we krijgen het goed gemanaged."</i>

1st order concept	Few structured meetings	No or few meetings are preplanned and reoccurring	<i>"Nou echt gepland samenzitten bijna nooit want het gros gaat gewoon over de tafel heen met [...]. En met [...] spreken we dan 10 minuten en dan is die ook weer bij. Het is nooit dat we zeggen op maandag middag om 11:00 gaan we de volgende punten bespreken."</i>
1st order concept	No formal processes of procedures	No or few processes or procedures are structured	<i>"Samenwerken doen we hier op gevoel, het is niet dat pietje met klaasje moet gaan vergaderen of dat we precies op deze manier moeten brainstormen. Dat gaat allemaal op organische wijze."</i>
1st order concept	Lacking documentation	No or few records are kept from meeting and operational actions or these records are poorly stored and structured	<i>"We hebben een Dropbox, maar daar heb ik best struggles mee gehad om bruikbare data uit te halen. Dit zorgde ervoor dat de kennis die er was niet direct bij mij terecht is gekomen. Ik heb nog steeds dat ik achter dingen kom waarvan ik denk "oww dat was leuk geweest als ik daar zes maanden geleden achter was gekomen".</i>
2 nd order theme	Influence of interpersonal relations	The effect that the quality of the interpersonal relationship between actors surrounding the boundary have on the boundary spanning process	<i>"Hier ligt dat [the innovation process] niet zo vast en is hetgeen wat gedaan wordt en hoe effectief teamleden samenwerken afhankelijk van hoe hun de taken interpreteren en hoe de sfeer van het team is."</i>
1st order concept	Personal conflicts inhibit collaboration	Actors at a boundary are unwilling to communicate with each other because of personal conflicts.	<i>"Let's keep the ball flat, the communication between management, sales, feed and so forth was poor. It has a personal aspect. I do not like mister [...], he does not like me. It does not work."</i>
1st order concept	Political forces inhibit communication	Double agenda's, incentive misalignment or misalignment in other power relations negatively influences the willingness to communicate	<i>"[...] en dat je naar een gezamenlijk doel toe werkt. Geen dubbele agenda's en geen ergernissen."</i>

1st order concept	Lack of trust inhibits communication	Lack of belief in the reliability or intentions of an actor in the start- and scaleup can negatively influence willingness to communicate	<i>"Je hoeft echt niet de beste vrienden te zijn, maar dat je elkaar vertrouwd."</i>
2nd order theme	Flexible human capital	Actors active in the start- and scaleups have flexible employment terms	<i>"Daarnaast werken we met stagiaires, technisch maar ook op marketing-gebied."</i>
1st order concept	Interns/ university collaborations	The start- and scaleups make use of interns and research projects to develop their technology-based value proposition	<i>" [professor at HAS] die heeft een leerstoel op bodemleven. Onder haar zitten stagiaires en afstudeerders en die hebben proeven en testen voor ons uitgevoerd."</i>
1st order concept	Secondment and consultants	The start- and scaleups make use of secondment and consultants to develop their technology-based value proposition or to fulfill operational tasks	<i>"De productiemensen zijn niet in dienst bij Plastic-Cycle, deze zijn van Profcore."</i>
1st order concept	Few/ no permanent employments	No or few employees active in the start- and scaleups have a permanent employment contract	<i>"We nemen in deze fase niet graag vaste krachten aan omdat dat de flexibiliteit verminderd, als ik ineens maar 20 uur werk heb voor mijn medewerker zou ik toch 40 uur moeten betalen."</i>
2nd order theme	External focus of boundary spanning	Majority of boundary spanning effort is directed to acquiring knowledge from external environment of the start- or scaleup	<i>"The focus lies on finding information outside of Plastic-Cycle because everything we [the actors of Plastic-Cycle] is already incorporated in the machine"</i>
2nd order theme	Young, emerging company	Start-up gaining presence and prominence in competitive market landscape	<i>"We zijn pas een aantal jaar bezig met het ontwikkelen van de coating, en we hebben nu pas de waarde propositie scherp voor te commercialiseren."</i>
1st order concept	Expansion from technical innovation to commercialization	The start-and scaleup transfer from technical innovation to a minimum viable product to finally reach commercialization with constant revenues	<i>"Het euvel waar we nu mee zitten in de hele sales. We hebben heel veel dingen op de plank liggen maar het moet nog landen bij de markt."</i>

1st order concept	Pre-mature business processes	Business processes not yet developed, structured or reported on	<i>We trachten daar structuur in aan te brengen, Pierre en ik bewegen hemel en aarde om daar wat vaste overlegstructuren in aan te brengen.</i>
2 nd order theme	Desire to stay agile	The start-and scaleups want to be able to react to external changes with a flexible internal organization	<i>“Maargoed, het is natuurlijk een venture, een startup, met een hele kleine lean en mean organisatie waar [...] 60, 70, en soms wel 80 uur per week bezig was en waar natuurlijk dingen blijven liggen.”</i>
1st order concept	Changing external environment	The external environment of the start- and scaleups changes (dynamics in social-, cultural-, demographic-, political-, economic- or technological factors) which the start- or scaleup cannot influence directly.	<i>“Terwijl we opereren in een commerciële markt die ontzettend veranderd. Vijf jaar geleden toen ik hier begon wilde niemand gerecyclede parafine of Nafta. De vraag naar chemisch gerecyclede producten kwam alleen van Unilever of P&G. Maar nu zeggen ze bij het eerste gesprek van hoeveel kunnen we kopen of zelfs hoeveel van jou bedrijf kunnen we kopen.”</i>
1st order concept	Reacting to opportunities	The start- and scaleup can react to favorable external circumstances by rearranging and adjusting its internal organization	<i>“Ik ben van mening dat je als startup alleen maar focus kunt brengen. Die markt is zo groot dat je niet op alle kansen in kunt gaan. We kunnen snel schakelen om te focussen op de kansen maar we zijn te klein om op alles te springen.”</i>
1st order concept	Lean and mean organization	Organization that focusses on the creation of value with the least amount of resources	<i>“Ik ben op dit moment de enige die fulltime bezig is met Agri-Improvement maar we maken wel goede stappen richting het verkopen.”</i>
2 nd order theme	Easy relocation of resources	The start- or scaleup can rearrange its resources with little impact on the current organizational actions	<i>“Alles staat nog in het teken van de coating ontwikkelen en klanten werven dus als we op dat gebied stappen kunnen maken moet en kan daar alles voor wijken. [...] Omdat we weinig dagelijks noodzakelijke acties hoeven uit te voeren zoals productie draaien of administratie en dergelijke.”</i>

1st order concept	Short communication lines	The threshold for any employee in the start- or scaleup to communicate directly or with little intermediaries with any other employee in the start- or scaleup is low	<i>“Ja we zitten gewoon tegenover elkaar, de lijnen zijn kort dus we schakelen snel en spreken elkaar gewoon aan.”</i>
1st order concept	Easy to quickly increase boundary spanning effort	The ability for a start- and scaleup to increase the amount or intensity of resources allocated to the boundary spanning process without influencing other business practices	<i>“We kunnen snel schakelen en inspringen als [...] bijvoorbeeld de coating moeten afstemmen en testen met een nieuwe klant.”</i>
1st order concept	Resources not stuck in existing business processes	Resources are not obligated to perform business processes in	<i>“Mijn agenda staat niet vol met allemaal meetings en afspraken dus ik kan mijn tijd zo indelen dat ik het meest efficiënt bezig ben voor Agri-Improvement. Als er zich een kans voordoet bijvoorbeeld een nieuwe klant of een ander product voor in het substraat, dan kan ik daar meteen op inspringen.”</i>
2 nd order theme	Distinct specializations and knowledge levels	The specializations, knowledge levels, and job titles active in the start- and scaleup are distant from each other because they span the same width of tasks with less employees	<i>“De businessplannen worden gemaakt op de getallen die ik aanlever. Maar dat is wel lastig, want ik heb vaak het idee dat ze [business-oriented employees] het niet meekrijgen. Maar dat is ook niet zo gek want het is heel gedetailleerd allemaal.”</i>
1st order concept	Distinct technology and business employees	Employees range from technological or scientific to financial specialist	<i>“Goh, [...] heeft een PhD in microbiologie die weet alles tot in detail van die bacteriën. [...] Mijn achtergrond ligt in de financieel juridische wereld</i>
1st order concept	No middle man between business and technology	No employees between the distinct knowledge domains of business and technology	<i>“Het euvel waar we nu mee zitten in de hele sales, ik ben opzoek naar een goede business developer. [...] Ik zie de potentie en weet hoe ik mijn beestje [the bacteria] moet aanpassen. Maar ik heb een verkoper nodig die me kan ondersteunen en daarin de nuances aan kan geven.”</i>
1st order concept	Scientists and operational employees present	Employees span a wide range of educational levels (academic professors to not educated)	<i>“We hebben de senior engineering group met professor [...] en [...] en aan de andere kant hebben we de gedetacheerde operators.”</i>

